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Australia's State of the Forests Report 2013

Five-yearly report

Prepared by the Montreal Process Implementation Group for Australia
and the National Forest Inventory Steering Committee
on behalf of the Australian, state and territory governments

AUSTRALIAN BUREAU OF AGRICULTURAL AND RESOURCE ECONOMICS AND SCIENCES

Cover and title page include the logo of the Montreal Process Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests.

Cover image: Blue Mountains National Park, New South Wales. Photo: iStockphoto.
Back cover images: Getty Images and iStockphoto.

Above: View of the Atherton Tablelands, Queensland.

Right: Shining gum (*Eucalyptus nitens*) plantation.

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Snowgums (*Eucalyptus pauciflora*) in Kosciuszko National Park, New South Wales.

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Foreword

Bark of *Corymbia henryi*.

Australia's forests are highly regarded for their environmental, social and economic values. Forests are biodiverse, protect soil and water resources, and contribute to the carbon cycle by storing carbon and offsetting greenhouse gas emissions. Forests are also an integral part of the cultural landscape. In addition, they contribute to the economic wellbeing of Australia through the production of timber, pulp and paper, and many non-wood products.

Australia's State of the Forests Report is produced every five years under a commitment made in 1992 in the National Forest Policy Statement. *Australia's State of the Forests Report 2013* is the fourth report in the series. It provides information for national and regional monitoring and reporting in relation to Australia's forests, delivers on a requirement of the Commonwealth *Regional Forest Agreements Act 2002*, and supports Australia's international reporting on forests and forestry.

Australia's State of the Forests Report 2013 reviews the management, conservation and use of Australia's forests across the period 2006–11. Among other things, it provides information on public, private and leasehold forests; native forests and plantations; forests managed for conservation and forests managed for wood production; and forests important for Australia's Indigenous people. It covers all of Australia's forests, including the closed tropical rainforests of Australia's north, the tall forests of eastern and south-western Australia, and the acacia and eucalypt woodland forests of inland Australia. The report brings fresh insight to the management of Australia's forests, with new information and the assessment of long-term trends.

Preparation of *Australia's State of the Forests Report 2013* has been coordinated by the Australian Bureau of Agricultural and Resource Economics and Sciences on behalf of the Montreal Process Implementation Group for Australia and the National Forest Inventory Steering Committee. The report is a product of close collaboration between the Australian, state and territory governments, as well as other agencies and individuals. *Australia's State of the Forests Report 2013* will be a key reference for managers, policy makers and the wider community, and it will provide a firm, factual basis for debate on the sustainable management of Australia's forests.

I thank all those who have contributed to the production of this comprehensive report.

Karen Schneider
Executive Director
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1 Contributors are listed according to their affiliation as at 30 September 2013.

2 From September 2013, the Department of the Environment.

3 Climate Change staff: from September 2013, at the Department of the Environment.

4 Tertiary Education staff: from September 2013, at the Department of Employment.

5 Indigenous Affairs staff: from September 2013, at the Department of the Prime Minister and Cabinet.

Acronyms and abbreviations[6]

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
ANZECC	Australian and New Zealand Environment and Conservation Council
BRS	Bureau of Rural Sciences (Australian Government)
BREE	Bureau of Resources and Energy Economics (Australian Government)
CAPAD	Collaborative Australian Protected Areas Database
CAR	Comprehensive, Adequate and Representative
CCWA	Conservation Commission of Western Australia
CFI	Carbon Farming Initiative
C&I	criteria and indicators
COAG	Council of Australian Governments
CO_2	carbon dioxide
CO_2-e	carbon dioxide-equivalent
CPI	consumer price index
CRA	Comprehensive Regional Assessment
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australian Government)
DAFF (Australia)	Department of Agriculture, Fisheries and Forestry (Australian Government)
DAFF (Queensland)	Department of Agriculture, Fisheries and Forestry (Queensland Government)
DCCEE	Department of Climate Change and Energy Efficiency (Australian Government)
DEC	Department of Environment and Conservation (Western Australian Government)
DENR	Department of Environment and Natural Resources (South Australian Government)
DEPI	Department of Environment and Primary Industries (Victorian Government)
DERM	Department of Environment and Resource Management (Queensland Government)
DEWHA	Department of Environment, Water, Heritage and the Arts (Australian Government)
DIA	Department of Indigenous Affairs (Australian Government)
DIICCSRTE	Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (Australian Government)
DIISRTE	Department of Industry, Innovation, Science, Research and Tertiary Education (Australian Government)
DLCM	Dynamic Land Cover Mapping
DPaW	Department of Parks and Wildlife (Western Australian Government)
DPI (NSW)	Department of Primary Industries (New South Wales Government)
DPI (Victoria)	Department of Primary Industries (Victorian Government)
DPIPWE	Department of Primary Industries, Parks, Water and Environment (Tasmanian Government)
DSE	Department of Sustainability and Environment (Victorian Government)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Australian Government)
EPA	Environment Protection Authority (New South Wales Government)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
ESDD	Environment and Sustainable Development Directorate (Australian Capital Territory Government)
FaHCSIA	Department of Families, Housing, Community Services and Indigenous Affairs (Australian Government)
FAO	United Nations Food and Agriculture Organization
FCNSW	Forestry Corporation of New South Wales
FFPC	Forestry and Forest Products Committee
FPA	Forest Practices Authority, Tasmania
FPC	Forest Products Commission of Western Australia
FT	Forestry Tasmania (Tasmanian Government Business Enterprise)
FTE	full-time-equivalent
FWPA	Forest and Wood Products Australia
GA	Geoscience Australia (Australian Government)

[6] A subsequent table relates agency names that applied during the SOFR 2013 reporting period, to agency names in use at 01 October 2013.

GDP	gross domestic product
GFCF	gross fixed capital formation
GFRA	Global Forest Resources Assessment
GVP	gross value of production
HWP	harvested wood products
ILC	Indigenous Land Corporation
IPA	Indigenous Protected Area
IUCN	International Union for Conservation of Nature
LA Act	*Land Administration Act 1997* (Western Australia)
LTER	long-term ecological research
LTERN	long-term ecological research network
MCFFA	Ministerial Council on Forestry, Fisheries and Aquaculture
MIG	Montreal Process Implementation Group for Australia
MLE	Multiple Lines of Evidence
MODIS	Moderate-resolution Imaging Spectroradiometer
Mt C	million tonnes of carbon
NCAS	National Carbon Accounting System
NCLD	National Conservation Lands Database
NCP	National Competition Policy
NFI	National Forest Inventory
NFISC	National Forest Inventory Steering Committee
NHL	National Heritage List
NIHSA	Non-Indigenous Heritage Sites of Australia
NNTT	National Native Title Tribunal
NPI	National Plantation Inventory
NRETAS	Department of Natural Resources, Environment, the Arts and Sport (Northern Territory Government)
NRMMC	Natural Resource Management Ministerial Council
NRS	National Reserve System
NSW	New South Wales
NT	Northern Territory
NVIS	National Vegetation Information System
NWFP	non-wood forest product
OEH	Office of Environment and Heritage (New South Wales Government)
PIRSA	(from October 2011) Department of Primary Industries and Regions South Australia
PIRSA	(before October 2011) Department of Primary Industries and Resources South Australia
PJ	Petajoule (10^{15} joules)
Qld	Queensland
R&D	research and development
RFA	Regional Forest Agreement
RIRDC	Rural Industries Research and Development Corporation
RNE	Register of the National Estate
SA	South Australia
SCoPI	Standing Council on Primary Industries
s.l.	sensu lato ("in the broad sense")
SLA	Statistical Local Area
SLATS	State-wide Landcover and Trees Study
SoE	State of the Environment
SOFR	State of the Forests Report
Tas.	Tasmania
TERN	Terrestrial Ecosystem Research Network
UNESCO	United Nations Educational, Scientific and Cultural Organization
VFMP	Victorian Forest Monitoring Program
Vic.	Victoria
WA	Western Australia
WHL	World Heritage List

Agency name changes

Agency names used in this report are the names correct during the reporting period (July 2006 to June 2011). Where the reference is explicitly to an ongoing function or activity of the agency, the agency name as at 01 October 2013 is also given if different to the agency name used during the reporting period. This applies to the following agencies.

Jurisdiction	Agency name and acronym during SOFR 2013 reporting period 01 July 2006 to 30 June 2011		Agency name at 01 October 2013
Australian Government	Department of Agriculture, Fisheries and Forestry	DAFF	Department of Agriculture
	Department of the Environment, Water, Heritage and the Arts	DEWHA	Department of the Environment
	Department of Climate Change and Energy Efficiency – *climate change function*	DCCEE	Department of the Environment
	Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education – *climate change function*	DIICCSRTE	Department of the Environment
	Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education – *tertiary education function*	DIICCSRTE	Department of Employment
	Department of Industry, Innovation, Science, Research and Tertiary Education – *tertiary education function*	DIISRTE	Department of Employment
	Department of Sustainability, Environment, Water, Population and Communities	DSEWPaC	Department of the Environment
New South Wales	Forests NSW	Forests NSW	Forestry Corporation of New South Wales
Northern Territory	Department of Natural Resources, Environment, the Arts and Sport	NRETAS	Department of Land Resource Management
Queensland	Department of Environment and Resource Management – *forestry function*	DERM	Department of Agriculture, Fisheries and Forestry
South Australia	Department of Environment and Natural Resources	DENR	Department of Environment, Water and Natural Resources
	Department of Primary Industries and Resources South Australia	PIRSA	Primary Industries and Regions South Australia
Victoria	Department of Primary Industries	DPI	Department of Environment and Primary Industries
	Department of Sustainability and Environment	DSE	Department of Environment and Primary Industries
Western Australia	Department of Environment and Conservation – *forest management and conservation functions*	DEC	Department of Parks and Wildlife
	Department of Environment and Conservation – *environmental regulation function*	DEC	Department of Environment Regulation
	Department of Indigenous Affairs	DIA	Department of Aboriginal Affairs

iStockphoto

Executive summary

Australia's State of the Forests Report 2013 (SOFR 2013) is the fourth in a series of national five-yearly reports on Australia's forests, and presents data from a wide range of sources. Previous national reports were published in 1998, 2003 and 2008.

Warren National Park, Western Australia.

Australia's forests are recognised and valued for their diverse ecosystems and unique biodiversity, for their cultural heritage, and for the provision of goods and services such as wood, carbon sequestration, soil and water protection, and aesthetic values and recreational opportunities. Australia's forests are subject to a range of pressures, including extreme weather, drought, climate change, invasive weeds, pests and diseases, changed fire regimes, urban development, mining, agricultural management practices such as grazing, and the legacy of previous land-management practices. The sustainable management and conservation of Australia's forests, whether on public or on private land, requires a sound understanding of their condition, use and management.

The seven criteria for sustainable forest management used in SOFR 2013 are those developed by the international-level Montreal Process Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests. The criteria address the following aspects of forest conservation and management:

1) biological diversity
2) the productive capacity of forest ecosystems
3) ecosystem health and vitality
4) soil and water resources
5) forest contribution to global carbon cycles
6) long-term multiple socioeconomic benefits
7) legal, institutional and economic framework.

Indicators grouped under these criteria allow the presentation of a substantial body of data, in a consistent and repeatable format, on Australia's forests, their condition, their management, and their importance for people. Reporting on the state of Australia's forests through SOFR 2013 will support progress towards the sustainable management of Australia's forests.

The material under each of the 44 indicators in SOFR 2013 includes a brief description of the context for the indicator, presents nationally compiled data for the reporting period July 2006–June 2011 (or as close to this period as the data allow), gives caveats on data quality, and in many instances includes one or more regional case-studies. Trends over time are presented for indicators for which suitable data are available over a sufficient period.

This Executive summary draws together into key themes the information presented in SOFR 2013.

Left: Forest near Bellingen, New South Wales.

Australia's forests

Australia's forests are dominated by eucalypt and acacia forests, and the majority are woodland forests.

Australia has 125 million hectares of forest, equivalent to 16% of Australia's land area, as determined at 2011. Australia's forest cover is shown on the map below. Australia has about 3% of the world's forest area, and the seventh largest reported forest area of any country worldwide. Data on Australia's forest estate are compiled in the National Forest Inventory. A new approach has improved the resolution of mapping and given a more accurate measure of Australia's forest area.

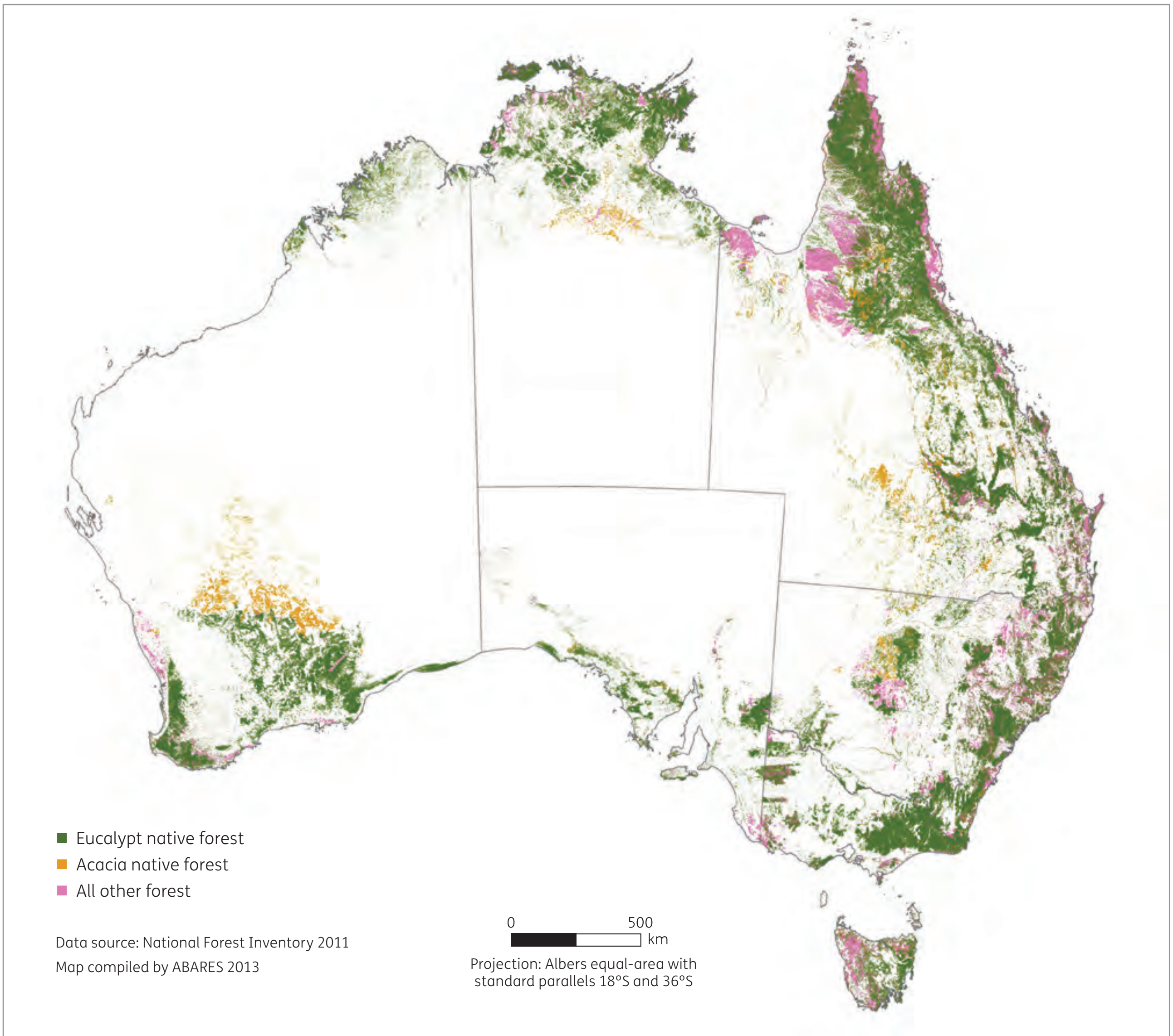
Australia's forests comprise 123 million hectares of native forests (98% of the total forest area), 2.02 million hectares of industrial plantations, and 0.15 million hectares of other forests. Australia's native forests are dominated by eucalypt forests (92 million hectares; 75% of the native forest area) and acacia forests (9.8 million hectares; 8%). The area of rainforest is 3.6 million hectares (3%).

About two-thirds of Australia's native forest (81.7 million hectares; 66.6%) is woodland forest with 20–50% crown cover.

An estimated 81.9 million hectares (66.8%) of Australia's native forest is privately managed on private and leasehold lands, including Indigenous owned and managed lands, or Indigenous managed lands (the term Indigenous is used in SOFR 2013 to refer to Aboriginal and Torres Strait Islander people).

Australia's Industrial plantations, for which data are compiled in the National Plantation Inventory, consist of similar areas of softwood species (1.03 million hectares, mostly pines) and hardwood species (0.98 million hectares, mostly eucalypts).

Australia's native forests are dominated by eucalypt forests and acacia forests.



SOFR 2013 reports Australia's total forest area as 125 million hectares, as shown in this map. Australia's 123 million hectares of native forests are dominated by eucalypt forests and acacia forests.

A new approach has improved the resolution of mapping and given a more accurate measure of Australia's forest area.

The forest area data for Australia presented in SOFR 2013 were derived using a 'Multiple Lines of Evidence' approach, which integrates forest cover data provided by state and territory land management agencies with data sourced from a variety of remote-sensing methods.

- This approach gives a higher level of certainty of reporting for areas of forest and areas of non-forest.
- The resultant National Forest Inventory forest cover dataset contains an updated and more rigorous and robust understanding of Australia's total forest area, the geographic distribution of national forest types, and the geographic distribution of forests of different tenure.

Australia's forest area reported in SOFR 2013, following application of the 'Multiple Lines of Evidence' approach, is 125 million hectares; Australia's forest area was reported in SOFR 2008 as 149 million hectares.

- Reporting a smaller forest area in SOFR 2013 does not mean that there has been a reduction in actual forest area, but rather results from improvements in technology that have enabled the use of better quality data on Australia's forests. The main reason is an improved resolution of forest mapping, resulting from the use of finer scale vegetation data, and often complemented by interpreted satellite imagery.
- Most of this improvement in resolution has occurred in Australia's less dense woodland forests, and has resulted from more careful delineation of the boundaries between woodland forest (with a crown cover of 20–50%) and other woody non-forest vegetation (with a crown cover of less than 20%). Much of the area previously reported as woodland forest in SOFR 2008 is now classified in SOFR 2013 as other woody non-forest vegetation.
- Another reason for reporting a smaller forest area is the incorporation of data on historical and recent land-use change for agriculture, mining or urban development.
- Most (83%) of the reduction in reported forest area between SOFR 2008 and SOFR 2013 is in the Northern Territory and South Australia, in forests generally managed under leasehold tenure.

SOFR 2013 reports no reduction in the areas of rainforest, multiple-use public forest, or forest in any of the Regional Forest Agreement regions compared with SOFR 2008.

- These areas have all been the subject of previous detailed forest mapping, and the Multiple Lines of Evidence approach led to only small amendments in their forest areas.

Continual improvements in understanding the extent of Australia's forests, and the reporting of forest area, have occurred since national figures were first reported in 1974.

- Australia's reported forest area has fluctuated between 105 million hectares and 164 million hectares since 1974, including across the three previous national State of the Forests reports in 1998, 2003 and 2008.
- These historical fluctuations in reported areas did not reflect actual changes in on-ground forest cover, but instead were mainly the result of changes in the basis of reporting (from only commercial forests to all forests), variability in state and territory data, mapping errors, and, before 1998, changes in the definition of forest.

The Multiple Lines of Evidence approach now adopted for the National Forest Inventory provides a forest area value, 125 million hectares, that is more accurate than previously reported values, and that is expected to be more suitable for the determination of changes in forest area over future reporting periods.

Change in forest area over time

Australia's forest cover changed over the period 2005–10, with a net loss estimated at 1.4 million hectares.

National figures for changes in on-ground forest cover are best determined using a single methodology applied consistently over time. The best available source of such data is currently satellite imagery interpreted for Australia's National Greenhouse Gas Inventory (previously known as the National Carbon Accounting System—NCAS). There are differences between the NCAS dataset used for carbon accounting, and the National Forest Inventory dataset used for the detailed recording and reporting of forest areas classified by forest structure, type and tenure. Overall, however, the NCAS dataset currently gives the most accurate measure of on-ground change in Australia's forest area.

Over the period 2005–10, the net loss of forest area calculated using the NCAS dataset is 1.4 million hectares (just over 1% of Australia's forest area). This was the result of land-use change for urban development and agriculture, plus short-term factors such as drought and fire. During this period, forest area decreased by 1.8 million hectares in 2005–08, then increased by 0.4 million hectares in 2009–10 as a result of recovery of forest from drought and fire.

Tenure and forest growth stage

The majority of Australia's native forests are in private and leasehold tenures. Smaller areas are held in formal nature conservation reserves and multiple-use public forests.

An estimated 81.9 million hectares (66.8%) of Australia's native forest is privately managed on private and leasehold tenures, while 21.5 million hectares of native forest (17.5%) is in formal nature conservation reserves. A further 10.2 million hectares of native forest (8.3%) is in multiple-use public forests. The remaining native forest (9.0 million hectares, 7.4%) occurs on other Crown land, or on land of unresolved tenure.

Regrowth karri (*Eucalyptus diversicolor*) forest in south-west Western Australia.

Woodland forest of snowgum (*Eucalyptus pauciflora*) in Kosciuszko National Park, New South Wales.

Nature conservation reserve and multiple-use public forest now both comprise a greater proportion of the native forest area than in SOFR 2008 (although for multiple-use public forest this is driven largely by forest tenure reclassification in Queensland), and there is a trend of progressive transfer of forest into reserves since the first SOFR in 1998. The distribution of native forest tenure types varies significantly across the different states and territories.

National data on native forest growth stage are available only for 15.4 million hectares of native forest, most of which is in Regional Forest Agreement regions in south-east and south-west Australia, where detailed measurements have been carried out. In this area of forest where growth stage is known, all four forest growth stages (regeneration, regrowth, mature and senescent) are present on all tenure types. More than 73% of Australia's identified old-growth forests are in formal or informal nature conservation reserves.

Protected forest areas on public and private land

A total of 39 million hectares (32% by area) of Australia's native forest is in areas protected for biodiversity conservation.

A total of 39 million hectares of Australia's native forest (32% of the native forest area) is designated as protected for biodiversity conservation. This comprises areas protected by prescription in multiple-use public forests, legally covenanted private land, formal and informal nature conservation reserves, and other protected areas on Crown-managed land.

Of this total protected area, the National Reserve System records 26 million hectares of forest (21% of Australia's forests) where nature conservation is the primary management intent (some types of protected area are not compiled into the description of the National Reserve System in the Collaborative Australian Protected Areas Database). All of the national native forest types in Australia, with the exception of Acacia forest, are represented at levels above the 10% area proportion target recommended by the International Union for Conservation of Nature.

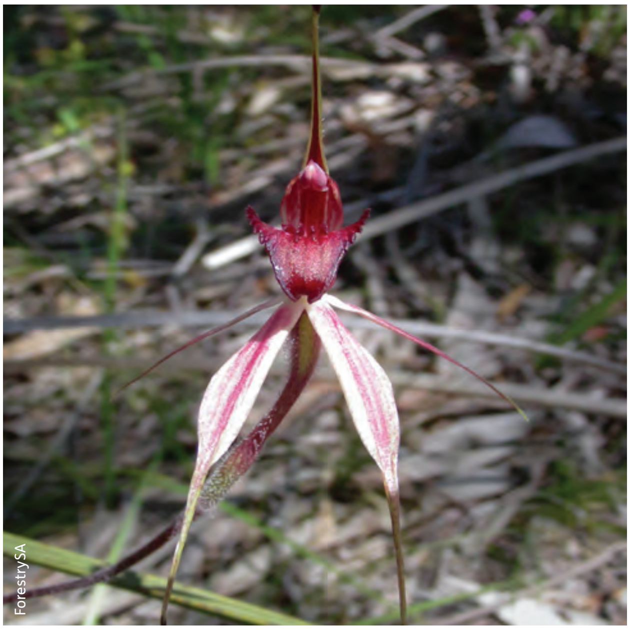
Improved information on forest biodiversity and threats to forest species

Increases in the recorded national numbers of forest-dwelling species, and threatened forest-dwelling species, have resulted from improved information.

SOFR 2013 presents data from new national compilations of forest-dwelling vertebrate animals (2,212 species) and forest-dwelling vascular plants (at least 16,836 species), prepared from lists held by states and territories. The number of forest-dwelling species has generally increased in each jurisdiction since data were first reported in SOFR 1998, reflecting improved information from surveys. SOFR 2013 also presents data from a new national list of forest-dependent vertebrate animals (1,101 species) compiled from habitat data.

The national list of threatened species includes 1,431 forest-dwelling species (283 vertebrates, 32 invertebrates and 1,116 vascular plants). During 2006–11, a total of 89 forest-dwelling species were added to the national list of threatened species, and 21 forest-dwelling species were removed. Most removals (76%) were made because of better information about species populations, distributions or ecology that indicated that the species was not threatened, and the remaining removals (24%) resulted from taxonomic revisions. Among newly listed forest-dwelling species, the primary threats that led to their listing were historical land clearing for agriculture, grazing, and urban and industrial development, and associated habitat loss; predation by or competition from introduced fauna; small or localised populations; unsuitable fire regimes; and various mortality agents. Forestry operations pose a minor threat to nationally listed threatened forest-dwelling fauna and flora species compared with other identified threats.

No forest-dwelling species is known to have become extinct since the release of the first SOFR in 1998. Seven forest-dwelling plant species previously categorised as extinct were rediscovered during the SOFR 2013 reporting period.



Spider orchid (*Caladenia behrii*), an endangered forest-dwelling vascular plant found in South Australia.

Conservation and use of forest genetic diversity

Australia's forest genetic resources are conserved by a variety of means, are widely distributed internationally, and constitute the basis of tree improvement programs.

Australia's native forest genetic resources are primarily conserved in Australia's native forest, and to a lesser degree in arboreta, seed banks, seed orchards and plantations. Significant amounts of Australia's forest genetic material have been exported for use internationally in industry development and environmental protection. Tree-breeding, improvement and genetic conservation programs exist for more than 30 native Australian wood-producing and oil-producing species and varieties.

Echidna (*Tachyglossus aculeatus*), a forest-dwelling animal found in many of Australia's forests.

Eucalypt seedlings in tubestock.

Health and dynamics of Australia's forests

Many of Australia's forests were affected by drought and wildfire during the reporting period, and are currently recovering from these events. In both number and area, most wildfires occur in northern Australia. The Black Saturday bushfires in Victoria in 2009 had exceptionally serious impacts. There was an incursion of myrtle rust into Australia, with the potential to damage plantations and native forests.

Generally, Australia's forests are well adapted to disturbances such as fire, drought, cyclones and outbreaks of native pests and diseases, and impacts are followed by periods of recovery.

Damage caused to forests from native pests (mostly insects) and pathogens (mostly fungi) over the period 2005–10 was generally of low severity, and only occasionally widespread in extent. Most of the observed damage to forests was caused by exotic pests and pathogens that have become established in Australia. Occasionally, damage from outbreaks adversely affected commercial values in plantations.

Phytophthora cinnamomi and a number of other *Phytophthora* species remained a threat to a wide range of plant species, predominantly in regions with an average annual rainfall of more than 600 millimetres. Quambalaria shoot blight caused damage in spotted gum plantations in Queensland, while fungal leaf pathogens caused occasional significant defoliation in plantations in Tasmania, Victoria, Queensland and Western Australia. Teratosphaeria (Kirramyces) leaf spot became a major problem for eucalypt plantation establishment in the central-coast region of Queensland. Spotted gum canker emerged as a health issue for *Corymbia* species in New South Wales. Spring needle cast remained one of the major problems affecting the radiata pine plantation estate, while Dothistroma needle blight affected radiata pine plantations in Victoria and New South Wales.

The major new disease incursion in the reporting period was the establishment and spread of myrtle rust (*Puccinia psidii*[7]) in New South Wales, Queensland and Victoria. The myrtle rust pathogen has a wide range of hosts within the Myrtaceae, the plant family that includes eucalypts and many other Australian tree species. Rust spores are predominantly disseminated by wind, and the rust has spread rapidly to new areas (including native forest) after it was detected initially in nurseries, but its likely impact on Australia's plantations and native forests remains unclear.

A number of tropical cyclones caused significant damage to native forests and plantations in Queensland during the reporting period, including Cyclone Yasi, the largest and most powerful on the eastern coast of Australia since 1918. Drought affected large areas of western and south-eastern Australia for much of the reporting period, with significant impacts on forest health.

A series of intense wildfires affected large areas of forest in western and south-eastern Australia during the reporting period. The previous drought contributed to the intensity and extent of these fires. The fires are expected to have a range of impacts on wood flows and environmental values, including by affecting seed supply and forest regeneration, and water yield and quality. In Victoria, the Black Saturday bushfires of 07 February 2009 were exceptionally serious, burning more than 400,000 hectares, and resulting in the deaths of 173 people.

Overall, however, most bushfires, in terms of number and area, continue to occur in northern Australia: 77% of the forest area burnt over the period 2006–07 to 2010–11 was in the Northern Territory and Queensland, with some areas burning more than once during the reporting period. The estimated total area of forest burnt in the period 2006–07 to 2010–11 was 39.0 million hectares, an increase of 14.3 million hectares over that burnt in the period 2001–02 to 2005–06, with the increase also being mostly in the Northern Territory and Queensland. Of this total, unplanned fires burnt an estimated 31.6 million hectares of forest (81% of the total forest area burnt), and planned fires burnt an estimated 7.4 million hectares of forest (19%).

However, the long-term impacts of projected climate change on the broader native forest estate are unclear; it is possible that the greatest impacts will be through altered fire regimes, and changes in the incidence of pests and diseases. The performance of individual plantation species is predicted to change, which could lead to regional changes in plantation productivity.

Epicormic growth in a eucalypt forest following fire.

[7] *Puccinia psidii* sensu lato, previously referred to by the name *Uredo rangelii*.

Soil and water management

The forest practices systems in Australia's states and territories contain guidelines designed to protect forest soil and water resources.

Codes of forest practice, guidelines and other instruments in place for Australia's forests aim to protect soil values and maintain water supply and quality, including by preventing or mitigating soil erosion. A total of 29.8 million hectares of public forest (24% of Australia's total forest area) is managed primarily for protection, including of soil and water values, an increase of about 2% over the 2006–11 reporting period. A variety of national-level programs have encouraged re-establishment, restoration and maintenance of native vegetation, including forests, for protective functions.

Major wildfires in native forest during the reporting period caused temporary declines in water quality. Increased water use by the resultant natural regrowth is expected to reduce water yields in some affected catchments in coming years.

Forest streams provide clean water and contain aquatic biodiversity. This stream flows through mountain ash (*Eucalyptus regnans*) forest in a Victorian water-supply catchment.

Role of forests and forest management in sequestering carbon

Carbon stocks in Australia's forests increased slightly over the period 2005–10, as did transfers of carbon from forests to forest products in service and in landfill.

Forests are an important component of the global carbon cycle, because they store substantial amounts of carbon, sequester carbon during growth, and release carbon during fire and decay. Forest carbon stocks vary over time according to natural processes of growth, disturbance and regeneration, and are also affected by forest management activities. There was a small increase in carbon stocks in Australia's forests (from 12,831 to 12,841 million tonnes) over the period 2005–10, driven by the recovery of forest from wildfires in the previous five years. Plantations accounted for 171 million tonnes of the forest carbon stock in 2010.

Tall open eucalypt forest, Victoria.

In addition, in 2010 a total of 103 million tonnes of carbon derived from forests was present in wood and wood products, including paper, in service (7 million tonnes more than in 2005 and 14 million tonnes more than in 2000); a further 123 million tonnes was present in wood and wood products, including paper, in landfill (6 million tonnes more than in 2005 and 13 million tonnes more than in 2000). The transfer of carbon from forests to wood products thus increased during the reporting period. The total amount of greenhouse gases emitted by forestry operations in producing logs represents only 3–7% of the equivalent amount of carbon dioxide sequestered in those logs.

Industry resource base

A total of 36.6 million hectares of native forest was both available and suitable for commercial wood production in 2010–11, comprising 7.5 million hectares of multiple-use public forests and 29.1 million hectares of leasehold and private forests. Australia-wide, 2.0 million hectares of industrial plantations were available for commercial wood production in 2010–11, an increase from 1.8 million hectares in 2005–06.

The major source of native forest wood and wood-based products is multiple-use public forests in New South Wales, Queensland, Tasmania, Victoria and Western Australia. The majority of the native forest estate on leasehold and private land, including forests used predominantly for extensive grazing, does not contribute significantly to national wood supply.

The area of native forest both available and suitable for commercial wood production determines the forest sector's capacity to meet demand for native forest wood and wood-based products. The availability of an area for wood production is determined by its tenure; state and territory regulatory frameworks, including codes of forest practice; and other requirements, such as the protection of soil, water values and biodiversity. The area of native forest not legally restricted from wood harvesting decreased steadily over the period 2000–01 to 2010–11 as a result of the transfer of significant areas of multiple-use public forests to nature conservation reserves. The suitability of an area of native forest for wood harvesting is also limited by commercial reasons, including the absence of tree species marketable in commercial quantities, low site productivity, isolation from markets or processing facilities, operational harvesting difficulties, and other infrastructure constraints.

A new, national, forest commerciality database was used in SOFR 2013 to identify spatially the area of forest both available and suitable for harvesting. A total of 36.6 million hectares of native forest was both available and suitable for commercial wood production in 2010–11. Of this, 7.5 million hectares of public native forests is both available and suitable for commercial wood production; however, when additional local restrictions to maintain and manage non-wood values are taken into account, the net harvestable area in multiple-use public native forest is 5.5 million hectares. A substantially larger area (29.1 million hectares) of leasehold and private tenure forest is potentially available and suitable for commercial wood production, but this is subject to landholder intent, markets, regulatory frameworks, and environmental constraints.

Regeneration of mountain ash (*Eucalyptus regnans*) forest, Victoria.

Australia also had 2.0 million hectares of Industrial plantations available for commercial wood production in 2010–11, an increase from 1.8 million hectares in 2005–06. Australia's softwood plantation estate has been approximately 1.0 million hectares in size since 1990 (and was 1.03 million hectares in 2011). The increase in Australia's hardwood plantation estate started in around 1990, with the area reaching 1.0 million hectares in 2009 and then remaining approximately constant (and was 0.98 million hectares in 2011).

Ownership of trees in the Industrial plantation estate changed significantly between 2005 and 2011. Of the total Industrial plantation estate, the area proportion where the trees are government-owned decreased from 35% in 2006 to 24% in 2011, while the proportion where the trees are privately owned increased from 65% to 76%. Private ownership identified as ownership by institutional investors increased to 31% in 2011; ownership by managed investment schemes rose to a high of 36% in 2009, then fell to 24% in 2011; other private ownership types, including farm foresters, timber industry companies and other private entities, totalled 21% by area in 2011.

Harvesting of wood and non-wood forest products

Over the period 2006–07 to 2010–11, the annual area of multiple-use public native forest harvested for wood decreased by 32%, with associated decreases in the volumes of sawlogs and pulplogs produced from native forests. Nationally, actual sawlog harvest levels were below sustainable yield levels by 17% for the period 2006–11, and below sustainable yield levels by 6–18% for each of the four SOFR five-yearly reporting periods. Average annual sawlog harvests from multiple-use public native forests declined from 1.96 million cubic metres in the period 2001–06, to 1.4 million cubic metres in the period 2006–11.

In the period 2006–11, there was an increase in the volumes of sawlogs and pulplogs harvested from plantations. In 2010–11, plantations produced 76% of Australia's total log supply.

The area of multiple-use public native forest harvested annually for wood declined from 117 thousand hectares in 2006–07 to 79 thousand hectares in 2010–11, a decrease of 32%. Of the area harvested over the 10-year period 2001–02 to 2010–11, 85% was harvested using a variety of selection logging systems, 12% by clearfelling silviculture systems (clearfelling, fire-salvage harvesting and intensive silviculture), and 3% by shelterwood systems.

Average sustainable sawlog harvest yields from multiple-use public native forests declined by 47% nationally between 1992–96 and 2006–11. This was a consequence of increased forest reservation, increased restrictions on harvesting in codes of forest practice, revised estimates of forest growth and yield, and the impacts of broadscale wildfires. In parallel with this trend, actual sawlog and pulplog harvests from native

Loading harvested radiata pine (*Pinus radiata*) logs in the Green Triangle region, South Australia.

forest both declined: for example, average annual sawlog harvests from multiple-use public native forests declined from 1.96 million cubic metres in the period 2001–06, to 1.4 million cubic metres in the period 2006–11. Nationally, the actual sawlog harvest levels were below sustainable yield levels by 17% for the period 2006–11, and below sustainable yield levels by 6–18% for each of the four SOFR five-yearly reporting periods.

In comparison, over the period 1992–96 to 2006–11, the sawlog and pulplog harvest from softwood plantations increased, as did the pulplog harvest from hardwood plantations. The sawlog harvest from hardwood plantations has been low but relatively stable over time, but the availability for harvest of plantation hardwood sawlogs is projected to increase over the next decade. In the period 2006–07 to 2010–11, plantations produced 71% of the total volume of logs harvested in Australia: hardwood plantations provided 35% of the pulplog supply and 1% of the sawlog supply, while softwood plantations provided 39% of the pulplog supply and 79% of the sawlog supply. In 2010–11, the final year of the SOFR 2013 reporting period, 76% of the volume of logs harvested in Australia was from plantations.

The residential use of firewood for heating and energy decreased slightly between 2006 and 2010, while industrial fuelwood use increased over this period.

Blue gum (*Eucalyptus globulus*) plantation being harvested in the Eden region, New South Wales.

[8] Dollar amounts are only adjusted for inflation where specified.

Australia also produces a wide range of non-wood forest products. High-value non-wood forest products include wildflowers, seeds, honey, and aromatic products derived from sandalwood. Generally, the extraction of non-wood forest products has a low environmental impact in Australia.

Trends in forest production

A total of 26.6 million cubic metres of logs was harvested in Australia in 2010–11, a decrease from 27.2 million cubic metres in 2006–07. This overall decrease was made up of a decrease in the harvest of native forest hardwood logs but an increase in the harvest of softwood and hardwood plantation logs.

The total value of logs harvested from native forests and plantations in 2010–11 was $1.85 billion. The wood and wood products industries contributed $8.3 billion or 0.59% of Australia's gross domestic product in 2010–11. Turnover of the Australian wood and wood products industries in 2010–11 was $24.0 billion. The trade deficit in wood products was $1.93 billion in 2010–11. The gross annual value of production of non-wood forest products in 2011–12 was estimated at $198 million.

A total of 26.6 million cubic metres of logs was harvested in Australia in 2010–11, a decrease from 27.2 million cubic metres in 2006–07. The volume of hardwood logs harvested from native forests declined by 26% over this period, from 8.55 million cubic metres to 6.3 million cubic metres. The volume of logs harvested in softwood and hardwood plantations (plus a small volume of softwoods harvested from native forests) increased by 8.1% over this period, from 18.4 million cubic metres to 20.2 million cubic metres; 76% of the volume of logs harvested in Australia in 2010–11 was from plantations.

Indexed to 2010–11 prices[8], the value of logs harvested from native forests and plantations decreased from $1.93 billion in 2006–07 to $1.85 billion in 2010–11, a decrease of 3.9%. Indexed to 2010–11 prices, the turnover (sales and service income) of the wood and wood products industries increased from $23.8 billion to $24.0 billion between 2006–07 and 2010–11, an increase of 0.9%. The value added by the wood and wood products industries was $7.4 billion in 2006–07, giving a contribution to Australia's gross domestic product of 0.68%. The value added was $8.3 billion in 2010–11, and the contribution to gross domestic product was 0.59%.

Australia is a net importer of wood and wood products. The trade deficit in wood products increased slightly over the reporting period, to $1.93 billion in 2010–11, due to an increase in imports linked to the strong Australian dollar, and an oversupply of wood products in international markets.

Recovery and recycling rates for paper and paperboard products increased over the reporting period, continuing a long-term trend.

Premium grade jarrah (*Eucalyptus marginata*) timber from Western Australia.

The gross annual value of production of non-wood forest products regarded as having high forest dependence was $198 million in 2011–12.

The value of benefits from forests other than provision of wood, such as biodiversity, carbon storage and sequestration, production of water and soil protection, is generally not integrated into an economic framework for forest conservation or management.

Investment in forests and forest research

The annual rate of establishment of new hardwood and softwood plantations declined from 87 thousand hectares in 2006–07 to 10 thousand hectares in 2010–11. Annual investment in new plantations thus decreased substantially over this period. Expenditure on research and development in forestry and forest products and associated capacity also declined.

Investment in new hardwood and softwood plantation establishment can be measured by the area of new plantations established. A total of 10 thousand hectares of new plantations was established in 2010–11, compared with 87 thousand hectares in 2006–07.

The forestry sector accumulated $6.0 billion of fixed capital between 2006–07 and 2010–11, including new plantations, equipment and buildings; over this period, fixed capital formation net of depreciation and amortisation was estimated at $1.08 billion.

Research, inventory and the development of assessment methodologies provide the basis for sustainable forest management by allowing an understanding of the characteristics and functions of Australia's forests, while forest products research and development aims to identify new forest-based products and processing methods. Between 2005–06 and 2008–09, total expenditure on research and development (R&D) reported by businesses in the forestry sector declined from $164 million to $137 million. Adjusted for inflation, and using a consistent methodology over time, there has been an overall decline in forestry and forest product R&D expenditure since 1982.

Changes in funding and delivery models by the Australian Government and by state and territory governments reduced forest R&D capacity across a number of national organisations and state and territory forest management agencies. The numbers of staff engaged in R&D activities fell, especially between 2008 and 2011; the reduction occurred in both the public and the private sectors, including CSIRO, state and territory governments, and academic institutions. An estimated 396 researchers and technicians were involved in forestry and forest products R&D in 2011, a reduction from 635 in 2008.

Indigenous forests

Approximately one-third of Australia's forests are Indigenous owned and managed, Indigenous managed, Indigenous co-managed or subject to Other special rights.

Access, management and ownership are key parts of the relationship of Indigenous people with land. Just over one-third of Australia's forests (41.9 million hectares, 34% by area) were identified as part of the Indigenous estate—that is, in one of four broad Indigenous land tenure and management categories: Indigenous owned and managed, Indigenous managed, Indigenous co-managed and Other special rights. About three-quarters of this forest area is in Queensland and the Northern Territory.

Interpretive sign, Walu Wugirriga, Daintree National Park, Queensland.

Non-Indigenous heritage

A total of 7.3 million hectares of forest is listed in the Non-Indigenous Heritage Sites of Australia dataset.

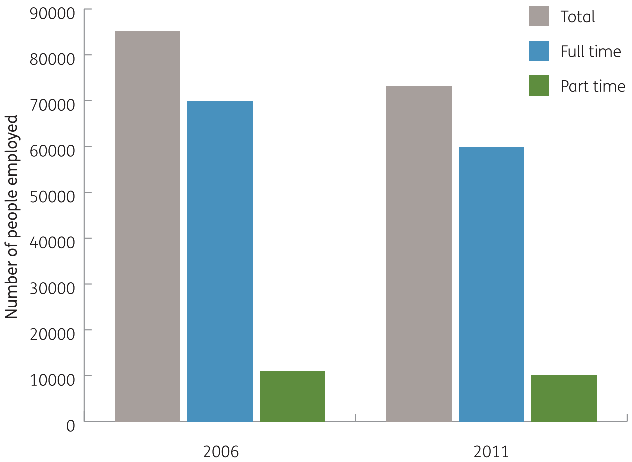
Australia's forests include many sites that provide evidence of the complex interactions between non-Indigenous people and forest landscapes. A total of 7.3 million hectares of forest is listed in the Non-Indigenous Heritage Sites of Australia dataset. Registered heritage sites occur in all tenure types, although many are not registered with the specific objective of protecting and conserving forests. Examples of larger sites with substantial protected forest components are Kakadu National Park, the Tasmanian Wilderness, the Gondwana Rainforests of Australia, and the Grampians National Park.

Forest-related employment

Total direct employment in the forest and wood products sector fell between 2006 and 2011, including in those Statistical Local Areas most dependent on these industries.

There was a fall in total direct employment in the forest and wood products sector over the reporting period, from 85 thousand people in 2006 to 73 thousand people in 2011, as reported in Australian census data. These figures comprise people employed full-time or part-time in forestry and logging; wood product manufacturing; pulp, paper and converted paper product manufacturing; forestry support services; and timber wholesaling. Direct employment in the forest and wood products sector also declined as a proportion of total national employment during this period. In Tasmania, forest-related employment fell by almost half between 2006 and 2011. The number of students commencing and graduating with forestry-specific university degrees also declined, and there were ongoing shortages of skilled workers across Australia's forest industry.

Total national employment in the forest and wood products sector, 2006 and 2011.



Note: Total employment may be higher than the sum of full-time and part-time employment because total employment includes people who were 'employed, but away from work' but for whom hours worked were not given. Source: Australian Bureau of Statistics.

In 2011, there were 28 Statistical Local Areas (SLAs) in which 4% or more of the working population (the level used to show medium-to-high relative community dependence on direct employment in the sector) was employed in forest and wood products industries. Of these 28 SLAs, 24 showed a decline in employment in the sector over the period 2006–11. Community adaptive capacity to change (resilience) can be affected by available human capital, social capital and economic diversity; of the SLAs with relatively high employment dependence on forest and wood products industries, several had relatively low rankings in an adaptive capacity index.

Visiting forests is a popular activity. Meroo National Park, New South Wales.

Public perceptions of forests

There is a range of public perceptions of forest management and of the acceptability of plantations.

Public perceptions are divided over whether Australia's native forests are sustainably managed. Wood is generally viewed as an environmentally friendly material. Harvesting trees is viewed favourably only if the trees are replaced with new ones. Understanding of the role of forests in carbon storage is high, and understanding of the role of wood in carbon storage increased appreciably over the reporting period. Public perceptions of the acceptability of plantations as a rural land-use are also divided, although with regional variations.

Policy and regulation

Australia has a well-established framework for forest management, including policy and legislative instruments, and codes of forest practice. The area of forest in which forest management is certified has continued to increase over the reporting period.

Australia's National Forest Policy Statement (1992) underpins a well-established policy and legislative framework for the conservation and sustainable management of Australia's forests, both nationally and at state and territory levels. Public native forest is governed and managed under state or territory regulatory frameworks and management plans. The management of forests on private land is also regulated under various native vegetation Acts. Twenty-six million hectares (21%) of Australia's forests are covered by management plans relating to their conservation and sustainable management. Fifteen million hectares of forest in the National Reserve System (56% of the area of forest in the National Reserve System) have management plans in place.

Codes of forest practice vary in their legal status and coverage, but generally they provide specific operational guidance for sustainable forest management practices in public and private forests available for wood production, including plantations.

The area of forest in which forest management is certified under either the Australian Forest Certification Scheme or the Forest Stewardship Council has continued to increase. In 2011, about 10.7 million hectares of native forests and plantations were certified, with some areas certified under both schemes.

New national data compilations, and remaining knowledge gaps

The analysis in SOFR 2013 of a number of new, national, forest-related datasets with improved coverage and quality has allowed improvements in reporting across a range of indicators, and has enabled a more complete description of trends over time. Data gaps remain in some indicators, especially for private and leasehold forests.

A number of new social, economic and environmental datasets have been compiled, analysed and presented in SOFR 2013. Compared with SOFR 2008, the coverage and quality of data presented in SOFR 2013 has improved for almost half (21) of the 44 national reporting indicators. These changes have increased the quality of the information, and confidence in its accuracy. For 16 indicators, data were sufficient to allow comparisons of metrics over longer periods of time, enabling analysis and presentation of trends.

However, quantitative information is not available equally across social, economic and environmental indicators, and a number of gaps remain in the data compiled for SOFR 2013. Some data are collected nationally, and other data are provided by states and territories. In addition, the ability to measure, monitor and report on forests varies considerably by tenure. Reliable and comprehensive information across a range of parameters is available for industrial plantations, and for native forests on multiple-use public tenure; data are more limited in other native forest tenure categories, including some nature conservation reserves and, especially, leasehold and private forests.

Overall, SOFR 2013 addresses its purpose of being a 'comprehensive national report', and provides the reader with information to assess progress towards sustainable forest management in Australia.

Forest officers inspecting a timber harvest operation, Victoria.

Introduction

The forests of Australia are diverse and highly valued, and are among the country's most important natural resources.

Eucalypt forest in a subalpine environment, Dinner Plain, Victoria.

Occurring in a broad range of geographic landscapes and climatic environments, Australia's native forests contain a wide array of mostly endemic species (that is, species naturally found nowhere else) combining to form unique and complex ecosystems.

Australia's native forests provide a range of wood and non-wood products that are used by Australians in their everyday lives. They also provide clean water; protect soil; provide opportunities for recreation and tourism, and scientific and educational pursuits; and support cultural, heritage and aesthetic values. Australia's plantation forests are a major source of commercial wood products.

In 1992, the Australian Government and state and territory governments issued a National Forest Policy Statement (Commonwealth of Australia 1992), which set out a vision for Australia's forests and associated goals, objectives and policies (Box I.i). The National Forest Policy Statement commits governments to prepare a review of the state of the forests every five years. In addition, the Commonwealth *Regional Forest Agreements Act 2002* states that 'the Minister must cause to be established a comprehensive and publicly available source of information for national and regional monitoring and reporting in relation to all of Australia's forests'. The *Australia's State of the Forests Report* series gives effect to these commitments. *Australia's State of the Forests Report 2013* (referred to as SOFR 2013) is the fourth report in this series; three earlier reports (referred to as SOFR 1998, SOFR 2003 and SOFR 2008, respectively) were published in 1998, 2003 and 2008.

The role of SOFR 2013 is to inform the public about Australia's forests, their management and use, and, where possible, to track changes or monitor trends over time. SOFR 2013 also assists Australia report the state of its forests internationally.

What is a forest in Australia?

The definition of forest used in this report is the same as that used in Australia's National Forest Inventory, and in all previous SOFRs:

> *An area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding 2 metres and with existing or potential crown cover of overstorey strata about equal to or greater than 20 per cent. This includes Australia's diverse native forests and plantations, regardless of age. It is also sufficiently broad to encompass areas of trees that are sometimes described as woodlands.*

Under this definition, large expanses of tropical Australia where trees are spread out in the landscape are forest, as are many of Australia's multi-stemmed eucalypt mallee associations. What many people would typically regard as forests—stands of tall, closely spaced trees—comprise a relatively small part of the country's total forest estate.

Box I.i: National goals set out in Australia's *National Forest Policy Statement*[a]

The governments agree that, to achieve their vision for the forest estate and to ensure that the community obtains a balanced return from all forest uses, eleven broad national goals must be pursued. These goals should be pursued within a regionally based planning framework that integrates environmental and commercial objectives so that, as far as possible, provision is made for all forest values. The eleven broad national goals are as follows:

- **Conservation.** The goals are to maintain an extensive and permanent native forest estate in Australia and to manage that estate in an ecologically sustainable manner so as to conserve the full suite of values that forests can provide for current and future generations. These values include biological diversity, and heritage, Aboriginal and other cultural values.
- **Wood production and industry development.** The goal is for Australia to develop internationally competitive and ecologically sustainable wood production and wood products industries. Efficient industries based on maximising value-adding opportunities and efficient use of wood resources will provide the basis for expansion in wood products manufacturing, which in turn will provide national and regional economic benefits.
- **Integrated and coordinated decision making and management.** The goals are to reduce fragmentation and duplication in the land use decision-making process between the States and the Commonwealth and to improve interaction between forest management agencies in order to achieve agreed and durable land use decisions.
- **Private native forests.** The goal is to ensure that private native forests are maintained and managed in an ecologically sustainable manner, as part of the permanent native forest estate, as a resource in their own right, and to complement the commercial and nature conservation values of public native forests.
- **Plantations.** One goal is to expand Australia's commercial plantations of softwoods and hardwoods so as to provide an additional, economically viable, reliable and high-quality wood resource for industry. Other goals are to increase plantings to rehabilitate cleared agricultural land, to improve water quality, and to meet other environmental, economic or aesthetic objectives.
- **Water supply and catchment management.** The goals are to ensure the availability of reliable, high-quality water supplies from forested land and to protect catchment values.
- **Tourism and other economic and social opportunities.** The goal is to manage Australia's forests in an ecologically sustainable manner for a range of uses, including tourism, recreation and production of non-wood products.
- **Employment, workforce education and training.** The goal is to expand employment opportunities and the skills base of people working in forest management and forest-based industries.
- **Public awareness, education and involvement.** The goals are to foster community understanding of and support for ecologically sustainable forest management in Australia and to provide opportunities for effective public participation in decision making.
- **Research and development.** The goals are to increase Australia's national forest research and development effort and to ensure that it is well coordinated, efficiently undertaken and effectively applied. This research will expand and integrate knowledge about the many aspects of native forests, plantations, forest management, conservation, and forest product development.
- **International responsibilities.** The goals are to promote nature conservation and sustainable use of forests outside Australia and to ensure that Australia fulfils its obligations under relevant international agreements.

a Commonwealth of Australia (1992)

Closed forest: an aerial view of rainforest showing typical closed canopy. Barron River, Queensland.

Open forest, Wombeyan Karst Conservation Reserve, New South Wales.

Woodland forest, Undara Volcanic National Park, Queensland.

Non-forest carrying other woody vegetation, Northern Territory.

Australia's forests are subdivided into closed, open and woodland forests to provide a better understanding of their characteristics. Closed forest is forest where the tree canopies cover more than 80% of the land area; open forest is forest where the tree canopies cover more than 50% and up to and including 80% of the land area; and woodland forest is forest where the tree canopies cover between 20% and up to and including 50% of the land area. Land with trees where the tree canopies cover less than 20% of the land area is not classified in Australia as forest, but categorised as non-forest carrying other woody vegetation.

Australia's definition of forest uses the phrases 'mature or potentially mature' with regard to stand height, and 'existing or potential' with regard to crown cover. Use of these phrases allows forest areas that have temporarily lost some or all of their trees (for example, as a result of bushfires, cyclones or harvesting for wood production) to be identified as part of the forest estate.

The definition of plantations used in this report is the same as that used in all previous SOFRs and for the National Plantation Inventory:

> *Intensively managed stands of trees of either native or exotic species, created by the regular placement of seedlings or seeds.*

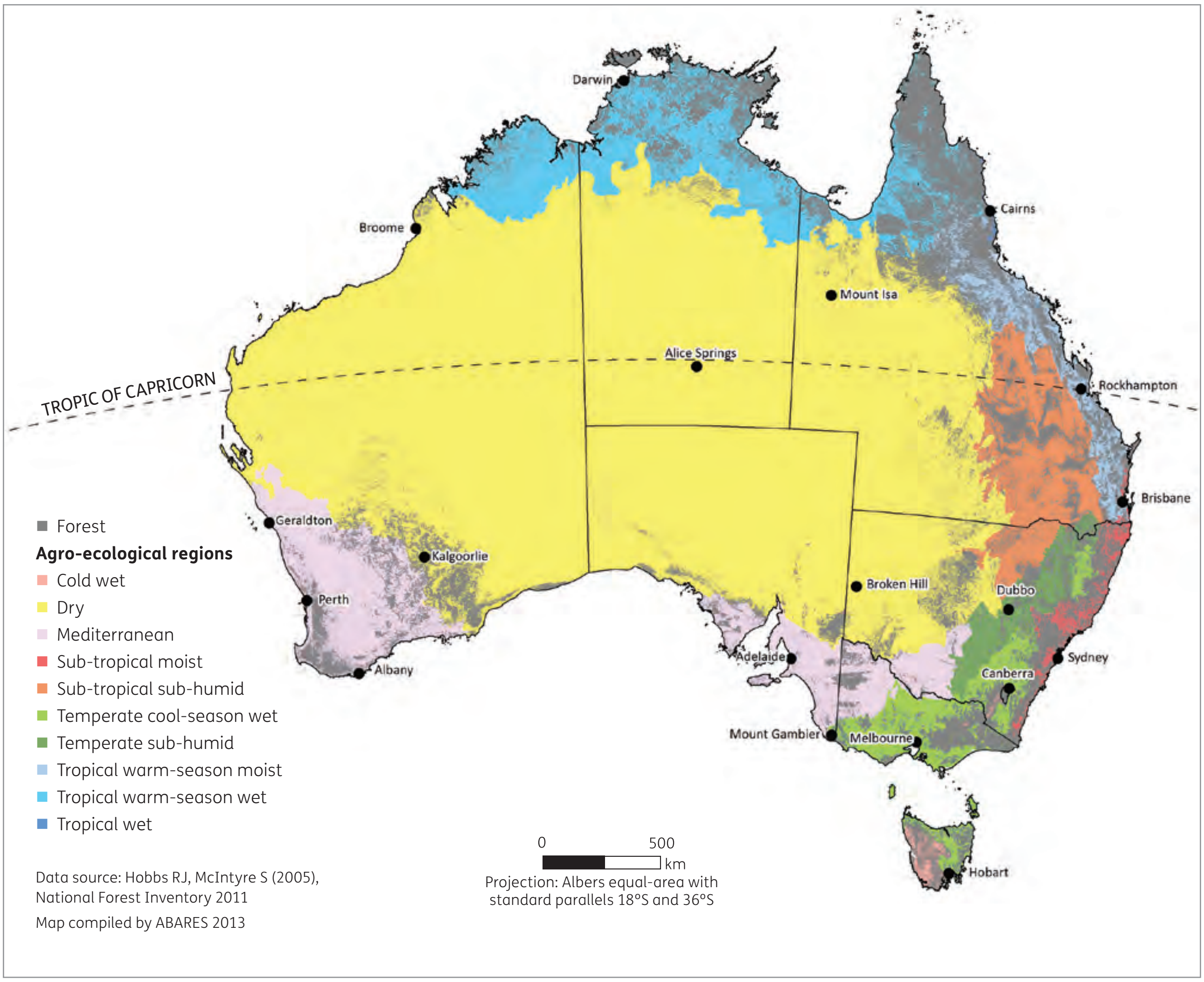
Australia's forests

Forests extend across the continent's northern tropical regions, and down the east coast through sub-tropical regions to temperate cool-season wet and cold–wet zones in the south-east; they are also found in Mediterranean climate zones in the south-east and south-west (Figure I.i). In some regions, forests extend from these wetter, coastal and sub-coastal areas into central, drier parts of the continent (Figure I.ii). Through these regions, forests grow on soils that vary from ancient, fragile and infertile soils, to more recent, fertile soils of volcanic origin.

Across the wide range of rainfall and soil conditions that support forest, more than 80% of Australia's 'Native forest' category of forest is dominated by eucalypts and acacias. Native forests are categorised in Australia's National Forest Inventory into eight national native forest types named after their key genus or structural form: Acacia, Callitris, Casuarina, Eucalypt, Mangrove, Melaleuca, Rainforest, and Other native forest.

In addition to 'Native forest', Australia's National Forest Inventory recognises two other categories of forest. 'Industrial plantations' are plantations grown on a commercial scale for wood production. 'Other forest' includes non-industrial plantations and planted forest of various types.

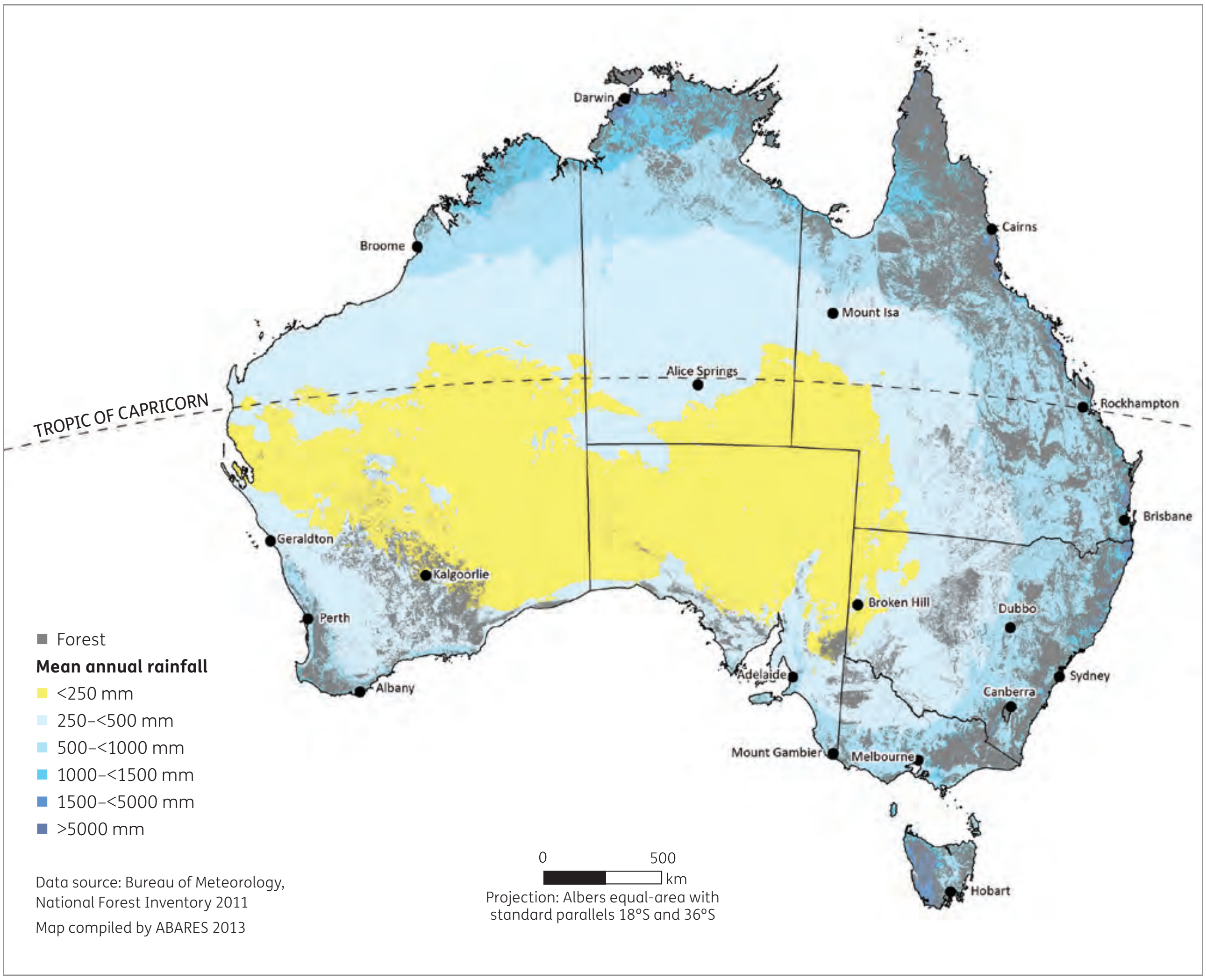
Figure I.i: Agro-ecological regions of Australia



Note: Grey shading across agro-ecological regions shows forest.

River red gum (*Eucalyptus camaldulensis*) forest, Murray River, New South Wales.

Figure I.ii: Mean annual rainfall across Australia



Note: Grey shading across rainfall zones shows forest.

Spotted gum (*Corymbia maculata*) forest in New South Wales.

Native forests

The eight national forest types are described below[9].

Acacia

Australia has almost 1000 species of *Acacia*, making it the nation's largest genus of flowering plants. Acacia species are remarkably varied in appearance, habit and location, from species with spreading forms to trees that are more than 30 metres tall.

Acacia forests are Australia's second most common forest type. They occur in all Australian states and the Northern Territory, with the largest areas in Queensland and Western Australia. Acacia forests are predominantly woodland forests in regions where the average annual rainfall is less than 750 millimetres, but are also present in wetter areas: in Tasmania, for example, blackwood (*Acacia melanoxylon*) dominates stands of swamp forest on poorly drained sites. Mulga (*A. aneura* and related species) is widespread in many parts of the arid and semi-arid zones of Australia. Brigalow (*A. harpophylla*) is widespread in Queensland and northern New South Wales, forming dense forests on flat or undulating country with clay soils. Both mulga and brigalow form forest and non-forest communities.

Callitris

The *Callitris* genus comprises 15 species, of which 13 occur in Australia. Callitris trees are commonly called cypress pines because they are related to, and resemble, Northern Hemisphere cypresses; they are not true pines.

Callitris forests typically occur in small patches in drier inland regions, but occasionally cover wide areas. Pure stands of *Callitris* are generally restricted to undulating or flat land with sandy soils, or to upland rocky areas that are protected from fire. More commonly, species of *Callitris* are present in Acacia, Casuarina and Eucalypt forest types over a shrubby, grassy or herbaceous understorey.

Casuarina

The family Casuarinaceae occurs naturally in Australia, South-East Asia and the Pacific. This forest type includes forests dominated by species of either *Casuarina* (6 species in Australia) or *Allocasuarina* (59 species in Australia). Commonly called she-oaks because of the similarity of their timber to that of European oaks, casuarinas are a distinctive part of many Australian coastal and riverine landscapes.

Only some casuarina species form forest communities; others grow in vegetation too short or sparse to be classified as forest. Most casuarina forests are low in height; the tallest casuarina forests grow along rivers, where trees can grow to more than 20 metres. Common inland species include belah (*Casuarina cristata*), desert oak (*Allocasuarina decaisneana*) and river she-oak (*C. cunninghamiana*).

Eucalypt

Eucalypts are iconic Australian forest trees. Eucalypt forests are by far the continent's most common forest type, covering about three-quarters of Australia's native forest estate and occurring in all but the continent's driest regions (Figure I.iii).

The term 'eucalypt' encompasses approximately 800 species in the three genera *Eucalyptus*, *Corymbia* and *Angophora*, with almost all of these species native to Australia. For national reporting, the Eucalypt forest type is divided into 11 forest subtypes based on the form of dominant individuals (multi-stemmed mallee or single-stemmed tree), height (low, medium or tall) and crown cover (closed, open or woodland, also shown in Figure I.iii).

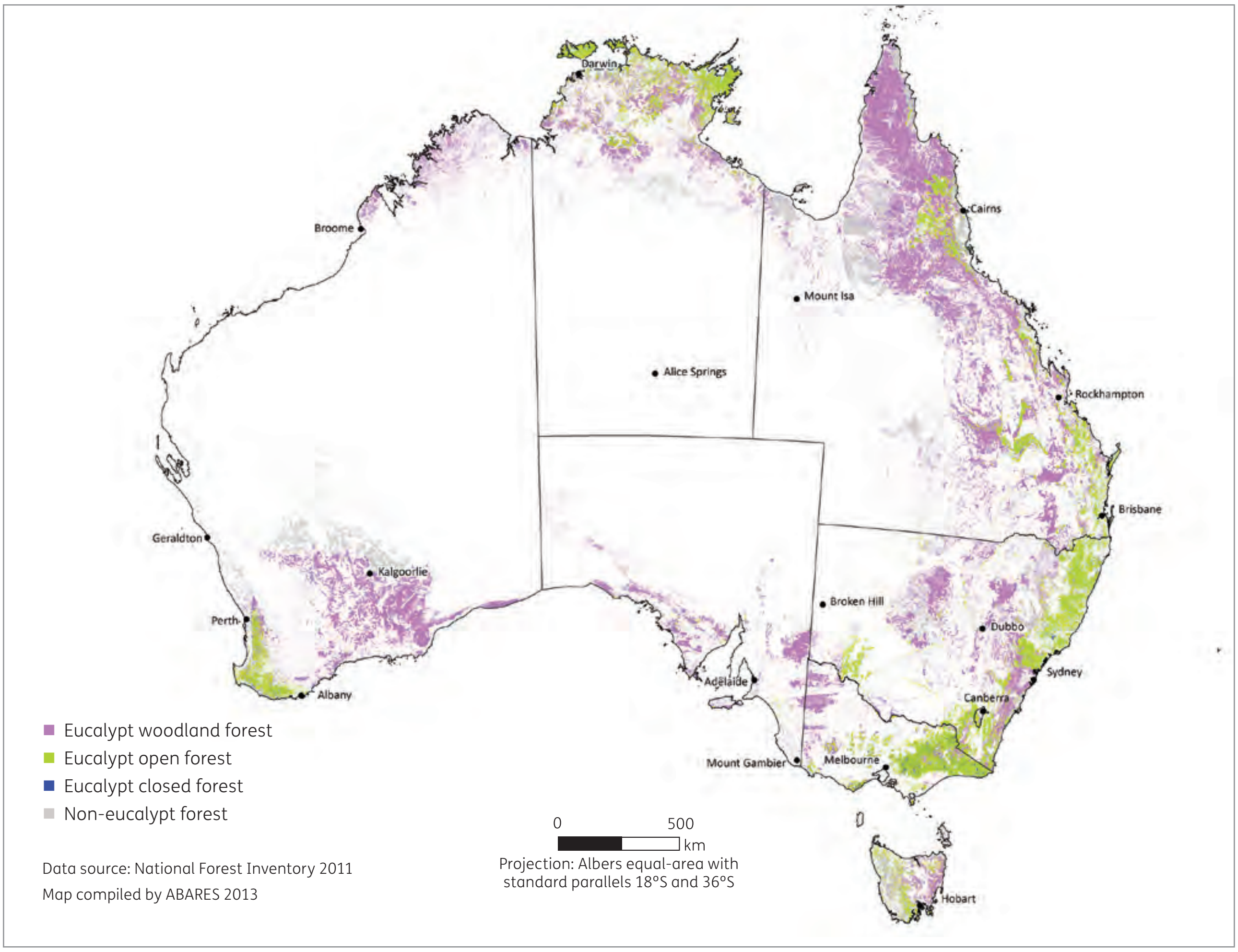
Eucalypts evolved from rainforest ancestors, adapting to an environment in which drought, nutrient-poor soils and fire were increasingly common. Eucalypt species have oil-rich foliage that burns readily, and they display a range of strategies to survive and recover from fire. The majority of eucalypt species are evergreen, retaining their leaves year-round.

River red gum (*Eucalyptus camaldulensis*) is the most widely distributed eucalypt, and is found in all Australian mainland states. The forests of south-eastern Australia contain a wide range of dominant eucalypt species, including major commercial timber species such as mountain ash (*E. regnans*), messmate stringybark (*E. obliqua*), alpine ash (*E. delegatensis*), silvertop ash (*E. sieberi*), blackbutt (*E. pilularis*) and spotted gum (*Corymbia maculata*). Some individual trees exceed 90 metres in height. Eucalypt forests in south-western Australia are dominated by jarrah (*E. marginata*) and karri (*E. diversicolor*). Typical eucalypts of northern Australia include Darwin woollybutt (*E. miniata*) and Darwin stringybark (*E. tetrodonta*). Many species of mallee eucalypts are found across the inland regions of southern Australia (Figure I.iv).

Eucalypt mallee woodland forest, Eyre Peninsula, South Australia.

9 The names of the national native forest types have capitalised initial letters (e.g. Acacia forest). The related common names do not have capitalised initial letters (e.g. acacias). The related formal genus names are italicised and have capitalised initial letters (e.g. *Acacia*).

Figure I.iii: Distribution of native eucalypt forest, by crown cover class



Mangrove

Although comprising less than 1% of Australia's forest cover, mangrove forests are an important and widespread ecosystem. They are found in the intertidal zones of tropical, subtropical and protected temperate coastal rivers, estuaries and bays, where they grow in fine sediments deposited by rivers and tides. Mangrove trees have a characteristic growth form, including aerial structural roots and exposed breathing roots, to help them cope with regular tidal inundation and a lack of oxygen in the soil.

Australian mangrove forests contain 41 species of mangrove from 19 plant families, and more than half the world's mangrove species occur naturally in Australia. White mangrove (*Avicennia marina*) is the most widespread and common species.

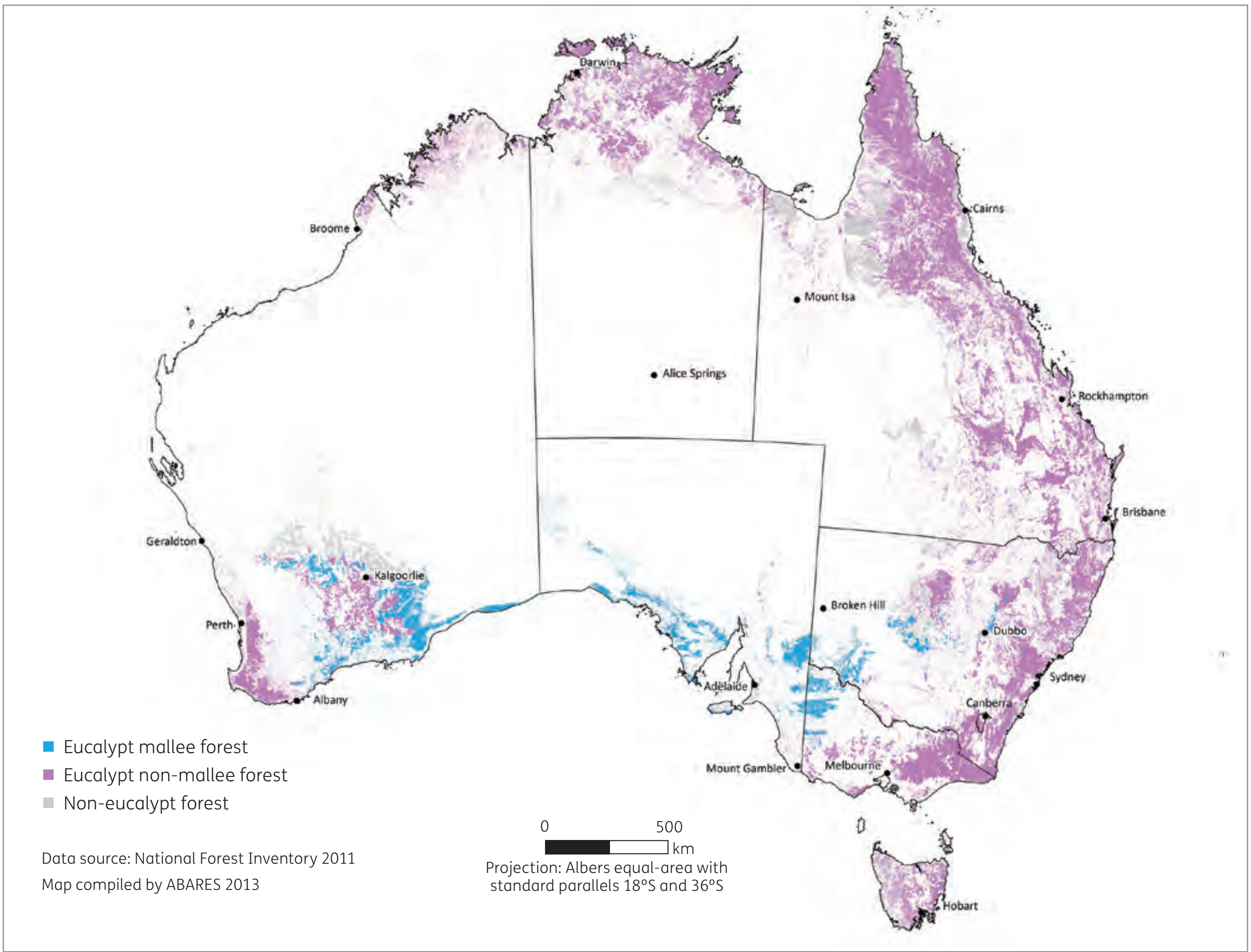
Mangrove forest, Cape Tribulation, Daintree National Park, Queensland.

Melaleuca

The genus *Melaleuca* contains more than 200 species, most of which are endemic to Australia. Only a few species develop the required community structure and height to be classified as forests; the taller species are known as tea-trees or paperbarks. Common species include broad-leaved paperbark (*M. viridiflora*) and weeping paperbark (*M. leucadendra*).

Melaleuca forests occur mainly as tracts of low woodland forest across estuarine plains and seasonal swamps in the coastal and near-coastal areas of monsoonal northern Australia, as well as narrow strips beside streams. Most of Australia's Melaleuca forest is in Queensland, particularly Cape York Peninsula, and the northern part of the Northern Territory. Swamps dominated by melaleuca also occur on poorly drained sites on the east coast of mainland Australia, and in north-western Tasmania.

Figure I.iv Eucalypt mallee, eucalypt non-mallee and non-eucalypt native forest



Rainforest

Australia's rainforests are characterised by high rainfall, lush growth and closed canopies; they rarely support fire, and generally contain no eucalypts or only occasional individual eucalypts above the rainforest canopy. Tree species of the rainforest canopy are shade-tolerant when young, able to establish in the understorey of mature forest, and grow into large trees when events such as tree falls, lightning strikes or wind damage (including from cyclones) create gaps in the canopy.

There are many types of rainforest in Australia, varying with rainfall and latitude. Tropical and subtropical rainforests are found in northern and eastern Australia in wet coastal areas. Temperate rainforests occur in eastern and south-eastern Australia: warm temperate rainforests grow in New South Wales and Victoria, while cool temperate rainforests grow in Victoria and Tasmania, with outliers at high altitude in New South Wales and Queensland. Dry rainforests occur in pockets protected from frequent fire in sub-coastal and inland areas of northern and eastern Australia. Monsoon rainforests occur in northern Australia in seasonally dry coastal and sub-coastal regions.

Rainforests support a significant part of Australia's biodiversity, including many of Australia's unique plant families. The tropical rainforests in far north Queensland are also rich in marsupial, frog and butterfly species.

Rainforest, Curtain Fig National Park, Queensland.

Other native forest

The Other native forest type includes a range of minor native forest types named after their dominant genera, including Agonis, Atalaya, Banksia, Hakea, Grevillea, Heterodendron, Leptospermum, Lophostemon and Syncarpia, as well as native forests where the type is unknown.

Industrial plantations

Australia's Industrial plantations comprise both softwood species (predominantly radiata pine, *Pinus radiata*) and hardwood species (with the most common species being blue gum, *Eucalyptus globulus*). Their primary purpose is commercial wood production, and they produce the majority of the volume of logs harvested annually in Australia. Industrial plantations also provide a range of environmental services, such as salinity and erosion control, and support regional employment. Plantations provide habitat for some native flora and fauna species that generally do not inhabit cleared agricultural land, although the population densities of forest-dwelling species are usually lower in plantations than in native forests. Industrial plantations are identified in the National Plantation Inventory.

Fifteen plantation regions are used by the National Plantation Inventory to represent economic wood supply zones (Figure I.v). Five of the National Plantation Inventory regions span a state or territory border, illustrating that wood flows are not constrained by state or territory boundaries.

Hardwood plantation (*Eucalyptus regnans*), Gippsland, Victoria.

Other forest

Other forest comprises small areas of mostly non-industrial plantations and planted forests of various types, including sandalwood plantations, some smaller farm forestry and agroforestry plantations, environmental plantings, plantations within the reserve system, and plantations regarded as non-commercial. Non-planted forest dominated by introduced species is also included in the Other forest category.

Tenure

The ownership of a forest, especially native forest, has a major bearing on its management. The six tenure classes used for forests in the National Forest Inventory are amalgamations of the wide range of classes used by various state and territory jurisdictions. The classes can be grouped on the basis of ownership as public or private, with a small area of unresolved tenure. Publicly owned forests include 'nature conservation

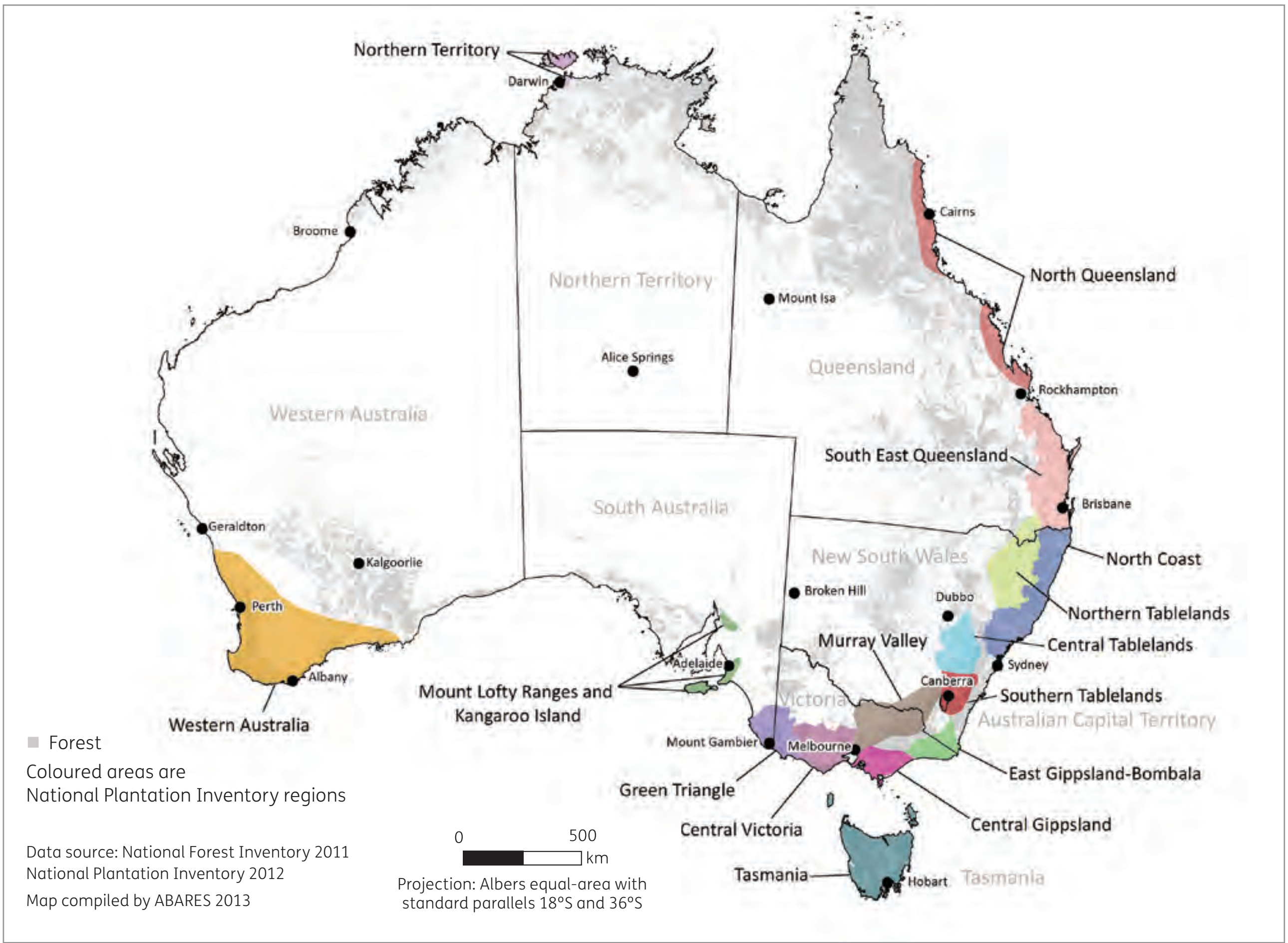
Radiata pine (*Pinus radiata*) plantation, New South Wales.

reserve', 'multiple-use public forest' and 'other Crown land'. 'Leasehold forest' is forest on Crown land (land that belongs to a national, state or territory government) that is typically privately managed. Some forests on private land are publicly managed as conservation reserves. For Industrial plantations, the ownership of the land can be different from ownership of the trees, and management arrangements can be complex.

The six tenure classes are described as follows:

- **Multiple-use public forest:** publicly owned state forest, timber reserves and other forest areas, managed by state and territory government agencies for a range of forest values, including wood harvesting, water supply, biodiversity conservation, recreation and environmental protection.
- **Nature conservation reserve:** publicly owned lands managed by state and territory government agencies that are formally reserved for environmental, conservation and recreational purposes, including national parks, nature reserves, state and territory recreation and conservation areas, and formal reserves within state forests. This class does not include informal reserves (areas protected by administrative instruments), areas protected by management prescription, or forest areas pending gazettal to this tenure. The harvesting of wood and non-wood forest products generally is not permitted in nature conservation reserves.
- **Other Crown land:** Crown land reserved for a variety of purposes, including utilities, scientific research, education, stock routes, mining, use by the defence forces, and to protect water-supply catchments, with some areas used by Aboriginal and Torres Strait Islander communities (referred to collectively as Indigenous communities in SOFR 2013).
- **Private forest:** forest on land held under freehold title and private ownership, and usually privately managed. This class includes land with special conditions attached for designated Indigenous communities.
- **Leasehold forest:** forest on Crown land held under leasehold title, and generally privately managed. This class includes land held under leasehold title with special conditions attached for designated Indigenous communities.
- **Unresolved tenure:** forests where data are insufficient to determine land ownership status.

Figure I.v: National Plantation Inventory regions of Australia



Farm forestry stand of trees planted by multiple generations of one family, Kyogle, New South Wales.

Forest administration in Australia

Australia has three levels of government: Commonwealth or federal (also referred to as the Australian Government or the national government); state and territory (in addition to the six states, there are two self-administered mainland territories: the Australian Capital Territory and the Northern Territory); and local (city-based or regionally based). The traditional law-making and land-management processes of Aboriginal and Torres Strait Islander people (referred to in SOFR 2013 as Indigenous people) also apply in some areas. The term 'jurisdiction' is used to denote any of the Australian, state or territory governments.

The state and territory governments have responsibility for land allocation and land management, including forest management. The Australian Government has limited forest management responsibilities, but may influence management through legislative powers associated with foreign affairs (particularly treaties and international agreements), commodity export licensing, taxation and biodiversity conservation, and through targeted spending programs to meet environmental, social or economic objectives. Such programs are generally developed cooperatively with state and territory governments. The management of Australia's forests is guided by the National Forest Policy Statement (Commonwealth of Australia, 1992), signed jointly by the Australian Government and state and territory governments.

Regional Forest Agreements

A key outcome of the National Forest Policy Statement was the negotiation of Regional Forest Agreements (RFAs) between the Australian Government and some individual state governments. RFAs are 20-year plans for the conservation and sustainable management of specific regions of Australia's native forests, and resulted from substantial scientific study, consultation and negotiation with a diverse range of stakeholders. Science-based methodology and Comprehensive Regional Assessments (CRAs) were used to determine forest allocation for different uses and to underpin forest management strategies. The RFAs are designed to provide certainty for forest-based industries, forest-dependent communities and conservation. Certain obligations of the Commonwealth under RFAs were given effect through the Commonwealth *Regional Forest Agreements Act 2002*.

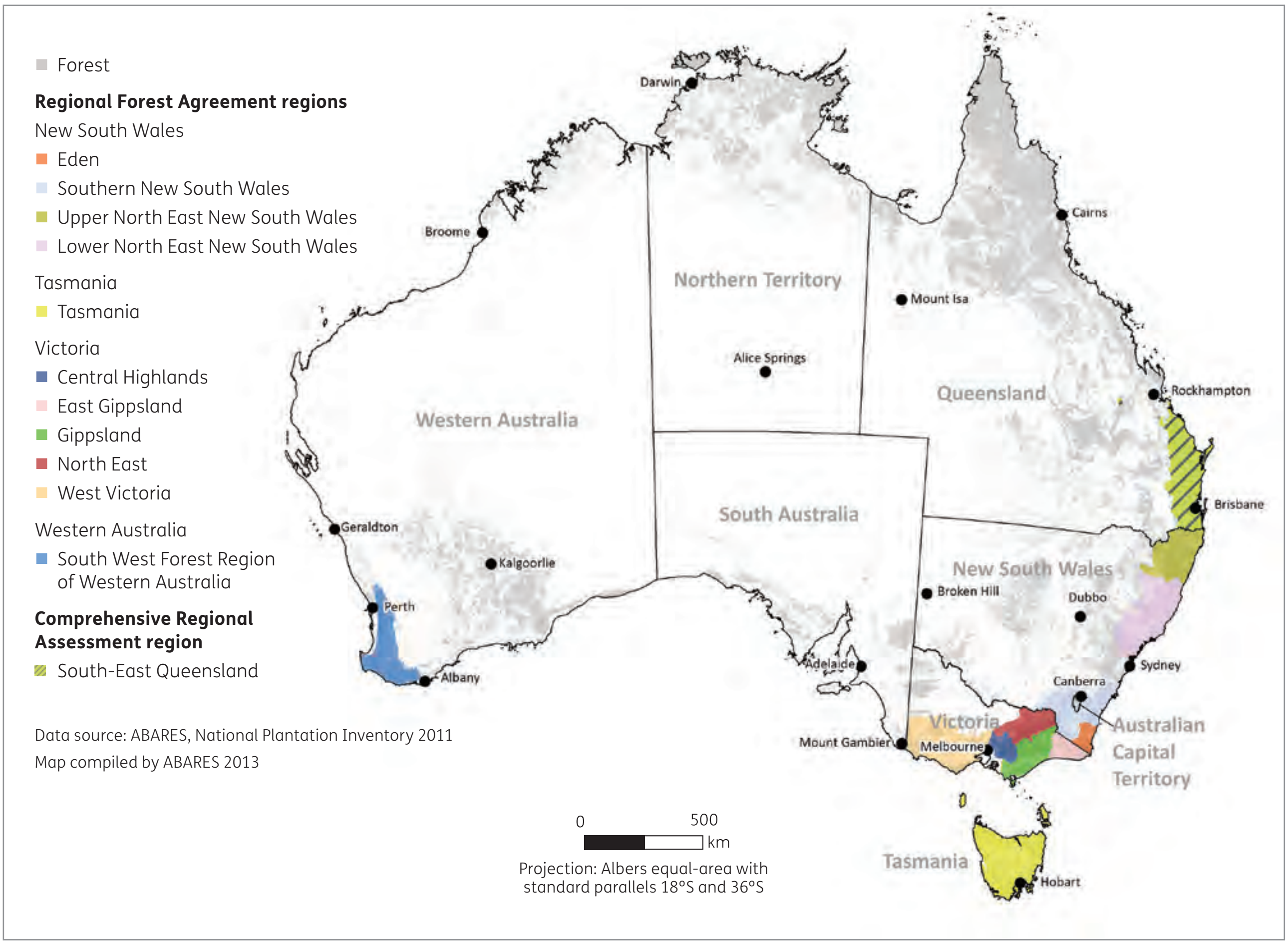
Ten RFAs were negotiated bilaterally between the Australian Government and four of the six state governments (New South Wales, Tasmania, Victoria and Western Australia— Figure I.vi). The Australian and Queensland governments completed a CRA for south-east Queensland but did not sign an RFA.

Forest inventory

The National Forest Inventory was established in 1988 as an entity that enabled the calculation of nationally consistent and comprehensive attributes describing Australia's forests. This was a critical step in developing a national approach to measuring and monitoring sustainable forest management. The National Forest Inventory is guided by a steering committee (NFISC) composed of members representing state, territory and Australian government bodies involved in forest information management.[10]

Forest description and measurement (inventory) activities have been taking place in Australian forests for more than a century, mainly in publicly owned native forests managed for wood production and in plantations, but also to a lesser extent in nature conservation reserves. Less has been done to inventory privately managed native forests—this has led to substantial gaps in the data available to describe these forests. Tenure can therefore be used as a broad surrogate for the availability, comprehensiveness and currency of native forest inventory data in Australia (Howell et al. 2008).

Figure I.vi: Regional Forest Agreement and related regions in Australia



Note: Grey shading across regions shows forest.

[10] Queensland withdrew from the NFISC in 2010.

Sustainable forest management and forest reporting

Sustainable forest management seeks to achieve environmental outcomes, economic development and social values of forests, to meet the needs of society without compromising the ability of future generations to meet their own needs.

This approach reflects the principal objectives of the United Nations Convention on Biological Diversity, to which Australia is a signatory—namely, the conservation and sustainable use of biological diversity, and the fair and equitable sharing of benefits arising from its use. The convention recognises that the key to maintaining biological diversity is using it in a sustainable manner (Secretariat of the Convention on Biological Diversity 2005). Sustainably managed forests thus maintain a broad range of values into the future, and the Australian, state and territory governments have a range of processes to help meet this goal.

Criteria and indicators provide a common understanding of what is involved in sustainable forest management, and a common framework for describing, assessing and evaluating a country's progress towards sustainable forest management. The criteria represent broad forest values, while the indicators represent measurable aspects of these criteria. The framework of criteria and indicators for sustainable forest management developed by the international-level Montreal Process Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests has been adopted in Australia. As with the international Montreal Process, Australia's framework includes the following seven criteria for sustainable forest management (Commonwealth of Australia 2008):

- conservation of biological diversity
- maintenance of productive capacity of forest ecosystems
- maintenance of ecosystem health and vitality
- conservation and maintenance of soil and water resources
- maintenance of forest contribution to global carbon cycles
- maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies
- legal, institutional and economic framework for forest conservation and sustainable management.

A set of 44 indicators for use in Australia was adapted from the Montreal Process Working Group's broader list of indicators to suit the particular characteristics of Australian forests, the goods and services they provide and the people who depend on or use them. This set was used in SOFR 2008 and is used again in SOFR 2013. Appendix A lists the 44 indicators used in Australia and shows the alignment with the 54 indicators of the international Montreal Process framework.

The SOFR 2013 process

SOFR 2013 is the result of collaboration among the Australian, state and territory governments, led by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) within the Australian Government Department of Agriculture[11], and coordinated by the NFISC and the Montreal Process Implementation Group for Australia (MIG).

In August 2011, ABARES requested data from each of the states and territories to populate SOFR indicators. On the basis of responses to these requests and information obtained from national agencies and other sources, ABARES prepared summary tables, figures and text for each indicator, paying particular attention to changes and trends over time. The state and territory governments, through the MIG and the NFISC, and officers from DAFF[12] and other Australian Government agencies were invited to participate in a drafting group, which met in 2012 to review manuscripts and provide supplementary information. The draft SOFR 2013 report was then reviewed by the MIG and the NFISC, as well as by relevant Queensland agencies, and was endorsed in 2013 by the national Forestry and Forest Products Committee, which reports to the Council of Australian Governments through the Productivity and Regulatory Reform Committee, the Primary Industries Standing Committee, and the Standing Council on Primary Industries.

Eucalypt tall open forest, south-western Western Australia.

[11] Before September 2013, the Department of Agriculture, Fisheries and Forestry (DAFF).

[12] After September 2013, the Department of Agriculture.

The SOFR series

The SOFR series constitutes a system for reporting the state of Australia's forests, as well as the directions of change across a range of social, economic and environmental aspects of forests. The SOFR series is therefore a resource for exploring the implications of such changes for sustainable forest management.

To the greatest extent possible, SOFR 2013 presents data for the five-year period between 01 July 2006 and 30 June 2011. The reporting period for SOFR 2003 was 01 July 1997 to 30 June 2001, and the reporting period for SOFR 2008 was 01 July 2001 to 30 June 2006 (SOFR 1998, the first in the series, had no specific coverage period). Thus, the three most recent reports comprise a continuous series on the state of Australia's forests spanning 15 years, and SOFR 2013 contains more information on trends over time than any previous report. However, the varied nature of the data sources across the 44 indicators means that not all data conform to these periods.

The forest area data presented in SOFR 2013 cover Australia's states and mainland territories and their close off-shore islands, but not the external territories of Norfolk Island, Lord Howe Island, Cocos (Keeling) Islands and Christmas Island. However, data for forest-dwelling species in these areas are reported in SOFR 2013. For the purposes of this report, forest data for Jervis Bay (administered by the Australian Capital Territory) are included in New South Wales data.

How to use this report

This report is organised by the seven criteria for sustainable forest management listed above. Within each criterion, various indicators address specific forest parameters and values. A synthesis of key findings across the indicators within each criterion is given at the start of that criterion. Each criterion is presented as a separate chapter of SOFR.

Individual indicators can be read as stand-alone papers by readers interested in particular aspects of Australia's forests and their management. A summary of key points is given at the start of each indicator, and case studies are presented within indicators as illustrations and to provide regional information.

The Executive summary at the front of the report gives an overview of the state of Australia's forests across the seven criteria. References, a glossary and an index are included at the end of the report.

SOFR 2013 and the three previous SOFRs are available at the Forests Australia website (www.daff.gov.au/forestsaustralia) and the ABARES publications website (www.daff.gov.au/abares/publications).

Young radiata pine (*Pinus radiata*) plantation.

Criterion 1

Conservation of biological diversity

Kookaburra. iStockphoto

Stuart Davey

Jim Jim Creek bordered by tropical forest in Kakadu National Park, Northern Territory.

Criterion 1
Conservation of biological diversity

Biological diversity, also known as biodiversity, is the full range of plants, animals and microorganisms occurring in a given area, along with the genes they contain and the ecosystems they form. Conservation of biological diversity is a key part of sustainable forest management, and its goal is the continued existence of ecosystems, species and the genetic variability within these species.

Biological diversity is usually considered at three levels: ecosystem diversity, species diversity and genetic diversity. The nine indicators in this criterion are divided into three subcriteria that match these levels.

Ecosystem diversity

Understanding the extent, geographic distribution, major forest types and growth stages of Australia's forests underpins the effective management of forest ecosystems, through the development of appropriate legislation and policies, monitoring of forest condition, and assessment of forest management outcomes.

The category 'Native forests' is the major category of forests; it is divided into closed, open and woodland forests according to canopy cover (decreasing from closed to open to woodland forests). Eight broad national native forest types have been defined, with the 'Eucalypt forest' type subdivided by height and growth form. 'Industrial plantations' form a second forest category, being commercial plantations grown for wood production. A small third category, 'Other forest', contains a range of small-scale planted forests, including those in agroforestry and farm forestry systems, sandalwood plantations and environmental plantings.[13]

Across these categories, forests are allocated to six tenures: leasehold forest, multiple-use public forest, nature conservation reserve, private land, other Crown land, and unresolved tenure.

Area statistics are required for the interpretation of many of the indicators used in SOFR 2013, and Indicator 1.1a ('Area of forest by forest type and tenure') is therefore a keystone indicator in the SOFR series. Area information is used to understand whether forest ecosystems and their embedded diversity are being maintained. The reported area of Australia's forest has changed over time as methodologies for forest assessment have improved. SOFR 2013 is the first national report to use a 'Multiple Lines of Evidence' approach to determining Australia's forest area, combining data from states and territories with a range of remotely sensed forest cover data to map forest communities at a finer scale and with increased accuracy.

Indicators for this subcriterion provide data on Australia's forest area by type, growth stage and tenure, and report on the forest area in reserves of various types or which are protected through other arrangements such as covenants. Different land ownership and management structures can affect forest ecosystems in different ways, and data on land tenure can therefore provide information on the extent of protection, clearing, fragmentation or other alteration. Fragmentation of native forest is also monitored as a measure of the effects of various kinds of natural disturbance and human-caused disturbance on forest ecosystems.

Species diversity

Australia is estimated to be home to some 566 thousand species, of which over 147 thousand species have been described. Of the described species, about 92% of the plants, 87% of the mammals and 45% of the birds are endemic—

[13] Urban land, industrial land, and horticultural and intensive agricultural land uses are excluded from categorisation as forest.

that is, found only in Australia. An important measure of species diversity is the number of forest-dwelling species, which are species that may use forest habitat for all or part of their lifecycles. Another important measure is the number of forest-dependent species, which are those species that require a forest habitat to complete all or part of their lifecycles; these are a subset of the total number of forest-dwelling species.

Knowledge of the plant, animal and other species present in a forest is a pre-condition for the effective management of that forest. Information on whether populations of species are increasing or decreasing can indicate the extent and condition of forest habitat and changes in habitat, and is needed to support conservation strategies. For forest covered by Regional Forest Agreements, state governments have developed a set of criteria that include broad benchmarks for the in-situ conservation of forest biodiversity.

A number of forest-dwelling and forest-dependent species and forest ecosystems are listed as threatened on lists compiled nationally and by states and territories. Knowledge of the threats and threatening processes faced by listed species and ecosystems assists in their protection.

Genetic diversity

Conservation of forest genetic resources is linked both to the conservation of forest biodiversity and to the availability of forest species for commercial or environmental use. Indicators in this subcriterion examine the risk of loss of genetic diversity in forest plants and animals, and the conservation measures in place to minimise that risk. The indicators also provide an inventory of tree breeding and improvement programs that act as repositories of native forest genetic resources, and that contribute to knowledge about the conservation of the genetic diversity of Australia's native forest and plantation tree species. Australia's forest genetic resources are generally highly accessible, and a very large amount of genetic material, mainly seed, has been made available throughout Australia and globally.

Native forest species and communities in Australia are conserved in protected areas such as nature conservation reserves and national parks. In addition to genetic resource conservation through forest reservation, conservation plantings and seed orchards (stands specifically planted and managed for seed production) have been established for a number of threatened species.

Australia's forest genetic resources also play an important role in maintaining and improving the productivity of commercial plantations grown for wood production. This can occur, for example, through selection of trees that have high growth rates and superior wood quality, that are better adapted to changing climatic conditions, such as lower rainfall or higher temperatures, or that are resistant or tolerant to pests and diseases. The genetic base of Australian native forest trees employed in commercial plantations has also been brought into seed collections, seed orchards, and improvement and breeding programs.

Key findings

Key findings are a condensed version of the Key points presented at the start of individual indicators in this criterion.

Ecosystem diversity

- In 2011, Australia had 125 million hectares of forest. Of this, 123 million hectares (98%) are Native forest, 2.0 million hectares are Industrial plantation, and 0.15 million hectares are Other forest. Data for Australia's forest estate are assembled in the National Forest Inventory.
- The best currently available measure of change in Australia's forest cover over time comes from annual Landsat satellite data interpreted for Australia's National Greenhouse Gas Inventory (previously known as the National Carbon Accounting System). These data indicate a net loss in Australia's forest area of 1.4 million hectares from 2005 to 2010, comprising a decrease of 1.8 million hectares from 2005 to 2008, followed by an increase of 0.4 million hectares from 2008 to 2010. These changes in forest cover are driven by a combination of land-use change and a range of short-term factors.
- The area of forests reported in SOFR 2013 was determined by combining state and territory data with remotely sensed forest-cover datasets not considered in previous SOFRs, to provide a more accurate knowledge base and allow a number of corrections to be made. This 'Multiple Lines of Evidence' approach led to the reduction in Australia's reported forest area from 149 million hectares in SOFR 2008 to 125 million hectares in SOFR 2013. Most of this correction has occurred in what was previously classified as Eucalypt low woodland forest on private and leasehold land, much of which is now classified as other woody non-forest vegetation with a canopy cover of less than 20%. None of the reported reduction in area has occurred in rainforests or in forest areas in the 10 Regional Forest Agreement regions.

- Australia's forest area is 16% of Australia's land area. Australia has about 3% of the world's forest area, and the seventh largest forest area of any country worldwide.
- Australia's native forest is dominated by Eucalypt forest (92 million hectares; 75% of the native forest area) and Acacia forest (9.8 million hectares; 8%), with only a small area of Rainforest (3.6 million hectares; 3%); the other types sum to 17 million hectares (14%). About two-thirds of Australia's native forest (81.7 million hectares; 66.6%) is woodland forest with 20–50% canopy cover.
- Some 81.9 million hectares (66.8% by area) of Australia's native forest is privately managed, on private or leasehold tenures, including Indigenous owned and managed lands, or Indigenous managed lands. A further 21.5 million hectares of native forest (17.5%) is in formal nature conservation reserves, while 10.2 million hectares of native forest (8.3%) is in multiple-use public native forests.

- Industrial plantations, reported through the National Plantation Inventory, comprise 1.03 million hectares of softwood species (mostly exotic pines), 0.98 million hectares of hardwood species (mostly eucalypts), and 0.01 million hectares of plantations for which the species is unrecorded or where there is more than one species.
- Australia's Industrial plantation estate increased in area by 0.20 million hectares between 2006 and 2011. Almost all this increase was due to an expansion in the area of hardwood plantations, although this expansion has slowed and some hardwood plantations have been converted to other land uses.
- Other forest comprises 0.15 million hectares of mostly non-industrial plantations and planted forests of various types.

- Australia's native forests comprise a mixture of growth stages, categorised as regeneration, regrowth, mature and senescent forest, or are uneven-aged forest.
- Within the 15.4 million hectares of native forest for which growth-stage information is available, all forest growth stages are present on all tenures. On average, multiple-use public native forest has a greater proportion of younger growth stages (regeneration and regrowth) and of uneven-aged forest than forests in nature conservation reserves, which have a greater proportion of forests in the senescent growth stage.
- Of the 23 million hectares of forest in Australia assessed for their old-growth status, 5.0 million hectares (22%) is classified as old-growth. More than 73% of forest classified as old-growth was within formal or informal nature conservation reserves in 2011.

- A total of 21.5 million hectares of Australia's forest (17% of Australia's forest area) is in the land tenure category 'nature conservation reserve' (an increase from the value of 15% reported in SOFR 2008).
- Several jurisdictions also report the area of forest in informal nature conservation reserves on public land, the area of forest in which values are protected by management prescription, and (in Tasmania) the area of forest in private reserves. In addition, approximately 1.8 million hectares of forest on privately owned or managed lands are covered by conservation covenants listed in the National Conservation Lands Database.
- The Collaborative Australian Protected Areas Database (CAPAD), which is a spatial representation of the National Reserve System, contains 26.4 million hectares of forest (21% of Australia's forest) for which the primary management intent is nature conservation. All of the broad national forest types in Australia, with the exception of Acacia forest, are represented in the National Reserve System at a level higher than the area proportion target of 10% recommended by the International Union for Conservation of Nature. About 4.3 million hectares of Australia's native forest is in sites on the World Heritage List.
- The total area of native forest in areas protected for biodiversity conservation, both included and not included in CAPAD, is 39.2 million hectares (32% of Australia's native forests). The Aichi Biodiversity Target (an area target of at least 17%) from the Strategic Plan for Biodiversity 2011–2020 of the Convention on Biological Diversity, to which Australia is a party, has thus been achieved with respect to Australia's native forest.

- A large proportion of Australia's native vegetation in the intensively managed agricultural and urban zones has been cleared or substantially modified since European settlement. As a result, any remaining forests in these areas are usually highly fragmented.
- The cessation of broadscale clearing of native forest in much of Australia, and the increased protection of remnant native vegetation, have been critical in reducing the rate of forest fragmentation. In some areas, forest restoration has reversed this fragmentation.

Species diversity

- The number of forest-dwelling vertebrates and vascular plant species reported in each jurisdiction has generally increased since the number was first reported in SOFR 1998, reflecting improved information from targeted surveys, and compilation into new national lists.
- A total of 2,212 vertebrate species are known to be forest-dwelling in Australia, of which 1,101 are identified as forest-dependent. Australia has at least 16,836 identified forest-dwelling vascular plants, 50% of which occur in Queensland.
- Partial ecological information is available for around 60% of forest-dwelling vertebrate and vascular plant species. Comprehensive ecological information is available for at least 10% of vertebrate species, mainly mammals, birds and amphibians. Since SOFR 2008, significantly better information has become available for species in regions that have been subject to formal assessment processes, such as those associated with Regional Forest Agreements, and for reptiles, frogs, bats and fish. Information remains very limited on forest-dwelling invertebrates, fungi, algae and lichens, apart from those in Tasmania and south-west Western Australia.

- A total of 1,431 forest-dwelling species are on a national list of threatened species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. These comprise 283 vertebrate species, 32 invertebrate species and 1,116 vascular plant species.
- Over the period 2006–11, a total of 89 forest-dwelling species were added to the national list of threatened species, and 21 forest-dwelling species were removed from the list. Most of the additions were made because species had inherently small population sizes and/or there were ongoing threats to habitat extent and quality, including those posed

by introduced species and unsuitable fire regimes. Most of the removals were a result of new information that indicated that the species was not threatened. Seven forest-dwelling plant species previously categorised as Extinct were rediscovered during the reporting period, and their status was changed to Critically Endangered or Vulnerable.

- Historical land-use change and forest loss caused by clearing for agriculture, grazing, and urban and industrial development have been the most significant threat to nationally listed forest-dwelling fauna species (vertebrates and invertebrates), followed by predation by introduced predators (e.g. fox, cat, rat and trout).
- Small population size and localised distribution are the most significant threats to threatened forest-dwelling plants, followed by mortality agents (including illegal collection, recreational pressure, and pressures from urban edges) and unsuitable fire regimes.
- Forestry operations pose a minor threat to nationally listed forest-dwelling fauna and flora species compared with the other identified threats listed above.

- Efforts to monitor forest-dwelling species vary across state and territory jurisdictions, and have diminished in some jurisdictions. Birds are the taxonomic group with the largest number of programs in place to track population trends. The monitoring efforts of state and territory agencies are supplemented by a large-scale investment by non-government organisations.

Genetic diversity

- The number of forest-associated species for which data on genetic variation are available is still very small, although understanding is increasing.
- Formal efforts are being made to improve long-term genetic conservation outcomes by increasing connectivity between fragmented patches of native vegetation, including forests.

- Australian native forest genetic resources are primarily conserved in situ in existing native forest in Australia, and to a lesser degree in arboreta, seed banks, seed orchards and plantations. Tree-breeding, tree improvement or genetic conservation programs exist for more than 30 Australian native wood and oil-producing species and varieties. Australia's native forest species are also important in the plantation industries in many other tropical or temperate countries.

Eucalypt mallee woodland forest, Eyre Peninsula, South Australia.

Indicator 1.1a

Area of forest by forest type and tenure

Rationale

This indicator uses the area for each forest type over time as a broad measure of the extent to which forest ecosystems and their diversity are being maintained. Reporting on forest tenure aids our understanding of how different land management regimes may impact on forest biodiversity.

Key points

- Australia has 125 million hectares of forest, which is equivalent to 16% of Australia's land area. Of this total forest area, determined as at 2011, 123 million hectares (98%) are Native forests, 2.02 million hectares are Industrial plantations and 0.15 million hectares are Other forest. Australia has about 3% of the world's forest area, and globally is the country with the seventh largest forest area. Data for Australia's forest estate are assembled in the National Forest Inventory.
- Australia's forest area was reported in SOFR 2008 as 149 million hectares. The smaller forest area (125 million hectares) reported in SOFR 2013 has not resulted from a reduction in actual forest area of this magnitude, but rather is due to improvements in the resolution of forest mapping that have enabled the use of better quality data on Australia's forests and a better understanding of Australia's forest area.
- The major category of Australia's forest is Native forest. This is dominated by Eucalypt forest (92 million hectares—75% of the native forest area) and Acacia forest (9.8 million hectares—8%), with only a small area of Rainforest (3.6 million hectares—3%). The majority of Native forest is woodland forest (82 million hectares—67%).
- The second category is Industrial plantation, reported through the National Plantation Inventory, and comprising 1.03 million hectares of softwood species (mostly exotic pines), 0.98 million hectares of hardwood species (mostly eucalypts) and 0.01 million hectares of unknown or mixed species.
- The final category is Other forest, which comprises 0.15 million hectares of mostly non-industrial plantations and planted forests of various types.
- The majority of Australia's native forest estate, 81.9 million hectares (66.8%), is privately managed on private and leasehold lands, including Indigenous-owned or Indigenous-managed lands. A further 21.5 million hectares of native forest (17.5%) is in formal nature conservation reserves, and 10.2 million hectares of native forest (8.3%) is in multiple-use public native forests.
- The best available measure of change in Australia's forest cover over time comes from annual Landsat satellite data interpreted for Australia's National Greenhouse Gas Inventory (previously known as the National Carbon Accounting System). These data indicate that Australia's forest area decreased by 1.8 million hectares from 2005 to 2008, then increased by 0.4 million hectares from 2008 to 2010; the net loss in forest area from 2005 to 2010 was 1.4 million hectares. These cover changes are driven by land-use change, and a range of short-term factors—including wildfire and regrowth from wildfire, and climate variability (especially drought)—that would not be interpreted as forest cover change in the National Forest Inventory.
- Australia's Industrial plantation estate increased in area by 0.20 million hectares between 2006 and 2011. Almost all of this increase was due to expansion in the area of hardwood plantations, although this expansion has slowed and some hardwood plantations have been converted to other land uses.
- Area data for native forests in this report (SOFR 2013) have been determined by combining state and territory data with remotely sensed forest-cover datasets not considered in previous SOFRs, to provide a more accurate knowledge base. This 'Multiple Lines of Evidence' approach has allowed a number of corrections to be made to the dataset assembled for SOFR 2008, and has led to the reduction in reported forest area from 149 million hectares in SOFR 2008 to 125 million hectares in SOFR

Table 1.1: Australia's forest area, by jurisdiction

Jurisdiction	Native forest		Industrial plantation[a,b]		Other forest[b,c]		Total forest		Total land	
	Area ('000 hectares)	Area as proportion of total Native forest (%)	Area ('000 hectares)	Area as proportion of total Industrial plantation (%)	Area ('000 hectares)	Area as proportion of total Other forest (%)	Area ('000 hectares)	Area as proportion of total forest (%)	Area ('000 hectares)	Forest area as proportion of jurisdiction's land area (%)
ACT	129	0.1	8	0.4	1	1	**138**	**0.1**	243	57
NSW	22,281	18	392	19	8	5	**22,681**	**18**	80,064	28
NT	15,169	12	40	2	5	3	**15,214**	**12**	134,913	11
Qld	50,782	41	232	12	22	14	**51,036**	**41**	173,065	29
SA	4,376	4	189	9	0	0	**4,565**	**4**	98,348	5
Tas.	3,362	3	311	15	33	22	**3,706**	**3**	6,840	54
Vic.	7,727	6	433	21	30	20	**8,190**	**7**	22,742	36
WA	18,752	15	413	20	57	37	**19,222**	**15**	252,988	8
Australia	**122,581**	**100**	**2,017**	**100**	**153**	**100**	**124,751**	**100**	**769,202**	**16**

a Reported through the National Plantation Inventory.

b 'Industrial plantation' plus 'Other forest' equals the international 'Planted forests' category used by the Food and Agriculture Organization of the United Nations for the Global Forest Resources Assessment.

c Includes mostly non-industrial plantations and planted forests of various types.

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory.

2013. Most of this correction has occurred in Eucalypt low woodland forest on private or leasehold land, much of which is now classified as other woody non-forest vegetation with a canopy cover of less than 20%. None of the reported reduction in area has occurred in rainforest or in forest areas in the 10 Regional Forest Agreement regions.

- Improvements in determining Australia's forest area are expected to continue as state and territory governments implement improved forest mapping and monitoring techniques.

Australia's forest area

As at 2011, Australia had approximately 125 million hectares of forest, covering 16% of the total land area (Table 1.1)[14]. This places Australia seventh in the world for countries ranked by forest area (FAO 2010). Data for Australia's forest estate are assembled in the National Forest Inventory (NFI). The spatial distribution of Australia's forests is shown in Figure 1.1.

Queensland has the largest area of forest (51.0 million hectares—41% of Australia's forest), with New South Wales (22.7 million hectares—18%), Western Australia (19.2 million hectares—15%) and the Northern Territory (15.2 million hectares—12%) making up much of the balance (Table 1.1).

There are three broad categories for Australia's forest:

- 123 million hectares (98%) is Native forest dominated by eucalypts and acacia.
- 2.02 million hectares is Industrial plantations reported through the National Plantation Inventory (NPI), and comprising 1.03 million hectares of softwood plantations (mainly pines), 0.98 million hectares of hardwood plantations (mainly eucalypts), and 0.01 million hectares of unknown or mixed species.
- 0.15 million hectares are Other forest, which are mostly non-industrial plantations and planted forests of various types.

The best estimate of the actual change in Australia's forest area during the reporting period for SOFR 2013, determined from annual forest area estimates from Landsat satellite imagery data interpreted for Australia's National Greenhouse Gas Inventory (previously known as the National Carbon Accounting System, NCAS), is a decrease by 1.4 million hectares from 2005 to 2010 (see section 'Change in forest cover'; Figure 1.6).

However, the forest area reported in SOFR 2013 is 24 million hectares less than that reported in SOFR 2008 (see section 'Changes in forest mapping'; Table 1.11). This revision in reported forest area is the result of using a more accurate technique to determine forest area, and does not represent an actual loss of this extent of forest or derive from any change in the definition of forest, which has not changed over the series of four SOFRs (see Introduction). The accuracy of the forest area figure has been improved by examining multiple datasets of forest cover, including data of higher spatial resolution. As well as state and territory data (as used in previous SOFRs), the datasets now also include other remotely sensed forest cover data that were not considered in previous SOFRs (Mutendeudzi et al. 2013a,b). This Multiple Lines of Evidence (MLE) approach and the use of data with improved spatial resolution allowed a more rigorous method of delineating forest, and thus enabled the

[14] The terms forest area, cover and extent are used interchangeably.

Box 1.1: Data sources for Indicator 1.1a (Area of forest by forest type and tenure)

This indicator assembles data from different sources to report on the area of forest by national forest type and land tenure, predominantly through the National Forest Inventory, held by the Australian Bureau of Agricultural and Resource Economics and Sciences, Australian Government Department of Agriculture[15]. The best data sources are those that give the most accurate value for the parameter of interest.

Parameter	2013 data sources	Notes
Forest area (cover, extent)	NFI 2011 based on the MLE process	New MLE data compilation approach used for SOFR 2013, involving examination of datasets supplied by state and territory agencies plus remote-sensing datasets sourced from other organisations. High-resolution imagery used for validation. NPI data used for Industrial plantations. Urban, industrial, horticultural and intensive agricultural land uses excluded.
Change in forest area	NCAS 2010[a]	Area change figures calculated from dataset assembled by calendar year consistently since 1990.
Forest type	NFI 2011 based on NVIS, NFI 2008, TASVEG, CRAFTI, NPI	Improved forest typing in 2013 to NFI forest type categories, using updated NVIS (v. 4.1) Levels V and VI, and application to smaller scale mapping units. NVIS data used to allocate forest types for areas where forest type and cover class were not previously listed in NFI. NFI 2008 data used if NVIS data unavailable. TASVEG (v. 2.0) data used in Tasmania. CRAFTI data used in northern New South Wales. NPI data used to determine types of Industrial plantations.
Forest tenure	NFI 2011, based on PSMA	New approach, which differs from SOFR 2008 in using national tenure information from PSMA (except New South Wales).

CRAFTI = Comprehensive Regional Assessment Aerial Photographic Interpretation, NSW; MLE = Multiple Lines of Evidence; NCAS = National Carbon Accounting System; NFI = National Forest Inventory; NPI = National Plantation Inventory; NVIS = National Vegetation Information System; PSMA = PSMA Australia Ltd; TASVEG = Tasmanian Vegetation Monitoring and Mapping Program.

a DCCEE (2012a).

identification of potential errors in native forest data provided to the NFI and reported in previous SOFRs; these potential errors have now been resolved through a validation process undertaken in consultation with relevant state and territory agencies.

Forest area figures presented in this indicator are national figures, and for various reasons may not align with figures published by individual states or territories. These reasons include the timing of publication of SOFR 2013 compared with the timing of publication of state and territory reports, different interpretation of forest cover from the National Vegetation Information System (NVIS) dataset, and data updates in the national figures resulting from a national Multiple Lines of Evidence (MLE) approach (Mutendeudzi et al. 2013a,b; see below).

The data sources used in this indicator are listed in Box 1.1.

Forest types

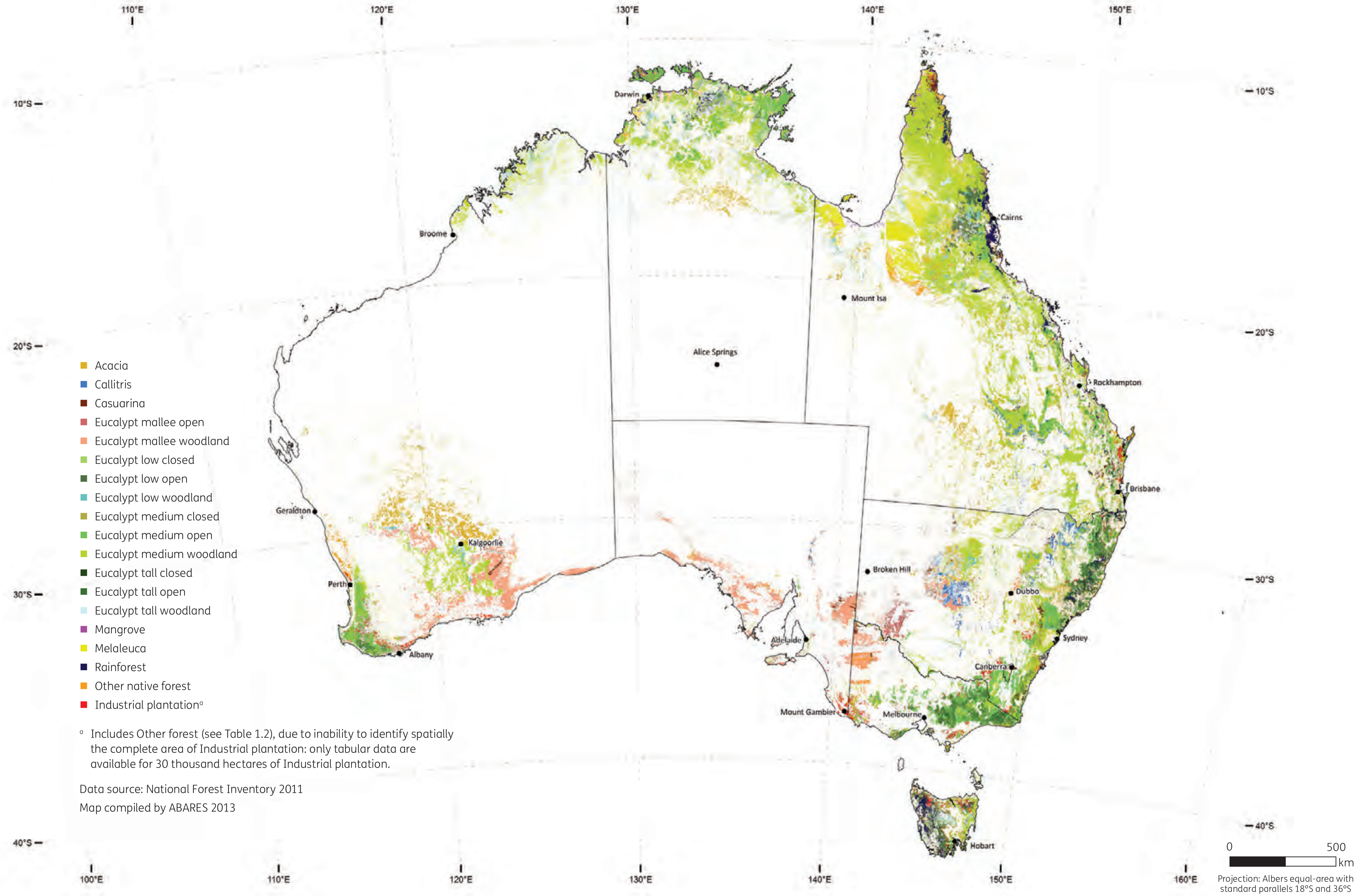
The vast majority of Australia's native forest area is hardwood species (evergreen broadleaf tree species). For national reporting, the NFI groups Australia's native forests into eight broad forest types defined by dominant species and structure (as described in the Introduction). The first seven distinctive types are Acacia, Callitris, Casuarina, Eucalypt (divided into 11 subtypes by height and cover class, including two mallee subtypes), Mangrove, Melaleuca and Rainforest. The eighth type, Other native forest, comprises less common native forest types with relatively small individual areas, as well as native forests where the type is unknown (generally because of an absence of data in NVIS). Industrial plantations are divided into two main types: hardwood (broadleaf) and softwood (coniferous). Other forest includes mostly non-industrial plantations and planted forests of various types. The areas of these forest types are presented in Table 1.2.

The Eucalypt forest type, comprising forests dominated by the genera *Eucalyptus*, *Corymbia* and *Angophora*, is dominant across most of Australia's forest area, with a total of 92 million hectares (74% of Australia's forest area). The second most common forest type is Acacia, comprising forests dominated by species of the genus *Acacia*, with a total of 9.8 million hectares (8%). Despite the overwhelming dominance of these two forest types, Australia's forests are nonetheless very diverse. There are more than 800 species of *Eucalyptus*, *Corymbia* and *Angophora*, and almost 1,000 species of *Acacia*, as well as many other genera of trees, in a rich array of ecosystems that vary in their floristic composition, their structure and the fauna they support. Rainforest, a forest type particularly rich in floral and faunal biodiversity, covers only 3.6 million hectares (3% of Australia's forest area).

Forests are generally confined to regions where average rainfall exceeds 500 millimetres per year. Most forests are in the northern, eastern, south-eastern and south-western coastal zones, although woodland forests extend into drier areas in many parts of the country (Figure 1.1).

15 Before September 2013, the Department of Agriculture, Fisheries and Forestry.

Figure 1.1: Australia's forest extent, and the distribution of forest types



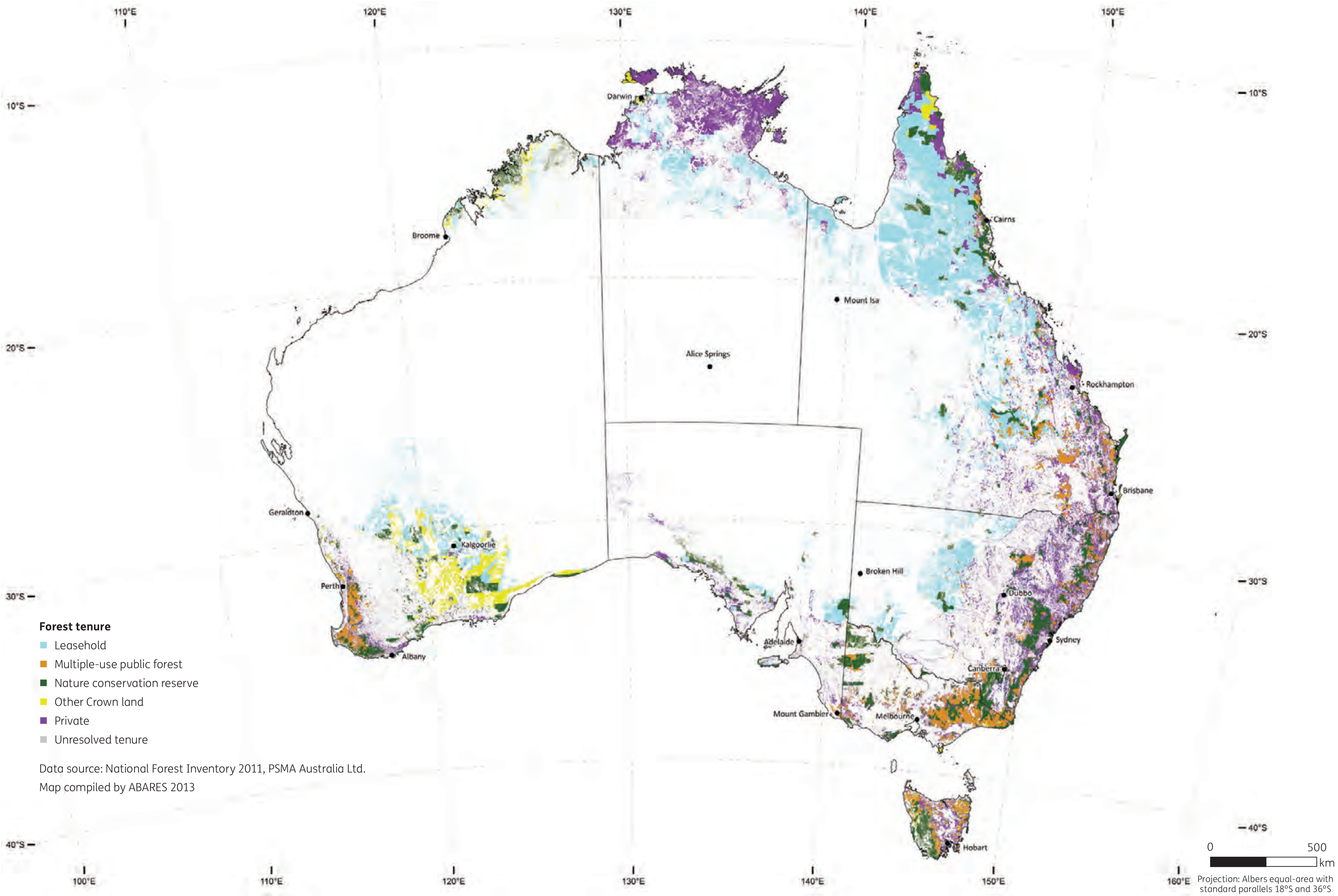
- Acacia
- Callitris
- Casuarina
- Eucalypt mallee open
- Eucalypt mallee woodland
- Eucalypt low closed
- Eucalypt low open
- Eucalypt low woodland
- Eucalypt medium closed
- Eucalypt medium open
- Eucalypt medium woodland
- Eucalypt tall closed
- Eucalypt tall open
- Eucalypt tall woodland
- Mangrove
- Melaleuca
- Rainforest
- Other native forest
- Industrial plantation[a]

[a] Includes Other forest (see Table 1.2), due to inability to identify spatially the complete area of Industrial plantation: only tabular data are available for 30 thousand hectares of Industrial plantation.

Data source: National Forest Inventory 2011

Map compiled by ABARES 2013

Figure 1.4: Australia's forest extent by tenure



Data source: National Forest Inventory 2011, PSMA Australia Ltd.
Map compiled by ABARES 2013

Table 1.2: Australia's forest area, by forest type

Forest type	Area ('000 hectares)	Proportion of total native forest area (%)	Proportion of total forest area (%)
Acacia	9,807	8	8
Callitris	2,136	2	2
Casuarina	1,288	1	1
Eucalypt	91,989	75	74
Eucalypt mallee open	813	1	1
Eucalypt mallee woodland	11,313	9	9
Eucalypt low closed	39	0.03	0.03
Eucalypt low open	2,173	2	2
Eucalypt low woodland	4,016	3	3
Eucalypt medium closed	247	0.2	0.2
Eucalypt medium open	19,450	16	16
Eucalypt medium woodland	48,246	39	39
Eucalypt tall closed	141	0.1	0.1
Eucalypt tall open	4,897	4	4
Eucalypt tall woodland	655	1	1
Mangrove	913	1	1
Melaleuca	6,302	5	5
Rainforest	3,598	3	3
Other native forest[a]	6,547	5	5
Native forest total	**122,581**	**100**	**98**
Softwood	1,025		1
Hardwood	980		1
Unknown or mixed species[b]	12		0.01
Industrial plantations total[c]	**2,017**		**2**
Other forest[d]	**153**		**0.1**
Total forest	**124,751**		**100**

a Other native forest comprises a range of minor forest types, including Agonis, Atalaya, Banksia, Hakea, Grevillea, Heterodendron, Leptospermum, Lophostemon and Syncarpia (named after their dominant genera), as well as native forests where the type is unknown.

b Plantations of mixed hardwood and softwood species, and plantations where the species type is not reported.

c Industrial plantations as reported through the National Plantation Inventory (see Gavran 2012).

d Other forest includes mostly non-industrial plantations and planted forests of various types, including sandalwood, farm forestry, environmental plantings, plantations within the reserve system, and plantations regarded as not commercial.

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory, National Plantation Inventory.

Tall eucalypt forest, Victoria.

Crown cover and height

Australia's definition of forest specifies a minimum existing or potential crown cover of 20% and a minimum mature or potentially mature stand height of 2 metres. Native forests are classified into three crown cover classes based on existing or potential crown cover (woodland forest, 20–50% crown cover; open forest, >50–80% crown cover; and closed forest, >80–100% crown cover), and three height classes based on mature or potentially mature stand height (low, 2–10 metres; medium, >10–30 metres; and tall, >30 metres), as shown in Figure 1.2. Land classified as non-forest comprises both land carrying other woody vegetation with less than 20% existing or potential crown cover or with a mature or potentially mature stand height of less than 2 metres, and land not carrying other woody vegetation. Whereas forest type and crown cover are reasonably well measured across Australia, forest height is less well measured outside forests in which wood is harvested.

Approximately 82 million hectares (67%) of Australia's native forest area is classified as woodland forest (Table 1.3). Open forests comprise 34 million hectares (28%) of the native forest area. Closed forests comprise 3.8 million hectares (3%) of the native forest area. Eucalypt forest types are the largest component of both woodland forest (64 million hectares) and open forest (27 million hectares), while Rainforest is the largest component of closed forest (2.6 million hectares) (Table 1.4).

Figure 1.2: Native forest crown cover, height classes, and area proportions

Note: Percentages are area proportions of each height class/cover class combination in Australia's total native forest area (National Forest Inventory).

Source: Adapted from Australian Land Information Group and JA Carnahan (1990). *Atlas of Australian Resources, Vegetation*. Australian Government Publishing Service, Canberra.

Table 1.3: Area of native forest, by crown cover class and jurisdiction

	Woodland forest		Open forest		Closed forest		Unknown		Total native forest
Jurisdiction	**Area ('000 hectares)**	**Proportion of jurisdiction's native forest area (%)**	**Area ('000 hectares)**	**Proportion of jurisdiction's native forest area (%)**	**Area ('000 hectares)**	**Proportion of jurisdiction's native forest area (%)**	**Area ('000 hectares)**	**Proportion of jurisdiction's native forest area (%)**	**Area ('000 hectares)**
ACT	38	29	87	67	0	0	4	3	129
NSW	10,449	47	9,797	44	509	2	1,526	7	22,281
NT	7,797	51	6,640	44	630	4	102	1	15,169
Qld	38,656	76	8,962	18	1,740	3	1,424	3	50,782
SA	4,122	94	255	6	0	0	0	0	4,376
Tas.	1,353	40	1,357	40	640	19	11	0.3	3,362
Vic.	2,809	36	4,669	60	249	3	0	0	7,727
WA	16,464	88	2,160	12	42	0.2	86	0.5	18,752
Australia	**81,688**	**67**	**33,927**	**28**	**3,810**	**3**	**3,158**	**3**	**122,581**

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory.

Table 1.4: Area of native forest, by type and crown cover class

	Area ('000 hectares)				
Forest type	Woodland forest	Open forest	Closed forest	Unknown	Total
Acacia	7,387	2,385	35	0	9,807
Callitris	971	1,165	0	0	2,136
Casuarina	1,106	165	17	0	1,288
Eucalypt	64,230	27,333	426	0	91,989
Eucalypt mallee	11,313	813	0	0	12,126
Eucalypt low	4,016	2,173	39	0	6,228
Eucalypt medium	48,246	19,450	247	0	67,943
Eucalypt tall	655	4,897	141	0	5,693
Mangrove	107	373	432	0	913
Melaleuca	5,357	907	38	0	6,302
Rainforest	0	1,008	2,590	0	3,598
Other native forest	2,530	590	271	3,158	6,547
Total native forest	**81,688**	**33,927**	**3,810**	**3,158**	**122,581**
Area as proportion of total native forest area (%)	**67**	**28**	**3**	**3**	**100**

Note: Totals may not tally due to rounding.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory.

The distribution of Australia's eight native forest types and nine structural classes (three height classes by three crown cover classes) varies across the continent, depending on climate, geology and soil type. It is most closely related to soil moisture regime and water availability, as well as past and present land management practices. Figure 1.3 shows the mapped distribution of native forest by crown cover class. Data from the NVIS were used to allocate forest types for areas where forest type and crown cover class were previously not listed in the NFI (see Box 1.1). Table 1.4 gives a full breakdown of the areas of the various forest types and crown cover classes, and Figure 1.2 shows the area proportions of the nine structural classes across Australia's native forests.

Woodland forest is the largest forest cover class in all jurisdictions except Victoria, the Australian Capital Territory and Tasmania (Table 1.3). In South Australia, woodland forest represents 94% of the native forest area, in Western Australia 88%, and in Queensland 76%; there are 39 million hectares of woodland forest in Queensland alone. Open forests dominate in the Australian Capital Territory (68% of the native forest area in that territory) and Victoria (60%). Woodland and open forests occur in similar proportions in Tasmania, while Tasmania has the highest proportion of closed forests (0.64 million hectares—19% of that state's native forest area).

More than half (26.8 million hectares—53%) of Queensland's forests are classified as Eucalypt medium woodland (Table 1.5). Queensland also has the largest area of Acacia forest (4.5 million hectares—46% of Australia's total) and Melaleuca forest (5.2 million hectares—83% of Australia's total), which are both mostly woodland forests, as well as the largest area of Rainforest (2.0 million hectares—56% of Australia's total).

Three-quarters of New South Wales forests (16.3 million hectares) are Eucalypt forest types, with approximately equal areas of Eucalypt woodland forests (low, medium and tall) and Eucalypt open forests (low, medium and tall).

Western Australia's forests are dominated by Eucalypt forests (14.8 million hectares—79% of the state's forest area) and Acacia forests (3.2 million hectares—17%). Almost half of Australia's Eucalypt mallee woodland is in Western Australia.

Eucalypt forests dominate the Northern Territory (12.3 million hectares—81% of the territory's forest area). The largest components are medium woodland and medium open forests, together with significant amounts of Acacia and Melaleuca forests. There are no tall Eucalypt forests in the Northern Territory.

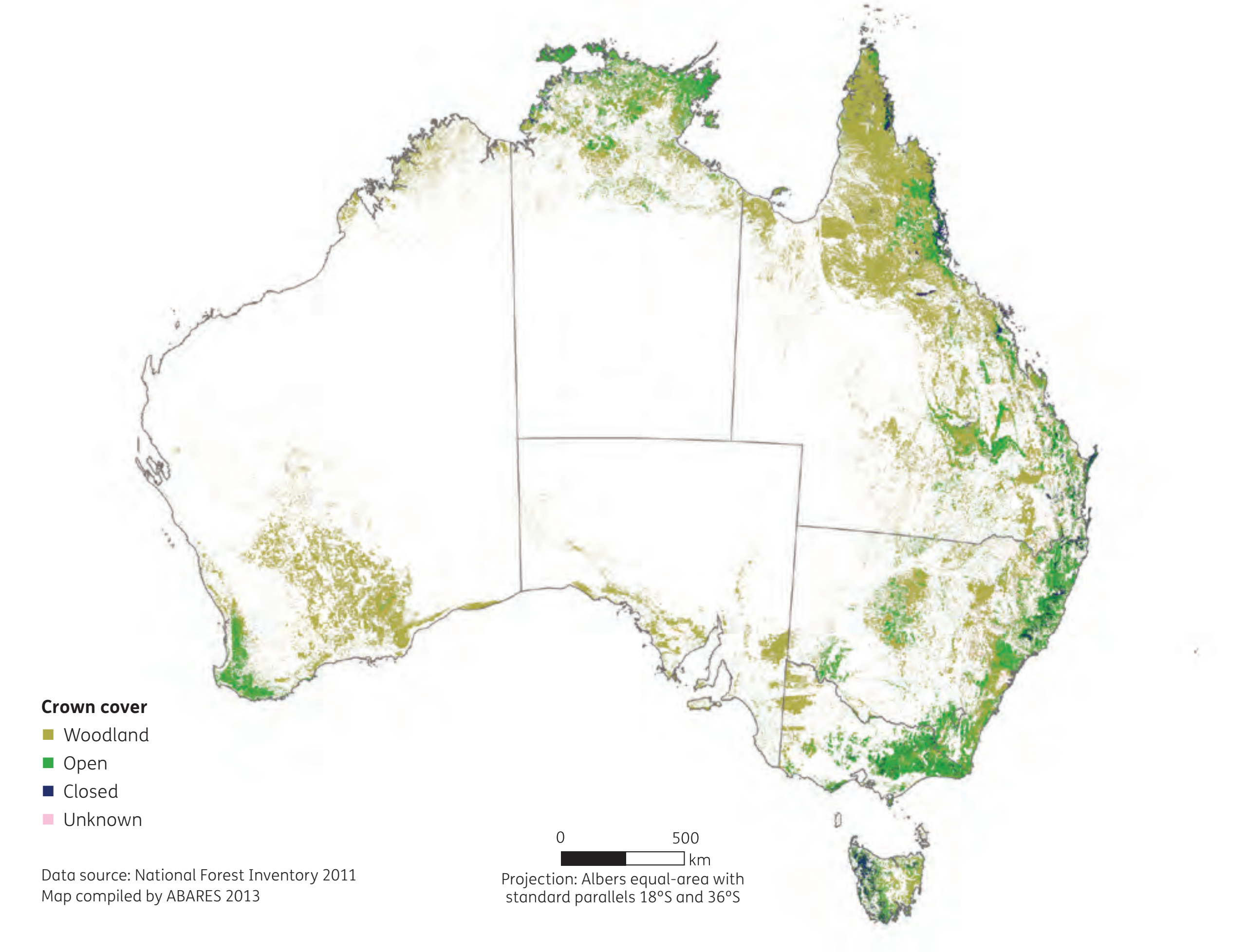
Victoria's forests are dominated by Eucalypt forests (7.2 million hectares—87% of the state's forest area). The largest component is Eucalypt medium open forests (3.1 million hectares), with just over 1 million hectares each of Eucalypt mallee woodland, Eucalypt medium woodland and Eucalypt tall open forest.

South Australia's native forests are dominated by eucalypt mallee forests (81% of the state's forest area). There are no tall eucalypt forests or rainforest in South Australia.

Although Tasmania and the Australian Capital Territory have the smallest areas of forest of all the states and territories, they have the highest proportion of forest area (Table 1.1). Forests in the Australian Capital Territory are almost completely Eucalypt forests (0.12 million hectares—96% of the territory's forest area), with the balance comprising Other native forest types and Casuarina (Table 1.5). Tasmania has the highest proportional area of Rainforest (21% of the state's forest area, covering 0.71 million hectares), with most of the balance represented by Eucalypt forests (2.5 million hectares—74%).

Australia has a total of 0.91 million hectares of Mangrove forests (Table 1.2). About 85% of these are in Queensland and the Northern Territory (Table 1.5). New South Wales and Queensland have the largest areas classified in the 'Other native forest' type, at 2.3 and 3.0 million hectares, respectively.

Figure 1.3: Native forest, by crown cover class



Native forest management for wood production occurs predominantly in the tall open and medium open forest types on public and private land within the 10 Regional Forest Agreement (RFA) areas and south-eastern Queensland (see Introduction and Indicator 7.1a). Low and medium open forests and woodland forests, typically on leasehold and private land, are generally used for livestock grazing. There is occasional low-intensity wood production in low open forests and woodland forests.

Tenure

Forest ownership is reported in six tenure classes that summarise the wide range of land tenures used by each jurisdiction across Australia (see Introduction for descriptions of tenure classes). Table 1.6 shows the areas of native forest in each tenure type by jurisdiction, and Table 1.7 shows the areas of native forest in each crown cover type by tenure. Table 1.7 also shows the summed areas of Industrial plantations and Other forest by tenure. Only tabular data are available for some Industrial plantations, with those tabular data in addition not distinguishing tenure types, so the areas by tenure of Industrial plantations and Other forest cannot be reported separately. The distribution of forest by tenure type is mapped in Figure 1.4 (see p. 36).

The land tenure dataset used in SOFR 2013 for forest tenure analysis is a national dataset compiled by PSMA Australia Limited.[16] The product compiles data sourced from state and territory government mapping agencies and land registries. New South Wales tenure data, however, were not collected through this process; they were acquired and processed in the NFI separately, before incorporation into the 2013 tenure dataset. This method of assembling consistent national tenure data is an improvement over the method used during the production of SOFR 2008, which involved collection and classification of inconsistent tenure information from each jurisdiction individually into the NFI (see Box 1.1).

Of the 123 million hectares of native forest in Australia, 48.5 million hectares (40%) are native forest on leasehold land, and 33.4 million hectares (27%) are native forest on land held under private freehold title or Indigenous land. Consequently, a total of 81.9 million hectares (67%) of native forest are under some form of private management. The Northern Territory (98%) and Queensland (80%) have the highest proportions of their total native forest area under private management, while the Australian Capital Territory (7%) and Victoria (19%) have the lowest proportions.

[16] www.psma.com.au/?product=land-tenure. Data were purchased from OMNILINK Pty Ltd (www.omnilink.com.au).

Table 1.5: Forest area, by forest type and jurisdiction

Forest type	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Australia
	Area ('000 hectares)								
Acacia	0	849	976	4,546	97	75	43	3,222	9,807
Callitris	0	1,489	0	557	65	1	24	0.08	2,136
Casuarina	1	570	38	290	139	11	146	94	1,288
Eucalypt	123	16,337	12,254	34,771	4,047	2,481	7,155	14,821	91,989
Eucalypt mallee open	0	600	0	0	205	0	3	5	813
Eucalypt mallee woodland	0	1,106	16	1	3,486	0.08	1,117	5,586	11,313
Eucalypt low closed	0	0.02	11	10	0	3	14	0.1	39
Eucalypt low open	0	84	473	1,314	7	56	70	169	2,173
Eucalypt low woodland	7	437	855	1,625	132	64	21	874	4,016
Eucalypt medium closed	0	19	67	43	0	0	97	20	247
Eucalypt medium open	86	4,833	5,015	4,522	23	240	3,140	1,590	19,450
Eucalypt medium woodland	30	6,840	5,816	26,849	193	1,028	1,127	6,363	48,246
Eucalypt tall closed	0	17	0	0	0	0	117	6	141
Eucalypt tall open	0	2,346	0	155	0	829	1,373	193	4,897
Eucalypt tall woodland	0	54	0	251	0	262	73	14	655
Mangrove	0	16	334	441	13	0	2	107	913
Melaleuca	0	77	896	5,216	11	24	26	53	6,302
Rainforest	0	606	260	2,004	0	708	20	0.3	3,598
Other native forest	5	2,338	411	2,958	5	61	314	456	6,547
Total native forest	**129**	**22,281**	**15,169**	**50,782**	**4,376**	**3,362**	**7,727**	**18,752**	**122,581**
Softwood	8	296	2	189	129	75	226	100	1,025
Hardwood	0	93	38	41	60	236	206	307	980
Unknown or mixed species[a]	0	3	0	2	0	0	1	6	12
Total Industrial plantations[b]	**8**	**392**	**40**	**232**	**189**	**311**	**433**	**413**	**2,017**
Other forest[c]	**1**	**8**	**5**	**22**	**0**	**33**	**30**	**57**	**153**
Total forest	**138**	**22,681**	**15,214**	**51,036**	**4,563**	**3,706**	**8,190**	**19,222**	**124,751**

[a] Plantations of mixed hardwood and softwood species, and plantations where the species type is not reported.

[b] Industrial plantations as reported through the National Plantation Inventory (Gavran 2012).

[c] Other forest includes mostly non-industrial plantations and planted forests of various types, including sandalwood, farm forestry, environmental plantings, plantations within the reserve system, and plantations regarded as not commercial. The inability to identify spatially the complete area of Industrial plantation means that a small area of Other forest cannot be reported with a high level of confidence.

Note: Totals may not tally due to rounding.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory, National Plantation Inventory.

Table 1.6: Area of native forest, by tenure and jurisdiction

Tenure type	Area ('000 hectares)									Proportion of total native forest area (%)
	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Australia	
Leasehold forest	9	5,745	5,228	30,656	1,318	16	2	5,559	48,533	40
Multiple-use public forest	4	2,022	0	2,905	20	923	2,994	1,291	10,159	8
Nature conservation reserve	115	5,581	13	5,098	1,509	1,240	3,313	4,610	21,478	18
Other Crown land	1	79	279	1,208	52	287	230	6,010	8,146	7
Private land (including Indigenous)	1	8,852	9,618	10,129	1,455	875	1,184	1,281	33,394	27
Unresolved tenure	0	2	31[a]	785	23	19	5	1	871	1
Total native forest	**129**	**22,281**	**15,169**	**50,782**	**4,376**	**3,362**	**7,727**	**18,752**	**122,581**	**100**

[a] A small area of native forest in the category Unresolved tenure in the Northern Territory cannot be reported with a high level of confidence.

Note: Totals may not tally due to rounding.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory, PSMA Australia Ltd.

Table 1.7: Area of native forest (by crown cover type) and plantation, by tenure

	Area ('000 hectares)						
Crown cover type	**Leasehold**	**Multiple-use public forest**	**Nature conservation reserve**	**Other Crown land**	**Private (including Indigenous)**	**Unresolved tenure**	**Total**
Woodland	40,337	3,628	12,325	7,097	17,818	483	81,688
Open forest	7,359	5,864	7,524	755	12,181	244	33,926
Closed forest	380	563	1,486	209	1,089	83	3,810
Unknown	457	105	145	85	2,305	61	3,158
Total native forest	**48,533**	**10,160**	**21,480**	**8,146**	**33,393**	**871**	**122,581**
Industrial plantations[a] and Other forest[b,c]	**25**	**964**	**9**	**12**	**1,157**	**3**	**2,170**
Total forest	**48,558**	**11,124**	**21,489**	**8,157**	**34,549**	**874**	**124,751**

a Industrial plantations as reported through the National Plantation Inventory. The land tenure for plantation forest cannot be used to determine ownership of the trees. Areas by tenure of Industrial plantations and Other forest cannot be reported separately as not all Industrial plantations data are reported spatially.

b Other forest includes mostly non-industrial plantations and planted forests of various types, including sandalwood, farm forestry, environmental plantings, plantations within the reserve system, and plantations regarded as not commercial.

c Spatial data are not available for all areas of Industrial plantations reported through the National Plantation Inventory, and areas by tenure of Industrial plantations and Other forest therefore cannot be reported separately.

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory, National Plantation Inventory, PSMA Australia Ltd.

Victoria (38%) and Tasmania (28%) have the highest proportions of their native forest area as multiple-use public forests. The proportion of multiple-use public forest area in all the other jurisdictions is 11% or less.

The Australian Capital Territory (83%) and Victoria (40%) have the highest proportions of their native forest area as nature conservation reserves. The Northern Territory (0.1%) and Queensland (10%) have the lowest proportions, noting that Kakadu National Park and some other national parks in these jurisdictions are Indigenous owned private tenure.

Queensland has the largest area of leasehold native forest (30.7 million hectares—63% of Australia's total area of leasehold native forest). Other substantial areas of leasehold native forest are in New South Wales, Western Australia and the Northern Territory. Together, Queensland, New South Wales and the Northern Territory contain more than 80% of Australia's private native forests, including large areas that are Indigenous owned and managed or Indigenous managed (see Indicators 6.4a and 6.4c).

A total of 21.5 million hectares of forest (17.5% of Australia's native forest, and 17.2% of Australia's total forest) is protected in nature conservation reserves, an increase from the 15.0% of Australia's total forest reported in SOFR 2008 (see Indicator 1.1c). In addition, some forests not included in the area reported as nature conservation reserve tenure are protected under other protocols and instruments. Thus, Indigenous owned and managed or Indigenous managed lands are classified in both SOFR 2008 and SOFR 2013 by their formal tenure type, which is generally private, leasehold or other Crown land (depending on the jurisdiction), even where the legislated management intent is conservation. An example of this is Kakadu National Park in the Northern Territory (see Indicators 1.1c, 6.4a and 6.4c).

The improved methodology used to determine Australia's forest extent has led to a small area of nature conservation reserves no longer being classified as forest; hence the absolute area of native forest in nature conservation reserves is lower in SOFR 2013 than in SOFR 2008. In addition, the tenure type of some areas of reserved native forest has been recategorised. For example, formal forest reserves legislated following the 2005 Tasmanian Community Forest Agreement[17] in areas such as the Tarkine and the Styx Valley in Tasmania, and large areas of formal forest reserves legislated as a result of the RFA in Western Australia, were reported as nature conservation reserves in SOFR 2008, but are classified in SOFR 2013 by their gazetted tenure type of multiple-use public forest.

Multiple-use public forests comprise 10.2 million hectares of native forest (8% of Australia's native forest area). Wood harvesting is permitted in some of these areas; however, wood harvesting in multiple-use public native forest is not permitted in the Australian Capital Territory or South Australia[18] (see Indicators 1.1c and 2.1a). The total area of multiple-use public native forest reported here is 0.7 million hectares more than the area reported in SOFR 2008 as the net result of a number of tenure changes, as well as the different tenure classification process used in SOFR 2013 (see above). Most of the increased area of multiple-use public forest is in Queensland, where almost 1 million hectares of forest previously reported as leasehold in 2008 is now reported as multiple-use public forest as a result of a previous misclassification in which State-owned forests on leasehold land were included in the private forest category.

There are notable differences in the distribution of forest with different crown cover types across the six tenure categories used in SOFR 2013 (Table 1.7). The majority (83%) of leasehold forest land carries woodland forests, and almost all the remainder of leasehold forest land carries open forest; leasehold forest land is predominantly in the drier parts of the forest estate (Figure 1.4). Forest on private land (including Indigenous land) is also primarily (87% by area) made up of woodland and open forests. Open forest comprises 53% of all multiple-use public native forests, and woodland forest comprises 33%. Closed forest comprises only a small proportion of the forest area of any tenure category, but is most common in nature conservation reserves.

17 www.daff.gov.au/forestry/national/info.

18 There is no multiple-use public native forest in the Northern Territory.

Industrial plantations

Australia has 2.02 million hectares of Industrial plantations, an increase of 0.20 million hectares over the area reported in SOFR 2008. Industrial plantations account for 1.7% of Australia's total forest area (Tables 1.1, 1.2, 1.5 and 1.7). Their primary purpose is wood production (mainly sawlogs, veneer logs and pulplogs), as reported in the NPI, and they comprise 1.03 million hectares of softwoods, 0.98 million hectares of hardwoods, and 0.01 million hectares of other, unknown or mixed species.

Victoria and Western Australia have the largest areas of Industrial plantations, at 0.433 million and 0.413 million hectares, respectively, each contributing more than 20% of the total area of Australia's Industrial plantations. New South Wales, Victoria and Queensland have the highest proportions of Australia's industrial softwood plantation area (29%, 22% and 18%, respectively). Western Australia, Tasmania and Victoria have the highest proportions of Australia's industrial hardwood plantation area (31%, 24% and 21%, respectively).

Planted forests, including both Industrial plantations and those reported as 'Other forest', comprise 9% of the forest area on multiple-use public land, and 3% of the forest area on private land (Table 1.7). Together, the Industrial plantations and Other forest categories (excluding any small areas of forest dominated by introduced exotic trees established without human intervention) comprise the 'Planted forests' category used by the Food and Agriculture Organization of the United Nations for the Global Forest Resources Assessment[19]. Spatial data are not available for all areas of Industrial plantations reported through the NPI, so areas by tenure of Industrial plantations and Other forest cannot be reported separately.

Other forest

Australia contains 0.153 million hectares of mostly non-industrial plantations and planted forests that are not reported through the NPI but satisfy the definition of forest and are collectively reported as Other forest. These include farm forestry and agroforestry plantations (typically less than 1000 hectares), sandalwood plantations (generally not intended for sawlog or fibre production), environmental plantings, plantations within the reserve system (such as plantations in New South Wales where the land tenure has changed to nature conservation reserve), and plantations regarded as not commercially viable. The small areas of forest dominated by introduced (exotic) species established without human intervention (that is, not planted) are also classified in this category.

The majority of the area of Other forest (57 thousand hectares—37% by area) is in Western Australia (Table 1.5), with significant amounts also in Tasmania (33 thousand hectares—22% by area) and Victoria (30 thousand hectares—20% by area).

[19] http://www.fao.org/forestry/fra/en/.

Forest cover in Regional Forest Agreement regions

Australia's 10 RFA regions cover 39.2 million hectares, which is 5% of Australia's land area (see Introduction). Within these regions of south-eastern and south-western Australia, forests cover 22.3 million hectares, which is 18% of Australia's total forest area, and 57% of the total land area of the RFA regions (Table 1.8). The forest area in RFA regions comprises 21.0 million hectares of native forest and 1.3 million hectares of plantation forest (Industrial plantations and Other forest).

RFAs were established to provide a framework for forest management and conservation in regions containing substantial forestry activities in south-western and south-eastern Australia. The national forest types are not evenly distributed between forest in RFA regions and forest outside RFA regions (Table 1.9). Although only 18% of the area of Australia's forest is within the RFA regions, these regions contain 94% of the area of Eucalypt tall open forests, and 43% of the area of the Eucalypt medium open forests, which are major wood-production forest types. On the other hand, the RFA regions contain only 2% of the area of Acacia forests, and 1% of Eucalypt mallee woodland forests. A total of 64% of Australia's Industrial plantations is in the RFA regions (Table 1.9).

View from Tahune Airwalk, southern Tasmania.

Table 1.8: Areas of forest in Regional Forest Agreement regions, by region

		Native forest		Plantation[a]		Total forest	
RFA region	Region area ('000 hectares)	Forest area ('000 hectares)	Proportion of RFA region area (%)	Forest area ('000 hectares)	Proportion of RFA region area (%)	Forest area ('000 hectares)	Proportion of RFA region area (%)
New South Wales							
Eden	814	562	69	41	5.0	603	74
Southern New South Wales	4,512	2,594	57	137	3.0	2,731	61
Upper and Lower North East	9,696	6,137	63	127	1.3	6,264	65
Tasmania							
Tasmanian	6,796	3,337	49	345	5.1	3,682	54
Victoria							
Central Highlands	1,125	708	63	12	1.1	720	64
East Gippsland	1,225	1,102	90	6	0.5	1,108	90
Gippsland	2,662	1,484	56	109	4.1	1,593	60
North East	2,318	1,293	56	61	2.6	1,354	58
West Victoria	5,779	1,109	19	272	4.7	1,381	24
Western Australia							
South-West Forest Region of Western Australia	4,257	2,672	63	228	5.4	2,900	68
Total RFA regions	**39,185**	**20,998**	**54**	**1,338**	**3.4**	**22,336**	**57**

RFA = Regional Forest Agreement
[a] Industrial plantations and Other forest.
Note: Totals may not tally due to rounding.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory, National Plantation Inventory.

Table 1.9: Areas of forest in Regional Forest Agreement regions, by forest type

Forest type	Area in RFA regions ('000 hectares)	Area in Australia ('000 hectares)	Area in RFA regions as proportion of area in Australia (%)
Acacia	174	9,807	2
Callitris	124	2,136	6
Casuarina	100	1,288	8
Eucalypt	17,884	91,989	19
Eucalypt mallee open	0	813	0
Eucalypt mallee woodland	65	11,313	1
Eucalypt low closed	17	39	44
Eucalypt low open	299	2,173	14
Eucalypt low woodland	142	4,016	4
Eucalypt medium closed	134	247	54
Eucalypt medium open	8,321	19,450	43
Eucalypt medium woodland	3,820	48,246	8
Eucalypt tall closed	140	141	99
Eucalypt tall open	4,580	4,897	94
Eucalypt tall woodland	366	655	56
Mangrove	14	913	2
Melaleuca	155	6,302	3
Rainforest	1,276	3,598	36
Other native forest	1,272	6,547	19
Total native forest	**20,998**	**122,581**	**17**
Softwood	563	1,025	55
Hardwood	736	980	75
Unknown or mixed species	0	12	0
Total Industrial plantation[a]	**1,298**	**2,017**	**64**
Other forest	**40**	**153**	**26**
Total forest	**22,336**	**124,751**	**18**

RFA = Regional Forest Agreement
[a] Industrial plantations as reported through the National Plantation Inventory (Gavran 2012).
Note: Totals may not tally due to rounding.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory, National Plantation Inventory.

Table 1.10: Areas of forest in Regional Forest Agreement regions, by forest tenure

RFA region	Leasehold	Multiple-use forest	Nature conservation reserve	Other Crown land	Private	Unresolved tenure	Total forest
	Area ('000 hectares)						
New South Wales							
Eden	6	213	249	1	134	0	603
Southern New South Wales	133	477	1,284	3	834	0	2,731
Upper and Lower North East	246	1,012	1,987	16	3,003	1	6,264
Tasmania							
Tasmanian	17	1,040	1,227	288	1,092	19	3,682
Victoria							
Central Highlands	0	399	183	9	129	0	720
East Gippsland	0	546	440	45	76	0	1,107
Gippsland	1	831	448	69	240	4	1,593
North East	1	742	361	32	218	0	1,354
West Victoria, Vic.	1	288	535	34	522	0	1,381
Western Australia							
South-West Forest Region of Western Australia	18	1,245	961	42	634	0	2,900
Total RFA regions	**422**	**6,793**	**7,676**	**538**	**6,883**	**25**	**22,336**
Proportion of Australia's forest area with that tenure (%)	**2**	**30**	**34**	**2**	**31**	**0**	**18**

RFA = Regional Forest Agreement
Note: Totals may not tally due to rounding.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory, National Plantation Inventory.

Rainforest, far north Queensland.

Similarly, forests on different tenures are not evenly distributed between forest in RFA regions and forest outside RFA regions. Although the combined RFA regions contain 18% of Australia's forest, they contain 30% of the multiple-use forest, 34% of the forest in nature conservation reserves, and 31% of the forest on private tenures, but only 2% of the forest on leasehold land (Table 1.10). This is again consistent with large areas of drier inland leasehold forest not being included in RFA regions.

Change in forest cover

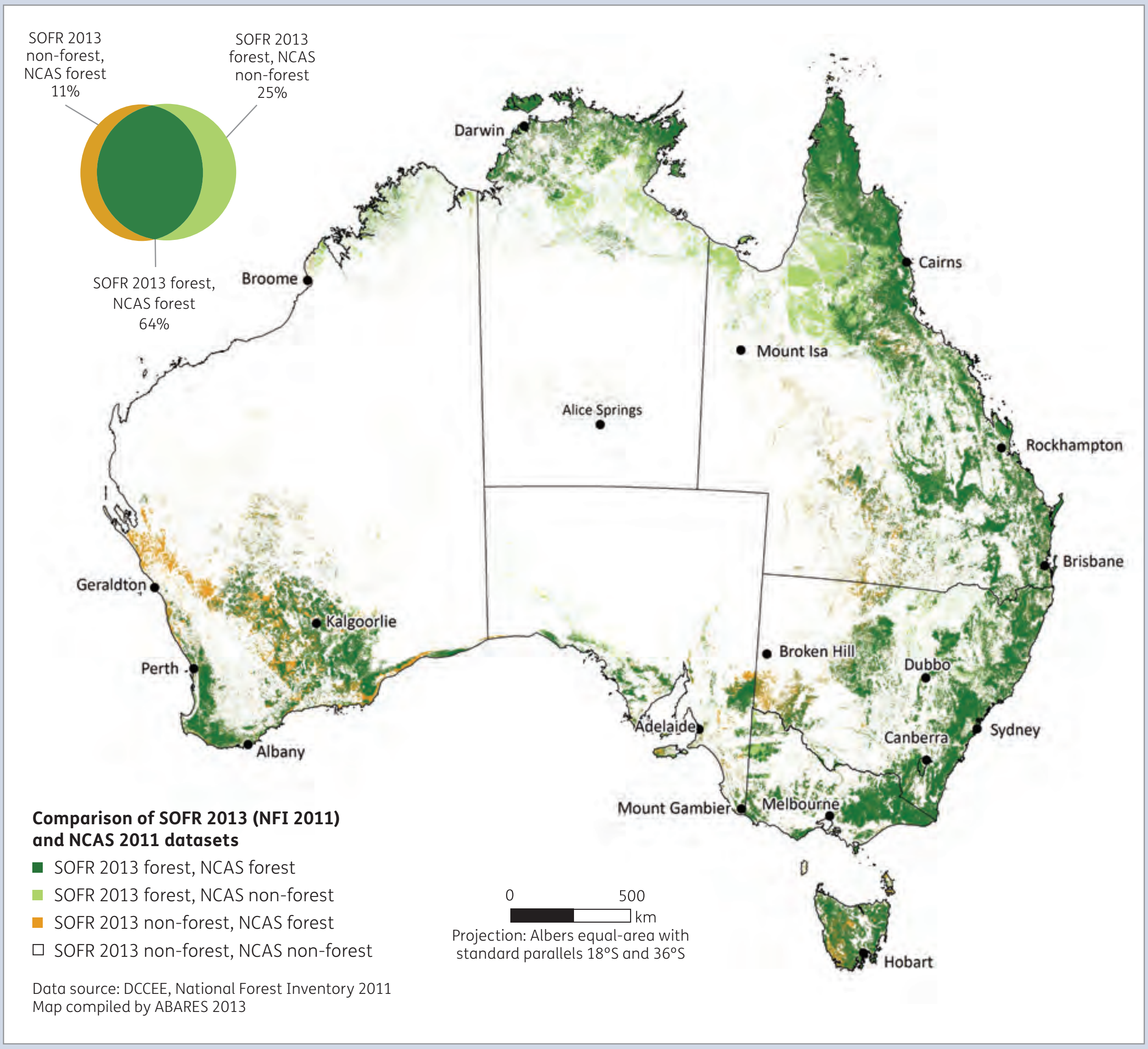
The best estimate of change over time in forest cover is obtained from the annual forest area estimates for the NCAS, managed by the former Australian Government Department of Climate Change and Energy Efficiency[20]. The NCAS area figures are derived using a national methodology that has been consistent since 1990, using remote sensing from Landsat satellites as well as other information on forest disturbances. The data are developed specifically to identify short-term change in forest cover (see SOFR 2008, p. 14). However, the NCAS data report a somewhat smaller area of forest than does the NFI (see Box 1.2 for details of the differences).

[20] From September 2013, the Department of the Environment.

Box 1.2: Comparison of forest area datasets from the National Forest Inventory (NFI) and the National Carbon Accounting System (NCAS)[a]

The area of overlap between the NFI 2011 forest area dataset reported in SOFR 2013, and the NCAS 2011 dataset reporting forest area for the end of 2010, is 64% of the summed area of both forest coverages (Figure 1.5).

Figure 1.5: Comparison of SOFR 2013 (NFI 2011) and NCAS 2011 datasets



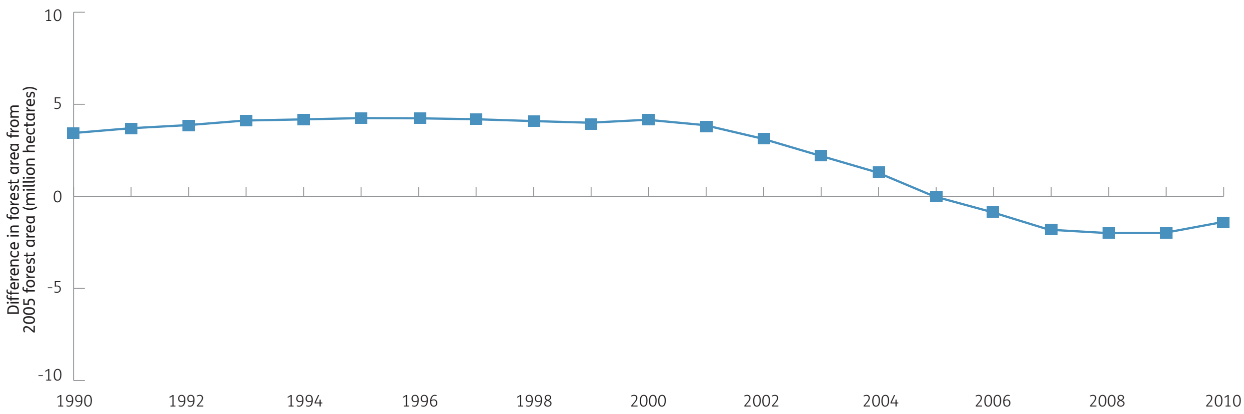
Note: The % figures on the diagram are based on the area derived from a spatial union of the SOFR 2013 (NFI 2011) and NCAS 2011 forest coverages.

The 64% current overlap compares with an overlap of 43% in the earlier datasets reported in SOFR 2008. This increase in overlap partly results from the Multiple Lines of Evidence approach used to determine Australia's forest cover for SOFR 2013, which includes the NCAS forest cover as one of the input datasets.

The overlap of the NCAS dataset with the NFI dataset is greatest in areas of closed and open forest, including the forests of south-western, eastern and south-eastern Australia used for wood production. The NCAS cover is weakest in woodland forests of northern Australia, and mallee forests in western New South Wales and north-east South Australia. However, it does include other woody vegetation that the NFI classifies as non-forest, such as tall shrublands in Tasmania and north-west Western Australia. The NCAS data used for analysis of forest cover change therefore report on a slightly smaller and slightly different area of forest than is reported through the NFI.

[a] The NCAS dataset is now known as the National Greenhouse Gas Inventory.

Figure 1.6: Australia's forest area compared with 2005 forest area



Note: In SOFR 2008 data from the then Australian Government Department of Climate Change and Energy Efficiency (DCCEE) were used to report change in forest area to 2005 (DCCEE data are reported by calendar year). Values above are calculated as differences from 2005 forest area reported by the National Carbon Accounting System (107.5 million hectares), which is set as zero.

Source: Calculated by the Australian Bureau of Agricultural and Resource Economics and Sciences from DCCEE data.

Through the 1990s, the NCAS estimate of Australia's forest area was relatively stable (Figure 1.6). This was followed by a gradual decline in forest area from 2000 until approximately 2008. Australia's forest area decreased by 1.8 million hectares between 2005 and 2008, then increased by 0.4 million hectares between 2008 and 2010. The net loss in forest area from 2005 to 2010 is 1.4 million hectares.

Australian National Greenhouse Accounts Report 2010 (DCCEE 2012a) attributes the fluctuations in the reported forest area to a range of factors, including impacts of fire, floods and cyclones, and regrowth from these disturbances; vegetation thickening; climate variability; extraction of forest products; land-use change (both forest clearing, including clearing of recent regrowth, and forest establishment, including plantation establishment); and degradation from grazing. Many of these factors affect the amount of canopy cover or the crown density of trees, which in turn determines which areas on the remote sensing images are classified as forest, based on the threshold requirement for 20% crown cover. However, only the permanent components of this change would be rated as deforestation under the NFI.

The NFI provides the best available representation of Australia's forest extent, classified by forest type and land tenure, as reported in SOFRs. However, the forest area estimates in all SOFRs (1998, 2003, 2008 and 2013) are based on data provided to the NFI after collection and collation at different scales, over different timeframes, and using different methodologies; as a result, these estimates cannot be used directly to measure change in forest area over time. Australia's forest area as reported in this SOFR incorporates substantial improvements in data quality derived from the new MLE approach (see below). However, changes in the forest area in the NFI dataset will only be able to be used to determine changes in actual forest cover when accurate methods are used consistently across a complete SOFR reporting period, or when a nationally consistent and comprehensive forest monitoring framework is implemented (for example, Wood et al. 2006).

Changes in forest mapping

Continual improvement in understanding the extent of Australia's forests, and the reporting of forest area, has occurred since national figures were first reported in 1974. Australia's reported forest area has fluctuated from 105 million hectares to 164 million hectares since that date, including across the three previous national State of the Forests reports in 1998, 2003 and 2008. These historic fluctuations in reported areas did not reflect actual changes in on-ground forest cover, but instead were largely due to changes in the area basis reported (from only commercial forests to all forests), variability in state and territory data, mapping errors, and changes prior to 1998 in the definition of forest.

At 125 million hectares, Australia's forest area reported in SOFR 2013 differs from the forest area reported in SOFR 2008 (149 million hectares). Again, this change in reported area does not equate to a similar change in actual on ground forest cover; rather, it reflects a substantial change in the approach to identifying forest area, as well as the incorporation of new and updated data.

The Multiple Lines of Evidence process

The process used to collect data on forest area for the previous three national reports (SOFR 1998, SOFR 2003 and SOFR 2008) involved the collation by Australia's NFI team of mapped data on native forest produced by each state and territory for its own specific needs. These state and territory data generally used the framework of the NVIS.[21] Data gaps were then filled for the NFI using best available data from Australian Government agencies, and research and industry institutions. Both SOFR 2003 and SOFR 2008 noted how the deficiencies in this process—such as the compilation of inconsistent data with different date stamps, data collection methods and mapping scales, both within and among jurisdictions—were the main reasons for the differences in forest area figures reported across the SOFR reporting periods.

To improve the accuracy of the forest area estimate in this SOFR, the NFI Steering Committee, with representatives from the state, territory and Australian governments, recommended the adoption of a new approach involving the examination of a range of other, independent forest cover datasets, including remotely sensed data, in conjunction with the previously used state and territory data. These additional data sources included the State-wide Landcover and Trees Study (SLATS), the NCAS and Dynamic Land Cover Mapping (DLCM). This Multiple Lines of Evidence (MLE) approach (Mutendeudzi et al. 2013a,b) identified areas of data agreement and disagreement; the areas of data disagreement were flagged as potential errors and subjected to a more detailed examination and validation process by the NFI team, in consultation with relevant state and territory agencies.

Remote-sensing technologies being adopted by agencies in Queensland, New South Wales and Victoria to monitor changes in forest cover are expected to further improve the quality of available information. The MLE approach implemented for the NFI will allow ongoing refinement in production of Australia's national forest cover dataset.

Spatial data are not available for some areas of Industrial plantations reported through the NPI, so these areas did not form part of the MLE process.

Outcomes from the Multiple Lines of Evidence process

Table 1.11 and Figure 1.7 show the differences in reported forest areas between SOFR 2008 and SOFR 2013. The MLE process confirmed as forest a total of 99 million of the 149 million hectares reported as forest in SOFR 2008 (Table 1.11; mapped as green areas in Figure 1.7). The MLE process also mapped as forest a further 26 million hectares that had been reported as non-forest in SOFR 2008 (Table 1.11; Figure 1.7, yellow areas), and mapped a total of 51 million hectares of non-forest that had been reported as forest in SOFR 2008 (Table 1.11; Figure 1.7, grey and brown areas). Of the 51 million hectares mapped as non-forest in the MLE process, approximately 39 million hectares were determined to be other woody vegetation (Table 1.11; Figure 1.7, brown areas)—that is, woody vegetation with a crown cover below the 20% threshold required to meet Australia's definition of forest.

The differences in forest area mapping between SOFR 2008 and SOFR 2013 are not evenly distributed across the different forest types. Most differences occur in woodlands, where the distinction between woodland forest (crown cover 20% or greater) and other woody non-forest vegetation (crown cover less than 20%) is traditionally difficult to determine because crown cover fluctuates in response to a range of factors, such

Table 1.11: Differences in reported forest areas between SOFR 2013 and SOFR 2008, by jurisdiction

	Area (million hectares)						
	Forest in SOFR 2008	Forest in SOFR 2008 and SOFR 2013	Non-forest in SOFR 2008, forest in SOFR 2013	Forest in SOFR 2008, non-forest in SOFR 2013		Net change from SOFR 2008 to SOFR 2013	Forest in SOFR 2013
Jurisdiction				Other woody vegetation in SOFR 2013	Not other woody vegetation in SOFR 2013		
ACT	0.1	0.1	0.0	0.0	0.0	0.0	0.1
NSW	26.6	18.2	4.4	1.8	6.5	–3.9	22.7
NT	31.0	13.1	2.1	17.2	0.6	–15.8	15.2
Qld	52.8	42.1	8.9	9.6	1.1	–1.8	51.0
SA	9.0	3.9	0.7	3.1	2.1	–4.5	4.6
Tas.	3.4	3.0	0.7	0.3	0	0.3	3.7
Vic.	8.2	7.8	0.4	0.4	0.0	0.0	8.2
WA	18.1	10.3	9.0	6.6	1.2	1.2	19.2
Australia	**149.2**	**98.6**	**26.2**	**39.3[a]**	**11.5**	**–24.5**	**124.8**

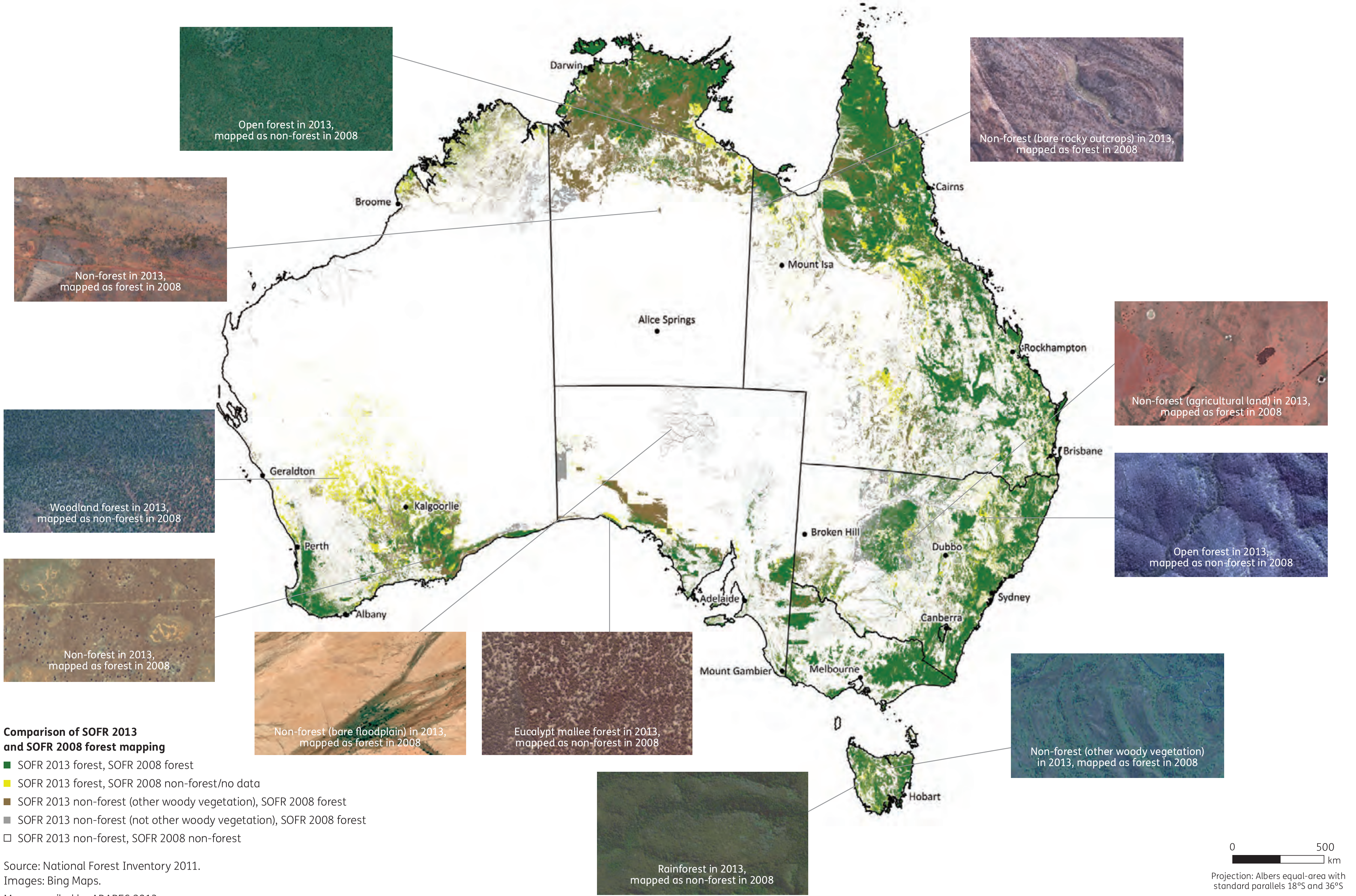
[a] Analysis to distinguish non-forest that carries other woody vegetation (<20% cover) from non-forest that does not carry other woody vegetation is less complete outside Qld and NT.

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory, National Plantation Inventory.

[21] www.environment.gov.au/erin/nvis/index.html.

Figure 1.7: Examples of differences between national forest mapping in SOFR 2013 and SOFR 2008



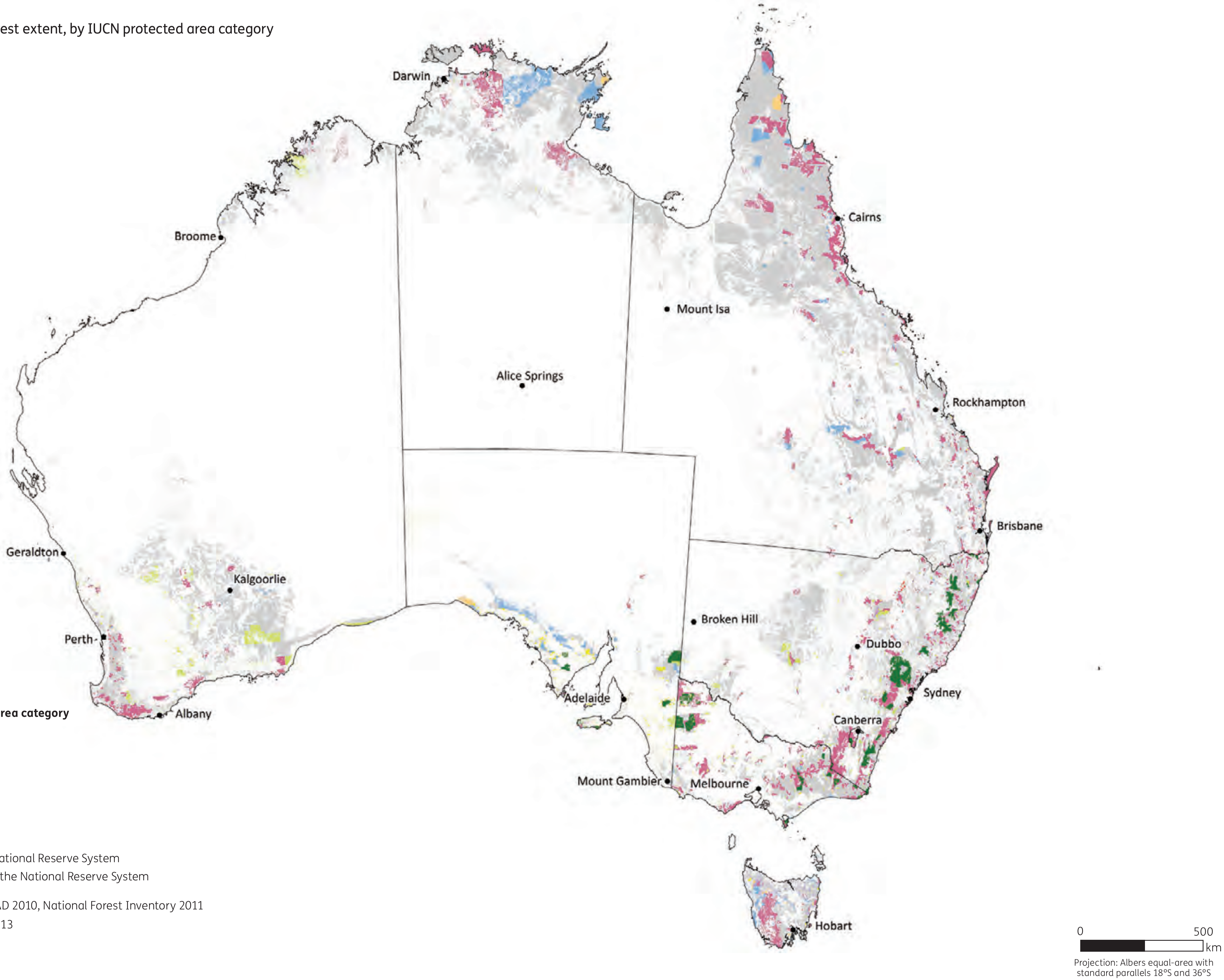
Comparison of SOFR 2013 and SOFR 2008 forest mapping

- SOFR 2013 forest, SOFR 2008 forest
- SOFR 2013 forest, SOFR 2008 non-forest/no data
- SOFR 2013 non-forest (other woody vegetation), SOFR 2008 forest
- SOFR 2013 non-forest (not other woody vegetation), SOFR 2008 forest
- SOFR 2013 non-forest, SOFR 2008 non-forest

Source: National Forest Inventory 2011.
Images: Bing Maps.
Map compiled by ABARES 2013

Figure 1.16: Australia's forest extent, by IUCN protected area category

(See p. 72)



Forest by IUCN protected area category

- 1a
- 1b
- II
- III
- IV
- V
- VI
- Non-IUCN forest in the National Reserve System
- Non-IUCN forest outside the National Reserve System

Data source: DSEWPaC CAPAD 2010, National Forest Inventory 2011

Map compiled by ABARES 2013

Figure 1.8: Differences between forest mapping in SOFR 2013 and SOFR 2008, northern part of the Northern Territory

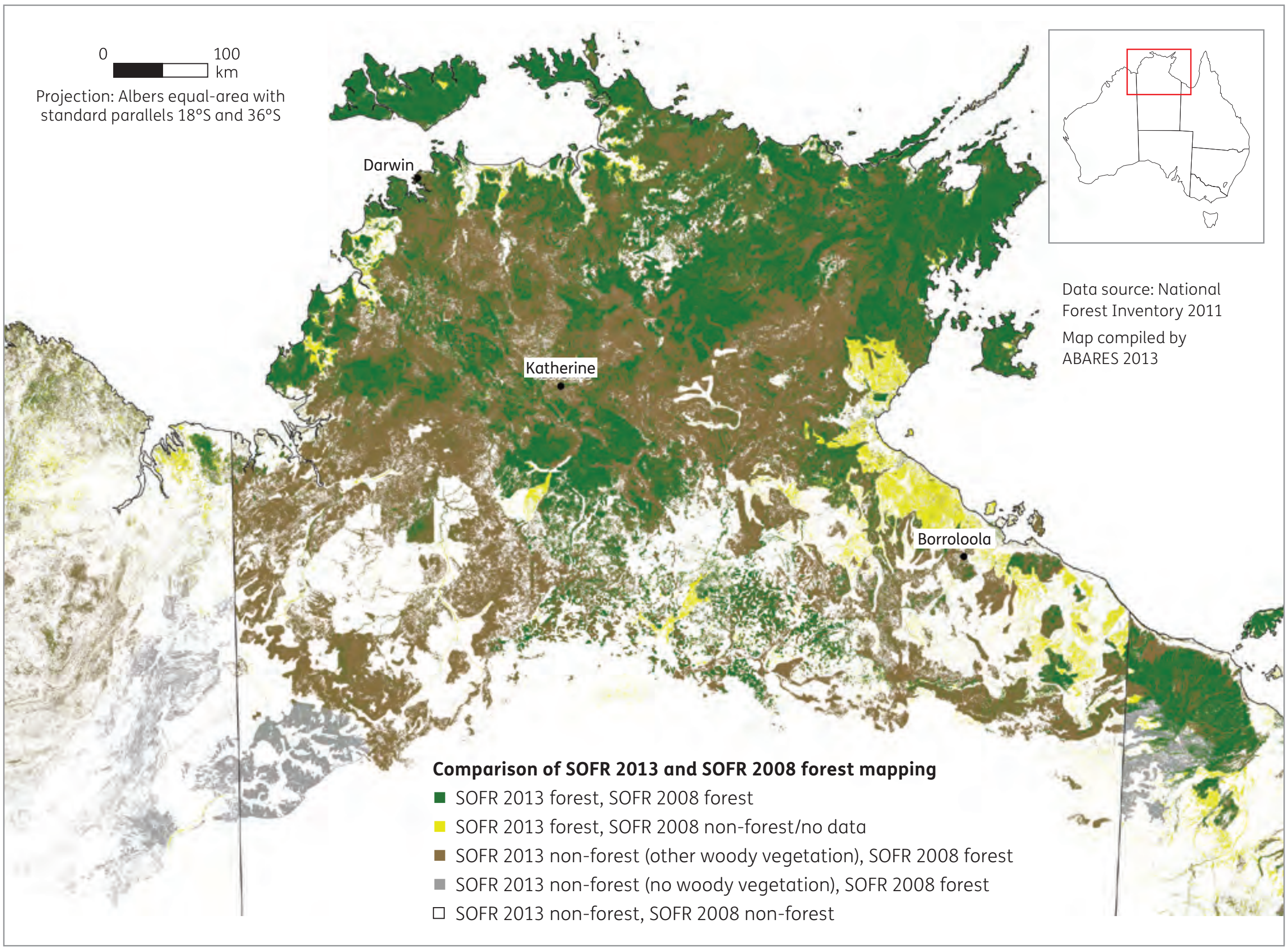


Table 1.12: Difference in areas of reported forest in Regional Forest Agreement regions between 2008 and 2013

		SOFR 2008		SOFR 2013		Difference	
RFA region	**Region area ('000 hectares)**	**Forest area ('000 hectares)**	**Proportion of RFA region area (%)**	**Forest area ('000 hectares)**	**Proportion of RFA region area (%)**	**Forest area ('000 hectares)**	**Proportion of RFA region area (%)**
New South Wales							
Eden	814	592	73	603	74	11	1.4
Southern New South Wales	4,512	2,719	60	2,731	61	12	0.3
Upper and Lower North East	9,696	5,687	59	6,264	65	577	6
Tasmania							
Tasmanian	6,796	3,312	49	3,682	54	370	5.4
Victoria							
Central Highlands	1,125	707	63	720	64	13	1.2
East Gippsland	1,225	1,106	90	1,108	90	2	0.2
Gippsland	2,662	1,546	58	1,593	60	47	1.8
North East	2,318	1,305	56	1,354	58	49	2.1
West Victoria	5,779	1,319	23	1,381	24	62	1.1
Western Australia							
South-West Forest Region of Western Australia	4,257	2,900	68	2,900	68	0	0
Total RFA regions	**39,185**	**21,193**	**54**	**22,336**	**57**	**1143**	**2.9**

RFA = Regional Forest Agreement

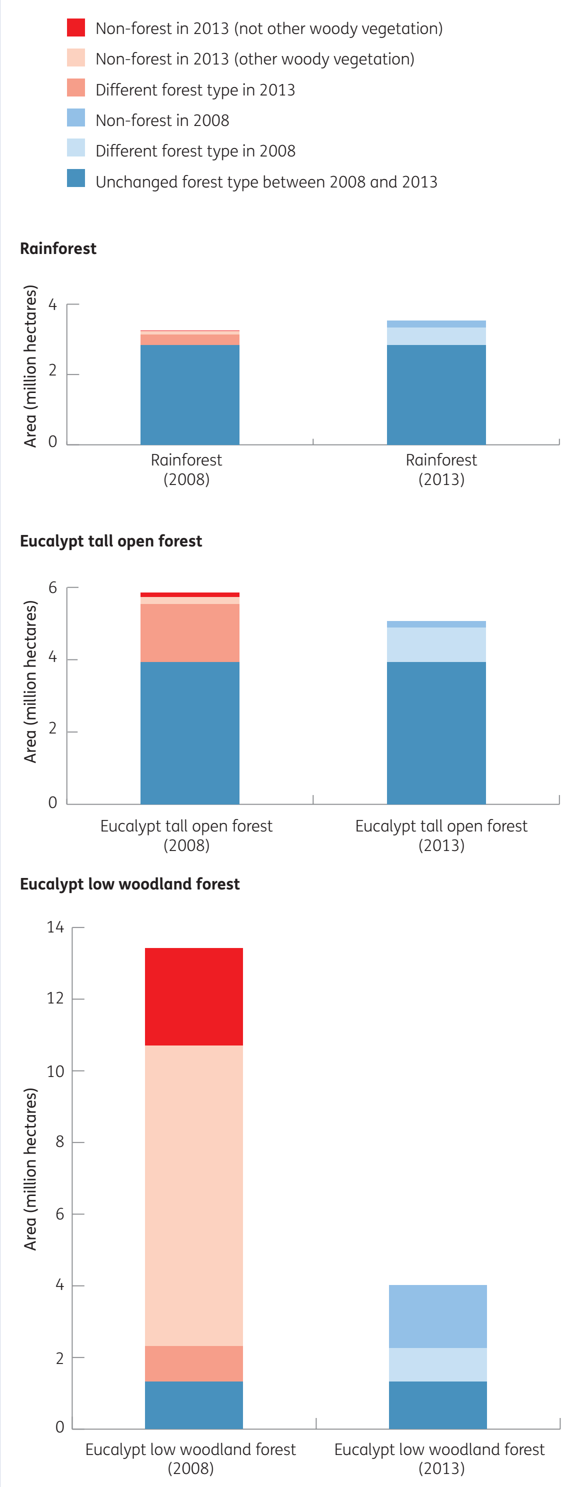
Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory, National Plantation Inventory.

Box 1.3: Differences in reported areas between SOFR 2008 and SOFR 2013, by forest type and tenure

The differences in reported forest areas between SOFR 2008 and SOFR 2013 for a closed forest type (Rainforest), an open forest type (Eucalypt tall open forest) and a woodland forest type (Eucalypt low woodland forest) are shown in Figure 1.9. The differences in reported forest areas between SOFR 2008 and SOFR 2013 for four tenures—leasehold, private, nature conservation reserve and multiple-use forest—are shown in Figure 1.10. Differences result both from the Multiple Lines of Evidence process, and from the change in the method for compilation of tenure data for SOFR 2013.

Figure 1.9: Box-plot of changes in forest type between SOFR 2008 and SOFR 2013



For each forest type, areas reported as that forest type in both SOFR 2008 and SOFR 2013 are coloured dark blue. Areas reported as that forest type in SOFR 2008 but as other forest types or as non-forest in SOFR 2013 are coloured red or pink. Areas reported as non-forest or forest of other types in SOFR 2008 but as the indicated forest type in SOFR 2013 are coloured other shades of blue.

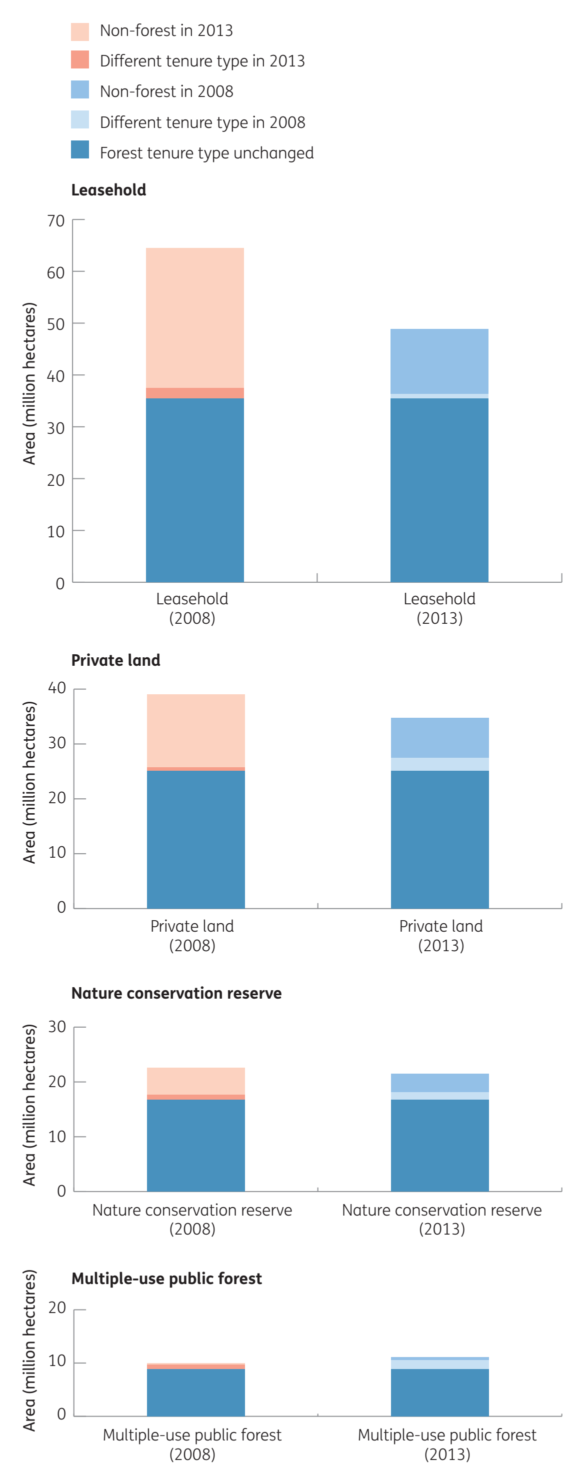
Of the 3.3 million hectares reported as Rainforest in SOFR 2008, 86% is reported as Rainforest in SOFR 2013, 11% is reclassified to other forest types, and very little is reclassified to either non-forest category.

Of the 5.9 million hectares reported as Eucalypt tall open forest in SOFR 2008, 67% is reported as Eucalypt tall open forest in SOFR 2013, 28% is reclassified to other forest types, and very little is reclassified to either non-forest category.

Of the 13.4 million hectares reported as Eucalypt low woodland forest in SOFR 2008, only 10% is reported as this forest type in SOFR 2013. More than half (69%) is reclassified as non-forest (other woody vegetation) with canopy cover less than 20%.

Box 1.3: Differences in reported areas between SOFR 2008 and SOFR 2013, by forest type and tenure continued

Figure 1.10: Box-plot of changes in forest tenure between SOFR 2008 and SOFR 2013



For each tenure, areas reported as forest on that tenure in both SOFR 2008 and 2013 are coloured dark blue. Areas reported as forest on that tenure in SOFR 2008 but as forest on other tenures or as non-forest in SOFR 2013 are coloured beige or pink. Areas reported as non-forest or forest on other tenures in SOFR 2008 but as forest on the indicated tenure in SOFR 2013 are coloured other shades of blue.

Of the 65 million hectares reported as leasehold forest in SOFR 2008, 54% is reported as forest of this tenure in SOFR 2013. Most of the remainder is reclassified as non-forest. A substantial area of leasehold non-forest is also reclassified as leasehold forest in SOFR 2013.

Of the 38 million hectares reported as forest on private land in SOFR 2008, 63% is reported as forest of this tenure in SOFR 2013. Most of the remainder is reclassified as private non-forest land.

Of the 22 million hectares of forest reported as nature conservation reserve in SOFR 2008, 74% is reported as forest of this tenure in SOFR 2013. Most of the remainder is reclassified as non-forest (but still nature conservation reserve tenure).

Of the 9.4 million hectares reported as multiple-use public forest in SOFR 2008, 87% is reported as forest of this tenure in SOFR 2013.

For forest type, the box plots show that the NFI information is reliable and consistent over time for Rainforest, relatively consistent for Eucalypt tall open forest, and not consistent for Eucalypt low woodland forest. Most of the reduction in reported forest area between SOFR 2008 and SOFR 2013 has derived from reclassification of Eucalypt low woodland forest and similar forest types into non-forest categories, including other woody vegetation.

For tenure, the box plots show that the NFI information on forest areas has been most reliable and consistent over time for multiple-use public forest, followed, in decreasing order, by forest in nature conservation reserves, private forest, and leasehold forest. This is consistent with much of the Eucalypt low woodland forest and similar forest types occurring on leasehold and private land.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory.

as seasonal variation in rainfall, climate variations, grazing and dieback. This is exemplified along a gradient of decreasing rainfall away from the coast in the Northern Territory: areas reported as forest in SOFR 2008 and SOFR 2013 (Figures 1.7 and 1.8, green areas) transition into areas reported as forest in SOFR 2008 but reclassified as other woody non-forest vegetation in SOFR 2013 (Figures 1.7 and 1.8, brown areas).

Differences in mapping for forest types with higher crown cover (open forests and closed forests) are smaller, largely because fluctuations over time in crown cover do not bring crown cover below the 20% threshold. In addition, the scale of forest cover mapping is generally coarser in woodland forests, so any changes in mapped areas of woodland forests can be large. Forest cover is mapped at a finer scale in open and closed forests because of historically more reliable mapping by public agencies responsible for wood production, so any changes in the mapped area of open and closed forests are generally smaller.

By jurisdiction, the greatest differences in reported forest area between SOFR 2013 and SOFR 2008 were in South Australia and the Northern Territory (Table 1.11). Large areas in the inland, drier areas of these jurisdictions that were previously reported as forest—largely as a result of the coarse resolution of NVIS mapping used—were revealed through the MLE process to be predominantly other woody non-forest vegetation (Figures 1.7 and 1.8). Smaller areas of previously unmapped forests were also detected in these jurisdictions (Table 1.11). Similar scenarios, but on a smaller scale, occurred in New South Wales, Queensland and Western Australia, and there were even smaller differences in net forest area for Victoria, Tasmania and the Australian Capital Territory.

The area of forest in RFA regions calculated and reported in SOFR 2013 is very similar to that calculated from the forest area reported in SOFR 2008 (Table 1.12). Differences are typically between 0 and 2% of the total forest area in each RFA region. These differences are small because the RFAs were established for forest management in production forestry regions where, historically, there are good data on forests. The larger differences in reported forest areas in the Tasmania and North East New South Wales RFA regions result from mapping changes associated with the new forest coverage developed for SOFR 2013, which identified additional areas of native forest in these regions; in Tasmania, there was also a substantial increase in plantation area. This analysis confirms that the differences in reported forest area between SOFR 2008 and SOFR 2013 are due to improved mapping of the inland woodland forests of Australia.

Differences in reported forest areas between SOFR 2013 and SOFR 2008 by forest type and tenure are shown in two series of box-plots in Box 1.3 (Figure 1.9 and 1.10).

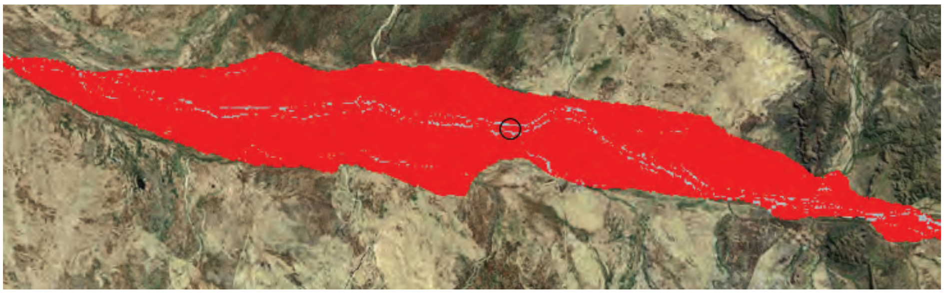
Reclassification due to use of finer-scale source data

Substantial areas reported as forest in SOFR 2008 and earlier, particularly in parts of the Northern Territory, Queensland, South Australia, New South Wales and Western Australia, had been allocated as forest based on coarse-scale data from the NVIS; some of these areas were mapped no more accurately than at a 1:2,000,000 scale. Entire large polygons had been mapped as forest, when only a small portion of their area was actually forest, resulting in a substantial exaggeration of reported forest areas. An example from the De Grey River, east of Port Hedland, Western Australia, is provided in Figure 1.11.

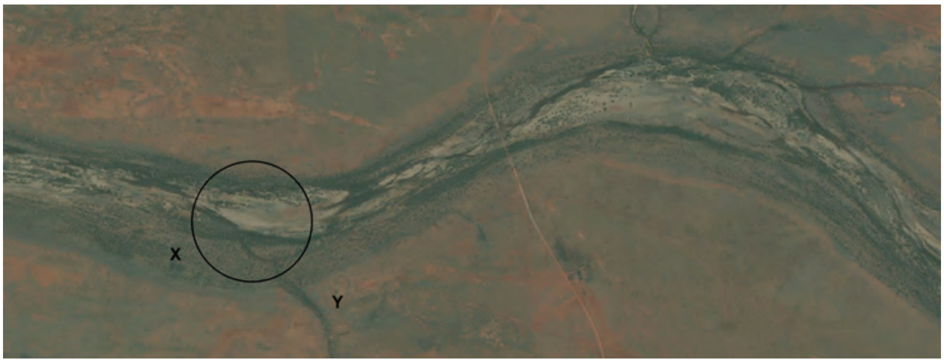
The use in the MLE approach of remote-sensing products with improved resolution, such as SLATS, NCAS and DLCM, has enabled more accurate delineation of forested areas at a finer scale. This improved accuracy of mapping accounts for most of the reductions in reported forest area in the Northern Territory, Queensland, South Australia, New South Wales and Western Australia in SOFR 2013.

Agricultural land bordering native forest in Queensland.

Figure 1.11: Example of the effect of better resolution data on mapped forest area

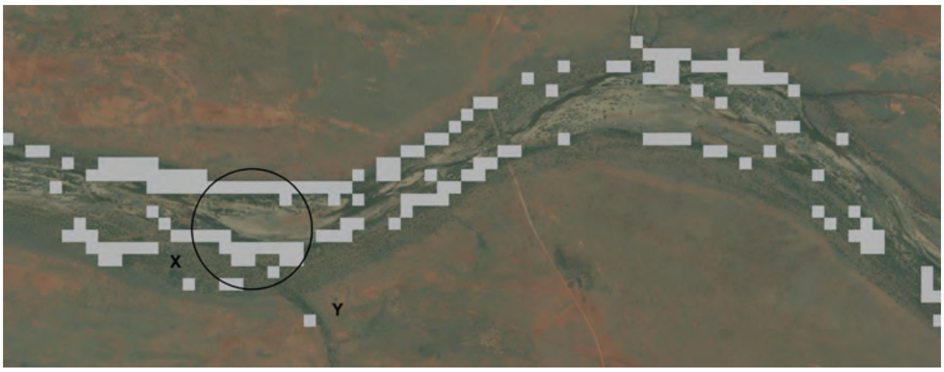


A. Single NVIS vegetation polygon (red) along De Grey River, east of Port Hedland, Western Australia, classified as 'Eucalypt low woodland of *Eucalyptus camaldulensis* and *Melaleuca leucadendron*' (20–30% crown cover), and reported as 27,279 hectares of forest in SOFR 2008. A total of 1,097 hectares of forest were reported in SOFR 2013 as a result of the Multiple Lines of Evidence approach (grey overlay, each pixel 1 hectare). Image dimensions are 60 km by 18 km.



B. Closer view of centre of NVIS polygon, showing that vegetation comprises a narrow band of riparian forest, plus non-forest communities, including both other woody vegetation (X) and land without other woody vegetation (Y). The circle from A is also shown to scale.

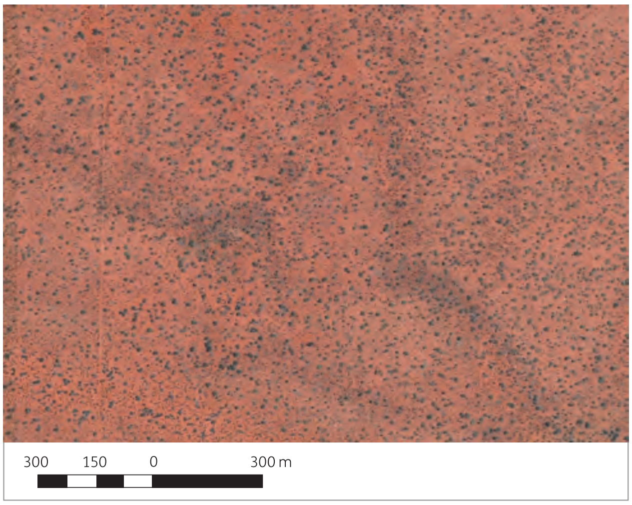
C. Same field of view as Figure B, showing area reported as forest in SOFR 2008 (red). The circle from A is also shown to scale.



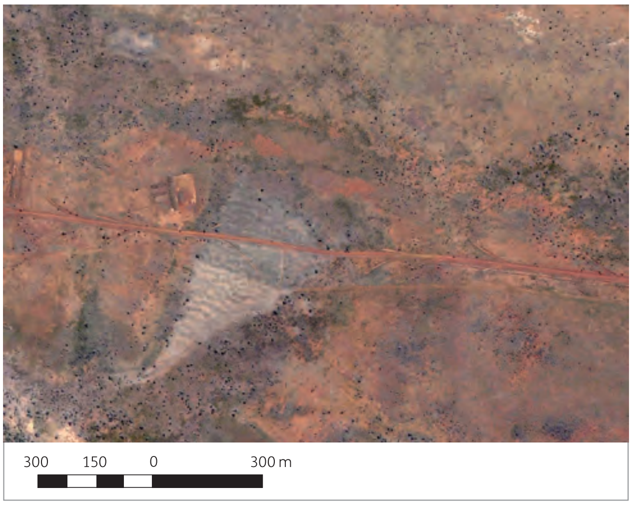
D. Same field of view as Figure B, showing area reported as forest in SOFR 2013 (grey). Grey pixels are 1 hectare each and more accurately track the distribution of riparian forest. The circle from A is also shown to scale.

Images source: Bing Maps.

Figure 1.12: Examples of areas reported as forest in SOFR 2008 but as non-forest in SOFR 2013, as a result of corrected vegetation classification



A. Land in central Australia carrying other woody vegetation.



B. Grassland with scattered shrubs, Renner Springs, Northern Territory.

Images source: Bing Maps.

Reinterpretation of vegetation mapping data for forest classes

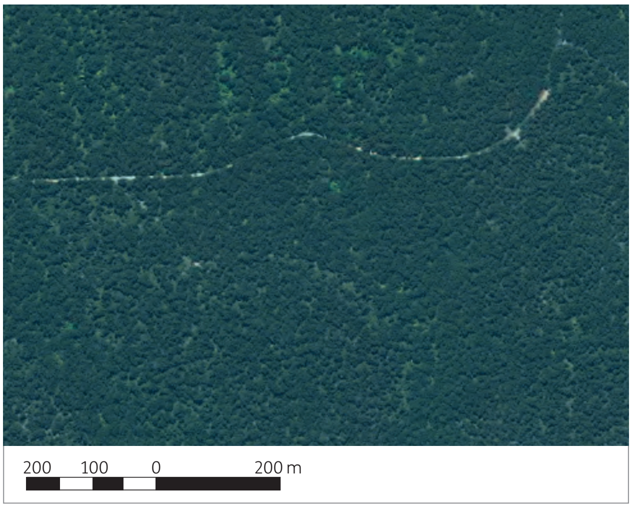
Development of the SOFR 2008 dataset used state and territory data provided using the NVIS vegetation framework at Level III (Broad Floristic Formation). This provides information on the dominant growth form, genus, cover and height of the uppermost canopy or dominant stratum. The analysis for SOFR 2013 used updated NVIS vegetation information at NVIS Levels V and VI (Association and Sub-Association, respectively), which provided more detailed information, including dominant growth form, species, cover and height for three strata. This increased level of detail resulted in significant areas previously reported as forest in SOFR 2008 being reclassified as non-forest in SOFR 2013 (see Figure 1.12A–B for examples). This approach also detected forests in areas reported as non-forest in SOFR 2008, which were reclassified as forest in SOFR 2013 (see Figure 1.13A–D for examples).

Correction of out-of-date data

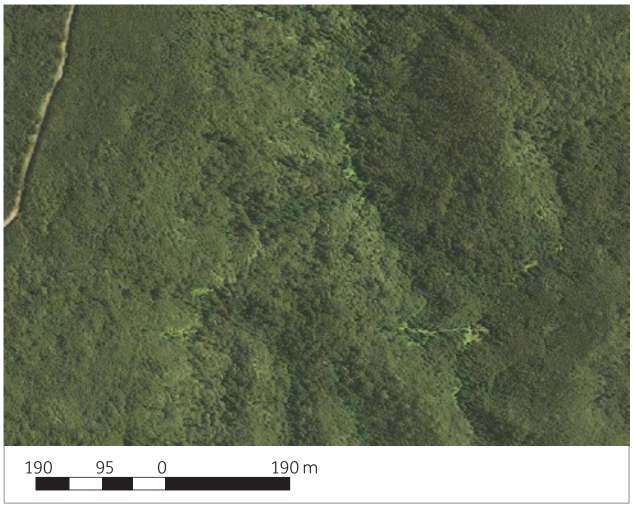
The NVIS mapping of floristic, structural and spatial attributes, underpinning the data supplied to the NFI by state and territory agencies, ranges in date stamp from the 1960s to 2009, although the majority of the data have a 1990s or later date stamp. Nevertheless, the age of much of these data precedes changes in forest cover resulting from land-use change from forest to mining, agriculture or urban expansion; such areas were incorrectly reported as forest in previous SOFRs. The MLE process used the most current data from any source, and was pivotal in identifying and correcting the reporting of such areas (see Figure 1.14A–C for examples).

Errors in the original NVIS mapping underlying state and territory data (omission errors), and forest regrowth after the capture date of the NVIS data (which, in some instances, is the 1960s), both led to the MLE process mapping as forest areas that were previously reported as non-forest in SOFR 2008. Examples of areas reported as forest in SOFR 2013 that were reported as non-forest in SOFR 2008 are shown in Figure 1.13A–D

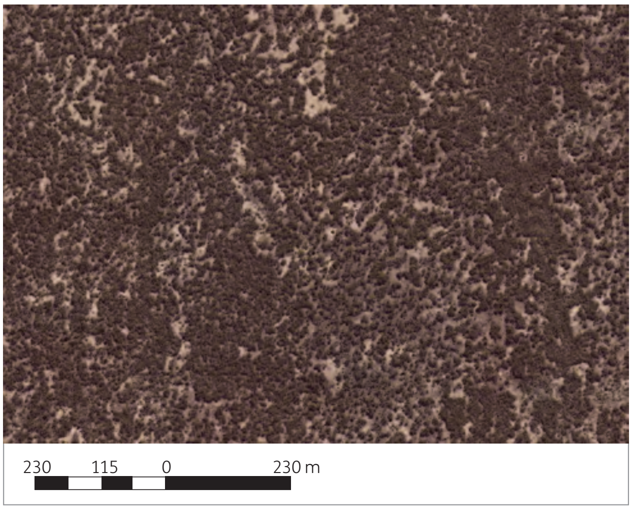
Figure 1.13: Examples of areas of reported as non-forest in SOFR 2008 but as forest in SOFR 2013



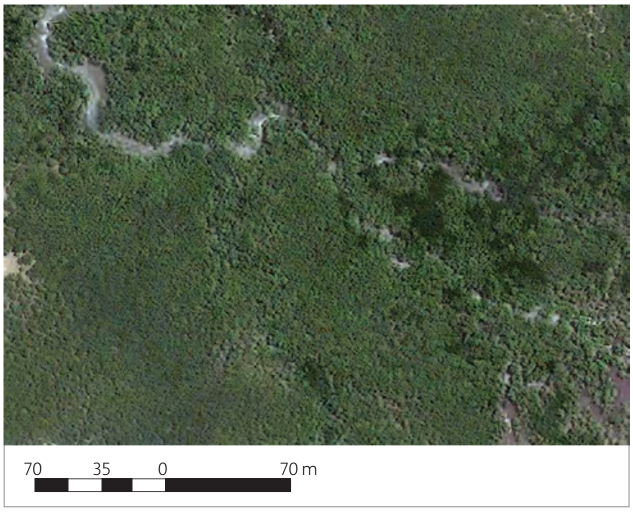
A. Eucalypt medium open forest, Captains Flat, southern New South Wales



B. *Nothofagus* temperate Rainforest, Queenstown, western Tasmania



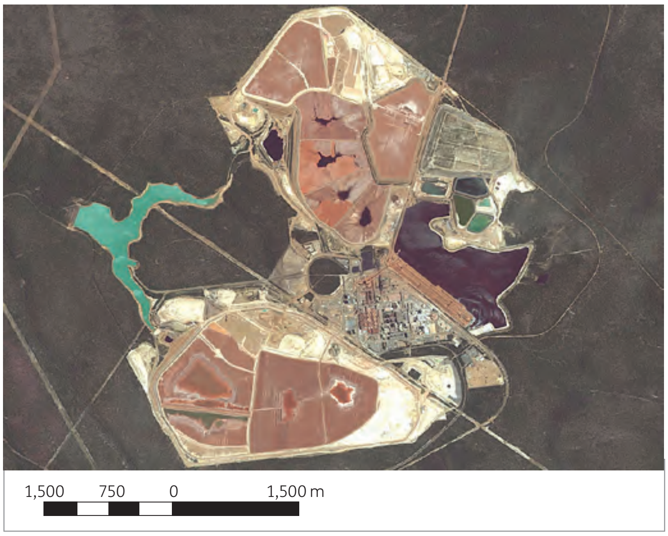
C. Eucalypt mallee woodland forest, Coorabie, south-west South Australia



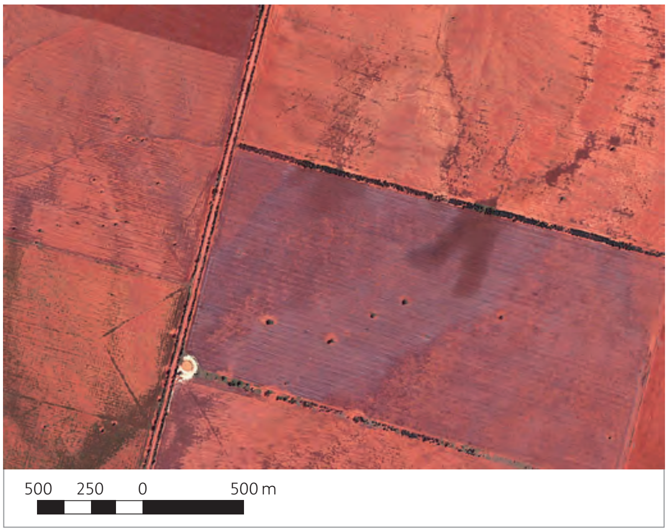
D. Mangrove forest, north-west Northern Territory

Images source: Bing Maps.

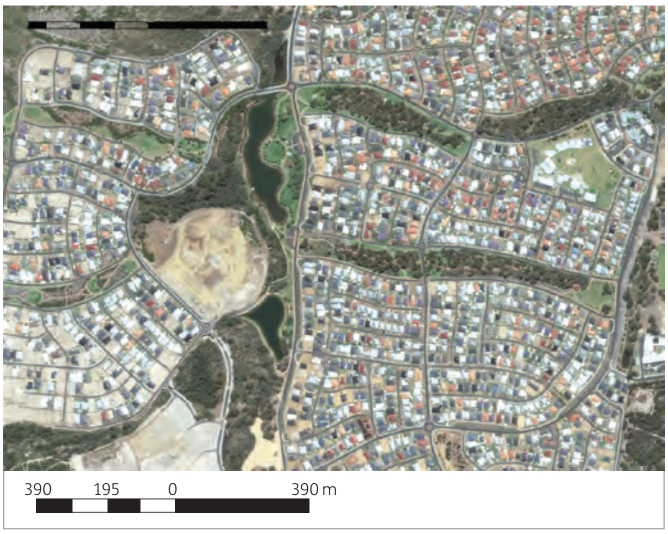
Figure 1.14: Examples of areas reported as forest in SOFR 2008 but as non-forest in SOFR 2013, as a result of detected land-use change. The timing of the land-use change from forest is not known and may have preceded the reporting period for SOFR 2008.



A. Mining development, south-west Western Australia



B. Agricultural land north of Condobolin, New South Wales



C. Urban development, south-west Western Australia

Images source: Bing Maps.

Indicator 1.1b

Area of forest, by growth stage

Rationale

This indicator measures the change in area of forest by growth stage to reflect how ecological processes and species associated with those processes change as forests grow. The age and size of trees is important in maintaining forest biodiversity.

Key points

- Australia's native forests comprise a mixture of regeneration, regrowth, mature, senescent and uneven-aged forest. Nationally, current information on growth stage is available for only 15.4 million hectares of forest, concentrated in south-eastern Australia.
- Within the area of forest for which current growth stage information is available, all forest growth stages are present on all tenures. On average, multiple-use public forest has a greater proportion of younger growth stages (regeneration and regrowth) and uneven-aged forest than does forest in nature conservation reserves, which has a greater proportion of senescent forest.
- Of the 23 million hectares of forest in Australia assessed for their old-growth status, 5.0 million hectares (22%) is classified as old growth. More than 73% of forest classified as old growth was within formal or informal nature conservation reserves in 2011.

Growth stage

The growth stage of a native forest[22] is one determinant of its biodiversity and ecological values. Growth stage assessment also gives some indication of the balance of different age classes across a forest estate. Both the sustainable production of wood and the maintenance of values such as species diversity, maximum carbon stocks or uniform water flows are often improved when an area contains a mix of forest stands in different age classes, forming a mosaic of growth stages in the landscape. In addition, some species depend on more than one growth stage—for example, Leadbeater's possum (*Gymnobelideus leadbeateri*) requires one forest growth stage for nesting and a different growth stage nearby for feeding.

Australian eucalypt forests are characterised by regular disturbance, predominantly by fire. The states and territories have developed various methods for describing the different growth stages or age classes of native forest that result from disturbance. Commonly, four main growth stages are identified in native forests: regeneration (generally taken as less than 20 years since disturbance), regrowth (generally taken as 20–80 years since disturbance), mature (generally taken as 80 or more years since disturbance) and senescent (various ages after 80 years since disturbance, when irregular crowns form), noting that these numerical values can differ substantially between forest types (Figure 1.15). These four categories apply reasonably well to wetter eucalypt forests that are even-aged as a result of a severe, uniform disturbance event. However, substantial areas of forests are mixtures of more than one growth stage, resulting from less severe or less uniform disturbance events; this is especially the case for drier eucalypt forests, or forests dominated by non-eucalypt species such as rainforest or drier open acacia woodlands.

Growth stage information is collected for only a small proportion of the native forest estate across Australia. Information is collected only for native forests allocated to wood production (i.e. multiple-use forests) and is not widely reported even for these areas. As a result, sufficient, consistent and coordinated data are not collected at the jurisdictional level to enable satisfactory data-based reporting against this indicator. Many of the issues associated with data collection and reporting on growth stage that are discussed in previous SOFRs remain the case for SOFR 2013.

Growth stages are best known for multiple-use public native forests used for wood production because the mapping of growth stages in such forests is important for ongoing forest resource assessments. The largest gaps in the data are on private, leasehold and other Crown land tenures. Table 1.13

22 Plantation growth stages are reported by Gavran et al. (2012).

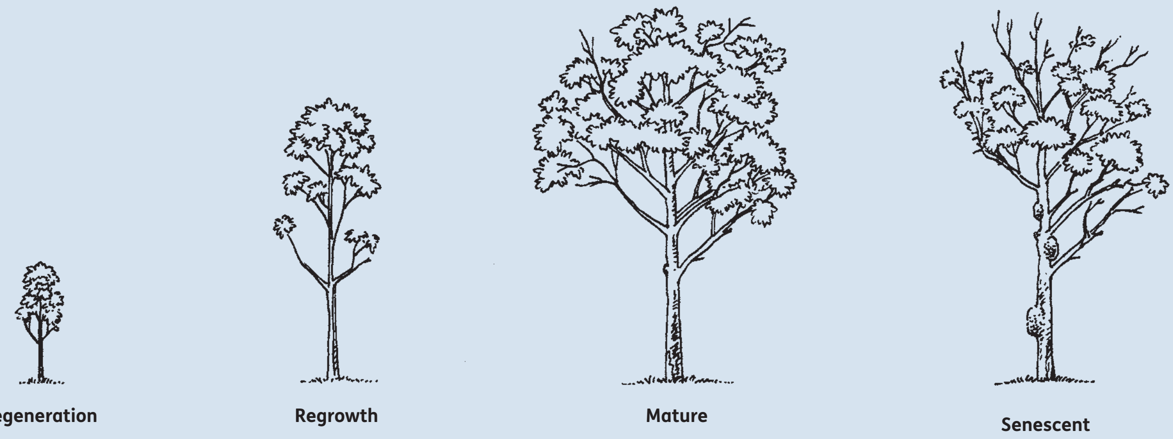
presents the level of data available for reporting against this indicator for 2006–11.

In 2011, growth stage information for native forests was available for 15.4 million hectares—12.3% of Australia's native forest estate—comprising:

- 74% of forests in Tasmania
- 66% of forests in Victoria (mostly on public land, but some on private land)
- 21% of forests in New South Wales (comprising all public and private forests in the Regional Forest Agreement regions)
- 11% of forests in Western Australia (comprising most public forest land in the South-West Forest Management area)
- 1% of forests in Queensland.

For this area, a breakdown of growth stages by tenure is shown in Table 1.14, and by forest type in Table 1.15. All native forest growth stages are present on all tenures. Nationally, 45% of the area of forest mapped for growth stage is categorised as mature forest, with large areas in nature conservation reserves, multiple-use public forest, and private land. Native forest mapped as senescent is predominantly found in nature conservation reserves. Multiple-use public native forest has a greater proportion of forest at younger growth stages (regeneration and regrowth) and uneven-aged forest than forests in nature conservation reserves.

Figure 1.15: Classification of growth stages in native forests



Regeneration	Includes juvenile and sapling stages, when trees are very small and crowns exhibit apical dominance. (Apical dominance is where the main central stem of the tree is growing more strongly than the side branches.)
Regrowth	Trees have well-developed stems with crowns of small branches but below mature stand height. Apical dominance is apparent in vigorous trees.
Mature	Trees are at maximum height and crowns at full lateral development. Branch thickening can occur.
Senescent	Crowns are contracting, and crown diameter and crown leaf area are decreasing.

Note: Uneven-aged forests can contain a mixture of two of more of these growth stages.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences.

Table 1.13: Status of native forest growth stage data over the SOFR 2013 reporting period

Jurisdiction	Status of growth stage data
ACT	No data available.
NSW	No revised growth stage data available.
NT	No data available.
Qld	No revised growth stage data available.
SA	No data available.
Tas.	Growth stage data available and remapped to 2010. The additional area mapped, using photo-interpretation mapping, was reportedly small, with minimal impact on the overall classification of growth stage (see Case study 1.1).
Vic.	Updated growth stage data available for some public forest. No data supplied for this report.
WA	Updated data for old-growth forest included in the Draft Forest Management Plan 2013–2023 (CCWA 2012a).
Australia	**No significant overall improvement in national mapping of growth stage.**

Table 1.14: Areas of native forest of known growth stage[a], by tenure

	Area ('000 hectares)					
Tenure	Regeneration	Regrowth	Mature[b]	Senescent[c]	Uneven aged[d]	Total
Leasehold	53	17	87	236	3	396
Multiple-use public forest	752	717	2,563	258	1,282	5,572
Nature conservation reserve	520	422	2,820	1,714	678	6,154
Other Crown land	13	20	135	69	49	285
Private	215	443	1,354	789	86	2,888
Unresolved tenure	26	21	28	27	0	102
Total	**1,580**	**1,639**	**6,986**	**3,092**	**2,099**	**15,396**
Proportion of total area of native forest of known growth stage (%)	**10**	**11**	**45**	**20**	**14**	**100**

[a] Growth stage definitions vary among states and territories and have been translated to closest national category.
[b] Mature forest includes both mature and senescent forest in Tasmania.
[c] Senescent forest excludes senescent forest in Tasmania.
[d] Uneven-aged forests exist in all states but were not reported in SOFR 2003, and were only reported for Victoria and Western Australia in SOFR 2008.

Note: Totals may not tally due to rounding.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory.

Table 1.15: Areas of forest of different forest types, by growth stage[a]

	Area ('000 hectares)					
Forest type	Regeneration	Regrowth	Mature	Senescent	Uneven aged	Total
Acacia[b]	1	0	15	0	2	20
Callitris[b]	7	0	19	22	1	48
Casuarina[b]	1	1	2	4	0	8
Eucalypt	1,477	1,569	6,831	2,967	2,084	14,930
Eucalypt mallee open	0	1	1	6	0	8
Eucalypt mallee woodland	3	0	35	1	1	40
Eucalypt low closed	3	5	5	0	1	14
Eucalypt low open	19	15	35	9	4	83
Eucalypt low woodland	2	35	77	75	2	192
Eucalypt medium closed	13	22	47	1	21	105
Eucalypt medium open	736	428	2,643	1,224	1,268	6,299
Eucalypt medium woodland	234	234	1,489	91	519	2,567
Eucalypt tall closed	24	29	48	1	22	123
Eucalypt tall open	414	744	2,187	1,538	231	5,114
Eucalypt tall woodland	29	56	264	21	15	385
Mangrove[b]	0	0	0	0	0	0
Melaleuca[b]	2	1	4	3	0	11
Rainforest[b]	68	55	35	59	2	219
Other native forest[b]	23	13	81	36	8	161
Total	**1,580**	**1,639**	**6,986**	**3,092**	**2,099**	**15,396**

[a] Growth stage definitions vary among states and territories and have been translated to closest national category.
[b] Non-eucalypt communities cannot readily be mapped by growth stage.

Notes:
Data for Regional Forest Agreement/Comprehensive Regional Assessment regions in New South Wales, Queensland, Tasmania, Victoria and Western Australia only.
Totals may not tally due to rounding.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory.

‘Old growth’

Some mature or senescent growth stages that have been assigned the term ‘old growth’ provide specific habitats for particular species, particular wood products, and a range of aesthetic and cultural values (Keenan and Read 2012). Old-growth forests generally have a layered structure, with large (girth and height) overstorey trees, a well-developed understorey of other tree species and shrubs, and ecological features such as dead standing trees and large decaying and hollow logs on the forest floor. Some wildlife species rely on old-growth forests because of the range of nesting hollows they provide and their greater structural complexity compared with forests in earlier stages of development. In addition, old-growth forests support a range of aesthetic and cultural values, and provide tourism opportunities.

However, old growth is not a distinct growth stage. Rather, it is a term that encompasses forest in the overmature and senescent growth stages that has received minimal recent disturbance. The National Forest Policy Statement (Commonwealth of Australia 1992) defines old-growth forest as:

> *… forest that is ecologically mature and has been subjected to negligible unnatural disturbance such as logging, roading and clearing. The definition focuses on forest in which the upper stratum or overstorey is in the late mature to over-mature growth phases.*

The national operational definition of old-growth forest developed by the Joint Implementation Subcommittee (ANZECC and MCFFA 1997) and used in planning for reservation to ensure the conservation of old-growth forest is:

> *Old growth forest is ecologically mature forest where the effects of disturbance are now negligible.*

The National Forest Policy Statement gives high priority to the protection of old-growth forests, with specific provisions to protect more than 60% of areas identified as old growth according to national criteria. This target was intended to apply flexibly, to include representative examples of old-growth forest, to ensure that high-quality habitat areas are included, and to incorporate the largest and least fragmented areas.

Fire, natural ageing, lack of fire, and disease represent the most significant threats to large areas of old-growth forests across all tenures. Harvesting is also a contentious issue, and several states have developed policies to exclude harvesting from old-growth forest, altered management prescriptions to reduce impacts, or management prescriptions to promote the development of old-growth characteristics in younger forest.

Mapping old-growth forests requires knowledge of the growth stage, growth trajectory and disturbance history of the forest. Disturbance history is often not well known and has to be interpreted from other information, such as forest structure or direct evidence such as tracks, stumps and fire scars. Some of this information can be identified using aerial photographs, but in many cases expensive and labour-intensive field validation is required. Therefore, only a relatively small area of Australia’s forests (mostly tall, wet forest) has been assessed for its old-growth status or, more generally, its old-growth values. Old-growth forests are usually identified in patches larger than 2–3 hectares.

Old-growth forests identified during the original comprehensive regional assessment surveys in the 1990s for the Regional Forest Agreement (and Comprehensive Regional Assessment) regions were discussed in SOFR 2008.[23] The area of old-growth forest in Australia reported at that time was 5.0 million hectares, and has not been updated.


Steve Colquitt, DEPI Vic.

Old-growth forest, Victoria.

[23] Pages 17–19 in SOFR 2008.

Case study 1.1: Forest growth stages in Tasmania

State of the forests Tasmania 2012 (FPA 2012) provides a good overview of the distribution of forest growth stages by forest type and tenure across Tasmania (Table 1.16) in 2010. (Forest categorised elsewhere as senescent is classified as mature in Tasmania.) The overview contains the following details:

- Of the 2.3 million hectares of forest in Tasmania for which growth stage mapping is available, the majority (1.7 million hectares; 73%) is mature.
- Conservation reserve tenures include 36% of the forest mapped as mature, and 20% of the forest mapped as regrowth.
- The areas mapped as regeneration are strongly linked to commercially managed forest communities. The proportion of younger forest growth stages (regeneration and regrowth) in state forest is 32%, which is higher than for other tenures. However, areas of regeneration are generally only identifiable in state forest, where harvest records can be used to determine stand age. Such data are not available or are incomplete for operations on private land and other tenures.
- In dry eucalypt forests of known growth stage, the proportion mapped as younger forest (regeneration and regrowth) is relatively low, averaging 19% across all tenures.
- In wet eucalypt forests of known growth stage, the proportion mapped as younger growth stages (regeneration and regrowth) is 41%, which is significantly higher than in the dry eucalypt forests. This is partly due to the ecology of wet eucalypt communities, which tend to grow in single-age stands in which regrowth is readily identifiable; dry eucalypt forests more usually grow in multi-aged stands, and even forests mapped as mature usually contain a proportion of younger trees resulting from fire that has not led to replacement of the whole stand.
- Within the wet eucalypt forests, the tenures with the highest proportions of younger growth stages are private land (53% younger growth stages by area) and state forest (51% younger growth stages by area). On conservation reserve tenures, only 17% of the wet eucalypt forest area is identifiable as younger forests.
- In state forest, the overall area of regeneration growth stage in dry eucalypt forest has decreased over the past decade by 4,600 hectares (an 18% drop) and now constitutes only 6.6% of the mapped growth stages in this forest type. This decrease is due to increasing use of selective or partial harvesting (instead of clear-felling) in dry forest communities; following such operations, a canopy of retained mature and regrowth trees continues to dominate the stand, so the stand continues to be mapped as regrowth or mature growth stage. At the same time, regeneration that was established and mapped before 1992 has reached 20 years of age and is now mapped as regrowth.
- In the wet eucalypt communities in state forest, the proportion of forest in the regeneration growth stage has remained approximately constant over the past decade. The area of new regeneration arising from harvesting operations balances the area of forest that is progressively remapped as regrowth as it reaches an age of 20 years. The overall area of regrowth is also relatively constant because the area being reclassified as regrowth from regeneration is being balanced by areas subjected to harvesting. This pattern reflects the increasing dependence of the sawlog and veneer industries on regrowth forests.

Disturbances such as flooding are one reason that native forests can be made up of trees of various age-classes. Native forest, Teepookana State Forest, Tasmania.

continued overleaf

Case study 1.1: Forest growth stages in Tasmania continued

Table 1.16: Area of Tasmanian native forest types by growth stage and tenure[a]

	Area (hectares)				
Tenure group and RFA forest vegetation community	**Regeneration**	**Regrowth**	**Mature and senescent**	**Unknown**	**Total**
Conservation reserves[b]					
Dry eucalypt forests	60	56,500	372,400	9,800	438,700
Wet eucalypt forests	400	39,000	193,900	2,000	235,300
Subalpine eucalypt forests	0	9,200	33,900	3,500	46,600
Non-eucalypt forests[c]	0	0	0	451,400	451,400
Total	**400**	**104,800**	**600,100**	**466,700**	**1,172,000**
Other state forest[d]					
Dry eucalypt forests	21,400	83,200	221,700	12,600	339,000
Wet eucalypt forests	49,500	171,300	215,200	11,900	447,900
Subalpine eucalypt forests	200	2,200	5,200	700	8,300
Non-eucalypt forests[c]	0	0	0	177,600	177,600
Total	**71,000**	**256,800**	**442,100**	**202,800**	**972,700**
Other publicly managed land					
Dry eucalypt forests	600	7,400	41,300	2,500	51,700
Wet eucalypt forests	500	3,300	7,000	300	11,000
Subalpine eucalypt forests	0	400	2,300	400	3,100
Non-eucalypt forests[c]	0	0	0	7,600	7,600
Total	**1,000**	**11,000**	**50,600**	**10,800**	**73,500**
Private freehold land					
Dry eucalypt forests	200	107,600	534,000	50,800	692,500
Wet eucalypt forests	300	54,100	48,400	10,000	112,700
Subalpine eucalypt forests	0	800	4,800	1,000	6,700
Non-eucalypt forests[c]	0	0	0	46,500	46,500
Total	**500**	**162,500**	**587,200**	**108,300**	**858,400**
Total of all tenures	**72,900**	**535,100**	**1,680,000**	**788,700**	**3,076,700[e]**

RFA = Regional Forest Agreement

a Forest extent is as at the first quarter of 2010, and tenure is as at 30 June 2011.

b *Nature Conservation Act 2002*, *Crown Lands Act 1976* and forest reserves.

c Non-eucalypt communities cannot readily be mapped by growth stage.

d Includes multiple-use forest.

e Differs from forest area for Tasmania reported in Indicator 1.1

Note: Area is rounded to nearest 10 hectares if less than 100 hectares, otherwise to nearest 100 hectares. 'Total' is the rounded actual total.
Source: FPA (2012).

Indicator 1.1c

Area of forest in protected area categories

Rationale

This indicator uses the area and proportion of forest ecosystems reserved through formal and informal processes as a measure of the emphasis placed by society on the preservation of representative ecosystems as a strategy to conserve biodiversity.

Key points

- A total of 21.5 million hectares of Australia's forest area is in the land tenure category 'nature conservation reserve', which is 17.2% of Australia's total forest area (and just over 17.5% of Australia's native forest area). The proportion of total forest in this tenure has increased from 15% since SOFR 2008, but the absolute area has decreased slightly; the reduction in area is due to reclassification for SOFR 2013 of some forest land into non-forest categories, and the change in reporting of some formal reserves to their official land tenure type of multiple-use forest.
- In addition to forest in formal nature conservation reserves, several jurisdictions report the area of forest in informal nature conservation reserves on public land, and the area of forest in which values are protected by prescription. The total area of forest in these three categories is 6.1 million hectares in New South Wales, 4.3 million hectares in Victoria, and 5.0 million hectares in Western Australia. Tasmania also reports the area of forest in private reserves, and the total area of forest in these four categories in Tasmania is 1.5 million hectares.
- Some private forests (including private freehold, leasehold and Indigenous-managed lands) are managed for conservation objectives through national and state and territory programs. Approximately 1.8 million hectares of forest are on privately owned or managed lands with conservation covenants listed in the National Conservation Lands Database.
- The Collaborative Australian Protected Areas Database (CAPAD), a spatial representation of the National Reserve System, includes 26.4 million hectares of forest that have a primary management intent of nature conservation (21% of Australia's forests). All of the broad national forest types in Australia, except for Acacia forest, are protected above the area proportion target of 10% recommended by the International Union for Conservation of Nature.
- Native forest in areas protected for biodiversity conservation, both included and not included in CAPAD, covers 39.2 million hectares (32% of Australia's native forests). The Aichi Biodiversity Target (an area target of at least 17%) from the Strategic Plan for Biodiversity 2011–2020 of the Convention on Biological Diversity, to which Australia is a party, has therefore been achieved with respect to Australia's native forest.
- About 4.3 million hectares of Australia's native forests are in sites on the World Heritage List established under the World Heritage Convention.

This indicator reports on the area of forests reserved or otherwise managed for conservation of biological diversity. The area of forest managed for protection of soil and water values is reported in Indicator 4.1a.

Classifying forests into protected areas has been challenging (Dudley 2008, Dudley and Phillips 2006). Three definitions are used nationally and/or internationally:

- *A geographically defined area which is designated or regulated and managed to achieve specific conservation objectives* (Article 2 of the Convention on Biological Diversity 1992[24]).
- *An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means* (IUCN[25] 1994).
- *A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values* (revised IUCN definition, Dudley 2008).

This indicator presents data for forests in a number of categories, namely the land tenure category 'nature conservation reserve', informal nature conservation reserves, forest in which values are protected by prescription, forests with conservation covenants, forest in the Collaborative Australian Protected Areas Database (CAPAD)[26], forest in land protection categories used by the IUCN, and forests in sites on the World Heritage List. In addition, a total area of forest protected for biodiversity conservation is calculated.

Formal public nature conservation reserves

The area of forest in formal public nature conservation reserves decreased slightly over the reporting period, from 22.4 million hectares reported in SOFR 2008 to 21.5 million hectares reported in SOFR 2013. This was primarily due to the reclassification of some reserved land from forest into non-forest categories (including other woody vegetation) as part of the improvement in Australia's forest area determination (see Indicator 1.1a), as well as the change in reporting of some formal reserves in SOFR 2013 to their official land tenure type of multiple-use forest (see Indicator 1.1a).

However, the proportion of forest in formal public nature conservation reserve tenure (virtually all is native forest) has increased steadily, from 11.3% reported in SOFR 1998 to 17.2% in SOFR 2013 (Table 1.17). The 21.5 million hectares of forest in formal public nature conservation reserves represents 17.2% of Australia's total forest area, and just over 17.5% of Australia's native forest area.

The Comprehensive, Adequate and Representative (CAR) reserve system

The National Forest Policy Statement (Commonwealth of Australia 1992) sets out Australia's approach to forest conservation:

> *The nature conservation objectives are being pursued in three ways. First, parts of the public native forest estate will continue to be set aside in dedicated nature conservation reserve systems to protect native forest communities, based on the principles of comprehensiveness, adequacy and representativeness (CAR reserves). The reserve system will safeguard endangered and vulnerable species and communities. The terms 'reserves' and the 'reservation system' mean National Parks and all other areas that have been specifically dedicated by government for the protection of conservation values. Other areas of forest will also be protected to safeguard special areas and to provide links where possible between reserves or other protected areas. Second, there will be complementary management outside reserves, in public native forests that are available for wood production and other commercial uses and in forests on unallocated or leased Crown land. Third, the management of private forests in sympathy with nature conservation goals will be promoted.*

The Regional Forest Agreements (RFAs) followed this approach in the allocation of areas to the nature conservation reserve system or to multiple-use public forests (including land where wood production can be a management objective). All states that undertook comprehensive regional assessments as part of the RFA process (New South Wales, Queensland, Tasmania, Victoria and Western Australia) have developed approaches to forest protection and conservation that include both formal and informal reserves:

- **Formal reserves** are publicly managed land tenures that cannot be revoked without parliamentary approval. "Dedicated" formal reserves exclude mining. Publicly owned reserves are an integral part of the national forest reserve system, and include the areas reported above under the land tenure of public nature conservation reserves.
- **Informal reserve**s on public land are protected through administrative instruments by public agencies. Informal reserves are an integral part of the national forest reserve system.
- **Private CAR reserves** are areas of private land that are managed in the long term for the protection of CAR values under secure arrangements, including proclamation under legislation and contractual agreements, such as management agreements and covenants; they also include reserves set aside under independently certified forest management systems.

24 www.cbd.int/convention/text/default.shtml.
25 International Union for Conservation of Nature.
26 http://www.environment.gov.au/topics/land/nrs/science/capad/2010.

Table 1.17: Forest area in formal public nature conservation reserves, as reported in SOFR 2013 and previous SOFRs

Forest area measure		SOFR 1998	SOFR 2003	SOFR 2008	SOFR 2013
Total forest area[a]	million hectares	156	164	149	125
Area of forest in formal public nature conservation reserves[b]	million hectares	17.6	21.5	22.4	21.5
Proportion of forest in formal public nature conservation reserves	%	11.3	13.1	15.0	17.2

[a] 'Total forest' includes both native forest and plantations. Reasons underpinning changes in Australia's total forest area and forest tenure are discussed in Indicator 1.1a.

[b] Does not include informal reserves or reserves on private or leasehold land.

Note: Figures may differ from those reported in state, territory or regional reports (Regional Forest Agreement reports or SOFR) as a result of different forest-type mapping or more recent data.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory for forest area (see Indicator 1.1a), PSMA Australia Ltd via OMNILINK Pty Ltd.

In addition, in some states and territories, forest values outside the National Reserve System may be managed by prescription based on a code of practice or forest management plan. These areas include Special Protection Zones in multiple-use forest in New South Wales, informal reserves, and fauna habitat zones in multiple-use forest in Western Australia[27].

Tables 1.18–1.21 show data on the area of forest in publicly owned formal and informal CAR reserves in New South Wales, Tasmania, Victoria and Western Australia, respectively. Areas of forest outside reserves that are managed by prescription based on a code of practice or forest management plan are also presented in Tables 1.18, 1.20 and 1.21. These areas are not reported in this format by Tasmania, and so are not shown in Table 1.19; however, Table 1.19 shows data on privately owned CAR reserves in Tasmania. Data on CAR reserves on public land in Queensland were incomplete and are not reported here.

All multiple-use public native forest in the Australian Capital Territory, the Northern Territory and South Australia is protected under jurisdictional legislation that excludes harvesting of any native forest, and data for these jurisdictions are therefore not reported in the same way as data for the other jurisdictions.

The total area of public native forest protected in New South Wales is 6.1 million hectares, which is 27% of the total forest area in that state (Table 1.18). Although the area of forest in formal and informal reserves in New South Wales was not reported in SOFR 2008, the area of each reserve type has increased over the reporting period through the conversion of other land tenures into nature conservation reserves. For example, in 2010, following an assessment on the Riverina Bioregion by the Natural Resources Commission[28], the New South Wales Government established more than 100,000 hectares of river red gum (*Eucalyptus camaldulensis*) reserves on lands that were previously multiple-use forests in the Riverina region. The new reserves include national parks, regional parks and Indigenous Protected Areas. Together with existing adjacent parks in Victoria, they form the largest area of conserved river red gum forests in Australia.

Data on forests located on private CAR reserves in New South Wales are incomplete. However, the available data indicate that the area of such reserves has increased. For example, since 2002, the Nature Conservation Trust[29] has established 60 private conservation reserves across New South Wales that offer legally binding protection through agreements and land covenants to more than 21,000 hectares of native vegetation on private land, which includes forested land.

The *State of the forests Tasmania 2012* report (FPA 2012) reports the total area of forest protected in CAR reserves across both private and public land in Tasmania. The total area of public and private native forest protected in Tasmania is 1.5 million hectares, which is 41% of the total forest area in that state (Table 1.19). This is an increase of 48,000 hectares of forest in reserves since 2008. The area of reserved forest as a percentage of the state's total forest is lower than the 47% reported in SOFR 2008 partly as a result of the increase of 0.364 million hectares in total reported forest in Tasmania (Indicator 1.1a). Table 1.19 also includes the area of forest on 'other formal reserves' on public land, such as those established under the Tasmanian Community Forest Agreement, which have the official tenure of multiple-use public forest and are therefore not reported as 'nature conservation reserve' in Indicator 1.1a. A total of 9% of Tasmania's forest is in either informal public CAR reserves or privately owned CAR reserves (Table 1.19); the area of forest in private CAR reserves has increased by 35,000 hectares over that reported in SOFR 2008.

Murramarang National Park, New South Wales.

[27] Special Protection Zones in Victorian state forests (http://www.vicforests.com.au/files/aursynexbe/16481-VForest-ForestManagemtPlan.pdf) are informal and formal reserves.

[28] www.riverredgums.nsw.gov.au.

[29] http://nct.org.au/what-we-do/about-nct/our-achievements.html.

Table 1.18: Area of protected native forest on public land in New South Wales, by CAR reserve type

Forest area measure		Dedicated formal reserves	Informal CAR reserves	Values protected by prescription	Total forest protected
Forest area	'000 hectares	5,601[a]	393	125	6,119
Proportion of total forest[b]	%	25	2	1	27

CAR = Comprehensive, Adequate and Representative

[a] Forest in tenure type 'nature conservation reserve' (Indicator 1.1a) plus forest in Special Protection Zones in tenure type 'multiple-use public forest'.

[b] Calculated based on reported forest area in NSW of 22.7 million hectares (Indicator 1.1a).

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory for forest area, Forests NSW.

Table 1.19: Area of protected native forest on public and private land in Tasmania, by CAR reserve type

Forest area measure		Dedicated formal reserves	Other formal reserves	Informal CAR reserves	Private CAR reserves	Total forest protected
Forest area[a]	'000 hectares	636	529[b]	264	83	1,513[c]
Proportion of total forest[d]	%	17	14	7	2	41

CAR = Comprehensive, Adequate and Representative

[a] Forest areas as reported in *State of the forests Tasmania 2012* (FPA 2012) and do not include any reserves resulting from the Tasmanian Forests Agreement process 2011–2013.

[b] Subject to the *Mineral Resources Development Act 1995* (Tas.).

[c] Total does not include 'values protected by prescription', because these are not reported by the state in this format.

[d] Calculated based on reported forest area in Tasmania of 3.7 million hectares (Indicator 1.1a).

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory for forest area, FPA (2012).

Table 1.20: Area of protected native forest on public land in Victoria, by CAR reserve type

Forest area measure		Dedicated formal reserves	Informal CAR reserves	Values protected by prescription	Total forest protected
Forest area	'000 hectares	3,316[a]	747	256	4,318
Proportion of total forest[b]	%	40	9	3	53

CAR = Comprehensive, Adequate and Representative

[a] Forest in the nature conservation reserve tenure type (Indicator 1.1a).

[b] Calculated based on reported forest area in Victoria of 8.2 million hectares (Indicator 1.1a).

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory for forest area, Victorian Department of Primary Industries.

Table 1.21: Area of protected native forest on public land in Western Australia, by CAR reserve type

Forest area measure		Dedicated formal reserves	Informal CAR reserves	Values protected by prescription	Total forest protected
Forest area	'000 hectares	4,778[a]	83[b]	165[c]	5,026
Proportion of total forest[d]	%	25	0.4	1	26

CAR = Comprehensive, Adequate and Representative

[a] Forest in tenure type 'nature conservation reserve' (Indicator 1.1a) plus forest in the 'Formal reserves' category in tenure type 'multiple-use public forest'.

[b] Forest in the 'CAR informal reserves' category in tenure type 'multiple-use public forest'.

[c] Forest in the 'Other informal reserves and fauna habitat zones' category in tenure type 'multiple-use public forest'.

[d] Calculated based on reported forest area in Western Australia of 19.22 million hectares.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory for forest area, Western Australian Department of Environment and Conservation.

The total area of public native forest protected in Victoria is 4.3 million hectares, which is 53% of the total forest area in that state (Table 1.20). This figure is 462,000 hectares less than reported in SOFR 2008, due to the area of forest in the tenure type 'nature conservation reserve' in Victoria being 189,000 hectares less than the area reported in 2008 (Indicator 1.1a), and due to modelled stream buffer exclusion[30] areas (forests that are protected through codes of forest practices based on land slope and proximity to water courses) no longer being included in the area of forested land now being reported as 'protected by prescription' by Victoria.

Data on forests on private CAR reserves in Victoria are incomplete. However, the available data indicate that the area of such reserves has increased. For example, since 1987, the organisation Trust for Nature[31] has established more than 1,000 conservation covenants across Victoria that offer legally binding protection to more than 45,000 hectares of native vegetation on private land, which includes forested land.[32] This is an increase of 10,000 hectares over the figure reported in SOFR 2008.

The total area of public native forest protected in Western Australia is 5.0 million hectares, which is 26% of the total forest area in that state (Table 1.21). Most is in the south-west of the state.

Data on forests located on private CAR reserves in Western Australia are incomplete. However, the data provided indicate that the area of such reserves has increased. For example, since 1971, the National Trust of Australia (WA)[33] has established approximately 157 conservation covenants across Western Australia that offer legally binding protection to more than 62,000 hectares, which includes 17,000 hectares of bushland (both forest and non-forest land).

Scribbly gum (*Eucalyptus rossii*) forest on a property with a private conservation covenant, Cooma region, New South Wales.

Conservation covenants on privately managed land

The Australian Government (through the Department of Sustainability, Environment, Water, Population and Communities[34]) maintains the National Conservation Lands Database (NCLD).[35] This database contains information on the area of privately owned land over which a legally binding conservation covenant is in place to ensure that natural, cultural and scientific values are protected. These lands can include forested land. Organisations that undertake conservation covenanting programs include Trust For Nature (Victoria), the Nature Conservation Trust (New South Wales) and the National Trust of Australia (Western Australia).

A total of 1.8 million hectares of forested land is on properties listed in the NCLD (Table 1.22). The largest areas are in Queensland, New South Wales and South Australia. The most common forest types on covenanted land are Eucalypt medium woodland forest, Eucalypt mallee woodland forest, Eucalypt medium open forest and Acacia forest.

Of this 1.8 million hectares of forested land, 1.4 million hectares are also listed in CAPAD as protected areas in the National Reserve System. However, the two datasets are assembled using different criteria, and data are collected using different methods. Data from the NCLD are not included in Tables 1.18–1.21.

The area of forests known to be in private reserves (including forests on private freehold, leasehold and Indigenous-managed lands) throughout Australia is increasing, both through the creation of new reserves and through more complete reporting. The establishment of national datasets such as the NCLD, and larger spatial datasets held by non-government organisations such as Bush Heritage Australia[36] and the Nature Conservancy[37], along with smaller, jurisdictionally based non-government organisations, have assisted greatly in the identification of these private forest reserves.

Although the privately owned or managed reserve estate across Australia is small compared with the publicly owned reserve estate (compare Table 1.22 with Table 1.17), these reserves are important because they are often selected to protect rare or endangered species or other important forest values that cannot be fully captured by reservation on public land.

30 http://www.giconnections.vic.gov.au/content/vicgdd/record/ANZVI0803002248.htm.

31 www.trustfornature.org.au.

32 www.trustfornature.org.au/download/library/7F000B007100/tfn-conservation-bulletin-issue-53-2011-09-pdf.

33 www.nationaltrust.org.au/wa/natural-heritage.

34 From September 2013, the Department of the Environment.

35 http://asdd.ga.gov.au/asdd/tech/zap/basic-full.zap?&target=ea-1&syntax=html&cclfield1=all&cclfield2=phrase&cclfield3=any&ccltermI=wetland&cclterm2=&cclterm3=&start=3&number=1.

36 www.bushheritage.org.au.

37 www.nature.org/ourinitiatives/regions/australia/index.htm.

Table 1.22: Area and type of forest in properties in the National Conservation Lands Database, by jurisdiction

	Area ('000 hectares)								
Forest type	**ACT**	**NSW**	**NT**	**Qld**	**SA**	**Tas.**	**Vic.**	**WA**	**Australia**
Acacia	0	25	0	145	0	1	0	1	172
Callitris	0	11	0	15	2	0	0	0	28
Casuarina	0	9	0	0	2	1	5	0	18
Eucalypt	0	261	0	662	412	48	27	52	1,463
Eucalypt mallee open	0	23	0	0	49	0	0	0	72
Eucalypt mallee woodland	0	43	0	0	335	0	6	27	411
Eucalypt low closed	0	0	0	0	0	0	0	0	0
Eucalypt low open	0	2	0	11	0	0	0	3	17
Eucalypt low woodland	0	13	0	4	10	0	0	2	29
Eucalypt medium closed	0	0	0	0	0	0	0	0	0
Eucalypt medium open	0	67	0	46	0	4	11	6	134
Eucalypt medium woodland	0	90	0	599	18	39	10	14	770
Eucalypt tall closed	0	0	0	0	0	0	0	0	0
Eucalypt tall open	0	22	0	1	0	3	0	1	26
Eucalypt tall woodland	0	0	0	0	0	2	0	0	3
Mangrove	0	0	0	1	0	0	0	0	1
Melaleuca	0	1	0	18	1	0	0	0	20
Other	0	27	0	17	0	0	2	7	53
Plantation hardwood	0	0	0	0	0	0	0	2	3
Plantation softwood	0	2	0	0	0	0	0	0	2
Plantation mixed or unknown	0	0	0	0	0	0	0	0	0
Rainforest	0	3	0	38	0	1	0	0	42
Total	**0**	**339**	**0**	**896**	**418**	**51**	**35**	**63**	**1,803**

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory for forest area, Australian Government Department of Sustainability, Environment, Water, Population and Communities (National Conservation Lands Database 2008).

Table 1.23: Area of forest in CAPAD, by tenure and jurisdiction

	Area ('000 hectares)								
Tenure	**ACT**	**NSW**	**NT**	**Qld**	**SA**	**Tas.**	**Vic.**	**WA**	**Australia**
Leasehold forest	1	23	608	884	110	1	0	11	1,637
Multiple-use public forest	1	193	0	131	16	134	68	1	545
Nature conservation reserve	111	5,428	12	4,921	1,482	1,217	3,066	3,441	19,678
Other Crown land	0	0	23	25	3	87	66	1	204
Private (including Indigenous)	0	23	3,138	547	499	99	30	1	4,338
Unresolved tenure	0	0	1	1	3	18	0	0	24
Total	**114**	**5,667**	**3,781**	**6,510**	**2,112**	**1,556**	**3,231**	**3,456**	**26,427**
Proportion of forest area in jurisdiction (%)	83	25	25	13	46	42	39	18	21

CAPAD = Collaborative Australian Protected Area Database

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory for forest area, Australian Government Department of Sustainability, Environment, Water, Population and Communities (CAPAD 2010).

Protected areas comprising the National Reserve System

Every two years, the Australian Government collects information on protected areas from state and territory governments and other protected area managers. This information is published in CAPAD as a spatial representation of the National Reserve System. A total of 26.4 million hectares of Australia's forest is recorded as protected through inclusion in CAPAD (Table 1.23). The Australian Capital Territory has the greatest proportion of its forest area protected.

CAPAD is primarily concerned with the management intent of a protected area rather than its tenure. Therefore, the total area of forest in formal 'nature conservation reserves', as reported in Indicator 1.1a and in the section 'Formal public nature conservation reserves' above, does not match the forest area in CAPAD (Tables 1.23 and 1.24). For example, some large national parks, including Kakadu National Park in the Northern Territory, are classified as private land tenure, even though they are managed primarily for conservation, and are therefore included in CAPAD.

CAPAD is used to provide a national perspective of the conservation of biodiversity in protected areas. It also allows Australia to regularly report on the status of protected areas to meet international obligations, such as those under the Convention on Biological Diversity. Australia's protected area information is also included in the World Database on Protected Areas.

Under *Australia's Strategy for the National Reserve System 2009–2030* (NRMMC 2009), all the state and territory governments and the Australian Government agreed to adopt international standards for the definition of a protected area and for management categories for protected areas. These are the categories used by the International Union for Conservation of Nature (IUCN), which defines a protected area as:

> *… an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.*

The IUCN classifies protected areas into the following categories as a basis for international comparison:

- **Ia Strict nature reserve**—protected area managed mainly for science
- **Ib Wilderness area**—protected area managed mainly for wilderness protection
- **II National park**—protected area managed mainly for ecosystem conservation and recreation
- **III Natural monument**—protected area managed for the conservation of specific natural features
- **IV Habitat/species management area**—protected area managed mainly for conservation through management intervention
- **V Protected landscape/seascape**—protected area managed mainly for landscape/seascape conservation and recreation
- **VI Managed resource protected area**—protected area managed mainly for the sustainable use of natural ecosystems.

Table 1.24: Area of forest in IUCN protected-area categories, by jurisdiction

Jurisdiction	Area ('000 hectares) IUCN protection category								Forest in categories I–IV	Forest in all categories	Total forest	Proportion of forest in all IUCN categories (%)
	Ia	Ib	II	III	IV	V	VI[a]	ND[b]				
ACT	0	28	85	0	0	0	0	0	114	114	138	83
NSW	718	1,739	2,952	6	212	12	5	23	5,628	5,667	22,681	25
NT	10	0	1,823	0	0	103	1,845	0	1,833	3,781	15,214	25
Qld	38	0	4,941	48	11	180	1,291	0	5,038	6,510	51,036	13
SA	253	381	90	442	13	115	819	0	1,178	2,112	4,565	46
Tas.	17	0	851	26	227	49	381	7	1,120	1,556	3,706	42
Vic.	355	706	1,993	51	30	29	66	0	3,135	3,231	8,190	39
WA	1,779	0	1,596	0	1	1	78	0	3,377	3,456	19,222	18
Australia	**3,169**	**2,854**	**14,331**	**573**	**495**	**490**	**4,485**	**30**	**21,422**	**26,427**	**124,751**	**21**
IUCN areas as proportion of total forest (%)	**3**	**2**	**11**	**0.5**	**0.4**	**0.4**	**4**	**0.02**	**17**	**21**		

IUCN = International Union for Conservation of Nature

[a] Multiple-use public forest could be classified under IUCN category VI; however, the Collaborative Australian Protected Area Database only classifies multiple-use public forest this way if it is principally managed for the conservation of biodiversity (see Dudley and Phillips 2006).

[b] 'ND' indicates that the IUCN category classification is unresolved.

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory for forest area, Australian Government Department of Sustainability, Environment, Water, Population and Communities (Collaborative Australian Protected Area Database 2010) for IUCN data.

Data derived from CAPAD show that a total of 21% of Australia's forest area is in IUCN protected area categories I–VI (Figure 1.16, see p. 50; Table 1.24).

In 1982, the IUCN recommended that at least 10% of each biome should be in one of these reserve categories[38]. SOFR is able to report against this target by forest type. Of Australia's 18 national native forest types and subtypes, 17 have reservation levels exceeding this target (Table 1.25), which is an increase from the 14 types with reservation levels exceeding the target reported in SOFR 2008. Only Acacia forests are represented below this target level, with 7% of their area protected. The IUCN target has been significantly exceeded in each of the 10 RFA regions.

Forest in areas protected for biodiversity conservation

CAPAD includes and reports on protected areas that meet IUCN categories and that have tangible evidence for being 'especially dedicated to the protection and maintenance of biological diversity', but is unlikely to include other types of protected area where conservation and sustainable use of biodiversity is one of multiple objectives, or where the area does not otherwise satisfactorily meet the CAPAD criteria. However, these other types of protected areas contribute significantly to the conservation of biological diversity, and include:

- other nature conservation reserves and legally covenanted land that are managed for conservation of biodiversity
- multiple-use public native forests used for timber harvesting that are also regulated and managed for conservation of biodiversity
- Crown land (either other Crown land or land leased by the Commonwealth) with another primary use that also has management objectives for the protection, conservation and maintenance of biodiversity (including defence training land such as Shoalwater Bay training area in Queensland, and the Buckland training area in Tasmania).

Across all these various categories, a total of 39.2 million hectares of native forest are on land protected for biodiversity conservation (Table 1.26). This represents 32% of Australia's native forest estate. The Australian Capital Territory, Victoria and Tasmania have the highest proportion of forest area protected for biodiversity conservation.

There are international targets for the proportion of land protected for biodiversity conservation, whether inside or outside the reserve system. In 2010, Parties to the Convention on Biological Diversity agreed a Strategic Plan for Biodiversity 2011–2020 including Aichi Biodiversity Targets[39]. Under the Plan's strategic goal "to improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity", Aichi Biodiversity Target 11 specifies

> *By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.*

The 32% of the Australia's native forest estate on land protected for biodiversity conservation (Table 1.26) (which includes the 21% of Australia's forest area in IUCN protected area categories I–VI in the National Reserve System, Table 1.24) therefore represents an achievement of Aichi Biodiversity Target 11 with respect to Australia's native forests.

Register of the National Estate

The Register of the National Estate was a national list of places of natural, historic and Indigenous significance. The register was closed in 2007 and is no longer covered by national legislation. All references to the Register of the National Estate were removed from the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 19 February 2012. However, the expiration or repeal of parts of the EPBC Act and the *Australian Heritage Council Act 2003* relating to the Register of the National Estate does not diminish protection of Commonwealth heritage places, as these parts have been replaced with stronger, ongoing heritage protection provisions under the EPBC Act through the National Heritage List, the Commonwealth Heritage List and the protection of the environment in Commonwealth areas.

The Register of the National Estate is now an archive of information about approximately 13,000 places throughout Australia, including areas of forest; further information is available in SOFR 2008 (page 23, Table 15 and Figure 17).

National Heritage List and Commonwealth Heritage List

The National Heritage List and the Commonwealth Heritage List were created in 2003 and, along with existing heritage registers maintained by each state and territory, have replaced the Register of the National Estate. The National Heritage List includes places of outstanding heritage value to the nation, and the Commonwealth Heritage List includes places with significant heritage value that are owned and/or controlled by the Commonwealth of Australia. Protection of these heritage places is provided through the EPBC Act and agreements with state and territory governments, and Indigenous and private landowners.[40] All proponents, not just the Commonwealth, are required to seek approval for actions that could have a significant impact on the heritage values of places on these lists.

A Non-Indigenous Heritage Sites of Australia dataset has been developed for use in this report by compiling spatial datasets of the National Heritage List, the Commonwealth Heritage List and the heritage registers of all states and territories (see Indicator 6.4b).

[38] The target of 10% was proposed at the Third World Congress on National Parks in Bali, Indonesia, in 1982 and endorsed as a target "that protected areas cover at least 10 percent of each biome by the year 2000" in the Caracas Action Plan at the IVth IUCN World Parks Congress held in Caracas, Venezuela in 1992

[39] Conference of Parties to the Convention on Biological Diversity (Tenth Meeting, Nagoya, Japan, 18-29 October 2010) Decision X/2 -The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets.

[40] www.environment.gov.au/heritage/about/national/index.html.

Table 1.25: Area of forest in IUCN protected-area categories, by forest type

Forest type	Area ('000 hectares) IUCN protection category Ia	Ib	II	III	IV	V	VI[a]	ND[b]	Forest type in all IUCN categories	Total forest	Proportion of forest type in all IUCN categories (%)
Acacia	62	11	434	8	13	15	184	0	727	9,807	7
Callitris	85	1	111	2	2	0	18	11	230	2,136	11
Casuarina	47	72	234	4	7	18	84	1	467	1,288	36
Eucalypt	2,825	2,473	10,600	526	360	360	3,655	12	20,812	91,989	23
Eucalypt mallee open	45	1	32	51	0	1	26	0	156	813	19
Eucalypt mallee woodland	1,328	726	941	343	15	106	782	0	4,242	11,313	37
Eucalypt low closed	0	0	12	1	0	0	6	0	19	39	49
Eucalypt low open	17	12	216	2	2	2	257	0	508	2,173	23
Eucalypt low woodland	70	47	321	16	3	7	135	0	600	4,016	15
Eucalypt medium closed	4	2	46	1	0	5	6	0	63	247	26
Eucalypt medium open	340	963	3,649	41	80	79	981	1	6,134	19,450	32
Eucalypt medium woodland	943	371	4,489	63	156	140	1,367	11	7,541	48,246	16
Eucalypt tall closed	2	3	20	0	1	0	0	0	27	141	19
Eucalypt tall open	73	345	809	8	92	16	69	0	1,412	4,897	29
Eucalypt tall woodland	2	1	66	1	10	3	25	0	109	655	17
Mangrove	27	0	105	7	0	8	32	0	178	913	19
Melaleuca	10	6	607	9	4	32	103	0	770	6,302	12
Rainforest	27	165	1,503	14	98	45	306	4	2,163	3,598	60
Other native forest	86	126	736	3	9	13	102	1	1,076	6,547	16
Industrial plantation and Other forest	0	0	2	0	1	0	1	0	5	2,170	0
Total	**3,169**	**2,854**	**14,331**	**573**	**495**	**490**	**4,485**	**30**	**26,427**	**124,751**	**21**

IUCN = International Union for Conservation of Nature

[a] Multiple-use public forest could be classified under IUCN category VI; however, the Collaborative Australian Protected Area Database only classifies multiple-use forest this way if it is principally managed for biodiversity conservation (Dudley and Phillips 2006).

[b] 'ND' indicates that the IUCN category classification is unresolved.

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory for forest area, Australian Government Department of Sustainability, Environment, Water, Population and Communities (Collaborative Australian Protected Area Database 2010) for IUCN data.

Table 1.26: Area of native forest on land protected for conservation of biodiversity, by jurisdiction

Jurisdiction	Area ('000 hectares) Native forest not in CAPAD but protected for conservation of biodiversity: Nature reserve	Legally covenanted land	Protected areas in multiple-use native forests[b]	Other protected areas on Crown-managed land[c]	Native forest in CAPAD[a]	Total native forest protected for biodiversity conservation	Proportion of native forest protected for biodiversity conservation (%)
ACT	4	0	0	2	114	120	93
NSW	153	293	1,829	39	5,667	7,981	36
NT	1	0	0	299	3,781	4,081	27
Qld	177	1	2,774	467	6,510	9,929	20
SA	27	7	4	33	2,112	2,183	50
Tas.	23	0	789	12	1,556	2,380	71
Vic.	247	34	2,926	20	3,231	6,458	84
WA	1,169	59	1,290	93	3,456	6,067	32
Australia	**1,801**	**394**	**9,612**	**965**	**26,427**	**39,199**	**32**

Note: Totals may not tally due to rounding.

[a] Includes approximately 5,000 hectares of Other forest (predominantly old hardwood plantations now reserved for biodiversity habitat).

[b] Multiple-use native forests are included where jurisdictional legislation designates protection of the forest area and conservation of biodiversity is specified in legislation and/or regulated or managed through a management planning instrument.

[c] Includes defence estates on various land tenures that have not been counted under other columns.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory for forest area; Australian Government Department of Sustainability, Environment, Water, Population and Communities (Collaborative Australian Protected Area Database and National Conservation Lands Database); Australian Government Department of Defence.

UNESCO[41] World Heritage List

The World Heritage Convention[42] establishes a list of places that have natural and/or cultural values of outstanding global significance. Inclusion of a place on the World Heritage List does not affect ownership rights, and a country's jurisdictional and local government laws still apply. However, as a signatory to the convention, Australia has an obligation to identify, protect and conserve places on the World Heritage List.

In 2011, Australia's 19 recognised World Heritage areas covered a total of 7.4 million hectares, of which approximately 4.3 million hectares was forested (Table 1.27; Figure 1.17).

A total of 3.5% of Australia's forest area is therefore in World Heritage areas. The area of forest in World Heritage List areas is 320,000 hectares less than was reported in SOFR 2008, due to changes in the method used to estimate Australia's forest extent, rather than an actual loss of forest in the World Heritage List areas.

Forested World Heritage List areas include Kakadu National Park (Northern Territory), the Wet Tropics of Queensland, Shark Bay (Western Australia), Fraser Island (Queensland), Gondwana Rainforests (New South Wales) and the Tasmanian Wilderness. Australia's World Heritage List areas contain a high representation of Rainforest (32.0% of Australia's Rainforest is in World Heritage List areas) and a low representation of Acacia, Callitris and Eucalypt mallee forests.

Table 1.27: Area of native forest in World Heritage areas[a]

	Area ('000 hectares)									
Forest type	**ACT**	**NSW**	**NT**	**Qld**	**SA**	**Tas.**	**Vic.**	**WA**	**Australia**	**Proportion of forest type in World Heritage areas (%)**
Acacia	0	0	0	15	0	2	0	0	17	0.2
Callitris	0	1	0	0	0	0	0	0	1	0.05
Casuarina	0	66	0	27	0	0	0	0	93	7.2
Eucalypt	0	1,113	703	397	0	423	0	1	2,637	2.9
Eucalypt mallee open	0	9	0	0	0	0	0	0	9	1.1
Eucalypt mallee woodland	0	8	0	0	0	0	0	0	8	0.1
Eucalypt low closed	0	0	1	0	0	0	0	0	1	2.6
Eucalypt low open	0	8	39	0	0	43	0	0	91	4.2
Eucalypt low woodland	0	35	46	6	0	33	0	1	121	3.0
Eucalypt medium closed	0	0	2	9	0	0	0	0	12	4.9
Eucalypt medium open	0	568	269	232	0	84	0	0	1,152	5.9
Eucalypt medium woodland	0	348	346	110	0	100	0	0	903	1.9
Eucalypt tall closed	0	0	0	0	0	0	0	0	0	0.0
Eucalypt tall open	0	137	0	40	0	132	0	0	308	6.3
Eucalypt tall woodland	0	0	0	0	0	31	0	0	32	4.9
Mangrove	0	0	11	65	0	0	0	0	77	8.4
Melaleuca	0	0	83	18	0	9	0	1	111	1.8
Rainforest	0	135	49	680	0	288	0	0	1,151	32.0
Other native forest	0	33	43	91	0	29	0	5	201	3.1
Total forest in World Heritage areas	**0**	**1,348**	**887**	**1,293**	**0**	**752**	**0**	**7**	**4,286**	**3.5**
Total forest in each jurisdiction	**138**	**22,681**	**15,214**	**51,036**	**4,565**	**3,706**	**8,190**	**19,222**	**124,751**	
World Heritage area forest as proportion of total forest in each jurisdiction (%)	**0.0**	**5.9**	**5.8**	**2.5**	**0.0**	**20.3**	**0.0**	**0.0**	**3.4**	

[a] World Heritage areas as at 2011

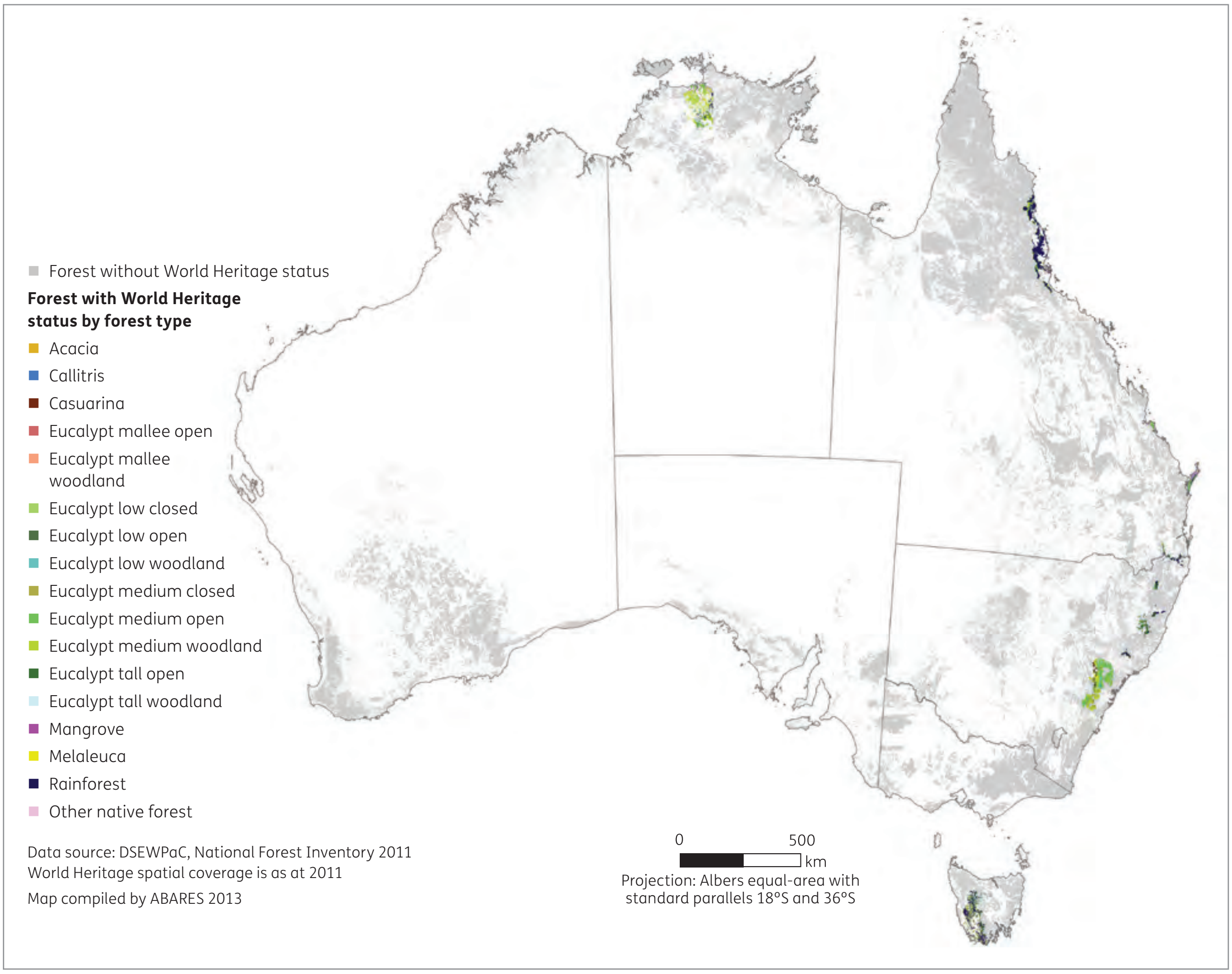
Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory; Australian Government Department of Sustainability, Environment, Water, Population and Communities.

[41] United Nations Educational, Scientific and Cultural Organization.

[42] http://whc.unesco.org/en/conventiontext.

Figure 1.17: Native forest areas with World Heritage status



Daintree National Park, Wet Tropics World Heritage Area, Queensland.

Lake Mimas and Arthur Range, Tasmanian Wilderness World Heritage Area.

Indicator 1.1d

Fragmentation of forest cover

Rationale

This indicator describes the loss of forest cover and the spatial configuration of that loss. Fragmentation can impact on forest-dwelling species and gene pools through changes in the connectivity of populations and the loss of species genetic variability.

Key points

- As much as one-third of Australia's native vegetation in the intensively managed agricultural and urban zones has been cleared or substantially modified over more than 200 years of European settlement. As a result, forest in these areas exhibits relatively high levels of fragmentation, in which areas of forest are separated by areas of non-forest.
- The cessation of broadscale clearing of native forest in much of Australia, and the increased reservation of forests and protection of remnant native vegetation, have been critical in reducing the rate of forest fragmentation in recent times.
- A review of forest fragmentation in Tasmania and south-east Queensland between 1972 and 2002 suggests that recent fragmentation can be dynamic, even in nature conservation reserves, with changing patch sizes and spatial arrangements of different forest types.

Forest fragmentation occurs naturally because of the presence of rock outcrops, frost hollows, cliffs, wetlands, lakes, streams, rivers, non-forest vegetation on skeletal soils and successional change between vegetation types. Fragmentation of the spatial arrangement of the age-class structure of the forest within continuous forest boundaries, associated with successional changes and driven by response to fire, climate change or other disturbance, has also always been a feature of Australian forests.

However, the main cause of forest fragmentation over the past 200 years has been land-use change, mainly for agriculture and urban development but also for associated infrastructure, such as roads, railways, pipelines and electricity transmission lines. As much as one-third of Australia's native vegetation in the intensively used areas—mainly the agricultural and urban zones—has been cleared or substantially modified over that time. As a result, some ecological communities now occupy less than 1% of their original extent, and others have become highly fragmented.

Clearing for cropping and grazing has led to forest fragmentation in many Australian landscapes.

Fragmentation involving permanent clearing of forested land can reduce the habitat quality for many plant, mammal, reptile, bird and amphibian species dwelling in Australian forests; the impact varies considerably by species and community. An increase in forest fragmentation also increases edge effects, reducing habitat quality for species adapted to forest interiors, but possibly improving habitat quality for species that live at forest edges or in open country. Threats from non-native species, including weeds and predators, generally increase when forests are divided into smaller patches. Consequently, historical fragmentation is a key threat to some forest-dwelling species (see Indicators 1.2c and 1.3a).

The general cessation of broadscale clearing of native forest in much of Australia (Indicator 1.1a) and increased protection of forests (Indicator 1.1c) have been critical in reducing further forest fragmentation. In addition, native trees and shrubs have been planted in corridors to re establish connectivity between patches of forest in open agricultural landscapes.

Managed forest landscapes contain patches of forest of different age and management history. Weld and Arve Valleys, southern Tasmania.

Measuring fragmentation

Analysis of fragmentation involves measuring one or more of configuration, connectivity and composition of native forest patches. Configuration addresses patch size and shape; connectivity addresses the dispersion pattern of patches within the landscape; and composition addresses the variation of disturbance and successional change within patches.

Increasingly sophisticated software (such as FRAGSTATS[43]) is available for analysing fragmentation using satellite imagery. Satellite-based remote-sensing data from the then Australian Greenhouse Office were used to support fragmentation analyses, by tenure, in a study area comprising two separate regions (Tasmania and south-east Queensland, each subdivided into their Interim Biogeographic Regionalisation of Australia bioregions[44]) over a 31-year period (1972–2002). The analyses only considered areas in which tenure did not change over the period, but were sensitive to map classification errors. Seven parameters of fragmentation were examined for the entire study area (Table 1.28). The results of the analyses for Tasmania, where there has been little broadscale clearing in recent decades, and south-east Queensland, where land clearing has occurred in recent decades, demonstrate key aspects of measuring changes in forest fragmentation. More details of the methodology are given in SOFR 2008, with numerical results in Appendix B of that report.

Table 1.28: Parameters of landscape fragmentation

Term	Definition and interpretive value
Forest type area	The sum of areas of all patches in a forest type. A measure of the abundance of each forest type in the landscape.
Percentage of landscape	The percentage of the landscape area composed of a particular forest type or class. A measure of landscape composition, quantifying the proportional abundance of each forest type in the landscape.
Number of patches	The number of patches of each particular forest type or class in a landscape.
Mean patch size	The sum of areas of all patches divided by the number of patches comprising that sum. An indicator of the 'grain' of the landscape: coarse grain is a mosaic of large patches, and fine grain is a mosaic of small patches. A minimum patch size of 0.2 hectare was used in this work.
Mean nearest neighbour	The average distance between nearest neighbouring patches, based on patch edge-to-edge distance. A measure of isolation: small values indicate that patches of similar type are close or clustered together, and large values indicate otherwise.
Patch density	Number of patches per unit area. A measure of spatial configuration that facilitates comparison among landscapes of varying sizes.
Edge density	The total length of edge of patches divided by the area of the patches (distance per unit area). A measure of landscape configuration.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences.

43 www.umass.edu/landeco/research/fragstats/fragstats.html.
44 www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html.

Tasmania

In Tasmania, the representation of forest types in the fragmentation analyses varied by tenure. Rainforests were prominent in nature conservation reserves, Eucalypt tall open forests in multiple-use public forests, and Eucalypt medium woodland forests in private forests.

Nature conservation reserves

In nature conservation reserves in the Central Highlands, King and West bioregions, fragmentation decreased over the period 1972–92—that is, the mean number of patches decreased, the mean patch size increased and the distance to nearest neighbour decreased. This was followed by an increase from 1992 to 2002. In the Northern Slopes, South East and Southern Ranges regions, fragmentation decreased between 1972 and about 1998, but then increased from 1998 to 2002. The reasons for these reversals in trend around the middle of the study period are unknown, but possibilities include the impacts of fire and drought.

Multiple-use public forests

In multiple-use public forests, fragmentation decreased in six of the nine bioregions over the period 1972–2002, most markedly in the South East bioregion. Fragmentation increased in the Southern Ranges region to about the mid-1990s but then decreased. In the West region, fragmentation increased between 1972 and 1980 but then decreased significantly. One region, Northern Midlands, experienced increasing fragmentation throughout the entire period.

Private forests

Fragmentation in private forests fluctuated across all regions, with no apparent trend over the period 1972–2002.

South-east Queensland

In south-east Queensland, the representation of forest types in the fragmentation analyses varied by tenure. Eucalypt medium woodland forests were prominent in nature conservation reserves and multiple-use public forests, while Eucalypt medium woodland forests and Eucalypt medium open forests were well represented on private land.

Nature conservation reserves

Fragmentation in nature conservation reserves decreased significantly between 1972 and 2002 in the Banana–Auburn Ranges, Burnett–Curtis Hills and Ranges, Inglewood Sandstones and Woorabinda bioregions; the number of patches decreased and patch size increased (but connectivity decreased). The Barakula and Southeast Hills and Ranges bioregions also showed decreased fragmentation, but the magnitude of the change was smaller. Fragmentation fluctuated over the period 1972–2002 in the Carnarvon Ranges bioregion.

Multiple-use public forests

In multiple-use public forests, fragmentation decreased in the Barakula, Burnett–Curtis Coastal Lowlands, Carnarvon Ranges, and Burnett–Curtis Hills and Ranges bioregions, but connectivity usually also decreased. Fragmentation fluctuated in the Banana–Auburn Ranges, Southeast Hills and Ranges, and Woorabinda bioregions.

Private forests

Fragmentation in private forests fluctuated across all bioregions, with no apparent trend over the period 1972–2002.

Case study 1.2: Strategic Biodiversity Corridors Project

The Department of Primary Industries and Resources South Australia (PIRSA)[45] undertakes ongoing monitoring of the Strategic Biodiversity Corridors Project[a], which was initiated in 2003 by ForestrySA and received seed funding from the then Natural Heritage Trust through the South East Natural Resources Management Board. In 2011, a report analysing data from the first five years of bird monitoring was produced for PIRSA by Ehmke (2011).

Trend analysis using regression and generalised linear mixed models showed that the composition of bird species was different between corridors of native forest and the adjacent pine plantations. Canopy-foraging insect eaters and nectar feeders were absent from pine plantation sites. Other guilds such as woodland-dependent birds and understorey-foraging insect eaters were present at both types of site, but were significantly more species rich at the corridor sites.

This analysis informs the land managers involved in the program that the revegetation work has provided useful habitat for species that would otherwise be restricted to habitat in the nearby native forest reserves and conservation parks.

Incidence rates for bird species were also analysed against the time since planting for the corridor sites and pine plantation sites. It was found that many species, although increasing in incidence over time, have not yet reached steady population levels. Further monitoring will be carried out annually, as well as a complementary program of leg banding to determine bird movements and hence the value of the corridors in providing connectivity in the landscape.

[a] www.forestry.sa.gov.au/Portals/0/Publications/Biodiversity_Corridors_Public_net.pdf.

[45] From October 2011, the Department of Primary Industries and Regions South Australia.

Indicator 1.2a

Forest dwelling species for which ecological information is available

Rationale

This indicator reports the level of information available to manage forest dwelling species and tracks changes in this knowledge over time. The amount of habitat, disturbance and life history information available to make management decisions indicates the capacity to assess risk to species and to implement conservation strategies.

Key points

- All states and territories have developed lists of forest-dwelling vertebrates and vascular plant species, allowing compilation into new national lists. These national lists show that the number of forest-dwelling species has generally increased in each jurisdiction since the number was first reported in SOFR 1998, reflecting improved information from targeted surveys.
- The new national list comprises 2,212 forest-dwelling vertebrates, with 1,101 of these species being identified as forest-dependent. Data for forest-dwelling vascular plants are incomplete, but Australia has at least 16,836 identified forest-dwelling vascular plants; 50% of these occur in Queensland.
- Partial ecological information is available on around 60% of forest-dwelling vertebrate and vascular plant species. Comprehensive ecological information is available on at least 10% of vertebrate species, mainly mammals, birds and amphibians.
- Since SOFR 2008, significantly better information is available for species in regions that have been subject to formal assessment processes, such as those associated with Regional Forest Agreements, and for reptiles, frogs, bats and fish.
- Information remains very limited on forest-dwelling invertebrates, fungi, algae and lichens, apart from south-west Western Australia and Tasmania.

Knowledge of the species present in a forest, and increases or decreases in their populations, can provide an indication of the extent and condition of forest habitat and ecosystem health. This is particularly important in Australia, where knowledge of species diversity is a precondition for the effective management of forest ecosystems. However, the changes in numbers reported in this indicator compared with those reported previously reflect improvements in the data on which the lists are based, and not actual changes in forest ecosystem diversity.

An important indicator of forest ecosystem diversity is the number of forest-dwelling species, which are species that may use forest habitat for all or part of their lifecycles. This is a broader set of species than forest-dependent species, which are species that must inhabit a forest habitat for all or part of their lifecycles.

Australia is home to an estimated 566,398 species, of which 147,579 species have been described (Chapman 2009). Of the described species, about 92% of Australian plant species, 87% of Australian mammal species, 45% of Australian bird species, 93% of Australian reptile species and 94% of Australian frog species are endemic—that is, are found only in Australia (Chapman 2009).

Forest-dwelling and forest-dependent vertebrate species

All states and territories have developed lists of extant[46] and extinct forest-dwelling vertebrate species. These lists have been used as inputs into the development of national databases for forest-dwelling vertebrate species. The number of species reported (Table 1.29) has increased from that reported in SOFR 1998, SOFR 2003 and SOFR 2008 as a result of improved information and targeted surveys, although data accuracy is limited by the absence of data from some states and territories for some reporting periods. Nationally, in 2011 there were 2,212 native forest-dwelling vertebrate species (Table 1.29).

[46] 'Extant' means still living, not extinct.

Table 1.29: Number of forest-dwelling vertebrate species, by jurisdiction[a]

Taxonomic group[b]	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Australia[c]
Fish	11	73	14	171	4	16	20	10	220
Amphibians	17	77	47	127	24	11	34	51	200
Reptiles	53	213	274	436	180	19	110	345	789
Birds	207	344	343	491	181	79	247	166	666
Mammals	46	120	110	198	92	40	97	139	336
Total, 2011	**334**	**827**	**788**	**1,423**	**481**	**165**	**508**	**711**	**2,212**
Total, 1998	–	504	449	582	–	125	485	239	1,227[d]
Total, 2001	8	780	439	1,214	462	131	415	646	1,817
Total, 2006	–	760	440	–	574[e]	137	513	226	–
Total, 2011	334	827	788	1,423	481	165	508	711	2,212

– = not available

[a] Forest-dwelling species are species that may use forest habitat for all or part of their lifecycles.

[b] Subspecies are included where they are managed by jurisdictions or nationally. Non-native species are not included.

[c] Numbers for Australia are less than the sum of numbers for each jurisdiction because many species occur in more than one jurisdiction. Numbers for Australia also include data from offshore forested islands—such as Torres Strait, Christmas, Lord Howe and Norfolk islands—which may not be reflected in individual state or territory figures.

[d] SOFR 1998 reported a national minimum estimate of forest-dwelling native vertebrate fauna, based on an incomplete compilation of data from New South Wales, the Northern Territory, Tasmania and parts of Queensland.

[e] Suspected incorrectly reported in SOFR 2008.

Source: National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences dataset of extant and extinct native vertebrate forest fauna, SOFR 1998, SOFR 2003, SOFR 2008, state and territory agencies.

Table 1.30: Number of forest-dependent vertebrate species, by jurisdiction, 2011[a]

Taxonomic group[b]	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Australia[c]
Fish	5	36	10	91	1	6	13	5	109
Amphibians	3	31	4	69	0	0	10	12	91
Reptiles	24	92	90	242	32	9	37	77	350
Birds	122	199	147	280	91	55	147	76	371
Mammals	32	68	49	131	38	27	53	49	180
Total	**186**	**426**	**300**	**813**	**162**	**97**	**260**	**219**	**1,101**

[a] Forest-dependent species are species that must inhabit a forest habitat for all or part of their lifecycles.

[b] Subspecies are included where they are managed by jurisdictions or nationally. Non-native species are not included.

[c] Numbers for Australia are less than the sum of numbers for each jurisdiction because many species occur in more than one jurisdiction. Numbers for Australia also include data from offshore forested islands—such as Torres Strait, Christmas, Lord Howe and Norfolk islands—which may not be reflected in state or territory figures.

Source: National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences dataset of extant and extinct native vertebrate forest fauna, state and territory agencies.

Numbers for Western Australia, except for fish, now relate to forest-dwelling species across the entire state, rather than solely its south-west forest region (as reported in previous SOFRs). An improved understanding of fish habitat has contributed to an increase in numbers of forest-dwelling fish species nationally. The greatest number of forest-dwelling vertebrate species in each taxonomic group, and in total, is found in Queensland.

A total of 1,101 known forest-dependent vertebrate species occur in Australia, as determined using information from a variety of sources. Table 1.30 shows their distribution by taxon and state and territory jurisdiction. Approximately half the forest-dwelling vertebrate species are forest dependent. The greatest number of forest-dependent vertebrate species in each taxonomic group, and in total, is found in Queensland.

These forest-dwelling and forest-dependent vertebrate species are found across a range of habitat types (Table 1.31). Thirty per cent of habitats used by forest-dwelling vertebrate species are in woodland or open forest, and the remaining six forest types represent 34% of habitats used. Non-forest habitats represent 36% of habitat types used. There are no substantial differences between taxon groups of forest-dwelling species in the extent to which they use forest versus non-forest habitats. Forests are naturally a more important habitat for forest-dependent species, with the eight forest habitats representing 85% of habitats used. Again, woodland and open forest are the most common habitat types used. Fish are the taxon group of forest-dependent species with greatest use of other habitat types.

Table 1.31: Percentage habitat use of forest-dwelling and forest-dependent vertebrate species

Habitat type	Forest dwelling: Fish	Amphibians	Reptiles	Birds	Mammals	Total	Forest dependent: Fish	Amphibians	Reptiles	Birds	Mammals	Total
Forest habitats												
Rainforest	7	10	6	6	9	7	11	23	17	11	17	14
Closed forest	1	9	3	7	5	5	1	22	9	13	11	10
Open forest	14	12	11	15	14	13	16	15	21	23	21	20
Woodland	15	12	21	16	17	17	15	8	24	17	20	19
Forested waterways	19	18	5	10	4	9	20	23	7	9	6	11
Mangrove	4	0	1	5	2	3	5	0	1	7	3	4
Other forest	9	5	12	6	8	9	10	5	6	4	4	6
Plantation	0	1	0	1	1	1	0	0	1	2	2	1
Non-forest habitats												
Arid	0	1	7	2	5	4	0	0	1	0	0	0
Marine and coastal	4	1	1	4	1	2	2	2	1	2	1	1
Alpine	0	1	0	0	1	0	0	0	0	0	1	0
Other woody vegetation	6	6	15	11	14	11	3	1	4	5	7	5
Grassland	5	12	10	8	10	9	2	0	2	1	3	2
Other non-forest	16	12	7	10	9	10	14	3	5	5	5	6
Total forest	**69**	**67**	**60**	**66**	**61**	**64**	**78**	**94**	**87**	**87**	**84**	**85**
Total non-forest	**31**	**33**	**40**	**34**	**39**	**36**	**22**	**6**	**13**	**13**	**16**	**15**

Notes:

Each species was allocated up to six habitat type descriptions based on habitat records. For each taxon group, the recorded allocations to each habitat type were then expressed as a percentage of the total recorded habitat type allocations for that taxon group.

Forest habitats are grouped into rainforest, closed forest, open forest, woodland dominated by eucalypts (including *Corymbia* and *Angophora*), forested waterways, mangroves, other forest (forest and woodland dominated by *Acacia*, *Casuarina*, *Callitris* or non-eucalypt species), and plantations (see Indicator 1.1a for descriptions and distribution). 'Forested waterways' includes riparian forests and woodlands, swamp forests, fringing forests around water features, and aquatic habitats found within rainforest, forest and woodland ecosystems; examples are creeks, rivers, seepage areas, swamps, wetlands, soaks, small lakes and dams. Non-forest habitats are grouped into arid (includes both arid and semi-arid ecosystems), marine and coastal (includes marine and wetland environments), alpine, other woody vegetation (includes open woodland, heathland and shrubland), grassland, and other non-forest (includes non-forest waterways and wetlands, rock outcrops, mudflats, farmland).

Totals may not tally due to rounding.

Source: National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences dataset of native vertebrate forest fauna, state and territory agencies.

Forest-dwelling and forest-dependent vascular plant species

All states and territories have lists of forest-dwelling plant species, but data on the number of known forest-dwelling vascular plant species are incomplete. A national minimum estimate of 13,622 forest-dwelling vascular plants, based on a compilation of data from New South Wales, the Northern Territory, Tasmania and parts of Queensland, was reported in SOFR 1998. The complete number of forest-dwelling vascular plant species nationally in 2011 remains unknown because the national list has yet to be finalised. A national database based on state and territory listings contains 16,836 forest-dwelling vascular plants (Table 1.32) but is known to be incomplete. Queensland has reported 8,470 such species, the most of any jurisdiction, representing 50% of the known forest-dwelling vascular plant species. Numbers across state jurisdictions have increased slightly since their reporting in 2006 (for Queensland, since 2001), because states continue to find more plant species occurring in forests. The Northern Territory reported a small decrease since 2006, which reflects improved information rather than changes in forest species composition.

The Australian Capital Territory reported a comprehensive list of forest-dwelling plant species for the first time.

The number of forest-dependent vascular plant species is not currently calculated from the number of forest-dwelling vascular plants, either by state and territory jurisdiction or nationally.

Black or tiger orchid (*Cymbidium canaliculatum*), found in woodland forests in the north of Australia.

Table 1.32: Number of forest-dwelling vascular plant species, by jurisdiction

Reporting date	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA[a]	Australia[b]
2011	1,551	7,472	3,854	8,470	2,453	1,034	2,913	3,313	16,836
2006	n.r.	7,461	3,970	n.r.	2,306	1,017	2,853	3,000	n.r.
2001	4	7,448	4,042	8,443	2,346	908	2,872	3,178	16,532
1998	–	–	1,691	7,830	–	1,043	2,959	2,639	13,622

– = not available; n.r. = not reported

a South-west Western Australia only.

b Numbers for Australia are less than the sum of numbers for each jurisdiction because many species occur in more than one jurisdiction.

Source: National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences dataset of forest flora, SOFR 1998, SOFR 2003, SOFR 2008, state and territory agencies.

Level of ecological knowledge

Conservation management mechanisms carried out as part of the Regional Forest Agreement process (see Indicator 7.1a), plus specific surveys of rare, threatened or endangered species, have been important in increasing knowledge of forest-dwelling species. Increased knowledge of populations and distributions of some threatened species has resulted in them no longer being classified as "threatened" and hence being removed from threatened species lists (see Indicator 1.2b). The number of species for which ecological knowledge is considered to be adequate is also increasing as a result of scientific surveys and studies, and regional planning exercises, especially for species that are considered under threat. As more surveys are undertaken, it is likely that species will be found in areas where they were previously unknown and, occasionally, that species previously unknown to science will be discovered.

There are no comprehensive lists of the invertebrate fauna, fungi, lichens, algae or microorganisms that occur in forests, even though they play key roles in ecological processes. The overall level of knowledge about these species is low, and priority is given to species listed in regulation or management plans. There are probably well over 100,000 terrestrial invertebrate species, of which only a small fraction have been described (SOFR 2008). The overall level of knowledge of non-vascular plants is also poor.

To date, south-west Western Australia and the Huon region of southern Tasmania are the only forest regions within Australia with a comprehensive list of forest-dwelling invertebrate species and non-vascular plants. Western Australia is collecting comprehensive information on lesser studied fauna and flora groups in the south-west through Forestcheck (see Case study 1.3 and also the special issue of *Australian Forestry*, Volume 74, December 2011). This should result in the development of a more comprehensive list of forest-dwelling invertebrates and non-vascular plants in the south-west of the state; SOFR 2003 reported an incomplete list of 1,992 forest-dwelling invertebrates occurring in south-west Western Australia alone. The Tasmanian Forest Insect Collection contains more than 216,000 beetle specimens of more than 2,200 species from Tasmanian forests; more than 60% of these species remain to be formally identified—many are undescribed. The website for this collection[47] contains a page for each species, with details of ecology, morphology and distribution. The collection specialises in beetle biodiversity, particularly saproxylic (log-dwelling) and ground beetles. Species lists for many taxa, including lichens, fungi and non-vascular plants, are also maintained for the Warra Long-term Ecological Research site in southern Tasmania.[48]

Table 1.33 illustrates the level of ecological knowledge about forest-dwelling animal and plant species. Knowledge varies markedly across taxa, but at least partial information is available for the majority of vertebrate and vascular plant species. State and territory agencies reported that confidence was greatest in the level of information for species occurring in areas where comprehensive regional assessments have been undertaken. All states and territories reported that confidence was low in the level of knowledge for invertebrates and non-vascular plants. The level of knowledge about amphibians has generally increased, as a result of heightened concerns about declines in the populations of frog species, many of which now have been given threatened species classification in state, territory or national legislation (see Indicator 1.2b). Taxonomic and habitat knowledge of reptiles, bats and fish has increased in quantity and improved in quality since SOFR 2008. Although there have been taxonomic changes and an improved understanding of the distribution of reptiles and fish, there has also been a reduction in assessed level of ecological knowledge for these taxonomic groups compared with that reported in SOFR 2008.

For all taxa for which ecological information is minimal or inadequate, risk assessments are necessarily based on information about better studied, closely related taxa in similar ecological niches. Management strategies can rely on general conservation measures, such as additions to the national reserve system (see Indicator 1.1c), additional environmental protection measures, and measures that provide for the maintenance of ecosystem processes.

47 www.tfic.net.au.

48 www.warra.com.

Table 1.33: Assessed level of ecological knowledge on forest-dwelling species, by taxonomic group

		Assessed knowledge level		
		Minimal or inadequate information available to inform management decisions[a]	Partial information available, but some crucial information may be absent or limited[b]	Comprehensive or adequate information available to inform management decisions[c]
Taxonomic group	**Number of forest-dwelling species assessed**	**% of species to which knowledge level applies**		
Invertebrates				
Insects	–[d]	85	11	4
Other arthropods	–[d]	90	8	3
Non-arthropods	–[d]	90	8	3
Fish	215	95	1	4
Amphibians	194	39	47	14
Reptiles	763	61	32	7
Birds	657	35	39	26
Mammals	343	30	56	14
Vascular plants	16,836	65	29	6
Non-vascular plants	–[d]	85	15	0

a Information limited to species taxonomic identification, with no or very limited knowledge of past and present distribution and population trends.

b Knowledge of at least broad habitat requirements and population trends.

c Knowledge of life history parameters, habitat requirements and distribution, and population status and trends.

d Only taxa listed as threatened by state and territory jurisdictions or the *Environment Protection and Biodiversity Conservation Act 1999* were assessed.

Note: Each state and territory was asked to assess the level of knowledge available for species by taxonomic group according to the descriptions in notes a, b and c. Figures are the mean of all responses; incomplete, unknown or uncertain responses are included under 'minimal or inadequate information' (except for arthropods, non-arthropods and non-vascular plants where incomplete, unknown or uncertain responses are not included). Figures are indicative and reflect subjective national understanding of ecological knowledge of taxonomic groups.

Source: Based on state and territory responses to SOFR 2008 and SOFR 2013. The New South Wales response to SOFR 2008 for vertebrate species lists Lunney et al. (2000) as a key reference for its response.

Eastern forest bat (*Vespadelus pumilus*), a forest-dwelling bat commonly found in Australia's forests.

Red-browed finch (*Neochmia temporalis*), southeast Queensland.

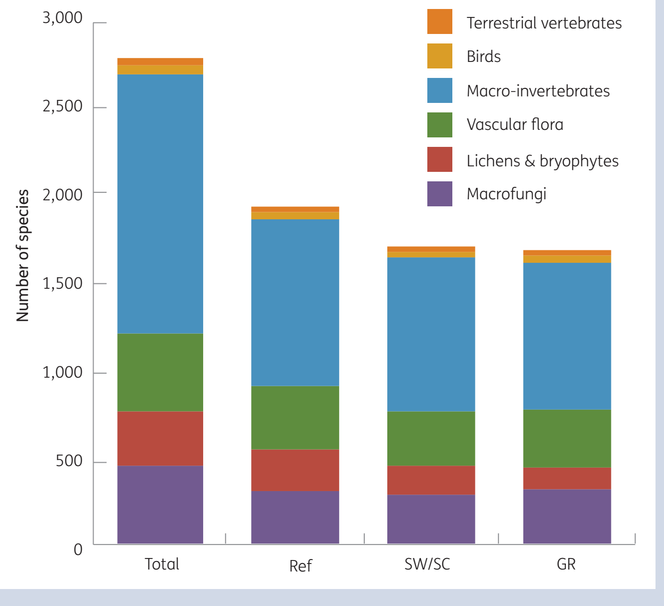
Case study 1.3: The Forestcheck project: integrated biodiversity monitoring in jarrah forest

Forestcheck is an integrated monitoring system designed to support forest management in the south-west of Western Australia. It provides information about changes and trends in key elements of forest biodiversity associated with management activities, including wood harvesting and silvicultural treatments in jarrah (*Eucalyptus marginata*) forest.

Forty-eight monitoring grids have been established throughout the range of the jarrah forest. Sets of grids are assessed on a five-yearly basis for attributes including forest structure, soil condition and levels of litter and coarse woody debris. Elements of biodiversity are also assessed, including vascular flora, vertebrate fauna (birds, mammals and reptiles), cryptogams (lichens, liverworts and mosses), macrofungi and invertebrate fauna. Grids in forest subjected to shelterwood/selective cut or gap-release silvicultural treatments during the period 1988–2002 have been compared with grids in forest that has never been harvested or that was subject to harvest more than 40 years ago.

To date, the grids have been monitored twice each—once between 2001 and 2006, and once between 2007 and 2012. Results from the analysis of data collected between 2001 and 2006 were recently published. More than 2,500 species were recorded. Few significant impacts of treatments were evident, and most species groups were resilient to the disturbances imposed. Silviculture treatments had little impact on species richness (Figure 1.18), but the species composition of communities in harvested treatments was different. Silvicultural disturbance was associated with increased species richness for fungi on wood and decreased species richness for cryptogams. Cryptogams (especially lichens; Figure 1.19) were the species group most sensitive to disturbance, although recovery of species richness was nearly complete 10 years after disturbance. The lack of fox baiting on some grids had a greater impact on terrestrial vertebrates than did silviculture treatments.

Figure 1.18: Species richness of all biodiversity groups recorded in each treatment



Ref = forest that has never been harvested or has not been harvested for 40 years or more; SW/SC = shelterwood and selective cut treatment; GR = gap-release treatment.

Source: Western Australian Department of Environment and Conservation.

Figure 1.19: *Tephromela alectoronica*, a crustose lichen associated with mature trees and large-diameter logs

For all species groups studied, the species compositions on grids in forest harvested 40 or more years earlier were indistinguishable from those on grids in forest that had never been harvested. Very few taxa were sufficiently widespread or sufficiently responsive to silvicultural disturbance to be of value as bio-indicators, demonstrating the benefit of biodiversity monitoring over bio-indicator monitoring. Data from the second round of monitoring are currently being analysed. All annual reports for monitoring are available at www.dec.wa.gov.au[49].

[49] Now see either www.dpaw.wa.gov.au or www.der.wa.gov.au.

Indicator 1.2b

The status of forest dwelling species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment

Rationale

This indicator measures the conservation status of nationally listed threatened forest dwelling species. Documentation of this information over time allows analysis of changes to species' conservation status, indicating the extent to which forest species biodiversity is being maintained.

Key points

- A total of 1,431 forest-dwelling species are on a national list of threatened species under the national *Environment Protection and Biodiversity Conservation Act 1999*. These comprise 283 vertebrates, 32 invertebrates and 1,116 vascular plants.
- During the reporting period, 89 forest-dwelling species were added to the national list of threatened species and 21 removed from the list. Most additions of forest-dwelling species to the national list of threatened species over the reporting period were based on inherently small population sizes and/or ongoing impacts on habitat extent and quality, including impacts of introduced species and unsuitable fire regimes. Most removals of forest-dwelling species from the national list over the reporting period were a result of improved information that indicated that the species was not threatened.
- Seven forest-dwelling plant species previously categorised as Extinct were rediscovered over the reporting period, and their status was changed to Critically Endangered or Vulnerable.
- Historical land-use change and forest loss caused by clearing for agriculture, grazing, and urban and industrial development has been the most significant threat to nationally listed forest-dwelling faunal species, followed by predation from introduced predators (e.g. fox, cat, rat and trout).
- Small population size and localised distribution are the most significant threats to threatened forest-dwelling plants, followed by mortality agents (including illegal collection, recreational pressure, pressures from urban edges, and genetic or breeding issues) and unsuitable fire regimes.
- Forestry operations pose a minor threat to nationally listed forest-dwelling fauna and flora species compared with other identified threats.
- States and territories have formal threat abatement plans in place to reduce the impacts of key threatening processes on threatened species.

Protecting listed threatened species and ecological communities

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Australian Government's principal piece of environmental legislation. Among other things, it is designed to protect Australia's native species and ecological communities by providing for:

- identification and listing of threatened[50] species and ecological communities
- development of conservation advice and, where appropriate, recovery plans for listed species and ecological communities
- development of a register of critical habitat
- identification and listing of key threatening processes[51]
- development of threat abatement plans to reduce the impacts of threatening processes where appropriate.

At the end of 2012, the EPBC Act listed 19 key threatening processes, 16 of which relate directly to threats to forest ecosystems. The listed key threatening processes to forest ecosystems are presented in Table 1.34. These are separate from the particular threats identified in individual species listing statements discussed above. One or more of the forest-related key threatening processes feature in the listing advice for each threatened forest-dwelling fauna and flora species and ecological community.

50 'Threatened' is a general term covering the formal categories of Extinct, Critically Endangered, Endangered and Vulnerable.

51 Threats to species are natural, human-induced or human-exacerbated factors or processes that increase the risk of population reduction or extinction. Threatening processes to species are natural, human-induced or human-exacerbated processes that increase the risk of population reduction or extinction.

All states and territories maintain legislation to protect native species of flora and fauna, including forest-dwelling and forest-dependent species. Recent changes in forest-related legislation, including those related to the protection of threatened species, are reported in Indicator 7.1a.

The EPBC Act requires the establishment of national lists of threatened species, key threatening processes and threatened ecological communities. Listing of species, processes or ecological communities is administered through a scientific assessment process overseen by the Threatened Species Scientific Committee. Once a species or ecological community is listed under the EPBC Act, its recovery is promoted using conservation advice, recovery plans where appropriate, and the assessment and approval provisions outlined in the EPBC Act. Recovery plans set out the research and management actions that are necessary to stop the decline of, and support the recovery of, listed threatened species or ecological communities, including the identification of critical habitat. The aim of a recovery plan is to maximise the long-term survival in its natural environment of the species or ecological community. Threat abatement plans are used to ameliorate key threatening processes. Under Regional Forest Agreements, states have made commitments to provide for the protection of listed threatened species.

Australia's Biodiversity Conservation Strategy 2010–2030 (NRMMC 2010) provides national direction for protection of Australia's biodiversity, including threatened species. *Australia's Native Vegetation Framework* (COAG Standing Council on Environment and Water 2012) guides the ecologically sustainable management of Australia's native vegetation, and provides national goals and targets to improve the extent, connectivity, condition and function of native vegetation.

Distribution of threatened forest-dwelling and forest-dependent species

Forest-dwelling species are species that occur in forest vegetation types, although they may also occur outside forests. As at December 2012, 1,352 extant (i.e. living, not extinct) forest-dwelling species were listed under the EPBC Act as Critically Endangered, Endangered or Vulnerable, and 79 species (including subspecies) were listed as Extinct (Table 1.35). Of this total of 1,431 species listed in the various categories of threatened, 283 were vertebrates, 32 were invertebrates, and 1,116 were vascular plants. A total of 44 forest-dwelling vertebrate fauna species and 35 forest-dwelling flora species are known to have become extinct since European settlement. No forest-dwelling species are known to have become extinct during the SOFR reporting periods.

Figure 1.20 shows the distribution of threatened forest-dwelling fauna and flora species across Australia. The number of listed forest-dwelling species per unit area is highest in wet coastal areas, where species diversity is also high.

Forest-dependent species are species that require a forest habitat for at least part of their lifecycles. There are 159 fauna and 684 flora species identified as threatened forest-dependent species. Figure 1.20 also indicates the distribution of threatened forest-dependent fauna and flora species across Australia. As for forest-dwelling species, the number of listed forest-dependent species per unit area is highest in wet coastal areas.

Table 1.34: Listed key threatening processes affecting forest-dwelling threatened species

Key threatening process	Effective date
Competition and land degradation by rabbits	16 July 2000
Competition and land degradation by unmanaged goats	16 July 2000
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	16 July 2000
Predation by European red fox	16 July 2000
Predation by feral cats	16 July 2000
Land clearance	4 April 2001
Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases	4 April 2001
Psittacine circoviral (beak-and-feather) disease affecting endangered psittacine species	4 April 2001
Predation, habitat degradation, competition and disease transmission by feral pigs	6 August 2001
Infection of amphibians with chytrid fungus, resulting in chytridiomycosis	23 July 2002
Reduction in biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta*	2 April 2003
Loss of biodiversity and ecosystem integrity following invasion by the yellow crazy ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean	12 April 2005
Biological effects, including lethal toxic ingestion, caused by cane toads (*Bufo marinus*[a])	12 April 2005
Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 hectares)	29 March 2006
Invasion of northern Australia by gamba grass and other introduced grasses	16 September 2009
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	8 January 2010

[a] Now known as *Rhinella marina*.

Note: Key threatening processes are as listed in the EPBC database.

Source: www.environment.gov.au/cgi-bin/sprat/public/publicgetkeythreats.pl.

Table 1.35: Threatened forest-dwelling species listed under the EPBC Act, by taxonomic group

	Threatened					Non-threatened	Total[a]	Proportion of taxa threatened (%)
Taxonomic group	Extinct	Critically Endangered	Endangered	Vulnerable	Total			
Mammals	20	4	26	48	98	238	336	29
Birds	19	4	34	28	85	581	666	13
Reptiles	0	2	11	26	39	750	789	5
Amphibians	4	3	15	11	33	167	200	17
Fish	1b	3	13	11	28	192	220	13
Total vertebrates	**44**	**16**	**99**	**124**	**283**	**1,928**	**2,211**	**13**
Invertebrates	**0**	**19**	**7**	**6**	**32**	**n.a.**	**n.a**	**n.a**
Vascular plants[a]	**35**	**79**	**418**	**584**	**1,116**	**n.a**	**n.a**	**n.a**
Total taxa	**79**	**114**	**524**	**714**	**1,431**	**n.a**	**n.a**	**n.a**

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; n.a = not available

a Threatened vascular plants include clubmosses, horsetails, ferns, gymnosperms (including conifers) and angiosperms (flowering plants).

b Pedder galaxid (*Galaxias pedderensis*) is listed as 'Extinct in the wild' to recognise captive populations.

Notes:

Species were determined to be 'forest-dwelling' if they were known to occur, were likely to occur or might possibly occur in vegetation types designated as being forest communities in the National Vegetation Information System, or were identified as forest-dwelling in National Forest Inventory datasets. Listed subspecies or races are reported separately. In some cases a more narrow definition of 'forest-dwelling' was used in previous SOFRs.

Figures include species found on forested islands.

The total number of forest-dwelling invertebrate and plant species is unknown.

Source: Environmental Resources Information Network Species of National Environmental Significance Database, available at www.environment.gov.au/metadataexplorer/explorer.jsp; National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences datasets of extant and extinct native vertebrate forest fauna, vascular forest plants and invertebrate forest fauna.

Threatening processes relating to forest fauna and flora

Table 1.36 provides an assessment of primary, secondary and tertiary threats for all forest-dwelling EPBC-listed threatened species, including Extinct species, based on current listing advice.

Land-use change and forest loss caused by clearing for agriculture, grazing, urban and industrial development has been the most significant threat for fauna species, followed by predation from introduced predators (e.g. fox, cat, rat and trout). Other significant threats are population size and localised distribution, competition from introduced fauna (e.g. rabbits, house mouse, foxes, cats, rats, trout, pigs and goats, and domestic livestock), mortality agents and unsuitable fire regimes. Disease and pathogens, indirect impacts of invasive species, forestry operations, hydrological changes and climate effects are comparatively smaller threats for forest fauna.

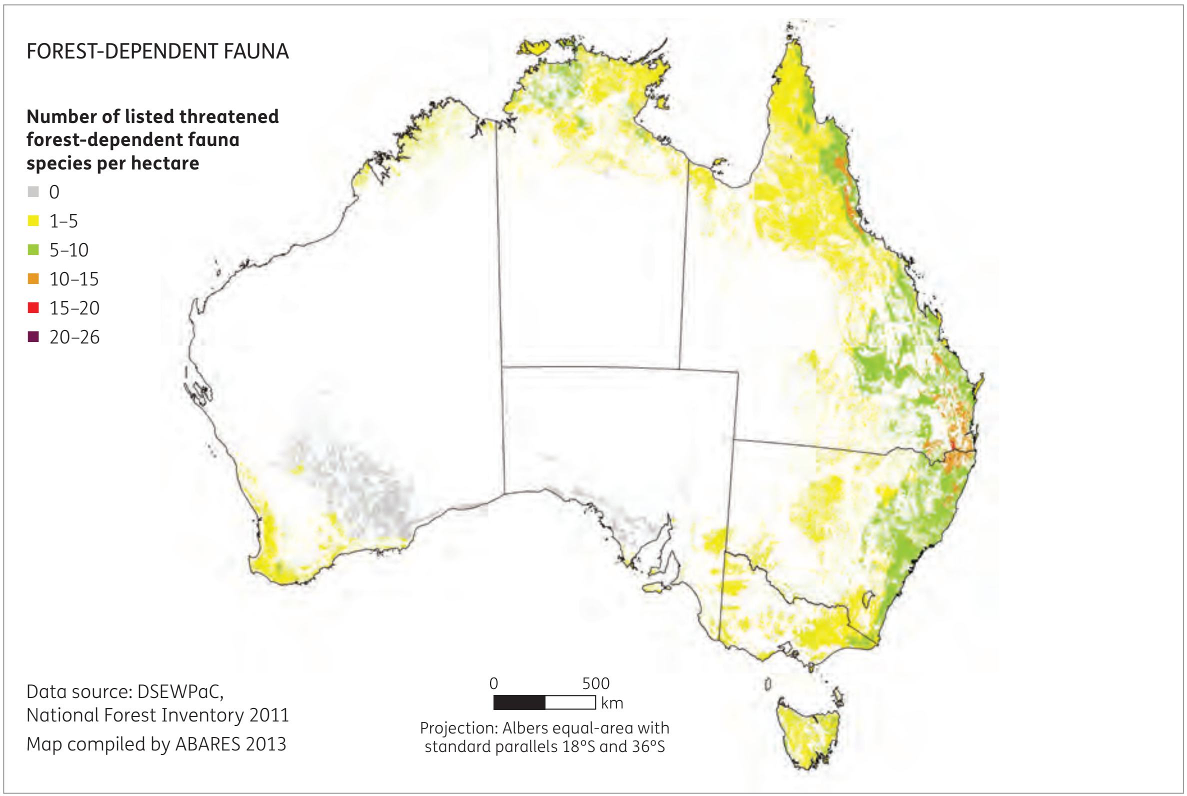
Small population size and localised distribution of threatened forest-dwelling plants is the most significant threat for threatened flora, followed by mortality agents and unsuitable fire regimes. Competition from introduced flora (primarily invasive and non-invasive weeds, and escaped pasture grasses), land-use change and forest loss, impacts of invasive species (e.g. rabbits, goats, pigs, buffalo and invasive weeds such as lantana and blackberry) and predation and grazing (primarily grazing by domestic livestock, rabbits and macropods) are also significant threats. Hydrological changes, disease and pathogens, climate effects and forestry operations are comparatively smaller threats for forest flora.

Unsuitable fire regimes include infrequent fire, too frequent fire, wildfire, lack of management of fire and, for flora, inappropriate intensity of fire. Fire regimes are an intrinsic part of forestry management activities and are applied widely across Australia's forests. Where fire is used in forestry operations and is an identified threat, the listings have been included under both 'unsuitable fire regime' and 'forestry operations'. However, forestry operations are a minor threat to threatened forest fauna and flora, compared with other identified threats.


Richard Thackway

Land clearance (here, land-use change and forest loss for agriculture) has been identified as a major threat to flora and fauna.

Figure 1.20: Distribution of threatened forest-dwelling and forest-dependent fauna and flora species



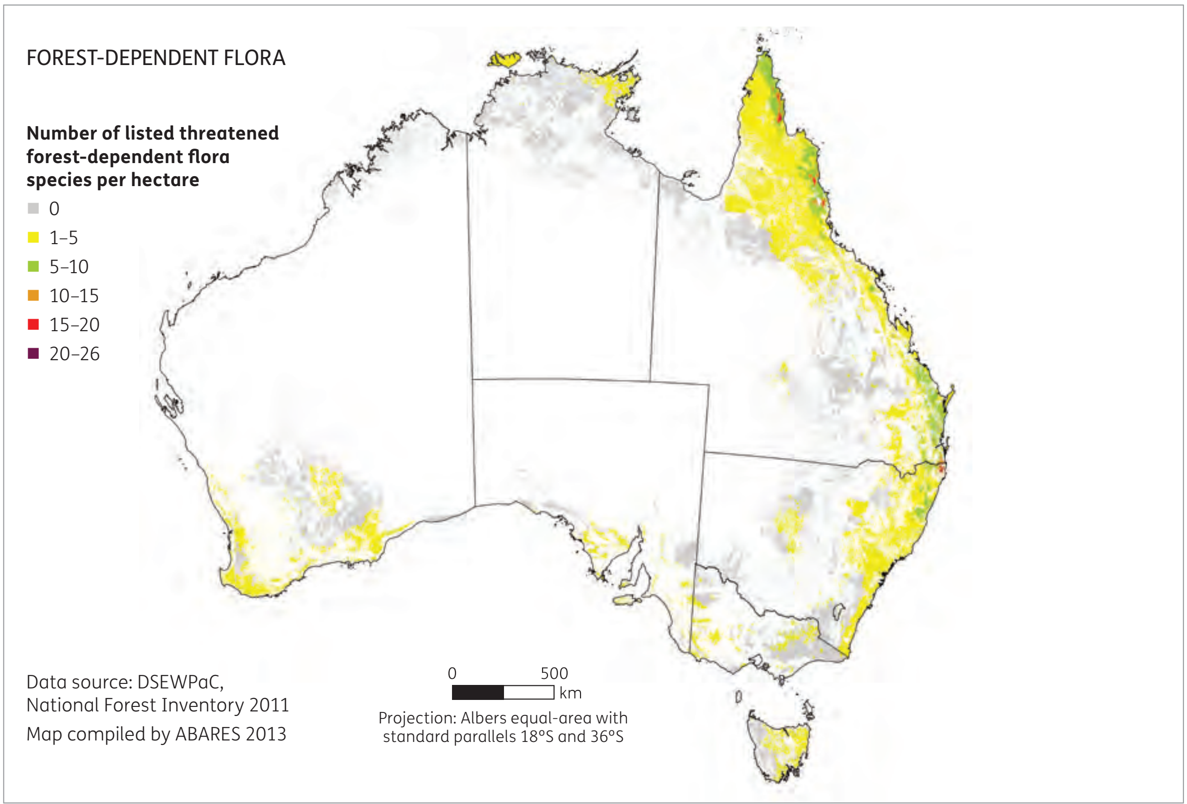
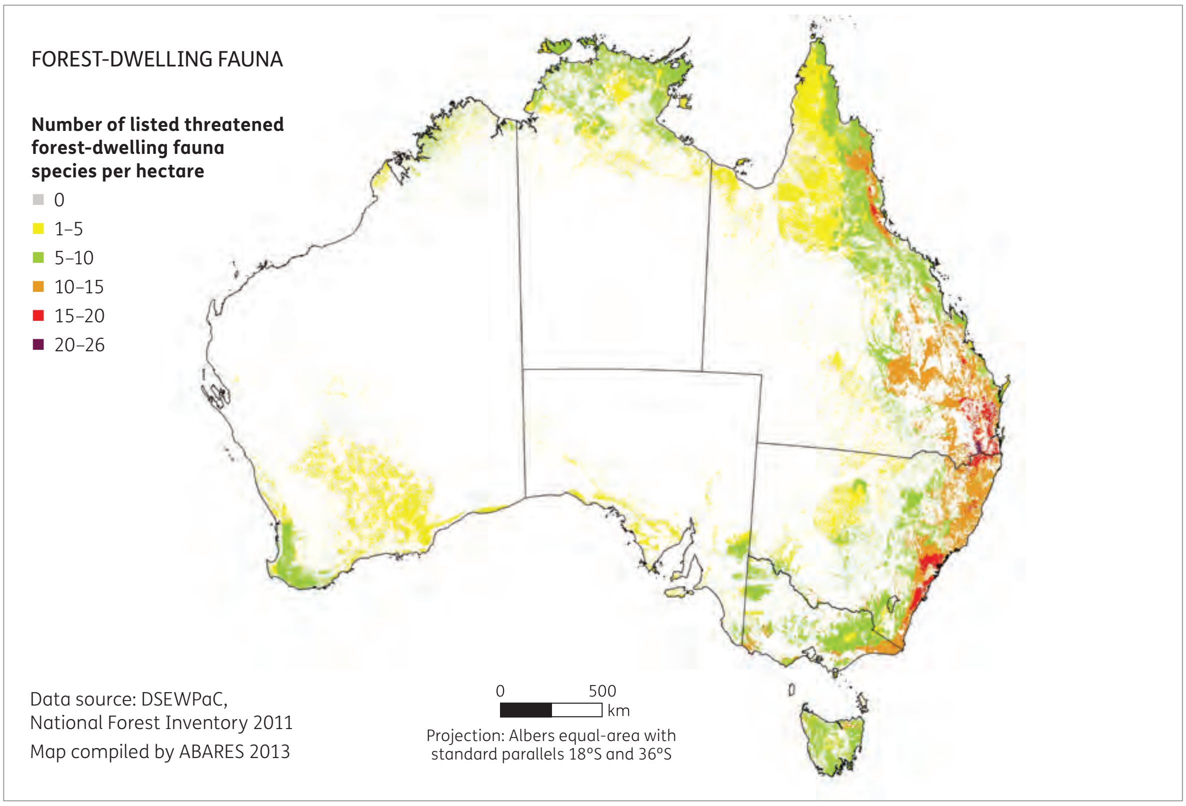
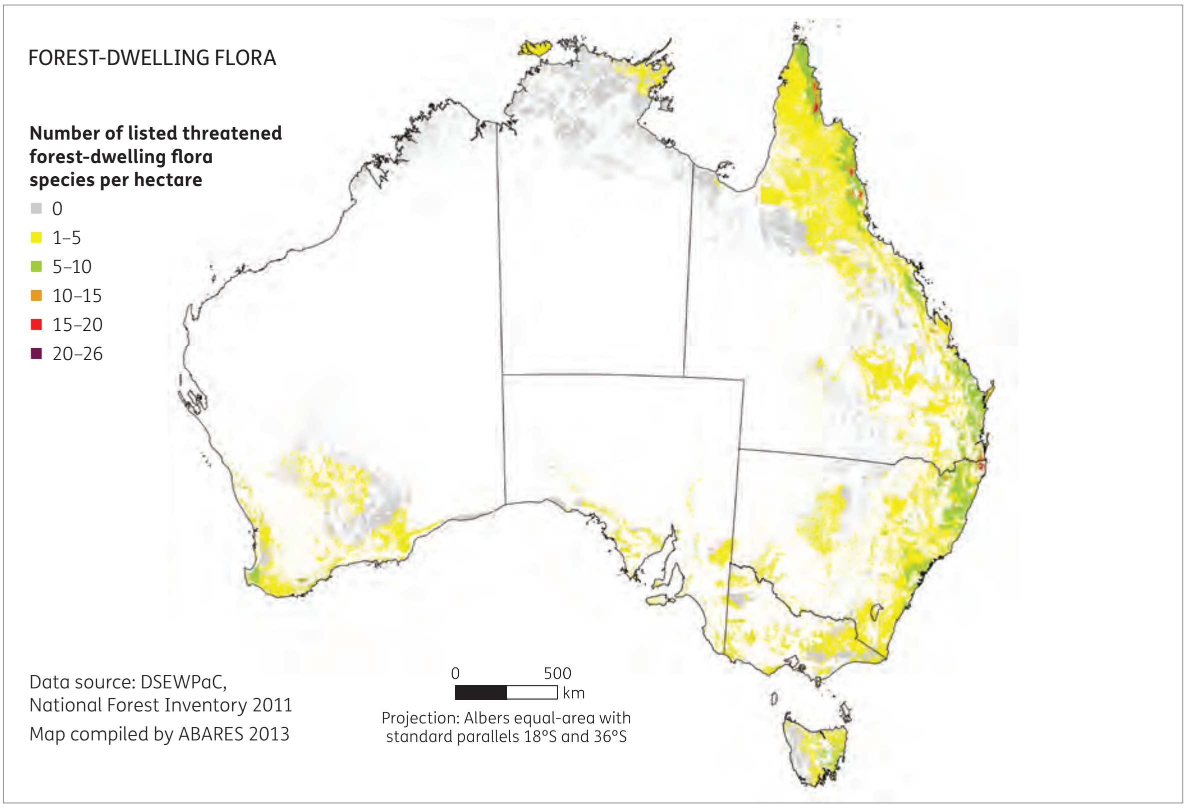


Figure 1.20: Distribution of threatened forest-dwelling and forest-dependent fauna and flora species continued





Notes:

Fauna include both vertebrate and invertebrate taxa.

Species were determined to be forest dependent if they are known to require, are likely to require, or if extinct are likely to have required, vegetation types designated as being forest communities in the National Vegetation Information System, or were reported as forest dependent by national, state or territory agencies. Map shows the modelled potential coincidence of threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* with the 2013 forest extent (National Forest Inventory), including areas where the species are known to occur, areas where they are likely to occur, and areas where they may occur.

Source: Environmental Resources Information Network Species of National Environmental Significance Database.

Table 1.36: Threats to forest-dwelling threatened species

Fauna (invertebrate and vertebrate)	Number of species for which threat was specified				
Description of threat	**Primary threat**	**Secondary threat**	**Tertiary threat**	**Total**	**Proportion of total specified threats (%)**
Land-use change and/or forest loss[a]	139	41	5	185	17.1
Predation by introduced fauna	78	46	42	166	15.3
Mortality agents[b]	34	54	30	118	10.9
Small or localised population	96	17	1	114	10.5
Competition from introduced fauna[c]	38	62	16	116	10.7
Unsuitable fire regime[d]	37	52	19	108	10.0
Disease and/or pathogens	23	14	28	65	6.0
Indirect invasive species impacts[e]	12	36	16	64	5.9
Hydrological change	26	22	9	57	5.3
Forestry operations[f]	20	18	11	49	4.5
Climatic effects[g]	7	24	11	42	3.9

Flora	Number of species for which threat was specified				
Description of threat	**Primary threat**	**Secondary threat**	**Tertiary threat**	**Total**	**Proportion of total specified threats (%)**
Small or localised population	612	205	25	842	15.2
Mortality agents[h]	495	240	9	744	13.4
Unsuitable fire regime[d]	419	287	17	723	13.0
Competition from introduced flora[i]	447	187	6	640	11.5
Land-use change and/or forest loss[a]	487	151	1	639	11.5
Invasive species impacts[e]	406	171	4	581	10.5
Predation and grazing[j]	421	137	5	563	10.1
Hydrological change	138	128	1	267	4.8
Disease and/or pathogens	75	139	14	228	4.1
Climatic effects[g]	59	112	1	172	3.1
Forestry operations[f]	63	72	13	148	2.7

a ‘Land-use change and/or forest loss’ includes forest conversion and forest clearing resulting from agriculture, mining operations, and urban and industrial development (excluding plantation developments).

b For fauna, ‘mortality agents’ include hunting, illegal collection, agricultural chemical poisoning, competition and predation from native fauna, road-kill, and genetic or breeding issues.

c ‘Competition from introduced fauna’ can include Australian fauna introduced to a locality.

d An unsuitable fire regime (flora and fauna) can include infrequent fire, too frequent fire, wildfire, lack of management of fire and (for flora) inappropriate intensity of fire.

e Invasive species include pest fauna and weeds. The threat rating is based on the emphasis given to that impact in the listing.

f ‘Forestry operations’ are operational forest management activities related to wood production such as silviculture, harvesting, forest roading, fire management relating to wood production, plantation operations and development, and indirect or off-site effects, including escaped plantation species.

g Climatic effects include climate change, climate variability, drought, winds and cyclonic impacts.

h For flora, ‘mortality agents’ include illegal collection, agricultural chemical poisoning, road pressures (e.g. mowing), human pressures (e.g. dumping, recreational pressure, pressures from urban edge), competition from native flora, and genetic or breeding issues.

i ‘Competition from introduced flora’ includes weeds, pasture plants and Australian flora introduced to a locality, but excludes off-site escaped plantation species.

j ‘Predation and grazing’ includes grazing by introduced and native herbivores, and vertebrate predation of seeds or plants.

Notes:

Classification of threats into primary, secondary and tertiary threats is based on the emphasis given in the listing advice to past and current threat impacts. More than one threat of each category may affect a species.

Totals may not tally due to rounding.

Source: Environmental Resources Information Network Species of National Environmental Significance Database available at www.environment.gov.au/metadataexplorer/explorer.jsp; National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences datasets of extant and extinct native vertebrate forest fauna, vascular forest plants and invertebrate forest fauna.

Changes in conservation status in reporting period

Since SOFR 2008, a number of changes in the national listing of threatened forest-dwelling species have occurred. The conservation status of 107 listed species was amended during the SOFR 2013 reporting period. Of these, 9 were moved into a category corresponding to a higher level of threat, 13 were moved into a category corresponding to a lower level of threat, 64 were updated but remained in the same category (Table 1.37), and 21 were removed from the list (Tables 1.38 and 1.39). There were also 89 additions to the list (Tables 1.40 and 1.41). Seven forest-dwelling vascular plant species that were previously reported as Extinct were rediscovered in the past decade as a result of increased survey efforts; of these, six were transferred from Extinct to Critically Endangered, and one was transferred from Extinct to Vulnerable.

Seventeen of the removals from the list of threatened forest-dwelling species were plants, including a plant previously listed as Extinct, and four of the removals were vertebrates (Table 1.38). The plant previously listed as Extinct was removed because of uncertainty about its taxonomic status. Removal of 76% of species was because of better information about species populations, distributions or ecology; 24% were removed because they were not scientifically recognised as a result of taxonomic revisions (Table 1.39).

Just over 50% (46 of 89) of the new listings of forest-dwelling vertebrates, invertebrates and plants were classed as Critically Endangered (Table 1.40).

An addition to the national list of threatened species, or the movement of a species to a higher risk category (e.g. from Vulnerable to Endangered), may indicate that additional steps need to be taken to ensure the survival of the species, such as improvements in the management regime or protection of additional habitat. However, because many listings (or non-listings) reflect changes in information, changes in the number of species listed need to be assessed with caution.

Most newly listed forest-dwelling fauna and flora species were added because of their small population size and/or restricted range, threats caused by land clearing (agricultural and urban), habitat degradation, mortality agents and unsuitable fire regimes (Table 1.41). Threats or impacts from land-use change were a primary reason in 66% of new listings of forest-dwelling fauna; these related primarily to agricultural and urban development and land clearing, rather than forestry operations. Small population size or localised distribution was a primary reason in 49% of the new faunal listings, and predation of fauna by introduced species was a primary factor in 38% of new listings.

Population size and distribution was a primary reason for listing in 88% of new listings of forest-dwelling flora. Land-use change and habitat loss was a primary reason in 74% of new flora listings; again, this related to agricultural and urban

Table 1.37: Forest-dwelling species on the national list of threatened species with changed rating during the SOFR 2013 reporting period

Change in rating	Invertebrate	Vascular plant[a]	Vertebrate	Total
Transferred up in category	0	4	5	9
Transferred down in category	0	13	0	13
Updated but remained in category	0	61	3	64
Total	**0**	**78**	**8**	**86**

[a] Threatened vascular plants include clubmosses, horsetails, ferns, gymnosperms (including conifers) and angiosperms (flowering plants).

Notes:

Species were determined to be forest dwelling if they were known to occur, were likely to occur or might possibly occur in vegetation types designated as being forest communities in the National Vegetation Information System, or were identified as forest dwelling in National Forest Inventory datasets. Listed subspecies or races are reported separately. A more narrow definition of forest dwelling may have been used in previous SOFRs.

Figures include species found on forested islands.

Reporting period is December 2007 to December 2012. The reporting period used in SOFR 2008 was January 2001 to December 2007.

Source: Environmental Resources Information Network Species of National Environmental Significance Database available at www.environment.gov.au/metadataexplorer/explorer.jsp; National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences datasets of extant and extinct vertebrate forest fauna, vascular forest plants and invertebrate forest fauna.

Table 1.38: Forest-dwelling species removed from the national list of threatened species during the SOFR 2013 reporting period

Taxa	Extinct	Critically Endangered	Endangered	Vulnerable	Total
Vertebrate fauna	0	0	0	4	4
Invertebrate fauna	0	0	0	0	0
Vascular plants[a]	1	0	3	13	17
Total	**1**	**0**	**3**	**17**	**21**

[a] Threatened vascular plants include clubmosses, horsetails, ferns, gymnosperms (including conifers) and angiosperms (flowering plants).

Notes:

Species were determined to be forest dwelling if they were known to occur, were likely to occur or might possibly occur in vegetation types designated as being forest communities in the National Vegetation Information System, or were identified as forest dwelling in National Forest Inventory datasets.

Figures include species found on forested islands.

Reporting period is January 2008 to December 2012. The reporting period used in SOFR 2008 was January 2001 to December 2007.

Source: Environmental Resources Information Network Species of National Environmental Significance Database available at www.environment.gov.au/metadataexplorer/explorer.jsp; National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences datasets of extant and extinct vertebrate forest fauna, vascular forest plants and invertebrate forest fauna.

Table 1.39: Reasons for the removal of forest-dwelling species from the national list of threatened species during the SOFR 2013 reporting period

Primary reason	Number delisted	Proportion of total number delisted (%)
Revised taxonomy or no longer considered valid species	5	24
Improved knowledge base to justify change in status	12	57
No longer considered to be in decline	3	14
No identified threat	1	5
Total	**21**	**100**

Notes:

Species were determined to be forest dwelling if they were known to occur, were likely to occur or might possibly occur in vegetation types designated as being forest communities in the National Vegetation Information System, or were identified as forest dwelling in National Forest Inventory datasets.

Only one primary reason is given for each delisting.

Source: Environmental Resources Information Network Species of National Environmental Significance Database available at www.environment.gov.au/metadataexplorer/explorer.jsp; National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences datasets of extant and extinct vertebrate forest fauna, vascular forest plants and invertebrate forest fauna.

Table 1.40: Forest-dwelling species added to the national list of threatened species during the SOFR 2013 reporting period

Taxa	Extinct	Critically Endangered	Endangered	Vulnerable	Total
Vertebrate fauna	0	4	10	14	28
Invertebrate fauna	0	14	3	2	19
Vascular plants[a]	0	28	8	6	42
Total	**0**	**46**	**21**	**22**	**89**

[a] Threatened plants include clubmosses, horsetails, ferns, gymnosperms (including conifers) and angiosperms (flowering plants).

Notes:

Species were determined to be forest dwelling if they were known to occur, were likely to occur or might possibly occur in vegetation types designated as being forest communities in the National Vegetation Information System, or were identified as forest dwelling in National Forest Inventory datasets.

Figures include species found on forested islands.

Reporting period is December 2007 to December 2012. The reporting period used in SOFR 2008 was January 2001 to December 2007.

Source: Environmental Resources Information Network Species of National Environmental Significance Database available at www.environment.gov.au/metadataexplorer/explorer.jsp; National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences datasets of extant and extinct vertebrate forest fauna, vascular forest plants, and invertebrate forest fauna.

development and land clearing, rather than forestry operations. Inappropriate fire regime was given as a primary reason in 50% of the new flora listings, but no primary threats relating to fire management associated with forestry operations were identified, even where forestry operations contributed to new listings (Table 1.41).

Case study 1.4 describes threats documented for the two listed subspecies of the red-tailed black-cockatoo (*Calyptorhynchus banksii*). The koala (*Phascolarctos cinereus*) (Australian Capital Territory, New South Wales and Queensland populations only) was listed as Vulnerable in 2012, and provides a case study of a forest-dependent species impacted by a range of threats (see Case study 1.9 in Indicator 1.3a).

Brush-tailed rock wallaby (*Petrogale pencillata*), listed as a Vulnerable species under the EPBC Act.

Table 1.41: Species added to the national list of forest-dwelling threatened species during the SOFR 2013 reporting period, and primary threats given as reasons for listing

Fauna species	**Extinct**	**Critically Endangered**	**Endangered**	**Vulnerable**	**Total**	**Proportion of new listings (%)**
Number of added fauna species (vertebrate and invertebrate)	**0**	**18**	**13**	**16**	**47**	**100**
Primary threat	**Number of added species for which primary threat was specified[a]**					**Proportion of new listings with this primary threat (%)**
Very small or localised population	0	16	7	0	23	49
Competition from introduced fauna	0	1	2	1	4	9
Disease and/or pathogens	0	0	2	1	3	6
Land-use change and/or habitat loss	0	11	10	10	31	66
Including forestry operations[b,c]	0	1	1	3	5	11
Not including forestry operations[b]	0	10	9	7	26	55
Predation by introduced fauna	0	11	5	2	18	38
Unsuitable fire regime[d]	0	2	4	5	11	23
Mortality agents[e]	0	3	6	7	16	34

Flora species	**Extinct**	**Critically Endangered**	**Endangered**	**Vulnerable**	**Total**	**Proportion of new listings (%)**
Number of added flora species	**0**	**28**	**8**	**6**	**42**	**100**
Primary threat	**Number of added species for which primary threat was specified[a]**					**Proportion of new listings with this primary threat (%)**
Very small or localised population	0	28	6	3	37	88
Weeds	0	13	4	0	17	40
Pathogens	0	3	1	2	6	14
Pest species[f]	0	7	3	1	11	26
Land-use change and/or habitat loss	0	23	6	2	31	74
Including forestry operations[b,c]	0	1	0	1	2	5
Not including forestry operations[b]	0	22	6	1	29	69
Overgrazing and/or overbrowsing	0	9	5	1	15	36
Unsuitable fire regime[f]	0	16	5	0	21	50
Mortality agents[g]	0	8	7	2	17	40

a More than one primary threat may affect a species.

b 'Forestry operations' include silviculture, harvesting, forest roading, fire management and its effect, plantation operations and development, and indirect or off-site effects, including escaped plantation species. Forestry operations are identified as a subset of the primary threats of land-use change and habitat loss. No fire management–related threats were identified as a primary threat where forestry operations contributed to new listings.

c Forestry operations were listed as a threat for only 7 species added to the national threatened species list during the period 2006–07 to 2010–11. These are the forest red-tailed black-cockatoo (*Calyptorhynchus banksii naso*) in western Australia; the masked owl (Tasmanian) (the Tasmanian population of *Tyto novaehollandiae castanops*); the blind velvet worm (*Tasmanipatus anophthalmus*), Vanderschoor's stag beetle (*Hoplogonus vanderschoori*) and Bornemissza's stag beetle (*H. bornemisszai*) in Tasmania; the blue top sun-orchid (*Thelymitra cyanapicata*) in south Australia; and the variable smoke-bush (*Conospermum hookeri*) in Tasmania. In each case, management prescriptions exist to mitigate the risks to these species from forestry operations.

d Unsuitable fire regimes (flora and fauna) can include infrequent fire, too frequent fire, wildfire, lack of management of fire and (for flora) inappropriate intensity of fire.

e For fauna, 'mortality agents' include human-induced impacts (e.g. fishing, illegal collection, agricultural chemical poisoning, road-kill), drought, natural events, competition and predation from native fauna, and genetic or breeding issues.

f 'Pest species' (flora only) can include feral animals (e.g. rabbits, goats, rats, pigs, buffalo), and feral animals and weeds in combination, but not weeds by themselves.

g For flora, 'mortality agents' include human-induced impacts (e.g. illegal collection, agricultural chemical poisoning, road pressures, dumping, recreational pressure, pressures from urban edge), drought, natural events, competition from native flora, and genetic or breeding issues.

Note: Primary threats from listing advice have been assembled into the primary threat categories shown in the table; secondary and tertiary threats have not been considered.

Source: Environmental Resources Information Network Species of National Environmental Significance Database available at www.environment.gov.au/metadataexplorer/explorer.jsp; National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences datasets of extant and extinct native vertebrate forest fauna, vascular forest plants and invertebrate forest fauna.

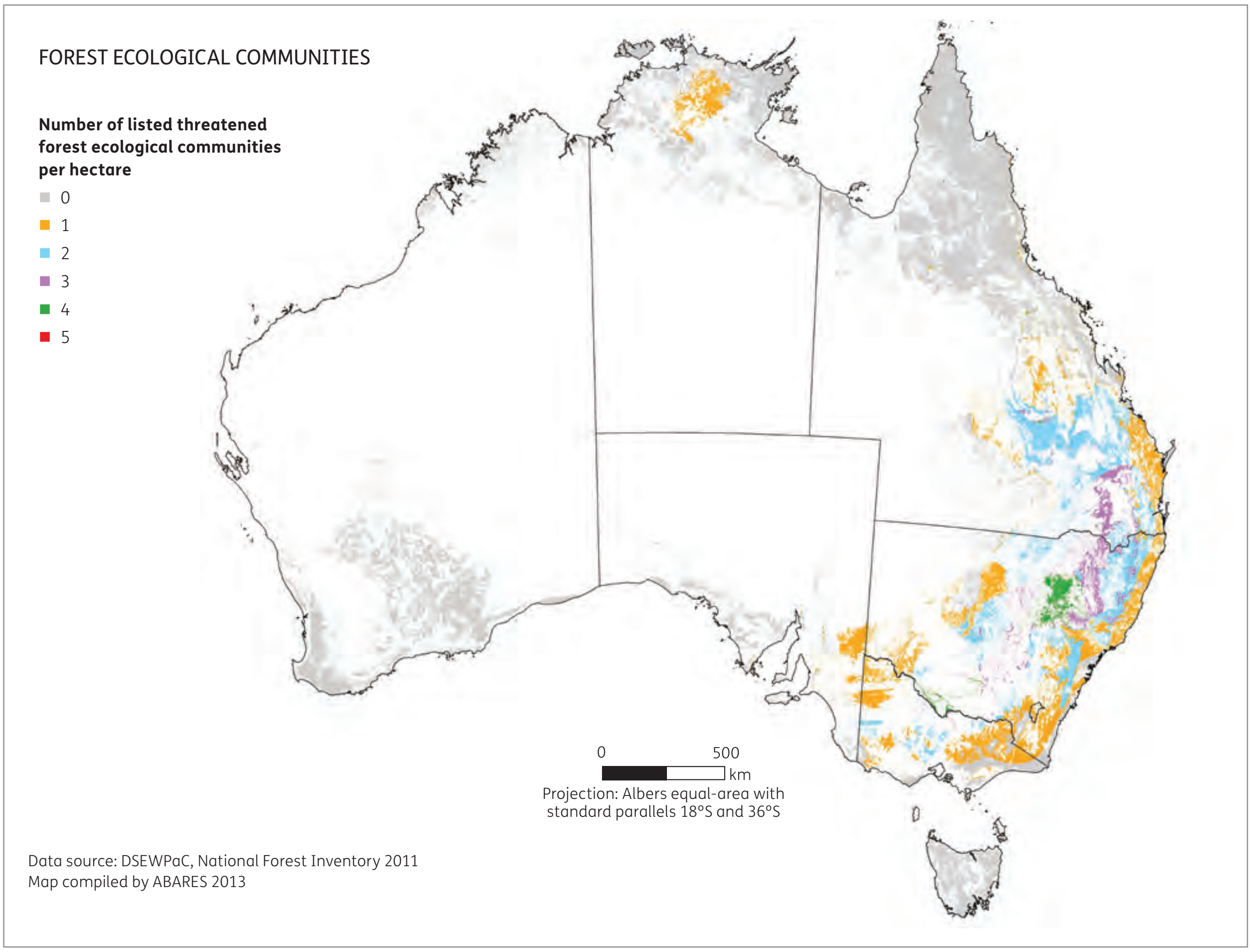
Threatened ecological communities

At December 2012, the EPBC Act listed 58 threatened ecological communities, of which 27 are forest communities or contain significant proportions of forest. Three threatened ecological communities that are non-forest communities, but contain small proportions of forest, have not been included in the set of 27 threatened forest communities. Of the 27 listed threatened ecological communities that contain forest, 13 are Critically Endangered, 13 are Endangered and 1 is Vulnerable.

Figure 1.21 presents the modelled potential distribution of threatened forest ecological communities (a community may cover more than one state or territory), calculated as a summed frequency of the listed threatened forest ecological communities that could occur at a site.[52] Nineteen threatened forest ecological communities occur in New South Wales, 13 in Queensland and 8 in Victoria; the other states and territories each have 5 or fewer (Table 1.42).

The historical and current threats listed for these 27 threatened forest ecological communities, based on listing and policy statements, are summarised in Table 1.43. Weeds, forest loss through agricultural clearance and grazing pressure (primarily by stock) are given as listing reasons in more than three-quarters of the forest ecosystems listed. Fragmentation, fire (inappropriate fire management or inappropriate fire regimes), feral animal pressures and impacts of hydrological change are identified in more than half of the listings. Human pressures, including urban fringe impacts (rubbish, recreation pressure, roading impacts and poor management) and pollutants, forest loss through urbanisation, and climatic impacts (drought and climate change) appear in 37% of the listings. Forestry operations appear in approximately one-third of the listings (nine listings), with seven of the nine referring to historical

Figure 1.21: Distribution of listed threatened forest ecological communities



Note: Map shows the modelled potential coincidence of threatened ecological communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* with the 2013 forest extent, including areas where the communities are known to occur, areas where they are likely to occur, and areas where they may occur. Some endangered ecological communities are restricted in extent and cannot readily be visualised at the scale of this map.

Source: Environmental Resources Information Network Species of National Environmental Significance Database.

52 Caveats are associated with maps of listed threatened ecological communities (see www.environment.gov.au/cgi-bin/sprat/public/publiclookupcommunities.pl).

wood production operations in native forests, two referring to past plantation establishment, and two identifying current forest practice (primarily on private land). Diseases and loss of ecological function are identified in 30% of listings, and 11% of the threatened communities are listed as naturally small and localised. Mining operations are noted in 2 of the 27 listings as a threatening pressure.

Table 1.42: Number of forest ecological communities listed under the EPBC Act, by jurisdiction

Jurisdiction	Critically Endangered	Endangered	Vulnerable	Total
ACT	1	1	0	2
NSW	9	10	0	19
NT	0	1	0	1
Qld	6	7	0	13
SA	2	3	0	5
Tas.	0	0	1	1
Vic.	5	3	0	8
WA	0	3	0	3
Australia	**13**	**13**	**1**	**27**

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*

Notes:

Individual listings can cover more than one state or territory.

Nationally listed ecological communities are considered in the Australia-wide context. Therefore, listed ecological communities can occur in one or more state or territory. Numbers are based on the distribution information in the listing advice for the relevant ecological communities.

Source: Environmental Resources Information Network Species of National Environmental Significance Database.

Table 1.43: Threats to threatened forest ecological communities listed under the EPBC Act

Threats (historical and current)	Number of listed communities with threat	Proportion of threatened forest ecological communities with threat (%)
Weeds	24	89
Forest loss—agriculture	22	81
Grazing pressures	21	78
Fragmentation	19	70
Fire pressures	19	70
Feral animals	19	70
Hydrological change	16	59
Human pressures	12	44
Forest loss—urbanisation	10	37
Climatic impacts	10	37
Forestry operations	9	33
Disease	8	30
Loss of ecological function	8	30
Naturally small and localised	3	11
Mining	2	7

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*

Note: more than one threat may be given for an ecological community

Source: Environmental Resources Information Network Species of National Environmental Significance Database available at www.environment.gov.au/metadataexplorer/explorer.jsp; National Forest Inventory, Australian Bureau of Agricultural and Resource Economics and Sciences datasets of extant and extinct native vertebrate forest fauna, vascular forest plants and invertebrate forest fauna.

Case study 1.4: Red-tailed black-cockatoo

The red-tailed black-cockatoo (*Calyptorhynchus banksii*) is a member of the parrot family. It is 55–60 centimetres long. Adult males are glossy black with bright red panels in the tail, while females and juveniles have yellow spots on the head, yellow bars on the chest and yellow–orange tail panels (Figure 1.22). Red-tailed black-cockatoos are seen alone, in family groups, or in flocks containing 100 or more birds.

There are five subspecies of the red-tailed black-cockatoo (Cameron 2007; Figure 1.23): Banks's (*C. b. banksii*), inland (*C. b. samueli*), forest (*C. b. naso*), northern (*C. b. macrorhynchus*) and south-eastern (*C. b. graptogyne*). All are forest-dwelling, and their dependence on forests varies by subspecies. All subspecies require large tree hollows for nesting in forest and non-forest habitats. Two of the five sub-species are listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*: the south-eastern subspecies was listed as Endangered in 2000, and the forest subspecies was listed as Vulnerable in 2009.

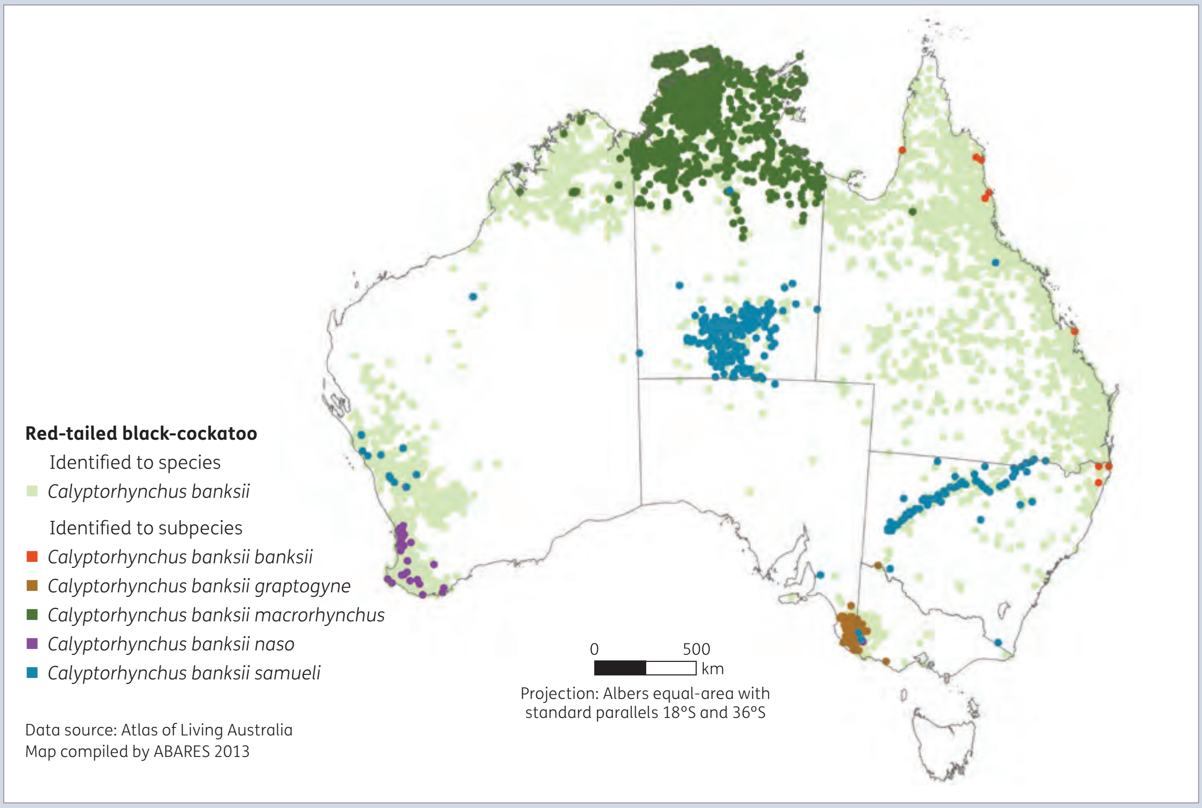
The population of the Vulnerable forest red-tailed black-cockatoo *C. b. naso* was estimated in 2006 to be approximately 15,000 birds (TSSC 2009a), inhabiting the dense jarrah (*Eucalyptus marginata*), karri (*E. diversicolor*) and marri (*Corymbia calophylla*) forests of south-west Australia. This subspecies feeds primarily on jarrah and marri seed. Illegal shooting, habitat loss, nest hollow shortage and competition from other species are the main threats to this subspecies, with habitat loss attributed to agricultural clearing, forestry operations, fire and mining (TSSC 2009a).

The population of the Endangered south-eastern red-tailed black-cockatoo (*C. b. graptogyne*) was reported as 500–1,000 birds (DEWR 2006), approaching 1,500 birds in 2012 (Figure 1.24). An annual count of this subspecies across approximately 18,000 square kilometres of western Victoria and south-east South Australia has taken place since 1996. Such counts provide a minimum number of birds in the population, determine patterns of habitat use, location of large flocks as well as indications of previous year's breeding success, and allow determination of trends in the population. This subspecies inhabits desert stringybark (*E. arenacea*) and brown stringybark (*E. baxteri*) woodlands on the Glenelg, Wimmera and Naracoorte Plains and adjacent woodlands of river red gum (*E. camaldulensis*), yellow gum (*E. leucoxylon*) and buloke (*Allocasuarina luehmannii*), but has a specialised diet and feeds primarily on stringybark and buloke seed. As a result of historical clearing, only 43% of suitable habitat remains. The degraded condition and patchy recovery of their stringybark woodland habitat, limited nesting hollows, fire impacts and periodic scarcity of their preferred food supply are the main current threats to this subspecies. The small numbers of breeding pairs, continuing loss of dead hollow-bearing trees, lack of regeneration of future hollow-forming trees, and declining health of scattered trees on private land are serious medium-term to long-term threats.

Figure 1.22: Female and male forest red-tailed black-cockatoo *Calyptorhynchus banksii naso* from south-west Western Australia

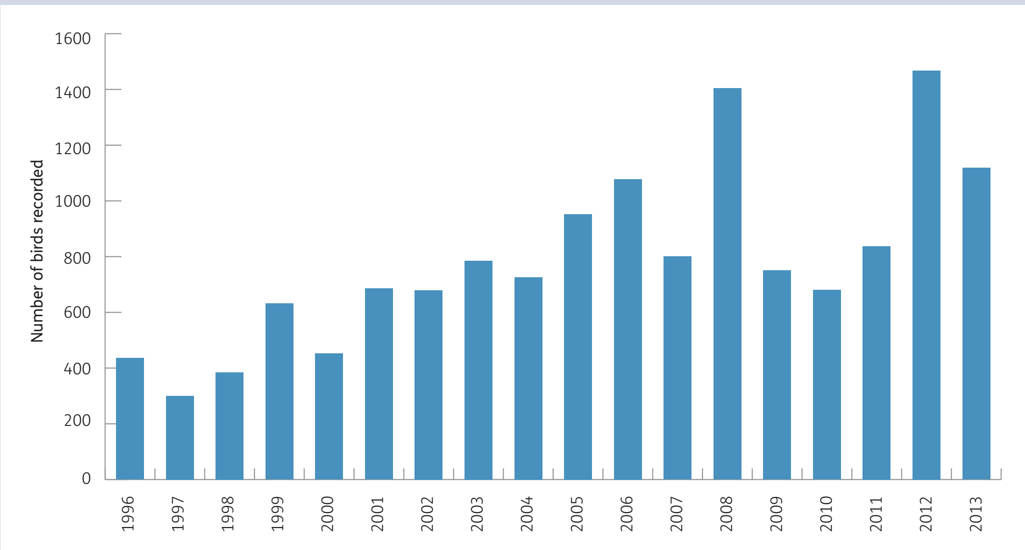
Case study 1.4: Red-tailed black-cockatoo continued

Figure 1.23: Distribution of the red-tailed black-cockatoo *Calyptorhynchus banksii* and its subspecies



Note: A total of 30,055 verified records are available. Queensland records are likely to be either *Calyptorhynchus banksii banksii* or *C. b. samuelii*.
Source: Atlas of Living Australia: http://biocache.ala.org.au/occurrences/search?q=Red-tailed%20Black%20Cockatoo&fq=#tab_mapView.

Figure 1.24: Annual population counts of the south-eastern red-tailed black-cockatoo *Calyptorhynchus banksii graptogyne*



Source: www.redtail.com.au/annual-counts.html.

Indicator 1.2c

Representative species from a range of habitats monitored at scales relevant to regional forest management

Rationale

This indicator provides broad habitat, population, and range information for representative forest dwelling flora and fauna. Evidence of changing ranges or densities of forest dwelling species can be used to guide forest management activities so that they are consistent with maintenance of forest biodiversity.

Key points

- Efforts to monitor forest-dwelling species vary across state and territory jurisdictions, and in some jurisdictions have diminished.
- Birds are the taxonomic group with the largest number of programs in place to track population trends. Monitoring efforts of state and territory agencies are supplemented by a large-scale investment by non-government organisations.
- The lack of comprehensive knowledge on the occurrence of representative species across land tenures and broad forest types limits the conclusions that can be drawn from available data.
- States and territories undertake separate monitoring for their own requirements, and their priorities may differ from national priorities.

Forest-dwelling species are monitored under programs implemented by a range of different bodies, including state forest management and conservation agencies, universities, non-government organisations and private individuals. These programs have been established for a variety of reasons and at various scales; for example, university programs are often designed to address particular research questions, usually at a localised scale. The states and territories monitor forest-dwelling species to meet requirements specified by relevant legislation and/or sustainable forest management policies; priorities at the state and territory level may differ from those set at the national level. There are few examples of long-term species monitoring programs.

The Island Ark program (Case study 1.5) involves monitoring a relocated threatened species affected by the spread of cane toads (*Rhinella marina*, previously *Bufo marinus*) in the Northern Territory. Case study 1.6 describes monitoring of breeding sites and populations of a threatened species, the swift parrot (*Lathamus discolor*). The Tasmanian devil (*Sarcophilus harrisii*; Case study 1.7) provides an example of monitoring the population of a threatened species and a causal agent (a disease) threatening the species. Case study 1.8 describes a long-term monitoring program of plants and beetles along an altitudinal transect at the Warra Long-term Ecological Research site in southern Tasmania.

Table 1.44 indicates the extent to which monitoring programs are in place for representative species in various taxonomic groups, by state and territory, and how the monitoring effort compares with that reported in SOFR 2008. This table is based on reporting by individual state and territory agencies and therefore might not include all existing programs—in particular, those carried out by tertiary institutions. Effort and capacity has diminished or is non-existent for particular taxonomic groups in some states and territories (Table 1.44).

At the national level, the most comprehensive monitoring is in place for birds, driven by a national volunteer program coordinated by the non-government organisation Birdlife Australia and supplemented by state and territory agency-specific programs. Birds are usually reasonably visible and hence amenable to direct monitoring, but this is not the case for all species, so innovative monitoring approaches are also required. A community partnership program, which is now active in most states and territories, has also been developed for amphibians and reptiles through the non-government organisations FrogWatch and ReptileWatch[53]. These fauna-monitoring approaches involve a non-government organisation working in collaboration with state and territory government agencies to develop comprehensive monitoring programs using public participation. Information material and supporting databases, such as the Australian Reptiles Online Database[54], support these monitoring activities.

[53] www.frogwatch.org.au and www.frogwatch.org.au/index.cfm?action=cms.page&section=2.

[54] www.arod.com.au/arod.

Table 1.44: Taxonomic groups for which representative species are being monitored

Jurisdiction	Mammals	Birds	Reptiles	Amphibians	Fish	Invertebrates	Vascular plants	Non-vascular plants
				Level of monitoring				
ACT	🟩	🟩	🟩	🟩	🟩	△	🟩	△
NSW	🟧	🟧	△	🟩	🟧	△	🟧	△
NT	🟩	🟩	△	△	△	△	🟩	△
Qld	🟩	🟩	🟩	🟧	🟩	△	🟩	△
SA	🟩	🟩	△	🟩	🟩	△	🟧	△
Tas.	🟧	🟧	△	△	△	🟧	🟧	△
Vic.	🟩	🟩	🟩	🟩	🟩	△	🟩	🟩
WA[a]	🟧	🟧	🟧	🟧	△	🟧	🟧	🟧
Australia[b]	🟩	🟧	🟧	🟧	🟧	△	△	△
Jurisdiction				Change in effort and capacity				
ACT	s	+	s	s	s	△	+	△
NSW	s	–	△	s	n	△	s	△
NT	s	s	△	△	△	△	s	△
Qld	s	s	s	s	+	△	s	△
SA	s	s	△	–	n	△	–	△
Tas.	+	+	△	△	△	s	s	△
Vic.	s	s	s	s	n	△	+	+
WA[a]	s	s	s	s	△	s	s	s
Australia[b]	s	s	n	s	n	△	△	△

Level of monitoring: 🟩 = at least one species of the taxonomic group is being monitored to detect changes in population size at a scale relevant to forest management; 🟧 = more than 10 species are being so monitored; △= no species in the taxonomic group is being so monitored, or no data available on monitoring effort

Change in effort and capacity since SOFR 2008: + = increased level; – = decreased level; n = new program; s = stable

[a] http://naturemap.dec.wa.gov.au/default.aspx and FORESTCHECK (see Case study 1.3 in Indicator 1.2a).

[b] Includes non-government mechanisms through Birdata (www.birdata.com.au), FrogWatch and ReptileWatch (www.frogwatch.org.au and www.frogwatch.org.au/index.cfm?action=cms.page&section=2), and fish monitoring (Davies et al. 2012).

Note: Studies of monitoring of forest ecosystems are not included. No data were available for the ACT or Qld for reporting in SOFR 2008, however change in effort and capacity reflects change since SOFR 2008 reporting period. Monitoring of fish is based on Davies et al. (2012); in Queensland, monitoring includes Murray–Darling Basin and coastal freshwater waterways.

Source: Australian Government, state and territory agencies.

Recognising the value of a structured, broad-based monitoring program in assisting long-term management, Western Australia established FORESTCHECK, a comprehensive approach to monitoring species in the state's south-western forests (McCaw et al. 2011). FORESTCHECK (Case study 1.3 in Indicator 1.2a) is one of only a few programs in the world collecting regional-scale information on mosses, lichens, fungi and invertebrates, as well as the better known components of forest biodiversity (vertebrates and vascular plants). A similar intensity of biodiversity monitoring has been carried out at the Warra Long-term Ecological Research site in the Huon region of southern Tasmania (see Case study 1.8). The Victorian Forest Monitoring Program[55] is being implemented to monitor and report changes in the extent, state and condition of Victorian public forests and parks, as well as changes in biodiversity (see Indicator 7.1d).

Sustainable forest management requires an understanding of ecological trends over long timescales. Long-term monitoring programs such as FORESTCHECK in Western Australia and the Warra study in Tasmania will deliver some of that information and thereby contribute to continuous improvement of sustainable forest management in those states. In general, there is more monitoring of species and their habitats on multiple-use public native forests than on other tenures.

Species that are commercially harvested for non-wood forest products are also monitored. Harvesting of tree ferns (*Dicksonia antarctica*), common brushtail possums (*Trichosurus vulpecula*), Bennetts wallaby (*Macropus rufogriseus*) and Tasmanian pademelon (*Thylogale billardierii*) in Tasmania are examples (see Indicator 2.1d).

[55] http://www.depi.vic.gov.au/forestry-and-land-use/forest-management/forest-sustainability/victorian-forest-monitoring-program#thevfmp.

Case study 1.5: Island Ark program

The cane toad (*Rhinella marina*, previously *Bufo marinus*) was first sighted in the Northern Territory in 1984. By 2001, the toads had reached southern Kakadu National Park and were in the river catchments surrounding the park. By 2004–05, they were detected in Darwin.

The northern quoll (*Dasyurus hallucatus*; Figure 1.25), which occurs in forested environments, is one of the Northern Territory's native mammals most threatened by the spread of cane toads. Quolls disappear from most areas colonised by cane toads soon after the toad's arrival. The northern quoll is now listed as endangered under the *Environment Protection and Biodiversity Conservation Act 1999*.

In 2003, to prevent the possible extinction of northern quolls in the Northern Territory, a small number of northern quolls were captured from the Northern Territory mainland and relocated to two islands off the Territory coast that do not contain cane toads, under the Northern Territory Government's Island Ark program. The founding population size of 64 individuals had increased to more than 5,600 by December 2007. In 2009, the population had stabilised on one island, at just under 3,000 individuals, and slightly declined on the other, smaller island. All other forest fauna on the islands appear healthy despite the large numbers of quolls.

This translocation program has ensured the ongoing survival of northern quolls in the Northern Territory. In the future, there is the possibility of relocating quolls from these islands back to their mainland habitat.

Quolls are now known to occur naturally on 11 Northern Territory islands, providing some further security from the threat posed by cane toads. Their persistence on these islands is heavily dependent on keeping cane toads from colonising the islands.

Figure 1.25: Northern quoll (*Dasyurus hallucatus*), which occurs in the tropical forests of northern Australia

Case study 1.6: Swift parrot

The swift parrot (*Lathamus discolor*) breeds only in Tasmania. It migrates to the Australian mainland in autumn to spend the winter foraging for lerps and nectar in flowering eucalypts, mainly in Victoria and New South Wales (Figure 1.26). In Tasmania, the bird's breeding range is mostly restricted to the east coast within the range of the Tasmanian blue gum (*Eucalyptus globulus*) (Figure 1.27). The breeding season coincides with the blue gum's flowering, when the tree's nectar provides the parrot with its main food source.

Persistence of the swift parrot is mainly threatened by loss and alteration of habitat as a result of clearing for residential, agricultural and industrial developments; forestry activities, including firewood harvesting; attrition of old-growth trees in the agricultural landscape; suppression of forest regeneration; and frequent fire. The species is also threatened by the effects of climate change, competition for food and nest sources, flight collision hazards, psittacine beak-and-feather disease, and illegal capture and trade (Saunders and Tzaros 2011).

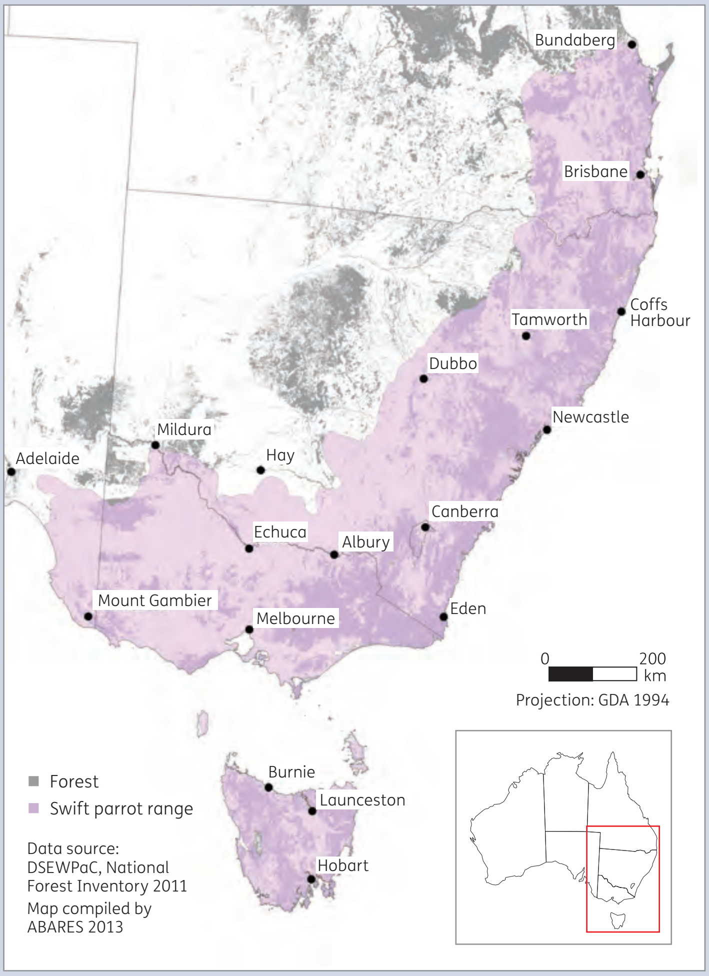
The Tasmanian forest practices system provides protection of the swift parrot's key habitats (forests containing *E. globulus* or *E. ovata*) from clearing and conversion of forests on both public and private land. Prescriptions for the management of swift parrot nesting and foraging habitat have been updated, with the aim of improving the management of nesting habitat (particularly as the species tends to exhibit aggregated nesting behaviour) and foraging habitat in wet forest types, especially near-coastal *E. globulus* forest.

In 2010, the Australian and Tasmanian governments initiated the Regional Forest Agreement (RFA) Priority Species Project to implement a strategic landscape approach to the management of RFA priority species, including the swift parrot and its habitats in Tasmania. The primary objective of the project is to develop a strategic plan and guidelines to support improved conservation management of swift parrot breeding habitat. This will include population and habitat monitoring.

A monitoring program was established to determine the extent of the population and to monitor population trends. The first season of population monitoring was conducted in the 1987–88 breeding season in Tasmania, which located an estimated 1,320 pairs (Brown 1989). Another survey was carried out during the 1995–96 breeding season, which located an estimated 940 pairs. These surveys attempted to locate and count a portion of all breeding birds. During the breeding seasons from 1999 to 2004, fixed-stationary observer techniques were used at 55 sites to estimate the density of swift parrots across the range of dry, grassy blue-gum forest in eastern Tasmania. The results from these surveys suggest that the swift parrot population was, at best, stable during that time (Saunders et al. 2010).

Breeding season surveys from 2004 to 2009 focused on the distribution of nesting and habitat use. These surveys recorded the annual variation in the spatial characteristics of breeding events. They have documented sites being used extensively by breeding swift parrots, followed by several years of little or no breeding activity at these sites. The finding of a large breeding event in the wet forests of southern Tasmania (Webb 2008) confirmed that wetter habitats provide an important alternative to areas dominated by dry forests and may serve as an important refuge habitat during drought.

Figure 1.26: Distribution of the swift parrot in Australia



Note: Distribution of the swift parrot is compiled using a range of datasets of varying quality and should only be used as a guide. The presence of the species or its habitat should be confirmed using local information services.

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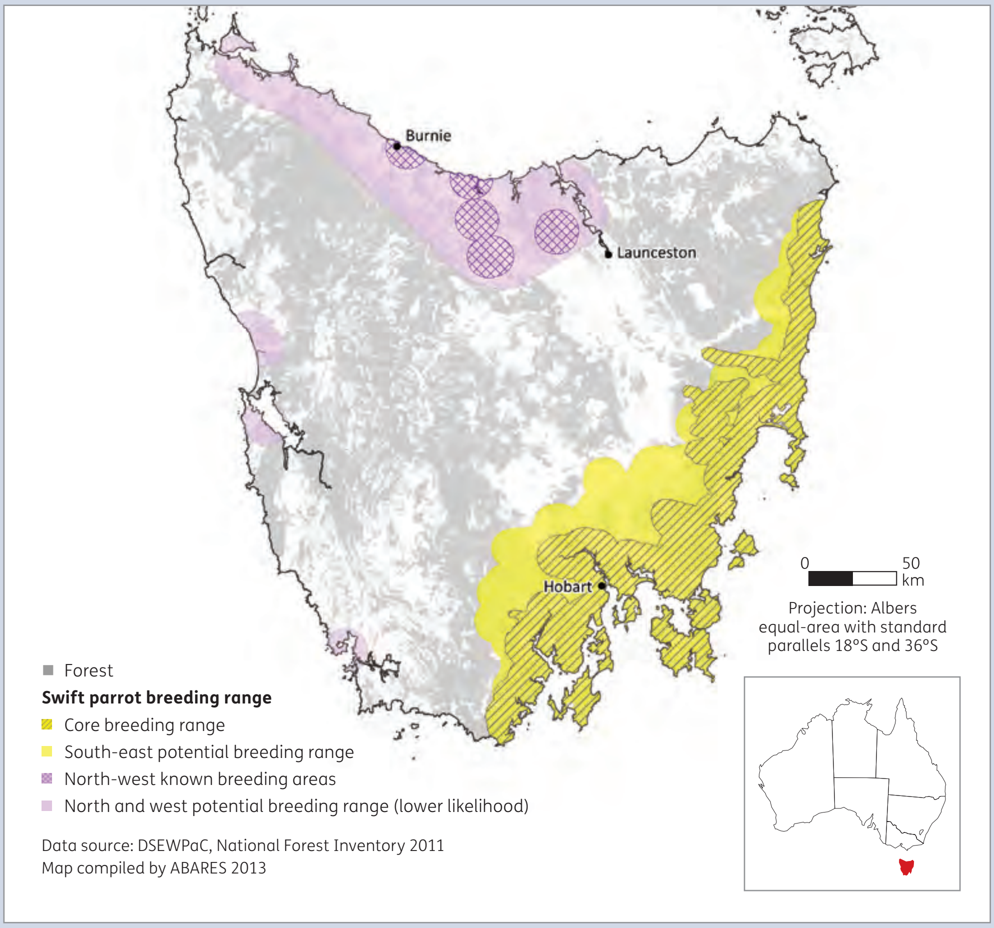
Case study 1.6: Swift parrot continued

Figure 1.27: Swift parrot breeding range



Note: Map shows the potential breeding range of the swift parrot in Tasmania, based on current information. The breeding range is divided into the core breeding range (the area, within the south-east potential breeding range, thought to be of highest importance for the maintenance of breeding populations), the south-east potential breeding range (areas in the south-east of Tasmania where breeding could occur based on the occurrence of breeding habitat and foraging habitat), north-west known breeding areas (sites in the north-west of Tasmania where nest sites are known to occur), and the north and west potential breeding range (areas in the north-west of Tasmania where breeding could occur based on the occurrence of small breeding habitat and foraging habitat, but is less likely to occur than areas in the south-east).

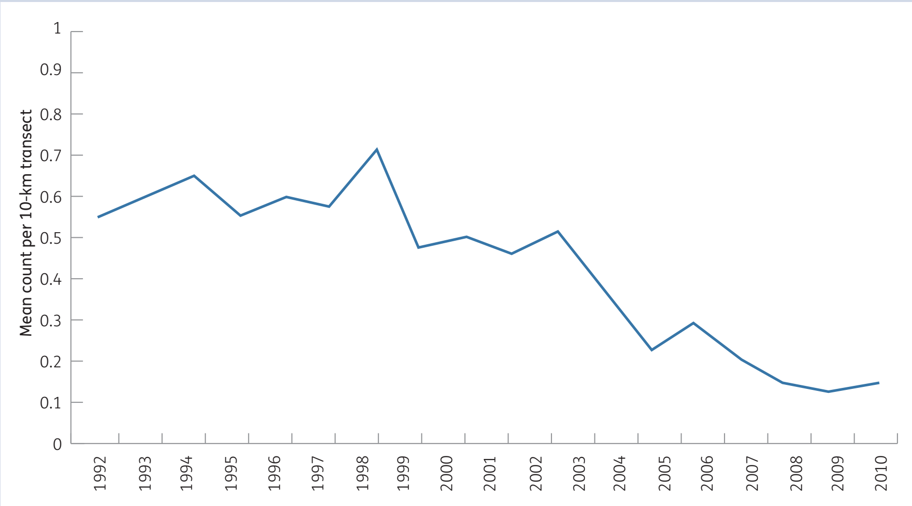
Source: Tasmania Department of Primary Industries, Parks, Water and Environment, adapted from FPA and Threatened Species Section (DPIPWE) (2012)[a].

[a] www.dpipwe.tas.gov.au/inter.nsf/WebPages/LJEM-8JN6YE?open.

Case study 1.7: Tasmanian devil

The Tasmanian devil (*Sarcophilus harrisii*), endemic to Tasmania, is the world's largest extant marsupial carnivore. Devils are found across Tasmania in a range of habitats, including open forests and woodlands. From being considered common and stable in 1992, the Tasmanian devil is now considered Endangered under the *Tasmanian Threatened Species Protection Act 1995* (since 2008) and under the *Environment Protection and Biodiversity Conservation Act 1999* (since 2009). The population has declined dramatically over the past decade (Figure 1.28), due to a fatal, contagious cancer—devil facial tumour disease (DFTD). Signs resembling symptoms of the disease were first reported in 1996 in north-east Tasmania, and the disease has since spread across more than three-quarters of the state.

Figure 1.28: Tasmanian devil population estimated from spot-light transects



Source: FPA (2012).

DFTD is a lethal cancerous disease, which to date has only been recorded in devils. The disease takes the form of tumours on the head of the devil, and these may spread to other parts of the body. It is an infectious disease that is believed to spread largely through biting, typically affecting only adults, and death occurs within months of the first signs. There is as yet no evidence to suggest that the spread of DFTD in Tasmania will cease, or that populations can recover once infected. However, Tasmanian devils still exist throughout the mainland of the state, in all rural habitats, and no local extinctions have yet been detected.

In response to the threat of DFTD to Tasmanian devils, the Save the Tasmanian Devil Program[a] was established as a joint initiative between the Australian and Tasmanian governments, with the long-term strategic goal of an enduring and ecologically functional population of Tasmanian devils in the wild. At the completion of the first phase in 2008, both governments committed to a second five-year phase, from 2008 to 2013, with a total investment of $25 million. The Save the Tasmanian Devil Program has made substantial progress in securing the species from extinction by establishing an insurance population, investigating novel approaches to manage populations in the wild, funding scientific research to advance understanding of the disease, and establishing major partnerships.

In 2011, a monitoring strategy was developed by the Save the Tasmanian Devil Program to streamline and coordinate monitoring activities and to align with the program business plan. Monitoring includes the use of remote-sensor camera technology, which is capable of assessing populations at a regional level. The monitoring strategy describes three different monitoring streams, with the first stream 'status of the devil populations' aiming to address the following questions:

- Is there local extinction or recovery in a diseased population?
- Are there devil populations that are demonstrating an atypical response to the disease?
- What is the population status of devils across the state?
- Where is the current disease front?

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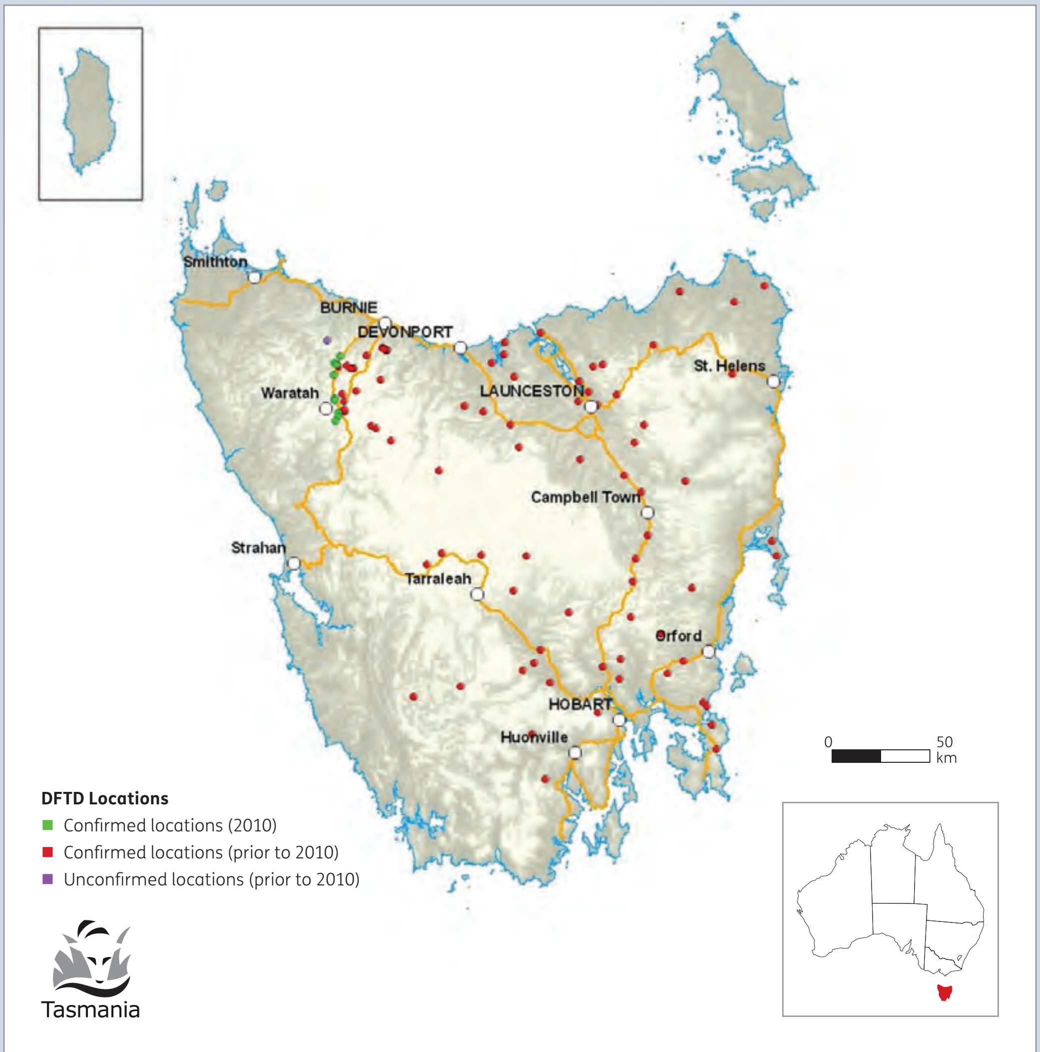
[a] Further information on the program can be found at www.tassiedevil.com.au/tasdevil.nsf.

Case study 1.7: Tasmanian devil continued

The spread of the disease across Tasmania is measured annually by detecting the disease front—the point at which disease is first detected in healthy populations. The disease, having started in the north-east corner of the state, has continued to spread west and south, and now affects 75% of the state. There has been an 84% decline in average sightings of devils across Tasmania during the annual spotlight surveys and at the original site of infection they have decreased by 97%. Figure 1.29 shows the distribution of the disease in 2010 (FPA 2012).

Monitoring the status of the devil populations and understanding the progression and impact of DFTD on wild Tasmanian devil populations is informing how the program manages the impacts of the disease on devil populations and plans for future actions, such as fencing and the possible reintroduction of devils into parts of Tasmania.

Figure 1.29: Devil facial tumour disease distribution in 2010



Source: Tasmania Department of Primary Industries, Parks, Water and Environment, adapted from FPA (2012).
Shading represents relief, with higher altitudes being a paler colour.

Case study 1.8: Monitoring changes in plants and beetles up an altitudinal transect

A series of altitudinal transects in the Warra supersite (see www.warra.com, Figure 1.30), southern Tasmania, is being monitored to investigate how plant and animal communities change with altitude, and whether those altitudinal patterns shift over time. The aim is to look for early indications of how climate change is affecting biodiversity in the cool temperate parts of Australia.

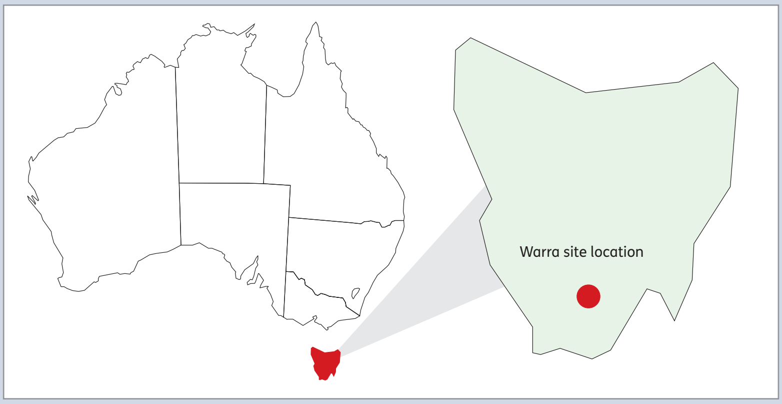
The two main transects run from lowland *Eucalyptus obliqua* forest on the banks of the Weld River at an altitude of 100 metres, through temperate rainforest and subalpine *E. coccifera* forest, to alpine heath on the summit of Mount Weld at 1,300 metres. Permanent plots have been located at every 100 metre altitude increment along the transects (Grove et al. 2004).

An initial survey of birds, vascular plants and arthropods in the plots was done by staff from the Department of Primary Industries, Parks, Water and Environment, and Forestry Tasmania, during the summer months of 2000 and 2001 (Figure 1.31). This survey has provided a baseline for comparison with future surveys.

The initial survey identified points along the altitudinal gradient where community composition changed rapidly with altitude (discontinuities). Interestingly, the altitudes corresponding with these discontinuities differed for different groups of species (Figure 1.32). The distributions of particular groups of species are expected to be most sensitive to climate change at these discontinuities.

A second survey of vascular plants and ground-dwelling arthropods in the altitudinal transects was done during the summer of 2011–12. Initial analysis found that no significant change in vascular plant communities had occurred since 2000–01.

Figure 1.30: Location of Warra Long-Term Ecological Research (LTER) site



Source: Fusebox Design.

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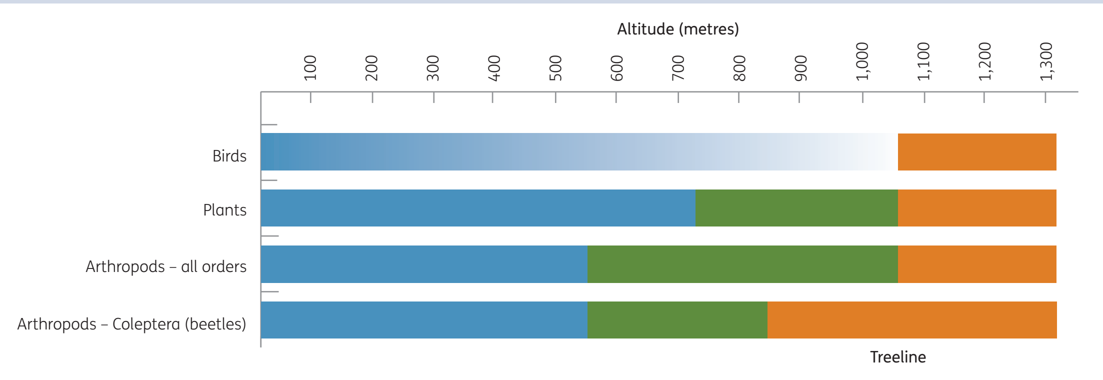
Case study 1.8: Monitoring changes in plants and beetles up an altitudinal transect continued

Figure 1.31: Malaise trap for sampling flighted arthropods, installed in the 600-metre altitude plot at Warra

Figure 1.32: Discontinuities in community composition with altitude



Note: Four species groups were sampled in 2000–01 in plots at 100-metre intervals along the Warra altitudinal transects. Arthropod data relate only to ground-dwelling species captured in pitfall traps. Altitude ranges corresponding to communities of similar composition are coloured similarly; discontinuities in community composition are represented by changes in colour. The decrease in intensity of the blue shading for birds with increasing altitude represents a decrease in diversity and abundance with increasing altitude up to the tree line (1,100 metres), without a distinct change in community composition; there is then a distinct change in community composition at the tree line.

Source: Forestry Tasmania.

Indicator 1.3a

Forest associated species at risk from isolation and the loss of genetic variation, and conservation efforts for those species

Rationale

This indicator assesses the risks to loss of forest genetic variation and describes the formal measures designed to mitigate this risk. A loss of genetic diversity in species can result in a decreased ability to adapt to future environmental change, and thus a higher risk of extinction.

Key points

- The number of forest-associated species for which data on genetic variation are available is still very small, although understanding is increasing.
- Formal efforts are being made to improve long-term genetic conservation outcomes by increasing connectivity among patches of native vegetation.

The distributions of many Australian species before European settlement are not well known. Historical records, expert opinion and analysis, evidence of major changes in species distributions over the past few decades and incidental observations have been used to compile maps of, or to model, the former distributions of species. For example, the comprehensive regional assessments used in Regional Forest Agreement (RFA) processes provided pre-1750 estimates of the extent of forest ecosystems within the main production forest estate across RFA regions. Estimates of the historical distribution of species are required to determine whether reductions in distribution could increase the risk of loss of genetic variation.

Risk to forest genetic variation

Species with a reduced level of genetic variation are widely held to be less able to withstand unexpected threats, and so to face a higher risk of extinction (although, naturally, many other factors are relevant in individual cases). In practice, it is difficult to determine how much of the genetic variation within a species has been lost historically. However, it is possible to identify whether certain threatened species are becoming endangered by the increased isolation of populations due to habitat depletion and fragmentation, and threatening biotic factors such as those discussed in Indicator 1.2b.

Forest fragmentation (see Indicator 1.1d), mainly caused by clearing for agriculture and urban expansion, is a significant contributor to a reduction in genetic variation of certain species. Many threatened plant populations that have become fragmented are increasingly identified in new or updated conservation advice and recovery plans as having genetic inbreeding and fecundity risks. Native populations at greatest risk and of greatest concern are those that are already small or fragmented and also have high conservation value. A change in climate, such as that predicted from the increasing atmospheric concentrations of greenhouse gases, is also likely to contribute to a reduction in forest genetic variation (Doley 2010).

Several institutions have programs to measure genetic diversity in forest fauna, but nationally conclusive results are available for only a few species.

Changes over time in the genetic diversity of forest-associated flora also have been little measured, although several studies have documented genetic variation and the distribution of this variation within existing populations at a single point in time. These studies suggest that a reduction in range is less likely to cause significant loss of genetic variation in species with a high level of diversity within populations and a low level of diversity between populations. This type of population genetic structure has been found for most of the limited number of tree species that have been surveyed to date. A reduction in range is more likely to reduce genetic variation in species that exhibit low genetic diversity within populations and high variability between populations, such as that typically encountered in species with naturally restricted ranges (e.g. narrow-leaved mallee, *Eucalyptus angustissima*).

Knowledge of genetic variation in Australia's native species, and conservation measures to maintain that variation, are greatest in non-threatened species of economic importance, such as southern or Tasmanian blue gum (*E. globulus*) (Thavamanikumar et al. 2011). The number of forest-dwelling species for which data on genetic variation are available has not greatly changed since SOFR 2008, when data were available for 10 faunal and 13 floral species.

Threatened species

The states and territories and the Australian Government maintain lists of threatened species; the Australian Government list is at the national level (see Indicator 1.2b).

Species with populations that are low in numbers, small in geographic extent or fragmented, and that have low genetic variability, hybridisation and fecundity issues, are candidates for listing as 'threatened'. Table 1.45 summarises the genetic-related reasons associated with listing species as threatened on the national threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Recent population decline and population fragmentation (resulting in population isolation and reduced genetic variation) contributed to the recent listing of the koala (*Phascolarctos cinereus*) as Vulnerable under the EPBC Act (see Case study 1.9). The change in listing status of the Tasmanian devil (*Sarcophilus harrisii*) to Endangered because of the threat posed by devil facial tumour disease also related in part to the low level of genetic variation in that species (TSSC 2009b; see Case study 1.7 in Indicator 1.2c).

For Tasmania and the Northern Territory, Tables 1.46 and 1.47 report by degree of risk the number of forest-dwelling species potentially at risk from isolation and loss of genetic variation as a result of past human-induced or natural events, based on the research and knowledge of state and territory agencies. A total of 277 forest-dwelling threatened and priority species in Tasmania were rated as potentially at risk from isolation and loss of genetic variation; half of these, mostly higher plants, were at potentially moderate and high risk. A total of 789 forest-dwelling threatened and priority species in the Northern Territory were rated as potentially at risk from isolation and loss of genetic variation, but it was not

Table 1.45: Threatened forest-dwelling species in Australia with conservation concerns about isolation or genetic capacity

	Genetic-related reasons associated with listing species as threatened[a]				
Taxonomic group	**Small population[b]**	**Fragmented population**	**Low genetic diversity**	**Hybridisation**	**Fecundity issues**
Plants	654	262	250	8	324
Mammals	32	15	12	0	0
Birds	42	4	6	3	9
Reptiles	11	1	0	0	1
Amphibians	14	0	0	0	0
Fish	2	0	0	0	0
Invertebrates	18	1	0	0	0

[a] Includes species that have become extinct where a genetic reason was identified.

[b] Includes populations low in numbers, small in geographic extent, or comprising only a few subpopulations (e.g. island species).

Source: National Forest Inventory; listing statements on the Australian Government Department of Sustainability, Environment, Water, Population and Communities database (www.environment.gov.au/biodiversity/threatened/index.html).

Table 1.46: Number of forest-dwelling threatened and priority species in Tasmania potentially at risk from isolation and loss of genetic variation

Taxonomic group	Potential high and moderate risk	Potential low risk	Unknown risk	Total
Vertebrate fauna				
Fish	5	5	–	10
Amphibians	2	–	–	2
Reptiles	–	–	2	2
Birds	7	5	–	12
Mammals	2	1	–	3
Total	16	11	2	29
Vascular plants				
Dicotyledons	89	92	10	191
Monocotyledons	11	22	7	40
Pteridophytes	10	5	–	15
Gymnosperms	2	–	–	2
Total	112	119	17	248
Total (vertebrate fauna and vascular plants)	**128**	**130**	**19**	**277**

– = inferred zero

Note: Level of risk was estimated qualitatively for vertebrate fauna and vascular plant groups (excluding orchids) that are listed as threatened in Tasmania, or are identified as Regional Forest Agreement priority species.

Source: FPA (2012).

Table 1.47: Number of forest-dwelling species in the Northern Territory potentially at risk from isolation and loss of genetic variation

Taxonomic group	Potential high and moderate risk	Potential low risk	Unknown risk	Total
Vertebrate fauna				
Fish	1	–	–	1
Amphibians	1	1	3	5
Reptiles	2	10	21	33
Birds	8	7	3	18
Mammals	12	9	2	23
Total	24	27	29	80
Invertebrate fauna				
Total	2	1	1	4
Vascular flora[a]				
Total	47	162	496	705
Overall total	**73**	**190**	**526**	**789**

– = inferred zero

[a] Includes dicotyledons, monocotyledons, pteridophytes and gymnosperms.

Source: Northern Territory Department of Natural Resources, Environment and the Arts.

possible to allocate a risk category to most of these. Minimal data are available for the other states and the Australian Capital Territory.

Formal measures to mitigate risk

Australia's Biodiversity Conservation Strategy 2010–2030 (NRMMC 2010) is a guiding policy framework for conserving the country's biodiversity, which includes genetic diversity. This framework uses a diverse mix of Australian, state, territory and local government and private sector approaches to biodiversity conservation. Formal measures are in place across state and territory jurisdictions to address the risk of loss of genetic variation in threatened species. These measures include recovery plans, habitat restoration, wildlife corridors, engineered animal movement mechanisms, seed-collecting programs, and management of habitat and populations under forest management systems. The overall status of Australia's forest genetic resources is described by Singh et al. (2013).

Possum bridge, to allow animals to move between forest fragments and maintain connectivity of populations.

Case study 1.9: Koala

The koala (*Phascolarctos cinereus*) is one of the most distinctive and iconic wildlife species in Australia. Koalas occur in the Australian Capital Territory, New South Wales, Queensland, South Australia and Victoria. They inhabit a range of open and woodland forest and other woody non-forest vegetation communities containing their preferred food species from the genus *Eucalyptus* (Figure 1.33).

The main threats to the koala are loss and fragmentation of habitat, vehicle strike, disease and predation by dogs. Drought and extreme heat are also known to cause very significant mortality. Post-drought recovery can be substantially impaired by other threatening factors (TSSC 2012a, 2012b). Genetic issues have also been raised as threats to the koala (SECRC 2011).

Victoria and South Australia have large koala populations, with an overabundance in some areas (e.g. Kangaroo Island) that can result in damage to ecological communities. The majority of these koalas are from reintroductions using limited genetic stock. As a result, the adaptive capacity is potentially limited, despite the numbers of individuals. Population fluctuations (cycles of population abundance and crashes) are associated with rainfall variation and overbrowsing—this makes determining natural population benchmarks difficult (TSSC 2012b).

Koala populations in the Australian Capital Territory, New South Wales and Queensland (northern populations; Figure 1.33) were listed in May 2012 as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) because a combination of factors had caused these populations to decline substantially over three generations (TSSC 2012a). The Threatened Species Scientific Committee (TSSC) advised that koalas in New

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Case study 1.9: Koala continued

South Wales (including the Australian Capital Territory) and Queensland can be sensibly grouped together on both biological and threat/management grounds (TSSC 2012b). In both states, inland koalas are threatened by the combination of habitat fragmentation and drought/climate change, while coastal populations are threatened by habitat loss and urban development. Populations in South Australia and Victoria (southern populations; Figure 1.33) were not listed under the EPBC Act. The TSSC (2012b) commented that the southern population would not be eligible for listing in any category.

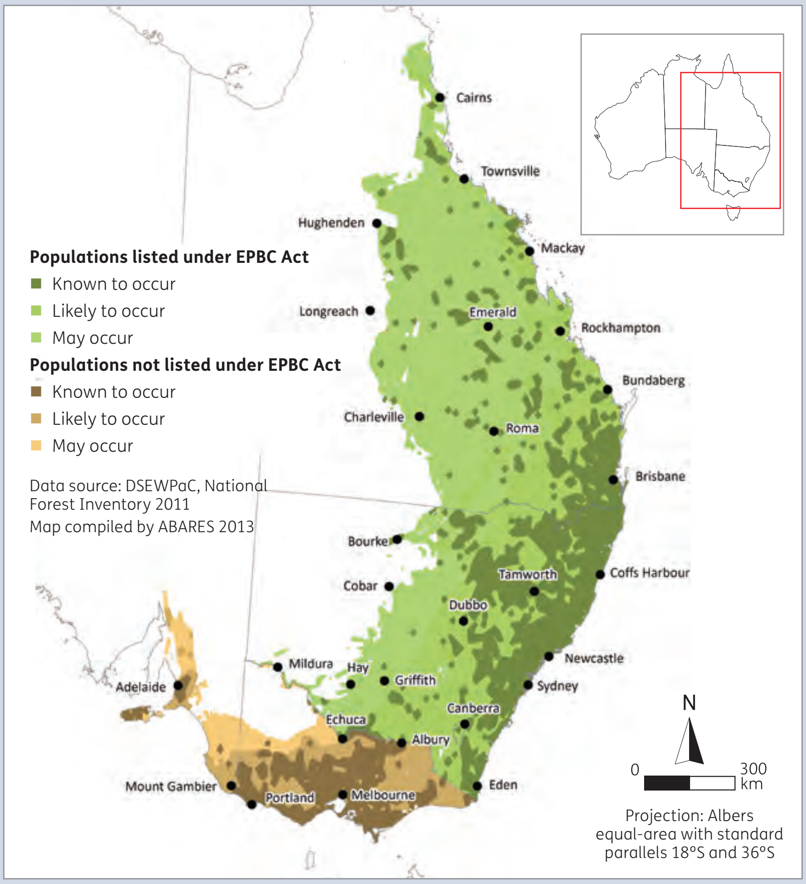
Koala populations have low levels of genetic differentiation, which reflect adaptations to different climates and environments (TSSC 2012b). Although southern populations of koalas are larger than those in the Australian Capital Territory, New South Wales and Queensland, they are not as genetically diverse because the majority of populations were founded from a small number of individuals. There are, however, a few populations that exhibit higher levels of genetic diversity, such as those in South Gippsland in Victoria (Lee et al. 2012), and which should therefore be prioritised for conservation. As a consequence of having low genetic variability, southern koala populations may have a reduced ability to adapt to change, which may exacerbate the risk of extinction of the population due to the effects of disease, loss of habitat through over-browsing or climate change (SECRC 2011).

Koala populations in New South Wales and Queensland possess greater genetic diversity than koala populations in Victoria and South Australia. However, these populations are becoming increasingly fragmented and isolated due to threats arising mainly from urban encroachment, which causes habitat loss, habitat fragmentation, and mortality from vehicle collisions and dog attacks. Stresses on individuals from these human-induced threats can exacerbate the effects of disease, drought and bushfires, and could reduce the capacity of populations to adapt to the effects of climate change.

The TSSC reported to the Australian Senate (SECRC 2011) that there is no evidence at present that population growth in southern populations is being affected by low genetic diversity. It reported that southern populations mostly show far greater population increase than the more genetically variable populations in parts of Queensland and New South Wales (SECRC 2011).

Koala and her joey in a eucalypt tree, New South Wales.

Figure 1.33: Indicative distribution of the koala in Australia



Note: Distribution maps of koala are compiled using a range of datasets of varying quality and should only be used as a guide. The presence of the species or its habitat should be confirmed by using local information services.

Indicator 1.3b

Native forest and plantations of indigenous timber species which have genetic resource conservation mechanisms in place

Rationale

This indicator uses the coverage and implementation of formal genetic resource conservation mechanisms as a measure of the degree to which timber species' genetic resources are managed and conserved.

Key points

- Australian native forest genetic resources are primarily conserved in Australian extant native forest, and to a lesser degree in arboreta, seed banks, seed orchards and plantations. Most states and territories have guidelines and management plans for conservation of the genetic diversity of forest species, often as part of broader programs for biodiversity conservation.
- Tree-breeding and genetic conservation and/or improvement programs exist for more than 30 native wood and oil-producing species and varieties. The infrastructure of tree-breeding and genetic improvement programs, such as arboreta and seed orchards, expands the scope for conserving native forest genetic resources, including non-commercial endangered species.
- Australia's native forest species are a dominant part of the hardwood plantation industry in many other countries, as well as Australia.
- The Australian, state and territory governments, research organisations, seed banks, arboreta and the private forestry sector all contribute to the conservation and sustainable management of forest genetic resources.

Conservation of native forest genetic resources

The level of conservation of forest genetic resources is linked to the level of conservation of forest biodiversity. There are significant ongoing activities for the conservation of native forest species and communities in Australia, including in protected areas such as nature conservation reserves or national parks. For forest covered by Regional Forest Agreements, state governments have developed a set of criteria that include broad benchmarks for the in-situ conservation of forest biodiversity (see Indicator 1.1c).

In addition to genetic resource conservation through forest reservation, a range of organisations, including the Australian Tree Seed Centre (ATSC), have established ex-situ seed orchards and undertaken conservation plantings for several rare and endangered species. Species in these conservation seed orchards include Queensland western gum (*Eucalyptus argophloia*), Barber's gum (*E. barberi*), Camden white gum (*E. benthamii*), Brooker's gum (*E. brookeriana*), Miena cider gum (*E. gunnii* subsp. *divaricata*), Risdon peppermint (*E. risdonii*), varnished gum (*E. vernicosa*), spinning gum (*E. perriniana*) and Morrisby's gum *(E. morrisbyi*) (Singh et al. 2013; SOFR 2008).

Australian forest genetic resources are generally highly accessible, and a very large amount of material has been dispersed throughout Australia and the world (Singh et al. 2013). Many Australian organisations, including botanic gardens, continue to contribute to global collections of Australian native forest genetic materials. Since the early 1960s, the ATSC has supplied more than 200,000 certified seed lots from more than 1,000 tree or shrub species to researchers in more than 100 countries. Seed lots also have been exported for research purposes through various institutions, including state forest services, botanic gardens, universities and private seed collectors. Australia is a partner in the Millennium Seed

Bank Project run by the United Kingdom's Royal Botanic Gardens—this is the largest ex-situ conservation project in the world. The Tasmanian Government has established the Tasmanian Seed Conservation Centre at the Royal Tasmanian Botanical Gardens, and has also entered into an agreement with the Millennium Seed Bank Project for seed storage (Harris et al. 2009). Similarly, the Botanical Gardens of Adelaide have established a partnership project with the Millennium Seed Bank Project, known as the South Australian Collection of Rare and Endangered Seeds (SACRED Seeds) Project. The Victorian Conservation Seedbank is situated in the National Herbarium of Victoria at the Royal Botanic Gardens, Melbourne.

Most states and territories have guidelines and management plans for conserving the genetic diversity of native forest wood species of commercial significance. In the regeneration of native production forest, the aim is to maintain local gene pools and the approximate composition and spatial distribution of the species (including non-wood product and understorey species) that were present before harvesting. Codes of forest practice, such as those in Victoria and Tasmania, therefore require harvested native forest to be resown with a species mix that approximates the natural mix of canopy trees present before harvest, while allowing for species that will regenerate naturally; seed to be sown is usually collected either from the stand to be harvested or from the nearest similar ecological zone. Management plans also include specifications for selection of seed trees of good form and health. In Western Australia, silvicultural guidelines specify the seed sources to be used in the rehabilitation of landings within all harvested coupes and areas cleared for bauxite mining in jarrah (*E. marginata*) forest (SOFR 2008).

Conservation and use of plantation genetic resources

Australia's forest genetic resources play an important role in maintaining and improving plantation forest productivity. For example, this can occur through selection of tree genotypes of higher growth rate and improved wood quality; genotypes that are potentially better adapted to projected warmer and drier conditions, as might be associated with climate change (Byrne et al. 2013); or genotypes that are resistant or tolerant to increases in pests and diseases, as could result from climate change or breaches of Australian quarantine. A substantial proportion of the genetic base of Australian native forest trees used in commercial plantations has been brought into collections (Table 1.48), seed orchards (plantations specifically planted and managed for seed production) (Table 1.49), and improvement and breeding programs (Table 1.50). Information on tree species included in improvement trials is reported in Table 1.51, and an example is shown in Figure 1.34.

Arboreta and private collections focus on species that are widely cultivated, including species of *Eucalyptus*, *Corymbia* and *Acacia*. Some collections of plantation genetic resources are held by forest industry agencies and companies, and some by industry cooperatives and research organisations.

The ATSC, based in Canberra, maintains a national collection of more than 900 species in some 75 genera, including more than 240 *Acacia*, 19 *Allocasuarina*, 11 *Casuarina*, 25 *Corymbia*, 330 *Eucalyptus* and 38 *Melaleuca* species. It provides a high-quality, representative, ex-situ sample of Australia's tree and shrub genetic diversity. Initially, the ATSC collected and stored seed mostly on a population or provenance basis, but the emphasis has increasingly shifted to collecting seed from individual parent trees. These genetically distinct acquisitions are important for ex-situ genetic resource conservation.

Table 1.48: Plantation species with reproductive material available in seed collections in Australia

Species	Type of material
Acacia auriculiformis	Seed (improved)
A. crassicarpa	Seed (improved)
A. mangium	Seed (improved)
Acacia other species	Seed (wild)
Casuarina various species	Seed (wild)
Corymbia maculata	Seed (improved)
C. citriodora subsp. *variegata*	Seed (improved)
Eucalyptus botryoides	Seed (improved)
E. camaldulensis subsp. *simulata*	Seed (improved)
E. camaldulensis var. *camaldulensis*	Seed (improved)
E. camaldulensis var. *obtusa*	Seed (improved)
E. cladocalyx	Seed (improved)
E. dunnii	Seed (improved)
E. globulus	Seed (improved)
E. grandis	Seed (improved)
E. nitens	Seed (improved)
E. occidentalis	Seed (improved)
E. pellita	Seed (improved)
E. saligna	Seed (improved)
E. tricarpa	Seed (improved)
E. tereticornis subsp. *tereticornis*	Seed (improved)
E. viminalis	Seed (improved)
Eucalyptus other species	Seed (wild)
Grevillea robusta	Seed (improved)

Source: Adapted from Singh et al. (2013).

In addition to the national ATSC collection, various institutions and forest and research agencies maintain their own forest seed collections. Some of these organisations are listed in Singh et al. (2013). The ATSC also has a number of provenance progeny tests (many in partnership with state governments and private growers) that serve as repositories of genetic material for species, including thick-podded salwood (*Acacia crassicarpa*), brown salwood (*A. mangium*), spotted gum (*Corymbia maculata* and *C. citriodora* subsp. *variegata*), large-leaved spotted gum (*C. henryi*), river red gum (*E. camaldulensis*), Dunn's white gum (*E. dunnii*), swamp yate (*E. occidentalis*), large-fruited red mahogany (*E. pellita*), red ironbark (*E. sideroxylon* and *E. tricarpa*), Sydney blue gum (*E. saligna*) and sugar gum (*E. cladocalyx*) (Singh et al. 2013).

The Southern Tree Breeding Association (STBA), formed in 1983, runs cooperative national tree improvement programs for the Australian species *E. globulus* and *E. nitens*. The program for *E. globulus* has been running since the amalgamation in 1994 of genetic material and data from eight selection and breeding programs previously managed by individual organisations. Grafted trees of *E. globulus* have been planted in the National Genetic Resource Centre for plantation forestry at Mount Gambier, South Australia, which was launched in August 2005 with support from the Australian and South Australian governments. Control-pollinated *E. globulus* seed is collected and stored in refrigerators, and diversity is maintained in numerous field trials spread across temperate Australia. The TREEPLAN® genetic evaluation system[56] is being used to update genetic values in *E. globulus* and *E. nitens*. This system was developed by the STBA in collaboration with the Animal Genetics and Breeding Unit (a joint unit of the New South Wales Department of Primary Industries and the University of New England).

Although breeding populations are maintained mainly for improving commercial wood production, they have an important spin-off in conserving genetic resources. Plant breeding strategies require a base population with wide-ranging genetic diversity. Normally, seeds are collected from native forest whenever new genetic material is needed. However, several of the best seed-source provenances of some eucalypts are no longer available in situ because the original populations no longer exist. For example, important parts of the genetic material for southern (Tasmanian) blue gum (*E. globulus*) and shining gum (*E. nitens*) are now held only in existing Australian plantations and special-purpose field trials.

Various state forest management agencies maintain tree improvement programs (Table 1.50). Forests NSW[57] manages a 45 year old hardwood tree improvement and breeding program that incorporates propagation and breeding facilities in conjunction with a production nursery. Clonal seed orchards include lemon-scented gum (*Corymbia citriodora* subsp. *variegata*), Dunn's white gum (*Eucalyptus dunnii*), shining gum (*E. nitens*) and blackbutt (*E. pilularis*). The Department of Environment and Conservation in Western Australia[58] runs provenance trials of karri (*E. diversicolor*) and associated wood species used for site restocking after wood harvesting.

Gene flow from plantations

The area of tree plantations of native species has been rapidly expanding in Australia (see Indicator 2.1b). Gene flow from these plantations into surrounding native forest (a phenomenon called 'introgression', in which infiltration of genes occurs from one species into another through hybridisation) could change the genetic make-up of local populations of native trees. Breeding strategies and genetic resource management plans aim to avoid gene flow that could damage the overall genetic resource. Strategies include careful selection of species and provenances; manipulation of flowering times and flower abundance; and silvicultural practices such as isolation distances, the use of buffer zones of non-interbreeding species, and closer planting to reduce the area of crowns able to produce flowers.

Table 1.49: Plantation species present in seed orchards in Australia

	Seed orchards		
Species	**Number**	**Generation**[a]	**Area (hectares)**
Araucaria cunninghamii	10	1, 1.5 and 2	29
Corymbia maculata	5	1 or 2	12
Eucalyptus botryoides	1	–	2
E. cladocalyx	14	1	30
E. dunnii	8	1,2	16
E. globulus	CSOs	1, 2 and 3	30
E. grandis	4	1	10
E. nitens	3	1 and 2	12
E. occidentalis	6	1	12
E. pellita	2	–	4
E. pilularis	CSOs	1	4.9
E. saligna	5	1	10

– = no data; CSO = clonal seed orchard

a Generation refers to first, second, third, etc. breeding cycle in the seed orchard.

Source: Adapted from Singh et al. (2013).

56 http://www.stba.com.au/page/treeplan.

57 From January 2013, the Forestry Corporation of NSW.

58 From July 2013, the Department of Parks and Wildlife.

Table 1.50: Plantation species in tree improvement and breeding programs in Australia

Species	Agency
Acacia crassicarpa	CSIRO – Queensland DERM[a]
A. mangium	CSIRO – Queensland DERM
Araucaria cunninghamii	HQPlantations Pty Ltd[b]
Corymbia maculata	Australian Low Rainfall Tree Improvement Group
C. henryi	Queensland DERM, Forests NSW[c]
C. citriodora subsp. *variegata*	Queensland DERM, Forests NSW
C. citriodora subsp. *citriodora*	Queensland DERM
C. torelliana	Queensland DERM
Eucalyptus argophloia	Queensland DERM, CSIRO
E. benthamii	CSIRO
E. biturbinata	Queensland DERM
E. camaldulensis	Australian Low Rainfall Tree Improvement Group, Queensland DERM
E. cladocalyx	Australian Low Rainfall Tree Improvement Group
E. cloeziana	Queensland DERM
E. dunnii	CSIRO – Forests NSW, SeedEnergy, Queensland DERM
E. grandis	Queensland DERM, Forests NSW
E. grandis × *E. robusta*	Forests NSW
E. globulus	Southern Tree Breeding Association Inc, Forest Products Commission Western Australia, Australian Bluegum Plantations, HVP Plantations
E. longirostrata	Queensland DERM, CSIRO
E. moluccana	Queensland DERM
E. nitens	Private industry, Forestry Tasmania
E. occidentalis	Australian Low Rainfall Tree Improvement Group
E. pellita	CSIRO – Queensland DERM
E. pilularis	Forests NSW, Queensland DERM
E. propinqua × *E. resinifera*	Forests NSW
E. robusta × *E. grandis*	Forests NSW
E. robusta × *E. tereticornis*	Forests NSW
E. saligna	CSIRO
E. saligna × *E. grandis*	Forests NSW
E. sideroxylon × *E. tricarpa*	Australian Low Rainfall Tree Improvement Group
E. tereticornis	Queensland DERM
Grevillea robusta	CSIRO – Queensland DERM

CSIRO = Commonwealth Scientific and Industrial Research Organisation; DERM = Department of Environment and Resource Management

[a] From April 2012, the Queensland Department of Agriculture, Fisheries and Forestry (DAFF).

[b] Before 30 June 2010, Forestry Plantations Queensland.

[c] From January 2013, the Forestry Corporation of NSW.

Source: Adapted from Singh et al. (2013).

Table 1.51: Tree improvement trials in Australia

	Plus trees[a]	Provenance trials		Progeny trials		Clonal testing and development	
Species		No. of trials	No. of provenances	No. of trials	No. of families	No. of tests	No. of clones tested
Araucaria cunninghamii	876 of first generation	20	50	~100	~900	–	–
Eucalyptus dunnii	n.a.	–	–	3	150	–	–
E. globulus	n.a.	91	30	87	3,836	~20	~100
Eucalyptus hybrids	n.a.	–	–	–	–	~10	~100
E. nitens	n.a.	–	–	4	150	–	–

– = not available; n.a. = not applicable

[a] Number of plus trees (superior trees) listed if program is beginning and only first-generation seed orchards have been established.

Note: This table shows the subset of species listed in Table 1.50 for which trial data were available.

Source: Adapted from Singh et al. (2013).

International collaboration and engagement

Australia is a party to many international organisations, agreements, treaties, conventions or trade agreements that are directly or indirectly relevant to genetic resource conservation (Singh et al. 2013). These include the Food and Agriculture Organization of the United Nations and its Commission on Genetic Resources for Food and Agriculture; the United Nations Forum on Forests; the Convention on Biological Diversity; the World Intellectual Property Organization and its Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore; the International Union for the Protection of New Varieties of Plants, established under the International Convention for the Protection of New Varieties of Plants; the Convention on International Trade in Endangered Species of Wild Fauna and Flora; and the International Plant Protection Convention.

In November 2010, the Conference of the Parties to the Convention on Biological Diversity adopted the 'Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization'. The Nagoya Protocol establishes a legally binding framework for biotechnology researchers and other scientists to gain access to genetic resources. It also establishes a framework for researchers and developers to share any benefits from genetic resources, or traditional knowledge associated with those resources, with the provider country. Australia signed the protocol on 20 January 2012.

Figure 1.34: Plant health experts observing superior red mahogany (*Eucalyptus pellita*) trees in a forest species trial in north Queensland

Sharan Singh

Criterion 2

Maintenance of productive capacity of forest ecosystems

Eucalypt flowers. iStockphoto

Unloading hardwood sawlogs from a truck at a sawmill, southern New South Wales.

Criterion 2
Maintenance of productive capacity of forest ecosystems

A key goal of sustainable forest management is to maintain the productive capacity of native and plantation forests. This allows provision of the forest goods and services required by society without compromising the ability of future generations to meet their own needs. Maintaining the output of both wood and non-wood forest products through harvesting therefore requires, among other things, forest regeneration and the maintenance of ecosystem health.

The five indicators in this criterion set out information on the area of native forest available for wood production and the size of the plantation resource, the volumes of wood harvested against the calculated sustainable yield, the regeneration and re-establishment of harvested native forest and plantations, and the volumes and types of non-wood forest products extracted.

Native forest

The area of native forest available for commercial wood production is a key determinant of the capacity of forest-based industries to meet domestic and export demands for native timbers and wood products. Harvest volumes can also vary markedly among forest types and localities, depending on forest productivity, the merchantability of a forest's standing wood for timber or other products, and other factors. Information on both the area harvested and the volume extracted is therefore required to gauge trends over time.

The main wood products harvested from Australia's native forests are high-quality sawlogs for solid wood products, and pulplogs for paper, cardboard, fibreboard and related products. Increasingly, logs are also used to produce veneer for wood-based panel products. Other products include logs for speciality timbers, low-quality sawlogs, round and split posts, poles, piles and girders, timber sawn and hewn in the forest, sleepers, firewood for residential use, and fuelwood for industrial use. Some of these are obtained as ancillary products during a sawlog harvest.

States and territories apply regulatory frameworks designed to ensure that environmental attributes and the productive capacity of the forest are maintained. Sawlog volumes permitted for harvest are set according to a calculated annual sustainable yield (also called sustained yield or allowable cut), which requires data on the net area of forest available for harvest, forest type and age class, standing wood volume, terrain, accessibility, and growth and yield. Estimates of sustainable yield also take into account restrictions on harvesting within the area available for harvest that may be imposed by codes of forest practice, and by other rules and regulatory frameworks established to ensure the protection and maintenance of biodiversity and soil and water resources. Harvesting levels can fluctuate over time for operational reasons, with occasional overcuts in some years balanced by prescribed undercuts in others, in compliance with state regulations.

Native forest harvest for wood production is permitted only if systems are in place for forest regeneration—regeneration of a new forest stand is critical to maintaining the productive capacity of the forest. Data are collected routinely on the area of harvested forest that is regenerated successfully in an allocated time period. Remedial treatments are applied, if required, to ensure adequate regeneration.

Firewood and fuelwood are major energy sources for many Australian households and industries, respectively. States and territories have established permit systems to regulate collection of firewood and fuelwood, including permission to collect firewood and fuelwood as a by-product of sawlog harvesting operations, voluntary codes of practice for commercial operators, and restrictions on the clearing of native vegetation, including forests. The unregulated collection of firewood poses a significant risk to forest health and biodiversity.

Plantation forests

The primary purpose of industrial plantation forestry in Australia is wood production. Plantation forests also make a contribution to a range of environmental services, including production of drinking-quality water, mitigation of dryland salinity, sequestration of carbon, and, especially where native species such as eucalypts are planted, provision of habitat for native plants and animals.

The area of Australia's plantation estate increases when new plantations are established. Recently, new plantations have mostly been established on cleared agricultural land. Simultaneously, existing plantations can be harvested and re-established. The decision to re-establish plantations after harvest depends on factors such as site suitability (including with regard to projected climate change), grower intent, market availability, projected economic returns, and rationalisation of the plantation estate. The prospects for alternative land uses and the availability of other investment opportunities are also important considerations, especially for privately managed plantations.

State and territory agencies and most private growers have management systems in place to assess plantation regeneration or re-establishment against stocking standards, and to prescribe remedial treatments. Silvicultural and tree improvement programs play large roles in maintaining and increasing plantation productivity.

Non-wood forest products

Non-wood forest products (NWFPs) are products other than wood derived from forest, including products generated directly or indirectly from organisms living in forest ecosystems, as well as some minerals. Industries such as honey production rely heavily on the flowering of native forest. Other categories of non-wood products are plant foods; animal products; landscape and garden products; health and personal care products; decorative and aesthetic products; and minerals, stone and gravel. Many Aboriginal and Torres Strait Islander peoples (referred to as Indigenous peoples in SOFR 2013) rely to varying degrees on the use of non-wood forest products for customary purposes (e.g. food, medicine and livelihood) and commercial purposes (e.g. art and craft).

The sustainable management of non-wood forest products is essential for the conservation of harvested species and for maintaining the livelihoods of people who depend on them. Knowledge of the ecological sustainability of harvesting non-wood forest products has grown rapidly, but is mostly in the form of studies on individual species or specific regions.

In all states and territories, the removal of native animals from forests is prohibited or subject to regulation. Permits to harvest native forest plants and animals are part of the system of ensuring the sustainability of production and harvesting. Issuance of permits takes into consideration factors such as population levels and reproduction rates of the species concerned, and environmental pressures such as disease and habitat loss. Harvesting under permit for meat and skins is restricted to common and widespread species, or to exotic species, many of which (such as pigs and water buffalo) are officially declared as pests.

CRITERION 2

Mature pine plantation canopy, Victoria.

Key findings

Key findings are a condensed version of the Key points presented at the start of individual indicators in this criterion.

Native forest

- The total area of Australia's native forest both available and suitable for commercial wood production was 36.6 million hectares in 2010–11, a decrease from 37.6 million hectares in 2005–06. This includes 7.5 million hectares of public native forests (19% of Australia's public native forest area). A further 29.1 million hectares of leasehold and private tenure forests are also potentially both available and suitable for commercial wood production, subject to landholder intent, markets and environmental constraints.
- Harvesting in multiple-use public native forest is subject to substantial requirements for maintaining and managing non-wood values. When these additional local restrictions are taken into account, the net area available and suitable for harvest in multiple-use public native forest (the net harvestable area) is 5.5 million hectares.
- The area of multiple-use public native forest harvested annually in Australia decreased from 117 thousand hectares in 2006–07 to 79 thousand hectares in 2010–11, a decrease of 32%. Of the area of multiple-use public native forest harvested over the 10-year period 2001–02 to 2010–11, 85% was harvested by selection logging silviculture systems (selection logging, native cypress pine logging and commercial thinning), 12% by clearfell silviculture systems (clearfelling, fire salvage clearfelling and intensive silviculculture), and 3% by shelterwood systems.
- The average sustainable yield declined nationally by 47%, and in all states except Tasmania, between 1992–96 and 2006–11. This decline was a consequence of increased reservation of public multiple-use native forests; increased restrictions on harvesting through prescriptions in codes of forest practice; revised estimates of forest growth and yield; and impacts of occasional, intense, broadscale wildfires.
- The volume of sawlogs harvested from multiple-use public native forest in the period 1992–93 to 2010–11 was at or below the calculated sustainable yield in New South Wales, Tasmania, Victoria and Western Australia, and at or below the calculated sustainable yield or allowable cut in Queensland. Nationally, sawlog harvest levels were 17% below the calculated sustainable yield for the period 2006–11, and were 6–18% below the calculated sustainable yield in each of the four SOFR five-yearly reporting periods. In the period 2006–07 to 2010–11, the average annual sawlog volume harvested from multiple-use public native forest was 1.40 million cubic metres, a decline from 1.96 million cubic metres in the period 2001–02 to 2005–06.
- As the supply of high-quality logs from public multiple-use native forests declines as a consequence of reservation of forest and other factors, the importance of private native forests for the supply of hardwood logs will increase, and management of private native forests will increasingly determine the long-term national supply of high-quality native hardwood logs. However, a national assessment found that there is insufficient information to determine whether the rate of wood harvest from private native forests is sustainable.
- The use of firewood for residential heating and energy decreased slightly between 2006 and 2010, while use of industrial fuelwood increased.
- State jurisdictions require the regeneration and/or restocking of harvested multiple-use public native forest to specified standards; some states have similar codes of practice and regulations for private forests. Five-year average reported regeneration success rates in multiple-use public native forest in the reporting period 2005–06 to 2010–11 varied from 85% in New South Wales, to 100% in Queensland; over the four SOFR reporting periods, five-year average reported regeneration rates varied from 72% in Victoria, to 100% in Queensland and Western Australia. Remedial action was carried out where specified regeneration and restocking standards in harvested areas were not achieved. Drought, fire, poor seed reserves, and difficulties in carrying out regeneration burns contributed to low regeneration success rates in some states.

Plantation forests

- The area of Industrial plantations managed for wood production in Australia increased from 1.818 million hectares in 2005–06 to 2.017 million hectares in 2010–11, with almost all the increase achieved by planting on cleared agricultural land. Of the total area of Industrial plantations as at 2010–11, 51% is planted with softwood species, and 49% with hardwood species. The area of Industrial softwood plantations was relatively stable over the reporting period, but the area of Industrial hardwood plantations increased from 0.807 million hectares in 2005–06 to 0.980 million hectares in 2010–11.
- The area proportion of the Industrial plantation estate where the trees are government-owned decreased from 35% in 2006 to 24% in 2011, while the area proportion where the trees are privately owned increased from 65% to 76%. Private ownership identified as ownership by institutional investors increased from 12% in 2006 to 31% in 2011.
- In the period 2006–07 to 2010–11, plantations produced 71% of the volume of logs harvested in Australia. Hardwood plantations provided 35% of Australia's pulplog supply and 1% of Australia's sawlog supply, while softwood plantations provided 39% of Australia's pulplog supply and 79% of Australia's sawlog supply. The harvest of sawlog and pulplog from softwood plantations has increased since 2000, as has the pulplog harvest from hardwood plantations, while sawlog harvest from hardwood plantations has been relatively stable. In 2010–11, the final year of the SOFR 2013 reporting period, plantations produced 76% of the volume of logs harvested in Australia.

- If the current plantation area is maintained, total wood production from softwood plantations is expected to plateau by 2035 at 18 million cubic metres per year. Total production from hardwood plantations will increase to around 15 million cubic metres per year by 2030.
- Rates of successful establishment of new plantations, and re-establishment of plantations after plantation harvest, are generally above 90%.

Non-wood forest products

- Australia produces a wide range of non-wood forest products derived from forest fauna, flora and fungi, and in general from forest biological resources. High-value non-wood forest products include wildflowers, seed, honey, and aromatic products derived from sandalwood.
- Data on annual removals and sustainable yields are limited for many non-wood forest products. The State of the Environment 2011 Committee assessed the extraction of non-wood forest products from native and plantation forests as generally having a low impact on the environment.

A honeybee collecting pollen from a eucalypt flower.

Indicator 2.1a

Native forest available for wood production, area harvested, and growing stock of merchantable and non merchantable tree species

Rationale

This indicator reports the capacity of forests to sustainably produce wood to meet society's needs into the future. The area of native forest available for wood production, the nature of the growing stock, and the area harvested over time provide means to demonstrate the sustainability of forest management.

Key points

- In 2010–11, 82.6 million hectares of native forest in Australia were in tenures (leasehold, private, and multiple-use public lands) in which wood production is not legally restricted.
- The extent of native forest that is both available and suitable for commercial wood production declined from 37.6 million hectares in 2005–06 to 36.6 million hectares in 2010–11. This decline is a consequence of increases in reservation, and changes in the reported total area of Australia's forests.
- Only 7.5 million hectares (19%) of public native forests were both available and suitable for commercial wood production in 2010–11. A further 29.1 million hectares of leasehold and private tenure forests were also potentially available and suitable for commercial wood production, subject to landholder intent, markets and environmental constraints.
- Harvesting in multiple-use public native forests is subject to substantial requirements to maintain and manage non-wood values. The net area available and suitable for harvest in multiple-use public native forests when these additional local restrictions are taken into account (the net harvestable area) is 5.5 million hectares (14% of public native forests).
- The annual area of multiple-use public native forests harvested in Australia decreased from 117 thousand hectares in 2006–07 to 79 thousand hectares in 2010–11, a 32% decrease. Of the area of multiple-use public native forest harvested over the 10-year period 2001–02 to 2010–11, 85% was harvested by selection logging silvicultural systems (selection logging, native cypress pine logging and commercial thinning), 12% by clearfelling silvicultural systems (clearfelling, fire-salvage clearfelling, and intensive silviculture), and 3% by shelterwood systems.

High-quality flooring made from timber sourced from multiple-use public native forests in south-east New South Wales.

The emphasis of this indicator is the area of native forests available for wood production—that is, the area in which harvesting is not legally restricted[59]. For Australia's purposes, the term "not legally restricted" in this indicator is confined to the tenures leasehold forest, multiple-use public forest and private land. The tenures nature conservation reserve, other Crown land and unresolved tenure are considered for the purposes of this indicator to be legally restricted from harvesting. Harvesting is also subject to various forms of regulation on tenures where it is "not legally restricted", as well as economic constraints.

In Australia, the area of native forest available for wood production is a function of tenure, state and territory regulatory frameworks, codes of practice, and—on public lands—requirements to manage the forest for multiple values. In turn, the area of native forests available for wood production is one determinant of the forest sector's capacity to meet domestic and export demand for native timbers and wood-based products, and is also an important input for calculating the level of sustainable yield from native forests (see Indicator 2.1c). This indicator concentrates on the area of forest that is available and suitable for commercial wood production.

Native forest area available for wood production

The major source of Australia's native timber and wood-based products is multiple-use public forests in New South Wales, Queensland, Tasmania, Victoria and Western Australia; forests on land with leasehold and private tenure also contribute to supply in these states. Limited and periodic supplies are provided from leasehold and private tenures in the Northern Territory. By regulation, no commercial harvesting is carried out in native forests in the Australian Capital Territory or South Australia. Wood harvesting of native forests is not permitted in nature conservation reserves in any jurisdiction in Australia.

Within the various tenure categories in which wood harvest is permitted, harvesting can be restricted by legislation, codes of practice and management plans. Reasons for these restrictions include conservation and management of biodiversity and heritage, and protection of the water supply (see Indicator 7.1a).

59 The Montreal Process guideline for this indicator (Montreal Process Working Group 2001) defines forest available for wood production as "forest land where wood product extraction is not legally restricted. For example, parks and other areas removed from harvest for protective purposes (i.e. soil protection) is legally restricted. Where harvesting is not legally restricted on private or public land and owners do or do not have a management intent to harvest, all this land would still be considered available for harvest".

60 See discussion of reported changes in Australia's total native forest area in Indicator 1.1a.

Native forest not legally restricted from harvesting

In 2000–01, the area of native forest not legally restricted from wood harvesting was 119.8 million hectares—74% of Australia's native forests at that time (SOFR 2003). This area decreased in absolute terms to 112.6 million hectares in 2005–06, representing an increase to 76% of Australia's native forests at that time (SOFR 2008). In 2010–11, 82.6 million hectares are not legally restricted from wood harvesting (Table 2.1), which is 67% of Australia's total 122.6 million hectares of native forest (reported in Indicator 1.1a).[60]

Forest available and suitable for harvesting

The area of native forest not legally restricted from wood harvesting is a poor representation of, and substantially overstates, the area actually available to the timber and wood-processing industries, because it includes forests that are unsuitable for wood harvesting or in which wood harvesting is not economically (commercially) viable.

Between 1960 and 1990, data were provided by state and territory agencies to Australian Government agencies on the area of native forest available and commercially suitable for wood production from multiple-use public forests, leasehold and private forests. Such reporting was not continued after 1992. Davey and Dunn (in preparation) therefore undertook a recent national assessment of commerciality, merchantability and productivity of native forests across all tenures, based on historical and recent data, and spatially identified native forests available and suitable for wood production.

Table 2.2 shows the estimated area of native forest both available and suitable for wood harvesting in 2006 and 2011, categorised by its commercial suitability for wood harvesting based on forest productivity and merchantability (Davey and Dunn, in preparation). Forest 'available and suitable' for harvesting is forest with a commerciality rating of very low, low, moderate, high or very high. A total of 37.6 million hectares of native forest was available and suitable for wood harvesting in 2006, which was 33% of the 112.6 million hectares of forest in the tenures leasehold, private and multiple-use native forest. In 2011, the estimate had decreased to 36.6 million hectares of native forest, which is 40% of the 92.1 million hectares of forest in the tenures leasehold, private and multiple-use native forest (Table 2.2).

Figure 2.1 shows the national distribution of native forest areas by their assessed level of commerciality in 2011. Only 7.5 million hectares (19%) of the 39.8 million hectares of public native forest (that is, native forest on the tenures multiple-use public forest, nature conservation reserve and other Crown land) are available and suitable for commercial wood production. A further 29.1 million hectares of leasehold and private tenure forests are also potentially available and suitable for commercial wood production, subject to landholder intent, markets and environmental constraints (Table 2.2). This is 1.0 million hectares less than in 2006–07, as a consequence of increases in reservation, and changes in the reported total area of Australia's forests. The increase in area of commercial multiple-use public forests resulted from changes in tenure classification in Queensland (see Indicator 1.1a).

Table 2.1: Area of leasehold native forest, multiple-use public native forest and native forest on private land legally restricted and not legally restricted from wood harvesting, by jurisdiction, 2010–11

	Area ('000 hectares)										
	Legally restricted[a]	Not legally restricted									Total forest in tenure[b]
Tenure		ACT[c]	NSW	NT	Qld	SA[c]	Tas.	Vic.	WA	Australia	
Leasehold forest	3,267	0	5,472	4,578	29,672	0	16	2	5,527	45,266	48,533
Multiple-use public forest	550	0	1,830	0	2,774	0	789	2,926	1,290	9,609	10,159
Private land (including Indigenous)	5,647	0	8,777	6,344	9,496	0	776	1,120	1,234	27,747	33,394
Total	**9,464**	**0**	**16,079**	**10,922**	**41,941**	**0**	**1,581**	**4,048**	**8,052**	**82,622**	**92,086**

[a] Within these tenures, wood harvesting is legally restricted on reserves on multiple-use public forest, private and leasehold land, and on covenanted private and leasehold land.

[b] Figures for total forest in each tenure category are from Indicator 1.1a.

[c] Commercial wood harvesting is not permitted in native forests in the ACT and SA.

Note: Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences.

Table 2.2: Area of leasehold, private and multiple-use native forest, by level of wood commerciality, 2006 and 2011

Year	Tenure	Non-commercial forest and forest legally restricted from harvesting[a]	Commercial forest (forest available and suitable for harvesting)						Total forest in tenure[c]	Comm-erciality[d]
			Level of wood commerciality							
			Very low	Low	Moderate	High	Very high	Total[b]		
			Area ('000 hectares)							%
2006	Leasehold forest	51,155	4	12,790	845	308	30	**13,977**	65,132	21
	Multiple-use public forest	2,194	84	2,203	2,496	1,784	649	**7,216**	9,410	77
	Private land	21,652	42	12,567	2,428	1,013	396	**16,447**	38,099	43
	Total	**75,001**	**130**	**27,561**	**5,769**	**3,105**	**1,075**	**37,640**	**112,641**	**33**
2011	Leasehold forest	35,737	0	11,753	702	317	24	**12,796**	48,533	26
	Multiple-use public forest	2,637	86	2,732	2,486	1,615	603	**7,522**	10,159	74
	Private land	17,099	54	12,156	2,551	1,119	415	**16,295**	33,394	49
	Total	**55,473**	**140**	**26,641**	**5,739**	**3,051**	**1,042**	**36,613**	**92,086**	**40**

[a] 'Non-commercial forest and forest legally restricted from harvesting' includes forest of limited, possible or no commerciality; sandalwood; forest of unknown floristics and structure; and conservation reserves where harvesting is excluded by covenant or regulation. Forests on formal nature conservation reserves, other Crown land and land of unresolved tenure are not included on this Table.

[b] 'Total' column is the sum of the areas of forest of very low, low, moderate, high and very high commerciality.

[c] Figures for total forest in each tenure category are from Indicator 1.1a for 2011, and SOFR 2008 for 2006; these area coverages were used to overlay the relevant commercial forest layer.

[d] 'Commerciality' is the proportion of the total area of forest in a tenure category that is classified as very low, low, moderate, high or very high commerciality.

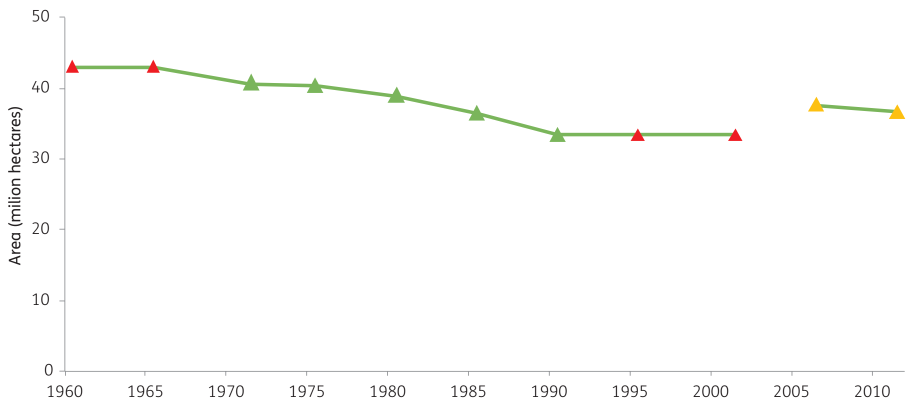
Notes:

'Total forest' uses area statements of forest reported in SOFR 2008 and this SOFR (Table 1.5, Indicator 1.1a); these area coverages were used to overlay the relevant commercial forest layer.

Totals may not tally due to rounding.

Source: Davey and Dunn (in preparation), Australian Bureau of Agricultural and Resource Economics and Sciences.

Figure 2.2: Australia's native forests available and suitable for wood production across the leasehold, private and multiple-use public forest estate



Note: Green data points are derived from tabular data provided by state and territory agencies to Australian Government agencies. Red data points are estimates based on the tabular data (green data points) and ancillary historical data. Yellow data points are based on recent spatial assessment (Davey and Dunn in preparation).

Source: Resource Assessment Commission (1992), Davey and Dunn (in preparation), and Australian Bureau of Agricultural and Resource Economics and Sciences (including historical forest resource datasets and publications from the Bureau of Agricultural Economics and the Commonwealth Forestry and Timber Bureau).

A large part of the native forest estate on leasehold and private land contributes minimally to wood supply. This includes forests used predominantly for grazing, forests containing few marketable species in commercial quantities, forests isolated from markets, or forests where harvesting is not operationally feasible. There is relatively little commercial native forest harvesting in the Northern Territory for a combination of these reasons.

Figure 2.2 shows the trend in the gross area of native forest available and suitable for wood production in the period 1960–2011, using these various data sources. Forests on leasehold, private and particularly multiple-use public forest tenures are increasingly managed for a range of values, such as water protection, flora and fauna protection, and conservation, as well as (or instead of) wood production. This trend of changing use has contributed to continuing reductions in the availability of multiple-use public forests for wood harvesting.

Net harvestable area of forest

The net harvestable area is the basis of sustainable yield calculations for multiple-use public native forests. Net harvestable area is estimated by subtracting from the gross available multiple-use public native forest area:

- areas within multiple-use forests that are reserved for nature conservation, water and heritage, and/or are zoned for management purposes that do not permit wood harvesting
- forest exclusions resulting from the application of codes of forest practice
- forests determined to have operational constraints (e.g. access) or to be non-merchantable—that is, they are not suitable for wood production because of the age, size and type of trees, or because they have been damaged by fire or disease.

The net harvestable area therefore represents the net area of available and suitable forest on multiple-use public native forest land after allowing for local and/or operational constraints on harvesting.

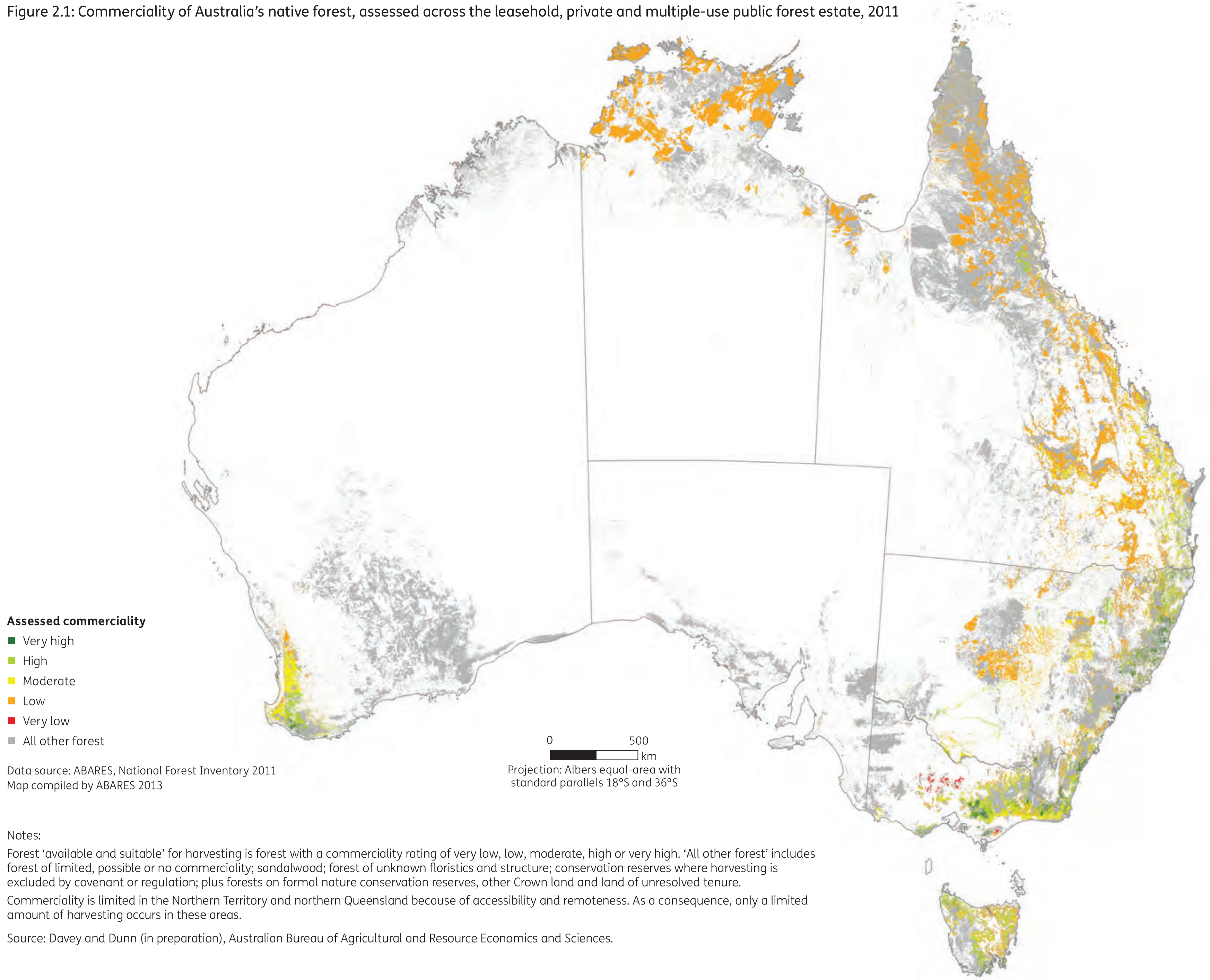
The net harvestable area of public native forest (that is, native forest on the tenures multiple-use public forest, nature conservation reserve and other Crown land) declined by 46% from 1995–96 to 2010–11, from 10.1 million hectares to 5.5 million hectares, including from decisions made by governments as a result of Regional Forest Agreements (Table 2.3). This is a direct result of significant amounts of multiple-use public native forest being transferred to nature conservation reserves (Davidson et al. 2008). The net harvestable area of public native forest in 2010–11 (5.5 million hectares) is 14% of the area of public native forest.

In New South Wales, the net harvestable area of public native forest declined from 2.35 million hectares in 1995–96 to 1.23 million hectares in 2010–11 (Table 2.3), a reduction of 48%.

In Tasmania, the net harvestable area of public native forest decreased from 0.811 million hectares in 1995–96 to 0.563 million hectares in 2010–11 (Table 2.3). The proportion of Tasmania's public native forest estate available for harvesting decreased from 36% in 1995–96 to 23% in 2010–11. This was due to the reallocation of areas of multiple-use public native forest as nature conservation reserves as a result of the 1997 Regional Forest Agreement and 2005 Tasmanian Community Forest Agreement, and to changes to prescriptions in the Tasmanian code of forest practice (FPA 2012).

The net harvestable area of public native forest in Victoria decreased by 67% between 1995–96 and 2010–11, from 2.55 million hectares to 0.835 million hectares (Table 2.3). There were several reasons for this decrease: some multiple-use public native forest was transferred to nature conservation reserves; some forest became unavailable as a result of exclusions associated with changes to the *Victorian Code of Practice for Timber Production* and to special protection zones; and some forest was reassessed as unsuitable for wood production because of operational constraints and a lack of merchantable (i.e. saleable) timber.

Figure 2.1: Commerciality of Australia's native forest, assessed across the leasehold, private and multiple-use public forest estate, 2011



Data source: ABARES, National Forest Inventory 2011
Map compiled by ABARES 2013

Notes:

Forest 'available and suitable' for harvesting is forest with a commerciality rating of very low, low, moderate, high or very high. 'All other forest' includes forest of limited, possible or no commerciality; sandalwood; forest of unknown floristics and structure; conservation reserves where harvesting is excluded by covenant or regulation; plus forests on formal nature conservation reserves, other Crown land and land of unresolved tenure.

Commerciality is limited in the Northern Territory and northern Queensland because of accessibility and remoteness. As a consequence, only a limited amount of harvesting occurs in these areas.

Source: Davey and Dunn (in preparation), Australian Bureau of Agricultural and Resource Economics and Sciences.

Table 2.3: Net harvestable area of public native forest[a], and proportion of total public native forest, by jurisdiction, 1995–96 to 2010–11

Jurisdiction	Public native forest	1995–96	2000–01	2005–06	2010–11
NSW	Net harvestable area ('000 hectares)	2,352	1,516	966[b]	1,229[b]
	Proportion (%)[c]	35	20	12	16
Qld	Net harvestable area ('000 hectares)	3,186	2,340	2,178	2,030
	Proportion (%)[c]	40	26	27	22
Tas.	Net harvestable area ('000 hectares)	811	787	607	563
	Proportion (%)[c]	36	35	27	23
Vic.	Net harvestable area ('000 hectares)	2,555	1,010	930	835
	Proportion (%)[c]	41	15	14	13
WA	Net harvestable area ('000 hectares)	1,157	904	848	848
	Proportion (%)[c]	6	6	7	7
Total	**Net harvestable area ('000 hectares)**	**10,061**	**6,557**	**5,528**	**5 505**
	Proportion (%)[c]	**22**	**14**	**13**	**14**

[a] Public native forest comprises the tenures multiple-use public native forest, nature conservation reserve and other Crown land

[b] The increase in the estimated net harvestable area between 2005–06 and 2010–11 for NSW public native forests resulted from use of a new standardised methodology involving a corporate geo-database.

[c] Proportion of public native forest area in that jurisdiction.

Note: Area statements of public forest reported in SOFR 1998, 2003, 2008 and Table 1.5 (Indicator 1.1a) are used to calculate proportion of total public native forest.

Source: State and territory government agencies, including FPA (2002, 2007, 2012) and DSE (2003, 2008); Australian Bureau of Agricultural and Resource Economics and Sciences.

An estimated 0.364 million hectares (27%) of Victoria's private and leasehold forests were available and suitable for timber production in 2000–01 (DSE 2003). No estimates of the area of net harvestable private and leasehold forests in other jurisdictions were available for this report.

In Western Australia, the net harvestable area of public native forest declined from 1.157 million hectares in 1995–96 to 0.848 million hectares in 2005–06 (Table 2.3), a decrease of 27%. This was a result of the transfer of parts of the multiple-use public native forest area to nature conservation reserves and the introduction by the Western Australian Government of policies for the protection of old-growth forests. The net harvestable area has remained steady from 2005–06 to 2010–11.

In 1999, the Queensland Government signalled a phase-out of harvesting in public native forest in south-east Queensland in favour of wood production from hardwood plantations (SOFR 2008). This phase-out, which subsequently applied statewide, resulted in a steady decrease in the proportion of the net harvestable area of public native forest, from 40% of public forest in 1995–96 to 22% of public forest in 2010–11. Net harvestable area decreased from 3.2 million hectares in 1995–96 to 2.0 million hectares in 2010–11, a decline of 36%. The phase-out of harvesting was terminated in 2012, with no further transfers of multiple-use public native forest to nature conservation reserves. Some areas of multiple-use public native forests (principally state forests), where harvesting was excluded, will return to ongoing native timber production.

Area of native forest harvested for wood

Limited data are available on the area harvested annually in Australia, although state forest agencies report annually or five-yearly the area of forests that they manage that is harvested and regenerated. Some data are also available for the area harvested in private forests in Tasmania.

Western Australia has a long history of reporting the annual area of forest harvested for wood. Table 2.4 shows the areas of jarrah (*Eucalyptus marginata*), karri (*E. diversicolor*) and wandoo (*E. wandoo*) forest types harvested since 1975. The average annual harvested area decreased from 30,180 hectares in 1976–80 to 8,956 hectares in 2006–10, a 70% reduction. The majority of harvesting occurred using selection and shelterwood systems.

A range of silvicultural systems are used in Australia (Figure 2.3). The area of multiple-use public native forest harvested in Australia is summarised by silvicultural system in Table 2.5, and by jurisdiction in Table 2.6. Nationally, the total area harvested annually declined steadily from 140,700 hectares in 2001–02 to 79,400 hectares in 2010–11 (Tables 2.5 and 2.6), a 44% decrease. Over the period 2006–07 to 2010–11, the total area harvested declined from 117,400 hectares to 79,400 hectares, a 32% decrease.

Table 2.4: Average area of multiple-use public native forest harvested in Western Australia

Period	Area (hectares): Selection, shelterwood and other harvest[a] (jarrah and wandoo)	Clearfelled or partially cut (karri)	Thinned[b] (karri)	Total
1976–80	27,340	2,792	48	30,180
1981–85	23,244	1,722	322	25,288
1986–90	18,266	1,330	656	20,252
1991–95	14,236	1,788	124	16,148
1996–2000	19,436	1,668	180	21,284
2001–05	11,032	724	608	12,364
2006–10	7,486	508	962	8,956

[a] Includes harvesting for a range of silvicultural objectives, including by thinning, selection and shelterwood silviculture systems used in jarrah and wandoo forest and in jarrah forest harvested before being cleared for bauxite mining.

[b] 'Thinning' of regrowth karri forests.

Source: CCWA (2012a), Western Australian Department of Environment and Conservation, Western Australian Forest Products Commission.

Table 2.5: Silvicultural systems used in multiple-use public native forest in Australia

Reporting year	Area (hectares): Silvicultural system[a]							All systems	Cleared for mining[d]	Total area harvested
	Clear-felling[b]	Fire salvage (clear-felling)[b]	Intensive silviculture with retention[b]	Shelter-wood	Selection[c]	Native cypress pine silviculture[c]	Commercial thinning[c]			
2001–02	10,607	100	7,958	7,920	68,968	29,576	14,952	140,081	630	140,711
2002–03	11,184	400	6,546	6,500	67,631	29,767	14,684	136,712	390	137,102
2003–04	10,440	1,800	5,862	4,330	60,150	33,075	12,995	128,652	–	128,652
2004–05	9,680	600	5,118	4,310	56,185	29,693	12,747	118,333	500	118,833
2005–06	7,580	900	5,719	2,870	60,755	30,954	9,895	118,673	340	119,013
2006–07	8,310	500	4,855	2,780	64,753	25,120	10,478	116,796	600	117,396
2007–08	6,710	1,500	3,566	3,040	61,715	38,200	12,039	126,770	920	127,690
2008–09	5,410	1,000	3,662	2,700	40,529	21,300	12,261	86,862	690	87,552
2009–10	4,910	1,600	3,018	3,710	47,299	27,450	8,032	96,019	990	97,009
2010–11	4,640	1,200	4,647	1,250	37,012	22,512	6,853	78,114	1,250	79,364
5-year mean, 2001–02 to 2005–06	9,898	760	6,241	5,186	62,738	30,613	13,055	128,490	372	128,862
5-year mean, 2006–07 to 2010–11	5,996	1,160	3,950	2,696	50,262	26,916	9,933	100,912	890	101,802
10-year mean, 2001–02 to 2010–11	7,947	960	5,095	3,941	56,500	28,765	11,494	114,701	631	115,332
10-year total as proportion of 10-year total for all silvicultural systems (%)	7	1	4	3	49	25	10	100		

– = not separately reported

[a] Some silvicultural systems are illustrated in Figure 2.3.

[b] Clearfelling, fire-salvage clearfelling and intensive silviculture with retention are all clearfelling silvicultural systems. Intensive silviculture with retention includes areas harvested with seed-tree and/or habitat-tree retention, and alternate coupe harvesting.

[c] Selection, native cypress pine silviculture and commercial thinning are all selection silvicultural systems.

[d] Jarrah forests in WA that are cleared for bauxite mining are shown as 'cleared for mining'.

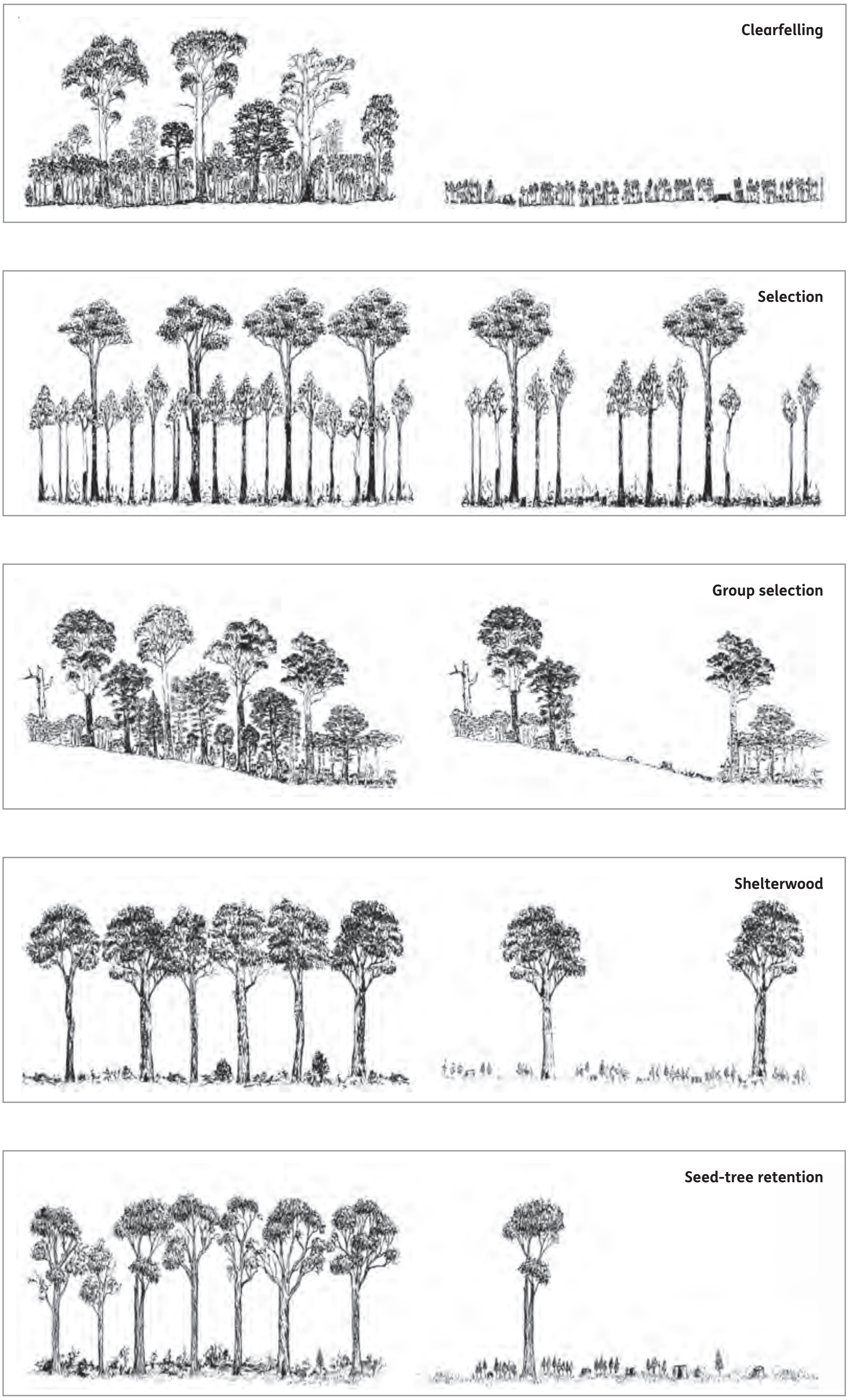
Notes:

No harvesting of native forest is permitted from public forests in the ACT, NT or SA.

Other than commercial thinning, Tasmania reports all non-clearfell silviculture (including variable retention) under selection logging.

Source: Data provided by NSW, Qld, Tas., Vic. and WA.

Figure 2.3: Silvicultural systems used in Australia's native forests



Source: Adapted from original artwork by Fred Duncan.

Tasmania, Victoria and Western Australia use clearfelling as a silvicultural system to promote native forest regeneration in certain forest types. Clearfelling data in Table 2.5 include native forest regenerated to native forest and, in Tasmania, native forest converted to plantation (Table 2.5). Fire salvage of damaged native forest stands using clearfelling systems in Victoria, and areas clearfelled for bauxite mining in Western Australia, are reported separately (Table 2.5). Intensive silviculture with retention includes areas harvested with seed-tree and/or habitat-tree retention, practised in Victoria, and alternate coupe harvesting in Eden, New South Wales; variable retention in Tasmania is reported under selection logging. A shelterwood silvicultural system used for nurturing and promoting regeneration in specific forest types is primarily practised in Western Australia.

Clearfelling, fire-salvage clearfelling and intensive silviculture account for 12% of the area harvested in multiple-use public native forest in Australia over the 10-year period 2001–02 to 2010–11. The average area harvested by these systems decreased from the 5-year period 2001–02 to 2005–06 to the 5-year period 2006–07 to 2010–11. Shelterwood silviculture represents 3% of the area harvested nationally from 2001–02 to 2010–11.

New South Wales, Queensland, Tasmania, Victoria and Western Australia apply selection harvesting silvicultural systems, including group or gap selection, Australian group selection, variable retention systems, single-tree selection (including light, moderate and heavy selection systems and diameter-limit cutting), and mixtures of group selection and single-tree selection. Native cypress pine silviculture (applied in New South Wales and Queensland) and commercial thinning (applied in New South Wales, Tasmania, Victoria and Western Australia) both use selection harvesting techniques but are reported separately (Table 2.5).

The various selection silviculture systems (selection logging, native cypress pine logging and commercial thinning) accounted for 85% of the area harvested in multiple-use public native forest over the 10-year period 2001–02 to 2010–11 (Table 2.5).

Table 2.6 reports the area harvested from multiple-use public native forest annually and the 5-year and 10-year mean, from 2001–02 to 2010–11, by jurisdiction. More than one-third of the area of multiple-use public native forest harvested in Australia is in New South Wales and Queensland; 12% is in Tasmania, 9% in Western Australia and 7% in Victoria.

Available growing stock

'Growing stock' is the total volume of wood in all living trees in a forest at a given time. Increases or decreases in growing stock can indicate (among other things) the sustainability of resource use. Previously, the Resource Assessment Commission (1992) compiled estimates of standing commercial wood growing stock, but no national estimates have been made since. Little information is available on the growing stock of non-merchantable tree species.

In New South Wales, Tasmania, Victoria and Western Australia, assessments of the growing stock of merchantable wood and tree growth rates are used to estimate sustainable harvesting levels in multiple-use public native forests (see Indicator 2.1c). In Tasmania, estimates of growing stock of merchantable wood are used to estimate wood supplies in private native forests. Few or no data are available on current growing stock in native forests outside the production areas of multiple-use public forests and those assessed in Tasmanian private forests.

Table 2.6: Forest area harvested annually from multiple-use public native forest in Australia

	Area (hectares)					
Reporting year	NSW	Qld	Tas.	Vic.	WA	Total
2001–02	50,351	47,700	14,900	10,500	17,260	140,711
2002–03	49,062	48,300	16,900	8,500	14,340	137,102
2003–04	45,337	48,400	17,090	8,100	9,725	128,652
2004–05	42,523	41,100	17,500	7,600	10,110	118,833
2005–06	43,233	47,700	12,500	7,800	7,780	119,013
2006–07	44,806	43,900	11,520	6,900	10,270	117,396
2007–08	52,960	44,200	12,990	7,800	9,740	127,690
2008–09	27,952	32,500	12,370	6,400	8,330	87,552
2009–10	38,499	32,300	8,660	5,900	11,650	97,009
2010–11	27,484	28,200	10,490	5,800	7,390	79,364
5-year mean, 2001–02 to 2005–06	46,101	46,640	15,778	8,500	11,843	128,862
5-year mean,2006–07 to 2010–11	38,340	36,220	11,206	6,560	9,476	101,802
10-year mean, 2001–02 to 2010–11	42,221	41,430	13,492	7,530	10,660	115,332
10-year total as proportion of 10-year total for all systems (%)	**37**	**36**	**12**	**7**	**9**	**100**

Notes:
No harvesting of native forest is permitted from public forests in the ACT, NT or SA.
Harvest areas include areas harvested before plantation establishment (Tas.) and bauxite mining (WA).

Source: Data provided by NSW, Qld, Tas., Vic. and WA.

Indicator 2.1b

Age class and growing stock of plantations

Rationale

This indicator uses the area, age class and growing stock of native and exotic species plantations to assess the volume of timber that Australia's plantation forests can supply now and into the future.

Key points

- The area of Industrial plantations managed for wood production in Australia increased from 1.818 million hectares in 2005–06 to 2.017 million hectares in 2010–11, with almost all the increase achieved by planting on cleared agricultural land.
- Of the total Industrial plantation estate, 51% by area is planted with softwood species and 49% with hardwood species. There are approximately 0.4 million hectares of Industrial plantations that are in their second, third or fourth rotation.
- The area of Industrial softwood plantations has been fairly stable over the reporting period, but the area of Industrial hardwood plantations increased from 0.807 million hectares in 2005–06 to 0.980 million hectares in 2010–11.
- The area proportion of the Industrial plantation estate where the trees are government-owned decreased from 35% in 2006 to 24% in 2011, while the proportion where the trees are privately owned increased from 65% to 76%. Private ownership identified as ownership by institutional investors increased from 12% in 2006 to 31% in 2011.

Industrial plantations provide two-thirds of Australia's log supply (see Indicator 2.1c). Growing trees in Industrial plantations, harvesting logs and processing them into sawn timber, paper, panels and other products generates substantial regional employment (see Indicator 6.5a). Industrial plantations therefore provide the raw material for major rural industries, even though they occupy only a small part of the rural land estate (see Indicator 1.1a).

The rationale for Indicator 2.1b identifies 'growing stock'—the total volume of wood in all living trees in a forest at a given time—as an indicator of potential wood supply from plantations. Growing stock is not usually measured in Australia, but the Australian Bureau of Agricultural and Resource Economics and Sciences, under the National Plantation Inventory (NPI), develops forecasts of plantation log supply every five years (see Indicator 2.1c).

Until the 1990s, most plantations established in Australia were pines and other softwood species grown to produce sawn timber. Many were planted on land where there had previously been native eucalypt forests. However, the clearing of native vegetation (including native forests) for new plantation development is now prohibited or restricted by state and territory policies and legislation, and new plantations are now mostly established on cleared agricultural land. Most plantations established over the past 15 years have been hardwood plantations grown to produce pulplogs.

Plantation areas and values

The area of Australia's Industrial plantation estate from 1940, including data from before the establishment of the NPI in 1995, is shown in Figure 2.4. Australia's plantations have expanded considerably since the NPI began collecting data in 1995, doubling in area from 1990 to 2010 (Figures 2.4 and 2.5), with almost all of the increase being in hardwood plantations. The first comprehensive map-based report from the NPI, published in 1997, showed that Australia had just over 1.0 million hectares of plantations. The plantation estate has since grown to 1.8 million hectares in 2005–06 (SOFR 2008) and to 2.0 million hectares in 2010–11 (Figures 2.4 and 2.5). Government policies and programs and joint government/industry initiatives such as *Plantations for Australia: the 2020 Vision* (Private Forestry Consultative Committee 2002) were important in removing impediments to plantation development over this period. Non-industrial plantations are reported separately, under the 'Other forest' category, in Indicator 1.1a.

Australia's Industrial plantation estate in 2010–11 was 2.017 million hectares, comprising 1.025 million hectares of softwood plantations, 0.980 million hectares of hardwood plantations, and about 12 thousand hectares classified as 'other' plantations (plantations of mixed hardwood and softwood species, and plantations where species type was not reported) (Gavran 2012). About 51% of the total Industrial plantation forest area is softwood plantations (mainly exotic pines), and 49% is hardwood plantations (mainly eucalypts).

The distribution of plantation establishment and re-establishment by five-year period is shown in Figure 2.6. After 1990, there was a shift from re-establishment of exotic softwood plantations (funded mainly by government investment) towards establishment of new hardwood plantations of a range of eucalypt species (funded mainly by private-sector investment).

The area proportions of hardwood and softwood plantations in Australia, by state and territory jurisdiction, are shown in Figures 2.7 and 2.8. In 2010–11, Victoria had the largest plantation area (Gavran 2012), with 21% of the national area of hardwood plantations and 22% of the national area of softwood plantations. This was followed by Western Australia (31% of all hardwood plantations and 10% of all softwood plantations) and New South Wales (9% of all hardwood plantations and 29% of all softwood plantations).

There are 1.1 million hectares of plantations known to be in their first rotation, and approximately 400,000 hectares of plantations known to be in their second, third or fourth rotation (Table 2.7). Rotation information is not available for a substantial part (approximately one-quarter) of the national plantation estate.

In 2011, there were 1.97 million hectares of Industrial plantations with plantation trees of known age. Younger age-classes dominate this growing stock (Figure 2.9): 10% of the growing stock was older than 30 years, while 69% was aged 15 years or less.

Plantation ownership

A significant change in Industrial plantation ownership (specifically, ownership of plantation trees) from public to private owners occurred over the period 2005–11 (Table 2.8). Government-owned plantations decreased from 37% of Australia's total plantation area to 24% over this period. Ownership by institutional investors (including international superannuation funding systems) increased from 12% in 2005 to 31% in 2011, as a result of transfer in 2010 and 2011 of tree ownership from managed investment schemes, and from state government plantations in Tasmania and Queensland. Plantation ownership by managed investment schemes rose from 23% in 2005 to a high of 36% in 2009, then fell to 24% in 2011. Ownership by farm foresters and other private owners (including small-scale plantation woodlots) declined from 13% to 8%. Timber industry company ownership fell from 15% in 2005 to 7% in 2009, and then rose to 13% in 2011.

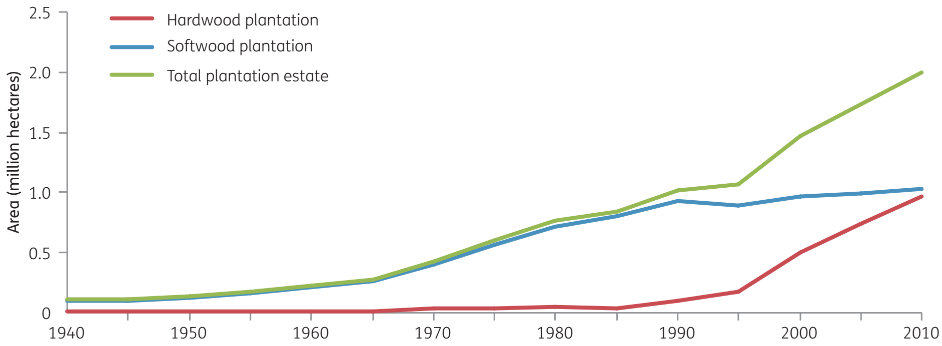
Figure 2.10 describes the Industrial plantation stock at 2011 by tree and land ownership categories for each age class. Plantations established pre-1981 and still standing at 2011 are mostly (83%) on public land (pink and pale blue segments, Figure 2.10), although the trees are now in a mixture of public and private ownership. On the other hand, most (83%) of the plantations established since 1996 and still standing at 2011 are on private land (primarily purple and light green segments, Figure 2.10). Managed investment schemes on private land (purple segments, Figure 2.10) own 36% of the area of the 2011 growing stock established since 1996.

Table 2.7: Area of components of Industrial plantation estate, by type and rotation, 2010–11

	Area ('000 hectares)			
Rotation	**Hardwood**	**Softwood**	**Mixed and other**	**Total**
1	672	435	9	1,117
2	92	272	2	366
3	1	28	0	29
4	0	1	0	1
Unknown	214	289	1	504
Total	**980**	**1,025**	**12**	**2,017**

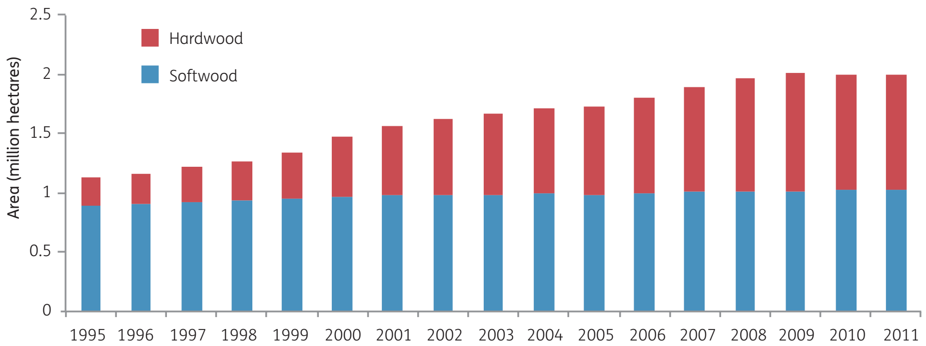
Note:
'Other' includes unspecified or unknown species, plantation area in fallow between rotations, and trial plantations; 'mixed' plantations (700 hectares in total) are plantations containing both hardwood and softwood. 'Unknown' is where information is unavailable about the rotation.
Totals may not tally due to rounding.
Source: National Plantation Inventory.

Figure 2.4: Australia's Industrial plantation area, 1940–2010



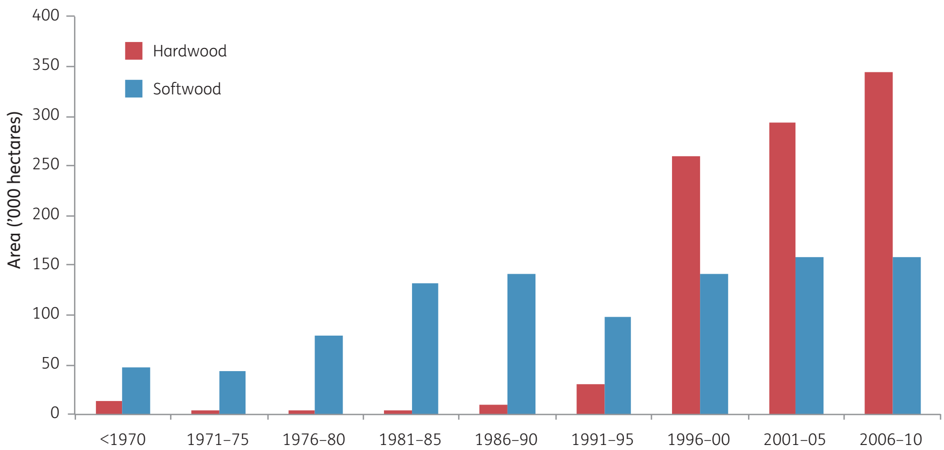
Source: Australian Bureau of Agricultural and Resource Economics, Bureau of Agricultural Economics, Commonwealth Forestry and Timber Bureau, National Plantation Inventory.

Figure 2.5: Australia's Industrial plantation area, 1995–2011



Note: 1995 to 2005 are calendar years, and 2006 to 2011 are financial years (i.e. 2005–06 to 2010–11).
Source: Gavran (2012), National Plantation Inventory.

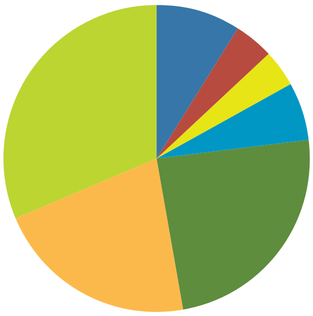
Figure 2.6: Area of Industrial plantation establishment and re-establishment by five-year period, to 2006–10



Source: Gavran and Parsons (2011), National Plantation Inventory.

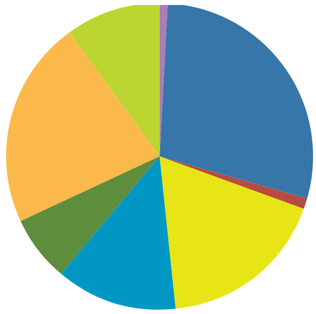
CRITERION 2

Figure 2.7: Area proportions of Industrial hardwood plantation estate in 2010–11, by jurisdiction



Notes:
The total Industrial hardwood plantation estate comprises 980,000 hectares.
There are no Industrial hardwood plantations in the Australian Capital Territory.
Source: Gavran (2012), National Plantation Inventory.

Figure 2.8: Area proportions of Industrial softwood plantation estate in 2010–11, by jurisdiction



Note: The total Industrial softwood plantation estate comprises 1,025,000 hectares.
Source: Gavran (2012), National Plantation Inventory.

Table 2.8: Area proportion of Industrial plantations by ownership category

	Area (%)						
Category	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Institutional investors	12	12	12	11	13	28	31
Timber industry companies	15	15	9	9	7	13	13
Farm foresters and other private owners	13	12	10	9	10	9	8
Managed investment schemes (MIS)	23	26	33	34	36	25	24
Governments	37	35	36	37	35	25	24
Total area of Industrial plantations (million hectares)	**1.74**	**1.82**	**1.90**	**1.97**	**2.02**	**2.01**	**2.02**

Notes:
Ownership data refer to ownership of trees. Joint venture arrangements between government agencies and private owners are included under 'Governments' where government is the manager of the plantation resource.
Totals may not tally due to rounding.

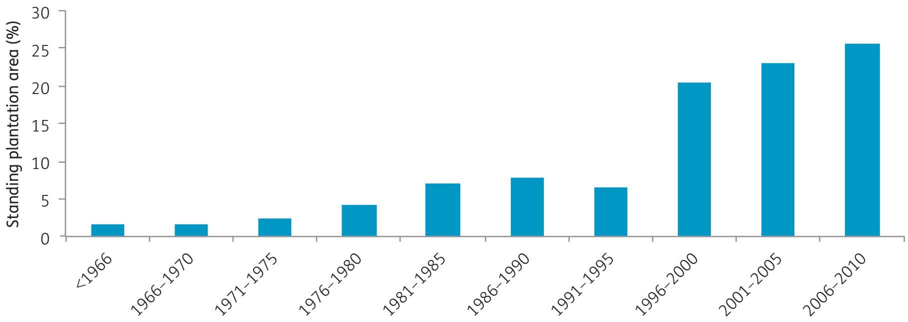
Source: National Plantation Inventory, Gavran (2012).

Table 2.9: Main plantation species by region, and main uses

Region	Main species	Main uses
Hardwoods		
Tropical—high rainfall	Mangium (*Acacia mangium*)	Paper products, veneer and sawn timber
	African mahogany (*Khaya senegalensis*), teak (*Tectona grandis*), some native eucalypt species	Sawn timber for building and furniture and other high-value uses
Subtropical—medium rainfall	Flooded gum (*Eucalyptus grandis*), Dunn's white gum (*E. dunnii*)	Paper products, veneer and sawn timber
Temperate—medium to high rainfall	Southern blue gum (*E. globulus*), shining gum (*E. nitens*)	Paper products, veneer and sawn timber
Several regions	Various eucalypts	Sawn timber for building and furniture and other high-value uses
Softwoods		
Tropical, subtropical—high rainfall	Hoop pine (*Araucaria cunninghamii*)	Sawn timber for building, joinery, furniture, plywood, other high-value uses, posts and poles; residues used for paper, particleboard and other panels
Tropical, subtropical—medium rainfall	Caribbean pine (*Pinus caribaea*), slash pine (*P. elliottii*), hybrid pines	
Temperate—medium rainfall	Radiata pine (*P. radiata*)	
Temperate—low to medium rainfall	Maritime pine (*P. pinaster*)	

Source: SOFR 2008.

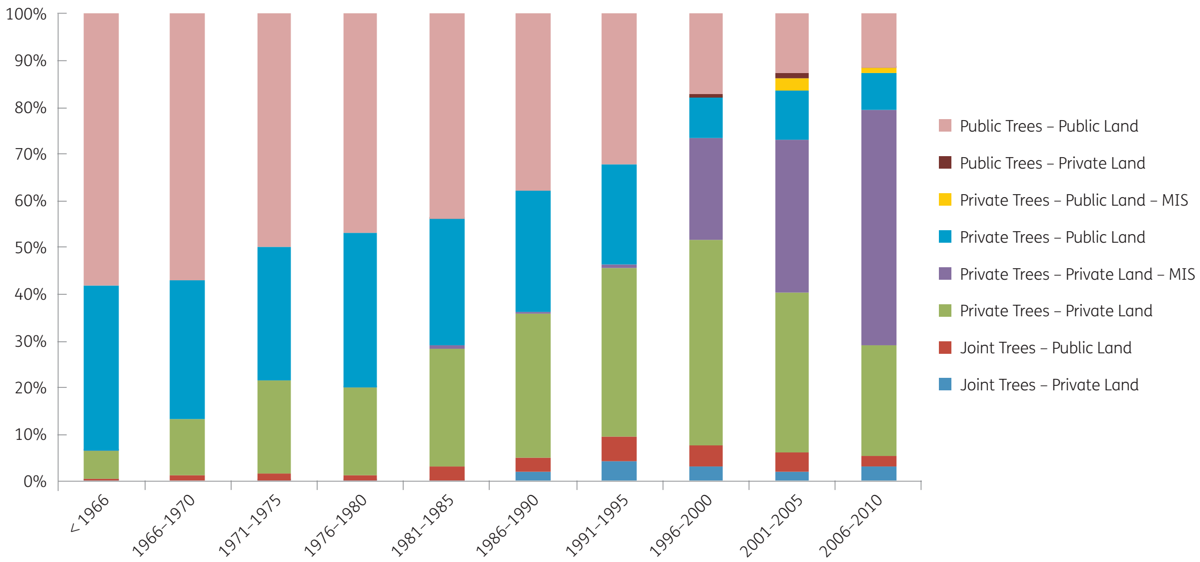
Figure 2.9: Area proportion of 2011 Industrial plantation growing stock by age-class



Note: Plantations of unknown age, harvested plantations awaiting re-establishment, and new plantations awaiting establishment are not included.

Source: National Plantation Inventory.

Figure 2.10: Area proportion of Industrial plantation land and trees in ownership categories in 2011, by establishment age-class



Notes:

Data are area proportions in 2011 for each age-class category.

Plantations of unknown age, harvested plantations awaiting re-establishment, and new plantations awaiting establishment are not included.
Joint ownership includes government and private ownership arrangements.

Source: National Plantation Inventory.

Plantation species

The main Australian plantation species by climate and rainfall region, and the main uses for the wood they produce, are shown in Table 2.9.

In 2010–11, the hardwood plantation estate was dominated by southern blue gum (*Eucalyptus globulus*; 55.1% by area) and shining gum (*E. nitens*; 24.1% by area), both of which are managed primarily for pulpwood production (Gavran 2012). These proportions are similar to those reported previously. Blackbutt (*E. pilularis*) and flooded gum (*E. grandis*) together comprise 2.6% of the total hardwood plantation estate area, and spotted gum (*Corymbia maculata*) comprises 2.2% by area. A further 5.6% by area is other eucalypts such as mountain ash (*E. regnans*) and Sydney blue gum (*E. saligna*), and 5.5% by area is other hardwood species, such as African mahogany (*Khaya senegalensis*) and teak (*Tectona grandis*); these species are all managed primarily for sawlog production.

In 2010–11, the softwood plantation estate was dominated by radiata pine (*Pinus radiata*; 75.5% by area) and southern pine (14.7% by area) (Gavran 2012). 'Southern pine' comprises Caribbean pine (*P. caribaea*), slash pine (*P. elliottii*) and several varieties of these; a hybrid between southern pine varieties is now the preferred plantation softwood in subtropical and tropical regions of Australia. Both radiata pine and southern pine are managed primarily for sawlog production. These proportions for the softwood plantation estate are similar to those reported previously. Other regionally important softwood species are maritime pine (*P. pinaster*) in Western Australia, and hoop pine (*Araucaria cunninghamii*) in south-east Queensland.

Indicator 2.1c

Annual removal of wood products compared to the volume determined to be sustainable for native forests, and future yields for plantations

Rationale

This indicator measures the harvest levels of wood products in relation to future yields. The capacity to implement strategies to deal with changing demand for forest products based on future yields from both native and plantation forests is an integral part of sustainable forest management.

Key points

- In the period 2006–07 to 2010–11, the average annual sawlog volume harvested from multiple-use public native forest was 1.40 million cubic metres, a decline from 1.96 million cubic metres in the period 2001–02 to 2005–06.
- The volume of sawlogs harvested from multiple-use public native forests in the period 1992–93 to 2010–11 was within sustainable levels in New South Wales, Tasmania, Victoria and Western Australia, and within sustainable yield or allowable cut in Queensland. Nationally, the actual sawlog harvest level was below sustainable yield levels by 17% for the period 2006-11, and the actual harvest volume was below sustainable yield levels by 6–18% for each of the four SOFR five-yearly reporting periods.
- Average sustainable yield declined nationally by 47%, and in all states except Tasmania, between the period covered by SOFR 1998 (1992–93 to 1995–96, sustained yield) and the period covered by SOFR 2013 (2006–07 to 2010–11). This decline was a consequence of increased reservation of multiple-use public native forests, which reduced the area of native forest available for harvesting; increased restrictions on harvesting in codes of forest practice; revised estimates of forest growth and yield due to improved information; and impacts of occasional, intense broadscale wildfires.
- Residential use of firewood for heating and energy decreased slightly in the 2006–10 reporting period, while industrial fuelwood use increased in this period.
- For the various wood product categories, sawlog and pulplog harvest from native forest has declined since 2000, sawlog and pulplog harvest from softwood plantations has increased, and sawlog harvest from hardwood plantations has been relatively stable, while pulplog harvest from hardwood plantations has increased significantly.
- In the period 2006–07 to 2010–11, plantations produced 71% of the volume of logs harvested in Australia. Hardwood plantations provided 35% of Australia's pulplog supply and 1% of Australia's sawlog supply—this was 5% of Australia's hardwood sawlog supply. Softwood plantations provided 39% of Australia's pulplog supply and 79% of Australia's sawlog supply. In 2010-11, the final year of the SOFR 2013 reporting period, plantations produced 76% of the volume of logs harvested in Australia.
- If the current plantation area is maintained, total wood production from softwood plantations is nearing its maximum potential and is expected to plateau by 2035 at 18 million cubic metres per year, while total production from hardwood plantations will increase to more than 14 million cubic metres per year by 2030.
- As the supply of high-quality logs from public multiple-use native forests declines as a consequence of reservation of forest, the importance of private native forests for the supply of hardwood logs will increase, and management of private native forests will determine the long-term national supply of high-quality native hardwood logs. However, a national assessment found that there is insufficient information to assess whether the rate of wood harvest from private native forests is sustainable.

This indicator examines the extent to which a sustainable harvest of wood products is being achieved in native forests, and the availability of future yields of wood products from native forests and plantations. The indicator reports the average annual sustainable yield in multiple-use public native forests, actual annual harvests in multiple-use public and private native forests, projections of sustainable yields from public native forests to 2055, forecast availability of wood products from public and private forests, and plantation harvesting rates and projected future yields to 2055. Indicator 2.1a describes the impact of changes in tenure and forest practices on the area available for the harvesting of wood products.

Plantation projections covering all plantation regions in Australia are reported in Gavran et al. (2012). This indicator presents plantation projections only for the regions contributing substantially to the plantation supply.

This indicator also reports only on those states where there is significant ongoing native forest harvesting: New South Wales, Queensland, Tasmania, Victoria and Western Australia. Native forest harvesting does not occur in the Australian Capital Territory or South Australia, and is small and limited in the Northern Territory.

The main wood products harvested in native forests are sawlogs, veneer logs (used for wood-based panel products) and pulplogs (used for paper products). Other wood products harvested in native forests include posts, poles, piles, girders, bush sawn/hewn timber, firewood, specialty timber and sleepers. The data presented in this indicator pertain mainly to sawlogs (generally including veneer logs in that category) and pulplogs.

Sandalwood is considered in this indicator and also in Indicator 2.1d, since sandalwood products are sometimes considered non-wood forest products (NWFPs). Sandalwood plantations are not considered Industrial plantations and so are included in the area statistics for 'Other forest' in Indicator 1.1a.

Most of Australia's native forest wood products are provided by multiple-use public native forests. Harvesting in public native forests is subject to regulatory frameworks designed to balance environmental, social and economic values, while maintaining environmental values and the productive capacity of forests. Harvest volumes in public native forests are set according to a calculated sustainable yield in all states other than Queensland, where an allowable cut is applied under long-term agreements issued as a result of the policy to phase out harvesting of multiple-use public native forest.[61] Calculated sustainable yield is the estimated volume of wood that can be removed each year while ensuring maintenance of the functioning of the native forest system as a whole.

Sustainable yield from native forests

States in which native forest harvesting occurs have formal processes, backed by a regulatory framework (including codes of forest practice), to calculate sustainable sawlog yields for publicly managed native forests, primarily multiple-use forests.[62] The volume of wood available for harvesting is calculated based on the net harvestable area (see Indicator 2.1a)—that is, the net area of forest available for high-quality sawlog and veneer production, after areas unavailable for economic, environmental and other reasons have been excluded.

Low-quality sawlogs, pulplogs and other wood products are also harvested from native forests, usually as a residual product of sawlog and veneer log harvesting; consequently, sustainable yields are not determined for these other wood products. An exception relates to Tasmanian special-species timbers (myrtle, blackwood, sassafras and various native pines), for which a strategy to sustain long-term production is in place (Forestry Tasmania 2010a). Similarly, sandalwood harvesting from Crown and leasehold forests in Western Australia is managed on an allowable harvest basis (DEC 2012a, FPC 2011) as specified in the Sandalwood (Limitation of Removal of Sandalwood) Order 1996 under the *Sandalwood Act 1929*.

Sustainable harvest volumes vary over time according to changing management strategies and utilisation standards, improved resource data, and changes in the net area of public native forest available for harvesting. To take account of these changes, estimates are reviewed periodically, usually every 5 to 10 years. For a range of reasons, annual harvesting levels are likely to fluctuate around the sustainable volume, but overcuts in some years must be at least balanced by undercuts in other years over a defined period.

Table 2.10 reports the proportional change in state and national sustainable yields across the four SOFR reporting periods, compared with the baseline of the first period (1992–93 to 1995–96). Average sustainable yield declined nationally, and in all states except Tasmania, between the periods covered by SOFR 1998 (1992–93 to 1995–96) and SOFR 2013 (2006–07 to 2010–11). This decline was a consequence of increased reservation of public native forests, which reduced the area of native forest available for harvesting (Davidson et al. 2008); increased restrictions on harvesting in codes of forest practice; revised estimates of forest growth and yield due to improved information; and, especially in Victoria (see Indicator 3.1b), impacts of occasional, intense broadscale wildfires (Forests NSW 2010a, VicForests 2011a). Sustainable yields from public multiple-use forests have decreased nationally by 47% from those reported in SOFR 1998 for the period 1992–93 to 1995–96 (Table 2.10).

Figures 2.11–2.16 show the reported harvested volume from multiple-use public native forests, by jurisdiction and aggregated nationally, averaged across the periods covered by the four SOFR reports: 1992–93 to 1995–96 (SOFR 1998), 1996–97 to 2000–01 (SOFR 2003), 2001–02 to 2005–06

61 The Queensland policy to phase out harvesting of multiple-use public native forests ceased in 2012. Multiple-use public native forests in Queensland are returning to long-term wood production.

62 Sustainable sawlog harvest volumes are calculated using data on forest type and age class, standing timber volumes, terrain, accessibility, timber growth and yield, recreational use, water supply and conservation requirements. Estimates also take into account restrictions on harvesting imposed by codes of practice and other regulations. Once calculated, the sustainable volumes are used to produce harvesting schedules and forecasts of the future spatial and temporal characteristics of the forest.

Table 2.10: Change in sustainable yield from public multiple-use forests across SOFR reporting periods, from those reported in SOFR 1998, by jurisdiction

	Change from SOFR 1998 (%)		
Jurisdiction	**SOFR 2003**	**SOFR 2008**	**SOFR 2013**
NSW	–16	–37	–42
Qld	–11	–14	–37
Tas.	20	17	7
Vic.	–3	–32	–47
WA	–17	–60	–76
Australia	**–8**	**–34**	**–47**

Notes:

Product groups and standards used in determining sustainable yield are consistent across reporting periods in all jurisdictions other than Victoria; for Victoria, the sustainable yield for the first reporting period has been adjusted from C+ sawlog to a D+ equivalent (see Figure 2.13).

Reporting periods are 1992–93 to 1995–96 (SOFR 1998), 1996–97 to 2000–01 (SOFR 2003), 2001–02 to 2005–06 (SOFR 2008) and 2006–07 to 2010–11 (this report, SOFR 2013).

Figure 2.11: Average annual harvest and sustainable yield for multiple-use public native forests in New South Wales, by SOFR reporting period

Notes:

Sustainable levels apply to multiple-use public native forests (with supplementation from hardwood plantations on multiple-use public forest). However, volumes of high-quality logs harvested from hardwood plantations (hardwood high-quality large and small sawlog, veneer log, poles, piles and girders: see Figure 2.19) are not included in the actual levels reported.

Figures for hardwood, brushwood (rainforest species), cypress pine and veneer logs are in 'quota sawlog equivalents' up to 1998–99, and figures for hardwood high-quality large and small sawlog, veneer sawlog and cypress pine are in 'high-quality equivalents' from 1999–2000. Poles, piles and girders are included in high-quality equivalents for calculating sustainable yield and reporting actual harvested level from 2006–07.

Source: Forestry Commission and State Forests of NSW annual reports from 1987 to 2000, SOFR 2003, SOFR 2008, Forests NSW (2007, 2008, 2009, 2010b, 2011) and additional data from Forests NSW.

(SOFR 2008) and 2006–07 to 2010–11 (SOFR 2013, this report). For all states except New South Wales, average harvested volumes were lower than the sustainable yields for each of the reporting periods.

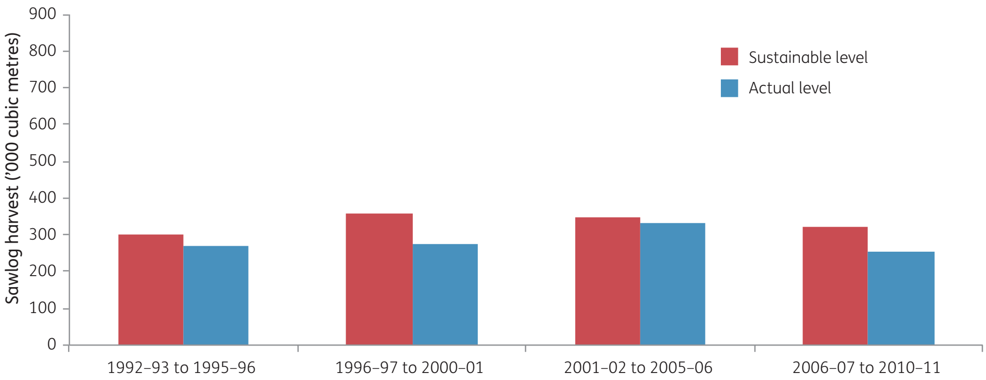
In New South Wales, the actual harvest was slightly higher than the sustainable yield in two of the four reporting periods (Figure 2.11) but within allowable limits. Under state agreements applicable to multiple-use public native forests, the wood-processing industry in New South Wales is permitted to vary its actual cut by ±5% of the allowable cut determined by sustainable yield calculations, allowing industry to access previous undercuts to its allocations when required. The variances indicated in Figure 2.11 are within these limits.

Sustainable yield from New South Wales public forests for the period 1992–98 was 791,000 cubic metres of hardwood quota and cypress pine sawlog. However, the figures previously reported in SOFR 2003 and SOFR 2008 from New South Wales for actual logs harvested for the periods up to 1997–98 included 'non-quota' sawlogs. These figures have now been adjusted to represent only the 'high-quality sawlogs' and cypress pine logs reported after this period, so that log quality is comparable across the four SOFR periods (Figure 2.11).[63]

In Tasmania, the sustainable sawlog yield from multiple-use public native forest increased in line with short-term forest management strategies (Figure 2.12; Table 2.10) (Forestry Tasmania 2007). The increase in sustainable yield in Victoria between the first (SOFR 1998) and second (SOFR 2003) reporting periods (Figure 2.13) is a result of changing log

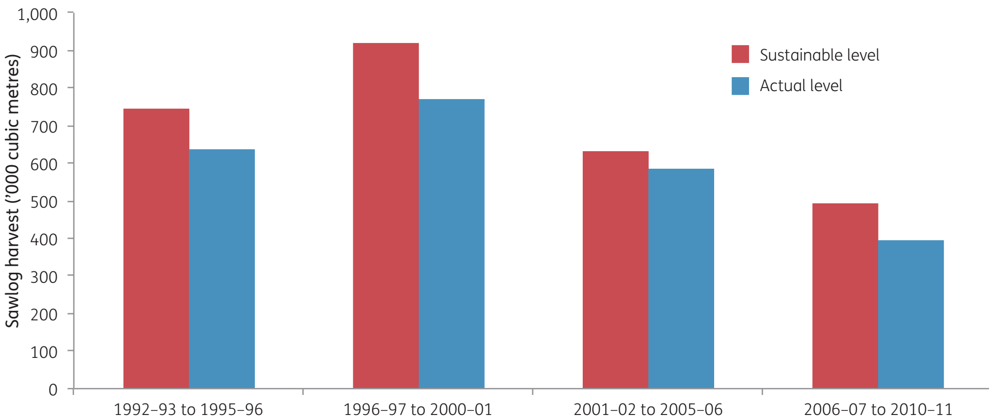
[63] Quota sawlogs are sawlogs of a specified quality and dimension that contribute to the committed volumes outlined in New South Wales Forest Agreements and Integrated Forest Operation Approvals (IFOAs) applying to multiple-use public native forests. Non-quota sawlogs are sawlogs that do not contribute to the committed volumes outlined in Forest Agreements and IFOAs. Further explanation of the grade categories used in New South Wales and reported in Figure 2.9 can be found in the NSW Government and Office of Environment and Heritage (2011).

Figure 2.12: Average annual harvest and sustainable yield for multiple-use public native forests in Tasmania, by SOFR reporting period



Note: Sustainable yield and actual harvested level are of category 1 and category 3 sawlogs and veneer logs.
Source: FPA (2012), SOFR 2003, SOFR 2008, Forestry Tasmania.

Figure 2.13: Average annual harvest and sustainable yield for multiple-use public native forests in Victoria, by SOFR reporting period



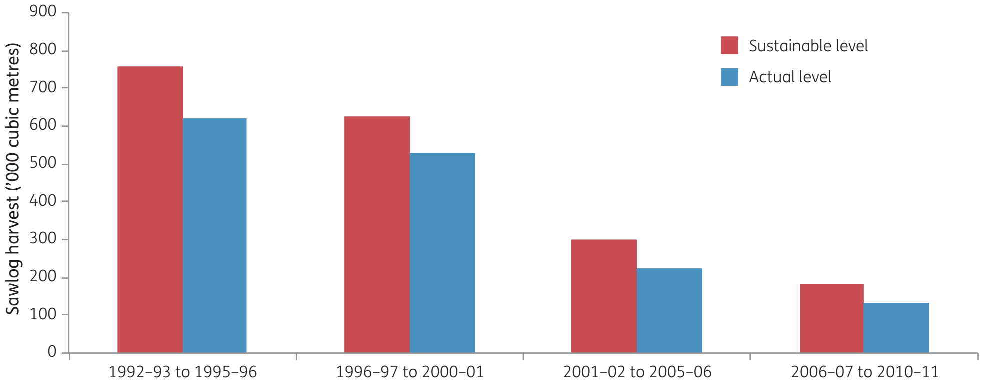
Note: Category C+ sawlogs are used to determine sustainable level and actual harvested level for the first reporting period; category D+ sawlogs apply in other periods. A D+ equivalent for the first reporting period equates to a sustainable level of 945,000 cubic metres and an actual harvested level of 809,000 cubic metres, and is used in calculations in Figure 2.16 and Table 2.10.
Source: SOFR 2003, SOFR 2008, Victorian Department of Sustainability and Environment.

quality categories. Overall, however, the general decline in sustainable yield and harvesting in Victoria (Figure 2.13) and Western Australia (Figure 2.14) has continued since SOFR 2008. The impacts of three intense broadscale wildfires (2003, 2006–07 and 2009; see Indicator 3.1b) contributed to the decline in sustainable yield and harvest level in Victorian multiple-use public native forests, and will also affect long-term sawlog supplies over a 100-year period (VicForests 2011a).

In Queensland, the state government agreed in 1999 to a 25-year transition in which public native forests in the state's south-east—its major wood-producing area—would be withdrawn from wood harvesting after a harvesting event has occurred, and subsequently gazetted as nature conservation reserves. With regard to other areas of the state, decisions have been progressively made on future harvesting levels and nature conservation areas, underpinned by a policy of not allowing harvesting of multiple-use public native forests after 2025. As a consequence, Figure 2.15 shows a sustainable yield volume to 1999 and an allowable cut level after this. Wood harvest volumes have declined over the SOFR reporting periods, and have remained close to the sustainable yield and allowable cut levels. Public hardwood plantations have been established in Queensland to provide an alternative wood resource after 2025[3].

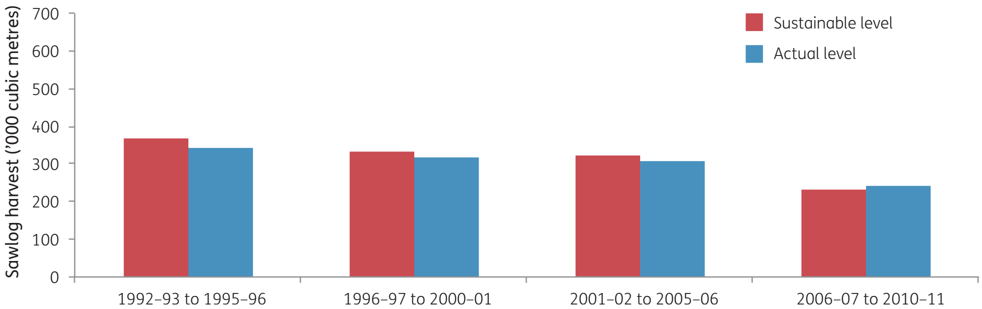
In the period 2006–07 to 2010–11, the average annual sawlog volume harvested from multiple-use public native forest nationally was 1.40 million cubic metres, a decline from 1.96 million cubic metres in the period 2001–02 to 2005–06 (Figure 2.16). The actual harvest volume from multiple-use public native forests nationally for this period was 17% below the estimated sustainable sawlog yield. Furthermore, for all SOFR reporting periods the national actual harvest volume from multiple-use public native forests was below the estimated sustainable sawlog yield by 6–18%, and the actual harvest volume has decreased over the past 20 years in line with the decrease in sustainable yields (Figure 2.16).

Figure 2.14: Average annual harvest and sustainable yield for multiple-use public native forests in south-west Western Australia, by SOFR reporting period



Note: Sustainable yield and actual harvested level are of first and second grade karri and jarrah sawlogs.
Source: DEC 2012a, SOFR 2003, SOFR 2008, Western Australian Department of Environment and Conservation.

Figure 2.15: Average annual harvest and sustainable yield for multiple-use public native forests in Queensland, by SOFR reporting period



Notes:
For the last three periods, sustainable level refers to sustainable yield or allowable cut.
Data are for hardwood and cypress pine sawlogs; other log categories (e.g. poles, fencing, sleeper and mining timber) are excluded.
Sources: Queensland Department of Agriculture, Fisheries and Forestry, SOFR 2003, SOFR 2008.

Figure 2.16: Average annual harvest and sustainable yield for multiple-use public native forests in Australia, by SOFR reporting period

Note: Sawlog includes only high-quality and veneer logs. The first reporting period includes an adjustment applied to Victorian C+ sawlogs and expressed as a D+ equivalent (see Figure 2.13, Table 2.10).

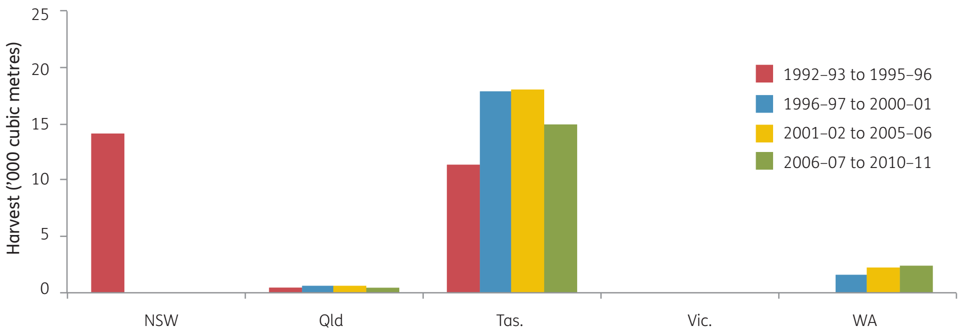
Source: Australian Bureau of Agricultural and Resource Economics and Sciences database, state agencies, SOFR 2003, SOFR 2008.

Tasmanian special-species timbers are harvested from public forests on a sustainable yield basis. Annual supply targets for special timbers logs ('category 4' sawlogs and 'utility' logs) for the 10-year period to 2019, based on sustainable yield estimates of Tasmanian special-species timbers, are blackwood (*Acacia melanoxylon*)—10,000 cubic metres; silver wattle (*A. dealbata*), myrtle (*Nothofagus cunninghamii*), sassafras (*Atherosperma moschatum*), celery-top pine (*Phyllocladus aspleniifolius*) and huon pine (*Lagarostrobos franklinii*)—500 cubic metres each; and King Billy pine (*Athrotaxis selaginoides*) and other species, including figured eucalypt (*Eucalyptus* spp.)—arisings[64] only with no volume target (Forestry Tasmania 2010a). Western Australian sandalwood is managed on an allowable harvest target of 1,500 tonnes per year of high-grade 'greenwood'.[65] Low-grade greenwood sandalwood, root, bark and dead sandalwood are harvested with the high-grade greenwood.

Figure 2.17 reports the average annual volumes of special-species timbers (including sandalwood) harvested from public native forests, by jurisdiction, for the four SOFR reporting periods. Removals of logs designated as cabinet rainforest timbers in New South Wales ceased after 1992–93. The volume of Western Australian sandalwood harvested is also separately reported in Figure 2.18.

Sustainable yield estimates of high-quality sawlogs from multiple-use public native forests in New South Wales and Tasmania include supplementation with estimates of sawlogs of similar quality and specification from public hardwood plantations, with this component of the estimates based on projected yields of high-quality sawlogs from these plantations (the extent of supplementation is very small for Tasmania). High-quality hardwood sawlogs have been harvested from public plantations in New South Wales since 1997–98, and New South Wales contains a resource of older plantations

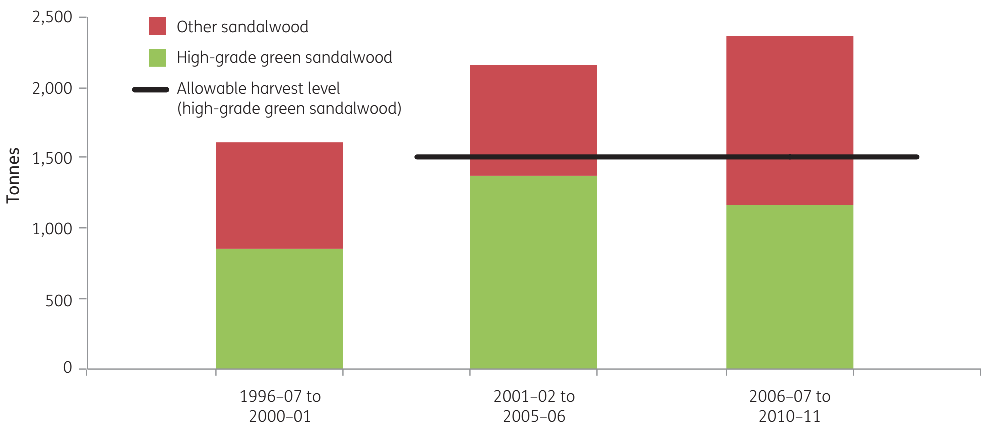
Figure 2.17: Average annual production of special-species timbers from multiple-use public native forests, by SOFR reporting period



Note: Special-species timbers include cabinet rainforest timbers (NSW), Tasmanian special-species timbers, and sandalwood (Qld and WA: cubic metre equivalent converted from tonnes).

Source: Australian Bureau of Agricultural and Resource Economics and Sciences databases, state agencies.

Figure 2.18: Average annual production of Western Australian sandalwood from public native forests, by SOFR reporting period



Notes:

No data are available for 1992–93 to 1995–96.

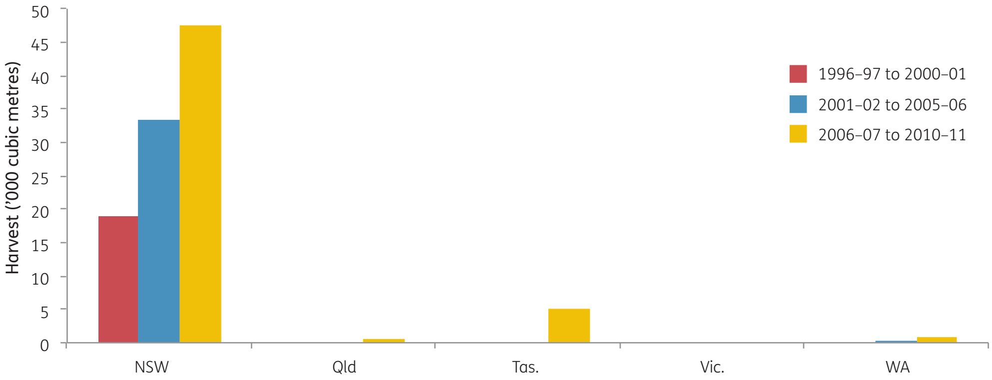
The allowable harvest level applies to 'High-grade green sandalwood' only, and not to the lower grade sandalwood, root, bark and dead material, which is included in the 'Other sandalwood' figures. Green (live) sandalwood trees produce more oil than dead trees and consequently have a higher commercial value.

Source: Western Australian Forest Products Commission annual reports.

64 'Arisings' refer to timber produced as a result of planned harvest of other species or timber grades.

65 Greenwood is wood from live sandalwood that meets a specified quality standard and size.

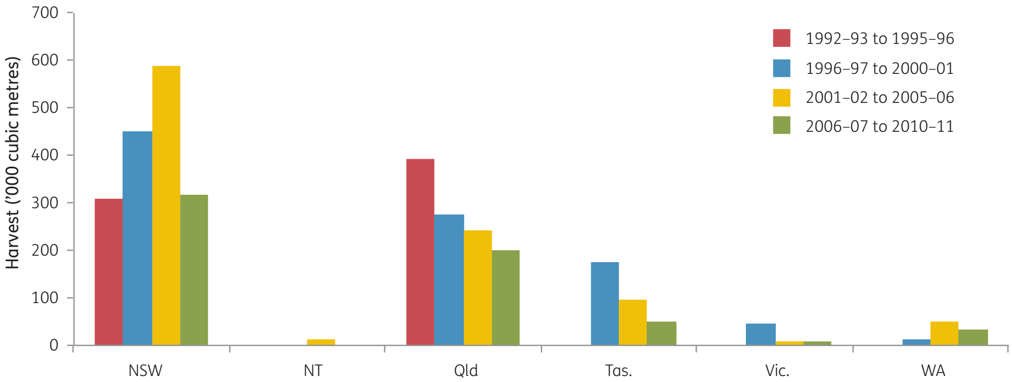
Figure 2.19: Average annual production of high-quality hardwood sawlogs from public plantations, by SOFR reporting period



Note: Plantation high-quality sawlogs are assessed against jurisdictional quality and size specifications for similar products from native forest. These specifications are similar between states.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, state agencies.

Figure 2.20: Average annual sawlog production from private native forests, by SOFR reporting period



Notes:

Sawlogs harvested from private forests include high-quality and low-quality hardwood sawlog, hardwood 'veneer sawlog' and cypress sawlog.

Data are unavailable for the 1992–93 to 1995–96 reporting period for NT, Tas., Vic. and WA.

No sawlogs are harvested from private native forests in the ACT or SA.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences databases, state agencies.

available for harvest; high-quality sawlogs from plantations are becoming available in Tasmania and Western Australia (Figure 2.19). To date, the yield of high-quality plantation sawlogs in any state is small compared with the yield of high-quality sawlogs from multiple-use public native forest in the same jurisdiction.

Yields from private native forests

Although there is no calculated sustainable yield for wood production from native forests on private land across Australia, harvesting operations on such land face increasing restrictions, which reduce yield. In practice, most private forest managers make limited use of their native forests for wood production, only responding to immediate needs and opportunities in the market. The supply of sawlogs from private native forests is significant in New South Wales, Queensland and Tasmania (Figure 2.20), but has decreased markedly in Queensland and Tasmania since 1992–96. Private Forests Tasmania (2005) provides an estimate of wood resource supply from private native forest in Tasmania.

A Queensland code of native forest practice on freehold land was introduced in December 2005, to allow commercial wood harvesting from private native forests while satisfying the requirements of the *Vegetation Management Act 1999* (Qld). The application of the code, compared with previous practice, contributed to the reduced supply of sawlogs from 2006–07 to 2010–11. In the longer term, implementation of silvicultural regimes is planned to improve the productivity of private native forests (DERM 2011).

A national assessment of the role, values and potential of private native forests completed in 2009 (Parsons and Pritchard 2009) provided estimates of the contribution of private native forests to regional wood supply. The assessment found that, despite adequate information on the area of private native forests, little information is available on their quality, condition, value, current management regime and future management intent. The assessment also found that, although a proportion of landowners (varying by region) want to manage their forests to provide wood and other products and services in the long term, there is insufficient information nationally and regionally to assess whether the rate of wood harvest from private native forests is sustainable.

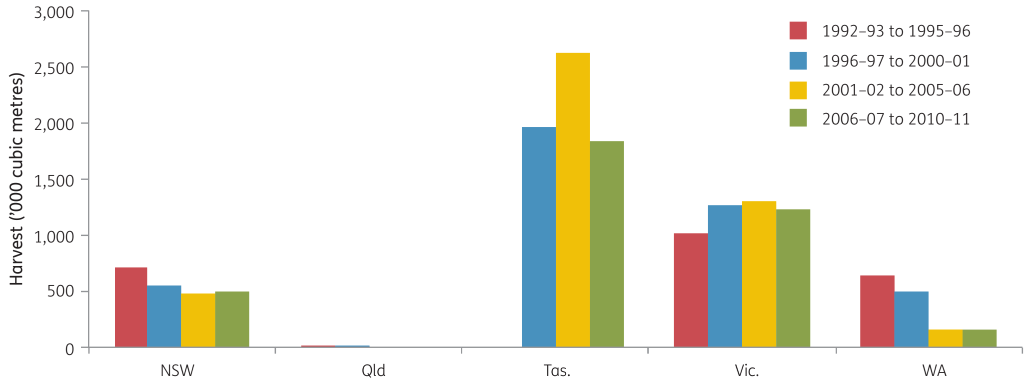
Pulplogs and pulpwood

Sustainable wood yields on public land are calculated based on high-quality sawlog and veneer production. Pulplogs, together with low-quality sawlogs and other wood products, are usually a residual product of sawlog and veneer log harvesting, and sustainable yields are not determined specifically for pulplogs or other wood products.

The volume of pulplogs harvested from multiple-use public native forests decreased substantially in Tasmania and slightly in Victoria, but remained essentially the same in New South Wales and Western Australia, between the SOFR 2008 and SOFR 2013 reporting periods (Figure 2.21). No pulplogs have been harvested from public native forests in Queensland since the 1996–97 to 2000–01 (SOFR 2003) reporting period.

Tasmania is Australia's major provider of pulpwood from both public and private forests (Figures 2.21 and 2.22); at the national level, only 13% of the pulplog harvest from private native forests was from mainland states between 2006–07 and 2010–11 (Figure 2.22). One reason for the decline in Tasmanian pulplog harvest was rotary-peeled veneer plants coming into full production during the reporting period (FPA 2012), and logs previously treated as pulplogs being used as feedstock for higher value rotary-peeled timber product.

Figure 2.21: Average annual pulplog harvest from multiple-use public native forests, by SOFR reporting period



Notes:

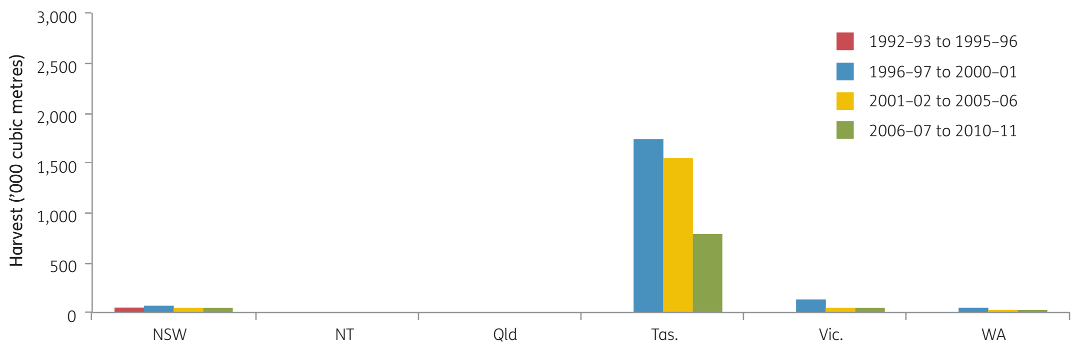
Data are unavailable for the 1992–93 to 1995–96 reporting period for Tasmania.

Pulplog includes logs sold for pulp or equivalent, and for woodchip.

Data have been converted from tonnes to cubic metres.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences databases, state agencies.

Figure 2.22: Average annual pulplog harvest from private native forests, by SOFR reporting period



Notes:

Data are unavailable for the 1992–93 to 1995–96 reporting period for all states and territories other than New South Wales.

Pulplog includes logs sold for pulp or equivalent, and for woodchip. No pulpwood has been harvested from private native forests from 1996–97 onwards in Queensland or the Northern Territory.

Data have been converted from tonnes to cubic metres.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences databases, state agencies.

Other wood products

The supply of other wood products, such as low-quality sawlogs, girders, poles, piles, non-pulpwood logs (logs that are not sawlogs or pulplogs), timber for mining, split and round posts, bush sawn/hewn timber and sleepers, varies by jurisdiction and is often opportunistic. These products are generally harvested in association with high-quality sawlogs and pulplogs, and are a major resource in New South Wales, Tasmania and Victoria. Figure 2.23 shows average annual harvest volumes for these products from multiple-use public native forests, by jurisdiction. Limited data are available on harvest rates for these products from private forests. Fuelwood and firewood are treated separately from these products, and are discussed separately.

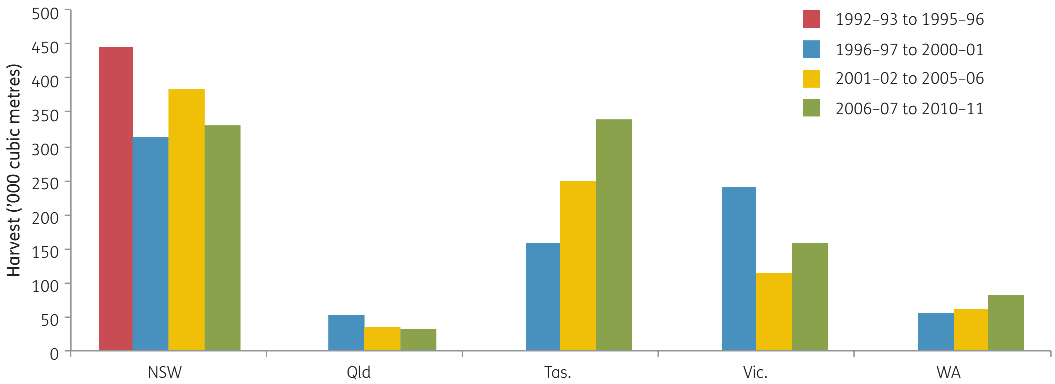
Firewood and fuelwood

Firewood is wood used for residential heating, whereas fuelwood is wood or wood products used as industrial fuel or for bioenergy production. Australian consumption of firewood and fuelwood increased from 5.6 million cubic metres per year in 1973–75 to 6.1 million cubic metres per year in 2006–10, with a peak of 6.8 million cubic metres per year in 1996–2000 (Table 2.11).

Firewood is one of the most commonly used wood products. Its use is an important segment of the forest sector and is important to regional communities. Residential firewood use declined across the 15-year period to 2009–10, and averaged 3.7 million cubic metres per year nationally for the five-year period 2006–10 (Table 2.11). Reporting of the quantities of firewood removed from multiple-use public native forests and plantations is variable across states and territories. Australian households used an estimated 4.0–5.0 million cubic metres of firewood per year from 1973–75 to 2001–05, with New South Wales and Victoria accounting for more than half of this volume (Figure 2.24).

Driscoll et al. (2000) reported that the five most common tree species used as firewood are river red gum (*Eucalyptus camaldulensis*—1.10 million tonnes[66]), jarrah (*E. marginata*—up to 0.61 million tonnes), red box and yellow box (*E. polyanthemos* and *E. melliodora*—0.54 million tonnes combined) and red ironbark (*E. sideroxylon*—0.47 million tonnes). Approximately half of the wood burned in households is collected by the residents. Sixty per cent of firewood was purchased through small suppliers. Of the firewood for private use or sale, 84% was collected from private property, 9% was collected from state forests, 3% was collected from roadsides and the remainder was from other sources (Driscoll et al. 2000).

Figure 2.23: Average annual harvest of 'other wood products' from native multiple-use public forests, by SOFR reporting period



Notes:

Data are unavailable for the 1992–93 to 1995–96 reporting period for all states other than New South Wales.

'Other wood products' are products that are not included in data for high-quality sawlogs and veneer logs, special-species timbers or pulpwood; they do not include firewood and fuelwood.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences databases, state agencies.

Table 2.11: Firewood and fuelwood use in Australia, 1973–75 to 2006–10

	1973–75	1976–80	1981–85	1986–90	1991–95	1996–2000	2001–05	2006–10
Industrial fuelwood ('000 cubic metres per year)	1,121	1,026	990	1,249	1,542	1,714	1,869	2,482
Residential firewood ('000 cubic metres per year)	4,510	4,108	4,254	4,412	4,921	5,049	4,284	3,659
Total ('000 cubic metres per year)	**5,631**	**5,134**	**5,244**	**5,661**	**6,463**	**6,763**	**6,153**	**6,141**
Firewood as proportion of total residential energy use (%)	31	26	25	24	23	21	18	14

Source: Bureau of Resources and Energy Economics.

[66] The conversion between tonnes and cubic metres for firewood and fuelwood is roughly 1:1.

Eucalypt firewood for domestic use.

Firewood is collected from plantations and agricultural lands as well as native forests. As a proportion of total residential energy use, firewood use decreased from 31% in 1973–75 to 14% in 2006–10 (Table 2.11), and is predicted to decrease to 8% by 2020 (DEWHA 2008). This predicted decrease may change as a result of consumer considerations (including price) relating to carbon emissions associated with the use of other energy types (DEWHA 2008).

Regulations and controls are in place across Australia to protect threatened species and ecological communities from the impacts of firewood collection. Collection is regulated in many states and territories through permit systems, controls on the clearing of native vegetation, and voluntary codes of practice applying to commercial firewood operators. A national approach was developed and endorsed by governments to increase the effectiveness of these regulations and controls, and place collection on a more sustainable basis (ANZECC 2001). In August 2005 the Natural Resource Management Ministerial Council endorsed a revised voluntary code of practice for firewood merchants[67].

Industrial fuelwood is used by a range of industry sectors, and usage has doubled since 1973–75 (Figure 2.25; Table 2.11). Fuelwood consumption in the wood, paper and printing manufacturing sector averaged around 75% of total industrial fuelwood use up to 1996–2000, mainly using the sector's waste product from the manufacturing process. Production of electricity from fuelwood and wood waste has grown significantly since 2001–05. The food, beverage and tobacco manufacturing sector has increased its use of fuelwood since the 1980s. Niche markets have also developed; for example, non-sawlog jarrah wood is used to make charcoal for silicon smelting in Western Australia.

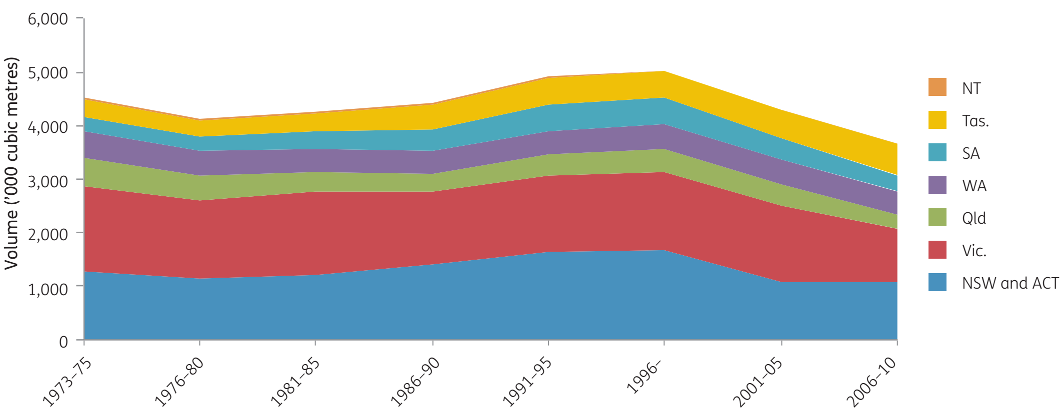
Wood products harvested from plantations and native forests

Table 2.12 and Figure 2.26 report the amount of wood harvested annually, for the period 2000–01 to 2010–11, by sector (native forest, softwood plantation and hardwood plantation; sawlog and pulplog). Figures 2.27 and 2.28 show the separate contributions of public and private land to the amount of sawlogs and pulplogs harvested from Australian native forests over the period 1996–97 to 2010–11.

Overall over the period 2000–01 to 2010–11, the sawlog and pulplog harvest from native forest has declined, the sawlog and pulplog harvest from softwood plantations has increased, and the sawlog harvest from hardwood plantations has been relatively stable while the pulplog harvest from hardwood plantations has increased significantly. A total of 6.5 million cubic metres of native forest logs, 5.1 million cubic metres of hardwood plantation logs and 14.9 million cubic metres of softwood plantation logs were harvested in 2010–11.

Sawlog production from native forests declined from 4.3 million cubic metres annually in 1996–97 to 2.4 million cubic metres in 2010–11 (Table 2.12; Figures 2.26 and 2.27). The decline has occurred in production from both public and private multiple-use native forests, although the reduction in production from multiple-use public forests has been proportionally greater (Figure 2.27). Pulplog production from native forests increased from 5.1 million cubic metres annually in 1996–97 to 7.0 million cubic metres annually in

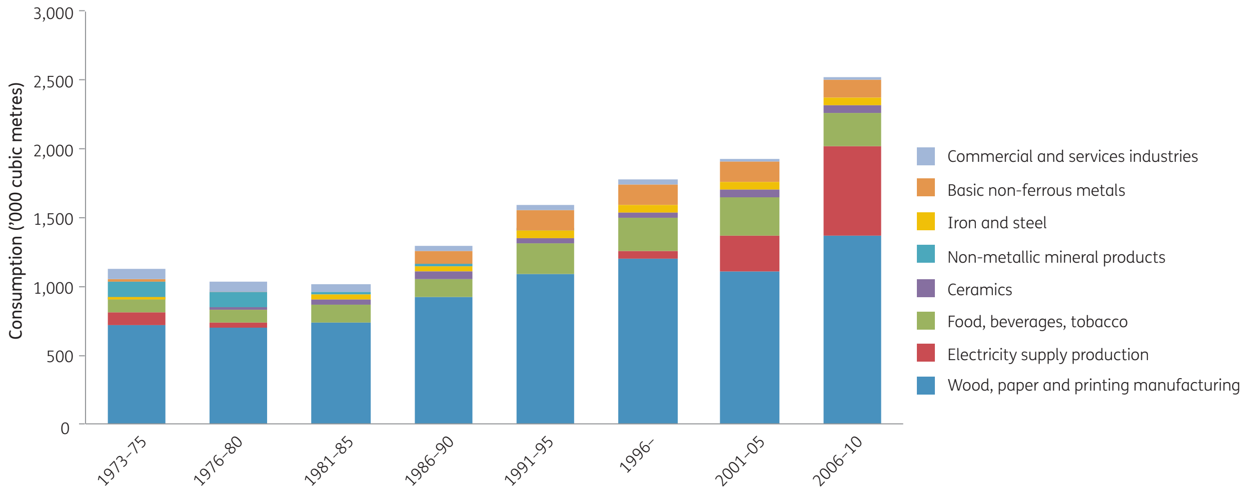
Figure 2.24: Average annual residential use of firewood, 1973–75 to 2006–10, by jurisdiction



Note: Data have been converted to cubic metres.
Source: Bureau of Resources and Energy Economics.

[67] http://www.environment.gov.au/land/publications/firewood-code.html.

Figure 2.25: Average annual Australian consumption of fuelwood, 1973–75 to 2006–10, by industry type



Note: Data have been converted to cubic metres.
Source: Bureau of Resources and Energy Economics.

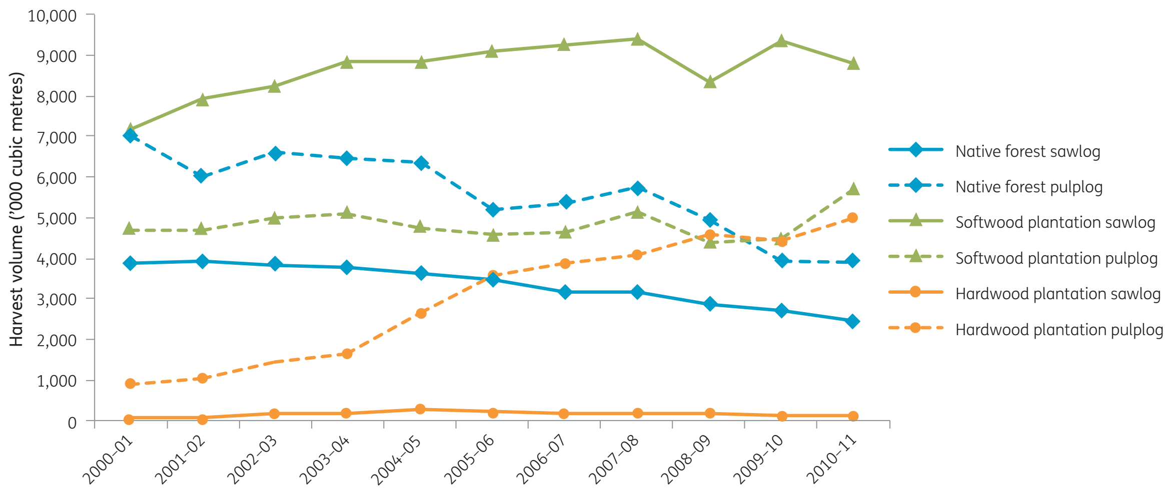
Table 2.12: Logs harvested by native forest and plantation sector, 2000–01 to 2010–11

	Volume ('000 cubic metres)										
Sector	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**
Native											
Hardwood sawlog	3,583	3,639	3,543	3,444	3,320	3,204	2,939	2,966	2,640	2,495	2,251
Other hardwood product	221	167	167	184	192	191	252	201	155	150	179
Native pine sawlog (cypress)	296	293	297	316	291	279	224	210	211	198	182
Hardwood pulplog	6,998	6,022	6,605	6,462	6,354	5,180	5,360	5,773	4,944	3,944	3,898
Native forest total	**11,098**	**10,121**	**10,611**	**10,406**	**10,158**	**8,855**	**8,774**	**9,150**	**7,950**	**6,787**	**6,509**
Plantation											
Hardwood sawlog	82	67	153	177	273	208	159	186	168	136	114
Other hardwood product	5	4	6	9	14	17	15	19	10	7	12
Hardwood pulplog	888	1,041	1,435	1,633	2,649	3,554	3,878	4,065	4,569	4,412	5,134
Hardwood total	975	1,112	1,594	1,819	2,936	3,779	4,052	4,270	4,747	4,555	5,259
Softwood sawlog	7,163	7,952	8,260	8,827	8,829	9,105	9,253	9,422	8,341	9,331	8,806
Other softwood product	528	415	377	343	347	415	486	400	392	394	361
Softwood pulplog	4,711	4,696	4,977	5,102	4,728	4,580	4,626	5,126	4,370	4,509	5,632
Softwood total	12,402	13,063	13,614	14,272	13,904	14,100	14,365	14,948	13,103	14,234	14,799
Plantations total	**13,376**	**14,175**	**15,208**	**16,092**	**16,841**	**17,879**	**18,418**	**19,218**	**17,849**	**18,790**	**20,058**
Grand total	**24,474**	**24,296**	**25,819**	**26,498**	**26,998**	**26,734**	**27,192**	**28,368**	**25,799**	**25,577**	**26,567**

Notes:
Native hardwood sawlog includes logs for railway sleeper production, but excludes logs collected for firewood.
Sawlogs include logs for plywood and veneer.
'Other product' categories include poles, piles, fencing and other logs not included elsewhere.
Totals may not tally due to rounding.

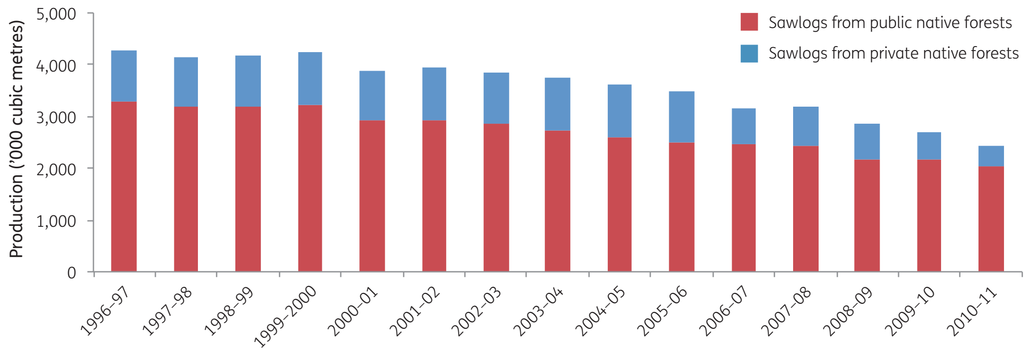
Source: Australian Bureau of Agricultural and Resource Economics and Sciences (figures are supplied by growers and producers), Australian Forest and Wood Products Statistics database, ABARES (2013c).

Figure 2.26: Harvest of sawlogs and pulplogs from Australia's native forests and plantations, 2000–01 to 2010–11



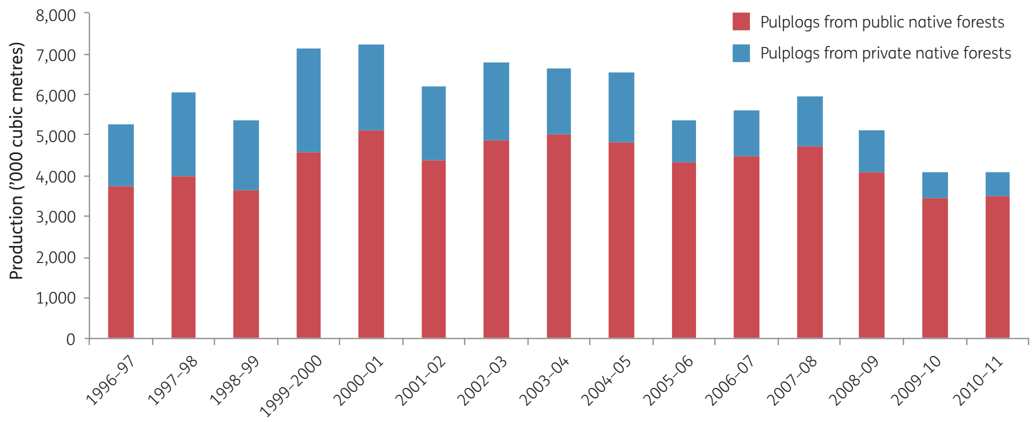
Note: Native forest sawlogs include hardwoods and native cypress pine.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, Australian Forest and Wood Products Statistics database.

Figure 2.27: Production of sawlogs from Australia's native forests, 1996–97 to 2010–11



Note: Sawlogs include native hardwood and cypress pine species.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, Australian Forest and Wood Products Statistics database.

Figure 2.28: Production of pulplogs from Australia's native forests, 1996–97 to 2010–11



Note: Pulplogs are sourced from native hardwoods.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, Australian Forest and Wood Products Statistics database.

2000–01, then declined to 3.9 million cubic metres annually in 2010–11 (Table 2.12; Figures 2.26 and 2.28).

Supply of both sawlogs and pulplogs from both hardwood and softwood plantations has increased since 1996 (Table 2.12; Figure 2.26), and nationally plantation logs accounted for 71% of all logs harvested, by volume, in the period 2006–07 to 2010–11, compared with 57% in the period 2000–01 to 2002–03 (Table 2.13). In 2010–11, the final year of the SOFR 2013 reporting period, 76% of the volume of logs harvested in Australia in 2010-11 was from plantations.

The sawlog supply from hardwood plantations increased from a very low base of 7 thousand cubic metres in 1996–97 to a peak of 273 thousand cubic metres in 2004–05, and declined to 114 thousand cubic metres in 2010–11 (Table 2.12; Figure 2.26). This increase has not matched the significant decrease in harvest of native hardwood sawlogs. Sawlog supply from softwood plantations increased from 7.2 million cubic metres in 2000–01 to 8.8 million cubic metres in 2010–11; pulplogs from softwood plantations increased from 4.7 million cubic metres to 5.7 million cubic metres over the same period. The supply of hardwood plantation pulplog increased from about 1,500 cubic metres in 1996–97 to about 5 million cubic metres in 2010–11.

Harvested sawlog volumes declined progressively from 1996–97 to 2010–11 on both public and private forests (Figure 2.27). Pulplog production from native forests varied over this period but declined after 2007–08 with an accompanying decline in the proportion produced from private forests (Figure 2.28).

During the past decade, the proportion of total wood supply and pulplog derived from native forest has decreased, although native forests have remained the main source of hardwood sawlogs (Table 2.13). Industrial plantations produced 71% of Australia's total log supply in the period 2007–08 to 2010–11. Approximately half of Australia's plantation log supply was used for pulp, and half for sawn timber. In the period 2007–08 to 2010–11, plantation hardwoods made up 35% of the total pulplog supply and 5% of Australia's hardwood sawlog supply (ABARES 2012g), which is 1% of Australia's sawlog supply (Table 2.13), while plantation softwood provided 39% of Australia's pulplog supply and 79% of Australia's sawlog supply.

Forecast plantation log availability

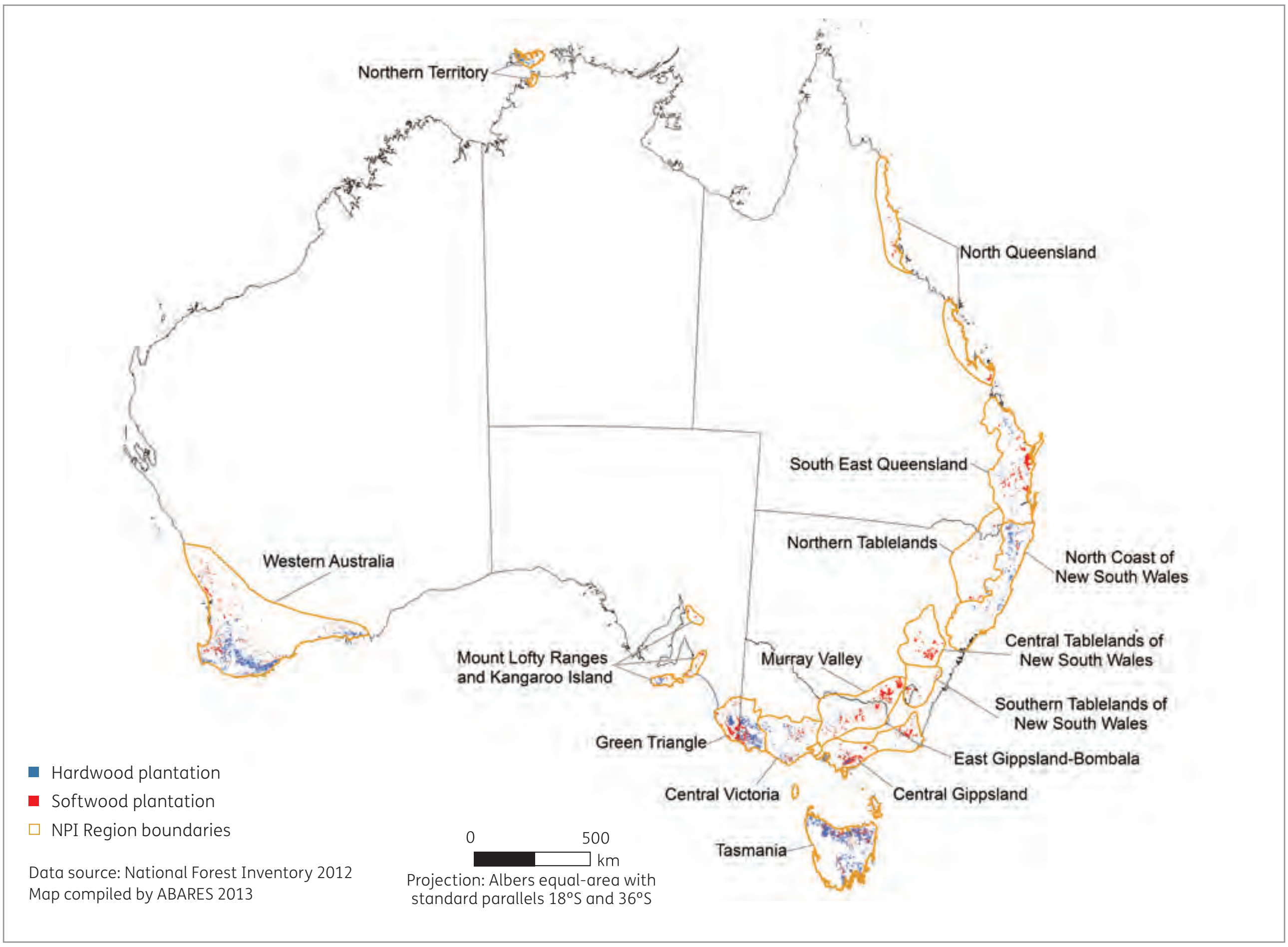
Industrial plantations are mainly located in 15 regions in Australia (Figure 2.29). Plantations are established mainly for the production of timber and other wood-based products. Plantation estates are managed as businesses, so the timing and volume of log harvests are determined primarily by market forces, rotation length and thinning regimes, rather than considerations of long-term regional yields.

Table 2.13: Proportions of wood harvest volumes derived from native forests and plantations, 2000–01 to 2010–11

Product	**Source**	**Proportions (%)**		
		2000–01 to 2002–03	**2003–04 to 2006–07**	**2007–08 to 2010–11**
Sawlogs	Native forest	33	28	23
	Plantation	67	72	77
	Hardwood	1	2	1
	Softwood	66	71	75
	Total	100	100	100
Hardwood sawlogs	Native forest	97	94	95
	Plantation	3	6	5
	Total	100	100	100
Softwood sawlogs	Native forest	4	3	2
	Plantation	96	97	98
	Total	100	100	100
Pulplogs	Native forest	53	43	33
	Plantation	47	57	67
	Total	100	100	100
Hardwood pulplogs	Native forest	85	67	50
	Plantation	15	33	50
	Total	100	100	100
Total wood products	**Native forest**	**43**	**36**	**29**
	Plantation	**57**	**64**	**71**
	Total	**100**	**100**	**100**

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, Australian Forest and Wood Products Statistics database.

Figure 2.29: Distribution of Industrial plantations and National Plantation Inventory regions



Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Plantation Inventory.

Table 2.14: Forecast plantation log supply, Australia, 2010–14 to 2050–54

	Volume ('000 cubic metres)								
Log type	**2010–14**	**2015–19**	**2020–24**	**2025–29**	**2030–34**	**2035–39**	**2040–44**	**2045–49**	**2050–54**
Hardwood									
Pulplog	9,763	12,571	13,499	10,145	13,776	12,448	12,236	13,099	11,495
Sawlog	290	530	1,079	1,271	1,159	1,244	1,417	1,178	1,091
Total	10,053	13,101	14,578	11,416	14,935	13,692	13,654	14,277	12,586
Softwood									
Pulplog	5,309	5,593	5,797	5,474	5,734	5,381	5,540	5,743	5,720
Sawlog	10,205	10,686	10,054	10,592	12,114	12,863	12,537	12,200	11,759
Total	15,514	16,279	15,851	16,066	17,848	18,244	18,076	17,943	17,479
Total	**25,566**	**29,380**	**30,429**	**27,482**	**32,783**	**31,936**	**31,730**	**32,220**	**30,065**

Notes:
Sawlogs include all quality classes of plantation sawlogs.
Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Plantation Inventory.

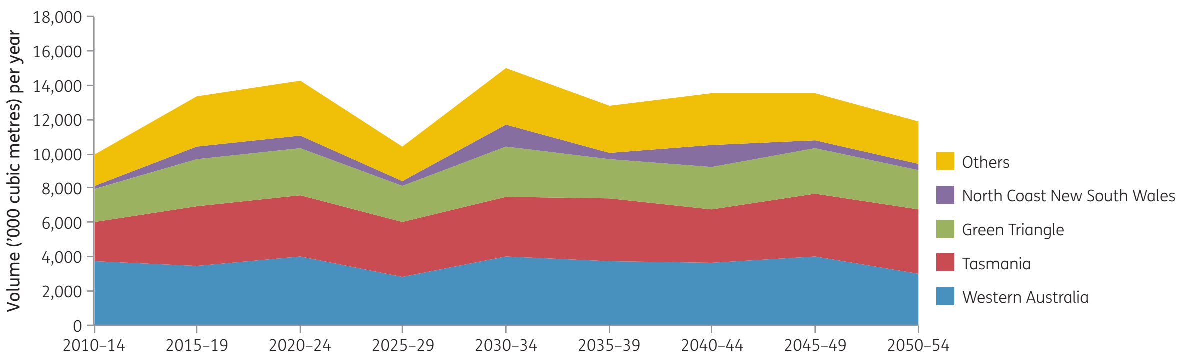
The National Plantation Inventory has developed a forecast of potential future log availability from existing plantations to 2050–54 (Table 2.14; Figure 2.30), based on data collected from the 15 plantation regions (see SOFR 2013 Introduction). The forecast is based mainly on the plantation areas in 2011, combined with assumptions about the yield of log products per unit area of land, and assuming that all harvested plantation sites are replanted. For softwood plantations, more than 100 years of growth and yield data are available to underpin the assumptions used to develop the forecast; fewer data are available for hardwood plantations, so the forecasts for hardwood log availability are less reliable. The proportion of the total volume produced that is suitable for hardwood sawlogs is particularly difficult to estimate accurately.

The potential annual average supply of logs from Australian plantations is forecast to be 26 million cubic metres in 2010–14, then to increase to more than 29 million cubic metres in 2015–19 (Table 2.14). Plantation log availability is forecast to reach an annual average peak of 33 million cubic metres in 2030–34 (Table 2.14). Based on current plantings, log production from softwood plantations is nearing its maximum potential and is expected to plateau by 2035 at around 18 million cubic metres per year, while production from hardwood plantations is forecast to peak at around 15 million cubic metres per year by 2030 (Table 2.14; Figure 2.30).

Total plantation hardwood supply in 2015–19 is forecast to be 13 million cubic metres per year on average (Table 2.14), more than three times the actual volume harvested in 2009–10 (Gavran et al. 2012) and reported in Table 2.12. Australia's hardwood plantation area has increased by 31.4% since 2004–05 (Gavran and Parsons 2011). However, the 2012 forecasts indicate a 2.3% decrease in national hardwood plantation log supply in 2015–19 compared with the 2007 report estimates, and the annual average hardwood sawlog supply forecast from 2012 for the 2010–45 period is around 17% lower than the 2007 forecast reported in SOFR 2008. These decreases in forecast volumes are a result of revised growth and yield forecasts by growers (Gavran et al. 2012). Increases in hardwood plantation area have not led to significant increases in sawlog volume because hardwood plantations are managed primarily for pulplog production, with only a small proportion managed for sawlog and veneer log production.

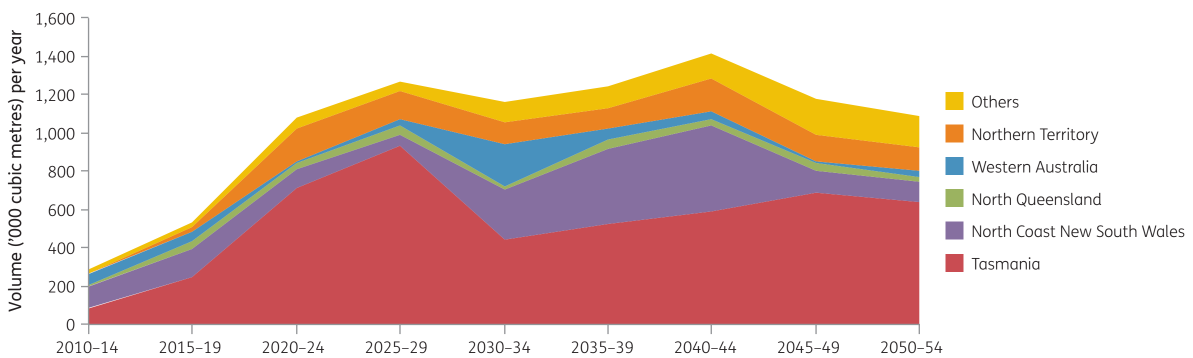
Hardwood plantation pulplog production was 4.4 million cubic metres in 2009–10. It is forecast to increase to about 13.5 million cubic metres per year in 2020–24, peaking at around 13.8 million cubic metres per year in 2030–34 (Table 2.14). By 2015–19, the major hardwood pulplog-producing regions will be Western Australia and Tasmania (Figure 2.31), each accounting for 27% of the national total pulplog volume, and the Green Triangle (South Australia–Victoria),

Figure 2.30: Forecast supply of plantation hardwood pulplog, by National Plantation Inventory region



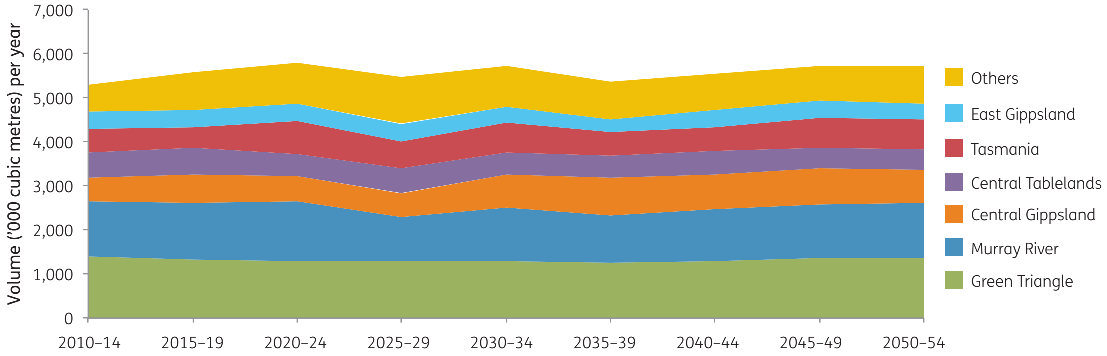
Source: Gavran et al. (2012).

Figure 2.31: Forecast supply of plantation hardwood sawlog, by National Plantation Inventory region



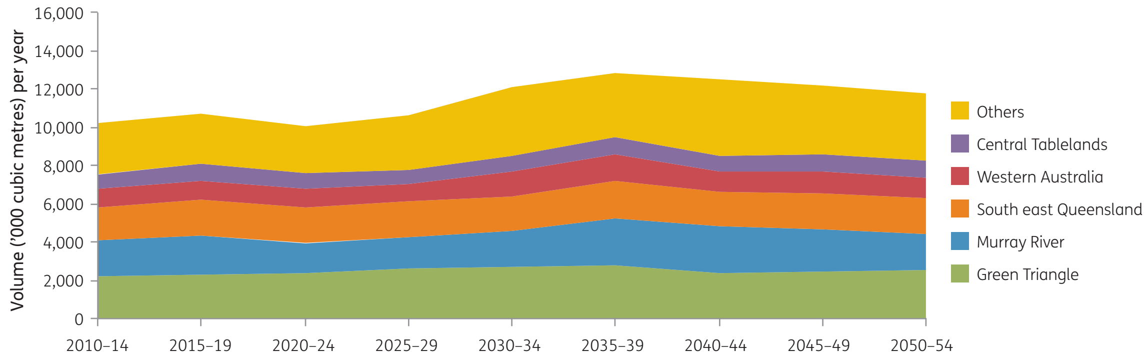
Source: Gavran et al. (2012).

Figure 2.32: Forecast supply of plantation softwood sawlog, by National Plantation Inventory region



Source: Gavran et al. (2012).

Figure 2.33: Forecast supply of plantation softwood pulplog, by National Plantation Inventory region



Source: Gavran et al. (2012).

accounting for another 22%. The North Coast New South Wales and Central Victoria regions are forecast to produce 6% each.

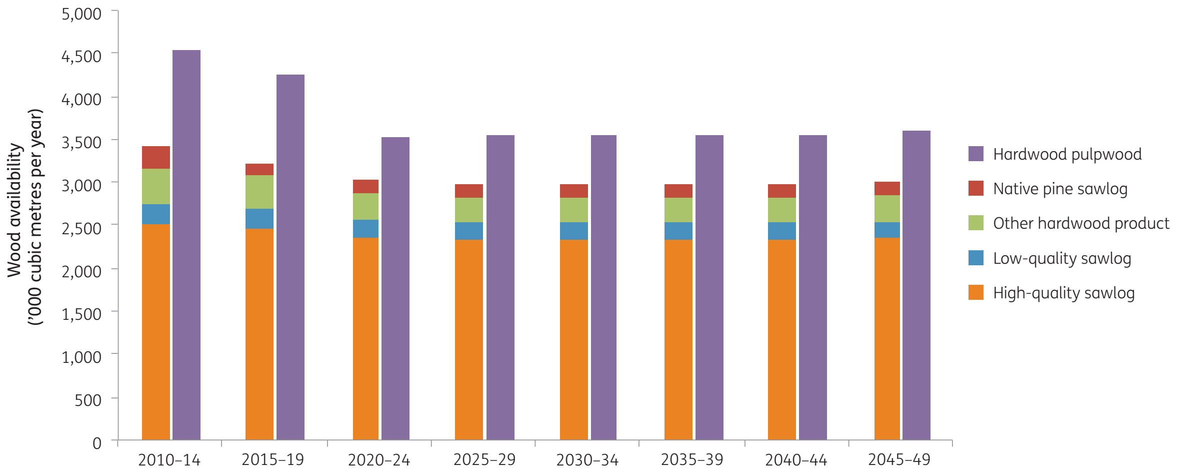
Hardwood sawlog production was 136,000 cubic metres in 2009–10. It is forecast to increase to almost 1.3 million cubic metres per year in 2025–29, peaking at around 1.4 million cubic metres per year in 2040–44 (Table 2.14). By 2015–19, Tasmania and the North Coast New South Wales will be the main regions for production of hardwood plantation sawlogs (Figure 2.31), with an annual average of about 251,000 and 145,000 cubic metres available, respectively. These figures include all sawlog grades; only a small component of the projected hardwood plantation sawlogs will be of similar quality to high-quality sawlogs from native forest.

The forecast 2010–45 annual average supply of softwood logs (Table 2.14) is 1.3% higher in this report than in the forecast of Parsons et al. (2007). The increase is a result of the total softwood area increasing by 34,000 hectares (Gavran and Parsons 2011).

The major softwood sawlog–producing regions are currently, and will remain, the Green Triangle, the Murray Valley and South East Queensland (Figure 2.32). In 2015–19, the Green Triangle will produce an estimated 21% of the national softwood sawlog volume, the Murray Valley 20% and South East Queensland 17%. The supply of softwood sawlogs—more than 9.5 million cubic metres per year in 2009–10—is forecast to be steady at around 10.5 million cubic metres per year for the next 15–20 years, and increase to about 12.1 million cubic metres per year in 2030–34 (Table 2.14). Most of the sawn timber used for housing and general construction in Australia is derived from softwood plantation sawlogs.

Most plantation softwood pulplog is forecast to be produced in the Green Triangle, Murray Valley and Central Gippsland (Figure 2.33). In 2015–19, the Green Triangle and the Murray Valley will contribute 22% each of the total national softwood pulplog supply, and Central Gippsland will contribute 12%. The supply of softwood pulplog was 4.6 million cubic metres per year in 2009–10. It is forecast to increase to 5.6 million cubic metres per year in 2015–19 and remain around that level until the end of the 2050–54 period, with a slight decline in 2035–39 (Table 2.14).

Figure 2.34: Forecast availability of wood from native production forest in Australia (public plus private), 2010–14 to 2045–49



Note: Projections are based on SOFR 2008 area statement and data used in ABARES (2012a–f). This projection does not include changes reported in Forests NSW (2010a) or VicForests (2011a), nor changes resulting from the Tasmanian Forests Intergovernmental Agreement 2013[68].

Source: ABARES (2012a–f), Australian Bureau of Agricultural and Resource Economics and Sciences database.

Forecast native forest log supply

Native forests produced 29% of Australia's total log supply over the SOFR 2013 reporting period; historically it was much higher (Table 2.13). A forecast of potential future wood supply from multiple-use public, leasehold and private native forest to 2050 is presented in Figure 2.34, derived from ABARES (2012a–f[69]). The forecast is a compilation of projected wood supply from native forests in six forest regions covering the majority of Australia's production forests; impacts of climate change, market forces or changing markets are not considered. The majority of native forest log supplies are from forests within Regional Forest Agreement areas (see SOFR 2013 Introduction). High-quality sawlogs are logs graded to standards used by state agencies; native pine sawlog is cypress pine; low-quality sawlog is sawlog not included in the high-quality category; and other hardwood product includes poles, piles, girders and other solid logs. Miscellaneous wood products such as firewood, industrial fuelwood, sleeper logs and fencing material are not included in the forecast projections.

Currently the supply of high-quality native forest sawlogs is primarily from multiple-use public native forests, with a smaller amount from private forests. A small amount of high-quality sawlogs is harvested from public hardwood plantations (Figure 2.19). The overall pulpwood supply from native forests is predicted to decrease from approximately 4.5 million cubic metres annually in 2010–14 to approximately 3.5 million cubic metres annually from 2020–24 onwards (Figure 2.34). This is a consequence of the predicted decrease in sustainable yield from public forests (Figure 2.35). As the supply of high-quality native sawlogs decreases from multiple-use public forests, the demand for supply of high-quality native sawlogs from private and leasehold forests will increase. Supplies from private and leasehold forests will depend on markets, and the objectives and goals of private and public owners.

Potential effects of climate change on forests

Forest growth and wood production are highly sensitive to changes in climate. The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES 2011a, 2012a–f) showed that most of Australia's production forest areas are likely to experience lower rainfall and higher temperatures by 2050 relative to 2005 as a result of predicted impacts of climate change. Two greenhouse gas emission scenarios (A1B and A2) developed by the Intergovernmental Panel on Climate Change were used to estimate climate change in 2030 and 2050. The A1B scenario assumes a moderate increase in atmospheric greenhouse gas levels, whereas the A2 scenario assumes a greater increase in greenhouse gas levels by the end of the century. The global mean annual temperature is expected to increase by 2030 and 2050 under both scenarios (0.8–0.9 °C increase in 2030 and 1.4–1.5 °C increase in 2050; see ABARES 2011a) when compared with the 1990 baseline.

Log availability from Australia's forests is projected to decline by 2050 under these climate predictions, relative to baseline projections in the absence of climate change. Both scenarios predict larger declines in log availability from softwood plantations than from hardwood plantations, and little change in log availability from native forests (Figure 2.36). The projected decline in log availability resulting from climate change varies by region. Jurisdictions are progressively factoring predicted changes into projected log supply from plantations and native forest.

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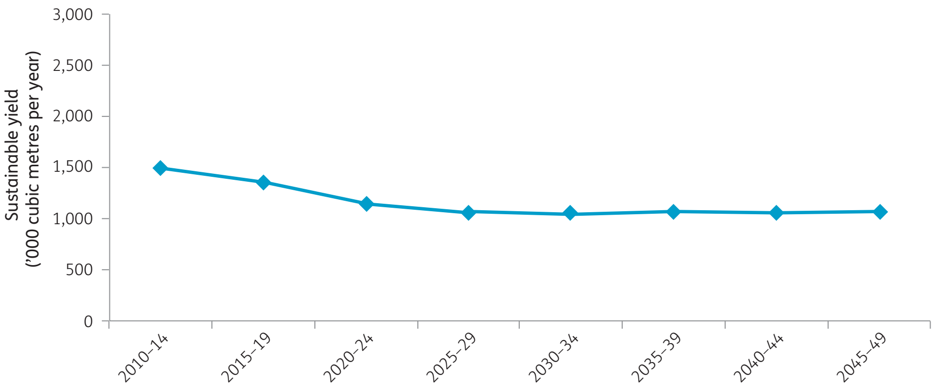
68 http://www.environment.gov.au/topics/land/forests/intergovernmental-agreement.

69 Six technical reports (ABARES 2012a–f) give assumptions, caveats and cautions regarding the underpinning data applying to these forecasts. Because of the variability in grower management intent, and less reliable data on growth, yield, commerciality and forest condition, on private land, the confidence and accuracy of estimates from private and leasehold forests are less than those from public forests.

Figure 2.35: Forecast sustainable yield of high-quality native forest sawlogs from public production forest in Australia, 2010–14 to 2045–49



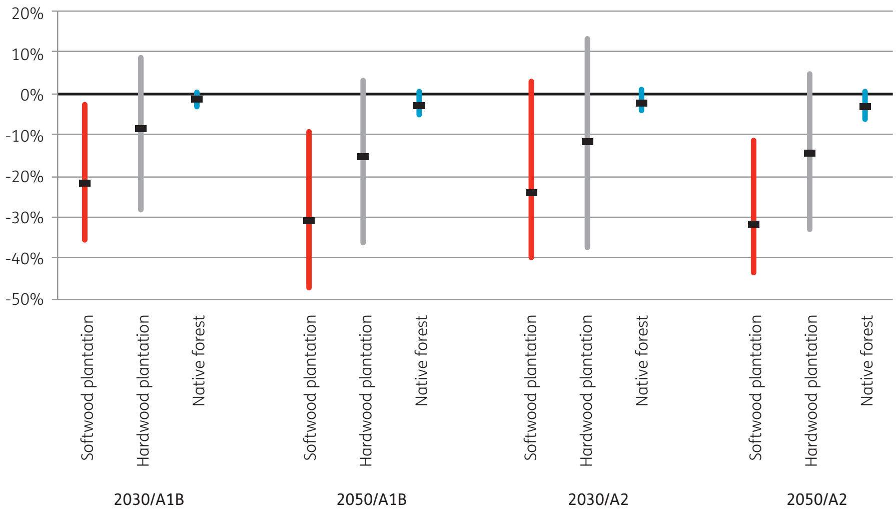
Notes:

Figures exclude changes resulting from the Tasmanian Forest Intergovernmental Agreement 2013 and supplementation with high-quality sawlogs from public hardwood plantations.

Figures include Queensland allowable cut estimates to 2025.

Source: ABARES (2012a–f), updates from Forests NSW (2010a) and VicForests (2011a), Australian Bureau of Agricultural and Resource Economics and Sciences database.

Figure 2.36: Projected changes in log availability due to effects of predicted climate change



Notes:

Horizontal black bars show the predicted change in log availability due to the median model effect of climate change. Vertical coloured bars are the range of predicted change.

The estimated national baseline log supply from softwood and hardwood plantations for 2030 and 2050 was about 16 million cubic metres (each); from native forests, it was about 8 million cubic metres.

Source: ABARES (2011a), based on aggregated data from the six regional assessments (ABARES 2012a–f).

CRITERION 2

Indicator 2.1d

Annual removal of non-wood forest products compared to the level determined to be sustainable

Rationale

This indicator is used to assess the sustainability of the harvest of non-wood forest products. These products can represent a significant asset base supporting the livelihoods of remote communities.

Key points

- Australia produces a wide range of non-wood forest products (NWFPs) derived from forest fauna, flora and fungi. High-value NWFPs include wildflowers, seed, honey, and aromatic products derived from sandalwood.
- State and territory governments regulate the removal of NWFPs in their respective jurisdictions, including through the issue of permits and licences. Commonwealth legislation, such as the *Environment Protection and Biodiversity Conservation Act 1999*, also regulates the removal of certain NWFPs.
- Indigenous Australians rely to varying degrees on the use of NWFPs for customary purposes (e.g. food and medicine) and commercial purposes (e.g. art and craft).
- Data on annual removals and sustainable yields are limited for many NWFPs, but are available for the more significant NWFPs.
- The extraction of NWFPs from native and plantation forests was assessed by the State of the Environment 2011 Committee as generally having a low impact on the environment. Climate variability and restrictions on resource access are among potential risks to the sustainability of NWFP-based industries.

Non-wood forest products (NWFPs) are products of biological origin, other than wood, derived from forests. For convenience, certain wood products, such as wood carvings and aromatic items produced from sandalwood (*Santalum* spp.), are included in this indicator. Sandalwood is also discussed in Indicator 2.1c. Water and carbon values derived from forests are discussed under Criteria 4 and 5, respectively, and the economic value and use of NWFPs are reported in Indicator 6.1b. Table 2.15 presents a non-exhaustive list of examples of Australian NWFPs.

The Australian, state and territory governments have regulations to limit and control the removal of plant and animal products from forests. Most commonly, this involves the issue of permits or licences for harvesting and hunting activities (Box 2.1). The allowable rates of extraction vary by jurisdiction.

The Australian Government has legislated measures to protect threatened species nationally through the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which also regulates, among other things, the ecologically sustainable use of wild native plants and animals that are exported.

The *Australia State of the Environment 2011* report (State of the Environment 2011 Committee 2011) provides an assessment of land-use pressures on forests (Table 2.16). Land use involving native production forest is assessed in the report as having 'very low impact' on the land environment. This assessment is attributed to diminished intensity of native forest

Table 2.15: Examples of NWFPs produced and used in Australia

Category	Examples
Terrestrial plants	Plants (trees, shrubs, wildflowers, grasses, tree ferns), seeds, essential oils, herbal health products, fragrances, bark, pigments, dyes, tannins, native plant food
Animals	Meat, skins, eggs, bee products
Fungi	Mushrooms, other fungi
Other products	Biochemicals, soil ameliorants, mulches, Indigenous artefacts

Source: Adapted from SOFR 2008.

Box 2.1: State and territory legislation relevant to the harvesting of non-wood forest products

Australian Capital Territory

The *Nature Conservation Act 1980* protects all native fauna and flora. A licence is required to take protected fauna or flora.

New South Wales

The *National Parks and Wildlife Act 1974* protects all native fauna (mammals, birds, reptiles and amphibians) and flora. A licence is required to take protected fauna or flora. Regulation of non-native fauna is under the control of the *Non-Indigenous Animals Act 1987*. The *Threatened Species Conservation Act 1995* and the *Environmental Planning and Assessment Act 1979* also have provisions relevant to the harvesting of non-wood forest products.

Northern Territory

The Territory Parks and Wildlife Conservation Regulations manage the use of native flora and fauna. A permit is issued to people wishing to take native flora or fauna from the wild. The Department of Natural Resources, Environment, the Arts and Sport[70] regulates this permit system. If the integrity of a species is starting to be compromised by commercial use, a management plan is required. Such management plans are in place for cycads, crocodiles, the magpie goose and the red-tailed black-cockatoo. The 1997 *A Strategy for Conservation through the Sustainable Use of Wildlife in the Northern Territory of Australia* encourages sustainable use of wildlife for commercial purposes that are ecologically sustainable and where landholders are the beneficiaries, and encourages the development of management plans.

Queensland

The *Nature Conservation Act 1992* specifically allows the ecologically sustainable use, including commercial use, of protected wildlife (animals or plants). Commercial activities operate through a licensing system that controls the taking and use of protected wildlife.

South Australia

The *National Parks and Wildlife Act 1972* provides the state's legislative framework for the conservation of wildlife and flora in their natural environment. Protected animals include only indigenous and migratory birds, mammals and reptiles. A permit is needed to take any protected species, except where the relevant Minister declares otherwise based on a threat to crops or property, or declares an open hunting season for protected animals of specified species. A permit is needed to take native plants on any public land, as well as certain native plants on private land.

Tasmania

Wildlife (defined as all living creatures except stock, dogs, cats, farmed animals and fish) in Tasmania is protected by the *Wildlife Regulations Act 1999*. Open season may be declared by the Minister for Environment, Parks and Heritage for particular species of wildlife, such as wallabies, possums, deer, wild ducks and mutton-birds. A tree fern management plan was formulated[71], and additions were made to Tasmania's *Forest Practices Act 1985*, to improve the sustainability of the tree fern harvesting industry.

Victoria

In Victoria, wildlife (defined as vertebrate species indigenous to Australia, some non-native game species, and terrestrial invertebrate animals that are listed under the *Flora and Fauna Guarantee Act 1988*) is protected under the *Wildlife Act 1975*. A licence or authorisation is needed to take, destroy or disturb wildlife or protected fauna. Flora is protected under the *Flora and Fauna Guarantee Act 1988*; it may include both indigenous and non-indigenous species.

Western Australia

The *Conservation and Land Management Act 1984* and the *Wildlife Conservation Act 1950* provide for the conservation and protection of all native flora and fauna in Western Australia through a system of licensing, area-specific and species-specific management, and monitoring. A management plan[72] (DEC 2008) governs the commercial harvesting of protected flora in Western Australia to June 2013 and satisfies the requirements of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Under the *Wildlife Conservation Act*, flora is defined as 'any plant, including any wildflower, palm, shrub, tree, fern, creeper or vine which is either native to Western Australia or declared to be flora under the Act and includes any part of flora and the seeds and spores thereof'. A licence is required for the commercial use of protected species on Crown or private land. For Crown land, the licensee must demonstrate that they have both an area in which to harvest the species and written permission from the government agency that is managing that land.

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[70] From October 2012, the Department of Land Resource Management.

[71] The 2012 version of this management plan is available at http://www.fpa.tas.gov.au/__data/assets/pdf_file/0005/58037/Revised_Tasmanian_treefern_management_plan_2012.pdf and http://www.environment.gov.au/system/files/resources/605a78d8-a9a1-4a72-81af-046442573488/files/tas-treefern-2012.pdf.

[72] A new management plan for protected flora covering July 2013 to June 2018 has been approved and was gazetted on 3 July 2013: http://www.environment.gov.au/resource/management-commercial-harvesting-protected-flora-western-australia-1-july-2013-30-june-2018.

Table 2.16: Contemporary land-use pressures on the land environment: forest

Component	Summary	Assessment grade	Confidence in grade and in trend
Native production forests	The intensity and scale of commercial wood harvesting in public native forests have diminished substantially; harvesting and other activities are strongly regulated.	Very low impact	Adequate high-quality evidence and high level of consensus
Plantation forests	The expansion of plantation forests is significant in some regions, but impacts on environmental values are generally limited, unless the site is converted directly from native vegetation. The area of plantation forests remains small as a proportion of land area, and plantation forestry has become very strongly regulated.	Very low impact	Adequate high-quality evidence and high level of consensus

Source: Adapted from State of the Environment 2011 Committee (2011).

harvesting, the small scale of harvesting practices, and strong regulation of these practices. Plantation forests are also assessed as having 'very low impact'; this is attributed to the small area of plantation forest in proportion to land area, and strong regulations on forest management and use. The assessment pertains to the extraction of both wood and NFWP.

Limited quantitative data are generally available for this indicator for reporting the harvest of NWFPs and the sustainability of harvest. Foster (2009) and Foster (in press) report that emerging rural industries based partly on forest plant and animal resources include buffalo, wild pig, crocodile, kangaroo and wallaby, possum, Australian native foods, essential oils from sandalwood, and wildflowers and native plants (including seed). The following is an overview, with examples of some high-value products for which data exist.

Terrestrial plant products

In general, factors that influence the sustainability of the harvest of native plant products in Australian forests include the plant part that is harvested; the plant's reproductive strategy, habitat specificity and growth rates; other uses for the land on which the plant grows (such as wood production or grazing); harvest methods; remoteness from human settlement; and land-use context or environmental factors (such as climate change). A number of forest-based non-wood plant product industries are subject to sustainability assessments.

In Tasmania, harvesting of tree ferns (only *Dicksonia antarctica* may be harvested) is strictly regulated under the provisions of the *Forest Practices Act 1985*, and a tree fern management plan (FPA 2005) endorsed by the Australian and Tasmanian governments governs the harvesting, transportation and trade of Tasmanian tree ferns[73]. Estimated stocks of tree ferns in Tasmania total more than 63 million tree ferns across tenure categories (Table 2.17). Tags are placed on harvested stems and must remain on the stems at all times to ensure that the origin of the tree fern can be tracked to approved harvesting areas. The annual average number of tags issued, representing tree ferns harvested, has decreased over the reporting period (Table 2.18). Harvesting of tree ferns may only occur under a forest practices plan for areas subject to clearfell, burn and sow silviculture in native forest, or (rarely) a forest practices plan that authorises permanent clearing and conversion of native forest. Tree ferns are supplied to domestic and export markets.

Seed and wildflowers are other important NWFPs, particularly in Western Australia. Wildflower and seed industries in Western Australia are based on a combination of horticulture and native resources from forest and non-forest vegetation on public and private lands. Whereas the wildflower sector of the industry has a large export component, seed is used mainly for revegetation projects within Western Australia (DEC 2008). The Department of Environment and Conservation[74] manages wildflower and seed harvesting in accordance with a management plan for commercial harvesting of protected flora in Western Australia on public and private land (DEC 2008). The Australian Government has approved the management plan for the purpose of the EPBC Act. The Western Australian *Forest Management Plan 2004–2013* contains Key Performance Indicator 15 (wildflower and seed picking), which is monitored, audited and reported by the Conservation Commission of Western Australia (CCWA 2012b) to ensure that wildflower and seed industries are based on conservation and sustainable use of native resources in accordance with the principles of ecological sustainability.[75]

Table 2.19 reports the harvest of wildflowers and seed for the region covered by the *Forest Management Plan 2004–2013* in south-west Western Australia from 2004 to 2010. The harvest of wildflowers from native environments decreased by 60% over the period, from 10.3 million stems in 2004 to 4.2 million stems in 2010. This coincides with wildflower harvesting moving to private property not covered by the forest management plan (CCWA 2012b). Harvest of seed varied from 5,400 to 20,400 kilograms over the reporting period. The variation is attributed to changing demand for seed for rehabilitation and revegetation, together with the variability in the availability of seed between dry and wet periods.

Seed collection of forest species is also important in other states and territories, for use in native forest regeneration, plantation establishment, propagating nursery stock and land-care plantings. Collection is regulated and reported

73 The 2012 version of this management plan is available at http://www.environment.gov.au/system/files/resources/605a78d8-a9a1-4a72-81af-046442573488/files/tas-treefern-2012.pdf.

74 From July 2013, the Department of Parks and Wildlife.

75 A new management plan for protected flora covering July 2013 to June 2018 has been approved and was gazetted on 3 July 2013: http://www.environment.gov.au/resource/management-commercial-harvesting-protected-flora-western-australia-1-july-2013-30-june-2018.

Table 2.17: Estimated tree fern numbers, by land tenure, in Tasmania

Tenure	Wet forest	Other forest	Total
Formal reserves	13,574,200	3,579,000	17,153,200
Informal reserves	3,849,700	378,100	4,227,800
Public land—state forest wood production areas	24,875,900	1,386,700	26,262,600
Other public land	4,789,200	1,223,400	6,012,600
Private land reserves	11,900	2,600	14,500
Other private land	8,985,200	803,000	9,788,200
Total	**56,086,000**	**7,372,800**	**63,458,900**

Source: FPA (2012).

Table 2.18: Tree fern harvesting in Tasmania

Financial year	Number of tree fern tags issued
2002–03	64,182
2003–04	54,886
2004–05	61,368
2005–06	45,131
2006–07	43,843
2007–08	35,361
2008–09	17,529
2009–10	19,905
2010–11	11,229

Source: FPA (2012).

Table 2.19: Wildflower and seed harvest from south-west Western Australian native environments covered by the *Forest Management Plan 2004–2013*

Year	Number of wildflower stems harvested	Seed collected (kg)
2004	10,328,670	15,744
2005	9,502,362	5,597
2006	8,667,680	5,407
2007	6,493,230	10,333
2008	4,768,136	20,363
2009	4,700,672	9,649
2010	4,237,221	12,653

Source: CCWA (2012b).

Harvested sandalwood logs, Western Australia.

by relevant public authorities. Forestry Tasmania reported collection of native tree seed for the period 1996–97 to 2010–11 in the *State of the forests Tasmania 2012* report (FPA 2012); the amount varied from a low of 564 kilograms during 1998–99 to a high of 7,897 kilograms in 2009–10.

Sandalwood is a parasitic plant that requires a host tree, such as raspberry jam wattle (*Acacia acuminata*), for its survival. Sandalwood is used in a range of products: the wood is used as incense and for carving, and sandalwood oil is distilled from the plant's heartwood. Almost all sandalwood products produced in Australia are derived from the Australian sandalwood (*Santalum spicatum*) in Western Australia (the largest producer), or northern sandalwood (*S. lanceolatum*) in northern Queensland. However, Indian sandalwood (*S. album*), the predominant sandalwood species in Asia, the Middle East and north Africa, has been planted in Australia since 2006. In 2012, there were more than 15 thousand hectares of *S. spicatum* plantations in Western Australia; there were also more than 8 thousand hectares of *S. album* plantations, mostly in Western Australia (Foster in press).

During the period 2005–06 to 2011–12, Australia produced 2,459–3,073 tonnes of sandalwood and 11–20 tonnes of sandalwood oil (Table 2.20). Virtually all parts of the tree—roots, bark and both live (green) and dead wood—are harvested for use. Western Australia is the major source of sandalwood, with small amounts harvested in Queensland. Much of the product is exported. Indicator 6.1b reports value, export amounts and consumption of sandalwood.

In Western Australia, the allowable harvest level is governed by the *Sandalwood (Limitation of Removal of Sandalwood) Order 1996* which provides for the removal of up to 1,500 tonnes per year of non-third-grade green sandalwood (excluding the harvest of dead wood, roots and third-grade green wood; see Indicator 2.1c). In 2010–11, the amount of green wood harvested from FPC-administered operations was 1,139 tonnes, compared with 1,239 tonnes in 2009–10.

In Queensland, sandalwood is a protected plant under the *Nature Conservation Act 1992*. Sandalwood harvesting must comply with the Nature Conservation (Protected Plants) Conservation Plan 2000, and the maximum allowable harvest for green sandalwood logs is set through a Nature Conservation (Protected Plants Harvest Period) Notice that is updated annually. The maximum allowable harvest of green sandalwood logs from 2008 to 2011 was 500 tonnes per year from state land and 50 tonnes per year from private land (excluding the harvest of dead wood, roots and stumps).

Table 2.20: Australian sandalwood production, 2005–06 to 2011–12

	Production (tonnes)						
Product	**2005–06**	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**	**2011–12**
Wood, Western Australia	2,512	2,369	2,269	2,601	2,857	2,864	2,814
Green	1,521	1,419	1,326	1,678	1,714	1,621	1,433
Dead	726	758	729	666	873	963	1,179
Roots	228	192	214	258	269	230	202
Bark	38	0	0	0	0	50	0
Wood, Queensland	132	118	190	274	167	209	130
Wood, total	**2,644**	**2,486**	**2,459**	**2,875**	**3,024**	**3,073**	**2,944**
Sandalwood oil	14.0	14.0	12.0	10.6	19.2	19.6	15.7

Source: Foster (in press).

Animal products

Mammals, reptiles, amphibians, birds, and insects and other invertebrates provide a range of NWFPs, such as meat, eggs, skins, fibres, honey and other bee products. In addition, many animal species provide important ecosystem services; for example, bees and other insects pollinate flowering plants.

The removal of native animals from Australian forests is prohibited or subject to regulations enforced by government agencies in all jurisdictions. Harvesting for meat and skin products is largely restricted to species that are considered to be common, and in most cases requires a permit. Permits are usually only issued after a detailed sustainability analysis based on monitoring of populations of the species. This analysis takes into account factors such as local population levels (including trends in population numbers), reproduction rates, and pressures such as disease or habitat loss that are likely to negatively affect the species. Harvesting of feral pest species does not require such sustainability analyses, since their populations have management targets for controlling populations.

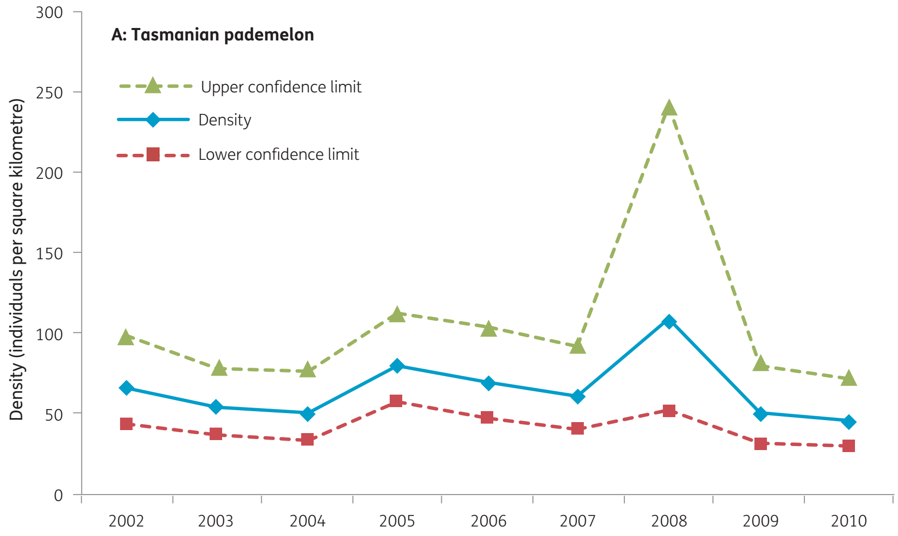
Kangaroos (common wallaroo or euro, *Macropus robustus*; eastern grey kangaroo, *M. giganteus*; red kangaroo, *M. rufus*; and western grey kangaroo, *M. fuliginosus*) are harvested commercially for meat and skins in New South Wales, Queensland, South Australia and Western Australia. Bennett's wallaby (*M. rufogriseus*) and Tasmanian pademelon (*Thylogale billardierii*) were commercially harvested in Tasmania on Bass Strait Islands (Flinders and King) until 2010, when harvest ceased as it was commercially unviable. Currently a small amount of wallaby skins and fur is traded on mainland Tasmania. All of these species dwell in both forests and non-forests, and are common and not endangered. Other kangaroo and wallaby species are protected from commercial harvesting.

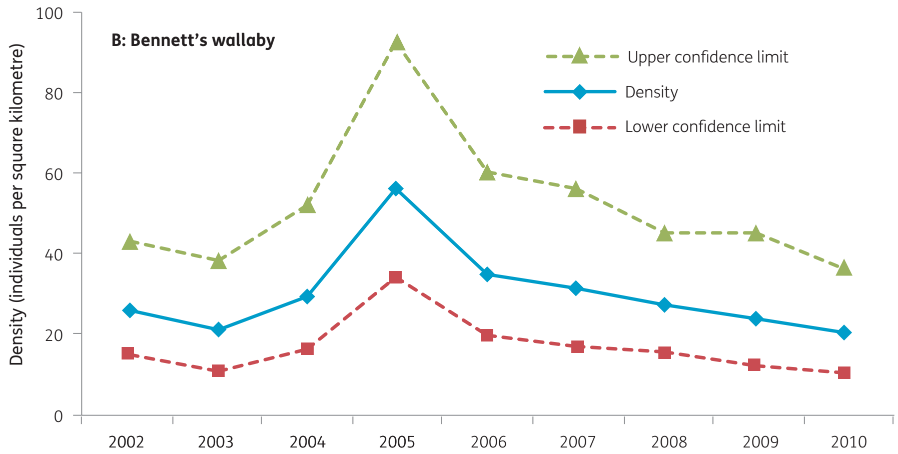
The commercial kangaroo harvest industry has management goals based on principles of sustainability (DSEWPaC 2012a). Annual quotas are set for each species by the relevant state agencies, and endorsed by the Australian Government under delegated authority provided by approved species management plans. The annual harvest quotas are published (DSEWPaC 2012b) and vary from year to year, based on the population estimates of the previous year. Quotas represent 10–20% of the populations estimated from direct population monitoring. In some states, subquotas are set regionally and allocated to individual property holders on a permit basis. In all states, commercial harvesting is done under a strict code of practice (NRMMC 2008) and a tag must be attached to each carcass before it can be processed. The proportion of harvest of wild kangaroos that is from forest lands is unknown; the harvest of Bennett's wallaby and Tasmanian pademelon is primarily from forested land.

Bennett's wallaby and Tasmanian pademelon are annually monitored by spotlight survey (Figure 2.37), and harvest rates in Tasmania are adjusted based on these statewide estimates. A sustainable yield formula under a commercial harvest plan covering forests and non-forests calculates the annual harvest based on the spotlight survey results (FPA 2012). Populations have remained relatively stable over the period 2001–10 (Figure 2.37); commercial harvesting levels have decreased substantially since 1996, while the number of non-commercial licences has increased (Table 2.21). Wallaby wildlife trade management plans were in place from November 2005 for harvesting wallabies on Flinders and King islands. They expired in 2010 and have not been renewed (FPA 2012).

Common brushtail possums (*Trichosurus vulpecula*) are harvested in Tasmania for skin and meat. Harvest is managed through a management plan approved under the EPBC Act and based on maintaining sustainable populations (DPIPWE 2010). The species is monitored annually (Figure 2.38), and harvest levels are based on monitored population levels. Table 2.22 reports the annual number of common brushtail possums harvested in Tasmania, which has varied substantially from 1996 to 2010–11; current harvesting rates are relatively low.

Figure 2.37: Density of macropods in Tasmania from annual spotlight surveys, 2002–10.
A, Tasmanian pademelon. B, Bennett's wallaby.





Note: Dashed lines show 95% confidence limits around density estimates.
Source: FPA (2012).

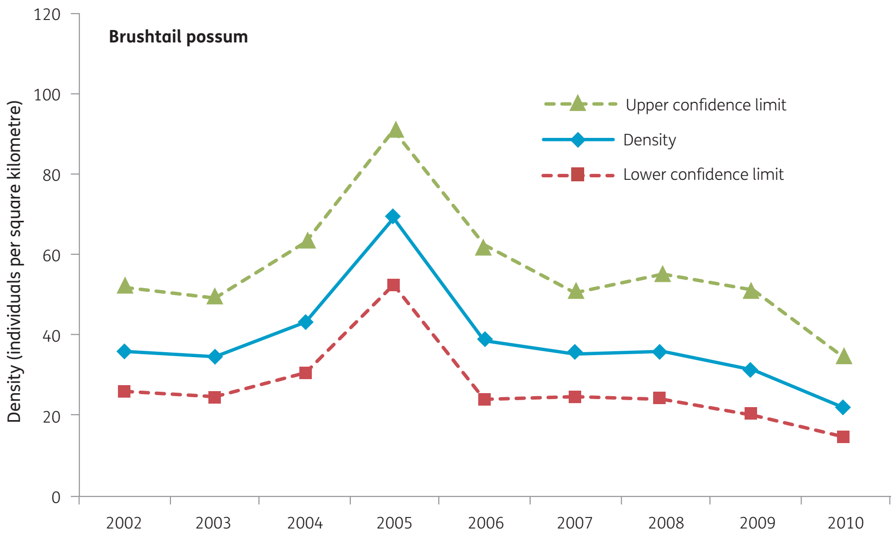
Table 2.21: Annual harvest of wallaby[a] meat in Tasmania

Year	Commercial licences sold	Game meat produced (kg)	Non-commercial shooting game licences sold
1996	113	69,617	4,956
1997	80	58,055	5,926
1998	61	50,974	4,989
1999	50	67,999	4,646
2000	44	61,642	4,392
2001	45	–	4,492
2002	49	–	4,769
2003	46	8,784	4,391
2004	60	2,630	4,518
2005	52	19,045	4,531
2006	27	20,920	5,840
2007	33	23,696	6,499
2008	28	20,746	6,534
2009	29	22,148	6,705
2010	32	27,670	6,835
2011	31	19,452	6,685

– = not available
[a] Includes pademelon.

Source: FPA (2012).

Figure 2.38: Density of common brushtail possums in Tasmania from annual spotlight surveys, 2002–10



Note: Dashed lines show 95% confidence limits around density estimates.
Source: FPA (2012).

Table 2.22: Annual harvest of common brushtail possums in Tasmania

Year	Commercial permits	Estimated commercial harvest
1996	59	13,917
1997	35	12,364
1998	176	10,596
1999	38	11,635
2000	42	55,200
2001	22	4,900
2002	40	1,100
2003	17	1,700
2004	47	120
2005	45	5,672
2005–06	13	14,497
2006–07	14	4,832
2007–08	4	1,558
2008–09	7	4,680
2009–10	6	1,375
2010–11	12	4,379

Source: FPA (2012).

Forest-dwelling exotic fauna species are also harvested in Australia for meat and skins, and form the resource base of rural industries (Foster 2009, Foster in press). Many of these, such as pigs, goats and water buffalo, are officially declared pests that negatively affect forest health. In these cases, the harvesting rate is usually determined by forest management considerations rather than ecological sustainability criteria. Deer are harvested for venison and antlers from forests in New South Wales, Tasmania and Victoria. In Tasmania, annual harvest of male deer during 1996–2011 varied from a low of 544 animals in 1999 to a peak of 1,631 animals in 2006 (FPA 2012).

Apiary products are another important animal NWFP. Most states and territories of Australia have a significant beekeeping industry, and hives are placed in forest ecosystems based on the annual availability of flowering tree and understorey resources. The dependency of the beekeeping industry on forest resources varies across states and territories; it is estimated as 70–90% in south-eastern Australia (including southern Queensland) and south-western Australia (Benecke 2007, CALM 2006, DSE 2008). States and territories regulate apiarists through issuing permits and licences for apiary sites and hives.

Table 2.23 reports the number of beekeepers and hives by jurisdiction. Table 2.24 reports the average number of apiary sites and hives on state forest land in Tasmania from 1996–97. In Tasmania in 2010–11, there were 10,662 hives reported from 422 sites in state forest; in addition, 5,006 hives were reported from 87 sites in national parks and reserves (FPA 2012).

Although Australia is a net exporter of honey, there are several potential threats to the sustainability of the industry. These include restrictions on access to native flora due to land clearing for agriculture, rural dieback[76], limited clearfelling of native forest for wood products, bushfires, and the conversion of Crown land to reserves or national parks where apiaries may be excluded (RIRDC 2007a). Changing climate conditions also affect flowering patterns of forest species.

[76] Rural dieback is a collective term used to describe the degradation and loss of vigour of trees and native forest ecosystems as a result of changes in hydrology, salinity and nutrient balances; deterioration in soil attributes; increased pest and pathogen impacts; and changed fire regimes.

Tree plantations, including of eucalypt species, are unlikely to increase substantially the floral resources available to the beekeeping industry (Somerville 2010).

Other important animal NWFPs are wild crocodile eggs and juveniles that are used by the farmed crocodile industry in northern Australia (see Indicator 6.1b).

Indigenous harvest, including traditional use

Indigenous people harvest wildlife for both traditional and commercial purposes. Non-wood Indigenous products include bark paintings, weavings, pigments and dyes, and subsistence products, such as those used for food and ceremonial purposes. For convenience of classification, Indigenous NWFPs also include carvings and wooden sculpture. The sustainable use of NWFPs is extremely important to Indigenous communities in remote regions of Australia; such products often constitute a significant proportion of local customary and non-welfare cash economies (SOFR 2008). Despite the importance of the Indigenous NWFP harvest to the conservation of particular species and the livelihoods of many Indigenous communities, little data and few studies are available to assess its size and impact nationally.

Table 2.23: Number of beekeepers and hives by jurisdiction

Jurisdiction	Beekeepers		Hives	
	Number	Proportion of national total (%)	Number	Proportion of national total (%)
NSW	3,195	31.9	265,474	43.8
NT	4	0.0	1,500	0.2
Qld	3,084	30.8	119,418	19.7
SA	740	7.4	66,013	10.9
Tas.	179	1.8	17,904	3.0
Vic.	1,927	19.2	96,455	16.0
WA	880	8.8	39,000	6.4
Total	**10,009**	**100.0**	**605,764**	**100.0**

Notes:
No data are available from ACT.
Totals may not tally due to rounding.

Source: Benecke (2007).

Table 2.24: Average number of apiary sites and hives on state forest land in Tasmania

Period	Number of sites	Number of hives
1996–97 to 2000–01	334	12,156
2001–02 to 2005–06	319	12,179
2006–07 to 2010–11	334	11,199

Note: Numbers are averages of the annual figures across each reporting period.
Source: FPA (2012).

Tasmanian state forest containing leatherwood (*Eucryphia lucida*). Leatherwood honey produced in Tasmania is exported around the world.

CRITERION 2

Indicator 2.1e

The area of native forest harvested and the proportion of that effectively regenerated, and the area of plantation harvested and the proportion of that effectively re established

Rationale

This indicator is used to assess the success of the re establishment of forests after harvesting. Re-establishment is critical to the maintenance of the productive capacity of the forest.

Key points

- State jurisdictions have codes of forest practice and other regulatory instruments requiring the regeneration and/or restocking of harvested multiple-use public native forests to specified standards; some states have similar codes of practice and regulations for private forests.
- Five-year average reported regeneration success rates in multiple-use public native forest in the reporting period 2005-06 to 2010-11 varied from 85% in New South Wales, to 100% in Queensland; over the four SOFR reporting periods, the five-year average reported regeneration rates varied from 72% in Victoria, to 100% in Queensland and Western Australia. Impacts of drought, bushfire, poor seed reserves and difficulties in carrying out regeneration burns contributed to low regeneration success rates in some states.
- In plantations, rates of successful establishment and re-establishment are generally above 90%.
- Remedial action is carried out by the grower or manager in native forest and plantations where specified regeneration and restocking standards are not achieved.

The term 'forest regeneration' usually refers to new trees that establish in a forest after harvesting, fire or other agents (e.g. wind or flood damage) have removed some or all trees from the forest overstorey. For native forests, this indicator provides annual information on the area regenerated after harvesting, the proportion of the total area of harvesting that this represents and the success of the regeneration effort. The indicator applies mostly to multiple-use public native forests in New South Wales, Queensland, Tasmania, Victoria and Western Australia, where significant volumes of wood are harvested, as well as private native forests in Tasmania, the only jurisdiction for which reliable data are available for that tenure. No native forest harvesting is permitted in multiple-use public native forests in the Australian Capital Territory or South Australia, and there is no multiple-use public native forest in the Northern Territory

For public plantations, this indicator reports on the area planted, or replanted after harvesting, and the success of the planting or replanting effort. Private plantations comprise 75% of Australia's plantation estate, but there is no available information about replanting success other than for private plantations in Tasmania. Regeneration audits are carried out in Tasmania on public and private native forest, and restocking or replanting audits apply to plantations.

Native forest regeneration

Effective regeneration of native forest after wood harvesting is a fundamental process in sustainable forest management, since regeneration determines the long-term productivity, growth, dynamics and composition of forest stands. Managers of multiple-use public forests are required by codes of forest practice, silvicultural manuals or guidelines, and other regulatory instruments to measure the effective regeneration (e.g. by stocking, density and species composition) of areas harvested for wood production, and to report the results publicly. Depending on the state, effective regeneration is judged by a combination of meeting a regeneration standard that prescribes the required stocking, and meeting specified silvicultural regeneration goals and objectives based on sustainable forest management objectives. For example, some of the silvicultural treatments applied to certain forest types promote the establishment of a cohort of trees for the next harvest. The guidelines, goals and objectives also consider both sustainable use and conservation requirements.

The states have established standards for the effective regeneration of multiple-use public native forests; some also have standards for private forests. Regeneration is usually assessed 1–3 years after harvesting, although the period is longer in some jurisdictions. Further follow-up treatments to promote regeneration, or supplementary planting with local tree species, are carried out if regeneration standards are not met at the first assessment. The definitions of, and standards for, effective regeneration vary between jurisdictions, but all aspire to stocking of the site that meets silvicultural manuals or guidelines, goals and objectives. Figure 2.39 illustrates effective regeneration four and six years after fire-salvage (clearfell) harvesting in Victoria.

Regional differences in forest type, climatic and biophysical conditions, and management objectives mean that each state has its own method for assessing the success or effectiveness of regeneration, and its own range of silvicultural techniques (see Indicator 2.1a). Whereas assessment techniques are well developed in even-aged native forests, they are more variable in multi-aged stands, where a single stand may contain trees of markedly varying growth stage (see Indicator 1.1b), age and height.

Retention of seed trees, prescribed fire and mechanical site disturbance are employed to encourage regeneration in many multiple-use public native forests. These methods are sometimes combined with aerial sowing of seed collected from the site (or a similar, local area) before harvesting of trees. Some silvicultural systems require adequate on-site regeneration to be present in the harvesting area before harvesting takes place; shelterwood and native cypress pine silvicultural systems are examples. Promotion of a subsequent regeneration event is not a priority where various thinning regimes are applied to young regrowth stands.

In New South Wales, effective regeneration in multiple-use public native forests for the period 2001–02 to 2010–11 was generally above 80% (see Table 2.25). In the three years when regeneration rates were below 80%, the impact of drought was a significant factor in the regeneration of some

Figure 2.39: Regeneration after harvesting using a fire-salvage (clearfell) silviculture system in Victorian native forests. A, Site immediately after harvesting; B, site four years after harvesting; C, site six years after harvesting. Granite Spur, Mitta Mitta, Victoria. Alpine Ash (*Eucalyptus delegatensis*) killed by wildfire in 2003 then salvage-logged and regenerated.

Table 2.25: Area proportion of harvested multiple-use public native forest effectively regenerated, New South Wales, 2001–02 to 2010–11

Year	Total area harvested (hectares)	Proportion of harvested area effectively regenerated (%)[a]
2001–02	50,351	68
2002–03	49,062	87
2003–04	45,746	86
2004–05	42,923	83
2005–06	43,709	74
2006–07	44,806	63
2007–08	52,960	94
2008–09	27,952	81
2009–10	38,499	95
2010–11	27,484	92

a Proportion of harvested area effectively regenerated with commercial species, based on sampled areas of forests of types that require post-harvest regeneration assessments and of forests harvested with silvicultural systems that require post-harvest regeneration assessments.

Notes:

Figures presented in Table 37 of SOFR 2008 were incorrect and have been updated with new figures.

Additional silvicultural treatment is undertaken when regeneration standards are not met, and the outcome of such treatment is not included in these data.

Source: Forests NSW.

of these forests (successful regeneration requires adequate soil moisture for seedling establishment). Wildfires also affected regeneration on harvested areas in some of these forests.

In Victoria, the area of multiple-use public native forest treated and regenerated after harvesting has been reported since 1993–94 (Table 2.26). Prior to 2001, there was a 4–5-year lag between reporting regeneration treatment and assessment of effectiveness. Since 2004, results have been reported annually, with effectiveness assessed sooner (between 2 and 5 years after treatment and, from 2007, up to 3 years after treatment). A harvested coupe that does not meet the minimum standard is further treated with a follow-up resurvey for the effectiveness of regeneration 18–30 months after the additional treatment, with the goal that over time all the harvested area is effectively restocked (DSE 2007a; VicForests 2011b). Harvested coupes are transferred from the commercial harvesting agency (VicForests) back to the custodial managing agency (Department of Sustainability and Environment[77]) once the coupe has been adequately regenerated and meets coupe regeneration handover guidelines (VicForests 2011b).

Table 2.26 shows for reporting years 1993–94 to 2010–11 the area of harvested multiple-use public native forest in Victoria that received an initial regeneration treatment; the area measured as meeting the standard and so effectively regenerated, including previously treated areas that were supplementary seeded or further treated; and the ratio between these two areas, which is the proportion effectively regenerated. Effective annual regeneration varies from 44% to 125% (inclusion of retreatment explains why this value can exceed 100%: see notes below Table 2.26), with a long-term area-weighted average success rate of 83%. Low regeneration percentages occur in years affected by drought, bushfire, poor seed reserves, or an inability to carry out adequate regeneration burns or mechanical disturbance. Harvest coupes that have not reached the regeneration standards at the first attempt have proven increasingly difficult to regenerate. Higher regeneration percentages occur in years with favourable conditions for regeneration establishment, or where areas from previous years have been effectively regenerated.

In Western Australia, the *Forest Management Plan 2004–2013* (CCWA 2004), which covers all the main wood production areas in the state's south-west, and supporting guidance documents such as the silvicultural guidelines (DEC 2004a, 2004b, 2005), require that regeneration success and effective stocking rates be monitored in publicly owned native forests and pine plantations. In the mixed-age jarrah (*Eucalyptus marginata*) forest, the regeneration stocking rates in areas cut over to establish regeneration are sampled; a target has been set that no more than 5% of the area regenerated annually will require remedial action because it is understocked. Similarly, in karri (*Eucalyptus diversicolor*) forest, the regeneration stocking rates within even-aged forest are assessed after the first winter, and infill planting is undertaken if the stocking of patches falls below agreed standards. Key performance indicators have been developed for public reporting of the timeliness and effectiveness of regeneration, and are audited and reported by the Conservation Commission of Western Australia (CCWA 2012b—see Key Performance Indicator 10, Effectiveness of regeneration of native forest and plantation). Effectiveness of karri and jarrah regeneration is reported, as well as re-establishment of *Pinus* plantations. Silvicultural guidelines are reviewed and updated in response to outcomes of monitoring regeneration success (Burrows et al. 2011).

Table 2.27 summarises the results of the effectiveness of regeneration after harvesting in multiple-use public native forests in Western Australia. Jarrah regeneration was 100% for all the years reported, and karri regeneration varied from 97% to 100% (CCWA 2012b).

Under the Tasmanian code of forest practice, which applies to public and private native forests and plantations, sowing and planting mixtures applied to native forests must approximate the natural composition of the canopy trees of the forest before harvesting. The code also requires that regeneration surveys be conducted one year after clearfelling or two years after partial harvesting in eucalypt forest. Where surveys show that survival is less than the required stocking, measures to increase stocking to the required stocking standard are applied.

Tasmania reports annually on the level of regeneration achieved in all harvested native forest areas in multiple-use public forests. It requires that at least 85% of harvested forest meets the required stocking rate standard, which is based on the number and spatial distribution of acceptable seedlings, saplings or trees that occur within the area being assessed, and varies depending on forest type and silvicultural system.

77 From April 2013, the Department of Environment and Primary Industries.

Table 2.26: Area of multiple-use public native forest treated for regeneration and area effectively regenerated, Victoria, 1993–94 to 2010–11

Year[a]	Total area treated for regeneration (hectares)	Total area effectively regenerated (hectares)	Proportion of total harvested area effectively regenerated (%)
1993–94	9,328	6,987	75
1994–95	6,742	5,902	88
1995–96	8,961	8,046	90
1996–97	6,650	5,050	76
1997–98	5,590	5,140	92
1998–99	6,730	5,820	86
1999–2000	7,714	6,939	90
2000–01	8,119	6,988	86
2001–02	6,964	6,129	88
2002–03	5,810	4,984	86
2003–04	5,817	4,968	85
2004–05	4,556	2,655	58
2005–06	4,749	2,112	44
2006–07	4,545	4,062	89
2007–08	4,997	3,367	67
2008–09	4,466	3,050	68
2009–10	4,263	5,311	125
2010–11	4,804	4,137	86

a Reporting year.

Notes:

The total area treated for regeneration in a reporting year is not equal to the total area harvested in the reporting year.

Areas not effectively regenerated are subject to subsequent remedial action: the total area treated for regeneration in a reporting year does not include areas of follow-up treatment.

There is a time lag of 2–5 years between regeneration treatment and assessment of the success of the regeneration. Consequently, the total area treated for regeneration, and the total area measured as effectively treated, in each reporting year are not measurements for the same area. Figures for total area effectively regenerated can include previously treated areas that were supplementary seeded or further treated and effectively regenerated from previous years. For this reason, the total area effectively regenerated can be higher than the total area treated for regeneration in any period.

Figures for the period 1999–2000 and 2000–01 are corrected from those reported in SOFR 2008.

Source: SOFR 2003, SOFR 2008, Victorian Department of Sustainability and Environment, VicForests.

Table 2.27: Area of multiple-use public native forest effectively regenerated, Western Australia, 2001–02 to 2010–11

Reporting year	Total area harvested and regenerated (hectares)	Proportion of harvested area effectively regenerated (%)[a]
2001–02	16,630	100.00
2002–03	13,950	100.00
2003–04	9,725	100.00
2004–05	9,610	99.94
2005–06	7,440	99.94
2006–07	9,670	99.98
2007–08	8,820	99.90
2008–09	7,640	100.00
2009–10	10,660	99.65
2010–11	6,140	–

– = not available

a Proportion of harvested area effectively regenerated, based on harvested areas where the silvicultural objectives of the silvicultural systems require regeneration establishment in the harvested area and follow-up assessment for effectiveness.

Notes:

Reported forest area harvested and regenerated is the gross harvested area and does not include jarrah forest cleared for mining.

Proportion of area effectively regenerated is the weighted average of regeneration success reported for karri and jarrah regeneration for that year; regeneration success can relate to areas harvested 18–30 months previously.

Source: CCWA (2012b), Western Australian Department of Environment and Conservation.

Native forest, Guy Fawkes River National Park, east of Armidale, New South Wales.

The standard was achieved from 1998–99 to 2010–11, with the majority of years having a proportion higher than 90% (Table 2.28).

The proportion of harvested private native forest area in Tasmania meeting required stocking rate standards during the period 2000–01 to 2002–03 averaged 89% and 95% for private independent and private industrial managers, respectively (FPA 2012).

Reporting of regeneration performance in private forests changed in 2003–04: after this, the Tasmanian Forest Practices Authority (FPA) applied a performance rating system to measure compliance with regeneration standards for public and private native forests and plantations. A compliance rating of 3.0 is considered the minimum acceptable level, and the maximum rating is 4.0. Table 2.29 presents the results on all management tenures from 2003–04 to 2010–11 for regeneration of native forest (results for plantations are presented later in this indicator). During this period, state forests averaged a rating of 3.6, with a minimum of 3.4, well above the acceptable minimum compliance level. Private industrial managers averaged 3.3, with one year at 2.6 being below the minimum acceptable compliance level. Private independent managers recorded two years that were below minimum acceptable compliance levels, and averaged a rating of 3.2. Tasmania is the only state or territory to report compliance with regeneration standards for harvesting of private native forests.

Single-tree selection silvicultural systems have been applied since 2000 to the harvest of wood products from multiple-use public native forests in Queensland. Because of the ecology of the relevant eucalypt and cypress forest types, regeneration is generally established continually and naturally from seed or lignotubers in the gaps produced by harvesting and associated soil disturbance, and/or post-harvest burning. Effective regeneration is monitored on harvested areas through the post-harvest audit process conducted by the Queensland Parks and Wildlife Service, and has been reported as being 100% since 2000–01.

Table 2.28: Area of regenerated multiple-use public native forest meeting stocking standards, Tasmania, 1998–99 to 2010–11

Reporting year	Regeneration year		Total area harvested and regenerated (hectares)	Total area that achieved standard (hectares)	Proportion of total area that achieved standard (%)
	Eucalypt clearfelling and partial logging	Rainforest/ blackwood swamp			
1998–99	1995–96	1993–94	4,006	3,815	95
1999–2000	1996–97	1994–95	5,466	5,184	95
2000–01	1997–98	1995–96	4,145	4,011	97
2001–02	1998–99	1996–97	4,808	4,568	95
2002–03	1999–2000	1997–98	4,148	3,837	93
2003–04	2000–01	1998–99	5,526	5,141	93
2004–05	2001–02	1999–2000	6,569	6,526	99
2005–06	2002–03	2000–01	7,226	6,942	96
2006–07	2003–04	2001–02	9,445	9,244	98
2007–08	2004–05	2002–03	10,207	10,010	98
2008–09	2005–06	2003–04	7,522	7,002	93
2009–10	2006–07	2004–05	6,882	6,220	90
2010–11	2007–08	2005–06	7,820	6,888	88

Source: FPA (2012).

Table 2.29: Annual assessment performance rating for regeneration in native forestry operations, Tasmania, 2003–04 to 2010–11

Reporting year	Private industrial	Private independent	State forest	All tenures
2003–04	3.3	4.0	3.5	3.4
2004–05	2.6	2.9	3.4	3.0
2005–06	3.3	3.5	3.8	3.6
2006–07	3.4	2.4	3.7	3.4
2007–08	3.4	3.0	3.8	3.5
2008–09	3.5	3.1	3.7	3.5
2009–10	3.4	3.0	3.5	3.3
2010–11	3.6	3.5	3.6	3.6
Average	**3.3**	**3.2**	**3.6**	**3.4**

Note: A rating of 3.0 is considered acceptable, and 4.0 is the maximum rating.
Source: FPA (2012).

Table 2.30: Percentage of regenerated multiple-use public native forest meeting the regeneration stocking standard or effectively regenerated

Reporting year	NSW	Qld	Tas.	Vic.	WA
1993–94	–	–	–	75	–
1994–95	–	–	95	88	–
1995–96	–	–	95	90	–
1996–97	–	–	95	76	–
1997–98	–	–	97	92	–
1998–99	–	–	95	86	–
1999–2000	98	–	95	90	–
2000–01	95	100	97	86	100
2001–02	68	100	95	88	100
2002–03	87	100	93	86	100
2003–04	86	100	93	85	100
2004–05	83	100	99	58	100
2005–06	74	100	96	44	100
2006–07	63	100	98	89	100
2007–08	94	100	98	67	100
2008–09	81	100	93	68	100
2009–10	95	100	90	125	100
2010–11	92	100	88	86	–
Average					
Before 1995–96	–	–	95.0	84.0	–
1996–97 to 2000–01	96.5	100.0	95.8	86.0	100.0
2001–02 to 2005–06	79.6	100.0	95.2	72.4	100.0
2006–07 to 2010–11	85.0	100.0	93.4	86.9	99.9

– = not available

Notes:

Averages are based on available records in the period, and do not include records marked '–'.

For Victoria, percentages can be greater than 100 (see notes for Table 2.26).

Source: SOFR 2003, SOFR 2008, data sources for Tables 2.25–2.28, Queensland state agencies.

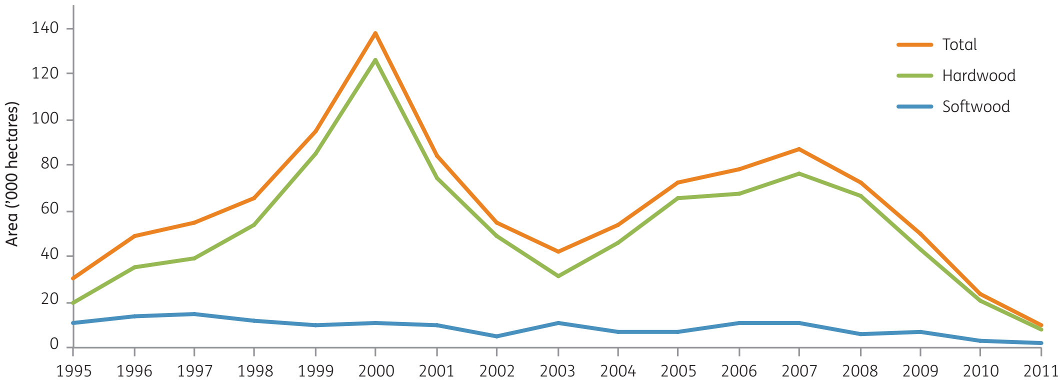
Table 2.30 compiles state data on effective regeneration where wood harvesting occurs in multiple-use public native forest. Western Australia and Queensland have experienced 100% effective regeneration since 2000, and Tasmania has averaged 93–96% effective regeneration for the four SOFR reporting periods. Victoria and New South Wales report much lower effective regeneration rates than the other three states. Factors contributing to low regeneration rates included drought, fire, poor seed reserves, and difficulties in carrying out regeneration burns or mechanical disturbance. Five-year averages of available data for the four reporting periods vary from 72% to 87% for multiple-use public native forest in Victoria, and 80% to 97% for multiple-use public native forest in New South Wales. In both states, in the years with low effective regeneration percentages, further treatment was applied to increase effective regeneration on harvested areas that did not meet required stocking standards.

Plantation establishment and re-establishment

The size of Australia's plantation estate continued to increase over the period 2006–11 as new plantations were established, almost all on already cleared agricultural land. However, the annual increase has declined since 2008 (Figure 2.40) due to a reduction in new plantation establishment (Gavran 2012). The size of Australia's plantation estate also depends on the extent to which existing plantations are re-established after clearfell harvesting at the end of a rotation. The decision to re-establish plantations, especially short-rotation hardwood plantations, depends on factors such as site suitability, previous yield, grower intent, market availability and alternative land uses.

Table 2.31 provides information on the planned subsequent land use of Tasmanian public and private plantations harvested since 1999–2000—either plantation re-establishment, re-establishment of native forest or conversion to non-forest land use. During the current SOFR reporting period, an annual average of 8,176 hectares of plantation was clearfelled and re-established to plantation, and 378 hectares was clearfelled and converted to non-forest

Figure 2.40: New plantation establishment, Australia



Source: Gavran (2012).

use; these average rates are higher than in the previous reporting periods (Table 2.31). Streamside reserves that had been established with plantation species before the introduction of the Tasmanian code of forest practice in 1987 have been progressively reforested with native species.

Conditions in Tasmania for plantation establishment were generally favourable over the SOFR reporting period. Forestry Tasmania reports annually on the level of restocking achieved for all plantation establishment operations on state forest. Stocking standards specify the minimum levels of growing stock to maintain a forest, and stocking success of plantations is reported two years after planting operations. The proportion of plantation establishment area meeting prescribed stocking standards varied between 97% and 100% (Table 2.32).

Table 2.33 reports the performance assessment for re-establishment of public and private plantations in Tasmania, based on the Tasmanian Forest Practices Authority's performance rating system. Private industrial and state forests rated highly, with all years being above the minimum standard of 3.0, and averaging 3.6 or 3.8 for private industrial and state forests, respectively. Private independent plantations rated lower, with an average of 3.3 and a range of 2.3–4.0.

Other state agencies and most private growers have internal management systems to assess plantation restocking or re-establishment levels and prescribe remedial treatment. Where plantations are re-established, the level of stocking is usually high, between 95% and 100%. Table 2.34 reports the re-establishment success of public softwood plantations in Western Australia from 2004 to 2010.

Tables 2.35 and 2.36 report the success of plantation establishment and re-establishment in South Australia and New South Wales. The rate of effective establishment or re-establishment of public softwood plantations in South Australia (Table 2.35) decreased from an average of 98% in the period 2001–02 to 2001–06 to 86% in the period 2006–07 to 2010–11. Results for establishing and re-establishing public plantations in New South Wales varied widely for both softwood and hardwood plantations (Table 2.36). Supplementary planting was used to reach adequate stocking levels in years when establishment rates were below prescribed levels.

Second-rotation radiata pine (*Pinus radiata*) plantation, southern New South Wales.

Table 2.31: Planned subsequent land use of harvested plantation forest (public and private), Tasmania, 1999–2000 to 2010–11

Reporting year	Plantation clearfelling followed by: Plantation re-establishment (hectares)	Conversion to non-forest use[a] (hectares)	Native forest re-establishment[b] (hectares)	Total (hectares)
1999–2000	3,600	50	0	3,650
2000–01	5,230	90	0	5,320
2001–02	5,350	360	0	5,710
2002–03	7,740	130	0	7,870
2003–04	8,250	420	0	8,670
2004–05	6,550	220	0	6,770
2005–06	7,590	510	0	8,100
2006–07	9,450	260	0	9,710
2007–08	9,760	610	0	10,370
2008–09	7,360	400	110	7,870
2009–10	7,940	280	240	8,460
2010–11	6,370	340	120	6,830
Average				
1999–2000 to 2000–01	4,415	70	0	4,485
2001–02 to 2005–06	7,096	328	0	7,424
2006–07 to 2010–11	8,176	378	94	8,648

[a] Conversion of harvested plantation forest to non-forest land use primarily applies to private plantations. It is minor in state forest and restricted to infrastructure requirements (roads, powerlines and dams)—these areas are not reported.

[b] Largely native streamside reserves re-established in pine plantations established before the Forest Practices Code 2000.

Source: FPA (2012).

Table 2.32: Proportion of plantation establishment meeting stocking standards on state forest lands, Tasmania, 2006–10

Reporting year	Plantation establishment year	Total area treated (hectares)	Area achieving standard (hectares)	Proportion of total area achieving standard (%)[a]
2006	2004	1,890	1,835	97
2007	2005	1,677	1,659	100
2008	2006	1,769	1,760	100
2009	2007	3,610	3,599	98
2010	2008	2,901	2,884	99

[a] Published figures taken directly from the State of the forest Tasmania 2012 (FPA 2012).

Source: FPA (2012).

Table 2.33: Annual assessment performance rating for re-establishment in plantation operations, Tasmania, 2003–04 to 2010–11

Reporting year	Private industrial	Private independent	State forest	Total of all tenures
2003–04	4.0	4.0	3.9	4.0
2004–05	3.3	3.6	3.1	3.3
2005–06	3.9	4.0	3.6	3.8
2006–07	3.8	2.5	3.8	3.7
2007–08	3.6	4.0	3.8	3.7
2008–09	3.3	3.3	4.0	3.4
2009–10	3.4	3.0	3.9	3.4
2010–11	3.5	2.3	4.0	3.4
Average	**3.6**	**3.3**	**3.8**	**3.6**

Note: A rating of 3.0 is considered acceptable, and 4.0 is the maximum rating.

Source: FPA (2012).

Table 2.34: Annual area of public softwood plantation re-established, and area achieving stocking density standards specified in the silviculture guidelines, Western Australia

Year	Area regenerated in previous year (hectares)	Area surveyed (hectares)	Area understocked (hectares)	Proportion of area requiring remedial treatment (%)	Proportion of area that met standard (%)
2004	1,418	1,418	105	7.4	93
2005	1,456	1,456	143	9.8	90
2006	1,433	1,433	45	3.1	97
2007	1,512	1,512	52	3.4	97
2008	1,627	1,627	24	1.5	99
2009	2,106	2,106	95	4.5	95
2010	570	570	28	5.0	95

Source: CCWA (2012b).

Table 2.35: Public softwood plantation establishment and re-establishment, South Australia, 2001–02 to 2010–11

Year	Total area treated (hectares)	Total area effectively planted or replanted (hectares)	Proportion effectively planted or replanted (%)
2001–02	2,603	2,603	100
2002–03	2,267	2,225	98
2003–04	2,470	2,468	100
2004–05	2,521	2,517	100
2005–06	2,600	2,367	91
2006–07	3,033	2,440	80
2007–08	4,159	3,535	85
2008–09	3,307	2,910	88
2009–10	3,287	2,827	86
2010–11	2,762	2,541	92
Average			
2001–02 to 2005–06	2,492	2,436	98
2006–07 to 2010–11	3,310	2,851	86

Note: Figures include new and re-established softwood plantations, and include plantations located in Victoria managed by ForestrySA.

Source: SAFC (2007, 2009, 2011), SOFR 2008.

Table 2.36: Public softwood and hardwood plantation planting, New South Wales, 1998 to 2011

Year	Planted area (hectares)		Proportion successfully established (%)	
	Softwood plantation	Hardwood plantation	Softwood plantation	Hardwood plantation
1998	5,750	7,800	97	94
1999	4,950	5,500	98	100
2000	3,867	3,392	96	95
2001	5,951	2,005	95	97
2002	5,500	1,680	81	97
2003	6,506	1,529	80	78
2004	6,764	1,164	93	100
2005	6,547	267	94	100
2006	7,260	889	37	n.r.
2007	6,037	462	74	n.r.
2008	9,874	945	74	n.r.
2009	10,581	1,979	71	13
2010	9,942	1,104	78	91
2011	8,969	592	88	70

n.r. = not reported

Note: Planted area includes both new plantation establishment and plantation re-establishment. Establishment is measured one year after planting; the rate applies to the planted area in the previous year. Successful establishment is attained where 80% of softwood seedlings and 90% of hardwood seedlings survive. Follow-up replanting occurs as required to fully stock the planted site. In the case of the low 2009 hardwood establishment rate, much of the plantation estate was just below the 90% guideline threshold and only required a low level of supplementary planting to adequately stock the planted area. Data to 2006 are regional compilations; data after 2006 are revised corporate data.

Source: Forests NSW (2004, 2005, 2006, 2012a), State Forests of New South Wales (2001, 2002, 2003).

Criterion 3

Maintenance of ecosystem health and vitality

Regeneration after a bushfire. iStockphoto

Myrtle rust (*Puccinia psidii* s.l.) on fruit of *Rhodamnia sessiliflora*, Queensland.

Criterion 3
Maintenance of ecosystem health and vitality

Sustainable forest management aims to maintain the productive capacity of native forests and plantations to provide the goods and services required by society while maintaining ecosystem health and vitality.

This criterion contains two indicators. The first considers the scale and impact of agents and processes affecting forest health and vitality, mainly pests and diseases, but also other environmental factors such as drought and extreme weather events. The second indicator considers the impacts of forest fire, and presents data on the area of forest burnt by planned and unplanned fires.

Forest health

Forest health and vitality are affected by vertebrate browsers, invertebrates (mainly insects), pathogens and weeds, but also by other potentially damaging processes such as drought, river regulation, soil changes, extreme climatic events, and climate change. Australia's forests are adapted to many of these disturbances, and impacts are generally followed by periods of recovery.

Many pests and diseases, particularly native ones, exhibit cyclical patterns of impact on native forests, and are generally of minor overall concern. Active management of agents affecting forest health is directed mainly at the protection of commercial values in multiple-use public and private native forests and plantations, and the protection of biodiversity and other forest values in all forests. In most states and territories, forest health surveillance is carried out regularly, to detect and identify the extent and severity of problems. Forest health surveillance is mainly undertaken in plantations, with the aim of detecting disease, insect and vertebrate pests, weeds, and nutrient deficiencies, and monitoring the impacts of these on tree survival and growth.

Vertebrate animals, both native and exotic, can damage forests by browsing and ring-barking vegetation, contributing to soil erosion, competing for food and habitat, and killing native fauna. Insect pests in Australian forests include defoliating leaf beetle and moth larvae, psyllids, aphids, sawflies, weevils, bark beetles, wood wasps and wood borers. The exotic root-rotting pathogen *Phytophthora cinnamomi* and related species, which occur in all states and territories, kill a wide range of plant species, and a range of fungal leaf pathogens can have significant impacts on hardwood and softwood plantations. Weeds compete with native forest flora and can become locally dominant, reducing biodiversity and other values. Weeds can also affect tree establishment, growth and product yield in commercial forest plantations, and reduce the ease of human access.

A wide range of persistent or intermittent crown dieback syndromes occurs to some degree in native forests in all states and territories, often resulting in significant tree mortality and associated ecosystem impacts. These syndromes are usually caused by combinations of factors such as climatic stresses, poor land management practices, severe insect attacks, and an imbalance in insect predator levels; ameliorating their impacts through forest management can be difficult.

Other factors that can affect forest health include river regulation, dryland salinity, soil acidification and drought. Drought, in particular, can cause production losses in plantations, including by increasing the susceptibility of trees to disease and pests.

Fire

Fire is a major component of the ecology of most Australian forests. Eucalypt forests, in particular, accumulate large amounts of flammable fuel, and the various types of eucalypt forest burn naturally with a characteristic seasonality, frequency and intensity (known collectively as the 'fire regime'), followed by regeneration and regrowth. Flora and fauna species have a range of adaptations for surviving fire, and the absence of fire or changed fire regimes are threats to many ecosystems and specifically to forest health. However, wildfire can be very dangerous to life and property, especially in south-west and eastern Australia, where the combination of climate and vegetation is particularly conducive to producing catastrophic fire conditions.

Fire is also an important forest management tool in Australia. Planned fire of the appropriate intensity is used in fire-adapted forest types to reduce fuel loads and increase the ability to manage subsequent unplanned wildfire, to promote forest regeneration after wood harvesting, to promote the health of forest stands, and for biodiversity management. Forest fires, both planned and unplanned, burn annually across large areas of the woodland forests of northern Australia.

Understanding the role of climate change and climate variability is important for management of planned and unplanned fires. Projected climate change may exacerbate the risk of unplanned fire, and reduce the opportunity for safe use of planned fire.

Banksia seed pod open after a fire event, Scamander, Tasmania.

Key findings

Key findings are a condensed version of the Key points presented at the start of individual indicators in this criterion.

Forest health

- In general, native insect pests and pathogens caused only low-severity damage to forest ecosystems over the reporting period. Most of the observed damage to forests was caused by exotic pests and pathogens that have become established in Australia. Occasional outbreaks caused damage that adversely affected commercial values, particularly in plantations.
- Quambalaria shoot blight caused damage in spotted gum plantations in Queensland, and fungal leaf pathogens caused occasional significant defoliation in plantations in Tasmania, Victoria, Queensland and Western Australia. Teratosphaeria (Kirramyces) leaf spot emerged as a major problem for eucalypt plantation establishment in the central-coast region of Queensland. Spotted gum canker became a health issue for *Corymbia* species in New South Wales. Spring needle cast remained one of the major problems affecting the radiata pine plantation estate, and Dothistroma needle blight had an impact on radiata pine plantations in Victoria and New South Wales.
- *Phytophthora cinnamomi* and a number of other *Phytophthora* species remained a threat to a wide range of plant species, predominantly in regions with an average annual rainfall of more than 600 millimetres. Spread of this pathogen is controlled with soil and water hygiene protocols, monitoring of quarries used in road-building, intensive monitoring to designate disease risk areas, and the use of management zones to protect threatened flora.
- Myrtle rust (*Puccinia psidii*[78]), a strain of guava or eucalypt rust, established and spread in New South Wales, Queensland and Victoria. Rust spores can be spread by the wind, and myrtle rust has a wide host range within the Myrtaceae family, but the likely impact of myrtle rust on Australia's forests is still unclear.
- A number of tropical cyclones caused significant damage to native forests and plantations in Queensland during the reporting period, including cyclone Larry in March 2006, cyclone Ului in March 2010, and cyclone Yasi in February 2011. Cyclone Yasi was the largest and most powerful on the eastern coast of Australia since 1918, and the extensive cyclone damage impacted industry confidence in the viability of future forest plantations in coastal regions of Queensland.
- Native and plantation forests affected by drought, fire and cyclones were colonised by pests such as bark beetles and ambrosia beetles during the reporting period. The pine-killing Sirex wood wasp remained a significant issue, although it had only localised adverse impacts. Sirex was detected for the first time in Queensland in this reporting period.

[78] *Puccinia psidii* s.l., previously referred to by the name *Uredo rangelii*.

CRITERION 3

- Drought affected large areas of the south-eastern states of Australia during much of the early part of the reporting period, and large areas of Western Australia for most of the reporting period, with significant impacts on forest health. Projected drier and warmer conditions in the rest of this century and beyond could make forests more susceptible to some pests and diseases.
- The Australian plantation industry is a significant user of biological control agents. Chemical pest and disease control methods used in plantations are highly regulated, and the Australian plantation forestry sector has been estimated to spend less than 1% of the total Australian spending on pesticides.

Fire

- An estimated 39.0 million hectares of forest was burnt by fire in Australia in the period 2006–07 to 2010–11. This estimate combines data derived from MODIS satellite imagery for northern Australia, with data provided by states and territories for southern Australia, and includes some areas of northern Australia that were burnt more than once during this period. A total of 77% of the forest area burnt was in the Northern Territory and Queensland. The reported forest area burnt increased by 14.3 million hectares compared with 2001–02 to 2005–06, with the increase mostly in the Northern Territory and Queensland.
- From 2006–07 to 2010–11, unplanned fires (wildfire) burnt an estimated 31.6 million hectares (81% of total forest burnt), and planned fires burnt an estimated 7.4 million hectares of forest (19% of total forest burnt).
- In southern Australia, all states and the ACT experienced serious bushfires over the reporting period. The most extensive bushfire activity was in Victoria, especially areas near Melbourne, with the Black Saturday bushfire of 2009 being exceptionally serious.
- Projected climate change could exacerbate the risk and impact of unplanned fire, and reduce the seasonal time 'window' in which planned fires can be used for management, especially in southern Australia. National fire research priorities are identified in the *National Bushfire Management Policy Statement for Forests and Rangelands*.

A planned fuel reduction burn in native production forest in Victoria.

Indicator 3.1a

Scale and impact of agents and processes affecting forest health and vitality

Rationale

This indicator identifies the scale and impact on forest health of a variety of processes and agents, both natural and human-induced. Through the regular collection of this information, significant changes to the health and vitality of forest ecosystems can be monitored and measured.

Key points

- Damage to forest ecosystems from most native insect pests and pathogens over the reporting period has usually been of low severity but sometimes widespread in extent. Most of the observed damage to forests was caused by exotic pests and pathogens that have become established in Australia. Occasional outbreaks and epidemics occurred over the reporting period, with the resultant damage adversely affecting commercial values, particularly in plantations.
- Quambalaria shoot blight caused damage in spotted gum plantations in Queensland, while fungal leaf pathogens caused occasional significant defoliation in hardwood plantations in Tasmania, Victoria, Queensland and Western Australia. Teratosphaeria (Kirramyces) leaf spot emerged as a major problem for eucalypt plantation establishment in the central coast region of Queensland. Spotted gum canker became a health issue for *Corymbia* species in New South Wales. Spring needle cast remained one of the major problems affecting the radiata pine plantation estate, while Dothistroma needle blight affected radiata pine plantations in Victoria and New South Wales.
- *Phytophthora cinnamomi* and a number of other *Phytophthora* species remained a threat to a wide range of plant species, predominantly in regions with an annual rainfall of more than 600 millimetres. Spread of the pathogen is controlled with soil and water hygiene protocols, monitoring of quarries for Phytophthora, intensive monitoring to designate disease-risk areas, and the use of management zones to protect threatened flora.
- Myrtle rust (*Puccinia psidii*[79]), a strain of guava rust or eucalypt rust, has entered, established and spread in New South Wales, Queensland and Victoria. Myrtle rust, which was initially detected in nurseries, is spreading rapidly to new areas, including bushland. The rust spores are predominantly disseminated by wind, and the pathogen has a wide host range within the Myrtaceae.
- Drought affected large areas of the south-eastern states of Australia during much of the early part of the reporting period, and large areas of Western Australia for most of the reporting period, with significant impacts on forest health. Drought also contributed to a series of intense wildfires that affected large areas of forest in south-eastern and western parts of Australia.
- A number of tropical cyclones caused significant damage to native forests and plantations in Queensland during the reporting period, including cyclone Larry in March 2006, cyclone Ului in March 2010, and cyclone Yasi in February 2011. Cyclone Yasi was the largest and most powerful on the eastern coast of Australia since 1918, and the extensive cyclone damage impacted industry confidence in the viability of future forest plantations in coastal regions of Queensland.
- Native and plantation trees that were stressed, dead or dying as a result of drought, fire and cyclones were colonised in increasing numbers by pests such as bark beetle (*Ips grandicollis*) and a range of ambrosia beetles. The pine-killing Sirex wood wasp (*Sirex noctilio*) remained a significant issue in *Pinus radiata* plantations, although it had only localised adverse impacts. Sirex was detected for the first time in Queensland in this reporting period. The death of bait trees caused by the combination of drought and bark beetle attacks caused concerns about the effectiveness of biological control agents in controlling Sirex wood wasp.
- The Australian plantation industry is a significant user of biological control agents, such as several species of parasitoid wasps, for control of insect pests. Chemical pest and disease control methods used in plantations are highly regulated, and the Australian plantation forestry sector has been estimated to spend less than 1% of the total Australian spending on pesticides.

[79] *Puccinia psidii* sensu lato, previously referred to by the name *Uredo rangelii*.

This indicator addresses the factors affecting the health and vitality of Australia's native forests and plantations. It focuses on the impacts of vertebrates, invertebrates, pathogens and weeds on forest health, but also covers other potentially damaging processes, such as drought, river regulation, soil changes, extreme climatic events and climate change. The active management of these agents in forests is directed mainly towards protecting commercial values in multiple-use public and private native and planted forests, and biodiversity and other forest values in all forests. It is important to note that many pests and diseases, particularly native ones, show cyclical patterns of impact and are generally of minor concern.

Some key quarantine pests[80] and pathogens of concern for Australian forests are not currently present in Australia (Plant Health Australia 2007), and so are not covered in this indicator. These include burning moth (*Hylesia nigricans*), gypsy moth complex (*Lymantria dispa*r), mountain pine beetle (*Dendroctonus ponderosae*), nun moth (*Lymantria monacha*), pine sawyer beetles (*Monochamus* spp.), pine shoot beetle (*Tomicus piniperda*), red turpentine beetle (*Dendroctonus valens*), subterranean termite (*Coptotermes* spp.), white-spotted tussock moth (*Orgyia thyellina*), pinewood nematode (*Bursaphelenchus xylophilus*), daño foliar del pino (*Phytophthora pinifolia*), eucalyptus cankers (*Chrysoporthe austroafricana*, *Teratosphaeria zululensis* and *T. gauchensis*), other strains of guava rust or eucalypt rust (*Puccinia psidii*), sudden oak death (*Phytophthora ramorum*), pine pitch canker (*Fusarium circinatum*), and western gall rust (*Endocronartium harknessii*). Australia's biosecurity measures aim to minimise the risk of introduction, establishment and spread of new exotic pests and pathogens, and to eradicate or manage incursions of introduced organisms.

The wide range of pests already present in Australia, including vertebrates, invertebrates (mainly insects), pathogens and weeds, that may affect forest health and vitality were described in SOFR 2008 in some detail, as were many other threatening processes. SOFR 2013 provides an update on the status of threats to forest health and vitality, and key events and trends over the period 2006–11.

Like most agricultural enterprises, plantation forestry uses pesticides for forest protection and to improve production. The Australian Pesticides and Veterinary Medicines Authority controls pesticide registration in a consistent manner across forestry and agriculture. Forestry relies mainly on pesticides developed for agricultural crops because the plantation forestry industry is too small to warrant the cost of specialised pesticide development and registration. The Australian plantation forestry sector was estimated to spend less than 1% of the total Australian spending on pesticides (Jenkins and Tomkins 2006).

Forest health surveillance systems in Australia were described in SOFR 2008. Further information on forest health surveillance in the states and territories was published in a series of papers in special issues of *Australian Forestry* (Carnegie 2008) and for Western Australia's Forestcheck program (McCaw et al. 2011). Most states and territories conduct annual surveys of forest plantations, but only limited surveys, or none, are conducted in native forests. In Victoria, ground-based plots for monitoring plantation forest health were established in 2001, and formalised aerial health surveillance of plantations was carried out for the first time in 2010–11. The Australian Capital Territory continued to monitor plantation forest health through aerial and on-ground observations; no significant health impacts were recorded over the monitoring period.

Vertebrate pests

Native and introduced vertebrate animals can damage native forests and plantations—for example, by browsing vegetation, by ring-barking saplings and trees, and by undermining, excavating and chewing root systems. These activities can contribute to soil erosion, increase competition for food and habitat. Introduced animals can also kill native fauna, and can act as vectors for pathogens.

Threat abatement plans have been developed for some vertebrate pest animals, such as rabbits, foxes, cats, pigs and goats. The plans address these species, which are listed as key threatening processes to nationally threatened species and endangered ecological communities.[81]

Native vertebrate species

Kangaroos, wallabies and possums continued to have an adverse impact in multiple-use public forests in most states and territories, particularly by grazing on seedlings in the early stages of forest regeneration and planting. In Tasmania, bark stripping by wallabies in 3 to 6-year-old pine plantations increased in this reporting period and remains a widespread problem. Possums continued to cause localised top death in mid- to late-rotation pine plantations (especially near Bombala in southern New South Wales), affecting tree form. Localised bark stripping and branch breakage caused by possums were also seen in a limited number of young shining gum (*Eucalyptus nitens*) plantations. Local populations of *E. gunnii* and *E. gunnii* subsp. *divaricata* in Tasmania experienced severe dieback and mortality following heavy possum browsing and drought episodes during the early 2000s. Remedial treatment involving caging and fencing of sites that have sufficient regeneration has generally given good results. In Victoria, significant damage by koalas was recorded in restricted areas of nature conservation reserves. In Queensland, the pale field rat (*Rattus tunneyi* var. *culmorum*) caused damage to young *Araucaria cunninghamii* (hoop pine) plantations, through excavating around root systems, and girdling of roots and stems.

80 A quarantine pest, as defined by the International Plant Protection Convention of the Food and Agriculture Organization of the United Nations, is a pest of potential economic importance to the area it endangers and not yet present there, or present but not widely distributed and being officially controlled. A pest is any species, strain or biotype of plant, animal or pathogenic agent that is injurious to plants or plant products.

81 www.environment.gov.au/biodiversity/threatened/tap-approved.html and www.nrm.gov.au/funding/previous/business-plan/12-13/priorities/biodiversity/vertebrate-pest.html.

Common brushtail possum (*Trichosurus vulpecula*).

In Western Australia, Australian Ringnecks (*Barnardius zonarius semitorquatus*, locally known as Port Lincoln parrots or Twenty-eights) continued to cause localised damage to seedlings and blue-gum (*Eucalyptus globulus*) plantations. Bark was peeled off young trees, and tops were snapped, leading to poor form or death. As a result of drought and lack of feed, the parrots were found in large numbers in blue-gum plantations in areas north of Mount Barker and west to Busselton, with 3200 hectares of plantations showing sign of moderate to severe damage in 2010–11. Bell miner–associated dieback continued to be observed in some plantations and native forests in New South Wales, especially on *E. grandis*, *E. dunnii* and *E. saligna*.

Exotic vertebrate species

Some introduced species, such as rabbits, foxes, pigs, deer and cats, continued to cause major damage in forests and to the environment generally (Hart and Bomford 2006). Examples are given below.

Rabbit numbers increased in Australia over the reporting period as resistance to rabbit haemorrhagic disease (rabbit calicivirus, introduced in 1995) developed, and as successive wet seasons increased feed. Rabbits caused significant issues in South Australia and Victoria.

Foxes had a high adverse impact in forests in all mainland states and territories except the Northern Territory, and cats were also a significant problem in many jurisdictions. Deer populations continued to increase in South Australia and Victoria. Pigs continued to have an adverse impact in some forest areas in south-west Western Australia.

Cane toads continued to be a problem in Queensland, and moved westwards across the Northern Territory and entered north-eastern Western Australia during 2008–09. Cane toads also moved southwards into northern New South Wales.

Invertebrate pests

A range of invertebrate (mainly insect) pests were recorded in Australian plantations and native forests.

Insect pests affecting hardwood plantations

Species of the chrysomelid leaf beetles *Paropsis* and *Paropsisterna* (formerly *Chrysophtharta*) continued to cause damage in eucalypt forests and plantations Australia-wide. The most destructive chrysomelid species was *Paropsisterna cloelia* on *E. dunnii* plantations in south-east Queensland. In subtropical areas of Queensland, *Paropsis atomaria* remained a major insect pest risk, while in Tasmania *Paropsisterna* spp. continued to cause significant damage to eucalypt plantations and required an ongoing, extensive integrated pest management program. In Western Australia, the distribution of *Paropsisterna m-fuscum* expanded westward.

Autumn gum moths (*Mnesampela privata*) were present in most states and territories and caused widespread damage to juvenile or young adult eucalypt foliage: young larvae skeletonised the leaf, and older larvae ate the whole leaf, rapidly defoliating trees. Populations of autumn gum moths, although widespread throughout Tasmania, were rarely high enough to cause significant defoliation. Damage by the gumleaf skeletoniser (*Uraba lugens*) in eucalypt plantations in Tasmania was usually restricted to edge trees.

Shothole miner (*Perthida* spp.) caused increasing damage in blue-gum plantations across the whole of the Green Triangle region in South Australia, and was identified in Victoria as far east as Ballarat. The psyllid *Creiis lituratus* was a threat to young *E. dunnii* plantations in northern New South Wales, causing significant damage in both young (1 to 2-year-old) and older (5 to 8-year-old) stands in 2007. Tent leafhopper (*Kahaono* spp.) was an emerging problem for *Corymbia* hybrids in the South Burnett region of Queensland, although it is not expected to have a significant effect on tree growth rates. Sawflies and weevils continued to cause damage in some areas in South Australia, with the eucalypt weevil (*Gonipterus scutellatus*) causing significant localised damage in 2010–11 in some young eucalypt plantations. Steel-blue sawfly (*Perga* spp.) caused some damage to plantation and native forest in the western and Gippsland regions of Victoria, and the psyllid *Cardiaspina squamula* caused moderate defoliation of roadside *E. dalrympleana* in the upper Derwent Valley in Tasmania during the summer of 2010.

Insect pests affecting softwood plantations

The pine-killing Sirex wood wasp (*Sirex noctilio*) remained a significant issue in *Pinus radiata* plantations. Although Sirex was widespread in distribution across most planted areas, it had only localised adverse impacts, with its impact being minimised through biological control agents. Sirex usually attacked stressed trees, and numbers high enough to cause significant tree mortality generally did not occur in vigorous, healthy stands. In the past, however, serious Sirex outbreaks have killed several million trees in *P. radiata* plantations in several states (SOFR 2008). The National Sirex Control Strategy encourages an integrated pest management approach that aims to keep Sirex populations low by the release of virulent strains of the nematode *Beddingia siricidicola*, as well as a range of parasitoid wasps, as biological controls, and by encouraging optimal plantation thinning practices and site selection to minimise the occurrence of stressed trees in areas at risk.

In New South Wales, several plantations in the Murray Valley region suffered sustained Sirex attacks from 2006 onwards, with up to 500 hectares affected, mainly in unthinned stands. In Victoria, small areas in the north-east of the state had higher than acceptable levels of Sirex damage in 2010. These areas were scheduled for early thinning, and inoculation with nematode (Kamona strain) in areas not yet thinned. In this reporting period, Sirex was found for the first time in Queensland in 2009, and the increasing number of Sirex detections in *Pinus radiata* and *P. taeda* plantations in the southern border region of Queensland is a major health concern for pine plantations in that state. Western Australia remains free from Sirex, and annual surveillance trapping occurs in the flight season across the pine estate. The Australian Capital Territory continued to monitor Sirex levels, and to introduce biological control nematodes into bait or trap trees.

Monterey pine aphid (*Essigella californica*) was widespread and caused significant damage in most *P. radiata* plantation areas in New South Wales. Mid-rotation to preharvest plantations were the most severely affected, and plantations in the Murray Valley and Central Tablelands were the most severely impacted. The area affected by the aphids decreased over the reporting period, with 47%, 32%, 21% and 9% of the New South Wales estate affected in 2007, 2008, 2009 and 2010, respectively. New South Wales, like all other eastern states, now uses a biological control program to manage Monterey pine aphid, with the parasitoid wasp *Diaeretus essigellae* being released into plantations over the past couple of years.

In South Australia, Monterey pine aphid remained a particular focus for control as higher numbers caused increased defoliation, including widespread significant damage in the Green Triangle region. Older plantations were most affected. In Victoria, Monterey pine aphid remained a concern for radiata pine plantations. In Tasmania, significant defoliation caused by Monterey pine aphid was restricted to localised areas in the Plenty Valley between 2006 and 2008. Monterey pine aphid was widespread in Western Australia, but numbers were consistently low and no damage to plantations was attributed to this pest.

The five-spined bark beetle (*Ips grandicollis*) has been present in Australia for at least 60 years. It occurs in all mainland states and the Australian Capital Territory, and is able to infest all plantation pine species grown in Australia (SOFR 2008). Population levels build primarily on fresh logging debris or in standing trees that are damaged (e.g. after fire) or severely stressed (e.g. after drought). High beetle numbers, particularly in trees in overstocked stands during periods of drought, can result in tree death. The beetle also acts as a vector for blue-stain fungi such as *Ophiostoma ips*. The parasitoids *Roptrocerus xylophagorum* and *Dendrosoter sulcatus* were introduced into Australia in the 1980s to limit numbers of the five-spined bark beetle.

In New South Wales, a significant and sustained outbreak of bark beetles in 2007 was associated with widespread tree mortality linked to drought; more than 17 thousand hectares were affected. Management included developing drought-risk maps (using historical forest health data and environmental and silvicultural data to develop drought-risk models) and site-specific silviculture (e.g. thinning regimes). In South Australia, *I. grandicollis* caused damage in mid-north pine plantations, as drought and high slash residue levels after clear-felling near young plantations led to build-up of the pest. In 2007, bark beetles caused death of trees (including healthy trees) in several plantations in the south-east of South Australia and significant deaths in some older plantations near Mount Gambier. *I. grandicollis* was not observed as a significant pest in Victoria—only two small localised areas in north-east and south-west Victoria were affected.

In south-east Queensland, *I. grandicollis* infected drought-affected and fire-scorched trees in coastal southern pine plantations, although rapid subsequent harvesting circumvented most production losses. Ambrosia beetles were commonly associated with delayed harvesting of felled and damaged timber, and at times defoliated adjacent *Araucaria* plantations and *Araucaria* in retained native vegetation, although the majority of defoliated trees recovered. In north Queensland, populations of the pin-hole borer (*Truncaudum agnatum*) expanded following damage to Caribbean pine (*Pinus caribaea* var. *hondurensis*) plantations by tropical cyclone Yasi in February 2011. Visual pin-hole damage and associated fungal staining caused by these and other beetles reduced recovered log values. Cacao armyworm (*Tiracola plagiata*) caterpillar defoliated large areas of young plantation *Araucaria* in south-east Queensland in 2010. Control was possible with aerial application of insecticide, as well as natural control through the parasitoid wasp *Lissopimpla excelsa*.

Larvae of Australian sawfly (*Perga sp.*).

The European house borer (*Hylotrupes bajulus*) was first detected in Western Australia in 2004 (SOFR 2008). This insect is a destructive pest of seasoned coniferous timber, including pine and oregon, and can cause major structural damage to buildings. Measures being taken to contain European house borer included regulations to control movement of seasoned pine, surveys to detect new infestations, better detection methods, removal and destruction of infested materials, and a communication program for the public and the building industry. Eradication activities for European house borer transitioned to ongoing management in 2011.

An outbreak of the native geometrid moth (*Chlenias* sp., 'pine looper') in 2009–10 completely defoliated more than 100 hectares of mature pine plantations in Tasmania at Pittwater, north-east of Hobart.

Insect pests affecting native forests

The gumleaf skeletoniser (*Uraba lugens*) causes widespread and severe defoliation of natural eucalypt stands across a range of climatic and vegetation types, but generally few trees die. Regional outbreaks tend to occur on a 5–10-year cycle (SOFR 2008). An outbreak of gumleaf skeletoniser occurred in southern Western Australia in 2009–11, causing moderate to severe temporary defoliation on extensive areas of forest. Outbreaks also occurred in Tasmania, Queensland and Victoria.

In Tasmania, several hundred hectares of peppermint forest (*Eucalyptus amygdalina*, *E. tenuiramis* and *E. pulchella*) near Hobart suffered near-complete defoliation by the cup moth (*Doratifera oxleyi*) in autumn 2010. The psyllid *Cardiaspina squamula* caused moderate defoliation of roadside *E. dalrympleana* in the upper Derwent Valley during the summer of 2010. In Victoria, significant cup moth defoliation was observed across the southern areas of the state, primarily in east Gippsland and the Otway Ranges. Damage (including dieback and tree mortality in severe cases) from *Cardiaspina psyllids* was widespread in remnant bushland areas and native forests in northern New South Wales and western Sydney. In Western Australia, bark and wood-boring beetles colonised more than 80% of jarrah and marri trees within selected sample plots of drought-affected forests in the Northern Jarrah Forest in the reporting period. Other important insect pests of native eucalypts included shothole miner (*Pertha* spp.) and spurlegged phasmatid or stick insect (*Didymuria violescens*). In the Australian Capital Territory, European wasp (*Vespula germanica*) was widespread and sometimes locally abundant in the forests of Namadgi National Park and Tidbinbilla Nature Reserve.

Pathogens

With the exception of the exotic soilborne and waterborne root-rotting pathogen *Phytophthora cinnamomi*, the pathogens significantly affecting native forests and plantations of native tree species continued to be indigenous plant pathogens.

Pathogens affecting hardwood plantations

Quambalaria shoot blight (*Quambalaria pitereka*) continued to cause major damage in spotted gum (*Corymbia citriodora* subsp. *variegata*) plantations in Queensland, and limits expansion of *Corymbia* plantations. Selection for resistance, supported by industry funding, has begun in Queensland.

The fungal leaf pathogens *Teratosphaeria* spp. (formerly *Mycosphaerella* spp.) can occasionally cause severe defoliation and shoot death in eucalypt plantations when moist, humid conditions coincide with periods of active growth. *E. globulus* plantations in the juvenile foliage phase are particularly susceptible to *Teratosphaeria nubilosa*, and planting of this species in high-risk areas, such as northern Tasmania, was discontinued in the early 2000s. Research has since shown that young *E. globulus* plantations can quickly recover growth after severe epidemics; in addition, resistance in *E. globulus* is under moderate genetic control, and heritability is stable across sites.

Conditions for epidemic leaf disease (unusually high regional summer and autumn rainfall) were widespread across northern and eastern Tasmania during the 2009–10 and 2010–11 seasons, and 2000 hectares of predominantly *E. nitens* plantations in these regions suffered defoliation at levels likely to cause significant growth reductions. Mycosphaerella leaf spot and target leaf spot (*Aulographina eucalypti*) also caused localised damage across Victoria. In Western Australia, *E. globulus* plantations in the Denbarker and Mount Barker areas were most affected by *Teratosphaeria* spp. Most damaging of the *Mycosphaerella* species was *M. heimii* (previously unknown in Australia) on *E. dunnii* plantations in south-east Queensland.

Teratosphaeria or Kirramyces leaf spot (*Teratosphaeria pseudoeucalypti*) emerged as a major problem for eucalypt plantation establishment (especially of *E. grandis* × *E. camaldulensis* hybrids, and *E. grandis*) in the central coast region of Queensland, resulting in plantations in this region being written off. In Victoria, *Teratosphaeria eucalypti* (Septoria leaf blight) caused significant defoliation of shining gum (*E. nitens*) in the Otway Ranges and Gippsland regions in 2010–11 as a result of wet and warm conditions.

Spotted gum canker (*Caliciopsis pleomorpha* and other *Caliciopsis* spp.) emerged as a health issue for *Corymbia* species in New South Wales and Queensland and caused significant losses in some plantations. Stem canker (*Caliciopsis* spp.) was found in Queensland on *E. grandis* hybrids, *E. dunnii* plantation species and non-plantation eucalypts. Canker pathogens, including *Holocryphia eucalypti*, *Neofusicoccum ribis* and *Cytospora eucalypticola*, were common in young (1 to 2-year-old) *E. dunnii* plantations in southern Queensland, with *H. eucalypti* identified as the causal pathogen of 'sudden death syndrome' and the only pathogen observed to be capable of rapid killing of its host (Whyte 2012). Stem canker (possibly *Fusarium solani*) causing dieback was an issue for teak plantations in Tully and Babinda in north Queensland.

The soilborne root-rot pathogen *Phytophthora cinnamomi* remained a threat to young *E. nitens* plantations on infertile sites across lowland northern Tasmania, although mortality rarely reached levels that necessitated replanting. An elevated incidence of windthrow in plantations that had suffered mortality from *P. cinnamomi* when younger suggests the possibility of ongoing root damage in surviving trees.

Pathogens affecting softwood plantations

Spring needle cast caused by the fungus *Cyclaneusma minus* remained one of the major problems affecting the pine plantation estate in New South Wales, Victoria and Tasmania. The impact is managed using alternative silvicultural regimes and more resistant genetic material.

In 2007, Diplodia canker (*Diplodia pini*) affected many *Pinus radiata* plantations in the south-east of South Australia. Top death due to *D. pini* infection of drought-affected plantations was widespread in north-eastern Tasmania, peaking in 2006–07, and then contracting over the following four seasons. In Victoria, observed Diplodia damage was generally confined to two areas in central and north-east Victoria; the damage recorded was minor and generally confined to either individual trees or small groups of trees.

An outbreak of Dothistroma needle blight (*Dothistroma septosporum*) in radiata pine occurred in Victoria and in Murray Valley plantations in New South Wales following above-average rainfall in 2010–11 and warm conditions. Dothistroma needle blight remains a significant issue on the Northern Tablelands in New South Wales, with up to 2000 hectares severely affected annually, and had an impact on a small, high-altitude radiata pine plantation in south-east Queensland. The pathogen remained restricted to localised hotspots in north-eastern Tasmania; damage intensified in these hotspots in 2010–12 following above-average summer rainfall, but control remains unnecessary. Low levels of suspected *Dothistroma* infection were reported in the Australian Capital Territory.

Pathogens affecting native forests

Phytophthora cinnamomi and a number of other *Phytophthora* species affect and kill a wide range of plant species in all states and territories, predominantly in regions with an annual rainfall of more than 600 millimetres (SOFR 2008). The most significant impacts are on biodiversity. *P. cinnamomi* is listed as a 'key threatening process' under the *Environment Protection and Biodiversity Conservation Act 1999*, and a national threat abatement plan was released in 2001. Spread of the pathogen is controlled with soil and water hygiene protocols, and use of management zones to protect threatened flora.

P. cinnamomi remains the most significant biotic threat to the health of native forests in Tasmania, with three significant new extensions to its known distribution. The movement of contaminated gravel for road and other construction is a major mechanism of spread of *P. cinnamomi*. Road-construction quarries on state forests and, increasingly, other land are monitored to determine if *Phytophthora* spp. are present, and materials are sourced from quarries determined to be free from *Phytophthora*. In Victoria, *P. cinnamomi* activity has increased as the state recovered from significant drought conditions. In the Australian Capital Territory, *P. cinnamomi* was recorded adjacent to Namadgi National Park in an old pine forest, with the main species affected being grass trees (*Xanthorrhoea* species). As many as 2300 of the estimated 5710 native plant species in south-west Western Australia are susceptible to *P. cinnamomi*. Intensive monitoring is undertaken to identify its distribution in commercial forests and conservation areas, and to designate 'disease risk areas' in which special measures apply to minimise the risk of infection.

Root and butt rots caused by *Armillaria* species, most significantly *A. luteobubalina* in eucalypt forest in southern Australia and south-west Western Australia, cause small patch deaths of a range of species. *Armillaria* root rot was the most notable native disease affecting native forest in Tasmania. Particularly active disease foci developed in the forest surrounding the Tahune Airwalk in southern Tasmania, and many mature celery-top pine (*Phyllocladus aspleniifolius*) died in the reporting period. *Armillaria* root rot also caused scattered mortality of blackwood (*Acacia melanoxylon*) regeneration in a research trial in the Circular Head area in Tasmania.

In Tasmania, myrtle wilt caused by the native pathogen *Chalara australis* was the most significant factor affecting the health and vitality of rainforest dominated by *Nothofagus cunninghamii*. Myrtle wilt continued to cause some deaths of mature *N. cunninghamii* in rainforests across Victoria, although at low levels.

The most significant new incursion of a fungal pathogen into Australia during the reporting period was myrtle rust (*Puccinia psidii* s.l.), a strain of guava or eucalypt rust. Myrtle rust is now widespread in New South Wales and Queensland and spreading in Victoria, in bushland areas as well as in nurseries and on cultivated trees, and is a potential threat to forests, forestry and forest based industries. Management measures are still being developed to contain the spread of the disease. More details are given in Case study 3.1.

In Western Australia, *Quambalaria coyrecup* caused the decline and death of marri (*Corymbia calophylla*) trees in some areas, and has the potential to emerge as a significant threat in some parts of the state. *Rigidoporus vinctus* and *Phellinus noxius* killed a low, but increasing, number of trees in Queensland, including young hoop pine (*Araucaria cunninghamii*), rainforest species, eucalypts and *Acacia* species, especially in regrowth forests or second-rotation plantations. Various species of native gall or phyllode rust fungi (*Racospermyces* and *Uromycladium*) affected *Acacia* species, sometimes with severe defoliation and effects on form. Impacts on natural stands are usually ephemeral, but impacts on *Acacia mangium* plantations in northern Australia have led to investigations into disease-resistant varieties.

Dieback and other syndromes in native forests

A wide range of chronic or episodic crown dieback syndromes occur to some degree in native forests in all states and territories, often causing significant tree mortality and associated ecosystem impacts. They are usually caused by combinations of factors such as climatic stresses, poor land-management practices, severe insect attacks and an imbalance in insect predator levels. Pathogenic fungi are not usually the primary causal agents, but canker-causing fungi, including *Holochryphia eucalypti* (formerly *Endothia gyrosa*) in Western Australia and New South Wales, and *Botryosphaeria* species in New South Wales, often have a secondary role.

The identification of syndromes and their causal agents is often difficult and, because a wide range of land tenures is also involved, there are impediments to the effective delineation of the areas affected. For example, 'Mundulla yellows' is a progressive and complex dieback condition that is often fatal in eucalypts and also affects a range of other tree species. It is characterised by distinctive intervein yellowing of foliage, and occurs most commonly along road verges and in paddock environments, as well as in some urban plantings. It is especially common in the south-east of South Australia, but similar symptoms are recognised to varying extents in most states and territories. Attempts to find a causal biotic agent have failed; it has been suggested that the symptoms of Mundulla yellows are actually the symptoms of a lime-induced chlorosis (Parsons and Uren 2007).

Weeds

More than 2700 exotic plant species have become established as pests in Australia.[82] Species such as blackberry (*Rubus fruticosus* and other *Rubus* spp.) and lantana (*Lantana camara*) compete with native flora and can become locally dominant, reducing biodiversity and other values; they can also affect tree establishment, growth and product yield in commercial forest plantations and native forests, and reduce the ease of human access. Several exotic plants common in Australian forests are listed as Weeds of National Significance under the Australian Weeds Strategy.[83]

In the Australian Capital Territory, blackberry spread from a major infestation in a pine plantation destroyed by the 2003 fires into montane eucalypt forests in the northern Namadgi National Park, Brindabella National Park and Bimberi Nature Reserve. Blackberry remained one of the main environmental weeds in wetter forest types in Tidbinbilla Nature Reserve. African love grass (*Eragrostis curvula*) and serrated tussock (*Nassella trichotoma*) were among the main environmental weeds in drier forest types in the Naas Valley and northern Clear Range, within and adjacent to Namadgi National Park. A number of new weed incursions in mountain forests in Namadgi National Park were contained, including Mexican grass (*N. tenuissima*), ox-eye daisy (*Leucanthemum vulgare*) and Shasta daisy (*L. maximum*).

Blackberry, lantana, boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*), gorse (*Ulex europaeus*) and water hyacinth (*Eichhornia crassipes*) are significant issues in New South Wales, while gamba grass (*Andropogon gayanus*), giant mimosa (*Mimosa pigra*) and bellyache bush (*Jatropha gossypiifolia*) are significant issues in the Northern Territory.

Lantana (*Lantana camara*), a shrub native to Central and South America that is a noxious weed in Australia with impacts on both native and plantation forests.

In Queensland cat-claw creeper (*Macfadyena unguis-cati*) was an increasing threat to plant biodiversity within a wide range of forest habitats from plantations to native forests, in particular riparian zones within *Araucaria* plantations. The leaf-tying moth (*Hypocosmia pyrochroma*) and the leaf mining jewel beetle (*Hylaeogena jureceki*), biological control agents specific for cat's claw creeper, have been released in south-east Queensland.

In South Australia, sallow wattle (*Acacia longifolia*) decreases biodiversity and habitat opportunities, and obstructs access for management in plantation forests. Asparagus weeds, including bridal creeper (*Asparagus asparagoides*) and bridal veil (*A. declinatus*), smother native vegetation and plantation species and obstruct access for management. Reproduction through seed, spread by birds, and large, long-lived tuber masses make control difficult and expensive. Blackberry (*Rubus fruticosus*) is also a problem, producing thorny thickets that are difficult to penetrate for control activities and obstruct access for management in plantation forests. Olive (*Olea europaea*) is the worst weed in native forest in South Australia, because it replaces native trees and allows little understorey. Birds and mammals spread olive seeds widely from existing feral olive infestations and commercial olive groves.

Pine wildings, blackberry and bridal creeper are a problem in Victoria; management of pine wildlings is an ongoing challenge during return of the Delatite pine plantation to native vegetation. These weeds are addressed in parts of Victoria by the Australian Government's Caring for our Country program. In Tasmania, pine wildlings are a significant invasive threat in dry forests adjoining pine

82 www.nrm.gov.au/funding/previous/business-plan/12-13/priorities/biodiversity/vertebrate-pest.html.

83 www.weeds.org.au/aws.htm.

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plantations, and rehabilitation of non-commercial pine plantations back to native forest has been undertaken in two plantation areas on state forest. Macquarie vine (*Muehlenbeckia gunnii*) has also emerged as a problem across Tasmania, having smothered a proportion of young trees across at least 129 hectares of plantation.

Widespread forest weeds requiring management in Western Australia included arum lily (*Zantedeschia aethiopica*), blackberry, bridal creeper, tea tree (*Leptospermum* spp.) and watsonia (*Watsonia* spp.), as well as gorse (*Ulex europaeus*), lantana and willow (*Salix* spp.) in more restricted areas.

Cyclone damage to native forest in the Northern Territory.

Climatic events and climate change

Drought

The south-eastern states of Victoria and New South Wales experienced three years of drought from 2007 to 2010, which contributed to the severity of several major fires (see Indicator 3.1b). The drought broke when La Niña weather systems brought drenching rains to the region in late 2010.[84] High levels of rain in the second half of 2009 reduced the impacts of drought experienced in previous years. Drought up to 2009 continued to affect forest health in South Australia, especially in the mid-north forests.

In Tasmania, *Eucalyptus coccifera* forests along the western edge of the Central Plateau have suffered severe dieback—a continuation of the syndrome that began in the late 1990s during a previous period of sustained drought. Drought also caused locally severe dieback of trees and understorey species in eastern, north-eastern and midlands Tasmanian forests; in some areas (e.g. the Waterhouse Conservation Area), forests have almost been eliminated. Forest trees affected include *E. obliqua* and *E. amygdalina* on ridges, *E. risdonii* and *E. pauciflora* on sands, and *E. viminalis* on dry sites, as well as *Allocasuarina verticillata* and some understorey species, such as the Tasmanian threatened species *Mirbelia oxylobioides*. In some eastern montane locations, pencil pine (*Athrotaxis cupressoides*) and King Billy pine (*A. selaginoides*) appear to be suffering dieback through gradual canopy thinning. However, the health of vegetation has improved, but not fully recovered, in many areas with the return to wet conditions in 2010. Drought conditions in Tasmania in 2006–08 also contributed to an increase in borer attack and subsequent mortality in mid-rotation plantations in drier areas of the state. Borer species involved included the wood moth (*Culama australis*) and longicorn beetles such as *Epithora dorsalis* and *Phoracantha mastersi*.

Very low rainfall, lowered groundwater levels and prolonged high temperatures led to widespread tree mortality on susceptible sites in south-west Western Australia over the reporting period. Extensive losses of pine plantations and impacts across vulnerable patches of forest in the Northern Jarrah Forest were observed during 2007–11, and had a major impact on forest productivity, biodiversity and visual amenity value. In coastal areas north of Perth, compartments of maritime pine (*Pinus pinaster*) plantations suffered losses up to 70%. Mortality was also observed in overstorey jarrah/marri (*Eucalyptus marginata*/*Corymbia calophylla*) and midstorey (*Banksia grandis*/*Allocasuarina* sp.) trees in native forest.

Wind and storm damage

In Queensland, cyclone Larry in March 2006 affected Caribbean pine plantations on the coast from Ingham to Cardwell, and on the Atherton Tablelands west of Cairns. In March 2010, cyclone Ului damaged half the mature Caribbean pine plantations in Cathu State Forest near Proserpine. Immediate salvage of affected stems helped reduce the severity of the loss that could have occurred due to ambrosia beetles infesting cyclone-damaged trees.

In February 2011, cyclone Yasi destroyed thousands of hectares of forest trees along the north Queensland coast near Mission Beach. The cyclone, which was the largest and most powerful on the eastern coast of Australia since 1918, produced winds exceeding 163 kilometres per hour in coastal areas between Innisfail and Ingham. The extensive cyclone damage to forest trees has led to a decline in industry confidence in future forest plantations in the region. The extent of damage varied with species, genetics, species mixtures and planting pattern, tree age, stand management and site characteristics. Species considered to have superior resistance to cyclonic winds include silver quandong (*Elaeocarpus grandis*), Queensland maple (*Flindersia brayleana*), Gympie messmate (*Eucalyptus cloeziana*), flooded gum (*E. grandis*) and red mahogany (*E. pellita*) (Lindsay and Dickinson 2012).

In north-eastern Tasmania, strong wind was one of the most damaging factors for radiata pine in 2009–11, causing windthrow and stem breakage. Nearly 100 hectares suffered moderate to severe damage. In New South Wales and Victoria, wind damage occurred on 2294 hectares of softwood plantations in areas in the Murray Valley and east Gippsland–Bombala regions in 2010–11.

[84] http://earthobservatory.nasa.gov/Features/WorldOfChange/australia_ndvi.php.

A severe wind event on 4 September 2010 and prevailing wet conditions resulted in windthrow damaging more than 130 hectares of softwood in ForestrySA's Bundaleer plantation in South Australia's mid-north; more than 20 thousand tonnes of timber were damaged.

Cold temperatures

Extreme low temperatures (–4 to –6 °C) led to rapid foliage and shoot mortality in marri and jarrah in the Northern Jarrah Forest in Western Australia in 2010–11. The damage was around drainage lines, which possibly acted as cold-air sinks.

Hail damage

In New South Wales, hail caused extensive damage in softwood plantations that led to 'dead topping' in 2010–11. In stands that were grown on, dead topping caused production of multi-leaders in recovering trees, and the trees were later downgraded because of development of blue stain in damaged wood.

Climate change

The nature of predicted climate change in Australia is complex when spatial and interannual variability is taken into account (CSIRO, Australian Bureau of Meteorology 2007). As described in SOFR 2008 (SOFR 2008), climate change of the magnitude predicted by some scenarios could have a profound effect on forests and forest production in Australia.

Climate modelling predicts that the productive capacity of forests will be affected by climate change in regions and subregions across Australia that are projected to receive lower rainfall and increased temperature. Potential increases in damage to forests by pests, diseases, weeds, fire, drought and severe cyclonic winds may also negatively affect forest health (ABARES 2011a, Select Carbon 2012). Projected increases in atmospheric levels of carbon dioxide may increase forest productivity or offset potential declines in forest productivity (ABARES 2011a).

River regulation

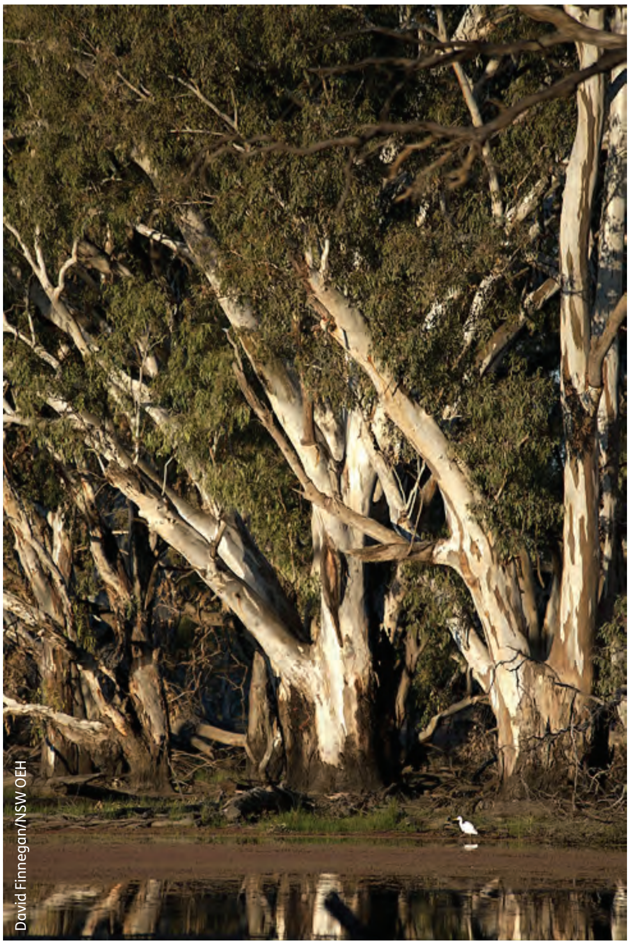
River regulation, overallocation of water resources and persistent drought have caused decline in river red gum (*Eucalyptus camaldulensis*) forest in the Murray–Darling Basin, with impacts on dependent industries and communities (Natural Resources Commission 2009). Large stands of river red gum in New South Wales and Victoria remain under ongoing long-term threat from water deficits.

Soil salinisation

Dryland salinity continues to be a widespread and growing problem in Australia. Although occurring predominantly on cleared agricultural land, it also affects adjacent forests. A contributing factor is historical widespread clearing of deep-rooted native tree species, causing watertables to rise and thereby mobilising salt in the soil (SOFR 2008). Catchments that are still largely forested are at less risk. Rehabilitation and salinity management may involve tree planting, and the regeneration and maintenance of native vegetation.

Soil acidification

Accelerated soil acidification involves formation of sulphuric acid when soils and sediments containing iron sulphides are drained or disturbed. It is a serious soil degradation problem across Australia (NLWRA 2001). The impact of forest plantations on soil acidity has yet to be examined in detail, and there are insufficient monitoring sites or measurements in soil profiles within forested lands to obtain baselines or trends for soil acidity in forests.



Mature river red gum (*Eucalyptus camaldulensis*) trees on the Murrumbidgee river, New South Wales.

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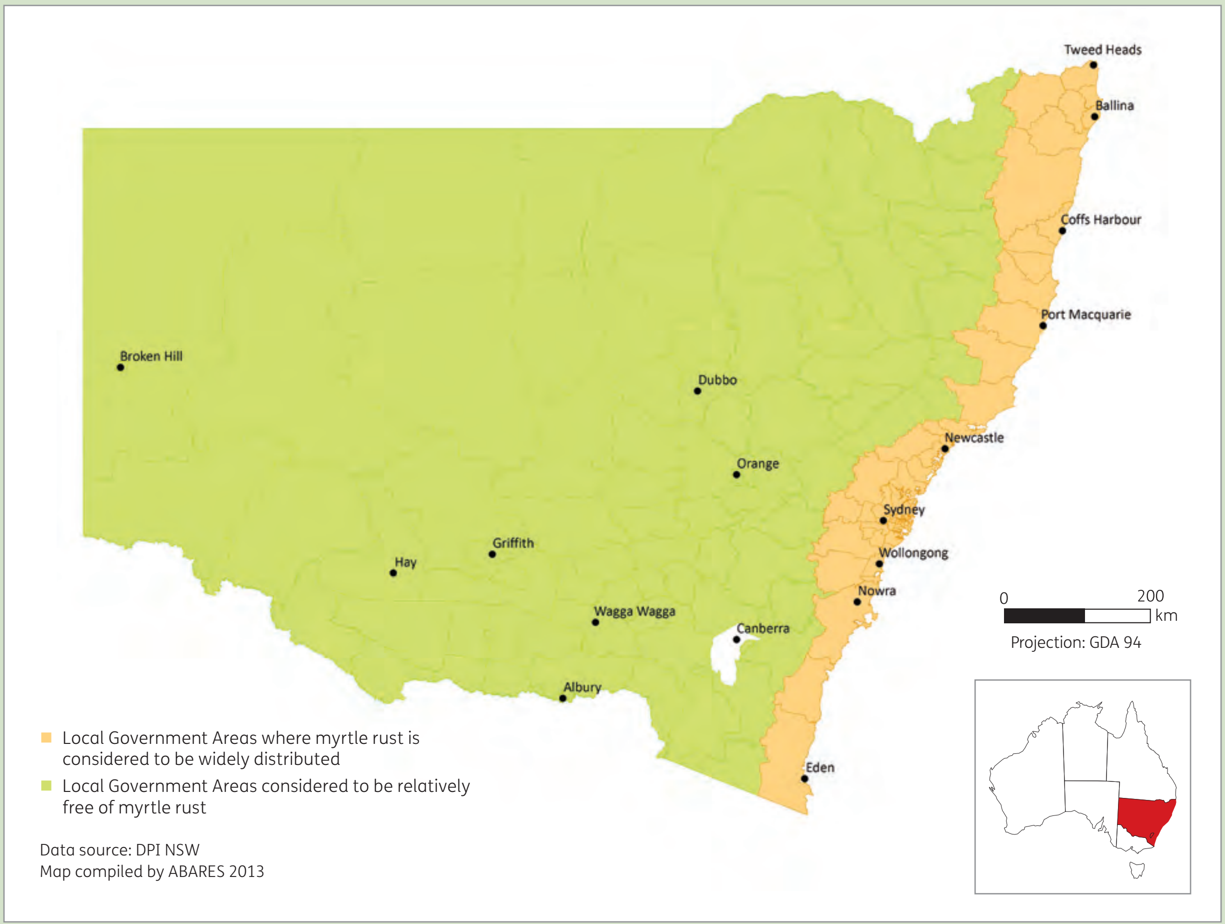
Case study 3.1: Myrtle rust[85]

Myrtle rust (*Puccinia psidii* s.l.), a strain of guava or eucalypt rust, was detected for the first time in Australia in April 2010 by a cut-flower grower on the central coast of New South Wales (Carnegie et al. 2010).

An emergency response was established to determine whether it was technically feasible to eradicate the rust. The response included surveys of a large number of nurseries, residential gardens and bushland sites; tracing plant movements to and from nurseries; destroying diseased material; establishing quarantine zones; and restricting interstate plant movements. However, rust spores are predominantly disseminated by air, and by December 2010 the rust had been detected on a large number of properties (nurseries and private gardens), spread to native bushland, and been identified on a large number of hosts in the Myrtaceae. Government agencies determined that eradication of the pathogen was not technically feasible, and the Australian Government invested $1.5 million for research to assist in the transition from the eradication program to ongoing management of the disease. This investment included developing information and tools to enable industries and communities to mitigate the impacts of the disease in urban, primary production and natural environments. Figure 3.1 shows the distribution of myrtle rust in New South Wales by Local Government Area.

Myrtle rust was detected in south-east Queensland in late 2010, and has since progressively spread north. It was first detected in and around Cairns in June 2012 (Pegg et al. 2012), and has been detected as far west as Toowoomba on the Great Dividing Range. The first detection of myrtle rust in Victoria was reported in December 2011, in a retail nursery on the Mornington Peninsula. The rust has spread progressively throughout Melbourne and to locations in regional Victoria, but is still restricted to nurseries, amenity plantings and urban backyards in that state. It was also recently found in a nursery in the Australian Capital Territory.

Figure 3.1: Distribution of myrtle rust in New South Wales by management zone (February 2012)



85 Source: Geoff Pegg, Queensland Department of Agriculture, Fisheries and Forestry; Angus Carnegie, New South Wales Department of Primary Industries; David Smith, Victorian Department of Primary Industries; and Fiona Giblin, New South Wales Department of Primary Industries

Case study 3.1: Myrtle rust continued

Myrtle rust is now established in native forests along the east coast of Australia, from Batemans Bay in southern New South Wales to the Daintree in far north Queensland. It occurs in a range of forest ecosystems, including coastal heath (*Austromyrtus dulcis*, *Homoranthus* spp.); coastal and river wetlands (*Melaleuca quinquenervia*); sand island ecosystems of Moreton, Stradbroke and Fraser islands; littoral, mountain temperate, subtropical and tropical rainforests (*Rhodamnia* spp., *Rhodomyrtus* spp.); and dry tropics around Mareeba in north Queensland. The disease has been detected in nurseries, urban and peri-urban environments, state forests and national parks, including World Heritage– or National Heritage–listed national parks (Royal, Gondwana, Fraser Island and Wet Tropics). Figure 3.2 shows the change in the distribution of myrtle rust in Queensland from 2011 to 2012.

Surveys since initial detection have shown a host range of more than 200 plant species in 41 genera of the Myrtaceae in New South Wales, Queensland and Victoria.[86] Symptoms detected range from restricted leaf spots (Figure 3.3) to severe shoot and stem infection—with repeat infection resulting in tree dieback and plant death (Figures 3.4 and 3.5)—and infection also on flowers and fruit (Figure 3.6) (Coutinho et al. 1998). In Queensland, 9 species are considered extremely susceptible and 28 highly susceptible.[87] Severe impact has been observed in several rainforest species, such as brush turpentine (*Rhodamnia rubescens*) and native guava (*Rhodomyrtus psidioides*), stands of broad-leafed paperbark (*Melaleuca quinquenervia*), and some amenity species, including rose apple (*Syzygium jambos*).

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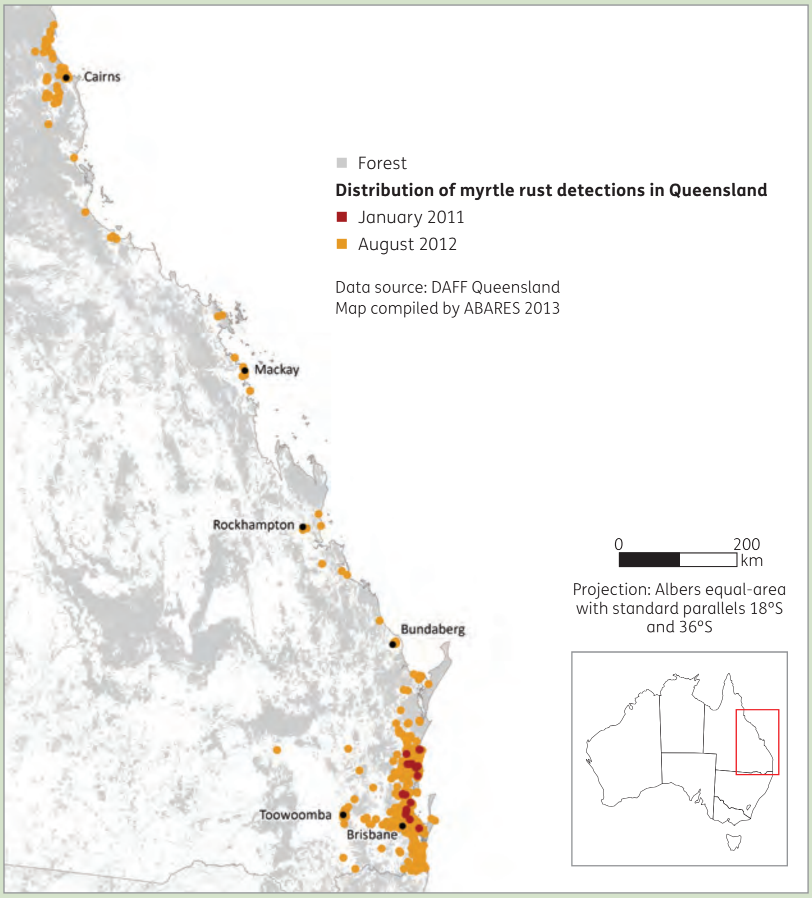
Figure 3.2: Distribution of myrtle rust detections in Queensland in January 2011 and August 2012



Note: Grey shading indicates forest.

[86] Qld: www.daff.qld.gov.au/4790_19788.htm; NSW: www.dpi.nsw.gov.au/biosecurity/plant/myrtle-rust; Victoria: www.dpi.vic.gov.au/forestry/pests-diseases-weeds/diseases/myrtle-rust.

[87] www.daff.qld.gov.au/4790_19788.htm.

Case study 3.1: Myrtle rust continued

Myrtle rust is a significant threat to Australia's native Myrtaceae. The overall impact on plant species or plant communities is not yet clear, and may not become evident for a number of years, and the level of natural resistance within populations of species in Australia is currently unknown. Observations since the first detection of myrtle rust suggest a number of species at risk of extinction, including *Rhodamnia maideniana* and the already rare and endangered *R. angustifolia*, *Gossia gonoclada* and *Backhousia oligantha*, all of which are highly or extremely susceptible to rust infection.

Preliminary studies have identified significant impacts of myrtle rust on regeneration of *Melaleuca quinquenervia*, with repeat infection resulting in tree dieback, but more importantly a reduction in flower production and seed set. *M. quinquenervia* flowers during autumn and winter, providing shelter, breeding sites, food sources and nectar for mammals, birds, amphibians and insects—for example, the grey-headed flying fox (*Pteropus poliocephalus*) and little red flying fox (*P. scapulatus*), which consume the flowers. Infection of flower buds, flowers and fruits has been observed in a further 17 species in Queensland, including *Eugenia reinwardtiana* and *Rhodamnia sessiliflora*, both of which are known food sources for the cassowary (*Casuarius casuarius*) (Coutinho et al. 1998).

Myrtle rust is likely to affect a range of industries that rely on the Myrtaceae, such as commercial nurseries and gardens, including the native cut-flower and native oil (lemon myrtle, *Backhousia citriodora*) industries; forestry and forest based industries, including beekeeping; and tea-tree oil production. Myrtle rust has been listed as a key biosecurity threat in several industry and national biosecurity plans.

A number of eucalypt species, including some of significance to the timber industry, have been identified as being susceptible, with infection found on seedlings in native forests and plantations. Susceptible species include *Eucalyptus grandis*, *E. cloeziana*, *E. pilularis*, *E. agglomerata* and *Corymbia citriodora* subsp. *variegata*. Surveys have revealed numerous young eucalypt plantations in New South Wales with myrtle rust, but the impact at this stage is minimal. However, many plantations are of an age at which infection is reported to be less frequent or in areas where reports of the disease have been restricted to nurseries (e.g. South Burnett in Queensland). Glasshouse studies suggest that species used in plantations are susceptible, with varying degrees of resistance within populations (Carnegie and Cooper 2011, Morin et al. 2012).

Current research is investigating the epidemiology and impact of myrtle rust in the native environment, identifying resistance in a range of Myrtaceae, and developing control options.

Figure 3.3: Restricted lesions caused by myrtle rust (*Puccinia psidii* s.l.) on older leaves of *Eugenia reinwardtiana*, Noosaville, Queensland

Case study 3.1: Myrtle rust continued

Figure 3.4: Shoot and stem of *Melaleuca quinquenervia* infected by myrtle rust (*Puccinia psidii* s.l.)

Figure 3.5: Dieback of *Rhodomyrtus psidioides* as a result of repeat infection by myrtle rust (*Puccinia psidii* s.l.), Byron Bay Lighthouse, Byron Bay, New South Wales

Figure 3.6: Fruit of *Rhodamnia sessiliflora*, a species native to far north Queensland, infected with myrtle rust

Indicator 3.1b

Area of forest burnt by planned and unplanned fire

Rationale

This indicator is used to provide an understanding of the impact of fire on forests through the reporting of planned and unplanned fire. Fire is an important part of many forest ecosystems in Australia and may have either positive or negative impacts on forest health and vitality.

Key points

- In the period from 2006–07 to 2010–11, the estimated total area of forest burnt was 39.0 million hectares. This estimate was determined using a combination of data on fire extent derived from MODIS satellite imagery for northern Australia and data provided by states and territories for southern Australia. This represents an increase in reported fire area of 14.3 million hectares compared with the period 2001–02 to 2005–06, with the increase being mostly in the Northern Territory and Queensland. The area figure includes some areas of northern Australia that were burnt more than once from 2006–07 to 2010–11.
- Of the total, unplanned fires burnt an estimated 31.6 million hectares, and planned fires burnt an estimated 7.4 million hectares of forest.
- The largest areas of forest fire occurred in the Northern Territory and Queensland, which had a combined total of 77% of the area of Australia's forest that was burnt over the period 2006–07 to 2010–11. More than half the forest area burnt in Victoria over this period was burnt in the single year 2006–07.
- Data from the MODIS satellite (MODIS Burned Area product) suggested a total area of forest burnt of 33.7 million hectares over the period 2006–07 to 2010–11. Of this, an estimated 32.4 million hectares was in northern Australia and 1.3 million hectares was in southern Australia, as defined by rainfall seasonality zones. However, the MODIS platform substantially underestimates the extent of fire in closed-canopy forests.
- In southern Australia, the states and the ACT experienced serious bushfires over the reporting period. The most extensive bushfire activity was in Victoria, especially areas near Melbourne, with the Black Saturday bushfires of 2009 being exceptionally serious. However, overall most bushfires, in number and area, occur in northern Australia.
- Fire is an important forest management tool in Australia. Planned fire is used in fire-adapted forest types for forest regeneration, to promote growth after harvest, to maintain forest health and ecological processes, and to reduce fuel loads and thereby increase the ability to manage subsequent unplanned bushfire and protect vulnerable communities.
- The incidence and severity of certain pests can increase in forests affected by fire when these pests colonise dead or dying trees. Pests, diseases, weeds and drought can make forests more vulnerable to fire, with stressed or dead stands being more flammable because of changes in the structure, amount and dryness of fuels. Absence of fire of appropriate intensity can also reduce the health of forest stands.
- Understanding the role of climate change and weather pattern variability is important for management of planned and unplanned fires. There is evidence that projected climate change may exacerbate the risk and impact of unplanned fire and reduce the window of opportunity for planned fires in southern Australia. Continued research on interactions between fire, biodiversity, people, fuel management and land-use change is required. National priorities are identified in the *National Bushfire Management Policy Statement for Forest and Rangelands*.

This indicator reports on the area of planned and unplanned fires in forested landscapes. Unplanned fire is used here to mean fire started naturally (such as by lightning), accidentally or deliberately (such as by arson), but not in accordance with planned fire management prescriptions. The terms 'unplanned fire', 'bushfire' and 'wildfire' are used interchangeably in this indicator—that is, 'bushfire' and 'wildfire' are restricted to unplanned fires. Planned fire, also called 'prescribed burning', is fire started in accordance with a fire management plan or planned burning program, such as fuel reduction burning. Bushfire response procedures such as back-burning are planned burns, but these are generally reported in the area of unplanned fire. Planned fires can, of course, become unplanned fires if they escape containment lines.

SOFR 2008 described in some detail the role of fire in Australian forests, impacts of fires on ecological values, fire management, the connection between fire and urban populations, and programs for reporting impacts of fires. Box 3.1 summarises the different types of fires, causes of fire and fire seasons across Australian landscapes. The drivers of fire are substantially different across the continent: the incidence of fire in northern Australia is essentially limited by fuel loads, and the incidence of fire in southern Australia is essentially limited by fuel dryness.

The *National Bushfire Management Policy Statement for Forests and Rangelands* (FFMG 2012) outlines Australian, state and territory government objectives and policies for the management of landscape-level fire in Australia's forests and rangelands. The statement was developed by the Forest Fire Management Group, a national body within the ministerial council structure, with the role of providing information to governments on major forest fire-related issues, policies and practices affecting land management. The Australasian Fire and Emergencies Authorities Council is the national peak organisation that provides advice on a range of polices and standards. Research on bushfires is performed by a number of organisations, including the Bushfire Cooperative Research Centre[89], which brings together experts from universities, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), other Australian, state and territory government organisations, and the private sector for long-term programs of collaborative research.

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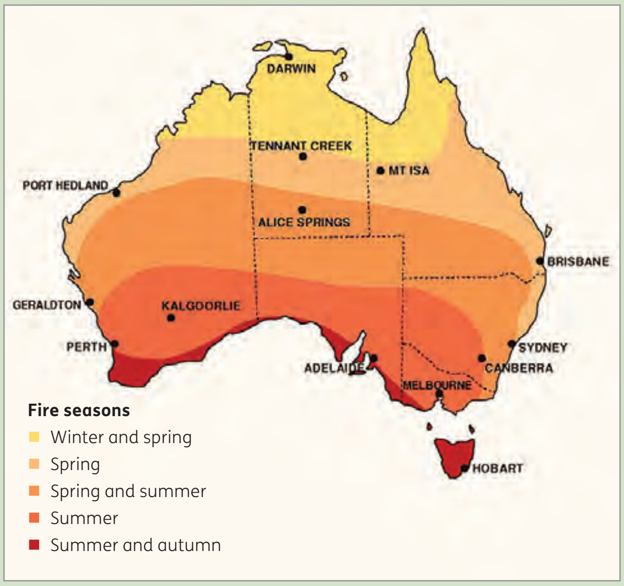
Box 3.1: Where and when do bushfires occur?

The Australian climate is generally hot, dry and prone to drought. At any time of the year, some parts of Australia are prone to bushfires with the widely varied fire seasons reflected in the continent's different weather patterns (Figure 3.7). For most of southern Australia, the danger period is summer and autumn. For New South Wales and southern Queensland, the peak risk usually occurs in spring and early summer. The Northern Territory experiences most of its fires in winter and spring.

Grassland fires[88] frequently occur after good periods of rainfall which results in abundant growth that dries out in hot weather. Bushfires tend to occur when light and heavy fuel loads in eucalypt forests have dried out, usually following periods of low rainfall.

The potential for extreme fire weather varies greatly throughout Australia, both in frequency and severity. When potential extreme fire weather is experienced close to populated areas, significant loss is possible. In terms of the total area burnt, the largest fires are in the Northern Territory and northern areas of Western Australia and Queensland. Most loss of life and economic damage occurs around the fringes of cities where homes are commonly in close proximity to flammable vegetation.

Figure 3.7: Distribution of fire seasonality across Australia



Source: Text from Geosciences Australia (www.ga.gov.au/hazards/bushfire/bushfire-basics/where.html); map courtesy of Bureau of Meteorology.

[88] Including in woodland forests with a grassy understorey.

[89] www.bushfirecrc.com.

Origin and spread of fire

Fire is an intrinsic part of Australia's landscape, and has been an important factor in Australian ecosystems for millions of years. Much of Australia's native vegetation has evolved to be tolerant of fire, and many species require fire to regenerate, with adaptations that promote the spread of fire. Indigenous Australians have long used fire as a land-management tool. Fire is still used by land managers to manage vegetation, for both agricultural and ecological purposes, and to protect properties from uncontrolled fires.

The main factors required for propagation of fire are the presence of fuel, oxygen and an ignition source. Fires can originate from both human activity and natural causes. Lightning is the predominant natural source. Fire intensity and the speed at which a bushfire spreads depend on fuel load, fuel moisture, prevailing temperature, wind speed and slope angle. The worst bushfires therefore occur when temperatures are high, humidity is low and winds are strong. Crown fires in Australia's forests largely involve eucalypts, and are very difficult to control and extinguish, in part because of the highly flammable oil released from eucalypt leaves, and the substantial amount of other flammable material (bark, dead twigs and branches) in the forest.

The extent and intensity of forest fires vary with latitude and seasonal rainfall. In northern Australia, low-intensity fires burn over large areas in the dry season. South-eastern and south-western Australia include areas that are prone to the most severe and frequent wildfires in the world, with hot, dry and windy summer conditions, especially following periods of drought, leading to fires that are often intense and difficult to control. Such fires can result in the loss of human life and destroy community assets such as buildings, fences, bridges and powerlines, as well as standing stocks of wood (both native forest and plantations). They can also have a significant impact on ecological values and affect water supplies. Unusually large and uncontrolled landscape-level fires have been called 'mega-fires' (Bartlett et al. 2007).

Fire is very rare in the tropical rainforests of northern Australia, and is occasional in the subtropical, temperate and cool-temperate rainforests of southern Australia, but during prolonged droughts even some of these forests can be damaged by fire entering from adjacent grasslands or sclerophyll forests.

Box 3.2: Potential effects of projected climate change on fires

- Climate change will affect fire regimes in Australia through changes to temperature, rainfall, humidity and wind—the fire weather components—and through the effects of increases in levels of atmospheric carbon dioxide (CO_2) and changes in atmospheric moisture on vegetation and therefore fuels. Climate change projections are for warming and drying over much of Australia, and hence an increased risk of severe fire weather, especially in south-eastern Australia.
- Modelling suggests an increase of 5–65% in the incidence of extreme fire danger days by 2020 in south-eastern Australia, compared with 2009. Modelling of fire regimes in the Australian Capital Territory predicts that a 2°C increase in mean annual temperature would increase landscape fire intensity by 25%, increase the area burnt and reduce intervals between fires.
- Fire danger at many sites in south-eastern Australia, as measured by the average annual sum of the Forest Fire Danger Index, rose by 10–40% between 1980–2000 and 2001–07. Increases in fire danger have also been detected in some other parts of Australia.
- Climate change will have complex effects on fuels. Elevated atmospheric CO_2 and temperatures may enhance vegetation production and thereby increase fuel loads. Drought may decrease long-term vegetation production and thereby decrease fuel loads; however, it might also reduce fuel moisture, thereby increasing potential rates of fire spread, especially in forested landscapes.
- Fire regimes within Australia differ because of variation in key drivers such as fuel accumulation and drying, fire weather and ignitions. Climate change may have a greater effect on fire regimes in regions where constraining factor(s) are related to fire weather and fuel dryness (e.g. temperate forests of the south-east) than in places where fuel load and ignition are more important (e.g. tropical woodland forests of the north).
- Climate change and changed fire regimes will have complex (positive and negative) feedback interactions with forest biodiversity, with different outcomes in different Australian biomes. There may be increased risks to species that are sensitive to either fire intensity or the interval between fires. Eucalypts and other species that are killed by fire and regenerate from seed may be at risk if fire frequency exceeds the time required for the plants to reach reproductive maturity.
- Managing fire regimes to reduce risk to property, people, biodiversity and ecosystem services will be increasingly challenging under climate change. In Australia, management of fire regimes for biodiversity conservation has variously emphasised fuel management, fire detection and fire suppression. Continued research on the complex interactions between fire, biodiversity, people, fuel management and land-use change is needed.

Source: Adapted from Williams et al. (2009)

Climate change and fire

Climate change and weather pattern variability are among the key factors that affect the occurrence and severity of fires. Projected increases in summer temperatures and declines in rainfall will exacerbate the risk of fire and increase the challenges associated with fire management (Box 3.2).

Forest fires are projected to have an increasing impact on the incidence and severity of certain pests, diseases and weeds (see Indicator 3.1a). Increases in populations of pests such as bark beetles (*Ips* sp.) may occur in response to higher availability of fire-damaged (dead, dying or stressed) trees that can be colonised by these pests. Furthermore, forests affected by pests, diseases and weeds may become more vulnerable to fire damage as a result of factors such as increases in fuel loads due to tree mortality (Singh et al. 2010).

Determination of the extent of fire in Australia's forests

Tools for capturing information on fire management and reporting are increasingly available to states and territories to assist fire management. However, there is currently no nationally coordinated approach to the systematic mapping and reporting of the extent, seasonality and intensity of fires, and whether they are planned or unplanned. A number of methods are used to estimate the total burnt area in each jurisdiction and nationally, including remote sensing (satellite data), operational knowledge and aerial reconnaissance.

Several satellite-based platforms, including the Advanced Very High Resolution Radiometer (AVHRR[90]), Moderate-resolution Imaging Spectroradiometer (MODIS[91]) and Landsat ETM[92] (Russell-Smith et al. 2007), can be used to derive meaningful wildfire datasets. Such datasets are useful for detecting fires in woodland forests, such as the savannas of Australia's tropical north, but are much less effective in open forests or closed forests, as in the southern mesic rainfall zones. In Australia's southern forests, particularly those managed for wood production, state agencies rely on a combination of ground-based approaches and high-resolution aerial photography to estimate the extent and distribution of wildfire. Williamson et al. (2013) report that MODIS detected only 15–19% of the fires (whether prescribed fires or wildfires) recorded in state agency databases for regions of Victoria and New South Wales.

This indicator assembles a nationwide analysis of fire, using MODIS satellite imagery to estimate fire occurrence across Australia's northern forests, and information provided by the states and territories for Australia's southern forests. Methodology changes over time mean that direct comparison of fire area figures with those reported in SOFR 2008 requires caution.

Planned and unplanned fire

Planned and unplanned fires tend to occur in different seasons, but this dependence varies with the rainfall zone in which the fire occurs. The occurrence and seasonality of fire from 2000 to 2006, as identified in MODIS satellite imagery, were used to identify 10 rainfall seasonality zones that affect fire (Figure 3.8; Russell-Smith et al. 2007). For this purpose, northern Australia was taken to comprise zones 4 and 6–10, and southern Australia was taken to comprise zones 1–3 and 5. The rainfall seasonality zones shown in Figure 3.8 determine in part the seasonality of fire occurrence shown in Box 3.1.

For each of these 10 zones, fires are classified as planned or unplanned according to the season of their occurrence (Table 3.1); for this purpose, winter is defined as July-September, spring as October-December, summer as January-March and autumn as April-June. Across northern Australia (zones 4 and 6–10), fires that occur during autumn (the early dry season) are considered planned, while fires that occur during spring (the late dry season) are considered unplanned because fires in that season would be most intense and least amenable to control, and so are less likely to be lit by land managers. For similar reasons, in the mesic regions of southern Australia (included in zones 1–3 and 5), fires that occur in autumn and winter are considered planned, whereas fires that occur in spring and summer are considered unplanned (Thackway et al. 2008). To different extents between jurisdictions, some unplanned fires will occur in seasons designated as 'planned', and some planned fires will occur in seasons designated as 'unplanned'. This system therefore produces only an approximate allocation of fires to the planned and unplanned categories.[93]

Remote sensing of fire in Australia's forests

In SOFR 2008, the areas burnt by fires in Australian northern forests were estimated using the MODIS Thermal Anomalies/Fire product, which provided data at a resolution of 1 kilometre. The fires were allocated as planned or unplanned according to the rainfall region and season in which the fire occurred (Table 3.1). Since SOFR 2008, the National Aeronautics and Space Administration (NASA) has developed, tested and validated a methodology to map the approximate day and extent of burning at a finer resolution, based on spectral, temporal and structural changes in burnt areas (Chang and Song 2009, Giglio et al. 2009, Roy et al. 2008). This new MODIS Burned Area product is available as monthly imagery at 500 metre

90 http://noaasis.noaa.gov/NOAASIS/ml/avhrr.html.

91 http://modis.gsfc.nasa.gov/.

92 http://landsat.gsfc.nasa.gov/.

93 For this indicator in SOFR 2008, financial years were incorrectly defined as June–May, and fire seasons as June–August, September–November, December–February and March–May. This caused a 10% average area overestimation for unplanned fires in Queensland, the Northern Territory and Western Australia, and a 20% average area underestimation for planned fires in these jurisdictions, but negligible error in total fire area for any jurisdiction over the reporting period.

resolution. The extent of burnt areas derived from the MODIS Burned Area imagery and the current Australian forest cover (Indicator 1.1a) were combined to estimate the extent of forest burnt by fires from July 2006 to the end of June 2011 across the various rainfall zones (Table 3.2).

The total area of forest burnt from 2006–07 to 2010–11, as estimated using MODIS Burned Area data, was 33.7 million hectares (Table 3.2). Over this period, a total of 32.4 million hectares of burnt forest was detected by MODIS in northern Australia (rainfall zones 4 and 6–10; Figure 3.8), of which 26.7 million hectares were in zones 6–8. Large areas of forest

Figure 3.8: Classification of geographical zones according to seasonal rainfall distribution

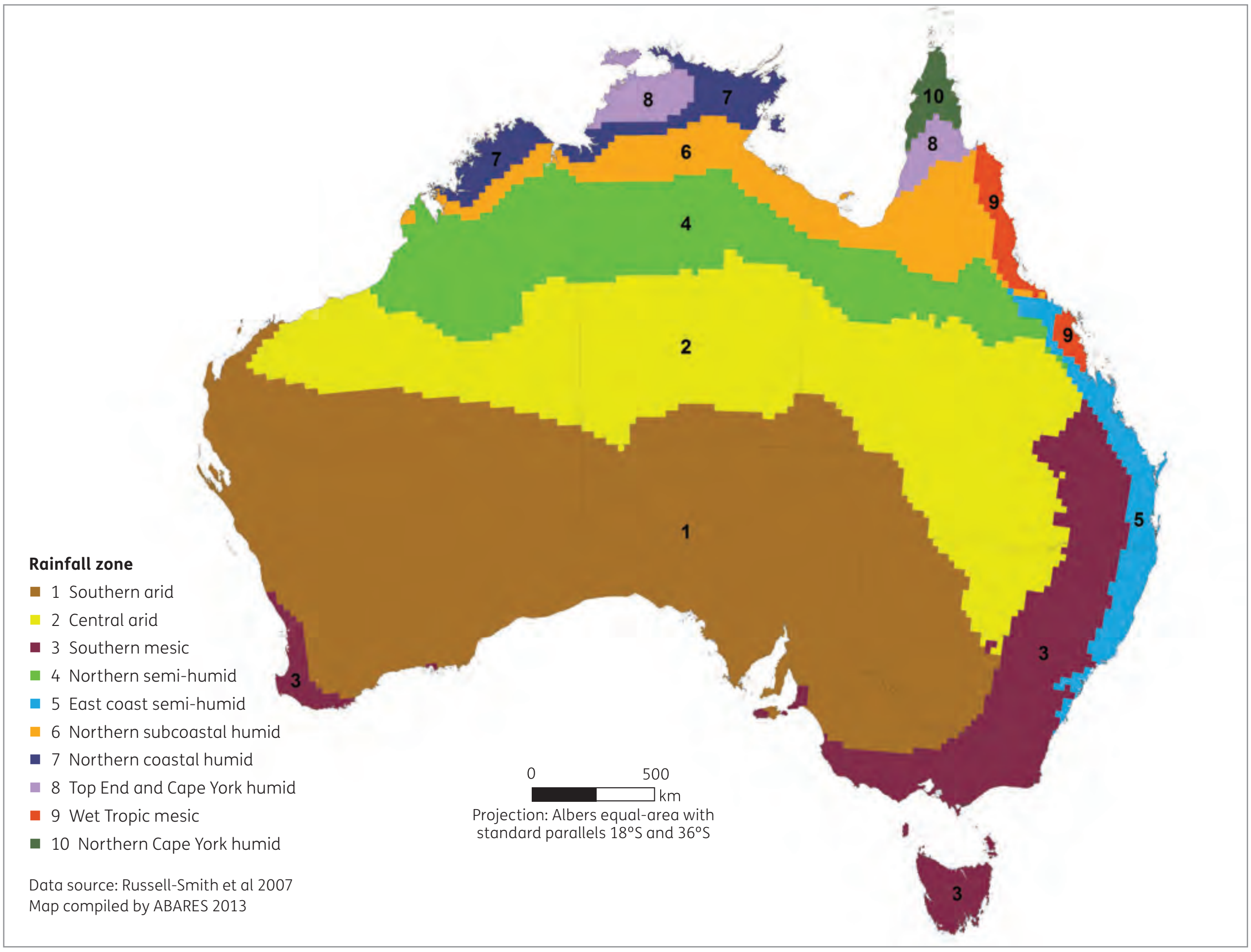


Table 3.1: Rainfall zones and seasons used to classify fires as planned or unplanned[a]

Rainfall zone[b]	Winter (Jul–Sep)	Spring (Oct–Dec)	Summer (Jan–Mar)	Autumn (Apr–Jun)
1 Southern arid	Unplanned	Unplanned	Unplanned	Planned
2 Central arid	Unplanned	Unplanned	Planned	Planned
3 Southern mesic	Planned	Unplanned[c]	Unplanned	Planned
4 Northern semi-humid	Planned	Unplanned	Planned	Planned
5 East coast semi-humid	Planned	Unplanned	Unplanned	Planned
6 Northern subcoastal humid	Unplanned	Unplanned	Planned	Planned
7 Northern coastal humid	Unplanned	Unplanned	Planned	Planned
8 Top End and Cape York humid	Unplanned	Unplanned	Planned	Planned
9 Wet Tropic mesic	Unplanned	Unplanned	Planned	Planned
10 Northern Cape York humid	Unplanned	Unplanned	Planned	Planned

a Occurrences of fire in shaded cells represent fires considered to be unplanned for analysis of MODIS Burned Area data.
b Zone numeric code precedes zone name. Zones 1–3 and 5 constitute the forests of southern Australia. Zones 4 and 6–10 constitute the forests of northern Australia.
c In south-west Western Australia, a proportion of planned burning takes place in spring.

Source: Thackway et al. (2008).

Table 3.2: Total forest area burnt, by rainfall zone, 2006–07 to 2010–11 (MODIS data)

Rainfall zone[a]	Area ('000 hectares)						Burnt forest area as proportion of total forest area in zone, 2006–11 (%)
	2006–07	2007–08	2008–09	2009–10	2010–11	Total 2006–11	
1 Southern arid	19	48	8	28	13	117	0.5
2 Central arid	9	17	55	225	9	315	2.9
3 Southern mesic	161	37	38	202	21	459	1.5
4 Northern semi-humid	421	380	264	607	113	1,784	22.5
5 East coast semi-humid	60	19	74	232	12	397	3.7
6 Northern subcoastal humid	2,773	2,376	1,743	2,622	727	10,241	60.1
7 Northern coastal humid	2,172	2,386	1,736	1,831	851	8,975	115.9
8 Top End and Cape York humid	2,104	1,319	1,499	1,832	705	7,459	113.8
9 Wet Tropic mesic	138	136	243	646	18	1,181	21.5
10 Northern Cape York humid	726	360	589	1,076	38	2,790	65.4
4, 6–10 Northern Australia	8,333	6,957	6,073	8,615	2,452	32,429	66.2
1–3, 5 Southern Australia	249	121	175	687	55	1,288	1.7
1–10 Total	**8,582**	**7,078**	**6,248**	**9,302**	**2,507**	**33,717**	**27.2**

[a] Zone numeric code precedes zone name. Zones 1–3 and 5 constitute the forests of southern Australia. Zones 4 and 6–10 constitute the forests of northern Australia.

Note: Totals may not tally due to rounding.

Source: MODIS Burned Area data (500-metre resolution), resampled to 100-metre resolution, and cut by rainfall zone and forest cover (from Indicator 1.1a).

in zones 7 and 8 were burnt repeatedly in the reporting period, so that the sum of areas burnt over the five years exceeded the total forest area in these zones (Table 3.2).

A total of only 1.3 million hectares of burnt forest was detected by MODIS in southern Australia (rainfall zones 1–3 and 5; Figure 3.8). The resolution of the new MODIS product (500 metres) is still relatively low, and small, low-intensity fires are not easily detected, particularly when obscured by cloud cover or a forest canopy. This may result in significant underestimation of the extent of both planned and unplanned fires in the closed-canopy forests of southern Australia (as also found by Williamson et al. 2013). Therefore, although MODIS detects the majority of Australia's burnt forest area, remote sensing is currently an accurate measure of fire extent only for high-intensity fire in the open and woodland forests of northern Australia.

The areas of planned and unplanned fires for the Northern Territory, Queensland[94] and Western Australia (excluding south-west Western Australia[95]) were determined from MODIS data (Table 3.3). In this analysis, fires are allocated as planned or unplanned according to the rainfall region and season in which the fire occurred (Table 3.1). The total area of forest fire detected by MODIS across these three jurisdictions in the period 2006–07 to 2010–11 was 33.1 million hectares, comprising 5.2 million hectares of planned fires and 28.0 million hectares of unplanned fires. A total of 14.3 million hectares of forest was burnt in Queensland, 15.4 million hectares in the Northern Territory, and 3.3 million hectares in Western Australia (excluding south-west Western Australia). These figures include the areas of forest burnt, as detected by MODIS, in all rainfall seasonality zones in these jurisdictions.

State and territory data on fire

Table 3.4 shows the extent of fire for 2006–07 to 2010–11 derived from aerial reconnaissance, and on-ground and operational data collated and supplied by state and territory agencies in the Australian Capital Territory, New South Wales, Victoria, South Australia, Tasmania and Western Australia (south-west of the state). Fires were allocated as planned and unplanned using information provided by the state and territory agencies, rather than according to the rainfall region and season in which the fire occurred. Over the period 2006–07 to 2010–11, approximately 1 million hectares of forest was burnt in each of New South Wales, South Australia and south-west Western Australia. Approximately 2.5 million hectares of forest were burnt in Victoria, and a comparatively small area (179,000 hectares) was burnt in Tasmania.

These areas of burnt forest in the southern states and territories are several-fold higher than those detected by MODIS for these states and territories, consistent with MODIS detecting fire areas in closed forest and some open forest at low efficiency.

[94] MODIS data will underestimate the area of fire in the mesic forests of Queensland, but fire is relatively rare in these forest types.

[95] MODIS data for lands managed by the Department of Environment and Conservation in south-west Western Australia are omitted because MODIS will underestimate fire areas in these forest types; data provided by Western Australia for that region were used instead (see Table 3.5).

Table 3.3: Forest areas burnt by planned and unplanned fire, 2006–07 to 2010–11, by jurisdiction (MODIS data)

	Area ('000 hectares)					
Jurisdiction	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**	**Total 2006–11**
NT						
Planned	465	897	991	293	330	2,977
Unplanned	3,899	2,583	2,031	2,712	1,245	12,471
Total	**4,365**	**3,480**	**3,022**	**3,006**	**1,575**	**15,448**
Qld						
Planned	112	157	413	299	128	1,108
Unplanned	3,480	2,125	2,013	5,149	450	13,217
Total	**3,592**	**2,281**	**2,426**	**5,449**	**577**	**14,325**
WA (excluding south-west WA)						
Planned	187	271	189	218	206	1,070
Unplanned	228	951	501	476	123	2,278
Total	**415**	**1,221**	**689**	**693**	**329**	**3,348**

Notes:

Data cover the whole of each state or territory (but not south-west WA), including areas in rainfall zones 1 and 3–5 (allocated to southern Australia).

Totals may not tally due to rounding.

Source: MODIS Burned Area data (500-metre resolution), resampled to 100-metre resolution, and cut by jurisdiction and National Forest Inventory forest cover (from Indicator 1.1a).

Table 3.4: Total forest area burnt by planned and unplanned fire, 2006–07 to 2010–11, by jurisdiction (data from states and territories)

	Area ('000 hectares)					
Jurisdiction	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**	**Total 2006–11**
ACT[a]						
Planned	0.7	0.5	0.5	3.2	0.8	5.6
Unplanned	0	0	0	0	0	0
Total	**0.7**	**0.5**	**0.5**	**3.2**	**0.8**	**5.6**
NSW[b]						
Planned	61	81	84	128	93	447
Unplanned	352	51	23	160	2	588
Total	**413**	**132**	**107**	**288**	**95**	**1,035**
SA[c]						
Planned	157	7	2	3	4	174
Unplanned	353	500	33	15	137	1,037
Total	**510**	**507**	**35**	**18**	**141**	**1,211**
Tas.[d]						
Planned	11	21	17	12	15	76
Unplanned	63	17	7	15	0.5	103
Total	**74**	**38**	**24**	**27**	**16**	**179**
Vic.[e]						
Planned	138	156	154	146	189	784
Unplanned	1,205	32	437	37	14	1,727
Total	**1,344**	**189**	**592**	**183**	**203**	**2,511**
South-west WA[f]						
Planned	139	144	152	212	137	783
Unplanned	32	10	24	47	28	141
Total	**170**	**154**	**176**	**259**	**165**	**924**

[a] Spatial data for fires in all vegetation types from ACT Parks and Conservation Service, supplied by ACT Environment and Sustainable Development Directorate; area of forest fires was then estimated using forest cover data from the Australian Bureau of Agricultural and Resource Economics and Sciences (Indicator 1.1a).

[b] Sum of data supplied by Forests NSW for multiple-use forests, and Parks and Wildlife Division, NSW Office of Environment and Heritage, for native forest areas in nature conservation reserves only.

[c] Spatial data for fires in *National Parks and Wildlife Act 1972* reserves and the majority of state forests supplied by the Department of Environment, Water and Natural Resources, SA; planned and unplanned fires were determined using rainfall zone data. Planned fires in South Australia also occur in March and October.

[d] Data from Forest Practices Authority, Tasmania (FPA 2012).

[e] Data supplied by the Victorian Department of Sustainability and Environment for burns on public lands only.

[f] Data from the WA Department of Environment and Conservation (DEC) for DEC-managed lands for south-west WA only.

Note: Totals may not tally due to rounding.

Table 3.5: Total forest area burnt by planned and unplanned fire, by jurisdiction, 2006–07 to 2010–11 (combination of MODIS data and state and territory data)

Jurisdiction	Area burnt ('000 hectares)[96]						Proportion of total, 2006–11 (%)
	2006–07	2007–08	2008–09	2009–10	2010–11	Total 2006–11	
ACT	0.7	0.5	0.5	3.2	0.8	5.6	0.01
NSW	413	132	107	288	95	1,035	2.7
NT	4,365	3,480	3,022	3,006	1,575	15,448	40
Qld	3,592	2,281	2,426	5,449	577	14,325	37
SA	510	507	35	18	141	1,211	3
Tas.	74	38	24	27	16	179	0.5
Vic.	1,344	189	592	183	203	2,511	6.4
WA	585	1,375	865	953	494	4,272	11
Australia	**10,883**	**8,002**	**7,072**	**9,926**	**3,102**	**38,985**	**100**

Notes:
Totals may not tally due to rounding.
Data are combination of MODIS data (Table 3.3) and state and territory data (Table 3.4).

Synthesis of methods

Data on the extent of fire derived from MODIS for states and territories containing Australia's northern forests (Northern Territory, Queensland, and Western Australia outside the south-west; Table 3.3) were combined with data on the extent of fire reported by the states and territory containing Australia's southern forests (Australian Capital Territory, New South Wales, South Australia, Tasmania, Victoria and south-west Western Australia; Table 3.4) to generate the total area of Australian forests burnt between 2006–07 and 2010–11. This total area is 39.0 million hectares (Table 3.5).

The largest areas of forest fire occurred in the Northern Territory and Queensland, with a combined total of 29.8 million hectares burnt, which is 77% of the area of Australia's forest that was burnt over the period 2006–07 to 2010–11. More than half the forest area burnt in Victoria over this period was burnt in the single year 2006–07. Of the total, planned burns contributed approximately 7.4 million hectares (19% of the total) from 2006–07 to 2010–11, and unplanned burns contributed 31.6 million hectares (81% of the total).

The differences between the two methodologies in detecting and reporting the extent of forest fire highlight the need for a nationally coordinated fire reporting program that extends across all land tenures, and takes into account the difficulty in using remote sensing to detect planned fires in the southern mesic rainfall zone. In the absence of such a program, the level of accuracy of the figures presented is unknown.

Wildfire data from the National Inventory Report

The National Inventory Report produced annually by the Australian Government Department of Climate Change and Energy Efficiency[97] reports on Australia's greenhouse gas emissions, including from wildfire. It also presents data on the annual area of forest burnt, compiled by CSIRO from data supplied by state and territory fire management organisations (similar to the approach underpinning Table 3.4). This totalled approximately 4.4 million hectares over the period 2006–2010 (Figure 5.3 in Indicator 5.1a). A number of reasons account for the difference between that figure and the figure reported in this indicator, including differences in data suppliers, methodological differences, and accounting for fires in a smaller area of forest cover than used in SOFR 2013 (see Box 1.2 in Indicator 1.1a, and Indicator 5.1a).

Prescribed burning

Prescribed burning is the deliberate use of fire to achieve particular management objectives, and is an important management tool on both public and private land. Management objectives can include reducing the levels of flammable fuels (fuel reduction burning), protection and enhancement of biodiversity in fire-adapted ecosystems, and promoting regeneration after forest harvesting. There is often a narrow window of time when fuel and weather conditions are suitable for achieving the objectives of the burn with appropriately managed risk, and target levels of prescribed burning are therefore often not met by state and territory agencies.

Prescribed burning will not prevent bushfires, but—depending on forest type—it can reduce future fire severity for a period. Prescribed burning can thus widen the range of weather and other conditions under which a bushfire may be controlled, and potentially allows firefighters to break the run of large fires, especially crown fires. A strategic approach to prescribed burning to protect assets is recommended or carried out

96 As in other tables, includes areas burnt more than once.
97 www.climatechange.gov.au/national-inventory-report-2010; the Department of the Environment from September 2013.

by a number of public agencies. The final report from the 2009 Victorian Bushfires Royal Commission (2010) states that:

> *Properly carried out, prescribed burning reduces the spread and severity of bushfire. It makes a valuable contribution to reducing the risks to communities and firefighters by complementing effective suppression and is one of the essential protective strategies associated with making it safer for people to live and work in bushfire-prone areas in the state.*

One comprehensive Australian study on prescribed burning is from Western Australia (Boer et al. 2009). It showed that extensive prescribed burning of open forest of jarrah, marri and karri changed fuel distribution, and reduced the incidence and extent of unplanned fires for up to six years after the most recent burn, including reducing the incidence of large fires.

In the tropical savannas of northern Australia, woodland forests with a grassy understorey are part of a patchy landscape mosaic that may include other vegetation types, such as rainforest. Fuel loads from the grassy understorey build up during the dry season, increasing the risk of high-intensity fires late in the season. Up to 50% of some northern Australian landscapes may be burnt in a single year, and most areas burn at least once every three years. Suppression of fire and a consequent reduced fire frequency can lead to increased tree and shrub invasion, which may adversely affect biodiversity and habitat values and reduce pastoral productivity. The management of fire in tropical savannas is a trade-off between the tree–grass balance and grazing values. Land managers are being encouraged to employ traditional early dry-season burning techniques that result in reduced fire intensity and also reduce carbon dioxide emissions.

Table 3.6: Mega-fires in southern Australia, 1993–94 to 2010–11

Fire season	Location	Area burnt (hectares)[a]
1993–94	Sydney, Blue Mountains, north coast, NSW	800,000+
1994	South-east Qld	333,000
1997–98	Hunter, Blue Mountains, Shoalhaven, NSW	500,000+
2001–02	Greater Sydney, NSW	744,000
2002–03	Eastern Highlands, Vic.	1.1 million
2002–03	Brindabella Ranges, Canberra, ACT and NSW	157,000+
2002–03	NSW east coast, including Greater Sydney	1.46 million
2002–03	Arthur Pieman, Tas.	100,000
2005	Eyre Peninsula, SA	145,000
2006–07	Eastern Highlands, Vic.	1.05 million
2007	Kangaroo Island, SA	95,000
2009	Eastern Highlands, Vic.	430,000

[a] Total area burnt, including vegetation types other than forests.

A Parks Victoria ranger igniting a planned fuel reduction burn.

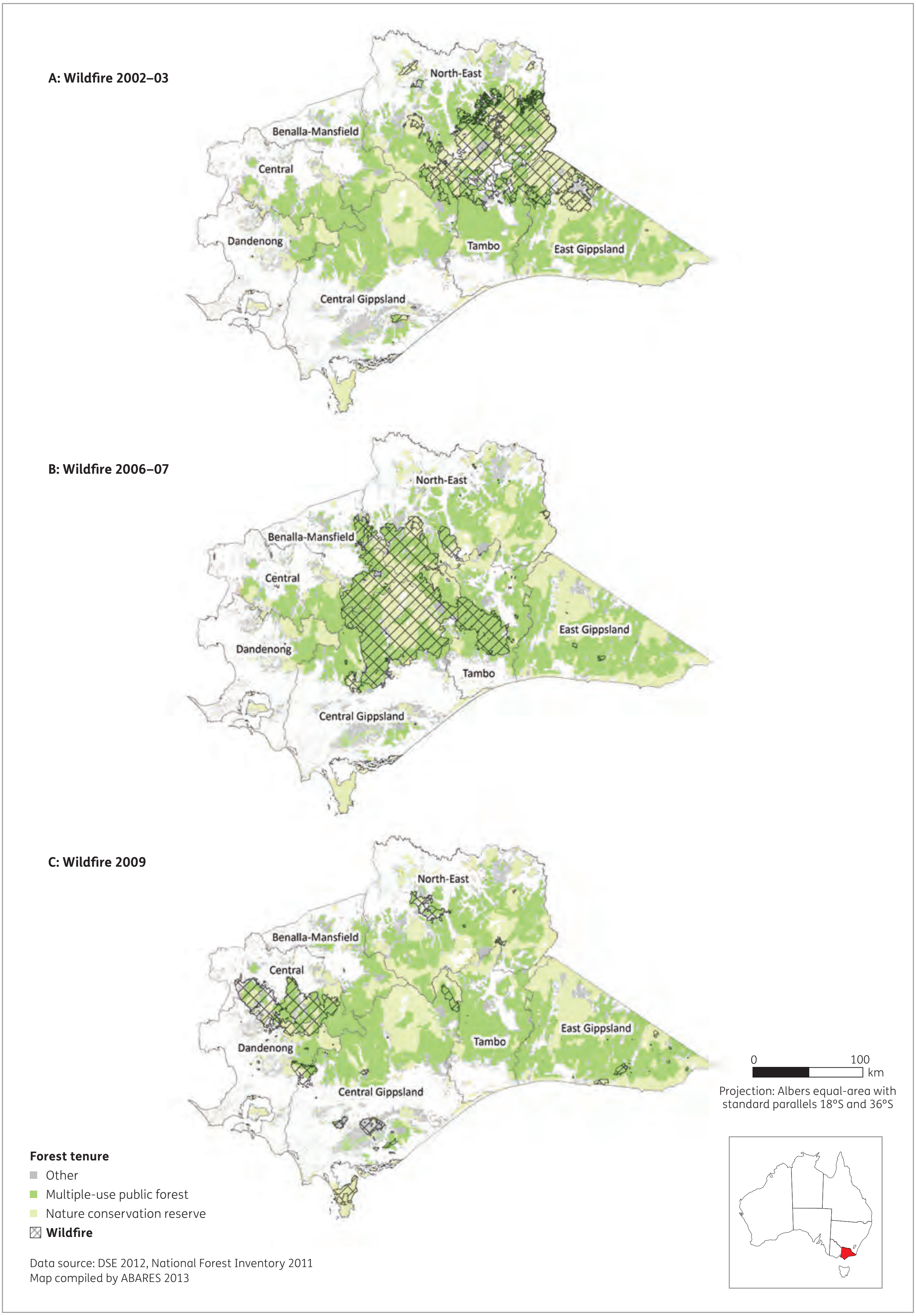
Mega-fires

Mega-fires are especially large and severe fire events that cause catastrophic damage, including human casualties or economic loss, and that have long-lasting social, economic and environmental consequences (Bartlett et al. 2007). The frequency of mega-fires has been increasing in a changing climate, due in part to warmer and drier conditions and increasing fuel loads (Attiwill and Binkley 2013).

Table 3.6 lists the main mega-fire events in southern Australia from 1993–94 to 2010–11. Fewer very large fire events (mega-fires) occurred during this SOFR reporting period (2006–11) than the previous reporting periods, but nevertheless individual events in Victoria were among the worst bushfires experienced in Australia in the past century.

The three recent intense broadscale wildfires in Victoria (2002–03, 2006–07 and 2009; Figure 3.9) had significant impacts across the alpine and other national parks and on multiple-use forests used for wood production. The total area of multiple-use forests burnt in these fires was 1.2 million hectares, and the total area of nature conservation reserves burnt was 0.94 million hectares.

Figure 3.9: Distribution of wildfires affecting Victorian forests, by forest management area, through the last decade. A, 2002–03; B, 2006–07; C, 2009



Case study 3.2: Black Saturday bushfires in Victoria

Victoria has experienced some of the worst bushfires in the nation's history, including 'Black Friday' in 1939, 'Ash Wednesday' in 1983 and 'Black Saturday' in 2009. The Black Saturday bushfires on 7 February 2009 were considered the worst in the history of Australia, causing the deaths of 173 people and serious injury to many others. The fires had impacts on 78 communities, and entire towns were left unrecognisable (Figure 3.10). The total direct and indirect cost of the fires has been estimated to be more than $4 billion.

The Black Saturday fires occurred after a long period of drought and significantly below-average rainfall. A wet November and December in 2008 permitted the growth of more fire fuels, but Victoria experienced some of the hottest conditions on record in January 2009, with temperatures in Melbourne reaching 43 °C for three consecutive days. The forests and grasslands were the driest since the Ash Wednesday fires in 1983. On 7 February 2009, record-breaking temperatures were recorded in many parts of Victoria, including a temperature of 46.4 °C in Melbourne, and relative humidity was as low as 6% at 3 pm. Strong winds grew to storm force as the day progressed, intensifying the fires.

In total, the Black Saturday fires burnt 406,337 hectares of land, comprising 118,958 hectares of private land, 101,740 hectares of nature conservation reserves, 170,169 hectares of multiple-use forest and 15,470 hectares of other Crown land.

The fires affected more than 200 historic places on public and private land and more than 200 places of recorded Indigenous heritage. Around 70 national parks and reserves, 61 businesses and 3,550 agricultural facilities were affected. Community assets on Crown land were damaged or destroyed; and a number of police stations, schools and kindergartens, fire and emergency services facilities, churches, community halls and sporting clubs were lost. Many landowners lost fences.

The fires severely affected forests of mountain ash (*Eucalyptus regnans*) and alpine ash (*E. delegatensis*), which are killed by even moderately intense fires and regenerate by seed. Famous old-growth ash forests (e.g. Wallaby Creek) and large areas of commercial forests in the Central Highlands were severely burnt. Some commercial wood assets were salvaged by VicForests in burnt forests, where time and wood quality permitted.

The habitats of more than 40 species of endangered animals were impacted by the bushfires. Two threatened species—Leadbeater's possum and barred galaxias (a native fish)—were affected. In addition, native flora and fauna were exposed to indirect effects such as ash deposition and sedimentation in streams, increased exposure to predators and increased weed invasion.

Victoria coordinated a massive whole-of-government rebuilding and recovery task, including funding for firefighting services and infrastructure, and targeted recovery and support packages, financed by the Victorian and Australian governments, the Victorian Bushfire

Figure 3.10: Bald Spur Road and Grandview Crescent junction, Kinglake, Victoria, after the 2009 fires

Case study 3.2: Black Saturday bushfires in Victoria continued

Appeal Fund and other donor contributions. In the autumn following the fires, about 4,600 hectares of burnt mountain ash and alpine ash forests were aerially sowed with 3,500 kilograms of seed, in the largest aerial sowing program ever undertaken in Victoria. Further seed-bed treatment and resowing were undertaken in the autumn of 2011. As well, 100,000 seedlings were nursery raised and replanted across 100 hectares in Bunyip and Tarago State Forests and Murrindindi Scenic Reserve.

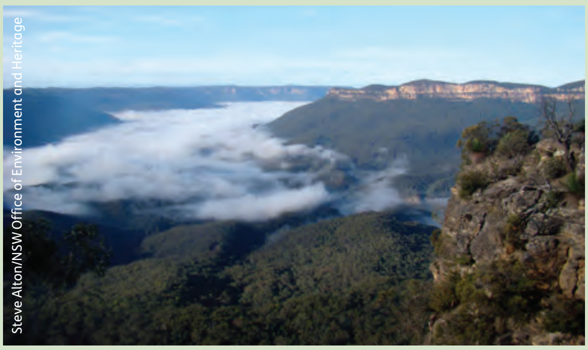
Long-term monitoring was put in place for measurement of populations of Leadbeater's possum. Parks Victoria and Zoos Victoria worked closely with volunteers at Lake Mountain to replace nest boxes and provide winter feeding stations for the only two family groups of Leadbeater's possum known to have survived at Lake Mountain. Native fish species faced degraded water quality and habitats smothered by ash, flooding and sedimentation after the fires. The state undertook rescue programs to relocate threatened native fish populations, and maintain them in aquariums, until they were returned to their natural habitats in 2011. Rains since the 2009 fires have helped some of Melbourne's waterways and catchments start their gradual recovery, and new vegetation growth has helped reduce the amount of ash and sediment entering rivers and creeks.

Case study 3.3: Monitoring fire regimes in the Greater Blue Mountains World Heritage Area

The Greater Blue Mountains World Heritage Area (GBMWHA; Figure 3.11) in New South Wales covers over 1 million hectares and comprises eight conservation reserves. It protects 70 different vegetation communities and more than 1,500 species of higher plants, representing 10% of Australia's total. It includes at least 150 plant species that are found only in the GBMWHA. It also protects examples of at least 100 species of eucalypts. The GBMWHA has extensive adjoining urban areas and is an important catchment area for Sydney's drinking-water supply. Protecting these features presents significant management challenges, including the need for good science to underpin decision making.

The GBMWHA is an extremely fire-prone region. Although fire is an important ecological process in the GBMWHA, inappropriate fire regimes can have significant adverse impacts. High-intensity and repeated fires at short intervals are of increasing concern. Such fires can lead to many adverse effects, including changes in ecosystem composition, increased risk of soil erosion, negative impacts on water quality and increased risk to property. Climate change is predicted to lead to an increase in fire frequency and intensity in the GBMWHA (Clarke et al. 2011); once started, a fire is more likely to spread rapidly, become difficult to control and ultimately affect larger areas. Consequently, the GBMWHA has become a focus for fire research (Tasker and Hammill 2011).

Figure 3.11: Blue Mountains, New South Wales



Research in New South Wales on monitoring fire regimes in the GBMWHA is investigating and documenting the pattern of fires, to help assess the risk to ecosystems in the face of climate change. The project aims to increase understanding of the effects of high fire frequency and intensity on vegetation communities in the GBMWHA, and to improve the information available for fire management. The project is producing:

- maps of the severity of all major fires in the GBMWHA since 1980, using remote-sensing methods and field validation
- analysis of the patterns of fire frequency across the entire GBMWHA
- a targeted field survey to assess the ecological condition of wet sclerophyll forests and rainforests in areas of repeated high fire intensities
- assessment of the status of the GBMWHA in relation to the fire ecological 'thresholds' recommended for maintaining biodiversity
- identification of the areas of 'sensitive' vegetation in the GBMWHA that are at risk from high fire frequency and intensity.

Other related national research is being undertaken by the Bushfire Cooperative Research Centre. The outcomes of these projects will be used to inform future fire management and as a baseline against which to assess climate change impacts.

Criterion 4

Conservation and maintenance of soil and water resources

Great Otway National Park, Victoria. iStockphoto

Original Cotter Dam, ACT, before it was enlarged in October 2013.

Criterion 4
Conservation and maintenance of soil and water resources

This criterion is concerned with two of the fundamental resources of a forest ecosystem: soil and water. Forests are important for soil conservation because they contribute directly to soil production and maintenance, prevent or reduce soil erosion, and provide and protect water supplies. In addition, forests provide quantities of clean water for a range of uses. This criterion has five indicators, the first of which is relevant for both soil and water. The second and third indicators address soil, while the remaining two indicators focus on water.

Management of forest for protective functions

The identification of forest managed primarily for protective functions, and specifically for protection of soil or water, is not always straightforward in Australia. This indicator calculates the area of forest managed primarily for protective functions as all public nature conservation reserves, plus (for some states and territories) those parts of multiple-use public forest in which harvesting and road construction are not permitted (such as on steep slopes and certain soil types, and in riparian—streamside—zones), plus catchments managed specifically for water supply. However, conservation of soil and water values is usually one of several forest management objectives across multiple-use public forests more broadly.

Disturbances that can directly affect soil and water in forested areas include road construction and maintenance, wood harvesting, fire, grazing, recreation, and the activities of feral animals.

Many government agencies, conservation organisations and community groups across Australia plant trees to protect riparian zones, counter rising water tables and salinity, provide wildlife corridors, and prevent or minimise soil erosion.

Management of risks to forest soils

Appropriate management of soils is fundamental to sustainable forest management. Minimising soil erosion protects soil and water values in forested areas, and is critical to maintaining many other forest values. Soil erosion on forested lands can be minimised through careful planning and management of road crossings and forestry operations, with detailed prescriptions depending on the nature of particular forest soils and the activities being undertaken.

Degradation of soil physical properties (such as soil structure, density, texture, permeability, and water-holding capacity) can affect seed germination and the growth and survival of trees, and can lead to increased water runoff and soil erosion. It is important, therefore, that forest management does not result in permanent adverse changes to soil physical properties.

Management of the risk to water quality and quantity

In Australia, large areas of forested land are used to provide reliable and clean supplies of water for human consumption, as well as for irrigation and industrial uses. Forested catchments provide a lower risk to water quantity and quality than do catchments carrying other, non-forest land uses. Establishment and growth of plantations on previously cleared land also affects water yields from this land.

The quantity of water available in streams and rivers flowing from forested catchments depends, among other things, on the quantity of rainfall, the volume of water used by forest vegetation or otherwise evaporated, and the volume that enters groundwater systems. The amount of water used by a forest stand depends on its age, density, species mix and growth rate. Major fire events influence water yields by changing the age-class structure of native forest, and changes in stream-flow can last for decades after a severe fire.

Management practices likely to increase or decrease water yields in forested catchments include the timing, scale and location of wood harvesting; the thinning of regrowth forest; management of planned and unplanned fires; and control of woody weeds.

Forested catchments are highly valued as sources of drinking water because forest vegetation, soil and litter serve as natural filters, and the quality of water flowing from such catchments is therefore usually very high. Natural disturbances such as fire can have negative impacts on water quality—for example, through increased runoff resulting in an increased erosion risk. Construction and maintenance of forest roads and tracks can also have adverse impacts, including through increased movement of sediment into water bodies. In addition, water quality can be adversely affected by fertiliser and herbicide residues from runoff and spray drift. Protective measures employed routinely in Australian forests include maintaining forested streamside buffer zones to minimise sediment movement (these also provide habitats and corridors for wildlife), and carefully planning and managing spray operations.

Babinda Boulders, Wooroonooran National Park, tropical north Queensland.

Key findings

Key findings are a condensed version of the Key points presented at the start of individual indicators in this criterion.

Management of forest for protective functions

- A total of 29.8 million hectares of Australia's public forest (24% of the total forest area, almost entirely native forest) is managed primarily for protective functions including protection of soil and water values. This area comprises all public nature conservation reserves; in some states and territories, those parts of multiple-use public forests in which wood harvesting and road construction are not permitted; and catchments managed specifically for water supply.
- In catchments managed specifically for water supply, jurisdictions either do not allow human disturbances, or approve limited activities such as public access and some restricted wood harvesting. As far as possible, natural disturbances such as fire are also managed.

Management of risks to forest soils

- Most Australian states and territories have in place regulatory instruments, such as codes of forest practice, guidelines and management plans, that provide for the prevention or mitigation of soil erosion as a result of activities on forested land, and to protect soil physical properties.
- In some jurisdictions, the forest practices system includes comprehensive soil assessment measures to manage associated soil erosion risk in multiple-use public forest. Knowledge of soil erosion risk is generally high for multiple-use public forest, but is lower in other tenures.
- Compliance in multiple-use public forest with soil mitigation measures for wood harvesting, and with associated standards for road and track construction and maintenance, has been assessed as 'high' in most jurisdictions.

Management of risk to water quantity and quality

- Most Australian states and territories have in place regulatory instruments, such as codes of practice, guidelines and management plans, that provide for management of water yields from forests. These regulatory instruments also mandate or guide practices that must be carried out to assist in maintaining water quality.
- The potential impacts of forestry operations on water quantity are managed by practices such as seasonal restrictions on wood harvesting, and limiting the annual proportion of catchments subject to wood harvesting. Some forestry operations such as thinning to decrease stand density can increase water yield.
- Water use by tree plantations continues to be the subject of community attention and scientific research.
- Major wildfires during the reporting period, and water use by the resultant natural regrowth, are expected to change water yields in some affected catchments in coming years. Wildfires also caused temporary declines in water quality during the period, mainly in Victoria and Western Australia.

Indicator 4.1a

Area of forest managed primarily for protective functions

Rationale

The area of forest land where priority is given to protecting soil and hydrological functions provides an indication of the emphasis being placed by society on the conservation of these values. This indicator includes areas managed to protect soil and water by excluding incompatible activities.

Key points

- A total of 29.8 million hectares of public forests in Australia, representing 24% of Australia's total forest area and comprising almost entirely native forest, is managed primarily for protective functions including protection of soil and water values. This represents an increase over the reporting period of about 3.5% in the proportion of Australia's forest area that is managed primarily for protective functions.
- This forest area includes all public nature conservation reserves and, in some states and territories, those parts of multiple-use public forests in which harvesting and road construction are not permitted, such as steep slopes, certain soil types, riparian zones or other reserved areas. This area also includes forested catchments managed specifically for water supply.
- Nationally, a total of 1.4 million hectares of forest land is recorded as being managed specifically to supply water for human or industrial use; however, current data are not available for all jurisdictions. In catchments managed specifically for water supply, jurisdictions either do not allow any human disturbance activities to occur or approve limited activities, including public access and some wood harvesting. As far as possible, natural disturbances such as fire are also managed.
- National-level programs such as Caring for our Country and other initiatives have encouraged re-establishment, restoration and maintenance of native vegetation, including forests, for protective functions.

Forests are vital for soil conservation, preventing soil erosion, protecting water supplies and maintaining other ecosystem functions. States and territories have measures in place to recognise and safeguard these functions.

Identification of forest managed primarily for protective functions—specifically, forest managed primarily for soil or water protection—is not always straightforward. In most states and territories, forests in public nature conservation reserves may be considered as 'managed primarily for protective functions'. Moreover, preservation of soil and water is usually one of several forest management objectives, including in multiple-use public forests.

The area of forest reported in this indicator is the area of forest from which wood harvesting is excluded, and therefore includes nature conservation reserves, but not the majority of multiple-use public forests. However, some areas of multiple-use public forests (such as those on steep slopes, on erosion-prone soils or close to streams) are managed for protective functions, with harvesting not permitted in these areas to ensure their protection. As far as possible, these areas are included in the reported areas (see notes for Table 4.1).

Some of the types of disturbance that can directly affect soil and water assets in forested areas are road construction and maintenance, wood harvesting, fire, grazing, recreation and disturbance by feral animals. Codes of forest practice, and licences issued by regulatory authorities, set out precautionary and mitigation measures to be undertaken in or near waterways, in erosion-hazard areas and in water catchments to minimise the impacts of disturbance, particularly from wood harvesting and road construction or maintenance. A comprehensive account of legal and non-legal instruments that are in place to protect forest areas managed for soil and water protective functions is given in Indicator 7.1a.

Table 4.1: Area of public forest from which wood harvesting was excluded, 2011

Jurisdiction	ACT[a]	NSW[b]	NT[a]	Qld[a]	SA[a]	Tas.[c]	Vic.[b]	WA[b]	Australia
Area ('000 hectares)	114	6,119	3,781	6,510	2,112	1,828	4,318	5,026	**29,808**

[a] Area of forest in Collaborative Australian Protected Area Database (CAPAD) International Union for Conservation of Nature (IUCN) categories I–VI (see Indicator 1.1c, Table 1.23); does not include forests on informal reserves in multiple-use public forests. CAPAD figure for Queensland includes Indigenous Protected Areas, and is substantially larger than the figure provided by Queensland in SOFR 2008.

[b] Area of protected native forest on formal and informal reserves, and forests protected by prescription in multiple-use public forests (see Indicator 1.1c, Tables 1.18, 1.20 and 1.21).

[c] Derived from figures published in *State of the forests Tasmania 2012* (FPA 2012); does not include the area of private land excluded from harvesting.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences; Australian Government Department of Sustainability, Environment, Water, Population and Communities—CAPAD for IUCN data; PSMA Australia Ltd; state and territory agencies.

Management of forests for protective functions

Legally and non-legally binding instruments exist in all states and territories to control and limit forest disturbances in designated water supply catchments. State and territory governments protect soil and water values through legislation, codes of practice, and various environmental management plans and standards. These are generally applied to catchment protection, areas vulnerable to erosion and slope instability, and riparian zones.

Forests NSW[98] plans and classifies its road network according to the *Forest Practices Code* (State Forests of NSW 1999). In accordance with this code, all forest road systems in public forests and plantations should be based on the principles of minimising the combined cost of log extraction and roading, and environmental care. The principle of environmental care requires that soil, water catchment, cultural and landscape values are protected by careful planning, location, construction and maintenance of roads and tracks, and regulation of their use. Areas of New South Wales state forests are assessed for soil erosion hazard before wood harvesting commences, as part of the harvest planning process. An environment protection licence is required to conduct specified forestry activities in areas of state forest that come under a NSW Forest Agreement or a Regional Forest Agreement. An integrated forestry operations approval (IFOA) is required for any forestry operations on state forests or other Crown timber lands, including in the western part of the state not covered by a Regional Forest Agreement. The New South Wales Government has also implemented a Private Native Forestry Code of Practice that sets minimum operating standards for harvesting (NSW EPA 2013).

In South Australia, various pieces of legislation and other instruments contribute to appropriate forest management to protect soil and water resources. These include the *Natural Resources Management (NRM) (Commercial Forests) Amendment Act 2011*, the *Environment Protection Act 1993*, the eight regional Natural Resource Management Plans, the state Natural Resources Management Plan and the *Guidelines for Plantation Forestry in South Australia 2009* (PIRSA 2009).

In Victoria, many catchments supplying water for domestic, irrigation or other purposes, including some catchments containing forest, are protected under the *Catchment and Land Protection Act 1994*. This assists planners and those managing land disturbance or development activities to determine the suitability of proposed activities within these catchment areas. Once a catchment is declared, approvals for activities conducted under other statutes and statutory planning schemes must be referred to the responsible land management authority for approval. There is also a range of mechanisms to protect water supplies under the *Victorian Water Act 1989*, including the declaration of water supply protection areas.

In the Northern Territory, the *Codes of Practice for Forestry Plantations* published in 2004 consists of 26 goal statements that collectively cover the main requirements for sound plantation planning and management. The Northern Territory also has Land Clearing Guidelines[99] developed by the then Department of Natural Resources, Environment, the Arts and Sport[100].

In Tasmania, soil and water values are protected on forest land, particularly through two key mechanisms: the *Forest Practices Code 2000* (Forest Practices Board 2000) and the *Tasmanian Reserve Management Code of Practice* (Parks and Wildlife Service et al. 2003). The *Forest Practices Code 2000* prescribes specific management measures for forest lands, particularly for activities associated with roading, harvesting or reforestation.

Area of public forest managed for protective functions

The area of forest from which wood harvesting activities that potentially affect soil and water values were excluded, across all tenures, totalled 29.8 million hectares in 2011 (Table 4.1). This represents 24% of the total forest area in Australia, an increase of about 3.5% during the reporting period, and comprises almost entirely native forest.

The absolute area of public forest excluded from wood harvesting has remained relatively stable in this reporting period. The area reported here (29.8 million hectares) is slightly (0.6 million hectares) smaller than that reported in 2008, largely as a result of the reduction in the total reported area of forest in the Northern Territory and South Australia, where areas described as forest in 2008 are now reported as woody non-forest vegetation (see Indicator 1.1a).

Across Australia, there has been an increase in the area of public land excluded from wood harvesting, as a result of both the declaration of new nature conservation reserves and the establishment of new formal and informal reserves

[98] From January 2013, the Forestry Corporation of NSW.

[99] www.lrm.nt.gov.au/natveg/guidelines.

[100] From October 2012, the Department of Land Resource Management.

on multiple-use public forest. For example, in Victoria, approximately 130 thousand hectares of new national parks and state parks have been established since 2006 on previous multiple-use public forest. This includes new parks and additions to existing parks at Cobboboonee, Barmah, Gunbower, Lower Goulburn, Warby-Ovens, Terrick Terrick and elsewhere along the Murray River. Wood harvesting is now excluded from all of these areas.

In Tasmania, the total area of forest excluded from wood harvesting within multiple-use public forest increased during the reporting period by 163,500 hectares. This is mainly due to an increase in informal reserves in state forest, including areas that are excluded from harvesting coupes for reasons such as steepness, potential erosion hazard and access. The total area of forest in public nature conservation reserves in Tasmania increased by 50 thousand hectares. There has been a net decrease of 12 thousand hectares of total forest in informal reserves on other publicly managed land. Across all public tenures, Tasmania has had an increase of 202,500 hectares of forest where wood harvesting has been excluded, reducing potential disturbance to water supply catchments (FPA 2012).

Areas of forest specifically managed to supply water for human or industrial use (Table 4.2) are a subset of areas of forest from which wood harvesting is excluded (Table 4.1), with the exception of Western Australia where, in the south-west forest region, catchments managed for water supply can include multiple-use public forest where wood harvesting is permitted.

The Cotter River catchment is almost wholly located within the Australian Capital Territory and feeds into the Corin, Bendora and Cotter dams. Much of the 48 thousand hectares of the catchment area, which includes parts of Namadgi National Park, is forested. The entire catchment is closed, with no farms or houses, and with restrictions on activities within the catchment in order to protect the quality of the water (ACTEW Water 2011).

In New South Wales, approximately 178 thousand hectares of forest are managed specifically for water supply in closed catchments from which human disturbance activities are excluded. Another 77 thousand hectares of forest in closed water catchments are available for wood harvesting, subject to scientifically based mitigation measures to protect soil and water values.

There has been no change in the total area of closed water catchment in the Northern Territory over the period 2006–11. The combined area of the Manton Dam and Darwin River Dam catchments is 28,800 hectares. This area is set aside solely for the protection of domestic water supply.

Collectively, Victoria's water supply catchments cover approximately 1.3 million hectares of nature conservation reserves, 1.9 million hectares of multiple-use forests and 2.2 million hectares of other land (not necessarily forested), totalling 5.4 million hectares. This total includes 157 thousand hectares of closed catchments, which comprise approximately 77 thousand hectares of nature conservation reserves, 71 thousand hectares of multiple-use forests and 9 thousand hectares of private land.

Current data are not available for the area of forests in catchments explicitly managed for water production in Tasmania. However, many catchments in the Comprehensive, Adequate, Representative (CAR) reserve system are used for water production, although the majority are not specifically reserved as water catchment areas. One reserve explicitly recognised as a water catchment is in Mount Field National Park, and another is in Wellington Park. The Lake Fenton/Lady Barron Creek drinking water catchment covers 1,530 hectares of the Mount Field National Park and supplies 20% of the drinking water of Hobart and its environs. The slopes of Mount Wellington are also managed for the supply of water to Hobart and adjacent localities (FPA 2012).

In Western Australia, the area from which wood harvesting is excluded includes nature conservation reserves, informal reserves and fauna habitat zones in multiple-use public forest. There has been minimal overall change in the total area managed specifically to supply water for human or industrial use. Public drinking-water source areas include both underground water pollution-control areas and catchment areas, including water reserves. Catchments identified as sensitive to rises in saline groundwater are managed to minimise this risk by re-establishing deep-rooted perennial vegetation over significant parts of the landscape. The existing commercial pine plantation on Perth's Gnangara Mound will be replaced with other land uses over time to increase the recharge of that water resource.

Table 4.2: Area of forest in catchments managed specifically to supply water for human or industrial use, 2011

Jurisdiction	ACT	NSW	NT	SA[a]	Tas.	Vic.	WA	Total
Area ('000 hectares)	48	178[b]	29	1	5	157	948[c]	1,366

[a] Area of multiple-use public forest managed by ForestrySA (pine forests on land managed by SA Water); does not include native vegetation and grassland areas in reservoir protection areas.

[b] Area of closed catchments on multiple-use public forest only.

[c] Includes only the public drinking water source areas on multiple-use public forest and conservation reserves in south-west of Western Australia.

Note: Only ACT, NSW, NT, Vic. and WA provided new data for 2011. Data for SA and Tas. are from SOFR 2008. Data were not available for Qld.

Rehabilitation and reforestation for protective functions

Many conservation organisations and community groups across Australia plant trees to protect riparian zones, counter rising watertables and salinity, provide wildlife corridors and arrest soil erosion. These plantings include a large range of projects supported by the Australian and state and territory governments and the private sector.

For example, during the five-year period to 2010, the national environmental organisation Greening Australia planted more than 15.5 million seedlings, direct-seeded 19 thousand kilometres of tree line, collected 18,250 kilograms of native seed, conserved more than 340 thousand hectares of native vegetation (including forest and non-forest areas) and constructed more than 8 thousand kilometres of protective fencing.

Environmental tree planting by a community group to protect a creek line and provide habitat for the endangered regent honeyeater (*Anthochaera phrygia*), Benalla, Victoria.

Case study 4.1: Caring for our Country

'Caring for our Country' is an Australian Government initiative that began in July 2008, following earlier Australian Government natural resource management programs (the National Action Plan for Salinity and Water Quality, and the Natural Heritage Trust). The goal of Caring for our Country has been to create an environment that is healthy, better protected and well managed, and that provides essential ecosystem services, such as food production, in a changing climate. It supports individuals, regional natural resource management organisations, Landcare and other non-government organisations, and community and Indigenous groups that are working to conserve Australia's natural environment and productive farmland. The Australian Government allocated more than $2 billion over five years to June 2013 under the Caring for our Country program.

In 2008–09, Caring for our Country invested $432 million in new projects involving farmers, Indigenous rangers, regional natural resource management organisations, Landcare and other voluntary environmental protection groups across Australia. With regard to soil protection measures, these investments included working to improve water quality in the Gippsland Lakes (Victoria) and Tuggerah Lakes Estuary (New South Wales). Under the Environmental Stewardship Program, five funding rounds were conducted in 2008–09 and 2009–10. From these rounds, 201 land managers will receive funding from the Australian Government for up to 15 years to manage box gum grassy woodland on their land. These contracts will result in the protection of 27 thousand hectares of this critically endangered ecological community.

Source: www.nrm.gov.au/about/caring/report-card; www.nrm.gov.au/funding/previous/stewardship/box-gum/index.html.

CRITERION 4

Indicator 4.1b

Management of the risk of soil erosion in forests

Rationale

This indicator assesses the extent to which the risk of soil erosion has been explicitly identified and addressed in forest management. The avoidance of soil erosion reflects the extent to which associated values, including soil fertility and water quality, are protected.

Key points

- Most Australian states and territories have codes of forest practice, guidelines and other instruments in place that provide for the prevention or mitigation of soil erosion as a result of activities on forested land, and that regulate clearing of forest land.
- In some jurisdictions, the forest practices system contains comprehensive soil assessment measures to determine soil properties and manage associated soil erosion risk in multiple-use public forests. Mechanisms exist in most of these jurisdictions to ensure compliance with mitigation measures for soil erosion.
- This indicator reports mainly on multiple-use public forest and nature conservation reserves because, in most jurisdictions, limited information is available for forested land under other tenures. Knowledge of soil erosion risk is generally high for multiple-use public forests, but lower in other tenures.

Soil erosion is the relocation of soil by environmental forces—that is, the loss of soil from one area and its deposition into another. Minimising soil erosion is essential to protecting soil and water values in forested areas, and is critical to maintaining many other forest values. Minimising soil erosion, and soil conservation measures in general, are therefore an essential part of sustainable forest management.

Soil erosion on forested lands can be minimised through careful planning and management of forestry operations. The actions taken to manage soil erosion can vary greatly, depending on the nature of the particular forest soils and the activities being undertaken in the forest. Key forestry management considerations with regard to minimising soil erosion include use of appropriate machinery, avoiding disturbance in high-risk areas, and retaining vegetation. Activities for which soil management needs to be considered include road construction and alignment, operations in or near streams or riparian areas, construction of extraction tracks or other temporary tracks, placement and management of log landings, wet-weather operations, use of vehicles on slopes, clearing on slopes, and development of infrastructure facilities.

This indicator reports on prevention and mitigation measures with regard to soil erosion on forested land, and external auditing of compliance with implementation of these measures. The indicator reports mainly on multiple-use public forest and nature conservation reserves because, in most jurisdictions, limited information is available for forested land under other tenures. Performance ratings reported are the results of self-assessment by the jurisdictions, and review of documents published during the reporting period.

Legal and non-legal instruments in Australian state and territory jurisdictions provide guidance and measures to address soil erosion associated with forestry operations. Codes of forest practice, for example, generally require wood harvesting to occur in ways that prevent and/or mitigate soil erosion, particularly for locations that are most susceptible. Soil erosion can also result from wildfire and recreational activities, particularly around roads, walking trails, picnic areas and campsites. The risk of soil erosion caused by recreational activities is generally managed through appropriate design, construction, access to and use of relevant infrastructure, especially during rehabilitation after wildfire.

Instruments to address the risk of soil erosion

General mitigation measures that can be undertaken during forestry operations to minimise soil erosion include:

- excluding identified vulnerable areas, including karsts, wetlands, and areas with high erosion hazard or landslip potential
- providing road drainage, such as well-designed bridges, culverts and table drains, and providing drainage to log extraction tracks by cross-drains and grips
- appropriate arrangement of log extraction tracks, for example, contouring; walk-over extraction, where applicable; and appropriate location of log dumps and landings, for example on ridges and saddles
- minimising stream crossings
- protecting riparian zones using buffers or filters
- closing operations during wet weather
- rehabilitating log landings and extraction tracks through, for example, ripping, replacement of topsoil or planting.

In all jurisdictions, measures to mitigate soil erosion were in place for the reporting period, but they did not necessarily cover all forest tenures. In Victoria and Tasmania, however, such measures apply to all forest harvesting operations regardless of tenure. Internal and external audits at various levels are used to ensure compliance with codes of forest practice.

The *Code of Practice for Timber Production* (DSE 2007a) is a key regulatory instrument that applies to commercial wood production in both public and private forests and plantations in Victoria. It is a statutory document under the *Conservation, Forests and Lands Act 1987*, and compliance of forest management activities with this code is required under the *Sustainable Forest (Timber) Act 2004* and the relevant Victorian planning provisions. The code states:

> *Soil erosion and water pollution are minimised by avoiding harvesting in inappropriate areas or slopes and undertaking necessary preventive measures.*
>
> *During or following wet weather conditions, timber harvesting operations are modified or where necessary suspended to minimise risks to soil and water quality values.*
>
> *Site preparation operations are appropriate to the characteristics of the particular site, and take into account the maintenance of soil and water values as well as site productivity.*

Forests NSW[101] has a comprehensive soil assessment program for forestry operations, consisting of four modules: inherent soil erosion and water pollution assessment, mass movement assessment, dispersibility assessment, and seasonality. Forests NSW is required to apply all four assessment modules during a pre-operational planning phase, which precedes commencement of any forestry activities.

A log landing prepared to protect soil values during harvesting activities, Gippsland, Victoria.

In the Northern Territory, the *Soil Conservation and Land Utilisation Act 1980*, the *Planning Act 2009*, the Forest Practice Code[102] (which is currently being reviewed) and *Land Clearing Guidelines* (DNRE 2010) prescribe ways to minimise and mitigate soil erosion following soil disturbance. In addition, management plans for conservation reserves include provisions to ensure that soils are managed to minimise soil erosion.

Western Australia's *Forest Management Plan 2004–2013* (CCWA 2004) has aims that include protecting soil and water values, and adopting a proactive approach to management. The plan provides a framework for the management of forest areas for a range of environmental, social and economic uses. It focuses on the management of state forest and timber reserves, and prescribes measures to prevent damage, as well as remedial measures to restore soil when damage occurs.

The Western Australian *Soil and Water Conservation Guideline* (DEC 2009a) is the implementation guide for soil and water conservation aspects of the *Forest Management Plan 2004–2013*. It has the overall objective of minimising the extent and severity of impacts on soil values. Ten guiding principles are described to protect soils, including rehabilitation of damaged soil, and protection of soil from erosion as a result of wood harvesting and associated forest management activities. The guideline sets out the key requirements for protecting soil, based on the types of disturbance (using visible soil disturbance categories), and limits activities for various levels of disturbance. For example, where visual soil disturbance indicates that the subsoil is removed and parent material is exposed, or subsoil is mixed with parent material, erosion control measures need to be installed. Rehabilitation needs to be conducted soon after severe or very severe soil disturbance, to facilitate soil repair. Together with associated manuals and reference material, the guideline provides a framework for, and guidance on, soil conservation associated with forestry operations in Western Australia.

101 From January 2013, the Forestry Corporation of NSW.

102 www.planningplantations.com.au/assets/pdfs/management/regulation/nt/KeepDraftNTCodesofPracticeforForestryPlantations.pdf.

In Tasmania, the *Forest Practices Code 2000* (Forest Practices Board 2000), together with a number of supporting manuals, other regulatory instruments, forest certification standards (such as the Australian Forestry Standard), and internal agency or company operational guidelines, provides a framework and good guidance for protecting soil values during forestry activities. The *Forest Practices Act 1985* requires assessment of risks to soils when a forest activity is carried out, irrespective of land tenure or forest type. Assessments are also commonly undertaken on public forests and large, industrially managed private forests in relation to road and site developments and ongoing maintenance, although these are not specified under the *Forest Practices Act 1985*.

The Sustainable Forest Management System of VicForests was certified to the Australian Forestry Standard in February 2007. Since then, VicForests has been independently audited every six months, and was recertified in January 2010 for a further three years. Targets of the Sustainable Forest Management System include maintenance and conservation of soil and water resources of state forests (VicForests 2012).

Assessment of legal instruments and regulatory framework

The extent to which a state or territory regulatory framework requires the maintenance of soil values is analysed according to five categories (Table 4.3). Ratings against these categories are used to assess the extent to which legally and non-legally binding instruments, such as codes of practice, guidelines and forest management plans, address soil values across state and territory jurisdictions (Table 4.4).

Legally binding instruments are in place in New South Wales, Victoria, Tasmania and Western Australia. South Australia's ratings relate to assessment under the *Environmental Management Guidelines for Plantation Forestry* (ForestrySA 1997), which have been endorsed by the plantation industry in that state. Native forest harvesting is not allowed in the Australian Capital Territory or South Australia, and only limited harvesting occurs under licence on private land in the Northern Territory. In New South Wales, the significantly lower risk of erosion assessed for nature conservation reserves means that prescriptions in that tenure are not as stringent as in multiple-use public forests. Overall, there has been no major change during the reporting period in the way legally and non-legally binding instruments address the risks to maintenance of soil values.

Table 4.3: Categories of the extent to which the regulatory framework requires the maintenance of soil values

Category	Category description
1	The instruments require the following components to be taken into account in addressing the risk of soil erosion from disturbance activities: • rainfall intensity • slope • soil erodibility • management practices resulting in soil disturbance. The instruments are also applicable to all erosion processes (wind, sheet, rill, gully, tunnel, stream bank, wave and mass movement).
2	The instruments address most of the components listed in category 1, and those not addressed are associated with low risks of soil erosion for the particular disturbance activity and geographical setting.
3	The instruments address most of the components listed in category 1 but do not specify all aspects or are limited in their application.
4	The instruments mention the need to address risks of soil erosion when conducting disturbance activities but do not specify the components listed in category 1.
5	The instruments do not mention the need to address risks of soil erosion.

Source: SOFR 2008.

Table 4.4: Extent to which legally and non-legally binding instruments address the risk of soil erosion due to forest operations, road and trail works, and recreation activities

Instrument	Tenure	Assessed category						
		ACT	NSW	NT	SA	Tas.	Vic.	WA
Legally binding	Multiple-use public forests and plantations	5	1	3	4	1	1	4
	Public nature conservation reserves	5	2	1	4	1–2	1	4
Non-legally binding	Multiple-use public forests and plantations	3	1	3	1-4	1	3	3
	Public nature conservation reserves	n.r.	1	3	n.a.	1–2	3	4

n.a. = not applicable; n.r. = not reported for this indicator

Notes:

Ratings relate to categories in Table 4.3.

Data were not available for Qld.

Source: State and territory agencies.

Assessment of erosion hazard

Erosion hazard is generally assessed using a combination of available information as overlays in geographic information systems. Relevant information includes erosion hazard maps, geographical settings such as slope, soil erodibility, rainfall intensity, and management practices that could contribute to soil erosion. This provides forest managers with information on the level and location of erosion hazards, which is then used to determine appropriate mitigation measures. The extent to which risks of soil erosion are assessed in planning processes is analysed according to four categories (Table 4.5).

Table 4.6 shows the area of multiple-use public forest for which disturbance activities were planned in 2010–11, the proportion of the area that was assessed for risk to soil values, and the category of assessment (from Table 4.5). In New South Wales, South Australia and Victoria, virtually all areas of multiple-use public forest subject to disturbance were assessed for risk to soil values.

In the Australian Capital Territory, the *ACT Code of Forest Practice* provides guidance for and describes actions to be taken during forest activities, based on the potential for the soil to erode (its erodibility). The code groups soil erodibility into five classes, and provides guidance for operations according to the soil erodibility class for a given area. In addition, a *Soil Erodibility and Maintenance Manual* (Environment ACT 2006) provides land managers with a general quick reference on:

- determining a soil's erodibility
- management of erodibility
- management of sodic soils, eroded soils and unstable regolith
- erosion control measures
- sediment retention measures.

In South Australia, formal soil erosion risk assessments are generally only undertaken for initial site establishment of plantations (during assessment of land-use capability). However, plantation management practices take into account soil erosion risk and aim to reduce it.

All Forests NSW[103] operations must meet the requirements of an environment protection licence, issued by the New South Wales Office of Environment and Heritage. This requires the agency to undertake comprehensive soil assessments as part of the planning process before wood harvesting. These identify the hazard category (risk of soil erosion and water pollution) and determine the level of protection required at each site to conserve soil and water values.

CRITERION 4

Table 4.5: Categories of the extent to which the risks of soil erosion are assessed in planning processes

Category	Category description
1	The soil erosion risk assessment system comprehensively takes account of rainfall intensity, slope, soil erodibility and management practices that could contribute to soil disturbance.
2	The soil erosion risk assessment system takes into account most of the components listed in category 1, and those not addressed are associated with low risks to soil values for the particular disturbance activity and geographical setting.
3	The soil erosion risk assessment system takes into account some of the factors listed in category 1 or only partly accounts for these factors.
4	The soil erosion risk assessment system is ad hoc and/or does not take into account any of the factors listed in category 1.

Source: SOFR 2008.

Table 4.6: Area of multiple-use public forest where disturbance activities were planned, proportion assessed for risk of soil erosion, and assessed category, 2010–11

Disturbance activity	Metric	NSW	SA	Tas.	Vic.	WA
Native forest harvesting and silviculture	Area (hectares)	27,484	0	16,000	5,250	n.r.
	Proportion assessed for risk of soil erosion (%)	100	n.a.	100	85	100
	Assessed category[a]	1	n.a.	1	2	3
Plantation operations	Area (hectares)	14,068	n.r.	4,600	n.r.	n.r.
	Proportion assessed for risk of soil erosion (%)	100	100	100	n.a.	n.a.
	Assessed category[a]	1	1	1	n.a.	n.a.
Road construction and maintenance	Area (hectares)	n.r.	n.r.	n.r.	n.r.	n.r.
	Proportion assessed for risk of soil erosion (%)	n.a.	100	100	n.a.	100
	Assessed category[a]	n.a.	3	1	n.a.	3
Fire management	Area (hectares)	36,936	n.r.	n.r.	n.r.	n.r.
	Proportion assessed for risk of soil erosion (%)	100	100	100	90	n.a.
	Assessed category[a]	1	3	1	2	n.a.

n.a. = not applicable; n.r. = not reported for this indicator

[a] Ratings refer to categories in Table 4.5.

Note: Data for Tas. and WA are from SOFR 2008. Data were not available for ACT and Qld. NT has no multiple-use public forests.

Source: State agencies.

[103] From January 2013, the Forestry Corporation of NSW.

Soil erosion knowledge base

The knowledge base on soil erosion continued to improve in the reporting period, particularly in the areas of soil disturbance by machinery, and assessment of soil erosion hazards in multiple-use public forests (Table 4.7). The impact of fire on the erosion of forest soils has also been the subject of investigation (see Indicator 4.1c).

In Tasmania, a number of soil management guidance documents, combined with ongoing research and training and the experience of forest managers, ensure that sufficient knowledge is available for identification and mapping of soil types, and for recording their characteristics and distribution. The recreation impact monitoring program undertaken by the Parks and Wildlife Service in the Tasmanian Wilderness World Heritage Area regularly records soil data. Knowledge developed through these activities enables identification and management of risks arising from the interactions between various factors, including slope, climate, soil type, rainfall, stream management and vegetation cover.

Compliance with measures to mitigate impacts on soils

Compliance with mitigation measures for soil impacts is assessed in various ways across Australia, including internal and external audits. Compliance is categorised in this report using the descriptions in Table 4.8. Table 4.9 provides an indication of the compliance outcomes for some jurisdictions. Tasmania achieved the highest level of satisfactory outcomes.

As an example of compliance reporting, the report on the end-of-term audit of performance under the *Forest Management Plan 2004–2013* (CCWA 2012a,b) for Western Australia noted that severe and highly visual forms of soil damage, such as rutting, puddling and mixing, were rarely seen in association with wood harvesting operations. It also found that major effort has gone into minimising soil compaction. Surveys in harvest coupes indicated that soil disturbance limits were exceeded at a relatively small number of sites each year between 2005 and 2011. The Department of Environment and Conservation investigated instances where allowable limits were exceeded and ensured that such instances were addressed appropriately. Tracks created by harvest vehicles accounted for the majority of occurrences where limits were exceeded.

Table 4.7: Knowledge base on soil erosion and soil physical properties, by jurisdiction

State	Soil knowledge base
ACT	Soil landscape mapping at the 1:100,000 scale was completed for the eastern half of the ACT, and published in 1993 and 2000. In this work, soil types (based on the Australian Soil Classification) were identified for each soil landscape, and their qualities and limitations were documented, including soil physical and chemical properties. Completion of 1:100,000-scale soil landscape mapping for the western half of the ACT, scheduled for 2015, may provide additional information relevant to the Forest Soil Erodibility Classes described in the *ACT Code of Forest Practice*, and may be useful in identifying soil limitations specific to plantations in the western half of the ACT.
NSW	A good knowledge of the impacts of activities and a comprehensive soil assessment procedure exist for multiple-use public forest. The assessment procedure is designed to minimise soil erosion and protect soil physical properties. For conservation reserves, there is reasonable knowledge of activity impacts on soil values, but improved knowledge is needed for some risk factors.
SA	There is reasonable knowledge of the impacts of activity on listed values, including local knowledge and training, and codes of practice. However, a need for improved knowledge has been clearly identified for some risk factors.
NT	Soil erosion knowledge is well developed, and the knowledge base is supported by published research, GIS tools, decision-support tools, codes of practice, local knowledge and training, and site-specific research and models. Private freehold land in urban and peri-urban regions is covered by legislation and plans designed to mitigate disturbance, whereas on Indigenous private lands the knowledge base is limited. A need for improved knowledge has been clearly identified for some risk factors.
Tas.	There is a sound knowledge base with regard to soil erosion on forest land. Ninety-five soil types with different properties and erosion risks have been identified throughout the state, mostly in multiple-use state forest, and soils on major areas of state forest in northern Tasmania have been mapped at 1:250,000 scale. Areas at risk from erosion are identified in plans, and protected or managed appropriately under the *Forest Practices Code 2000* (Forest Practices Board 2000). Landslides are recorded on a joint Forest Practices Authority/Mineral Resources Tasmania database. Research continues on erosion by headwater streams. Regular training is given to foresters and forest managers. However, for nature conservation reserves, knowledge of the impacts of forest activities on soil erosion is often site-specific and limited to areas of management interest, such as World Heritage Area walking tracks.
Vic.	There is reasonable knowledge of the impacts of activity on listed values for both multiple-use public forests and nature conservation reserves, including local knowledge and training, and codes of practice. A need for improved knowledge has been clearly identified for some risk factors.
WA	The Department of Environment and Conservation[104] and the Forest Products Commission have invested substantial resources into planning and managing operations to reduce soil damage, which has improved the protection of soil under the Forest Management Plan. A combination of measures, including assessing the soil dryness index, a two-stage approvals process, operational controls and monitoring protocols, is used to manage the risk of soil damage according to seasonal conditions, soil type and operation type. Forest Products Commission officers and their contractors apply a risk-based combination of visual surveillance triggers and formal survey techniques to monitor operations and suspend the movement of heavy vehicles before soil damage limits are exceeded. Knowledge of the use of cording and matting to reduce soil compaction and rutting under moist soil conditions fed into improvements in guidance documents and operational practices.

Source: State and territory agencies. No data available for Qld.

104 From July 2013, the Department of Parks and Wildlife.

Table 4.8: Categories for the performance of forest managers in complying with prescribed mitigation measures for soil impacts

Category	Category description
1	Fully compliant with all process requirements and environmental outcome requirements, with minimal adverse impacts
2	Generally compliant with all process requirements and environmental outcome requirements, with minimal adverse impacts
3	Fully or generally compliant with all process requirements and environmental outcome requirements, but with moderate adverse impacts
4	Not generally compliant with process requirements and environmental outcome requirements, with minimal adverse impacts
5	Not generally compliant with process requirements and environmental outcome requirements, with significant adverse impacts
6	Insufficient or no objective evidence to make a judgment
7	No formal audit conducted

Source: SOFR 2008.

Table 4.9: Compliance outcomes for soil impacts achieved in multiple-use public forests, 2005–06

Disturbance activity	Assessed category				
	NSW	Vic.	SA	Tas.	WA
Native forest harvesting	2	3	NA	1	3
Plantation operations	2	2	3	1	4
Roads and trails	2	2	6	1	4
Fire management	2	2	3	1	4

Notes:
Ratings refer to category descriptions in Table 4.8.
Data for some jurisdictions have not been reported since SOFR 2008. No data available for Qld.

Source: State agencies.

Factors that influence the ability to remain below allowable soil disturbance limits were forest type, the type of vehicles used for harvest, topography, dimensions of the harvest area, and compliance with forest hygiene requirements.

Fire

Wildfire affects soils directly—for example, through the loss of carbon and nutrients—and indirectly through rendering the soil more susceptible to erosion. In 2009, the Black Saturday and associated bushfires in Victoria burnt 170 thousand hectares of state forest, 100 thousand hectares of nature conservation reserves, 15 thousand hectares of other Crown land, and 120 thousand hectares of private land.

Environmental care principles of the *Victorian Code of Practice for Bushfire Management on Public Land* (DSE 2012) include a requirement that the soil be protected during fire management activities, either by preventing inappropriate destruction of its physical and chemical properties or by promoting stabilisation of bare or disturbed earth following disturbance. Under this code, the Department of Sustainability and Environment must prepare maps that show areas that are particularly sensitive to soil disturbances, and these maps must be considered when planning the use of heavy machinery during firefighting operations. Although effects are much greater for intense fires, low-intensity fires such as prescribed burns can also increase the risk of erosion, particularly on erodible soils, where terrain is steep, or when there are subsequent, intense rain events.


Leon Bren and John Costenaro

A research weir in a forested catchment (Clem Creek, Victoria), shortly after a fire event.


Leon Bren and John Costenaro

The same research weir two years post-fire, showing siltation and soil movement after rain.

CRITERION 4

Indicator 4.1c

Management of the risk to soil physical properties in forests

Rationale

This indicator measures the extent to which the risk to soil physical properties in forests has been explicitly identified and addressed. The protection of soil physical properties, including minimising soil compaction and redistribution, affects soil integrity and, as a consequence, many associated values.

Key points

- In most states and territories, measures to protect soil physical properties in forests were in place for the reporting period.
- These measures include a mix of legally and non-legally binding instruments, including codes of practice, guidelines and management plans.
- Assessment of the measures required to protect soil physical properties during disturbance activities associated with forest management continued to be comprehensive, particularly for multiple-use public forests.
- In most states and territories, almost all forests that were subject to disturbance activities associated with forest management were assessed for risk to soil physical properties.
- Compliance with soil mitigation measures for wood harvesting and associated road and track construction and maintenance in multiple-use public forest has been assessed as high in most jurisdictions.

Appropriate management of soils as the substrate for forests is fundamental to sustainable forest management. Soil physical properties include soil structure, density, compaction, texture, permeability and water-holding capacity. Degradation of these properties can affect seed germination and growth and survival of trees, and lead to other consequences, such as increased water runoff and consequent erosion. It is therefore important that forest operations do not result in permanent adverse changes to soil physical properties.

This indicator reports on the measures undertaken to minimise adverse impacts on soil physical properties on forested land. It focuses on multiple-use public forest and public nature conservation reserves because, generally, limited information is available for other forest tenures.

Impacts of forestry operations on soils

The principal areas of concern for impacts of forestry operations on physical properties of soils are wood harvesting, activities at log dumps and log landings, site preparation, and construction of roads, trails and log extraction tracks (snig tracks). Common impacts of these forest disturbance activities are soil compaction, soil redistribution, and removal of organic matter. The impact of heavy tracked vehicles, in particular, on the physical characteristics of soils is immediate and generally obvious, but the degree of impact depends on the soil type, the soil moisture content, the loading pressure, and the duration and frequency of such pressure, including the number of passes over the track (CCWA 2012a).

Acid sulphate soils could cause problems for forest ecosystems if such soils are exposed through excavation activities. However, forestry operations are unlikely to create such problems because they do not generally involve substantial excavation.

The physical impact on soils from wood harvesting can be minimised by using appropriate harvesting equipment, harvesting methods (e.g. walk-over slash, cable or 'shovel logging'), extraction track layout, timing of operations to avoid high soil moisture, and protection of soils with matting or cording. Modern harvesting vehicles and accumulated operational knowledge have combined to greatly reduce soil impacts (e.g. reducing ground pressure by using rubber-tyred vehicles).

In all states and territories, measures to protect soil physical properties were in place for the reporting period. In some jurisdictions, these have been implemented in multiple-use public forests for many years, but only in Victoria and Tasmania are these measures applied to all forest harvesting operations, regardless of tenure.

A range of measures are undertaken to maintain soil physical properties, varying with the nature of the soils, the seasonal conditions and the type of activities being undertaken. Measures undertaken to protect soil physical properties include actions relating to:

- felling and log extraction operations in or near streams or riparian areas
- cording and matting
- construction and maintenance of extraction and other temporary tracks
- size, placement and management of log dumps and log landings for storage, and loading of logs for transport
- wet-weather shutdowns
- selection of harvesting machines, including whether machines are tracked or tyred
- machinery restrictions on slopes
- restrictions on clearing steep slopes for plantations
- infrastructure development.

Instruments in place to address risks to soil physical properties

Table 4.10 provides a set of category descriptions used to assess legally and non-legally binding instruments, such as codes of practice, guidelines and forest management plans, that address soil properties. The ratings for various jurisdictions are shown in Table 4.11 for both legally and non-legally binding instruments.

Legally binding instruments relating to soil physical properties are in place in New South Wales, the Northern Territory, South Australia, Tasmania, Victoria and Western Australia.

Operational-level requirements or guidance to manage impacts on soil physical properties are described in various legally and non-legally binding instruments, particularly codes of practice, at state or territory and regional levels. The general principles

Table 4.10: Categories of the extent to which a regulatory framework requires the maintenance of soil physical properties

Category	Category description
1	The instruments require the following components to be taken into account in addressing the risk to soil physical properties from disturbance activities: • site factors, including the soil properties of moisture content, organic matter content, soil type and texture; presence of litter, trash or slash; slope; and rainfall distribution and intensity • management factors, including timing of operations (season), harvesting system, harvesting pattern and slash distribution • vehicle factors, including machine configuration, vehicle weight, dynamic load, tyre size, tyre inflation pressure, wheel slip, tracks or wheels, vibration, number of passes, vehicle speed, area affected, and whether logs are dragged, lifted or carried.
2	The instruments address most of the components listed in category 1, and those not addressed are associated with low risks to soil physical properties for the particular disturbance activity and geographical setting.
3	The instruments address most of the components listed in category 1 but do not specify all aspects or are limited in their application.
4	The instruments mention the need to address risks to soil physical properties when conducting disturbance activities but do not specify the components listed in category 1.
5	The instruments do not mention the need to address risks to soil physical properties.

Source: SOFR 2008.

Table 4.11: Extent to which legally and non-legally binding instruments address the risk to soil physical properties from forest operations, road and trail works, fire management and recreation activities

Instrument	Tenure	Assessed category[a]					
		NSW	NT	SA	Tas.	Vic.	WA
Legally binding	Multiple-use public forests	1	1–5[b]	4	1	1	4
	Public nature conservation reserves	2	2	4	2	1	4
Non-legally binding	Multiple-use public forests	1	5	1[c]	1	3	3
	Nature conservation reserves	2	5	4	2	3	4

a Values refer to category descriptions in Table 4.10.

b Extent to which instruments address the risk to soil physical properties varies between 1 and 5 for different management disturbance activities.

c The *Guidelines for Plantation Forestry in South Australia 2009*[105] were released during the reporting period, and supersede the *Environmental Management Guidelines for Plantation Forestry in South Australia* (ForestrySA 1997).

Note: Data were not available for ACT and Qld.

Source: Compiled by the Australian Bureau of Agricultural and Resource Economics and Sciences from information obtained from state and territory agencies.

105 http://www.pir.sa.gov.au/__data/assets/pdf_file/0020/104735/guidelines_for_plantation_forestry_in_sa_web.pdf.

Bark and branches being used as brush matting at a log landing to protect the soil from vehicle tyres.

of the codes of practice are that the extraction of logs is to be carried out in a manner and by methods that do not result in significant soil disturbance. Consequently, any potential damage is mitigated. In addition, damage caused by the operation, including damage to soil physical properties, is to be repaired. Aspects that are covered in codes of forest practice include assessment and management of soil compaction, mitigating soil movement, creation and management of filter strips or buffers, and consideration of appropriate machinery to protect soil physical properties.

In Queensland, the *Code of Practice for Native Forest Timber Production on State Lands* (EPA 2007) requires soil assessment to be used to identify soil compaction hazards. The document provides guidance for managing these hazards, including estimating the soil compaction rating, which is subsequently used to determine operational restrictions.

The Queensland code covering native forest on freehold land, *Field Guide. Code applying to a Native Forest Practice on Freehold Land* (DNRW 2007), sets a minimum acceptable environmental management standard to ensure that soil physical fertility is protected from compaction or mass movement. This code specifically requires that a native forest practice must not occur in areas where an activity will disturb acid sulphate soils, unless soils are managed in accordance with the soil management guidelines in the *Queensland Acid Sulfate Soil Technical Manual* (Dear et al. 2002); the manual requires that roads and tracks must not be used when soils are saturated and surface water pools or flows in table drains. In 2009, Timber Queensland produced a draft code for stakeholder consultation covering private plantation forests in the state, titled the *Code of Practice for Queensland Commercial Private Plantations*[106], which includes soil protection as one of its goals, and specifies guiding principles to achieve this goal.

Harvesting activities by Forests NSW[107] in multiple-use public forests in New South Wales require a comprehensive soil assessment procedure, designed to minimise soil erosion and protect soil physical properties. These assessments must meet the requirements of environment protection licences issued by the New South Wales Office of Environment and Heritage. The licence ensures adherence to several Acts, including the New South Wales *Soil Conservation Act 1938*.

In Tasmania, forest activities carried out under the *Forest Practices Act 1985* require assessment of risks to soil physical properties in accordance with the *Forest Practices Code 2000* (Forest Practices Board 2000), irrespective of land tenure or forest type.

In the Northern Territory, the draft *Northern Territory Codes of Practice for Forestry Plantations*[108] aims to protect soil quality by requiring a range of mitigation measures to prevent structural change during forestry operations. Minimising adverse impacts on soil, such as compaction and fertility loss, is a major focus during forestry and associated operations.

In Victoria, the *Code of Practice for Timber Production* (DSE 2007a) covers operations in both native and plantation forests. It requires each forest to have a Forest Coupe Plan to describe measures to protect and rehabilitate soils. For example, in protecting soil physical properties, the code requires that the machinery must not enter any set filter strip, except at stream crossings. It also requires that the potential for mass soil movement must be assessed when operating on steep soils, and necessary preventive actions must be undertaken; these include felling trees out of filter strips to reduce soil disturbance, and using techniques such as cable logging to minimise soil movement.

In the Australian Capital Territory, all operations carried out within a forest need to be conducted according to an Operational Plan based on the *ACT Code of Forest Practice* (Environment ACT 2005). The code emphasises that protection of soils must be considered of high importance in the management of forested land, and that measures to mitigate the impact of soil disturbance need to be an integral feature of all operational plans. The code also requires that soil compaction and rutting depth are considered when assessing suitability of machinery for operations, particularly in areas where low-impact machinery is required.

The Western Australian *Forest Management Plan 2004–2013* (CCWA 2004) covers the main wood production areas in the state, and places strong emphasis on the protection of soil and water values. The plan recognises that wood harvesting is the operation with the greatest potential to affect the physical structure of soils, particularly since it can occur over larger areas than some other activities (e.g. extraction of minerals), and the plan identifies protection of soil resources in forested areas as one of its key goals. For example, it requires the Forest Products Commission, which is responsible for the harvest and sale of the state's wood resources, to conduct its operations in a manner that protects soils in accordance with the *Code of Practice for Timber Plantations in Western Australia* (FIFWA 2006).

106 www.timberqueensland.com.au/Docs/News%20and%20Events/News/Draft-Qld-private-plantation-code-of-practice_stakeholder-consultation_Oct09.pdf.

107 From January 2013, the Forestry Corporation of NSW.

108 www.planningplantations.com.au/assets/pdfs/management/regulation/nt/KeepDraftNTCodesofPracticeforForestryPlantations.pdf.

In addition to the *Forest Management Plan 2004–2013*, instruments in Western Australia that assist in the protection of soil physical properties include the *Soil and Water Conservation Guideline* (DEC 2009a) and the *Manual of Procedures for the Management of Soils Associated with Timber Harvesting in Native Forests* (DEC 2010a). The *Soil and Water Conservation Guideline* provides a number of guiding principles, supported by relevant strategies, for the conservation of soil values. The *Manual of Procedures for the Management of Soils Associated with Timber Harvesting in Native Forests* provides a guide for managing soil properties, including a trafficability index that defines soil management risk periods and permissible activities in relation to soil moisture. The manual also specifies the additional planning and approval requirements for operations during the wetter part of the year, and includes definitions of soil disturbance categories and procedures for assessing and monitoring soil disturbance.

Assessment of risk to soil physical properties during planning processes

Assessment of the potential risk to soil physical properties is usually covered in the codes of practice and other instruments. It is generally carried out by forest managers, in conjunction with an assessment of soil erosion hazard, using the various processes reported in Indicator 4.1b. These assessments usually consist of a combination of office-based assessments and field verification. Many forest managers make such assessments using similar parameters to those in Table 4.12 as a series of overlays in a geographic information system.

Table 4.13 shows the area of multiple-use public forest for which disturbance activities were planned in 2010–11, the proportion of that area that was assessed for risk to soil physical properties and the category of assessment used (using categories defined in Table 4.12). In New South Wales, South Australia, Tasmania and Western Australia, almost all areas of multiple-use public forest subject to disturbance were assessed for risk to soil physical properties.

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Table 4.12: Categories of the extent to which soil physical properties are assessed in planning processes

Category	Category description
1	The soil physical properties risk assessment system takes into account all the following factors: • site factors, including the soil properties of moisture content, organic matter content, soil type and texture; presence of litter, trash or slash; slope; and rainfall distribution and intensity. • management factors, including timing of operations (season), harvesting system, harvesting pattern and slash distribution. • vehicle factors, including machine configuration, vehicle weight, dynamic load, tyre size, tyre inflation pressure, wheel slip, tracks or wheels, vibration, number of passes, vehicle speed, area affected, and whether logs are dragged, lifted or carried.
2	The risk assessment system takes into account most of the components listed in category 1, and those not addressed are associated with low risks to soil physical properties for the particular disturbance activity and geographical setting.
3	The risk assessment system takes into account some of the factors listed in category 1 or only partly accounts for these factors.
4	The risk assessment system is ad hoc and/or does not take into account any of the factors listed in category 1.

Source: SOFR 2008.

Table 4.13: Area of multiple-use public forest where disturbance activities were planned, proportion assessed for risk to soil physical properties, and assessed category, 2011–12

Disturbance activity	Metric	NSW	SA[a]	Tas.	Vic.	WA
Native forest harvesting and silviculture	Area (hectares)	27,484	n.a.	n.a	5,250	n.r.
	Assessed for risk to soil properties (%)	100	n.a.	100	25	100
	Assessed category[b]	1	n.a.	1	3	3
Plantation operations	Area (hectares)	14,068	n.r.	4,600	n.r.	n.r.
	Assessed for risk to soil properties (%)	100	100	100	90	n.r.
	Assessed category[b]	1	1	1	2	n.r.
Road construction and maintenance	Area (hectares)	n.r.	n.r.	n.r.	n.r.	n.r.
	Assessed for risk to soil properties (%)	100	100	100	60	100
	Assessed category[b]	1	3	1–2	2	3
Fire management	Area (hectares)	36,931	n.r.	n.r.	n.r.	n.r.
	Assessed for risk to soil properties (%)	100	100	100	90	n.r.
	Assessed category[b]	1	3	1–2	2	n.r.

n.a. = not applicable; n.r. = not reported

[a] South Australia does not harvest native forest.

[b] Ratings refer to category descriptions in Table 4.12.

Note: Data were not available for ACT, NT and Qld.

Source: State agencies.

Knowledge base on soil physical properties

The protection of soil during wood harvesting and other disturbance operations has been an area of considerable development during the past decade (CCWA 2012a). The potential impacts on soils of various forest activities —in particular, disturbance by machinery—are well known. Assessments of risks to soil physical properties and management of such risks are generally carried out in multiple-use public forests in all state and territories according to science-based procedures. Table 4.7 in Indicator 4.1b describes the knowledge base on soil erosion and soil physical properties.

The knowledge base is less developed for nature conservation reserves. In that tenure, knowledge is generally site-specific, since it has been developed to meet specific needs such as recreational activities.

Knowledge of risks to soil properties is progressively incorporated into appropriate state and territory legally and non-legally binding instruments, and disseminated to the industry in various ways. For example, in Tasmania, dissemination of knowledge occurs through the Forest Practices Authority, which provides landowners and managers with access to soil management resource materials, including manuals and fact sheets. Combined with ongoing research and training and the experience of forest managers, these resources assist with the identification and mapping of soils, and enable assessment and management of risks arising from the interactions of factors such as slope, climate, soil type, rainfall, stream management and vegetation cover.

Rolling dip construction, south-west Western Australia. Rolling dips divert water off roadways and reduce the risk of soil erosion.

The coverage and detail of mapping of soils in forested areas varies across states and territories, For example, major areas of state forest in northern Tasmania have been mapped at 1:250,000 scale, and 95 soil types with differing properties and erosion risks have been identified throughout the state, mostly in multiple-use state forests. The Forest Practices Authority has issued 34 forest soil fact sheets for forest managers.[109]

[109] www.fpa.tas.gov.au/publications/document_list.

Indicator 4.1d

Management of the risk to water quantity from forests

Rationale

This indicator measures the extent to which the risk to water quantity has been explicitly identified and addressed in forest management. Water quantity is important for ecosystem health and water supply for human use.

Key points

- A widespread drought from 1997 to 2009 contributed to the recent increase in awareness among Australians of the importance of managing water resources effectively.
- Most jurisdictions have in place regulatory instruments, such as codes of practice or management guidelines, to manage water yields from forests.
- Practices such as selecting the location of forest to be harvested, limiting the proportion of catchments to be harvested in a year, and thinning to increase water yield, continue to be implemented to manage potential impacts of forestry operations on water quantity.
- Understanding of the impacts of forest type, age, growth rate and density on water yield continues to improve, but the ability to predict changes in water yield in specific circumstances is less well developed.
- Water use by tree plantations continues to be the subject of community attention and scientific research. The Murray–Darling Basin Plan includes coverage of water interception by commercial plantations.
- Major wildfires during the reporting period, and water use by the resultant natural regrowth, are expected to change water yields in some affected catchments in coming years.

Large areas of forest land are used to provide reliable and clean supplies of water for human drinking, as well as for irrigation and industrial uses. The quantity of water available in streams and rivers flowing from forested catchments depends on the combination of rainfall, water use by the forest vegetation, run-off, and entry to groundwater systems. Rainfall varies seasonally and across longer periods, and the amount of water used by a forest stand depends on its age, density, species mix and growth rate. In general, however, forested catchments provide a lower risk of variation in water quantity and quality than do catchments with other (non-forest) land uses.

Management practices likely to affect water yields in forested catchments include the timing, scale and spacing of wood harvesting; thinning of regrowth forest; fire management; control of woody weeds; modifications to rotation length; and land-use change (e.g. deforestation for agriculture, or reforestation of former agricultural land).

Major bushfire events can also influence water yields by changing the age-class structure of native forests. Bushfires pose a risk to water yields in forests in all tenures, including both nature conservation reserves and multiple-use public forests, because the greater water use by regrowth forest can result in stream-flow reductions. Recent large bushfires in Australia (see Indicator 3.1b) and the subsequent establishment of regrowth forests are expected to affect current and future water yields in some burnt areas.

Most of south-eastern Australia was subject to drought from 1997 to 2009, a period sometimes referred to as 'the big dry' (Gergis et al. 2011) or, more formally, the millennium drought. This drought affected water availability, agriculture and ecosystem function in a region that supports about 60% of Australia's population and 40% of the nation's total agricultural production. Australia officially became drought free in the first half of 2012 (Ludwig 2012).

The millennium drought contributed to a recent general increase in awareness among Australians of the importance of managing water resources effectively (Heberger 2012). It also prompted steps towards a more proactive approach to drought management, and preparing land managers, particularly farmers, for a potentially increasingly variable future climate.

Climate change is predicted to cause rainfall deficits in southern Australia, reducing water yields (see Indicator 3.1a), and to affect forest productivity (ABARES 2011a). Climate change could also increase the impact of forest activities on water yields, especially in drier parts of Australia.

Instruments in place that address the risk to water quantity

Regulatory instruments, such as codes of practice and management guidelines, specify measures to be implemented to maintain stream flows and water quantity in particular locations. These instruments also provide benchmarks against which the management of water quantity can be assessed. Table 4.14 sets out the various categories of regulatory instruments, and Table 4.15 indicates the extent to which legally binding and non-legally binding regulatory instruments address the risk to water quantity posed by forest management activities in multiple-use public forests.

In Tasmania, the *Forest Practices Code 2000* restricts wood harvesting to no more than 5% of any water supply catchment in any given year.

In Victoria, Melbourne's water supply catchments include large areas of national parks and some state forests. VicForests conducts wood harvesting in certain state forest catchments (e.g. Thomson, Tarago, Bunyip and Yarra tributaries) after forest areas have been allocated for harvesting by the Department of Sustainability and Environment[110]. The Victorian *Code of Forest Practices for Timber Production* regulates wood harvesting; it contains measures to protect water yield and water quality, including leaving buffer zones along streams, installing drainage on harvesting tracks, and ensuring that access roads are well maintained. In the Yarra tributaries (four small catchments in the Warburton area), wood harvesting is conducted in only one catchment per year. During the period of harvesting (December–April), water from the harvested catchment is not used for urban water supply and, instead, is delivered to the Yarra River as an environmental flow.

In South Australia, draft water allocation plans that address the impacts of forest management (principally in plantations) have been released for the lower Limestone Coast (south-east South Australia), eastern Mount Lofty Ranges and western Mount Lofty Ranges. Water quantity policies are also included in the 2009 Kangaroo Island Regional Natural Resources Management Plan (see http://www.naturalresources.sa.gov.au/kangarooisland/about-us/our-regions-plan). In November 2011, the South Australian Parliament amended the *Natural Resources Management Act 2004*, to enable natural resource management boards to control significant plantation water use through licensing or a forest permit system.

In New South Wales, operations in public multiple-use native forests are required to be dispersed in space and time under conditions of integrated forestry operations approvals; these include environment protection licences, as required by the *Forestry and National Park Estate Act 1998*. Harvesting activities are generally restricted to 1–2% of the total catchment area in any one year.

In Western Australia, a 10-year forest management plan (the *Forest Management Plan 2004–2013*) is applied to the main wood production areas in the state's south-west. The plan includes a broad requirement to maintain water quantity.

Across Australia, and in line with management objectives, there is generally very little disturbance apart from fire in forested public nature conservation reserves. Where planned disturbance occurs (such as during road construction, trail maintenance, fire management or infrastructure development), legal instruments in all states and territories require the protection of water values.

Water quantity knowledge base

Knowledge of the effects of forest operations on water quantity is well developed, particularly in New South Wales and Western Australia (Table 4.16). Capacity to model the effects of forest type, forest age, soil type and climatic variation on catchment water yield improved during the reporting period (Benyon et al. 2009, Bren et al. 2011), and continues to be a key area of research.

In Victoria, a range of studies have been undertaken on the impacts of wildfires on stream flow. Modelled impacts on water yields are very sensitive to assumptions about the mortality and recovery of forest vegetation in response to fire severity, and about post-fire rainfall.

In New South Wales, Forests NSW[111] has been conducting catchment-scale research on the impacts of forest management activities on water quantity for more than 30 years. This includes studies in the Red Hill plantation catchment near Tumut (Case study 4.2) and the Canobolas plantation catchment near Orange (Webb 2009), as well as modelling work in the south-east native forests (Webb 2012).

Long-term hydrological studies in three types of mixed-species eucalypt forest in New South Wales found an increase in water yield after harvesting, dependent on the proportion of the catchment area harvested. The increase persisted for at least three years, after which water yield returned to pre-harvest levels, before progressively declining in regenerating forest in some catchments by up to 20% of the pre-harvest yield; this reduction was generally temporary and was related to changes in forest species composition, basal area and stocking rates. The water yield reductions observed in studies in other states on ash eucalypt forests do not typically occur in mixed-species eucalypt forests in New South Wales (Webb et al. 2012b).

110 From April 2013, the Department of Environment and Primary Industries.

111 From January 2013, the Forestry Corporation of NSW.

Table 4.14: Categories of the extent to which regulatory frameworks aim to maintain water quantity after disturbances associated with forest management

Category	Category description
1	The instruments require the following components to be taken into account in addressing the risk to water quantity posed by forest management–related disturbance activities: • local and regional requirements relating to water yield, and the sensitivity of the water supply system to changes in water yield • age structure of stands in forested catchments • the conversion of mature stands to regrowth • rotation lengths • stand density.
2	The instruments address most of the components listed in category 1, and those not addressed are associated with a low risk to water quantity for the particular disturbance activity and geographical setting.
3	The instruments address most of the components listed in category 1 but do not specify all aspects or are limited in their application.
4	The instruments mention the need to address risks to water quantity when conducting disturbance activities but do not specify the components listed in category 1.
5	The instruments do not mention the need to address risks to water quantity.

Source: SOFR 2008.

Table 4.15: Extent to which legally binding and non-legally binding instruments address the risk to water quantity from forest management activities in multiple-use public forests (including plantations)

Type of instrument	Assessed category				
	NSW	SA	Tas.	Vic.	WA
Legally binding	2	2	1	2	4
Non-legally binding	2	4	1	2	5

Note: A lower number implies a higher level of prescriptive detail in the regulatory instrument (see Table 4.14 for category descriptions). No data available for Qld.
Source: Compiled by the Australian Bureau of Agricultural and Resource Economics and Sciences from information obtained from state agencies.

Table 4.16: Knowledge base on water quantity, by jurisdiction

Jurisdiction	Water quantity knowledge base
ACT	Increasing knowledge of how pine plantations affect the quantity of water collected in catchments.
NSW	Well-developed knowledge based on long-term (30-year) forest hydrology research on catchments in a number of locations. Research has been published. Models have been developed to assess the impacts of operations in plantations and native forests.
SA	Reasonable knowledge of impacts of activities on water quantity, including local knowledge and training, codes of practice, published research and geographic information systems. However, the need for improved knowledge to assist managers with some risk factors has been identified.
Tas.	Increasing knowledge of impacts of activities on water quantity, including local knowledge, modelling, research results, training and codes of practice. Models have been developed to assess the impacts of plantation growth.
Vic.	Reasonable knowledge of impacts of activities on water quantity, including local knowledge and training, modelling and codes of practice. However, the need for improved knowledge to assist managers with some risk factors has been identified.
WA	Well-developed knowledge, including published research, geographic information systems, decision-support tools, codes of practice, local knowledge, training and site-specific research models.

Note: Data were not available for NT or Qld.
Source: State and territory agencies.


Wendy Whitby

Native forest protecting a riparian zone in a softwood plantation in southern New South Wales.

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This prediction of a relatively small change in water yield is supported by a recent study that investigated the impact of native forest harvesting on water yield in Murray–Darling Basin catchments (Bren et al. 2011). The study showed that, for most of the Murray–Darling Basin, native forest harvesting would increase water yields by a small amount compared with the yield in mature forest. However, catchments with high rainfall—namely, the Goulburn/Broken River, the Ovens/Kiewa River and the upper Murray River catchments—showed decreased yields for a period after harvesting. The study also found that cessation of harvesting would lead to a small decrease in flow, before flows increased after about 20 years. Potential water yield gains would take a long time to achieve and would depend on the absence of natural disturbances, such as fire, that would result in further forest regeneration. Overall, the study concluded that it is possible to manage native forests to achieve an optimal level of wood and water production through a combination of carefully scheduled harvesting and fire management.

A study undertaken as part of the CSIRO Water for a Healthy Country Flagship assembled and analysed data spanning 19 years on forests and catchments in the south-west region of Western Australia (Li et al. 2010). The study demonstrated the effects of forest density on run-off, and provided new information and tools to predict changes in run-off under various forest management and rainfall scenarios.

Toorongo Falls on the Toorongo River, managed production forest, Gippsland, Victoria.

Plantations

In Australia, forest plantations occupy only a small percentage of the catchments in which they occur (Gavran 2012). The location and management of plantations are subject to land-use policies and planning controls. Sustainability considerations are encompassed by forest management systems, including codes of practice and management prescriptions. Development of large-scale plantation forestry was included as one of the land-use changes to be considered by the *Intergovernmental Agreement on a National Water Initiative*[112], which provided a framework for considering the impacts of activities that could intercept water.

Water use by trees varies with species, soil type, rainfall and location. Because rainfall and hydrological factors are highly variable, it is difficult to measure the impact of plantations on water yields in small catchments if the plantations occupy less than 15–20% of the catchment; this threshold is lower in larger catchments. Nevertheless, community concern about water use by plantations has increased in the past decade as the prolonged drought has affected the availability of water in many catchments. This has created policy questions about water allocation and the entitlement of land managers to water resources, including rainfall.

The Murray–Darling Basin Plan (MDBA 2012) lists commercial plantations as a form of water interception, and specifies the maximum amount of water that commercial plantations may take from each sustainable diversion limit resource unit.[113] Under certain circumstances, the Murray–Darling Basin Plan requires that water resource plans set out a process for monitoring the impact of commercial plantations on water resources. Water resource plans also need to identify actions to be taken if such monitoring shows that a commercial plantation (alone or with other types of water interception) is compromising the environmental water requirement, or that there is an increase in the quantity of water being taken by the plantation.

Concerns about plantations and water use expressed in the literature have been built on assumptions that have not necessarily been tested. Many factors affect plantation water use, and alternative approaches to the design and management of forest plantations to maximise water-use efficiency have been proposed, but few have been tested (Vanclay 2009).

[112] http://nwc.gov.au/__data/assets/pdf_file/0008/24749/Intergovernmental-Agreement-on-a-national-water-initiative.pdf.

[113] A sustainable diversion limit resource unit comprises the water resource, or particular parts of the water resource, of a water resource plan area, and is either a surface-water sustainable diversion limit resource unit or a groundwater sustainable diversion limit resource unit.

Case study 4.2: Response of stream flow to afforestation and thinning at Red Hill, near Tumut, Murray–Darling Basin

Competition for water resources in the Murray–Darling Basin has led to a need to account for changes in water use arising from land-use change, including establishment and management of plantation forests. Generalised forest conversion models have been used in the past to assess the likely impacts of future afforestation on stream flows within the Basin. These models are a useful starting point, but do not account for changing forest age or for silvicultural interventions such as thinning. At various locations in the Basin, Forests NSW[114] has been conducting research into, and monitoring, plantation water use at the catchment scale since 1989. The aim is to improve the models so that they more accurately determine stream flow, leading to improved management of the impacts of plantations on water interception.

Forests NSW analysed 20-year stream-flow monitoring results from the Red Hill paired catchment study to see if forest age is a significant factor in determining stream flow. The analysis compared the Kileys Run pasture catchment with the Red Hill catchment, which is afforested with *Pinus radiata* plantations. Stream flow in the Red Hill catchment declined steadily over time, particularly six years after planting, when stand basal area rapidly increased.

Mixed-effect model analysis indicated that, over the first 20 years of the plantation rotation, the mean annual impact of afforestation with pines (that is, the increased water use per unit area compared with pasture) was 155 mm, peaking at 211 mm in year 14. Thinning at age 14 years had a significant positive effect on stream flow, which persisted for at least 6 years. Drought conditions, coupled with a process of recharging the catchment soils, contributed to a delayed response of stream flow to thinning.

Collectively, the results indicate that factors such as forest age and thinning can usefully be incorporated into models used in water resources planning to allow more accurate prediction of the hydrological effects of afforestation.

Source: Webb and Kathuria (2012).


Mark Parsons

Plantations in Tasmania.

[114] From January 2013, the Forestry Corporation of NSW.

Indicator 4.1e

Management of the risks to water quality in forests

Rationale

This indicator measures the extent to which the risk to water quality has been explicitly identified and addressed in forest management. Water quality is important for forest ecosystem health and water supply for human use.

Key points

- The effect of forest management activities on water quality is reasonably well understood. The knowledge base improved during the reporting period and informs mitigation of potential risks to water quality that arise from forest management activities.
- In most states and territories, instruments such as legislation, codes of forest practice or best management practice manuals mandate or guide practices that must be carried out to assist in maintaining water quality.
- Assessment of the risk to water quality posed by wood harvesting is reasonably comprehensive across most jurisdictions.
- Assessment of compliance with mitigation measures to protect water quality occurs in all states and territories. Compliance is generally high for wood harvesting operations. There is limited monitoring of the effects of forest management on water quality.
- Bushfires during the reporting period caused temporary declines in water quality across forest tenures, mainly in Victoria and Western Australia.

This indicator reports on the mitigation measures that are in place to protect water quality during forest management activities. The focus of reporting is on multiple-use public forest and public nature conservation reserves, with data generally not available for other tenures in most states and territories.

Water quality

Large areas of forest land supply water for human consumption, as well as for irrigation and industrial uses, with the forest soil and litter acting as a filter that produces clean water. In general, forested catchments provide a lower risk of variation in water quantity and quality than catchments with other (non-forest) land uses. Forestry activities and other disturbances such as fire, however, can have negative impacts on water quality, unless planned, managed or mitigated appropriately—for example, through measures such as drainage of extraction tracks, and maintaining vegetated streamside buffer zones to reduce sediment movement into streams (and also provide habitats and corridors for wildlife).

Four broad disturbance activities that can affect water quality in forested areas are roading, wood harvesting, burning and recreation. The most common impact associated with forest management activities is the generation and movement of sediment into water bodies. However, a number of other factors can also negatively affect water quality. These include pollution from fertiliser and herbicides, elevated water temperature in clearings, and an increase in biological oxygen demand (the oxygen required for breakdown of organic matter by microorganisms).

Reforestation can reduce adverse impacts of dryland salinity and waterlogging, by lowering groundwater levels and decreasing the volume of saline groundwater entering streams.

Planned and unplanned fires have the potential to affect water quality through increased erosion risk, coupled with more intense run-off, which increase flows of sediment, nutrients and other determinants of water quality such as trace elements. Recent examples of major bushfires that caused temporary declines in water quality are the Victorian Black Saturday fire of 2009 and the Western Australian Margaret River region fire of 2011. Although the 2009 wildfires burned 30% of Melbourne's water supply catchments, water quality in storage reservoirs returned to pre-fire condition in nine months, with storm-driven turbidity peaks rapidly returning to baseline conditions (Frame et al. 2009, Smith et al. 2011).

Planning to reduce the impact of recreation infrastructure and activities (such as roading and traffic) on water quality in reserves is managed under various pieces of state and territory legislation. Although recreation activities are often permitted in reserved forests, a relatively small area is used for access and other visitor infrastructure. Hence, most of the area of nature conservation reserves is not subject to such disturbance activities that might affect soil and water values. Wildfire is the major threat to water quality in reserved forests.

Instruments in place that address the risks to water quality

Generally, instruments are in place to control the risks of forestry activities impacting on the quality of water in forested catchments. However, the level of control varies across jurisdictions.

Using the categories described in Table 4.17, the extent to which legally and non-legally binding regulatory instruments, such as codes of practice, guidelines and forest management plans that address water quality, exist across state and territory jurisdictions is rated in Table 4.18. Key mitigation measures include providing adequate drainage for roads, trails and tracks; and protecting streamsides with buffer or filter strips that minimise soil movement into streams.

Legally binding regulatory instruments are in place in New South Wales, South Australia, Tasmania and Victoria. South Australia also has non-legally binding guidelines for its plantation estate that seek to minimise the risk to water quality by considering streams, drainage lines, water bodies and slope, and by specifying appropriate management practices and streamside buffers.

Table 4.17: Categories of the extent to which the regulatory framework requires the maintenance of water quality

Category	Category description
1	The regulatory instruments require the following components to be taken into account in addressing the risk to water quality from disturbance activities: • stream and drainage lines (e.g. including exclusion zones) • road drainage and stream crossings (e.g. cross-draining of log extraction tracks) • slope • sensitive aquatic habitat.
2	The instruments address most of the components listed in category 1, and those not addressed are associated with low risks to quality for the particular disturbance activity and geographic setting.
3	The instruments address most of the components listed in category 1 but do not specify all aspects or are limited in their application.
4	The instruments mention the need to address risks to water quality when conducting disturbance activities but do not specify the components listed in category 1.
5	The instruments do not mention the need to address risks to water quality.

Source: SOFR 2008.

Table 4.18: Extent to which legally and non-legally binding regulatory instruments address the risk to water quality from forest operations, road and trail works, fire management and recreation

Instruments	Tenure	Assessed category[a]				
		NSW	SA	Tas.	Vic.	WA
Legally binding	Multiple-use public forests	1	4	1	1	4
	Public nature conservation reserves	1	4	1	1	4
Non-legally binding	Multiple-use public forests	1	1	1	2	1 (NF) 3 (P)
	Public nature conservation reserves	1	n.a.	1	2	4

n.a. = not applicable; NF = native forest; P = plantation

[a] A lower number implies a higher level of prescriptive detail in the regulatory instrument (see Table 4.17 for category descriptions).

Note: Data were not available from ACT, NT or Qld.

Source: State agencies.

All states and territories undertake auditing in some form. For example, in New South Wales, all forestry operations in multiple-use forests are audited through a four-tier system, along with a monitoring and review exercise. These audits assess both the implementation of systems and the application of specifications or prescriptions, including standards of planning and compliance with regulatory approvals, codes of practice, Australian standards, and statutory requirements such as the *Pesticides Act 1999*. Compliance and monitoring results are reported. As part of the implementation of the Forests NSW[115] Environmental Management System, all operational control documents are periodically reviewed and updated.

In Victoria, the *Code of Practice for Timber Production* (revised in 2007) applies to all timber production on private and public land, and outlines specific requirements to prevent soil sediments, nutrients, chemicals, petroleum products and fertilisers from entering waterways. Mitigation measures outlined in the code include the establishment of buffer and filter strips, the installation of appropriate drainage systems and stream crossings, restrictions on disturbances on steep slopes, the use of silt traps alongside roads, and road closures in wet weather. The *Code of Practice for Bushfire Management on Public Land* addresses the potential impacts of fire disturbance on water quality.

Western Australia has limited legally and non-legally binding instruments, which do not address all the aspects listed in Table 4.17. However, the *Forest Management Plan 2004–2013*, which is currently being reviewed and updated, covers all of the main wood production areas in the state's south-west. The plan places strong emphasis on the protection of water values.

In Tasmania, the risk to water quality is assessed for forest activities when they are carried out under the *Forest Practices Act 1985*, irrespective of the land tenure or forest type. The *Forest Practices Code 2000*, supporting manuals such as the *Guidelines for the Protection of Class 4 Streams*, and forest certification standards such as the Australian Forestry Standard, are also used to minimise the risk to water quality from forestry activities.

In 2009, Timber Queensland produced a draft *Code of Practice for Queensland Commercial Private Plantations*[116], which was circulated for stakeholder consultation. The draft code covers private plantation forests in the state. Along with Queensland's *Code of Practice for Native Forest Timber Production* for public land, this aims to address some of the potential risks that forestry activities may pose to water quality.

Assessment of the risk to water quality

Water quality is generally monitored at many sites across the states and territories to determine whether water for different uses, including drinking water, meets the required standards. Not all these sites are located in forests. It is not always possible to identify the causes of changes in water quality because many factors that determine the spatial and temporal impacts of forest activities are difficult to measure at the local level.

Assessment of the risk of forestry activities to water quality is generally based on field monitoring of water at a limited number of locations, and comparing water quality parameters against recommended thresholds set out in various guidelines and standards. Many forest managers make such assessments using similar categories to those listed in Table 4.19 as a series of overlays in a geographic information system, and then seek advice from the relevant regulatory agencies, if necessary.

Table 4.20 shows disturbance activities planned in multiple-use public forest in 2010–11, the proportion assessed for risks to water quality and the category of assessment, by jurisdiction.

In New South Wales, South Australia, Tasmania, Victoria and Western Australia, assessments of the potential risks to water quality are conducted for forest activities and roading operations in multiple-use public native forests and plantations. However, the assessments have varying levels of robustness. In the states and territories for which data were available, almost all the proposed activities were assessed for risks to water quality.

Water quality knowledge base

The knowledge base of water quality relating to forestry activity is generally reasonably strong (Table 4.21).

The knowledge base is highly dependent on knowledge of soil erosion and appropriate soil erosion mitigation measures. Supported by research, the knowledge base continues to develop, particularly for suspended sediment exports and concentrations after wildfire.

In New South Wales, Forests NSW[117] is undertaking a water-monitoring program in native forests to assess the impacts of its activities on water quality, principally sediment loads (Webb 2008; Webb et al. 2012a). In addition, state and territory authorities in New South Wales, the Australian Capital Territory and Victoria are designing a decision-support system for the management of run-off from unsealed roads.

In South Australia, the Environment Protection Authority monitors water quality to protect environmental values, as set out in the *Environment Protection (Water Quality) Policy 2003*.

A recent study (Smith et al. 2011) reviewed nutrient losses following post-wildfire salvage harvesting of a radiata pine plantation catchment in south-eastern Australia, and compared it with an adjacent eucalypt forest catchment that

115 From January 2013, the Forestry Corporation of NSW.

116 www.timberqueensland.com.au/Docs/News%20and%20Events/News/Draft-Qld-private-plantation-code-of-practice_stakeholder-consultation_Oct09.pdf.

117 From January 2013, the Forestry Corporation of NSW.

Table 4.19: Categories of the extent to which risks to water quality are assessed in planning processes

Category	Category description
1	The water quality risk assessment system comprehensively takes account of all the following factors: • stream and drainage lines (e.g. including exclusion zones) • road drainage and stream crossings (e.g. cross-draining of log extraction tracks) • slope • sensitive aquatic habitat.
2	The water quality risk assessment system takes into account most of the components listed in category 1, and those not addressed are associated with low risks to water quality for the particular disturbance activity and geographic setting.
3	The water quality risk assessment system takes into account some of the factors listed in category 1 or only partially accounts for these factors.
4	The water quality risk assessment system is ad hoc and/or does not take into account any of the factors listed in category 1.

Source: SOFR 2008.

Table 4.20: Proportion of disturbance activities in multiple-use public forest assessed for risk to water quality in 2010–11, and assessed category

Disturbance activity	Metric	ACT	NSW	SA	Tas.	Vic.	WA
Native forest harvesting and silviculture	Assessed for risk to water quality (%)	n.a.	100	n.a.	100	95	100
	Assessed category[a]	n.a.	1	n.a.	1	1	2
Plantation operations	Assessed for risk to water quality (%)	100	100	100	100	95	100
	Assessed category[a]	1	1	1	1	1	3
Road construction and maintenance	Assessed for risk to water quality (%)	100	100	100	100	95	100
	Assessed category[a]	2	1	2	1 (MUF) 2 (NCC, C, Pv)	1	2
Fire management	Assessed for risk to water quality (%)	100	100	100	100	95	–
	Assessed category[a]	2	1	2	1 (MUF) 2 (NCC, C, Pv)	1	–

– = not available; C = Crown lands; MUF = multiple-use forest; n.a. = not applicable; NCC = nature conservation reserve; Pv = private

[a] Ratings refer to categories in Table 4.19.

Note: Data were not available for NT or Qld.

Source: State and territory agencies.

Table 4.21: Knowledge base on water quality, by jurisdiction

Jurisdiction	Knowledge base
ACT	The ACT Government has well-developed knowledge on best management and continuous improvement of water quality within its plantation estate. Codes of practice have specific clauses for protection of riparian zones and drainage lines, for authorisation by the Environment Protection Authority, and for ongoing water monitoring.
NSW	Forests NSW[118] has a well-developed system of research catchments and has published research results. Forests NSW has also developed models to assess impacts of plantation and native forestry operations on water quality.
SA	There is reasonable knowledge on the impacts of forest management activities on water quality. Data on breaches and non-compliance are recorded in ForestrySA's auditing process and in the auditing of other businesses that have forest certification.
Tas.	Tasmania has well-developed knowledge for multiple-use public forest and some private forest. This includes published research, GIS tools, decision-support tools, local knowledge and training, and site-specific research models. Code of practice has specific requirements for protection of watercourses and water quality. The Forest Practices Authority provides regular training to forest managers.
Vic.	There is reasonable knowledge of the impacts of forestry activity on listed values, including local knowledge and training, and codes of practice. However, for some risk factors, a need for improved knowledge to assist managers has been clearly identified.
WA	There is well-developed knowledge, including published research, GIS tools, decision-support tools, codes of practice, local knowledge, training and site-specific research models.

GIS = geographic information system

Note: Data were not available from NT or Qld.

Source: State and territory agencies.

[118] From January 2013, the Forestry Corporation of NSW.

was also burnt but not harvested. Median values of total suspended solids and turbidity returned to pre-fire levels within three years in both catchments. Maximum levels of total suspended solids during storm events in the harvested pine catchment exceeded maximum levels in the eucalypt catchment. In contrast, the impact of harvesting in the pine catchment on solute concentrations was minor, and most solutes returned to pre-fire levels within 2–3 years in both catchments. Nutrient exports from the pine catchment exceeded those from the eucalypt catchment.

Substantial monitoring undertaken in Tasmania indicated that streams within catchments with significant forestry operations showed no significant impacts of these operations on river health. Harvested catchments, for example, had similar macroinvertebrate communities to those without such operations. However, some plantation establishment activities caused minor contamination of water supplies and streams, especially where long-term residual herbicides such as simazine had been applied on soils (McIntosh 2007, 2008). This finding prompted a significant reduction in the use of simazine.

The Tasmanian Department of Primary Industries, Parks, Water and Environment maintains an extensive water quality and river health monitoring network in major rural catchments. Water quality is regularly monitored at 52 sites for a range of nutrients, turbidity, dissolved oxygen and pesticides, and river health is monitored at 60 sites. Floodwaters are also tested for a range of pesticides in four catchments with significant forestry activities.

A water gauge, used to monitor stream flow from a forested water-course, Tasmania.

Compliance with water quality measures

Assessing compliance with requirements for the protection of soil values and water quality is part of the process of assessing compliance with measures to prevent soil erosion (see Indicator 4.1b).

Forestry Tasmania conducted extensive water monitoring tests at sites downstream of chemical application operations between 2006 and 2011. It did not detect any contamination that exceeded Australian drinking water guidelines.

In New South Wales, legislation, codes of practice and the conditions of environment protection licences are implemented in state forests to ensure that any adverse impacts of forest management activities on the quality of water supplies are minimised. Forests NSW[119] monitors the environmental effects of its forestry activities, including on aquatic habitats and water sources, and has implemented a comprehensive, mandatory water quality monitoring program, called the ‘Phase 1’ program, since 1999. The aim of this program is to determine whether forestry activities have an identifiable impact on water quality, such as turbidity and suspended sediment concentration, and, if so, to quantify the level of impact.

A catchment experiment conducted in a control native forest catchment and two pine plantation catchments within Canobolas State Forest, Orange, New South Wales (Webb et al. 2007) found that plantation catchments that were harvested in 2002–03 using legislated best management practices did not have significant impacts on water quality indicators such as turbidity and suspended sediment concentration. In these catchments, the management practices used were adequate to protect streams from the effects of forestry activities. Similarly, a replicated catchment experiment in native eucalypt forest in Kangaroo River State Forest, near Coffs Harbour, New South Wales, showed that selective harvesting using best management practices did not affect suspended sediment yields in two of three treated catchments; in the third catchment, an increase in event sediment loads and concentration, at the time of harvesting, subsided within 12 months (Webb et al. 2012a).

Victoria has a network of stream water quality monitoring sites that record parameters such as acidity, dissolved oxygen, electrical conductivity, sediments and total dissolved solids, temperature, phosphorus and nitrogen, mostly in or downstream from forested areas. Melbourne Water plays a key role in monitoring. It has five water quality monitoring sites on waterways within forested catchments: one in the upper Dandenong Creek catchment and four in the upper Yarra catchment. Monthly grab-sample data have been collected at most of these sites since 2007. The data from these and others sites in the Melbourne Water network are combined with other information to assess the overall health of waterways in the region.

[119] From January 2013, the Forestry Corporation of NSW.

Case study 4.3: Water quality in forested catchments

Stream water quality can depend on many factors, including the topography, geology and vegetation upstream of the monitoring point, and the history of natural or management disturbance in the catchment. Forestry Tasmania researchers used an eight-year dataset collected for 15 streams in the Warra Long-Term Ecological Research site in southern Tasmania (www.warra.com) to compare the relative influence of environmental and disturbance factors on water quality, predominantly assessed by colour and turbidity.

Mean turbidity and mean water colour showed a strong association with landscape position: grouping catchments by water quality attributes (Figure 4.1) produced similar results to grouping catchments geographically (Figure 4.2). Large, high-altitude, reasonably steep catchments in the west of Warra (Crystal, Isabella and Tomalah) contained water that was pale in colour with little suspended sediment; these catchments also had a low proportion of wet sclerophyll forest and a low road density, but high rainfall and good drainage. Streams draining to the south (Bren, Tahune, Leighs, Johns and Laurel creeks) had higher turbidity (possibly from inorganic sediments) and moderate colour. Streams in the central-east (including Glovers, King, Warra, Kroanna and Swanson creeks) had reasonably low turbidity but dark-coloured water, probably resulting from greater input of organic matter to these streams from relatively poorly drained catchments. Water quality therefore varies between catchments according to a range of geographic factors.

Principal component analysis showed relatively strong relationships between geographic and environmental variables and water quality, but weaker relationships between disturbance variables and water quality. This indicates that natural variation in stream water quality in this area of southern Tasmania plays a more important role in water quality at the landscape level than does the catchment history of fire, roading or harvesting.

Figure 4.1: Scatterplot of mean turbidity and mean colour over eight years for water in 15 catchments in the Warra Long-Term Ecological Research site

CU = colour unit;
NTU = nephelometric turbidity unit (a unit of turbidity measured by light scattering).

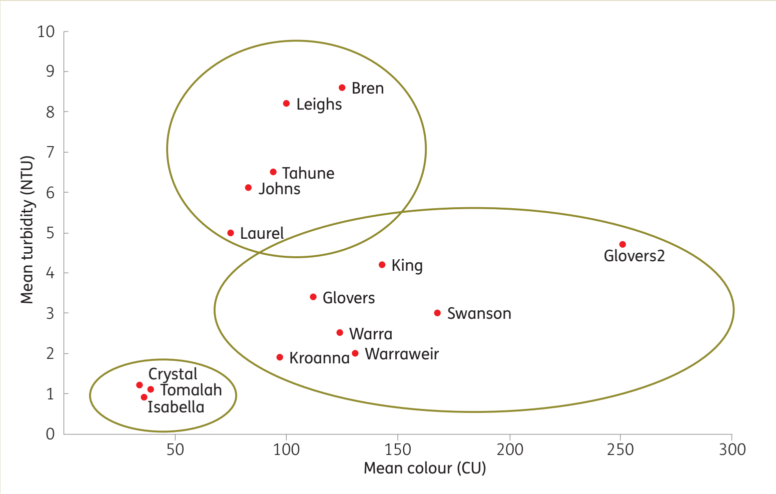
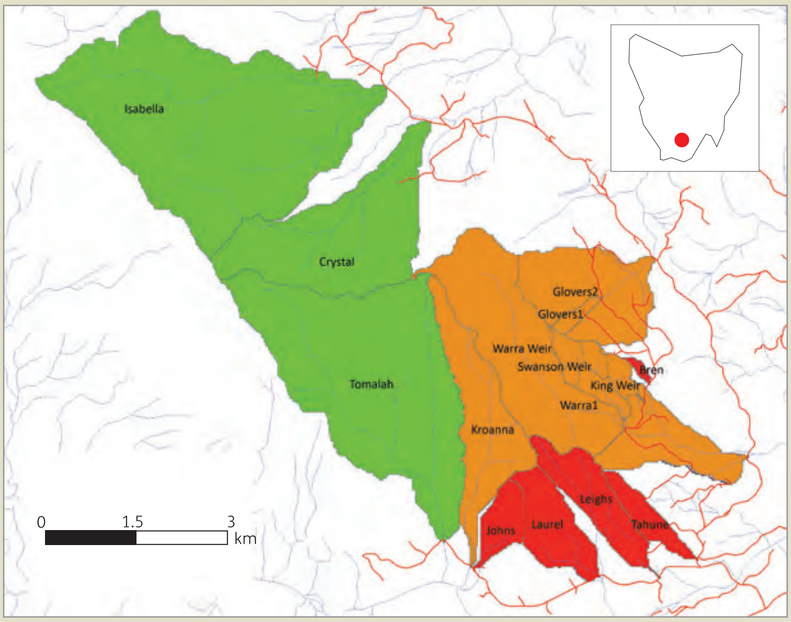


Figure 4.2: Sampled catchments in the Warra Long-Term Ecological Research site coloured by mean turbidity and water colour

- Catchments of low turbidity and low colour
- Catchments of medium turbidity and high colour
- Catchments of high turbidity and medium colour



CRITERION 4

Criterion 5

Maintenance of forest contribution to global carbon cycles


Softwood plantation, Michael F Ryan

Harvested plantation pine logs.

Criterion 5
Maintenance of forest contribution to global carbon cycles

Internationally, concern about the effects on climate of increased atmospheric concentrations of greenhouse gases, such as carbon dioxide (CO_2), has focused attention on the global carbon cycle and human-induced changes to it. Forests are an important component of the global carbon cycle because of the large amounts of carbon stored in forests, the sequestration of carbon in growing forests, the storage of carbon in wood and wood products in service and (at the end of service life) in landfill, and potentially the reduction in emissions when wood is used instead of fossil fuels or more energy-intensive structural materials.

Sustainable management of forests includes maintenance of forest carbon stocks. This criterion, which comprises only one indicator, reports on and quantifies the effects of natural disturbance, forest management and forest land-use change on carbon dynamics.

Forests absorb CO_2 from the atmosphere during photosynthesis, and release it by respiration and the decay or burning of plant material. Early forest growth stages remove net amounts of CO_2 from the atmosphere as the forests grow and store carbon in their biomass. In mature and older forests, however, the net absorption from the atmosphere is usually low, with absorption due to growth balanced by emissions due to death and decay. At the landscape level, the amount of carbon stored in forests changes over time because of:

- the natural developmental or successional dynamics of the forest
- natural disturbances such as wildfire (bushfire), dieback and storms
- variation in climatic factors such as temperature and rainfall
- human activities such as wood harvesting, or clearing for agriculture, urban expansion or other land uses
- increases in forest area due to reforestation of cleared areas, or establishment of commercial plantations and environmental plantings.

Once wood has left the forest, its role in the carbon cycle is determined by factors such as:

- energy used and emissions produced during wood processing and transport
- change in the stocks of wood and wood products in service and in landfill
- reductions in greenhouse gas emissions due to the use of wood for energy generation instead of fossil fuels, and the use of wood for structural purposes in place of other, more energy-intensive structural materials.

For emissions reporting, the forest sector is defined as all living forests (native and plantation) and all wood products. The role of forests and forest management in the carbon cycle is determined by their net effect across the landscape and the economy over a relatively long time, rather than by short-term local changes at individual forest sites. National forest carbon dynamics thus need to be considered over long time frames (more than a decade) to properly assess the contribution of Australia's forests and forest management to the global carbon cycle.

Key findings

Key findings are a condensed version of the Key points presented at the start of the indicator in this criterion.

- A total stock of 13,067 million tonnes of carbon was held in Australia's forests and harvested wood products at the end of 2010. Almost all this carbon (12,841 million tonnes; 98%) was stored in living forest.
- Carbon stocks in Australia's forests declined by approximately 91 million tonnes of carbon in the period 2001–05, then increased by 10 million tonnes of carbon in the period 2006–10. These changes were driven by the net effects of natural disturbances such as wildfire, regrowth following wildfire, and the clearing and conversion of forest land to other land uses, mainly agriculture.
- A total of 103 million tonnes of carbon was held in wood and wood products in service in 2010, which is an increase of 7 million tonnes from 2005, and an increase of 14 million tonnes from 2000. The 123 million tonnes of carbon stored in wood and wood products in landfill in 2010 was 6 million tonnes more than in 2005, and 13 million tonnes more than in 2000.
- Harvested logs contain sequestered carbon. On average, one cubic metre of plantation softwood logs contains sequestered carbon equivalent to 787 kilograms of CO_2, while on average one cubic metre of native forest hardwood logs contains sequestered carbon equivalent to 982 kg of CO_2. The total amount of greenhouse gases emitted by forestry operations to produce a given volume of logs is, on average, equivalent to 3.2% (for softwoods) and 7.3% (for hardwoods) of the amount of CO_2 sequestered in that volume of logs.
- Increasing the use of wood products in place of greenhouse gas–intensive construction materials could increase the greenhouse gas mitigation benefits of forest management.

Sawn plantation softwood timber.

CRITERION 5

Indicator 5.1a

Contribution of forest ecosystems and forest industries to the global greenhouse gas balance

Rationale

This indicator assesses the contribution of Australian forests to the global carbon cycle. Forest management can have a significant positive or negative impact on the global carbon cycle.

Key points

- The effects of natural disturbance, management and land-use change on carbon sequestration by forests, forest carbon stocks and carbon in wood products are quantified and reported in this indicator. The forest area for which carbon stocks are reported (106 million hectares) is the forest area held in the National Greenhouse Gas Inventory and used for Australia's National Greenhouse Accounts.
- A total stock of approximately 13,067 million tonnes of carbon (Mt C) was held in Australia's forests, plus harvested and discarded wood products, at the end of 2010. Almost all this carbon (12,841 Mt C; 98%) is stored in forests; 103 Mt C (0.8%) is stored in wood and wood products in service, and 123 Mt C (0.9%) is stored in wood and wood products in landfill. Of the carbon stored in forests, 16% is stored in production forests and 1.3% in plantations.
- Carbon stocks in Australia's forests declined by approximately 91 Mt C in the period 2001–05. This change was driven by natural disturbances such as wildfire (especially in 2003), and clearing and conversion of forest land to other land uses, mainly agriculture. Over the period 2006–10, forest carbon stocks recovered by 10 Mt C, mainly due to regrowth following wildfires, and less forest being affected by clearing and wildfire. Between 2001 and 2010, therefore, the stock of carbon in Australia's forests decreased by an estimated 81 Mt C (0.6%). Timeframes of more than one decade are needed to determine long-term trends in carbon stocks in forests.
- In the period 2001–10, transfers of carbon from forests to harvested wood products were approximately 103 Mt C; carbon stocks in the pool of wood and wood products in service increased by 14 Mt C (net); and carbon stocks in the pool of wood and wood products in landfill increased by 13 Mt C (net).
- The average plantation softwood log contains sequestered carbon equivalent to 787 kilograms of CO_2-equivalents per cubic metre (kg CO_2-e/m^3), while the average native forest hardwood log contains sequestered carbon equivalent to 982 kg CO_2-e/m^3. Total greenhouse gas emissions from forestry operations for production of these average logs represent 3.2% of the CO_2 sequestered in the softwood log and 7.3% of the CO_2 sequestered in the hardwood log.
- Increasing the use of wood products in place of greenhouse gas–intensive construction materials could increase the greenhouse gas mitigation benefits of forest management.

International concern about the effects on climate of increased atmospheric concentrations of greenhouse gases, such as carbon dioxide (CO_2), has focused attention on the global carbon cycle.[120] Forests are an important component of the global carbon cycle, and maintenance of forest carbon stocks is a key indicator of sustainable forest management. This indicator quantifies and reports on the greenhouse gas balance of Australia's forests, and how this is affected by both natural disturbances and the stewardship and use of Australia's forested lands. The indicator also considers how the forest sector contributes to the global carbon cycle through storage of carbon in wood and wood products in service and, at the end of service life, in landfill.[121]

Forests absorb CO_2 from the atmosphere during photosynthesis and store carbon in biomass, litter and soil organic matter. A significant amount of carbon is stored in wood (Figure 5.1). Carbon is released from forests by respiration, and by the decay and combustion of plant material. The rate of storage of carbon in woody tissue is highest in early-age to mid-age growth phases of trees (regenerating and regrowth forests). In mature and older forests, net exchange of carbon with the atmosphere is usually low—slower growth is balanced by death and decay. Nitrous oxide (N_2O) may be emitted from forest ecosystems as a by-product of nitrification and denitrification processes, as well as the burning of organic matter. Other gases released during biomass burning include methane (CH_4), carbon monoxide (CO), other oxides of nitrogen (NO_x), and non-methane volatile organic compounds (NMVOC).

The amount of carbon stored in Australian forested landscapes can change over time because of:

- the natural developmental or successional dynamics of forests
- natural disturbances such as wildfire (bushfire), dieback and storms
- variation in climatic factors such as temperature and rainfall
- human activities such as wood harvesting, or clearing for agriculture, urban expansion or other land uses
- increases in forest area due to reforestation, or establishment of commercial plantations and environmental plantings.

The role of forests in the carbon cycle is best interpreted at a macro scale—that is, the atmosphere is influenced by the net effect of forest biology and forest management across landscapes, the nation and the economy, rather than local changes at individual forest sites.

Activities such as site preparation and planting, fertiliser application, spraying for pests and weeds, pruning and thinning, and preparation for harvesting influence the uptake and release of greenhouse gases by production plantation forests.

Figure 5.1: Cross-section of stem of radiata pine (*Pinus radiata*)

Forests NSW

Note: Annual growth is marked by the rings. During photosynthesis and active growth, carbon dioxide (CO_2) captured from the atmosphere is combined with water taken up from the soil to produce wood and return oxygen to the atmosphere; about 1 tonne of CO_2 is captured to produce 1 cubic metre of wood containing 0.27 tonnes of carbon.

Once wood has left the forest, its role in the carbon cycle is determined by factors such as:

- energy used and emissions produced during wood processing and transport
- change in the stocks of wood and wood products in service and in landfill
- reductions in greenhouse gas emissions from fossil fuels due to the use of wood for energy generation instead of fossil fuels, and the use of wood for structural purposes in place of more energy-intensive structural materials.

Australia's National Greenhouse Accounts during the SOFR reporting period were published annually by the then Australian Government Department of Climate Change and Energy Efficiency[122], DCCEE[123]. These accounts are derived from Australia's National Greenhouse Gas Inventory, and are prepared according to the rules specified under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. National inventories report anthropogenic emissions by sources, and removals by sinks, of greenhouse gases not controlled by the Montreal Protocol.[124]

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120 Greenhouse gases other than carbon dioxide are included in national greenhouse accounts by converting them to carbon dioxide equivalents (CO_2-e).

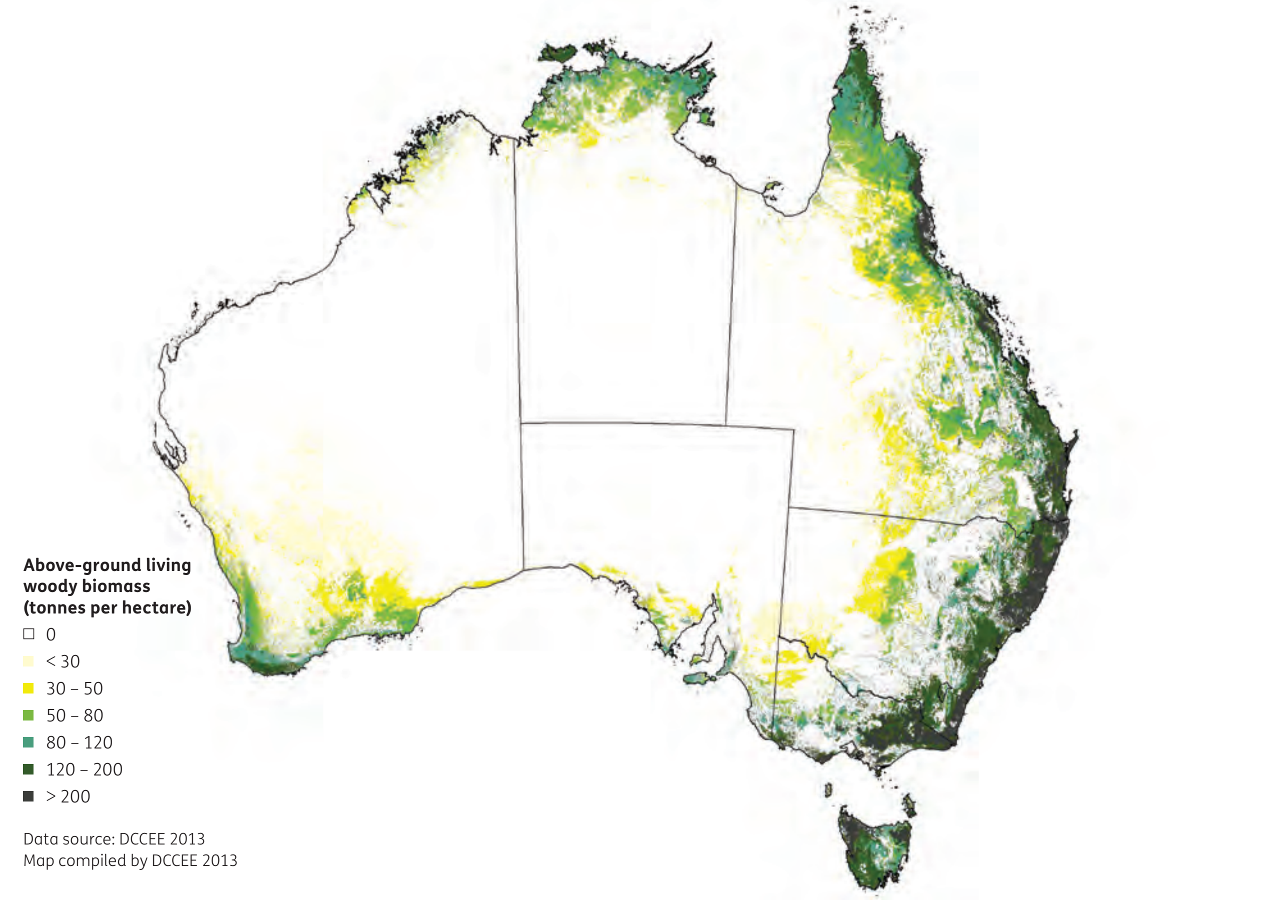
121 For formal emissions reporting, the forest sector includes all forests (native and plantation) and wood products in service, but not wood products in landfill (emissions from which are accounted for in the waste sector).

122 From September 2013, the Department of the Environment.

123 See www.climatechange.gov.au/climate-change/emissions.aspx.

124 The Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol to the Vienna Convention for the Protection of the Ozone Layer) is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances believed to be responsible for ozone depletion.

Figure 5.2: Biomass density of Australia's forests, 2010



Notes:

Forest extent (106.4 million hectares) as determined for Australia's National Greenhouse Gas Inventory for greenhouse gas accounting as at the end of 2010 differs from that used elsewhere in this report because of methodological and measurement reasons: see Indicator 1.1a.

Forests with higher carbon densities are found in the wetter areas of the south-west, south-east and east of Australia; the northern and inland forests have lower carbon densities.

In Australia, the National Greenhouse Gas Inventory (DCCEE 2012b) has been developed to provide emissions estimates from the entire economy, including Australia's extensive land sector. The land sector includes approximately 106 million hectares of forests, as assessed by DCCEE as at the end of 2010[125] (Figure 5.2), and contributes about 7% of total human-induced greenhouse gas emissions to the annual national inventory, primarily through activities such as land clearing. The analyses of carbon stocks presented in this indicator result from the application of Australia's national inventory system to the quantification of carbon stocks in the forest area of Australia assessed for the purpose of the National Greenhouse Accounts.

DCCEE has monitored forest cover using national coverages of Landsat satellite data (using the Landsat MSS, TM, and ETM+ products[126]) over 20 time periods from 1972 to (most recently) 2011, including annually from 2004. This imagery is assembled as maps, and used to detect fine-scale changes in forest cover at a resolution of 25 metres by 25 metres. The changes are analysed to identify whether they are due to human activity (e.g. wood harvesting, forest clearing, plantation establishment) or natural events (e.g. dieback, wildfire).

Changes in the carbon stock in Australia's forests are estimated using modelling methodologies consistent with international requirements (Penman et al. 2003). Changes in carbon stock in production forests are estimated using the Full Carbon Accounting Model (FullCAM), an ecosystem model that uses a mass-balance approach to carbon cycling for each of the following carbon pools:

- biomass
  - above-ground biomass (stem or bole, branches, bark, leaves)
  - below-ground biomass (roots)
- dead organic matter
  - dead wood
  - litter
- soil organic matter.

[125] For methodological and measurement reasons, this forest area used for Australia's national inventory system for greenhouse gas accounting differs from the forest area presented in Indicator 1.1a and used elsewhere in this report (see Indicator 1.1a).

[126] http://landsat.gsfc.nasa.gov/.

Box 5.1: The Carbon Farming Initiative

The Carbon Farming Initiative (CFI) is a voluntary offsets scheme that allows farmers and land managers to create carbon credits either by reducing greenhouse gas emissions or by storing carbon in vegetation or soils.

CFI methodologies set out the rules and instructions for undertaking projects, estimating abatement, and reporting to the Clean Energy Regulator. Each CFI project must use an approved CFI methodology to ensure that abatement is measurable and verifiable.

Sequestration projects remove CO_2 from the atmosphere by sequestering carbon in plants as they grow and as they increase soil organic matter. Projects that avoid losses of vegetation or soil organic matter are also sequestration projects. Examples are reforestation, revegetation, restoring rangelands, increasing soil carbon, and protecting native forests or vegetation at imminent risk of clearing.

In addition to boosting farmers' and landholders' incomes through the sale of carbon credits, the CFI provides other benefits. For example, the environmental plantings methodology could be used by landholders who want to establish plantings to provide shelter for stock, minimise erosion, reduce salinity, improve water quality or provide habitat for wildlife.

Carbon stored in vegetation and soils can be released to the atmosphere, reversing the environmental benefit of the sequestration project. For this reason, all sequestration projects are subject to permanence obligations. The CFI permanence rules recognise the realities of Australia's natural environment and climatic conditions. Owners of environmental planting projects will not be penalised for losing carbon because of bushfire, drought, pests or disease. In most cases, vegetation and other carbon stores will recover naturally after these events; if not, landowners must take reasonable action to re-establish carbon stores.

The permanence rules allow landholders to cancel their projects and remove carbon stores at any time by handing back the credits that were issued for the project. Credits could be purchased at the prevailing market price or transferred from another project.

Participants can use the CFI Reforestation Modelling Tool to calculate carbon stocks. They may also use the CFI Mapping Tool to monitor and report on geospatial information in line with the spatial mapping guidelines. These tools are free and, together with the mapping guidelines and additional information about the CFI, are available at www.climatechange.gov.au/cfi.

CO_2 emissions related to harvested wood products (HWPs) are reported in the land use, land-use change and forestry (LULUCF) component of Australia's National Greenhouse Gas Inventory. Emissions over time depend on the service life of wood-based products. Emissions from disposal of HWPs are reported in the waste sector if HWPs are transferred to landfill, or the energy sector if HWPs are combusted for electricity generation.

Carbon stock account for Australia's forests, 2001–10

Causes of carbon stock changes in forest systems

Major events causing reductions in national forest carbon stocks that are monitored and estimated include natural disturbance events, such as bushfires; wood harvest from production forests; and forest clearing for agriculture, urban or industrial development.

Major increases in carbon pools occur in forests regrowing from past disturbance events such as fire or wood harvesting, and also following planting events, afforestation and reforestation. Regrowth may take 100 years for the trees to approach maturity (see Indicator 1.1b).

This assessment also includes changes in carbon stocks as a result of temporary or intermittent changes in forest cover, gains and losses of leaf area in areas that remain forest, and natural growth or woody thickening.

Carbon stock changes, 2001–05 and 2006–10

The stock of carbon in Australia's forests in 2010 is estimated to be 12,841 million tonnes of carbon (Mt C) (Table 5.1). The stock of carbon in forests decreased by 81 Mt C (0.6%) between 2001 and 2010. While these figures are indicative, timeframes longer than one decade are needed to properly assess trends in carbon stocks in Australia's forests.

The key feature of carbon stock changes in the decade 2001–10 is the shift from a net loss of carbon in the period 2001–05 (91 Mt C) to a net gain in the period 2006–10 (10 Mt C). A key driver of the carbon stock decline in the period 2001–05 was wildfire. During this period, the 'millennium drought' had taken hold and, with fuel loads that had built up over decades and the hot dry conditions caused by the drought, wildfire (especially in 2003—see Figure 5.3) caused a high loss of carbon (93 Mt C) from Australia's forests. Another driver of carbon stock decline in this period was reclassification to 'non-forest' of land that lost its forest cover through clearing; this accounted for a loss of 97 Mt C in the forest carbon accounts (Table 5.1).

Table 5.1: Carbon accounts for Australia's forests, 2001–10

Parameter	Carbon stock (million tonnes)		
	2001–05	2006–10	2001–10
Initial stock	**12,922**	**12,831**	**12,922**
Gains in stock[a]			
Growth in stock			
Native forests	175	182	357
Plantations	27	32	59
Total	202	214	416
Reclassification to forest[b]			
Native forests[c]	–	–	–
Plantations	8	5	12
Total	8	5	12
Total gains in stock	**209**	**219**	**428**
Losses from stock			
Transfer to product pools[d]			
Native forests	35	31	66
Plantations	18	19	37
Total	53	50	103
Managed losses[e]			
Native forests	58	32	90
Plantations[f]	–	–	–
Total	58	32	90
Major disturbances[g]			
Native forests	93	55	148
Plantations	0	0	0
Total	93	55	148
Reclassification to non-forest[h]			
Native forests	97	72	169
Plantations[i]	–	–	–
Total	97	72	169
Total losses in stock	**300**	**209**	**509**
Final stock	**12,831**	**12,841**	**12,841**
Net change	–91	10	–81
Net change from reclassification of land to and from forest and transfers to products[j]	–142	–117	–259
Net exchange with atmosphere[k]	51	127	178

– = not reported

[a] Carbon stock change due to tree growth, plus increases in the debris and soil pools, minus losses due to decay of forest debris and loss of soil carbon.

[b] Gain by the forest sector of carbon in debris and soil associated with transfer of land into the sector.

[c] Not reported: current land classifications are being evaluated to determine how to characterise reclassifications to native forest.

[d] Transfers to wood and wood products in service.

[e] Emissions from prescribed burns, post-harvest burns, and burning as part of forest clearing.

[f] Not separately reported: carbon stock changes due to managed losses in plantations are currently aggregated with net carbon stock gain data.

[g] Emissions from major bushfires or potentially other disturbances.

[h] Loss from the forest sector of carbon in debris and soil associated with transfer out of the sector of cleared forest land or land where forest cover has been lost through dieback or degradation.

[i] Conversion of plantations to non-forest land use is not reported here.

[j] Sum of reclassification to forest, transfer to product pools and reclassification to non-forest.

[k] Sum of growth in stock, managed losses and major disturbances.

Note: Figures may not tally due to rounding.

Source: Australian Government Department of Climate Change and Energy Efficiency.

Over the period 2006–10, the recovery of forest carbon stocks was driven by less reclassification of forest land to non-forest land, by smaller wildfire losses, and by growth in stock associated with regeneration and recovery of forests following wildfires in the period 2001–05.

Carbon stock gains—growth in stock

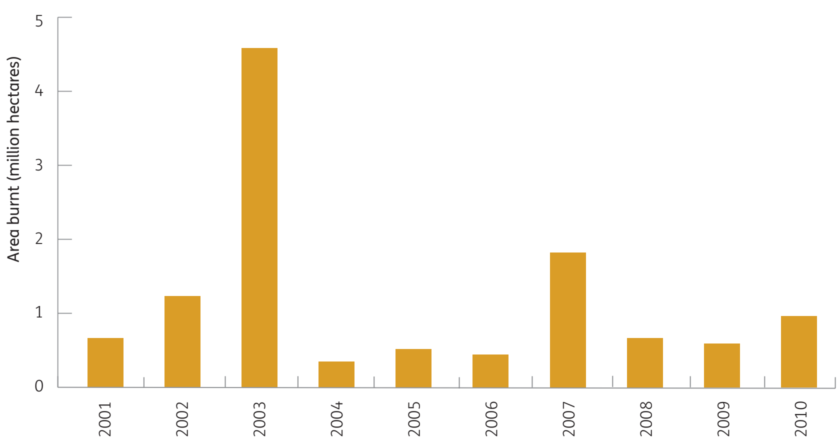
Over the period 2001–10, gross increases in carbon stocks in Australia's forests (due to tree growth and increases in the debris and soil pools, minus losses due to decay of forest debris and loss of soil carbon) were estimated to be 416 Mt C (Table 5.1). These gross increases do not include losses to the atmosphere (e.g. fire), transfers out of forest land (e.g. to harvested products), or land reclassification (e.g. to agriculture), which are presented separately.

The majority of the gross carbon stock gains (357 Mt C—88%) occurred in Australia's native forests (Table 5.1). Gains in both plantations and native forests were slightly higher in 2006–10 than in 2001–05 (Table 5.1). Drivers for the increase in native forest carbon stock included forests regenerating or regrowing after fire early in the decade, and drivers for the increase in plantation carbon stock included the early growth of young plantations following the peak planting period between 2000 and 2005 (Gavran and Parsons 2011).

Carbon stock gains—reclassification to forest

The reclassification of land from grassland to forest appears as a gain in stock in the carbon accounts (Table 5.1); however, it does not represent a gain in carbon from the atmosphere. This item represents carbon stocks on the land transferred into the forest land base—that is, when a plantation is established on ex-agricultural land or when native forests regenerate naturally on non-forest land, all of the carbon in soil and debris on that land at the time of reclassification is transferred into the forest carbon accounts.

Figure 5.3: Area of forest burnt by wildfire, 2001–10



Note: Fire activity only in forests in southern Australia, as considered by DCCEE. Indicator 3.1b reports on fires across all of Australia's forests.

Source: DCCEE (2012b), states and territories.

Carbon stock losses—transfer to product pools

Over the period 2001–10, an estimated 103 Mt C was transferred to the product pool. This transfer occurred at a relatively stable rate between 2001–05 and 2006–10 (Table 5.1). However, between these periods, there was a slight increase (from 34% to 38%) in the proportion of carbon transferred to the product pool that originated from plantations (Table 5.1).

In the period 2001–10, an estimated 50 Mt of firewood was burnt for heating (DCCEE 2012b), equivalent to the consumption of about 25 Mt of carbon.

Carbon stock losses—managed losses

Managed losses are losses of carbon directly from forests to the atmosphere that are associated with the management of forests—for example, prescribed burning of forest fuels or post-harvest burning of harvest debris (losses due to decay of slash following harvesting are incorporated in net growth in stock)—and losses associated with burning of forest debris followed land clearing. In the period 2001–10, managed losses were estimated to be 90 Mt C, with 58 Mt C in 2001–05 and 32 Mt C in 2006–10.

Post-harvest burning as part of native forest harvesting operations and for fire suppression was estimated to cause the loss of approximately 15 Mt C in 2001–05 and 16 Mt C in 2006–10. However, the largest source of carbon stock loss in the 'managed losses' category was clearing of forests in preparation for land-use change to agriculture or other development. As part of this process, forest debris is generally burnt, resulting in a direct loss of greenhouse gases to the atmosphere that is not balanced by subsequent forest regrowth.

No emissions from this source were recorded for plantation forests as part of this analysis. The carbon stock changes associated with post-harvest burning in plantations are included in the modelling of carbon stocks in these forests, and embedded in the data on overall carbon stock gain.

Carbon stock losses—major disturbances

Losses of carbon stocks attributed to wildfire were 93 Mt C in 2001–05, and declined by 40% to 55 Mt C in 2006–10. The higher losses of carbon attributed to wildfire in 2003 (Figure 5.3) were a key contributor to the net loss of carbon from Australia's native forests recorded for the period 2001–05. The lower carbon losses from Australia's native forests in 2006–2010, and the carbon stock increase resulting from forest regeneration and regrowth after fires in 2001–05, were key drivers of a net increase in carbon stocks in Australia's native forests in 2006–10.

Relative to the carbon stock losses attributed to wildfire in native forests, the loss of carbon stocks attributed to wildfire in plantations is minor (0.01% and 0.03% of total losses in 2001–05 and 2006–10, respectively). The low losses from this source are due to the small area of plantations relative to native forest, and may also indicate that it is easier for management to limit losses from wildfire in plantations.

Carbon stock losses—reclassification to non-forest land

Reclassification of 'forest land' to 'non-forest land' occurs after forest cover is lost in preparation for agriculture, urban development or mining. It involves the transfer of carbon in soils and residual debris from the forest accounts into the accounts associated with the new land use, and does not represent a loss of carbon to the atmosphere. It does not include the temporary losses of carbon in forests that are managed on a harvesting and regrowth cycle, or in forests that degrade and regenerate in response to physiological drivers of growth.

Over the period 2001–10, reclassification of 'forest land' to 'non-forest' land resulted in a reported decrease of carbon stocks in forest lands of approximately 169 Mt C (Table 5.1). The decline in human-induced forest clearing in 2006–10 (see Figure 5.4) was one of the main reasons that Australia's forest changed from a net source to a net sink of carbon between 2001–05 and 2006–10 (Table 5.1).

Net exchange with atmosphere and net effect of transfers and reclassification

The net change in Australia's forest carbon stocks was a loss of 91 Mt C in 2001–05, and a gain of 10 Mt C in 2006–10 (Table 5.1). This net change can be separated into the net transfers in and out of the forest (e.g. through harvesting operations for wood products) and the net exchange with the atmosphere (e.g. through tree growth and fire) (Table 5.1).

In the decade to 2010, there was a decrease in losses associated with carbon stock transfers from the forest sector due to transfer of carbon to the product pool and reclassification of land, from 142 Mt C in 2001–05 to 117 Mt C in 2006–11. One of the key causes of this reduced loss was a decline in losses from reclassification of land to non-forest associated with land-use change (see Figure 5.4).

Over the same period, net exchange with the atmosphere increased from a gain in forest carbon stock of 51 Mt C during 2001–05 to a gain in forest carbon stock of 127 Mt C during 2006–10 (Table 5.1). This was primarily due to a reduction in carbon stock losses associated with fire and an increase in gains associated with regeneration and recovery of forests from fire during 2006–10.

Table 5.2: Carbon stored in forest lands and harvested wood products

	Carbon (million tonnes)		
Carbon pool	**2000**	**2005**	**2010**
Forests			
Production native forests[a]	2,051	2,051	2,057
Non-production native forests[b]	10,734	10,626	10,613
Plantations[a]	137	153	171
Total	12,922	12,831	12,841
Harvested wood products			
Wood and wood products in service	89	96	103
Wood and wood products in landfill	110	117	123
Total	199	213	226
Total forests and harvested wood products	**13,121**	**13,044**	**13,067**

a Modelling with FullCAM is used for carbon stocks in 'Production native forests' and 'Plantations'. Carbon losses and gains associated with wildfire and subsequent regrowth in all forests are also included in the 'Production native forests' data.

b Carbon stocks in the 'Non-production native forests' category are derived from separate assumptions and modelling, not using FullCAM.

Source: Department of Climate Change and Energy Efficiency.

Carbon in forests

At the end of 2010, forests stored approximately 12,841 Mt C (Tables 5.1 and 5.2). This carbon is stored in living biomass (above ground and below ground), debris and soil. The majority of the carbon in forests (10,613 Mt C—83%) was held in the category 'Non-production native forests', which includes all protected forest areas plus areas of extensive inland woodland forests. The remaining carbon was held in production native forests (16%) and plantations (1.3%). Figure 5.2 shows the distribution of above-ground living woody biomass in Australia's forest.

In summary, a loss of 91 Mt in carbon stocks occurred in 2001–05, followed by a small gain of 10 Mt C in 2006–10 (Tables 5.1 and 5.2). These changes were the result of the combined effects of wildfire and land clearing.

Production native forests—harvesting

The gross production area of multiple-use public forest is estimated to be 9.6 million hectares (see Indicators 1.1 a, 1.1c and 2.1a). An additional 0.39 million hectares of private native forest is categorised as managed for timber production.[127]

Harvesting from production native forests declined from 10.8 million cubic metres of roundwood per year in 2000–01 to 6.5 million cubic metres in 2010–11 (see Indicator 2.1c), with a sharp decline in 2009–10. Over the period 2001–10, approximately 86 million cubic metres of roundwood was removed from native forests, which equates to the transfer of approximately 42 Mt C from forest land to the harvested wood products pool.[128] Carbon losses from decay of harvested wood products, including losses associated with processing, are accounted for within the harvested wood product pool.

After taking into account harvesting losses, decay of slash and other material, and transfers to wood products, the carbon stored in production native forests has remained relatively constant over the decade to 2010 (Table 5.2). In 2010, the amount of carbon stored in production native forests was approximately 12 times the amount stored in plantations (Table 5.2).

Plantations

Carbon stored in Australia's plantation forests increased from 137 Mt C in 2001 to 171 Mt C in 2010 (Table 5.2). This increase in carbon stock was caused by the continued expansion of Australia's plantation estate, as well as the continued growth of plantations established since 1990 (Gavran and Parsons 2011); the carbon stock in older plantations, established before 1990, declined by 5 Mt C in the period 2001–10 as the net result of harvesting and growth.

Natural disturbances

The effects of natural disturbances on the carbon stocks of Australia's forests are included in the carbon stock accounts under the classification of major disturbance losses (Table 5.1).

Wildfires occur every year in Australia's forests (see Indicator 3.1b)[129]. The fire regime in forests varies with climatic zone, soil type and vegetation type. In particular, climatic variability contributes large year-to-year variations in the extent of fires across southern Australia (Figure 5.3).

Natural events such as wildfires have significant impacts on Australia's forests, and losses of carbon stocks from forest lands can be very high in years in which substantial wildfires occur. In the period 2001–10, wildfires burnt a total of approximately 12 million hectares, and resulted in the direct loss of 148 Mt C from forest stocks (Table 5.1). The largest area was burnt in 2003 (Figure 5.3)—this was approximately three times the area burnt in 2007, the year of the next largest area burnt. The large area burnt in 2003 caused high losses of carbon stocks from forest lands in the period 2001–05 (Table 5.1).

Losses of carbon caused by fire are determined by the size of the areas burnt and the amount of biomass burnt per unit area. The rates of recovery of forest carbon stocks after fire (a component of 'Growth in stock' in Table 5.1) vary with climate, ecosystem type, previous fire history and site conditions. Many Australian tree species are fire tolerant; fire of moderate intensity often primarily burns fine debris and leaves, without killing trees, so recovery can be quite rapid. When a large forest landscape is in steady state over time, the amount of carbon lost as a result of fire is balanced over time and space by that reabsorbed by plant growth.

Forest clearing

Forest clearing is associated with the conversion of forested land to agricultural, urban or other land uses. Root material can be extracted ('tree-pulling') to allow subsequent cultivation for pasture and cropping; limited use of tree poisons, with subsequent decay of standing biomass and roots, also occurs in some agricultural areas. When forest land is reclassified as non-forest land, the carbon stock remaining after harvesting is transferred to the carbon stock of the non-forest land. Conversion of forests to non-forest land uses was one of the largest causes of greenhouse gas emissions and carbon loss from the forest sector in the periods 2001–05 and 2006–10 (Table 5.1).

Historically, economic considerations are an important driver of land clearing for farmers and other land managers. When the prices of agricultural products have been high (reflected in farmers' terms of trade[130]), landowners have had a stronger incentive to clear land and expand production (Figure 5.4). Typically, an increase (or decrease) in farmers' terms of trade has been followed by an increase (or decrease) in forest clearing about one year later (DCCEE 2012b).

In recent decades, state governments have passed legislation to restrict land clearing. The Queensland Government substantially restricted clearing from 2007 onwards and reinforced the restrictions in 2009. This policy change is reflected in the sharp drop in national land clearing figures

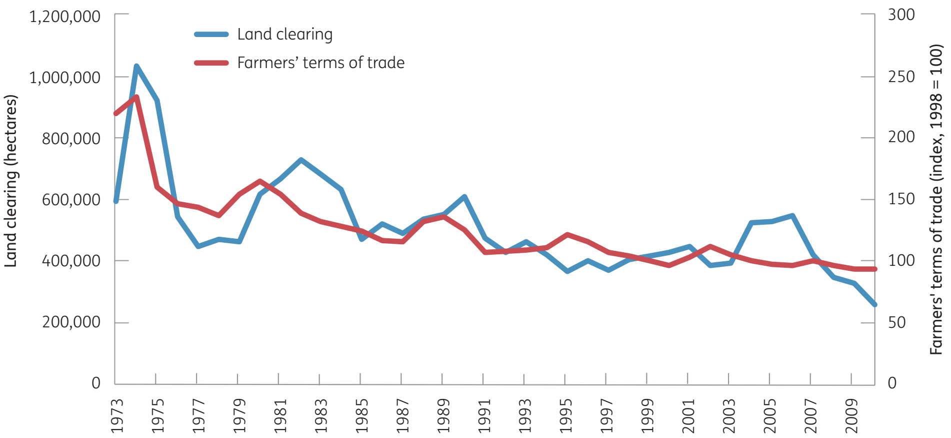
127 http://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/australia_290911.pdf.

128 The density of carbon in hardwood is assumed to be 0.5 tonnes per cubic metre.

129 Only fire activity in forests in southern Australia is considered for the forests component of Australia's national greenhouse accounts.

130 'Farmers' terms of trade' is the ratio of an index of prices received by farmers to an index of prices paid by farmers.

Figure 5.4: Time series of land clearing in Australia from 1973, and farmers' terms-of-trade index



Note: Land clearing data include first-time clearing and reclearing, and are from the National Greenhouse Gas Inventory datasets used for Australia's greenhouse accounts.
Source: DCCEE (2012b).

since 2007 (Figure 5.4). Other recent reductions in rates of land clearing, deriving from legislation rather than economic conditions, were not accompanied by significant changes in farmers' terms of trade (Figure 5.4). Both regulatory constraints and farmers' terms of trade can therefore be useful indicators of land clearing.

Forest soil carbon

Based on estimates derived from the National Greenhouse Gas Inventory (DCCEE 2012b), approximately 3,600 Mt C was stored in the soils of Australia's forests in 2010. This equates to approximately 30% of total forest carbon stocks (see Table 5.1). This value is likely to be an underestimate because soil carbon data are currently unavailable for large areas of forest land, and because measurements and calculations are only made to 0.3 metres in depth.

High uncertainty exists in the calculation of the flow of carbon into and out of forest soils. The high spatial and temporal variability of soil carbon stocks and fluxes makes sampling and measurement of soil carbon stocks and change impractical over large land areas, and overall understanding of the dynamics of soil carbon in Australian forests is low, especially in native forests.

Both the rate of input of carbon to the soil carbon pool and the rate of output from the soil carbon pool are affected by management events, particularly forest clearing and soil cultivation, intensive harvesting and wildfire (Page et al. 2011). Changes in total soil carbon stocks in response to management depend on initial soil carbon levels and past management practices. For example, soil carbon stocks generally decline under pine plantations established on land that had previously carried pastures, associated with a large loss of nitrogen from the soil and soil acidification, but do not decline on land that was formerly under broadleaved forests (Paul et al. 2002).

In most Australian forests, the above-ground carbon pools (trees and debris) are likely to be most vulnerable to rapid loss through management events or natural disturbances. The temporal pattern of change in soil carbon stocks is generally much slower than rates of change in above-ground carbon pools (Page et al. 2011), and the mass ratio of above-ground to below-ground carbon can vary markedly across the landscape.

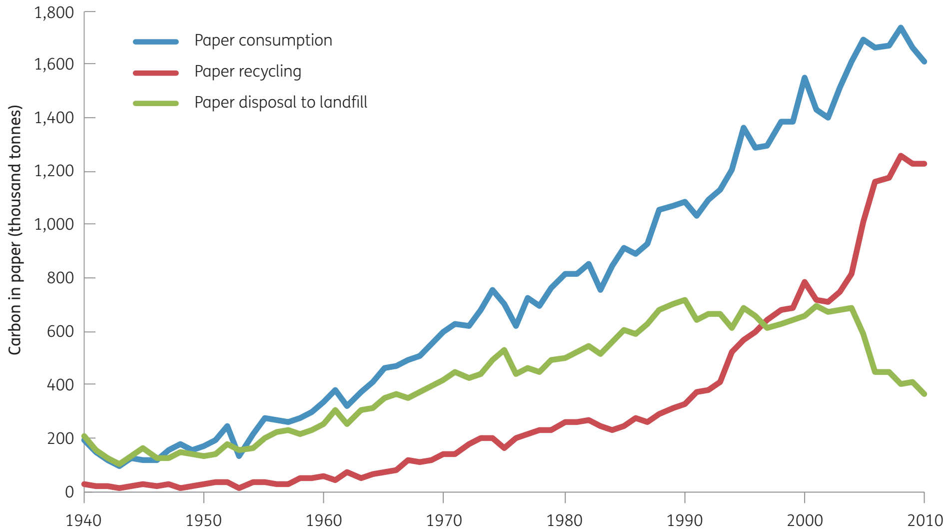
Carbon stored in wood products in service and landfill

Harvesting of forest lands for wood products results in the loss of forest carbon stocks to the atmosphere during and after the harvesting event, and a transfer of some carbon to the wood products pool. The lifecycle of wood products varies from very short term (e.g. some paper) to very long term (e.g. structural timber), although some types of paper products can be relatively stable in landfill.

In total, a stock of approximately 13,067 Mt C was held in Australia's forests and in wood products at the end of 2010 (Table 5.2). Of this, only 1.7% is stored in harvested wood products in service and in landfill. However, the carbon stocks of harvested wood and wood products in service and in landfill increased progressively over the decade to 2010 (Table 5.2). This trend reduced the net loss of 81 Mt C in forests alone over the period 2001–10 (from 12,922 Mt C to 12,841 Mt C), to a net loss of 54 Mt C in forest plus wood and wood products over this period (from 13,121 Mt C to 13,067 Mt C) (Table 5.2).

Carbon stock changes of harvested wood products are quantified using a model-based method, which employs decay rates for each wood product category (DCCEE 2012b). There is still considerable uncertainty in the rates of turnover of some pools, especially for wood and paper going into landfill, so modelled estimates of change are approximate. A national database of domestic wood production, including import and export quantities, has been maintained in Australia since the 1930s (most recently reported in ABARES 2012g). This consistent and detailed collection of time-series data has been useful for development of a national wood products model. The model links intake of raw materials, through various

Figure 5.5: Carbon in paper consumed, recycled and disposed to landfill, Australia, 1940–2010



Note: Consumption is calculated as production plus imports minus exports.
Source: DCCEE (2012b).

processing options, to outputs of products and by-products, including to export, recycling, entry to and decomposition in landfill, use for bioenergy, and loss to atmosphere. For a detailed description of the harvest wood products model, see DCCEE (2012b, Appendix 7.I).

Both paper and wood in landfill decay relatively slowly. In Australia, 23% of the carbon in wood transferred to a well-managed landfill was estimated to decay over a span of some decades, with the remainder present for longer periods (Ximenes et al. 2012b). Consequently, with the current quantities of wood being disposed of to landfill, the total stock of carbon stored in landfills will continue to increase.

Trends in waste paper generation and disposal

Over relatively short periods, the amount of paper waste generated for disposal will be consistent with the amount of paper consumed, given the short service life of this product. Overall, annual paper consumption rose from 190 thousand tonnes of carbon (kt C) in 1940 to 1,612 kt C in 2010 (Figure 5.5), reflecting both increasing population and increasing per capita consumption (from an estimated annual 26 kg C per person in the 1940s, to 72 kg C per person in 2010). The amount of waste paper transferred to landfill is estimated to have increased from 204 kt C in 1940 to a maximum of 719 kt in 1990, declining to 367 kt C by 2010 as a result of a shift from disposal in landfill to recycling since the late 1980s (Figure 5.5). The amount of waste paper recycled increased from 30% in 1990 to 75% in 2010; a sharp jump was recorded in 2006. Commensurately, the proportion of paper disposed of to landfill declined in the same period (Figure 5.5). The increase in the proportion of product recycled partly reflects the effectiveness of a number of state government waste management initiatives.

Trends in wood products in service, for disposal and in landfill

On average, carbon accumulated in harvested wood products (HWPs) in service by 1.6% per year over the period from 2001 to 2010 (Table 5.3). The bulk of this was stored in stable products such as timber used for construction. In 2010, 103 Mt C was stored in HWPs in service (Table 5.3).

The amount of wastes generated with disposal of HWPs to landfill depends on how much of the wastes are diverted to other disposal paths or uses, including combustion for energy, use to produce other products (e.g. paper), or disposal to aerobic treatment processes. Disposal of wastes to combustion processes has increased in recent years, with a reduction in wood wastes going to landfill.

In the period 2001–10, approximately 12.6 Mt C in wood products (wood, wood waste and paper) was transferred to landfill (Table 5.3). The total mass of carbon in wood products stored in landfill in 2010 was estimated to be 123 Mt C (Table 5.2).

Handling bulk waste at a paper recycling plant.

CRITERION 5

Table 5.3: Carbon input to, and output from, the harvested wood products pool in Australia

	Carbon ('000 tonnes)						
Year	Domestic production	Imports	Exports	Net increase[a]	Losses (decay, use and disposal)	Wood products in service[b]	Wood, wood products and paper disposed of to landfill[c]
2001	10,423	804	7,042	4,185	2,985	90,611	1,358
2002	11,575	795	8,070	4,300	3,022	91,890	1,310
2003	11,957	873	8,268	4,562	3,149	93,303	1,386
2004	12,817	955	9,120	4,653	3,213	94,743	1,427
2005	12,702	1,005	9,010	4,696	3,264	96,175	1,430
2006	13,060	960	9,471	4,550	3,186	97,539	1,271
2007	13,692	985	10,163	4,515	3,189	98,866	1,203
2008	13,180	1,056	9,450	4,785	3,347	100,304	1,147
2009	11,763	922	8,286	4,398	3,235	101,468	1,052
2010	12,380	989	8,947	4,423	3,215	102,676	1,005
Total 2001–10	**123,549**	**9,344**	**87,827**	**45,067**	**31,805**		**12,589**

a Net increase in pool = domestic production + imports – exports.
b Wood products in service = previous wood products in service + net increase – losses (decay, use and disposal).
c Subset of loss due to decay, use and disposal.

Source: Department of Climate Change and Energy Efficiency.

Energy from biomass

Consumption of solid biomass accounts for more than half of all renewable energy production in Australia. In 2010–11, this comprised the production of 95 petajoules[131] (PJ) of energy produced by burning wood and wood waste and 43 PJ of energy produced by burning bagasse (sugarcane waste). The majority of energy produced from wood and wood waste (57 PJ) is consumed in the residential sector; the pulp, paper and printing sector (17 PJ) and the wood and wood products sector (12 PJ) are also significant consumers. The electricity generation sector is a relatively small consumer of wood and wood waste, consuming 3 PJ in 2010–11 (BREE 2012).

The electricity generation capacity of bagasse was 444 megawatts (MW) in 2010-11, with most of the capacity in Queensland (370 MW). The electricity generation capacity of wood and wood waste and black liquor generators amounted to 120 MW in 2010–11. The majority of black liquor combustion capacity (55 MW) is in Victoria, while the majority of wood and wood waste combustion capacity (38 MW) is in Queensland.

Renewable energy certificates can be generated from combustion of biomass, including energy crops such as oil mallee; woody weeds; wood from certain timber plantations; and agricultural wastes.

131 1 petajoule = 10^{15} joules.

Emissions from forestry operations for wood production

The carbon sequestered in wood products has been estimated as 787 kilograms of CO_2-e per cubic metre (kg CO_2-e/m^3) for average softwood log products, and 982 kg CO_2-e/m^3 for average hardwood log products (Table 5.4). A relatively small amount of greenhouse gases are emitted during forestry operations in the course of production of these wood products, which reduces the net sequestration (Table 5.4).

Direct emissions from forestry operations for wood production include release of CO_2 and other greenhouse gases from machines and vehicles (including haulage), and emissions of methane and nitrous oxide from residue burning and fertiliser application. Indirect emissions include those from processes used to obtain and process raw materials, produce and distribute fuel and energy, and manufacture machines and infrastructure.

Emissions from forestry operations—particularly burning, but also harvesting and haulage operations—were higher for native hardwood forest than softwood plantations (Table 5.4). Total greenhouse gas emissions from forestry operations for production of an average log varied from 3.2% of the CO_2-e sequestered (plantation softwood log) to 7.3% of the CO_2-e sequestered (native forest hardwood log).

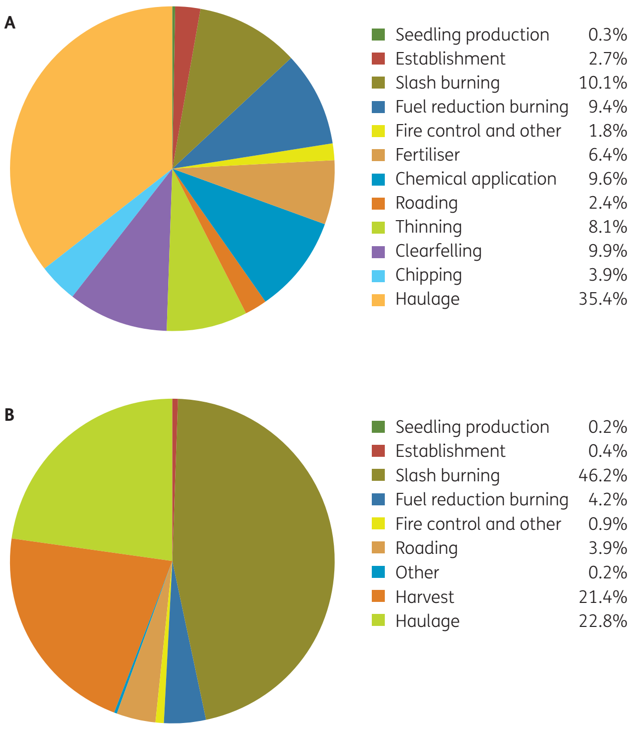
The proportions of greenhouse gas emissions from various forestry operations used for production of softwood plantation logs were 35.4% for haulage, 21.9% for harvesting (thinning and clear-felling) and chipping, 16% for fertiliser use (fertiliser and chemical application) and 19.5% for slash and fuel reduction burning (Figure 5.6a). For native hardwood forests, the proportions of emissions from forestry operations were 50.4% for slash and fuel reduction burning, 22.8% for haulage and 21.4% for harvesting (Figure 5.6b).

Table 5.4: Emissions and sequestrations of greenhouse gases during production of plantation softwood and native hardwood logs

Forest type and product	CO_2-e sequestered (kg/m³)	CO_2-e emitted (kg/m³)	Net CO_2-e sequestered (kg/m³)	Proportion of sequestered CO_2-e emitted during production (%)
Plantation softwood				
Sawlog, high value	810	36.8	773	4.5
Sawlog, low value	824	24.7	799	3.0
Pulplog	735	10.8	724	1.5
Woodchips	726	26.9	699	3.7
Other log	662	20.9	641	3.2
Average log	**787**	**25.4**	**761**	**3.2**
Native hardwood				
Sawlog, high value	1,065	139.6	925	13.1
Sawlog, low value	1,147	56.1	1,091	4.9
Pulplog	906	49.7	857	5.5
Other log	1,301	362.8	938	27.9
Average log	**972**	**70.6**	**902**	**7.3**

Source: England et al. (2013).

Figure 5.6: Contribution of various forestry operations to total (direct and indirect) CO_2-e emissions for an average log from (A) softwood plantation, and (B) native hardwood forest



Note: Figures may not tally due to rounding.
Source: England et al. (2013).

Wood pellets, used for energy generation.

Consequences for greenhouse gas mitigation of forest management

Determining the impact on greenhouse gas mitigation of forest management for multiple uses, including wood products, requires a synthesis of forest carbon dynamics, harvesting productivity and waste, and use of wood and wood products instead of other materials. Case study 5.1 provides a recent example from New South Wales.

Case study 5.1: Carbon dynamics of managed native forests in New South Wales

An increasingly important component of the response to climate change involves increasing the amount of carbon stored in forests and wood products, and considering the greenhouse gas implications of managing or not managing forests.

Researchers from Agriculture NSW, the New South Wales Department of Primary Industries, the University of New England, and Forests NSW (Ximenes et al. 2012a, 2012b) used a complete lifecycle analysis to model the greenhouse gas implications over 200 years of various native forest management scenarios in areas of New South Wales. Figure 5.7 shows the implications of managing forests on the north coast of New South Wales solely for conservation ('conservation' scenario) or as multiple-use production forests (the 'harvest' scenario), with all storage and emissions consequences expressed in the same units (tonnes of carbon per hectare).

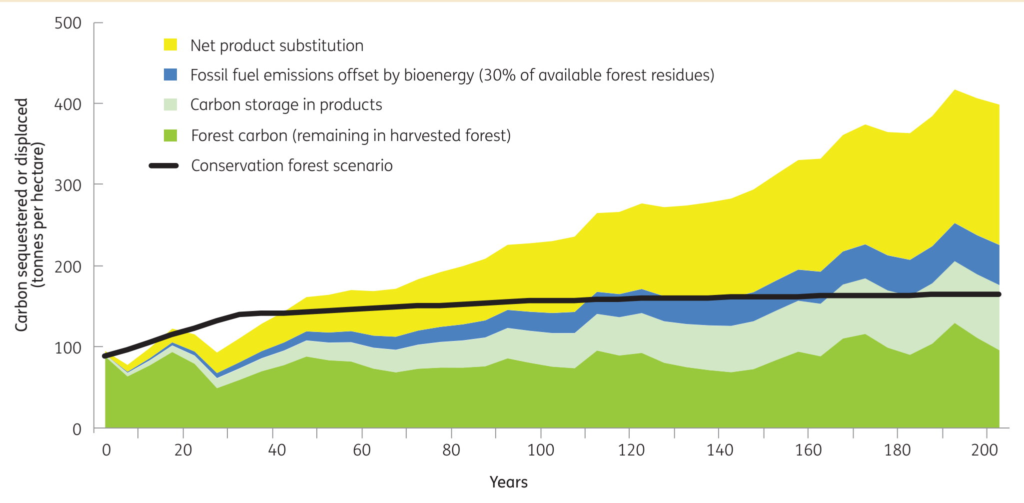
The modelling results showed that the 'harvest' option delivered greater climate change mitigation than the 'conservation' scenario over long periods of time.

However, the magnitude of the difference, and the point in time after which the 'harvest' option delivered greater climate change mitigation than the 'conservation' scenario, depended on which components of the analysis were included:

- The carbon stock in the harvested forest averaged just under 100 tonnes per hectare, and was always less than the carbon stock in the forest managed for conservation, which averaged about 165 tonnes per hectare.
- Accounting for the carbon stored in the wood products pool from harvested forest gave the 'harvest' scenario a greater greenhouse gas mitigation benefit than the 'conservation' scenario from about 160 years.
- Accounting for use of 30% of the harvest residues for bioenergy instead of fossil fuels gave the 'harvest' scenario a greater greenhouse gas mitigation benefit from about 110 years (higher residue utilisation would increase the benefit, but would need to account for potential impacts on biodiversity and soil health).
- Accounting for the use of wood products in place of more greenhouse gas–intensive construction materials gave the 'harvest' scenario a greater greenhouse gas mitigation benefit from about 40 years.
- Full accounting of the possible consequences of managing forests for wood production gave greenhouse gas abatement equivalent to 400 tonnes of carbon per hectare after 200 years—this is 2.5 times greater than that of the 'conservation' scenario.

This modeling therefore suggests that management of multiple-use production forest could have the capacity to produce greater mitigation of climate change than management of forest for conservation, when the amount of carbon stored on-site is considered alongside the carbon stored in products off-site and the consequences of using wood products and harvest residues instead of other materials used in construction or for generating energy.

Figure 5.7: Greenhouse gas implications of 'conservation' and 'harvest' scenarios for native forests on the north coast of New South Wales, modelled over a 200 year period



Notes:

Thick black line = 'conservation' scenario; shaded areas = components of 'harvest' scenario.

'Carbon storage in products' does not include carbon in paper products.

Forest carbon (remaining in harvested forest)' includes carbon in the decomposing slash from harvest events.

'Net product substitution' is the greenhouse gas benefit of using wood products, calculated using a conservative product displacement factor of 2 tonnes of carbon per tonne of carbon in wood products, minus harvesting and processing emissions and methane from landfill, specific to the modelled product mix for this forest type.

Source: Ximenes et al. (2012b).

Criterion 6

Maintenance and enhancement of long term multiple socio-economic benefits to meet the needs of societies

Use of timber in the construction industry. iStockphoto


Isaac Overton

Processed hardwood timber from native production forests.

Criterion 6
Maintenance and enhancement of long term multiple socio-economic benefits to meet the needs of societies

The 17 indicators in this criterion are designed to show the extent to which Australia's forests contribute to national and regional economies, benefit personal and community wellbeing, and support cultural values. Socio-economic data are important measures of the monetary and non-monetary value and benefits of forests to society. In addition, Australian communities, especially Aboriginal and Torres Strait Islander communities (referred to as Indigenous communities in SOFR 2013), have strong social, spiritual and cultural attachments to forests, whether for traditional needs, provision of wood and non-wood forest products and other benefits, direct and indirect employment, or active and passive recreation.

The indicators in this criterion are considered in five sub-criteria.

Production and consumption

Wood from forests provides employment for workers in harvesting and processing, revenues to governments, and incomes to landholders and businesses. Analysis of trends in the value of wood and wood products harvested from Australia's forests enables an assessment of a portion of the socio-economic benefits derived from forests. Consumption trends over time provide a measure of the capacity of forest and wood-processing industries, through domestic production and importation, to meet Australian society's demand for wood products, and a measure of the industry's contribution to the national economy. Wood and wood product categories examined in this report are sawn wood; wood-based panels; and pulpwood, woodchips, paper, cardboard and fibreboard.

Rising global and national demands for forest products, with consequent increased demands on forest resources, have led to calls for greater reuse and recycling of forest products. Considerable quantities of wood-based forest products, such as structural timbers, pulp, paper and sawmill residue, are recycled in Australia.

Although wood is economically the most valuable forest product, many Australian non-wood forest products (NWFPs) are harvested and sold commercially, including for emerging export markets. Some NWFP industries are based on wild harvesting and hunting, including hunting of feral animals such as wild pig and deer.

Australia's forests also provide a range of other services, such as carbon sequestration, soil conservation, protection of catchments for water production, ecotourism, and biodiversity conservation. These can broadly be divided into amenity services and environmental services. Markets or other economic mechanisms exist for some of these services, allowing forest-based services to provide monetary value as well as social and environmental benefits.

Investment

The quantity of investment and expenditure in developing, maintaining and obtaining goods and services from forests is a measure of the economic commitment to forest utilisation and management.

The Australian, state and territory governments undertake many activities that, together, constitute forest management. A range of data on investment in forest management is available, although differences in the classification of activities, accounting arrangements and reporting timelines means that it is not possible to calculate national expenditure on forest management. Similarly, information on investment by the private sector, whether for native forest management or for plantation establishment, is either not collected or is not publicly available because it is commercial-in-confidence; expenditure on the management of nature conservation reserves is also generally unavailable in a consistent form. However, data are available on establishment of new plantations and re-establishment of harvested plantations, as indicators of investment in future wood availability.

Investment in research, development and adoption of new or improved technologies can lead to improvements in forest management and industry practices. The focus of research and development in the forestry and logging subsector is on improving wood production, harvesting and transport; and identifying new markets for standing wood. Research and development in the wood product manufacturing subsector tends to focus on identifying new forest-based products and processing methods, such as new applications for timber in construction, new timber treatments, and new export markets. Research and development in the pulp, paper and converted paper product manufacturing subsector covers a range of areas, such as energy efficiency in pulping and drying, and the development of new products.

Tourism and recreation

Australia's forests are highly valued for tourism and recreation, and a wide range of forest-based recreation and tourism opportunities is available. Some facilities, such as walking and riding tracks, picnic sites and campgrounds, are provided specifically to meet the needs of recreational visitors and tourists. Other facilities, such as roads and vehicular tracks, are provided for a range of management purposes but are also available for use for recreation and tourism. The dispersed nature of forest tourism and recreation nationally means that data are limited across jurisdictions and tenures, and difficult to compile nationally.

An area of forest is considered to be available for recreation and tourism if there is no legal or other prohibition on public access to the forest. Most publicly owned forested lands designated for multiple use or as nature conservation reserves are available for recreation and tourism. Some data are collected for areas where visitors have to pay for access to private land (e.g. forest wildlife parks).

Although various outdoor recreation and tourism activities, such as bushwalking and camping, are allowed in most public forests, some areas have exclusions or restrictions to ensure visitor safety, or to protect specific scientific, natural, cultural or water-supply values. Other activities such as horse-riding and mountain-bike riding may be permitted only in certain areas. Limited road, track and trail access, a lack of facilities and other practical considerations may also restrict or prevent public use of forests.

One way to measure the financial value of the amenity service of forest-based tourism and recreation is to estimate the number of people visiting forests in various tenures, and how much money they spend to do so. Changes in visitor numbers to national and state parks and to forests in other tenures can reflect changes in the perceived value of forests; it should be noted, however, that not all national parks are forested, and moreover that data on visitor numbers are not comprehensive.

Cultural, spiritual and social values

Forests are recognised as one of Australia's greatest natural assets and are highly valued by the community for their wide range of environmental and socio-economic benefits. Understanding the importance that people place on Australia's forests provides an insight into the acceptance and approval by communities of activities related to forest management. The extent to which Indigenous people participate in forest management reflects their connection with the land, and the integration of Indigenous values into forest management practice, policy and decision-making.

Access, management and ownership are key parts of the relationship of Indigenous people with land. The Indigenous estate can be broadly divided into land tenure and management categories based on the degree of Indigenous ownership, management and other rights over the land. Effective Indigenous participation can occur through a variety of direct or consultative mechanisms, but it is difficult to measure the extent of this participation at the national scale. All state and territory jurisdictions maintain registers of Indigenous heritage sites that afford legal protection to registered sites, including those in forests, and also provide a level of protection for heritage sites that are not yet included in the register.

Australia's forests include many sites that provide evidence of the interactions between non Indigenous people and forest landscapes, and the activities that have taken place on the continent since first European settlement. A wide variety of forest sites, features, structures and landscapes have recorded non-Indigenous cultural value.

Employment, worker welfare, and community resilience

Employment is an important measure of the contribution of forests to viable communities and the national economy. Reductions in forest-sector employment can indicate a reduced economic contribution from forests, and may have implications for forest-dependent communities. A sustainable industry will maintain wage rates, workforce health and worker safety at levels that are comparable with national averages for similar occupations.

The Australian forest and wood products sector has undergone significant structural changes in recent years, with reductions in the areas of native forest available for harvest and consequently in the volume of wood harvested from native forests, reduced investment in new plantations, and reduced demand for wood products. Moreover, older processing facilities have been closed or decommissioned. Such changes have economic and social implications for forest-dependent communities.

The capacity of both Indigenous and non-Indigenous communities to accommodate and adapt to change is influenced by their level of economic dependence on the forestry industries, and by the resources they are able to draw on to assist them in responding to change. Resilient communities can adapt to, and remain viable in, changing social and economic conditions. Community resilience can be conceptualised and measured in different ways. It is sometimes interchangeable with adaptive capacity, since increasing adaptive capacity will enhance community resilience.

The town of Bright in north-east Victoria.

Key findings

Key findings are a condensed version of the Key points presented at the start of individual indicators in this criterion.

Production and consumption

- A total of 26.6 million cubic metres of logs were harvested in Australia in 2010–11, a decrease from 27.2 million cubic metres in 2006–07. Over this period, the volume of hardwood logs harvested from native forests declined from 8.6 million cubic metres to 6.3 million cubic metres, a decrease of 26%. The volume of logs harvested in softwood and hardwood plantations (plus a small volume of softwoods harvested from native forests) increased from 18.6 million cubic metres in 2006–07 to 20.2 million metres in 2010–11, an increase of 8.6%. In 2010–11, 76% of the volume of logs harvested in Australia was from plantations.
- Indexed to 2010–11 prices to adjust for inflation[132], the value of logs harvested from native forests and plantations decreased from $1.93 billion to $1.85 billion between 2006–07 and 2010–11, a decrease of 3.9%. Indexed to 2010–11 prices, the turnover (sales and service income) of the wood and wood products industries increased from $23.8 billion to $24.0 billion between 2006–07 and 2010–11, an increase of 0.9%. The value added by the wood and wood products industries in 2006–07 was $7.4 billion, a contribution to Australia's gross domestic product of 0.68%; the value added in 2010–11 was $8.3 billion, representing a contribution to gross domestic product of 0.59%.
- The most recent (2011–12) estimate of the gross annual value of production of NWFPs regarded as having high forest dependence was $198 million. However, information on the production, consumption and trade of NWFPs is often difficult to obtain because of the small size and dispersed nature of the industries.
- In addition to providing wood and non-wood forest products, Australia's forests provide a range of amenity and ecosystem services, such as carbon sequestration, soil conservation, watershed protection, ecotourism and biodiversity conservation. Markets exist for few of these services. National numbers are not collected to enable estimation of the number of people visiting forests or the total economic benefit of these services.
- The total value of wood product imports increased from $4.3 billion in 2006–07 to $4.4 billion in 2010–11, and the total value of wood product exports increased from $2.4 billion to $2.5 billion (unadjusted for inflation). The trade deficit in wood products therefore increased slightly, from $1.91 billion in 2006–07 to $1.93 billion in 2010–11, and Australia remains a net importer of wood and wood products.

[132] Dollar amounts are only adjusted for inflation where specified.

- The highest-value export category of wood products in 2010–11 was woodchips ($884.4 million). Printing and writing paper accounted for the largest proportion, by value, of Australia's imports of wood products in 2010–11 (30.6%).
- Consumption of hardwood sawn wood decreased from 1.23 million cubic metres in 2006–07 to 0.748 million cubic metres in 2010–11. In comparison, the consumption of softwood sawn wood increased from 4.1 million cubic metres to 4.3 million cubic metres over the same period.
- The collection rate of recycled paper and paperboard products increased from 66.3% in 2006–07 to 77.4% in 2010–11, with an increase in exports of recovered paper, particularly to China.
- Households reused and recycled more waste paper products in 2009 than in 2006. Australia-wide, household recycling and reuse increased from 91.5% to 95% over this period.

Investment

- The annual rate of establishment of new hardwood and softwood plantations in Australia, a measure of investment in future wood availability, declined from 87 thousand hectares in 2006–07 to 10 thousand hectares in 2010–11. Annual investment in new plantations thus decreased substantially over this period.
- Combined, the forestry and logging subsector, the wood product manufacturing subsector, and the pulp, paper and converted paper product manufacturing subsector accumulated about $6.0 billion of fixed capital between 2006–07 and 2010–11, including in new plantations, equipment and buildings. Fixed capital formation net of depreciation and amortisation over this period was estimated to be $1.08 billion.
- Australian Bureau of Statistics data show that total expenditure on research and development (R&D) reported by businesses in the forest and wood product sector declined from $164 million to $137 million between 2005–06 and 2008–09. Business R&D expenditure increased in the forestry and logging subsector but decreased in the wood product manufacturing subsector and the pulp, paper and converted paper product manufacturing subsector.
- A separate survey of the forest and forest products sector, using a different definition of the sector from that used by the Australian Bureau of Statistics, estimated R&D expenditure at $106 million in 2007–08. Adjusted for inflation, and using a consistent methodology over time, the expenditure on forestry and forest product R&D is estimated to have declined by 13.4% between 1981–82 and 2007–08.

Tourism and recreation

- Nationally, 10.1 million hectares of publicly owned multiple-use forest and 20.7 million hectares of forest in nature conservation reserve are available for recreation and tourism, a total of 30.8 million hectares of publicly owned forest available nationally for these uses. Additional private forest areas are available, usually under commercial arrangements. Substantial areas of reserved forest in northern Australia, such as in Kakadu National Park, are on private land tenure and are available for recreation and tourism through leasing and management arrangements with the Australian Government.
- A wide range of forest-based recreation and tourism services is available in Australia to meet demand by the general public, but a national estimate of the number of people visiting forests is unavailable. In forest areas for which data are available, the number of areas, tracks and sites available for recreation and tourism activities remained the same or increased over the reporting period.

Cultural, spiritual and social values

- The Indigenous estate can be divided into four land tenure and management categories: Indigenous owned and managed, Indigenous managed, Indigenous co-managed and Other special rights.
- In 2011, 41.9 million hectares of forest land (34% of Australia's total forest area) were in the Indigenous estate. This is an increase of 22.1 million hectares over the figure reported in SOFR 2008. The increase was driven primarily by improved availability of spatial information on Indigenous land tenure, as well as a real increase in the area of land over which Indigenous people have legislated rights. Of the total area of forest in the Indigenous estate, 31.7 million hectares (76%) is in Queensland and the Northern Territory.
- Approximately 4.4 million hectares of forest are on Indigenous owned and managed lands where the legislated management intent is conservation. The total area of forest on sites with Indigenous heritage value listed on the Register of the National Estate in 2011 was 1.5 million hectares, of which 1.2 million hectares (81%) was in Queensland and the Northern Territory.
- Effective Indigenous participation can occur through a variety of direct or consultative mechanisms, but it is difficult to measure the extent of Indigenous participation through these mechanisms at the national scale.
- Data on non-Indigenous heritage sites in Australia have been compiled in a national dataset based on non-Indigenous heritage lists and registers from all jurisdictions. Across all jurisdictions combined, the total forest area on heritage-listed sites is estimated at 7.3 million hectares. This is an overall increase of 6.8 million hectares since SOFR 2008, attributable to compilation and reporting of the new dataset.
- Several surveys conducted between 2006 and 2012 have provided considerable insight into the attitudes of Australians to a range of forest-related issues.

- More than 40% of the respondents to an Australia-wide series of surveys agreed that Australia's native forests were being managed sustainably. The proportion of respondents who agreed that 'we should not be cutting down any trees for wood products' decreased between 2009 and 2012, and the proportion of respondents who agreed that 'we should use more wood because it is more environmentally friendly than alternative materials' increased. Harvesting trees is viewed favourably only if the trees are replaced with new ones.

- The level of understanding about the role of forests in carbon storage is high and increasing. In 2012, more than 90% of respondents agreed that trees absorb carbon dioxide, and 71% (up from 52% in 2008) agreed that 'carbon is stored in wood, even after the tree is harvested'.
- In south-west Western Australia and Tasmania, views are polarised on the acceptability of eucalypt plantations for pulp and paper, and pine plantations for timber.
- About 80% of respondents to a survey in south and central rural New South Wales indicated that they would consider planting trees for carbon sequestration, and nearly 70% indicated that being paid for carbon sequestration would increase the likelihood that they would plant trees for purposes such as reducing land degradation and providing shelter for stock.

Employment, worker welfare and community resilience

- Total direct employment in the forest sector was estimated at 73,267 people in 2011, down from 85,254 people in 2006. Direct employment declined from 2006 to 2011 in the forestry and logging subsector; the wood product manufacturing subsector; the pulp, paper and converted paper product manufacturing subsector; and the timber wholesaling subsector. Direct employment in the forestry support services subsector increased.
- A study on Tasmania by the Cooperative Research Centre for Forestry, using different employment categories, showed that forest-related employment in Tasmania fell by 46% in the period from 2006 to 2011, from 6,409 to 3,460 people. The number of forest-related businesses in Tasmania also fell over this time.
- Total wages and salaries in the wood and wood product industries varied in the range \$3.8 billion to \$4.2 billion from 2005–06 to 2010–11. The average wage over the period (not adjusted for inflation) increased in the forestry and logging subsector; in the wood product manufacturing subsector; and in the pulp, paper and converted paper product manufacturing subsector.
- Average annual wages in the forestry and logging subsector were estimated at \$34,467 in 2010–11, which is high compared with most other primary sectors, but low compared with the mining sector. The average wage in the wood product manufacturing subsector was estimated at \$48,568 in 2010–11, which is lower than in most other manufacturing industries. In comparison, the average annual wage in the pulp, paper and converted paper product manufacturing subsector was estimated at \$72,381 in 2010–11.
- The number of serious injury claims in both the forestry and logging and the wood and paper product manufacturing subsectors has declined in recent years. There were 25 reported compensated fatalities in the forestry and logging subsector and 21 compensated fatalities in the wood and paper product manufacturing subsectors between 2003–04 and 2009–10.
- A reduction in wood harvest from native forest, lower investment in establishment of new plantations, reduced demand for wood products, and the closure of large mills, had significant impacts on forest-dependent communities over the period from 2006 to 2011.
- In 2011, there were 28 Statistical Local Areas (SLAs) in which 4% or more of the working population (the level used to show medium-to-high relative community dependence on forests) was employed in forest and wood products industries. Of these, 24 SLAs showed a decline in employment in the forest and wood products industries over the period from 2006 to 2011. Several of these SLAs also had relatively low rankings in an adaptive capacity index that combined the levels of training qualifications and skills, income, and community participation, with regional industry diversity.
- Access to native forest enables Indigenous people to practise and maintain cultural values, leading to an improved sense of wellbeing, and personal and community resilience. The financial and educational resources developed through engagement with commercial forest management activities can help build the capacity of Indigenous peoples to manage change, and increase broader community resilience. Successful Indigenous forest-sector projects can deliver both social and economic benefits, strengthening the resilience of Indigenous communities in the face of social and economic change.

Woodchips being stockpiled for export, Eden, New South Wales.

Indicator 6.1a

Value and volume of wood and wood products

Rationale

This indicator measures the size and economic contribution of the wood products sector to Australia's economy. Analysis of trends in the value and volume of wood and wood products enables socio-economic benefits derived from the forest industry to be assessed.

Key points

- A total of 26.6 million cubic metres of logs were harvested in Australia in 2010–11, a decrease from 27.2 million cubic metres in 2006–07. Over this period, the volume of hardwood logs harvested from native forests declined from 8.6 million cubic metres to 6.3 million cubic metres, a decrease of 26%. In comparison, the volume of logs harvested in softwood and hardwood plantations (plus native forest softwoods) increased from 18.6 million cubic metres to 20.2 million cubic metres, an increase of 8.6%. In 2010–11, 76% of the volume of logs harvested in Australia was from plantations.
- The value of logs harvested from native forests and plantations increased by 8.1% over the period, from \$1.71 billion in 2006–07 to \$1.85 billion in 2010–11[133]. However, adjusting to 2010–11 prices (that is, adjusting for inflation), the value of logs decreased by 3.9%, from \$1.93 billion to \$1.85 billion in 2010–11.
- Industry turnover (sales and service income) of the wood and wood products industries increased from \$21.2 billion to \$24.0 billion between 2006–07 and 2010–11, an increase of 13.6%. Adjusting to 2010–11 prices, the turnover in these industries increased by 0.9% from \$23.8 billion to \$24.0 billion over the period.
- The value added by the wood and wood products industries in 2006–07 was \$7.4 billion, a contribution to Australia's gross domestic product of 0.68%. The value added in 2010–11 was \$8.3 billion, representing a contribution to gross domestic product of 0.59%.

This indicator presents information on the value and volume of wood and wood products that are directly generated by industry. Secondary or flow-on economic activity, such as turnover generated through indirect employment, is not examined. Estimates of value and volume of wood products are subject to various assumptions, as noted in figure legends; the assumptions for volume estimates may be different from the assumptions for value estimates.

Two estimates of value are presented in this indicator: 'actual' and 'adjusted to 2010–11 prices'. Actual values, often called 'nominal' values, are the values actually recorded in the reporting period, with no further adjustments. In comparison, the 'adjusted to 2010–11 prices' estimate indexes the actual values against the consumer price index (CPI), a measure of inflation on the price of goods and services over time. The CPI index is sourced from the ABS (2012a).

Contribution of the forest and wood products industry

The value added by the Australian forest and wood products industry was \$7.4 billion in 2006–07 ('Industry value added'[134]), contributing 0.68% of Australia's gross domestic product (GDP) in that year. In 2010–11, this Industry value added increased to \$8.3 billion. However, because national GDP grew faster over this period, the contribution of the industry to Australia's GDP in 2010–11 was 0.59% (ABARES 2013a).

133 Dollar amounts are not adjusted for inflation unless this is specified.

134 In the context of SOFR 2013, 'Industry value added' omits some downstream parts of the industry, particularly wholesaling, retailing and value-adding (and thus the manufacturing of some commodities).

Harvested logs

A total of 26.6 million cubic metres of logs were harvested in Australia in 2010–11, a decrease from 27.2 million cubic metres in 2006–07 (Table 6.1; see Table 2.12 for more detail). More than half (56.4%) of logs harvested in Australia in 2010–11 were softwood, almost completely from plantations. The remainder was mostly hardwoods sourced from native forests (23.8%) and from plantations (19.8%). A very small proportion of the total log harvest is composed of native forest softwoods.

Australia's forest resource base has therefore changed in recent years. In 2006–07, the native forest hardwood log harvest contributed 31.4% of the total harvested log volume (8.6 million cubic metres), but this declined to 23.8% (6.3 million cubic metres) in 2010–11, a fall of around 26% (Figure 6.1). The largest falls in native forest hardwood harvest were in two main areas: logs harvested for woodchip export (Figure 6.14), and saw and veneer logs (Figure 6.6). Native forest hardwood logs for woodchip export declined from 4.7 million cubic metres to 3.2 million cubic metres between 2006–07 and 2010–11, a fall of 30.7%. Harvest of native forest hardwood saw and veneer logs experienced the second largest fall (23.4%), from 2.9 million cubic metres to 2.3 million cubic metres.

The decline in native forest hardwood log harvests corresponded with increases in log harvests from Australia's hardwood plantation estate (Figure 6.1), which rose from 4.1 million cubic metres in 2006–07 to 5.3 million cubic metres in 2010–11. The largest change came from a higher harvest of hardwood plantation logs for woodchip export, which increased from 3.6 million cubic metres to 4.9 million cubic metres between 2006–07 and 2010–11. Harvest of softwood logs from both native and plantation forests also increased 2.7% from 2006–07 to 2010–11, from 14.6 million cubic metres to 15.0 million cubic metres. Overall, the volume of logs harvested in softwood and hardwood plantations (plus the small proportion of harvested native forest softwood) increased from 18.6 million cubic metres in 2006–07 to 20.2 million cubic metres in 2010–11, an increase of 8.6%, and 76% of the volume of logs harvested in Australia in 2010–11 was from plantations.

The actual value of harvested logs increased by 8.1% between 2006–07 and 2010–11, from $1.71 billion to $1.85 billion. However, the adjusted value of harvested logs, indexed to 2010–11 prices, declined by 3.9% from $1.93 billion to $1.85 billion over the period (Figure 6.2).

The largest contributors to Australia's total log harvest in 2010–11, in both volume and value terms, were Victoria, New South Wales, Tasmania and Western Australia (Figures 6.3 and 6.4). The average value of logs differs in different states, due largely to differences in the type of log harvested (such as softwood or hardwood) and wood source (such as native forest or plantation).

Table 6.1: Volume of logs harvested by log type

Log type	Volume harvested ('000 cubic metres)				
	2006–07	2007–08	2008–09	2009–10	2010–11
Native forest hardwood[a]	8,551	8,940	7,739	6,589	6,326
Hardwood plantation	4,052	4,270	4,746	4,555	5,259
Softwood plantation[b]	14,590	15,157	13,314	14,433	14,981
Total	**27,192**	**28,368**	**25,799**	**25,577**	**26,567**

a Does not include the small proportion of native forest softwood logs reported in this Indicator under softwood plantation.

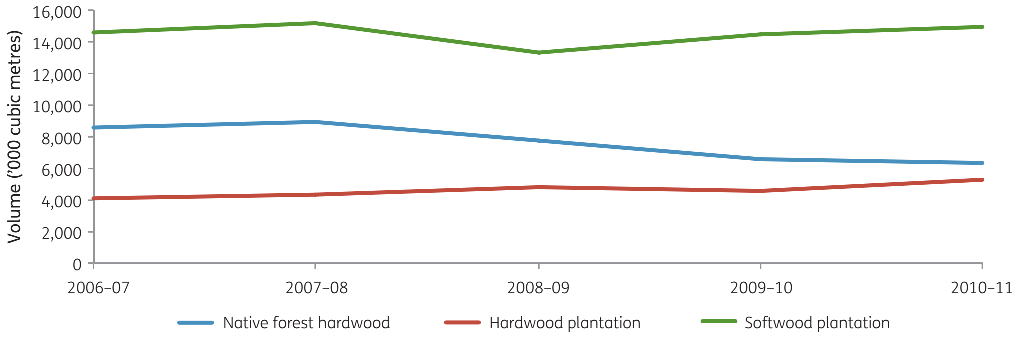
b Includes a small proportion of native forest softwood logs.

Note: Totals may not tally due to rounding.

Source: ABARES (2013a).

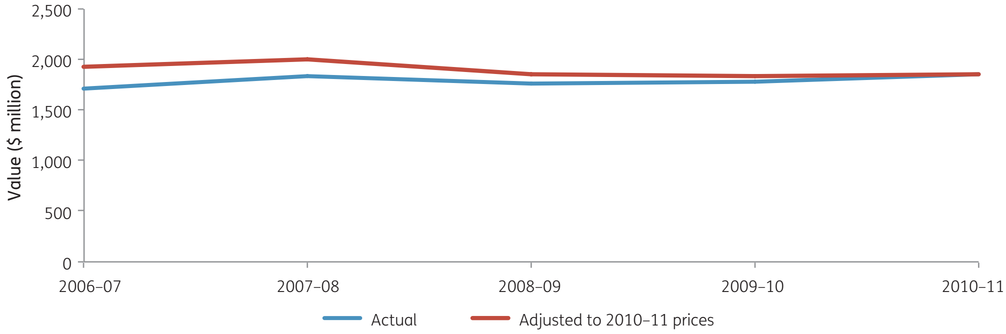
Native and plantation forest near Bright, Victoria.

Figure 6.1: Volume of logs harvested, 2006–07 to 2010–11



Note: Softwood plantation logs include a small proportion of native forest softwood logs.
Source: ABARES (2013a).

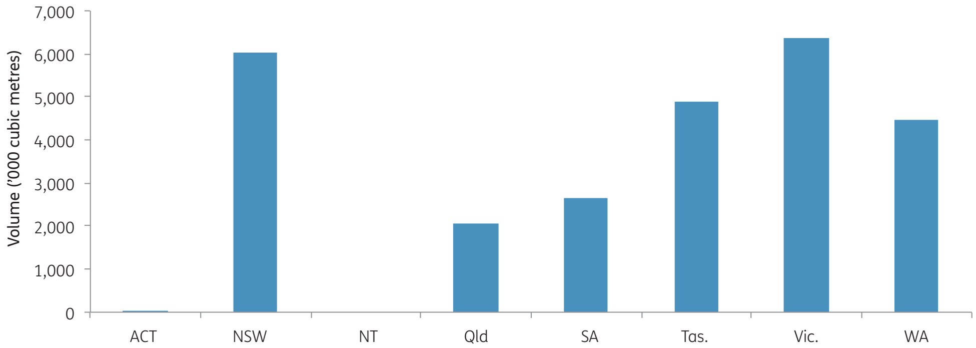
Figure 6.2: Value[a] of logs harvested, actual and adjusted, 2006–07 to 2010–11



a Estimated gross value of logs delivered to mill door or wharf gate.

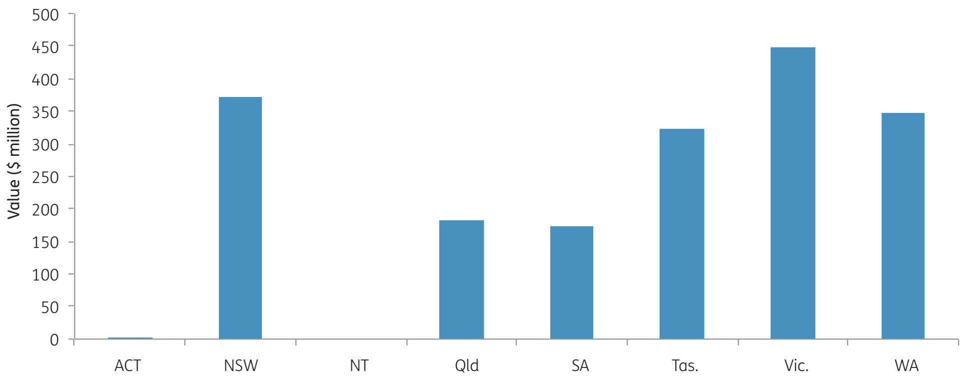
Source: Adjusted values are indexed to 2010–11 prices using actual values reported in ABARES (2013a) and the consumer price index as reported in ABS (2012a).

Figure 6.3: Volume of logs harvested, 2010–11, by jurisdiction



Source: ABARES (2013a).

Figure 6.4: Value of logs harvested, 2010–11, by jurisdiction



Source: ABARES (2013a).

CRITERION 6

Wood products

Turnover ('sales and service income') in the Australian wood and wood products industries (defined according to the Australian and New Zealand Standard Industrial Classifications given in Figure 6.5) increased from $21.2 billion to $24.0 billion between 2006–07 and 2010–11, an increase of 13.6% (Figure 6.5; ABARES 2013a). After adjusting to 2010–11 prices, the turnover in these industries increased by 0.9% over the period, from $23.8 billion to $24.0 billion. The wood and wood products industries contributed 5.7% of total national value added of manufacturing in 2006–07, and 6.2% in 2010–11 (ABARES 2013a).

Sawn wood

The total production of sawn wood declined from 5.2 million cubic metres in 2006–07 to 4.6 million cubic metres in 2010–11. There was a small decline in sawn softwood production, from 4.0 million cubic metres in 2006–07 to 3.8 million cubic metres in 2010–11 (a decrease of 4.6%). In comparison, sawn hardwood production experienced a larger decline, from 1.2 million to 730 thousand cubic metres (36.6%) (Figure 6.6).

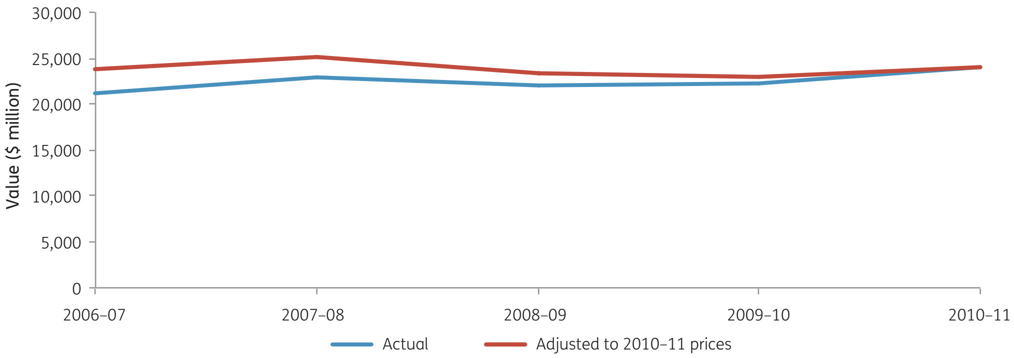
Changes in sawn hardwood and softwood production over the period reflect the response of the wood products industry to competitive pressures, expectations of future wood product demand and log supply (Burns and Burke 2012), and resource availability. Over the reporting period, growing interest in forest conservation in Australia has reduced access to native forest for wood production, thereby reducing the amount of hardwood sawlogs available for the industry. The hardwood plantation estate, which is estimated to have harvested 5.3 million cubic metres of hardwood logs in 2010–11, supplied only around 38 thousand cubic metres of sawlog. The remainder was pulplogs for domestic paper production, wood-based panels, and woodchip export (ABARES 2012g).

In comparison, the sawn softwood industry relies almost entirely on plantations, and is thus less sensitive to reductions in native forest access. However, easing activity in housing construction—a major consumer of sawn softwood—over the reporting period, as well as relatively cheaper imports because of the high value of the Australian dollar later in the reporting period, have also increased competitive pressure on the sawn softwood industry.

The actual value of sawn wood production increased from $3.7 billion to $3.8 billion between 2006–07 and 2010–11 (Figure 6.7).

A sawmill employee grading freshly sawn timber.

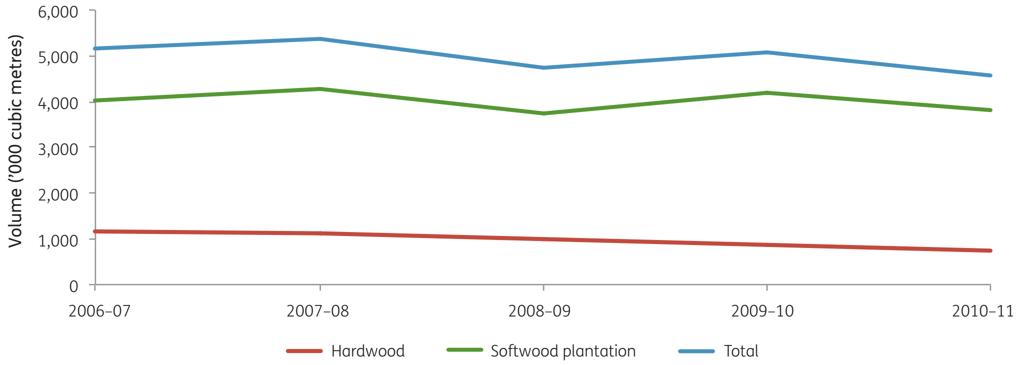
Figure 6.5: Value of turnover in wood and wood products industries[a], 2006–07 to 2010–11



[a] The wood and wood products industries relate here to the Australian and New Zealand Standard Industrial Classification 2006 Division A, Subdivision 3—forestry and logging; Division C, Subdivision 14—wood product manufacturing; and Division C, Subdivision 15—pulp, paper and paperboard manufacturing (Trewin and Pink 2006).

Source: Adjusted values are indexed to 2010–11 prices using actual values reported in ABARES (2013a) and the consumer price index (CPI) as reported in ABS (2012a).

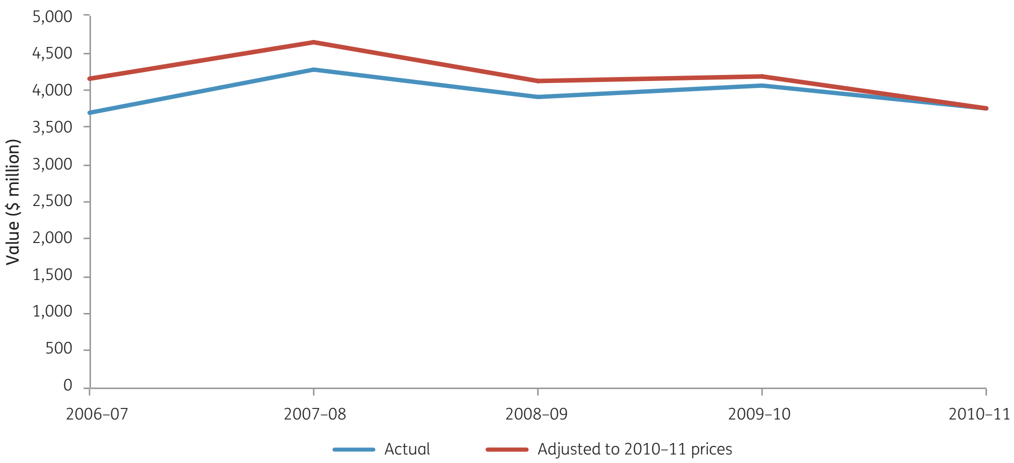
Figure 6.6: Volume of sawn wood production, 2006–07 to 2010–11



Note: Hardwood logs are the total of native forest hardwood logs and hardwood plantation logs. Softwood plantation logs include a small proportion of native forest softwood logs.

Source: ABARES (2013a).

Figure 6.7: Value[a] of sawn wood production[b], 2006–07 to 2010–11



[a] Values are expressed in terms of turnover.

[b] Sawn wood production relates here to the Australian and New Zealand Standard Industrial Classification 2006 Division C, Subdivision 14/1411—log sawmilling; and Division C, Subdivision 14/1413—timber re-sawing and dressing (Trewin and Pink 2006).

Source: Adjusted values are indexed to 2010–11 prices using actual values reported in ABARES (2013a) and the consumer price index as reported in ABS (2012a).

CRITERION 6

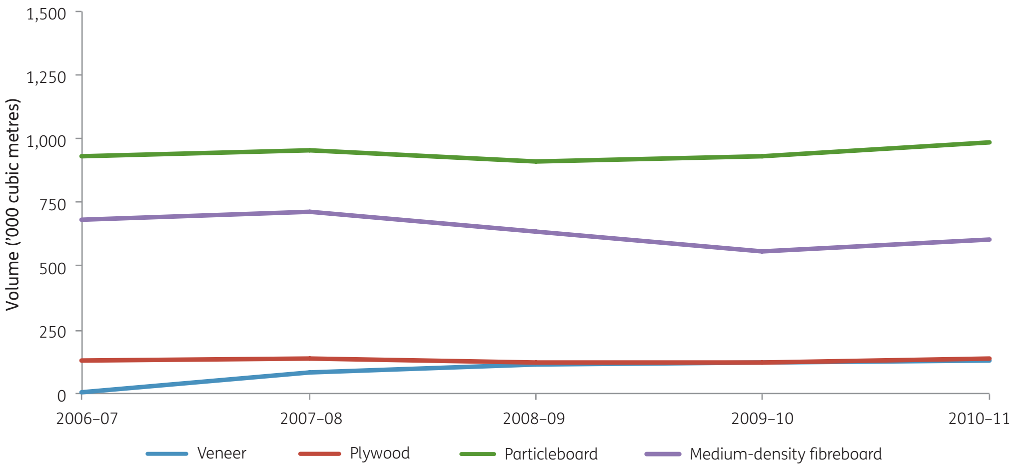
Wood-based panels

The total volume of wood-based panel production was reasonably steady in the period 2006–07 to 2010–11, although there were changes in the mix of products. The establishment of new infrastructure and the commissioning of two export veneer mills in 2007–08 by Ta Ann led to a significant increase in veneer production and export (mostly to Malaysia). Medium-density fibreboard was the only product that declined in production over the period, from 680 thousand cubic metres in 2006–07 to 605 thousand cubic metres in 2010–11 (Figure 6.8).

The actual value of Australia's wood-based panel production increased from $1.5 billion in 2006–07 to $1.6 billion in 2010–11 (Figure 6.9).

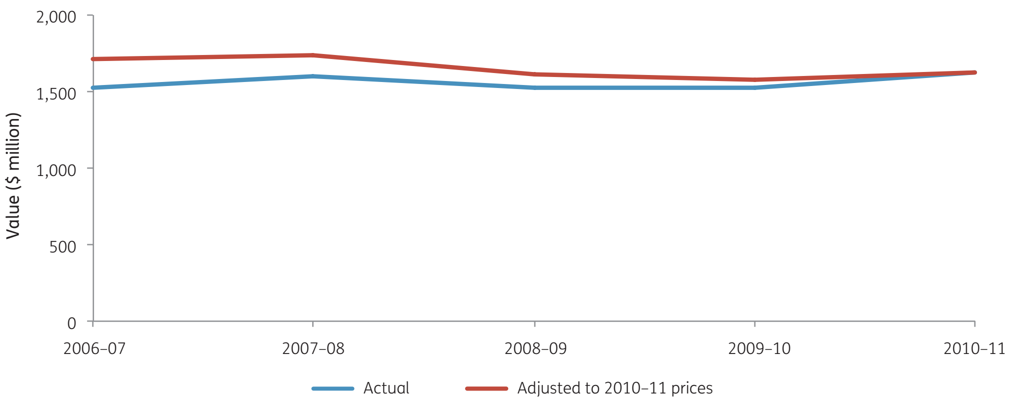
Timber framing used in building construction.

Figure 6.8: Volume of wood-based panel production, 2006–07 to 2010–11



Source: ABARES (2013a).

Figure 6.9: Value[a] of wood-based panel production[b], 2006–07 to 2010–11



a Values are expressed in terms of turnover.

b Wood-based panel production relates here to the Australian and New Zealand Standard Industrial Classification 2006 Division C, Subdivision 14/1493—plywood and veneer; and Division C, Subdivision 14/1494—reconstituted wood products (Trewin and Pink 2006).

Source: Adjusted values are indexed to 2010–11 prices using actual values reported in ABARES (2013a) and the consumer price index as reported in ABS (2012a).

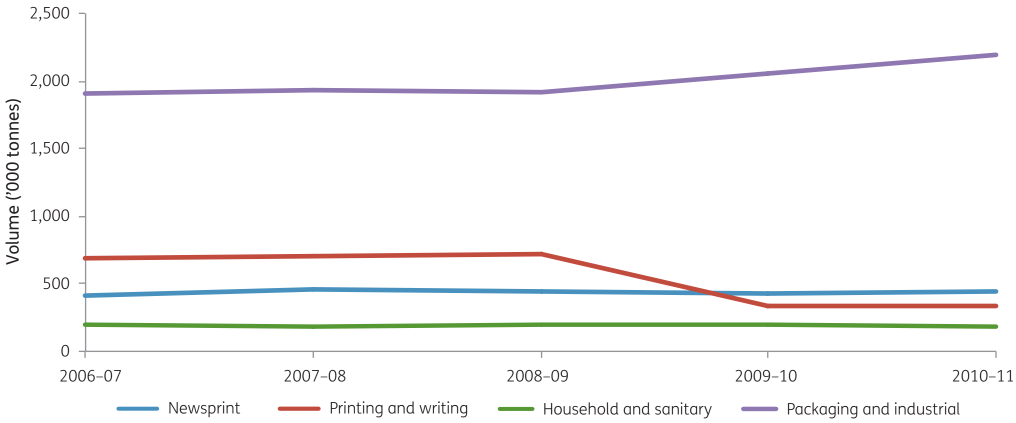
Paper and paperboard products

In 2010–11, Australia produced 3.2 million tonnes of paper and paperboard, consisting of newsprint, printing and writing papers, household and sanitary products, and packaging and industrial products. Of these products, production of packaging and industrial goods increased the most, from 1.9 million tonnes in 2006–07 to 2.2 million tonnes in 2010–11 (Figure 6.10). In comparison, the production of printing and writing goods decreased from 693 thousand tonnes to 342 thousand tonnes—that is, by 50.6%—over the period, the largest fall in production within this reporting category.

The actual value of Australia's paper and paperboard production increased from $9.6 billion in 2006–07 to $10.9 billion in 2010–11, a 13.7% increase. However, when indexed to 2010–11 prices, the value increased more modestly, from $10.8 billion in 2006–07 to $10.9 billion in 2010–11, after declining for most of the period (Figure 6.11).

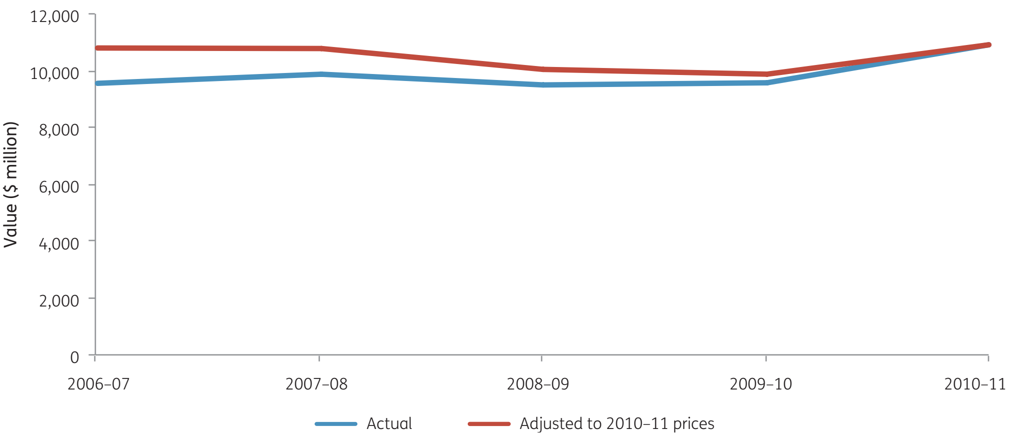
Newsprint and printing paper products.

Figure 6.10: Volume of paper and paperboard production, 2006–07 to 2010–11



Source: ABARES (2013a).

Figure 6.11: Value[a] of paper and paperboard production[b], 2006–07 to 2010–11



a Values are expressed in terms of turnover.

b Paper and paperboard production relates here to the Australian and New Zealand Standard Industrial Classification 2006 Division C, Subdivision 15/1510—paper and paper product manufacturing (Trewin and Pink 2006).

Source: Adjusted values are indexed to 2010–11 prices using actual values reported in ABARES (2013a) and the consumer price index (CPI) as reported in ABS (2012a).

CRITERION 6

Pulpwood for domestic pulp and paper manufacturing

The volume of pulplogs harvested for domestic pulp and paper production increased by 32.1%, from 3.1 million cubic metres in 2006–07 to 4.1 million cubic metres in 2010–11. Throughout the period, softwood plantations contributed more than 70% of pulp for domestic pulp and paper manufacturing each year. The remaining 30% is sourced from native forests and hardwood plantations (Figure 6.12).

The actual value of pulpwood harvested for pulp and paper manufacture increased from $131 million to $189 million between 2006–07 and 2010–11. In comparison, the adjusted value of the pulpwood, indexed to 2010–11 prices, increased from $147 million to $189 million (Figure 6.13).

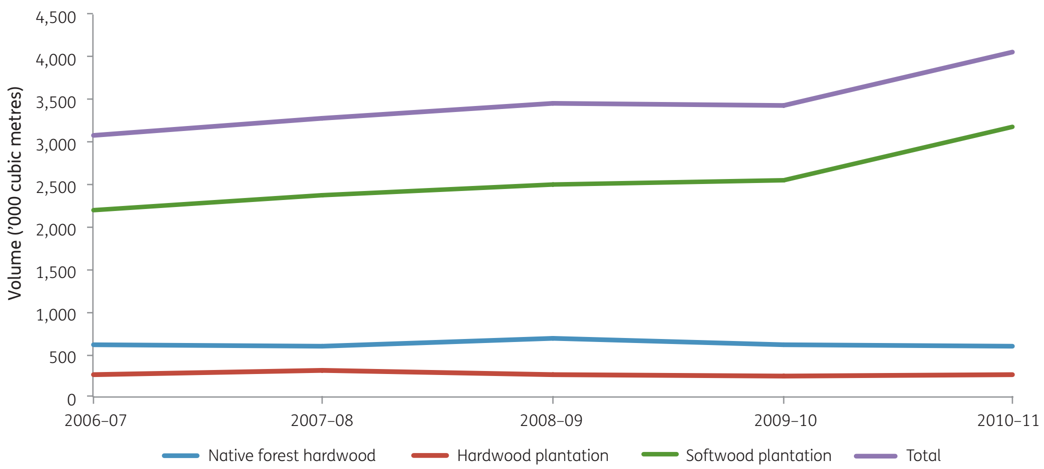
Pulpwood for exported woodchips

In 2010–11, Australia exported 9.4 million tonnes of woodchips, compared with 9.6 million tonnes in 2006–07. Of this, softwood woodchip exports decreased from 1.3 million tonnes in 2006–07 to 1.2 million tonnes in 2010–11 (a decrease of 3.8%), and hardwood woodchip exports decreased from 8.3 million tonnes to 8.1 million tonnes (a decrease of 2.5%) over the same period (Figure 6.14).

The value of both softwood and hardwood woodchip exports decreased between 2006–07 and 2010–11. The actual value of hardwood woodchip exports decreased from $795 million in 2006–07 to $766 million in 2010–11. Indexed to 2010–2011 prices, the value of hardwood woodchip exports decreased from $894 million in 2006–07 to $766 million in 2010–11 (Figure 6.15).

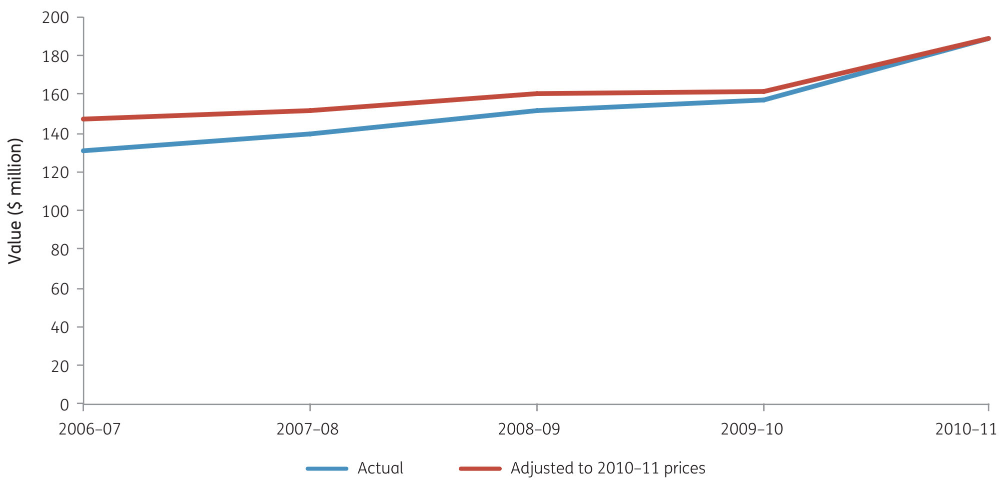
The actual value of softwood woodchip exports decreased from $155 million in 2006–07 to $119 million in 2010–11 (Figure 6.16).

Figure 6.12: Volume of pulpwood for domestic pulp and paper manufacturing, 2006–07 to 2010–11



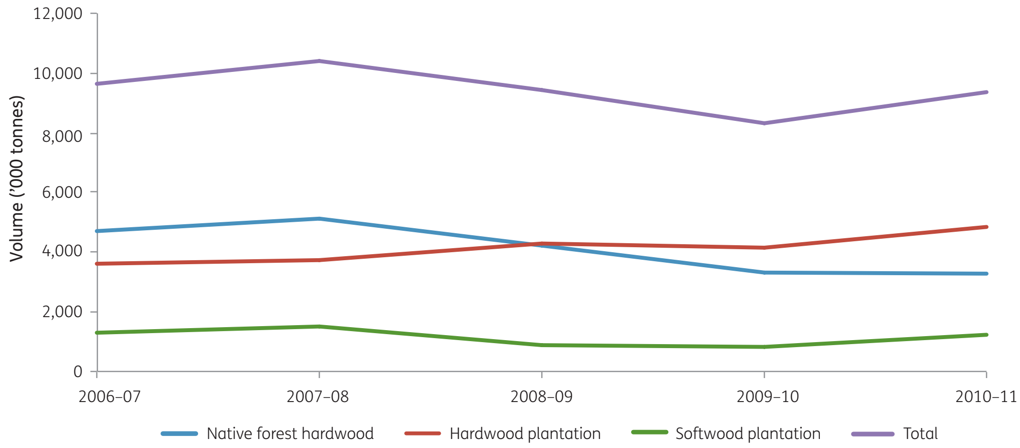
Note: Softwood plantation logs include a small proportion of native forest softwood logs.
Source: ABARES (2013a).

Figure 6.13: Value[a] of pulpwood for domestic pulp and paper manufacture, 2006–07 to 2010–11



a Estimated gross value of logs delivered to mill door or wharf gate.
Source: Adjusted values are indexed to 2010–11 prices using actual values reported in ABARES (2013a) and the consumer price index as reported in ABS (2012a).

Figure 6.14: Volume of logs harvested for woodchip exports, 2006–07 to 2010–11[a]



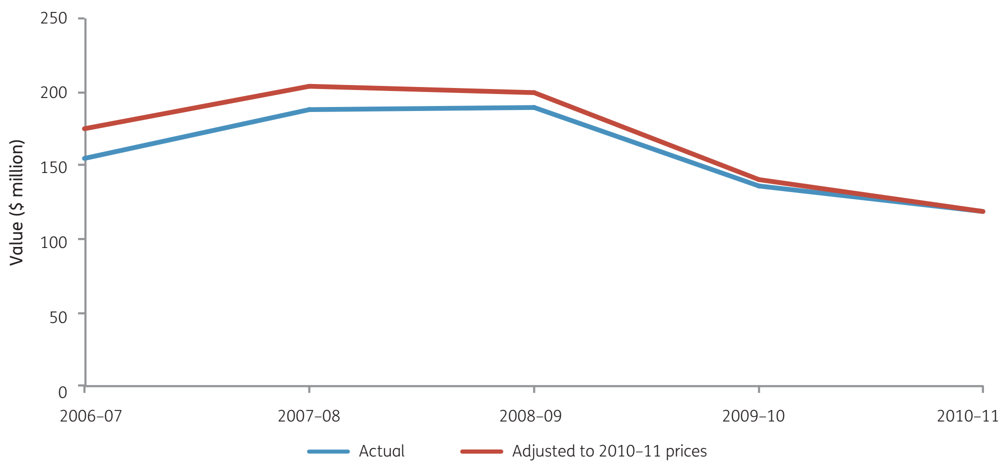
Source: ABARES (2013a).

Figure 6.15: Value[a] of hardwood woodchip exports, 2006–07 to 2010–11

a Values are expressed in terms of free-on-board value.

Source: Adjusted values are indexed to 2010–11 prices using actual values reported in ABARES (2013a) and the consumer price index as reported in ABS (2012a).

Figure 6.16: Value[a] of softwood woodchip exports, 2006–07 to 2010–11



a Values are expressed in terms of free-on-board value.

Source: Adjusted values are indexed to 2010–11 prices using actual values reported in ABARES (2013a) and the consumer price index as reported in ABS (2012a).

Indicator 6.1b

Values, quantities and use of non-wood forest products

Rationale

This indicator measures the quantities, values and usage of non-wood products. It enables socio-economic benefits to be monitored by ascertaining trends in quantities, values and usage of non-wood products.

Key points

- Many Australian non-wood forest products (NWFPs) are commercialised, including for emerging export markets.
- Some NWFP industries are based, partly or wholly, on wild harvesting and hunting, including of animals that are considered to be pests, such as wild pigs and deer.
- The most recent estimate of the gross annual value of production of NWFPs regarded as having high forest dependence was $198 million.
- In 2010–11, Australia's emerging plant industries had an estimated gross value of production of about $530 million, and the emerging animal industries had an estimated gross value of production of $382 million. Because these data on emerging industries include data on non-forest plants and animals as well as data on forest plants and animals, the values provide an upper limit to the value of emerging NWFP industries.

Non-wood forest products (NWFPs) are products of biological origin other than wood derived from forests. In some countries, NWFPs are still harvested predominantly for subsistence purposes. In Australia, however, many NWFPs have been commercialised and are traded both domestically and internationally (Hansda 2009, RIRDC 2010). This indicator provides an overview of selected commercialised NWFPs; there are insufficient data to examine other NWFPs.

Additional information about the sustainability of NWFPs is presented in Indicators 2.1c and 2.1d. Case study 6.4 in Indicator 6.1d covers the native plant food industry. Some tree-based industries—such as horticultural crops—are not discussed in this indicator because they are not generally based on forests and are regarded as distinct from the forest industry.

Classification of non-wood forest products

Not all products reviewed in this indicator are fully forest-dependent, because some of the plants and animals on which they are based also exist outside forests. Data limitations are a major barrier to providing a complete measure of the harvested quantities, market value and usage of NWFPs.

The non-exhaustive list of NWFPs in Table 6.2 features products considered to have high forest dependence or to be derived from forest-based animal and plant stocks. The estimated gross value of production of these products was $126 million in 2006–07 and $198 million in 2011–12. These figures do not include forest-related production in the kangaroo and wallaby industry (discussed below). A component of the buffalo and goat industry (Foster in press) comprising the harvest of feral animals would also derive from forests, but these industries are not reported here.

Table 6.2: Estimated gross value of production of selected non-wood forest products

Sector	Value ($ '000) 2006–07	2011–12
Crocodiles	10,179	51,859
Deer	3,047	1,659
Game pigs	12,738	8,697
Eucalyptus oil	1,100	1,260
Tea-tree oil	11,021	12,132
Native bush foods[a]	6,828	17,915
Sandalwood	9,906	14,740
Honey and beeswax	70,000	85,000
Truffles	1,640	5,152
Total	**126,459**	**198,414**

[a] See Case study 6.4 in Indicator 6.1d for further discussion of this industry.

Note: Gross value of production is the value placed on recorded production at the wholesale prices realised in the marketplace, where the marketplace is at a market point to be consumed locally or exported, refers to a raw material for a secondary industry, or is at a market point before being value-added by an industry. In many cases, the value of production of an industry will be less than the value of exports because of substantial value-adding through processing before export.

Source: ABARES (2013b), Foster (in press).

Crocodiles

The Australian crocodile industry is mostly farm-based, but wild crocodile eggs are also harvested. The industry raises mainly saltwater crocodiles (*Crocodylus porosus*) for skin products, meat and eggs, although a few farms also raise freshwater crocodiles (*C. johnstoni*) (Shim-Prydon and Camacho-Barreto 2007). Saltwater crocodile eggs can be considered NWFPs because they are often taken from forested (melaleuca) wetlands (SOFR 2008).

The Australian crocodile industry produced 23,278 hides in 2006–07 and 48,532 hides in 2011–12 (Table 6.3), of which about 74% was exported in 2011–12. The major end market for Australian crocodile skins is the manufacture of high-quality leather goods, some of which are exported. Other parts of the crocodile (such as teeth, skulls and feet) are used as components in accessories, jewellery, medicine, the food industry (see below) and the production of oils. Australian crocodile meat production, exports and domestic consumption in 2006–07 and 2011–12 are shown in Table 6.4.

Table 6.3: Australian crocodile hide production and exports, 2006–07 and 2011–12

Product statistic	2006–07	2011–12
Production		
Number of hides (saltwater and freshwater)	23,278	48,532
Exports		
Number of hides (freshwater)	3	516
Number of hides (saltwater)	20,479	36,044
Number of leather pieces	88	3

Source: ABS (2013), Foster (in press).

Table 6.4: Australian crocodile meat production, exports and domestic consumption, 2006–07 and 2011–12

Product statistic	2006–07	2011–12
Production (tonnes)	116.4	243.0
Exports (tonnes)	12.6	25.9
Domestic consumption (tonnes)[a]	103.8	217.1

[a] Domestic consumption is calculated as production less exports.

Source: ABS (2013), Foster (in press).

The Northern Territory reported a harvest of 36,796 crocodile eggs from farms and the wild in 2010–11 (Table 6.5). The major market for crocodile eggs is food consumption. To help prevent overharvesting, the Northern Territory Government regulates the harvest of crocodile eggs by requiring and managing permits for harvest.

Table 6.5: Crocodile egg harvest, from farms and the wild, Northern Territory, 2006–07 to 2010–11

Period	2006–07	2007–08	2008–09	2009–10	2010–11
Number of eggs	40,702	37,608	33,117	33,078	36,796

Source: Northern Territory Department of Natural Resources, Environment, the Arts and Sport.

Deer

Deer are raised on farms for consumer markets. In some parts of Australia, wild (feral) deer are a pest species. The main products from deer farming are venison and velvet antler. Australia's herd comprises approximately 50% fallow deer (*Dama dama*), 40% red deer (*Cervus elaphus*), 7% rusa deer (*C. timorensis*), and 3% elk (*C. canadensis*) (Foster 2009).

Feral deer are common and widespread in forested areas of Queensland, South Australia, Tasmania and Victoria (Figure 6.17); they are less common in New South Wales and Western Australia (NLWRA 2008). Feral deer are commonly hunted for recreation and as a method of pest management.

Saltwater crocodile, Kakadu National Park, Northern Territory.

Figure 6.17: Location of feral deer populations, Australia

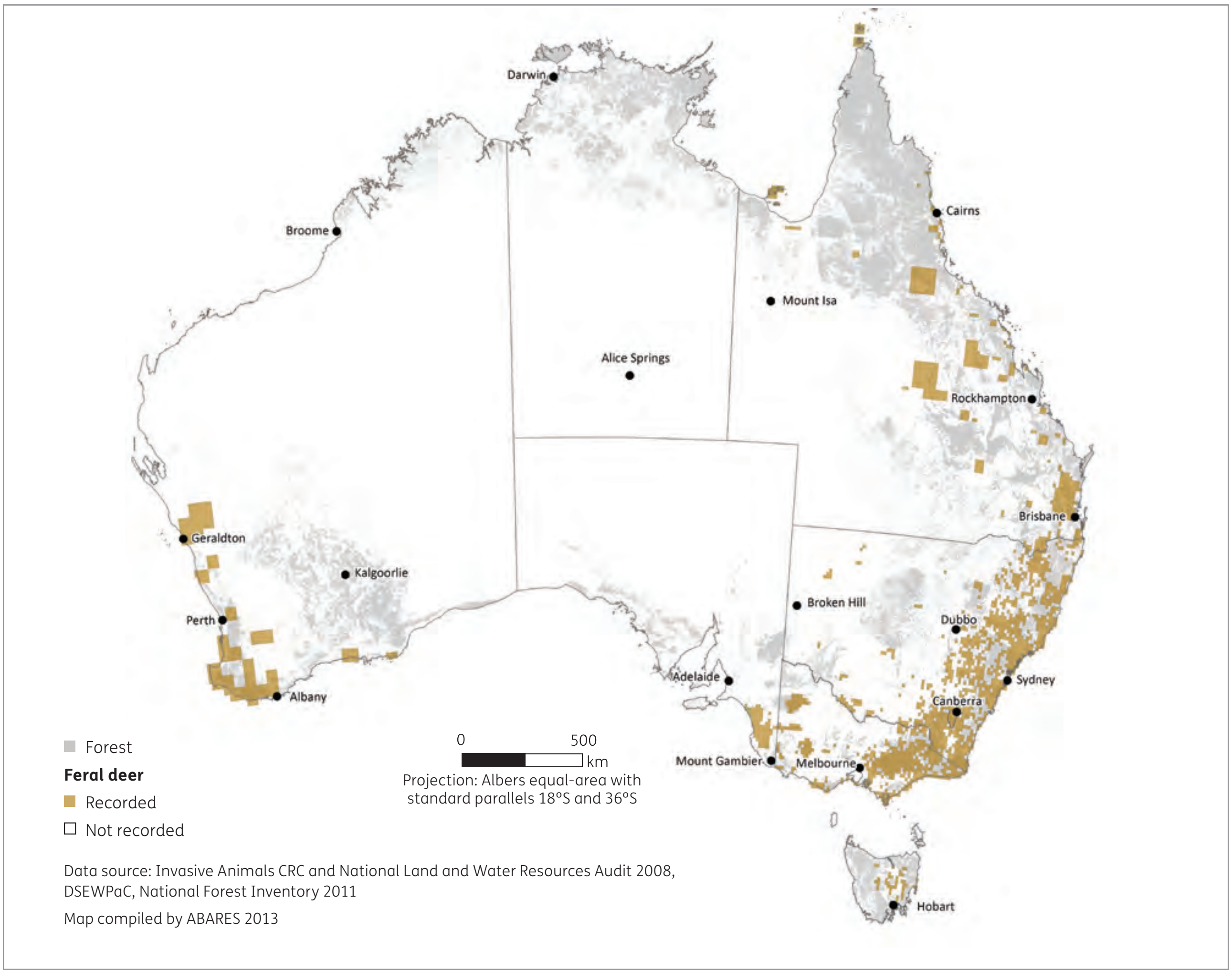


Table 6.6 shows the volume of venison production, exports and consumption, as well as the number of live deer and deer hides exported, in 2006–07 and 2011–12. Volumes in Table 6.6 include venison sourced from commercial deer farms. Australia also imports venison from New Zealand, but no data are available on the quantity or value of that trade.

Table 6.6: Venison production, exports and consumption, and exports of live deer and deer hides, 2006–07 and 2011–12

Product statistic	2006–07	2011–12
Venison production (tonnes)[a]	616	223
Venison exports (tonnes)[a]	523	190
Domestic venison consumption (tonnes)[b]	93	33
Live deer exports (number)	404	0
Deer hide exports (number)	16,989	4,415

a Venison production and exports are reported as hot carcass weight.

b Venison consumption is calculated as venison production less venison exports.

Notes:

Australia imports venison from New Zealand, but no data are available on the quantity or value of venison imports.

The proportion of wild harvest from forests is unknown.

Source: Foster (in press).

Velvet antlers are widely used in traditional Asian medicines. In 2006–07 and 2011–12, Australia exported nearly its entire production of velvet antlers, and apparent domestic consumption was around 510 kilograms (Table 6.7). However, actual domestic consumption of deer antlers may be higher as a result of imports (the extent of which is not reported) or use of previously held inventories.

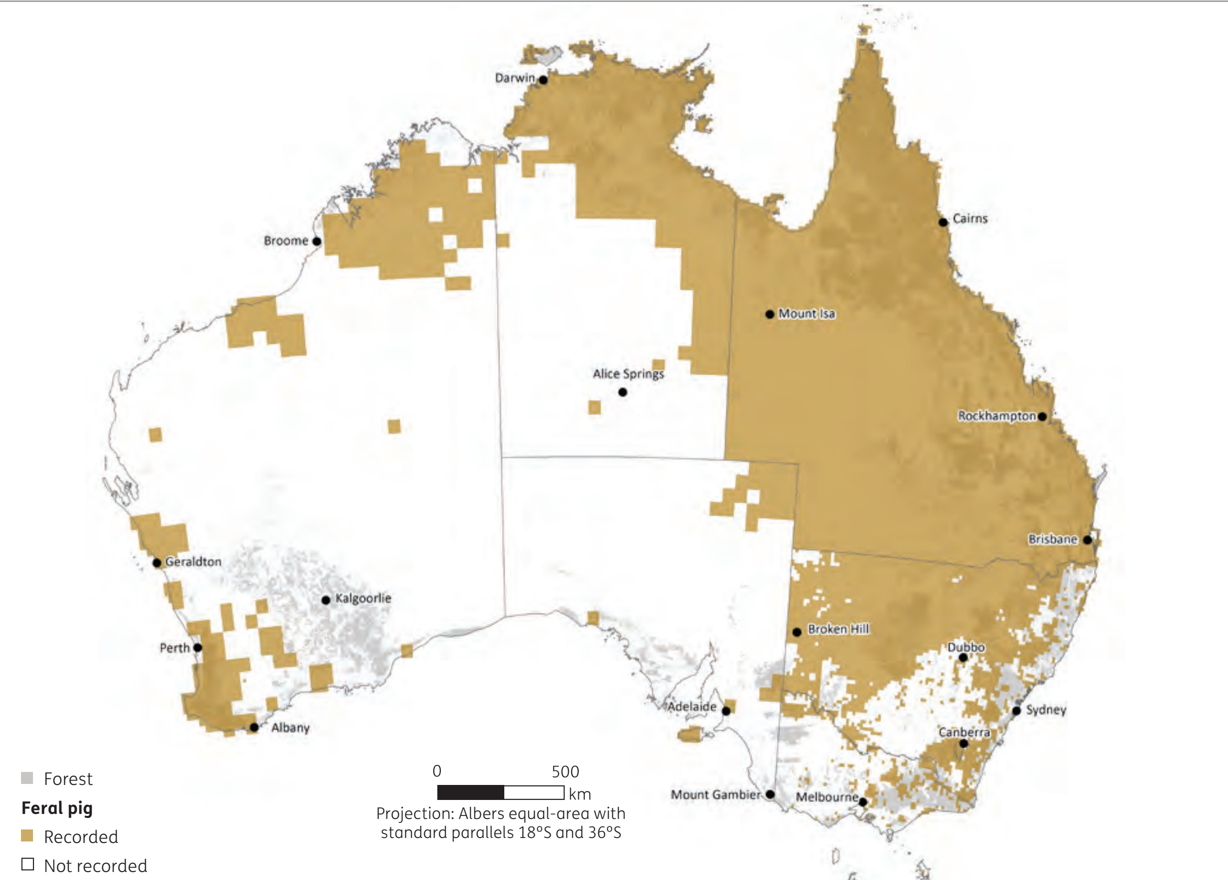
Table 6.7: Velvet antler production, exports and consumption, 2006–07 and 2011–12

Product statistic	2006–07	2011–12
Production (kg)	20,877	12,089
Exports (kg)	20,361	11,577
Domestic consumption (kg)[a]	516	512

a Domestic consumption is calculated as production less exports.

Source: Foster (in press).

Figure 6.18: Location of feral pig populations, Australia



Data source: Invasive Animals CRC and National Land and Water Resources Audit 2008, DSEWPaC, National Forest Inventory 2011

Map compiled by ABARES 2013

Game pigs

The game pig industry is based on the harvest of feral pigs (*Sus scrofa*), primarily in northern and eastern Australia, where they are more prevalent (Figure 6.18). This industry is distinct from the mature Australian pork industry, which has more stringent health and safety requirements for its products. Game pigs are hunted for their meat, as a recreational activity and as a pest management practice.

Table 6.8 shows the number of reported game pig kills, and game pig meat production, exports and consumption, in 2006–07 and 2011–12. Almost all the production was exported. Domestic consumption for both periods was 20 tonnes.

Table 6.8: Number of game pig kills, and game pig meat production, exports and consumption, 2006–07 and 2011–12

Product statistic	2006–07	2011–12
Kills (number)	165,300	112,400
Meat production (tonnes)	2,066	1,405
Meat exports (tonnes)	2,046	1,385
Domestic meat consumption (tonnes)[a]	20	20

[a] Domestic consumption is the implied level of consumption, calculated as production less exports.

Source: Foster (in press).

Kangaroo and wallaby

Kangaroos and wallabies are harvested from the wild by shooters. An industry has developed over the past 30 years from this harvest, producing meat for human consumption and pet food, and skins. Kangaroos and wallabies are harvested under a quota system administered by the state, territory and Australian governments, based on the principles of sustainability (see Indicator 2.1d).

Kangaroos (common wallaroo or euro, *Macropus robustus*; eastern grey kangaroo, *M. giganteus*; red kangaroo, *M. rufus*; and western grey kangaroo, *M. fuliginosus*) are harvested commercially for meat and skins in New South Wales, Queensland, South Australia and Western Australia. Bennett's wallaby (*M. rufogriseus*) and the Tasmanian pademelon (*Thylogale billardierii*) are commercially harvested in Tasmania from Flinders and King islands. All these species dwell in both forests and non-forests, and are common and not endangered. Other kangaroo and wallaby species are protected from commercial harvesting.

The total commercial harvest of kangaroos was 1.77 million in 2011–12, with a gross value of $28.6 million, around 50% less than figures reported in 2005–06 (Table 6.9). The value of exports of kangaroo products (meat and skins) decreased from $99 million in 2006–07 to $47 million in 2011–12. Export destinations for kangaroo meat in 2011–12 were South Africa (28% of total exports), Germany (19%), Netherlands (17%), Papua New Guinea (14%), and Belgium (11%) (Foster in press). Kangaroo skins are now the largest component of the kangaroo export industry by value, with exports totalling $25.7 million in 2011–12. The proportion of production and value from kangaroos derived from forests (animals living or sheltering in forests) is unknown.

Wallabies are commercially harvested for meat and skin. Agreed quotas and numbers of wallabies harvested (including pademelons) are based on management plans (see Indicator 2.1d). Export of wallaby product from Tasmania ceased after 2007–08. The Tasmanian Government allows harvesting of wallabies for the domestic market, provided the harvesting is within sustainable levels. Production of wallaby meat in Tasmania was estimated to be around 29 tonnes in 2011–12, and the gross value of wallaby production was $250,000 (Table 6.10).

Kangaroo skin, the largest component of the kangaroo export industry.

Table 6.9: Kangaroo products: production, export and value, Australia

Product statistic	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12
Harvest							
Harvest quota ('000)[a]	3,809	3,641	3,765	4,264	4,141	3,870	5,408
Harvest ('000)	3,431	3,017	2,674	2,516	1,985	1,752	1,768
Gross value of production ($'000)	59,843	54,073	35,665	45,232	25,765	27,869	28,646
Meat production							
Human consumption (tonnes)	15,567	16,176	16,968	15,920	10,863	9,237	12,350
Pet food (tonnes)	21,648	16,344	11,419	10,572	9,238	8,052	5,320
Total (tonnes)	37,215	32,520	28,387	26,492	20,101	17,290	17,670
Exports							
Meat (tonnes)	11,445	13,788	12,289	8,873	3,907	2,983	4,525
Pet food (tonnes)	607	585	327	405	213	133	328
Hides, skins, leather ('000 pieces)	2,691	2,505	2,524	1,895	1,535	1,372	1,827
Total export value ($'000)	92,958	99,223	89,367	77,672	43,599	36,093	46,553

a Quota figures are for calendar year—for example, quota in 2011–12 refers to quota for 2012; includes sustainable quotas and special quotas.

Source: Foster (in press); Australian Bureau of Agricultural and Resource Economics and Sciences databases, using data from the Australian Bureau of Statistics; Australian Government Department of Sustainability, Environment, Water, Population and Communities; Levies Revenue Service.

Table 6.10: Wallaby products[a]: production, export and value, Tasmania

Product statistic	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12
Harvest							
Harvest quota (number)[b]	34,750	27,000	0	26,000	10,000	0	0
Harvest (number)[b]	9,054	10,180	0	6,360	9,223	9,500	10,000
Meat (tonnes)[b]	20.9	23.7	20.7	22.1	22.1	27.7	28.6
Gross value of production ($'000)	226	255	–	129	231	238	250
Exports							
Meat (tonnes)	5	0	0	0	0	0	0
Hides, skins, leather (pieces)	0	0	250	0	0	0	0
Total export value ($'000)	59	0	6	0	0	0	0

– = not available

a Includes pademelon.

b Data as reported in source.

Source: Foster (in press); FPA (2012a); Australian Bureau of Agricultural and Resource Economics and Sciences databases, using data from the Australian Bureau of Statistics; Australian Government Department of Sustainability, Environment, Water, Population and Communities; Levies Revenue Service.

Beekeeping

There is a significant beekeeping industry in most states of Australia, producing products such as honey, dried pollen, beeswax, royal jelly, propolis and bee venom. The industry also performs (often paid) pollination services, and there is a trade in queen and packaged bees. An estimated 80% of Australia's honey is derived from eucalypts and related species (Somerville 2010).

In 2008, the estimated production of honey in Australia was 21,000 tonnes, of which 7,800 tonnes was exported. An estimated 4,411 tonnes of honey was imported in that year; domestic consumption, therefore, was 17,611 tonnes (Table 6.11). Production of honey in 2011–12 was 23,872 tonnes, imports were 3,638 tonnes, exports were 4,879 tonnes, and consumption was 22,631 tonnes. Australia also manufactures honey-based products for both domestic and international markets. Table 6.11 shows domestic distribution of honey to end-use markets. Supermarkets and other retail outlets constituted 68% of the domestic market in 2008 and 74% in 2011–12.

Table 6.11: Volume of Australian honey production, export, import and consumption, 2008 and 2011–12

	(tonnes)	
Product statistic	**2008**	**2011–12**
Farm gate		
Production	21,000	23,872
Imports	4,411	3,638
Exports	7,800	4,879
Bulk	3,510	2,683
Packed	4,290	2,195
Domestic consumption[a]	17,611	22,631
End-use market		
Processing/manufacturing	4,774	5,000
Supermarkets	9,198	10,184
Other retail	2,759	6,547
Food services	880	900
Total end-use market	**17,611**	**22,631**

[a] Consumption is calculated as production plus imports less exports.
Source: ABS (2013), Kneebone (2010), Australian Bureau of Agricultural and Resource Economics and Sciences databases.

Eucalyptus oil

Eucalyptus oil is an essential oil extracted from the leaves of species of *Eucalyptus*. It is used in perfumes, as a topical treatment in therapy, and as a food additive and industrial chemical. Other Australian essential oils are sandalwood, tea-tree and boronia.

Table 6.12 shows Australia's production, exports and consumption of eucalyptus oil in 2006–07 and 2011–12. Exports of Australian eucalyptus oil include re-exports, such as after reprocessing activities undertaken in southern Africa. Australia is also reported to import eucalyptus oil, but no data on the quantity of such imports are available (RIRDC 2008a).

Table 6.12: Eucalyptus oil production, exports and consumption, 2006–07 and 2011–12

	(tonnes)	
Product statistic	**2006–07**	**2011–12**
Production	103	120
Exports[a]	83	149
Domestic consumption[b]	20	n

n = negative, more export than production
[a] Includes re-exports; could also include stock from previous year.
[b] Consumption is calculated as production less exports.
Note: Import data for eucalyptus oil were unavailable in both periods.

Source: ABS (2013), Foster (in press).

Tea-tree oil

Tea-tree oil from *Melaleuca* species has applications in the pharmaceutical industry because of its antiseptic and anti-inflammatory properties (RIRDC 2007b). It is used in topical treatments to treat fungal, bacterial and viral infections, as well as bruises and skin allergies. It also has industrial applications, such as in solvents and disinfectants.

Table 6.13 presents data on production, exports and consumption of Australian tea-tree oil in 2006–07 and 2011–12. More tea-tree oil was exported in 2006–07 than was produced annually, implying export of stored stock. Consumption in 2011–12 was 27 tonnes.

Table 6.13: Tea-tree oil production, exports and consumption, 2006–07 and 2011–12

	(tonnes)	
Product statistic	**2006–07**	**2011–12**
Production	379	400
Exports[a]	446	373
Domestic consumption[b]	n	27

n = negative, more export than production
[a] Figures in 2006–07 include exports of 'other essential oils', as reported by New South Wales and Queensland (which are Australia's largest producers of tea tree oil).
[b] Consumption is calculated as production less exports.

Source: ABS (2013), Foster (in press).

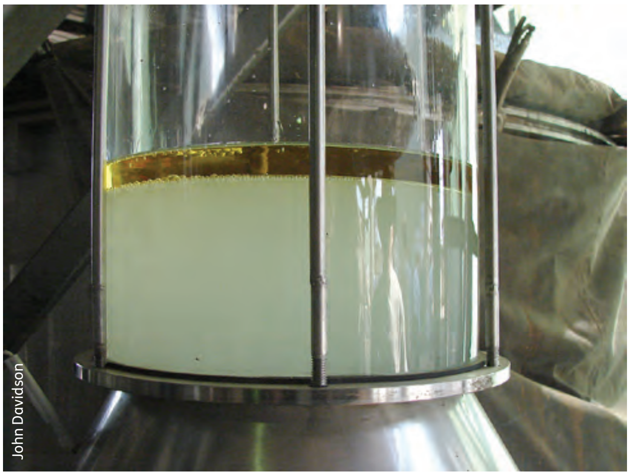
Sandalwood products

Australia's current sandalwood production comes primarily from harvesting of native stands of *Santalum spicatum* in Western Australia and *S. lanceolatum* in Queensland. Indicator 2.1d provides detailed national production figures from 2005–06 to 2011–12. Western Australia produces most of the sandalwood in Australia (Table 6.14). Harvesting in Western Australia is based on an allowable cut as specified in the *Sandalwood (Limitation of Removal of Sandalwood) Order 1996* under the *Sandalwood Act 1929* (Indicator 2.1c), and an inquiry into the industry is in progress (WA Legislative Council 2012). Indicator 2.1c discusses the sustainability of sandalwood production in Western Australia.

Around 130 tonnes of *S. lanceolatum* was harvested in Queensland in 2011–12, the smallest harvest since 2006–07. Sandalwood harvesting in Queensland is regulated by the state government, and the production quota is around 550 tonnes.

In 2012, there were more than 15 thousand hectares of *S. spicatum* plantations in Western Australia; there were also more than 8 thousand hectares of *S. album* plantations, mostly in Western Australia (Foster, in press). These plantations are reported in the 'Other forest' category in Indicator 1.1a. The first major harvestings of plantation sandalwood are expected for *S. album* in 2013 or 2014 (Foster in press).

Table 6.14 presents the estimated annual value, supply, consumption and export of Australian sandalwood for the period 2005–06 to 2011–12. The sandalwood harvest in Australia during this period varied from 2,459 tonnes to 3,073 tonnes, with 480–930 tonnes consumed domestically each year. Sandalwood oil production ranged from 10.6 tonnes in 2008–09 to 19.6 tonnes in 2010–11. Most of the oil was exported; domestic consumption of oil ranged from 0.6 tonnes to 2.0 tonnes annually (Table 6.14). The estimated gross value of production of sandalwood in Australia varied from $9.9 million in 2006–07 to $18.6 million in 2007–08, with the value in 2011–12 being $14.7 million. The estimated value of Australian exports of sandalwood products in 2011–12 was $21.6 million (Table 6.14). Around 60% of Australian sandalwood exports go to Taiwan, with Australia suppling 43% of Taiwan's sandalwood imports (Foster in press).



John Davidson

Australian sandalwood oil floating on residual aqueous condensate following extraction by steam distillation, Mt Romance Sandalwood Australia Pty Ltd factory, Albany, Western Australia.

Table 6.14: Sandalwood production, value, consumption and exports, 2005–06 to 2011–12

Product statistic	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12
Production							
Wood, Western Australia (tonnes)	2,512	2,369	2,269	2,601	2,857	2,864	2,814
Wood, Queensland (tonnes)	132	118	190	274	167	209	130
Total, wood (tonnes)	2,644	2,486	2,459	2,875	3,024	3,073	2,944
Sandalwood oil (tonnes)	14.0	14.0	12.0	10.6	19.2	19.6	15.7
Gross value of production ($'000)[a]	10,999	9,906	18,560	12,196	16,870	17,806	14,740
Export[b]							
Wood[c]							
Volume (tonnes)	1,944	1,786	1,909	2,395	2,114	2,143	2,210
Value ($'000)	17,030	13,544	18,730	13,208	15,332	16,142	14,385
Unit value ($/tonne)	8,760	7,582	9,814	5,514	7,253	7,532	6,508
Oil							
Volume (tonnes)	12	12	11	10	18	19	15
Value ($'000)	9,600	9,600	5,775	5,117	8,673	8,920	7,252
Unit value ($/kg)	800	800	1,050	1,066	953	959	988
Total							
Export value ($'000)	26,630	23,144	24,505	18,325	24,005	25,063	21,636
Domestic consumption[b]							
Wood (tonnes)[d]	700	700	550	480	910	930	734
Oil (tonnes)	2	2	1	0.6	1.2	0.6	0.7

[a] Gross value of production does not include added value of oil conversion.

[b] Harvested sandalwood can be stored for a period of time before further trading, processing, domestic consumption or export. Product reported as exported may include material currently in storage prior to export or potential domestic processing. Domestic consumption is the implied level of consumption, calculated as production less exports.

[c] Includes unprocessed wood and processed product such as sandalwood powder.

[d] Wood consumption is primarily converted to sandalwood oil.

Source: ABS (2013), Foster (in press), Australian Bureau of Agricultural and Resource Economics and Sciences databases.

Sandalwood use in ceremonial incense coils.

Forest wildflower, Queensland.

Other non-wood forest product-based industries

Australia produces a range of other non-wood products that are at least partly forest-dependent, including wildflowers, other native plants, herbs, spices, nuts, and vegetables and fruits as native bush foods, but limited information is available about these products. The Australian native bush food industry was estimated to have a gross value of production of $17.9 million in 2011–12, up from $6.8 million in 2006–07 (Foster 2009, Foster in press). This estimate includes the production of various Australian bush foods, including bush tomato, lemon aspen, lemon myrtle, muntries, native pepper, quandong, native mint, wattle seed, riberry, native citrus and wild plums. Some tree-based industries, such as horticultural crops, are generally regarded to be distinct from the forest industry.

Total value of emerging industries

Estimates of emerging animal and plant industries provide an upper limit to the total value of emerging NWFP-based industries, because many of these enterprises may use non-forest landscapes, such as rangelands and irrigated areas.

According to Foster (in press), Australia's emerging plant industries had an estimated gross value of production (GVP) of about $530 million in 2011–12, an increase from $308 million in 2006–07. These industries include activities and products relating to native Australian flora, such as native flowers, bush food, native plant oils and sandalwood. Around 14% of total plant-based GVP for emerging plant industries was accounted for by essential oils (boronia, eucalyptus, tea-tree and sandalwood), bush foods (mainly lemon myrtle, but also bush tomato, Davidson's plum, Kakadu plum, mountain pepper, native limes, quandong and wattleseed: see Case study 6.4), and wildflowers and foliage, the majority of which are forest-dwelling species.

The GVP of the emerging animal industries (including seaweed and inland aquaculture) was estimated at about $382 million in 2011–12, an increase from $293 million in 2006–07. Nearly 90% of the GVP of emerging animal industries was from harvest of wild resources such as kangaroos, wallabies, wild pigs and feral goats (Foster in press). This estimate excludes the added value arising from the control of animal populations that can adversely affect agricultural systems and the environment. Around 12% of the estimated animal-based GVP was generated by the farming or wild harvesting of Australian native animals such as kangaroos, crocodiles, emus (farming only), possums, wallabies, Murray cod (farming only) and freshwater crustaceans (predominantly farmed), all of which are forest-dwelling species; farmed stock has been derived from wild stock.

Indicator 6.1c

Value of forest-based services

Rationale

This indicator measures forest-based services such as ecosystem services, carbon credits, salinity mitigation and ecotourism. Forest-based services provide economic values and contribute to the sustainability of forests by providing significant social and environmental benefits.

Key points

- In addition to providing wood and non-wood forest products, Australia's forests provide a range of other services, such as carbon sequestration, soil conservation, watershed protection, ecotourism and biodiversity conservation. These services can broadly be divided into amenity services and ecosystem services. Markets exist for few of these services.
- One way to measure the financial value of forest-based ecotourism is to estimate the number of people visiting forests in various tenures, and the amount they spend. Changes in visitor numbers can reflect changes in the perceived value of ecotourism.
- In general, there is limited data on the value attributed to forest-based services.

The services and benefits provided by forests can be categorised by a number of frameworks (Australia21 2012)[135]. The Millennium Ecosystem Assessment (MEA 2005) defines ecosystem services as those processes of ecosystems that support (directly or indirectly) human wellbeing (Figure 6.19). A common classification of ecosystem services is into:

- supporting services (e.g. soil formation, nutrient cycling)
- provisioning services (e.g. provision of wood in growing trees, clean water in streams and rivers, genetic resources)
- regulating services (e.g. regulation of water flows)
- cultural services (e.g. recreation, ecotourism, amenity, aesthetic and heritage values).

Ecosystem services are provided by ecosystems without human input (e.g. supply of clean water, growth of trees). These services become benefits with human input (e.g. collection of water, harvesting of wood). Common ecosystem services in forests are provision of wood, non-wood forest products and wildlife habitat; provision of high-quality water; carbon sequestration and storage; and provision of recreation opportunities.

The concept of ecosystem services—how they are valued and their role—and the overall value of natural ecosystems is of growing interest to decision makers and the public with regard to how ecosystem services contribute to human quality of life and wellbeing (DEWHA 2009a). Some intermediate ecosystem services support other, final ecosystem services. Some, but not all, of these services or their associated benefits have a financial value or are tradable in markets. Case study 6.1 describes an approach to the valuation of forest-based ecosystem services in south-east Queensland.

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[135] www.daff.gov.au/natural-resources/ecosystem-services.

In addition to providing wood for wood-based industries (considered in Indicator 6.1a) and non-wood forest products (considered in Indicator 6.1b), forests provide a wide range of environmental (ecosystem) services. Storage and sequestration of carbon is addressed further in Indicators 5.1a and 7.1c, water and soil are addressed in Indicators 4.1a–e, and a case study on valuation of water is included in this indicator (Case study 6.3).

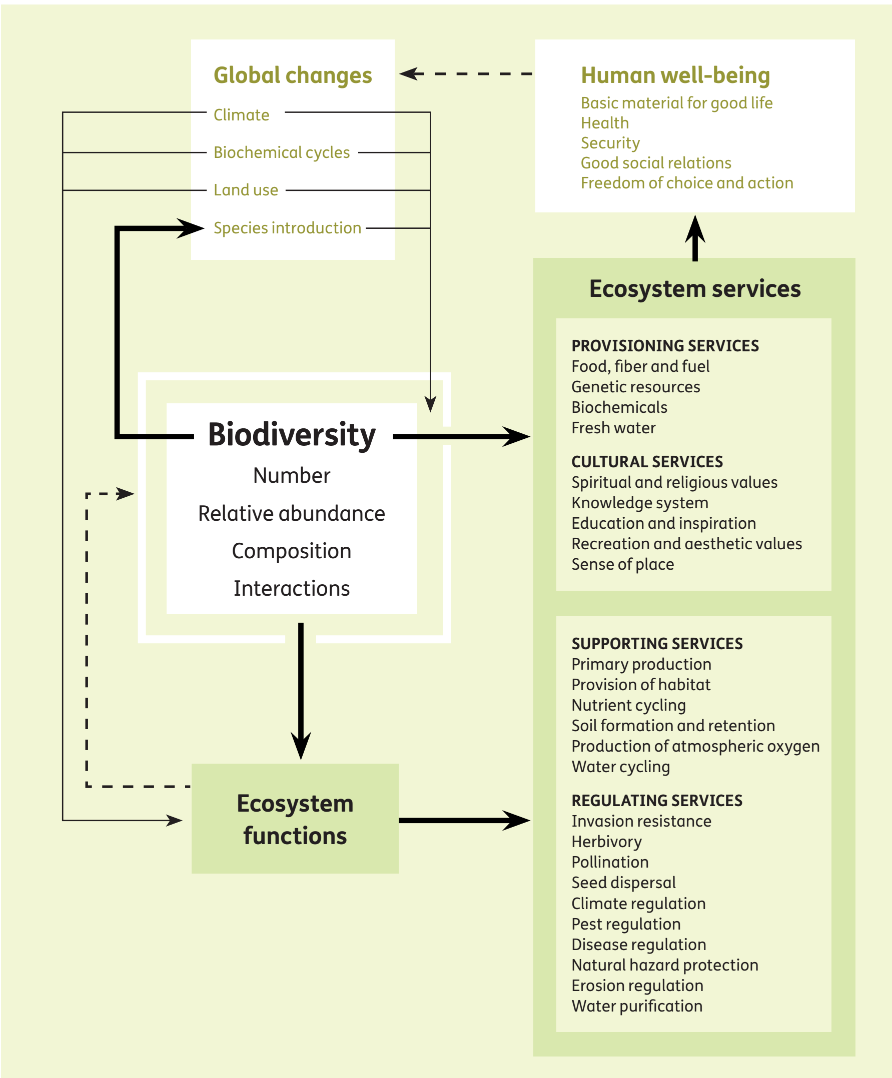
The production of quantities of high-quality water is a good example of an environmental service derived from forests (Bren et al. 2011; Case study 6.3). Traditionally, many such services have been treated as public goods with little or no financial value, but more recently mechanisms have been developed to encourage payments for some of those services. These include government programs that pay landholders to manage forests and other types of native vegetation for environmental benefits. Other mechanisms will derive from legislation in regard to carbon emissions (see Indicator 7.1a), which may enable farmers and other landholders to receive payments for reducing greenhouse gas emissions through avoided deforestation and forest management, and for increasing carbon sequestration through reforestation and revegetation activities on their lands.

Ecotourism

The aesthetic quality of forests can be viewed as an amenity service that benefits the ecotourism sector. Ecotourism generates considerable benefits for communities by providing tourist services, as well by supporting complementary sectors such as restaurants and resorts (see Indicator 6.3b).

Tourist visits to national and state parks, and forests in other tenures, provide an indication of forest use for ecotourism, although not all national parks are fully forested (some contain no forest). Approximately 8 million visits were made by international and domestic tourists to forest destinations in New South Wales in both 2009 and 2010 (Table 6.15). In South Australia, the recorded number of visitors to state forests managed by ForestrySA declined over the five-year period to 2010–11 (Table 6.16).

Figure 6.19: Millennium Ecosystem Assessment's overview of ecosystem services



Source: Millennium Ecosystem Assessment; redrawn by Fusebox, Melbourne, from DEWHA (2009a).

Case study 6.1: The South East Queensland Ecosystem Services Project

The south-east Queensland (SEQ) region is rapidly developing, with an expected increase in population to 4 million by 2031 (DERM 2009), placing strong development pressures on ecosystems, resources and the environment. The *South East Queensland Natural Resource Management Plan 2009–2031* (DERM 2009) has as a guiding principle that 'The natural environment supplies a range of goods and services. These goods and services are known as "ecosystem services" and the preservation and management of these are essential for the region's response to climate change, long-term economic, social, cultural and environmental sustainability, and community quality-of-life'.

The South East Queensland Ecosystem Services Project commenced in 2005 (Maynard et al. 2010), to:

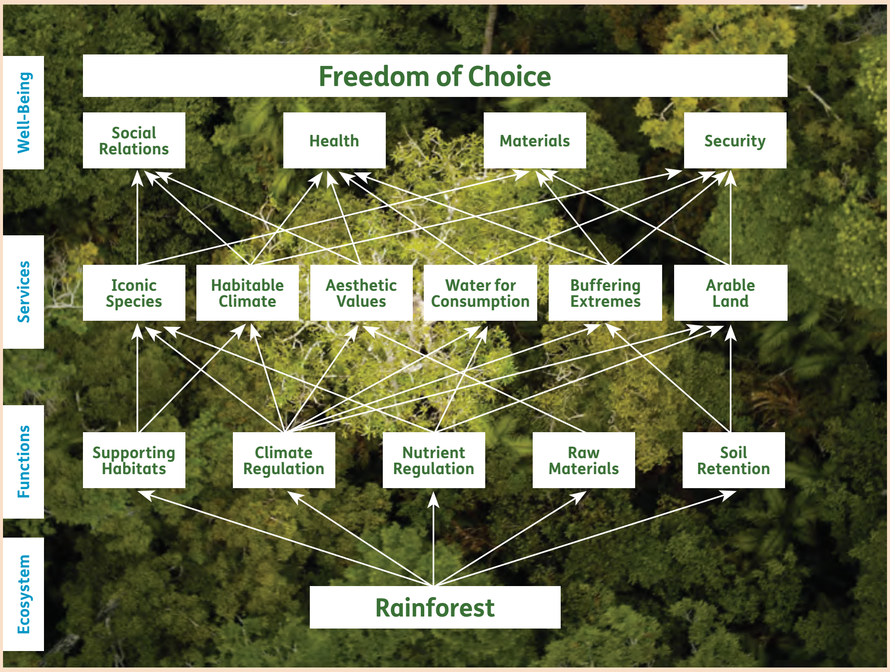
- identify, measure and value the ecosystem services provided by the SEQ region
- provide tools for a consistent approach to assessing ecosystem services in SEQ
- incorporate ecosystem services into natural resource decision-making in a way that addresses the need to protect, manage and enhance ecosystems in SEQ, while contributing to the general wellbeing of the regional human population.

The key aim of the project was to develop an ecosystem services framework based on concepts in the Millennium Ecosystem Assessment (MEA 2005), with modifications to make it more suitable for application at the regional scale and for the particular conditions of SEQ. This tool has enabled government, industry, business, researchers, non-government organisations and land managers to apply the concept of ecosystem services in management, planning and policy. In 2009, ecosystem services and the framework were incorporated into state planning policy through the statutory regional plan for managing growth and development in SEQ: the *South East Queensland Regional Plan 2009–2031* (QDIP 2009).

An adaptive participatory approach was adopted to develop the framework (Maynard et al. 2012), which included direct participation of experts and stakeholders. A detailed classification of ecosystems, ecosystem functions, ecosystem services and human wellbeing was undertaken. Other features of the approach included the use of relatively simple systems models based on subjective expert judgments about causal connections among key variables, transparency in reporting of results, and the generation of spatial information to support planning (Petter et al. 2012).

Ecosystem services were valued by experts and the community using a scoring and ranking system, with weighting applied based on the services' relative contributions to the wellbeing of the SEQ community. The framework is presented as linkages and weightings between its constituent parts. The baseline information supporting the framework can be revised dynamically using outcomes of management and planning decisions. Figure 6.20 illustrates these linkages using rainforest ecosystems. Outcomes of the South East Queensland Ecosystem Services Project are reported in more detail in Maynard et al. (2010, 2012) and Petter et al. (2012).

Figure 6.20: Ecosystem services and linkages



Note: This is a simplified model of links between functions occurring in a rainforest ecosystem, the services they have the potential to provide, and how this can contribute to human wellbeing (see www.ecosystemservicesseq.com.au/constituents-of-well-being.html). Diagram for illustration only. Redrawn by Fusebox Design, Melbourne.
© SEQ Catchments.

Table 6.15: International and domestic visitors to forest nature-based tourism destinations, New South Wales, 2009 and 2010

Destination	Number of visitors ('000)					
	2009			2010		
	International	Domestic	Total	International	Domestic	Total
National and state parks	1,327	1,853	3,180	1,379	1,794	3,173
Botanical and public gardens	1,164	766	1,930	1,198	693	1,891
Bushwalking/rainforest	807	1,982	2,789	815	2,136	2,951
Total	**3,298**	**4,601**	**7,899**	**3,392**	**4,623**	**8,015**

Source: Tourism NSW (2009, 2010).

Table 6.16: Visitors to state forests, South Australia, 2006–07 to 2010–11

Year	2006–07	2007–08	2008–09	2009–10	2010–11
Number of visitors ('000)	212	191	146	149	145

Notes:
The fall in visitor numbers after 2007–08 is partly a result of a change in the methodology to record visits to state forests in South Australia.
Figures shown are the number of visitors to Mount Lofty Ranges and Mid North forest reserves only; the number of visitors to Green Triangle forests is unrecorded.
Source: SAFC (2007, 2008, 2009, 2010, 2011).

Markets for forest-based conservation services

A range of government programs that seek to enhance forest-based services provided by private land, such as biodiversity conservation, do so by allotting value to conservation actions with market-based mechanisms. These include programs that offer information support, positive branding or the opportunity for formal protection of land. Other programs offer a range of funding mechanisms, including direct payments and grants, reduced council rates, taxation benefits and in-kind contributions. In exchange for receiving this funding, landholders agree to undertake activities that promote biodiversity conservation, retention of native vegetation or improvements in natural resource management. Such initiatives usually have monitoring mechanisms to provide assurance that participants are meeting their conservation obligations. The BushBids program in South Australia is an example (see Case study 6.2).

Mel and Nick Crouch, working on their property at Finnis, Mount Lofty Ranges, South Australia, which is part of the BushBids program. The Eastern Mount Lofty Ranges BushBids program is run by the South Australian Murray Darling Basin Natural Resource Management Board.

Case study 6.2: BushBids supports biodiversity stewardship in the eastern Mount Lofty Ranges

The South Australian BushBids program for the eastern Mount Lofty Ranges is a market-based initiative to conserve native vegetation on private land. Its four main objectives are to:

- protect and enhance the biodiversity of the eastern Mount Lofty Ranges
- improve the condition of native vegetation
- increase the area of native vegetation actively managed for conservation
- increase the area of native vegetation protected in long-term conservation agreements.

Under the BushBids program, applicants negotiate and agree on 10-year management plans and actions for the conservation of native vegetation on their land, in return for financial payments. A cost–benefit score called the Biodiversity Benefits Index (BBI) is used to determine the relative value for money offered by each bid; the higher the BBI, the greater the biodiversity outcome.

Two BushBids rounds had taken place by the end of 2008, producing 39 successful bids, with management plans covering a total of 2,256 hectares of private forest land. The total amount invested in the program to 2008 was $1,229,677. More locations have been included under subsequent rounds.

Source: O'Connor et al. (2008).

CRITERION 6

Case study 6.3: Valuation of water from forested catchments

Forest vegetation is intimately connected to the hydrological cycle on forest land, and forest management actions will be reflected in changes in hydrological flows. The common finding of many studies around the world is that forest harvesting leads to a decrease in site transpiration and hence an increase in stream flow. Regrowth forests of one Australian species—*Eucalyptus regnans* (mountain ash)—use more water than older forests of this species; this has been taken to be the case for other species as well but has not been so formally demonstrated. The broader link between forest transpiration and rainfall has also not yet been elucidated.

Quantification and valuation of water flowing from forests is always challenging (Bren 2009). The value of water when purchased through a tap or a bottle is fixed, but the value of water in the landscape is not. The following factors need to be taken into account.

- If river flows are already very high, the value of additional water is negligible—at times of flooding, it might even be negative.
- Water released or absorbed as a consequence of forest management activities is geographically dispersed and often only detectable at periods of high flows.
- As suggested by an Amazon Basin study (Rodriguez et al. 2010), water released as a consequence of forest modification can be absorbed by riparian (streamside) processes and may not reach a point of collection.
- Valuation of forested catchments involves a trade-off between water quality and water quantity—that is, these catchments produce clean and sustained stream flow but a lower volume of water than many other forms of land use.
- The outcome of forest water valuations depends heavily on the interest rate adopted, because of the long time periods involved in changing forest characteristics and thus the long time periods for a (water) return on (forest management) investment. Most successful valuations consider a range of interest rates but base their decisions essentially on public-good criteria—the function of the valuation is to provide insight on these criteria.

Many economists argue that the closest guide to the valuation of water in a river system is given by the 'spot water price' in irrigation areas. Typically, this fluctuates between zero and $2,000 per megalitre, but a common historical price used to value water has been around $200 per megalitre for water that is already in a storage location and with enough gravitational energy to flow to the purchaser (see for example Bren 2009). City users of river or dam water often pay a much higher price than irrigators, which can further complicate the valuation of water.

More dramatic examples of the marginal valuation of water from forested landscapes involve cities that are faced with drought or an inadequate catchment area, and have constructed large pipelines to remote areas, commissioned desalination plants or accessed deep groundwater. In these cases, there is a large energy component implicit in the cost of water delivered, and the marginal value of the water can be very high—typically $5–10,000 per megalitre. Such solutions highlight the relative cheapness of water from traditional forested catchments, where the major cost is the simple collection and distribution of the water. Methods that might increase the yield of water from forested catchments but not impair conservation values are under investigation.

Source: Bren L.

Indicator 6.1d

Production and consumption, and import/export of wood, wood products and non-wood products

Rationale

This indicator measures the consumption of forest-based products in Australia. Consumption trends over time provide a measure of the ability of Australian forest and timber industries, through both domestic production and importation, to meet Australian society's demand for forest-based products and of the industries contribution to the economy.

Key points

- Australia is a net importer of wood and wood products. The total value of wood product imports increased from $4.3 billion in 2006–07 to $4.4 billion in 2010–11, and the total value of wood product exports increased from $2.4 billion to $2.5 billion (unadjusted for inflation). The trade deficit in wood products therefore increased slightly, from $1.91 billion in 2006–07 to $1.93 billion in 2010–11. This was due to an increase in imports of sawn wood and wood-based panels linked to the strong Australian dollar, and an oversupply of wood products in international markets as a result of a slowdown in the United States housing market, especially in the second half of the reporting period.
- The highest value export category for wood products in 2010–11 was woodchips ($884.4 million). The largest share of the export woodchip trade in 2006–07 to 2010–11 went to Japan, but exports to China have increased in recent years.
- Printing and writing paper accounted for the largest proportion, by value, of Australia's imports of wood products in 2010–11 (30.6%).
- Consumption of sawn wood decreased by 6% between 2006–07 and 2010–11, from 5.3 million cubic metres to 5.0 million cubic metres. Consumption of hardwood sawn wood decreased from 1.23 million cubic metres in 2006–07 to 748 thousand cubic metres in 2010–11, but consumption of softwood sawn wood increased from 4.1 million cubic metres to 4.3 million cubic metres over this period.
- Information on the production, consumption and trade of non-wood forest products is often difficult to obtain because of the generally small size of industries based on these products and their dispersed nature.

This indicator reports on the production, consumption and trade of wood, wood products and non-wood products by product category. Categories of wood and wood products are sawn wood, wood based panels, and paper and paperboard. Because of their small size and highly dispersed nature, and (consequently) the relative lack of information about them, non-wood forest products are mostly dealt with in this report (including in Indicators 2.1d and 6.1b) in case studies.

Domestic consumption is assessed and reported by assuming that it equals domestic production plus imports minus exports. The production figures used in this indicator are those reported in Indicator 6.1a and sourced from ABARES (2012g).

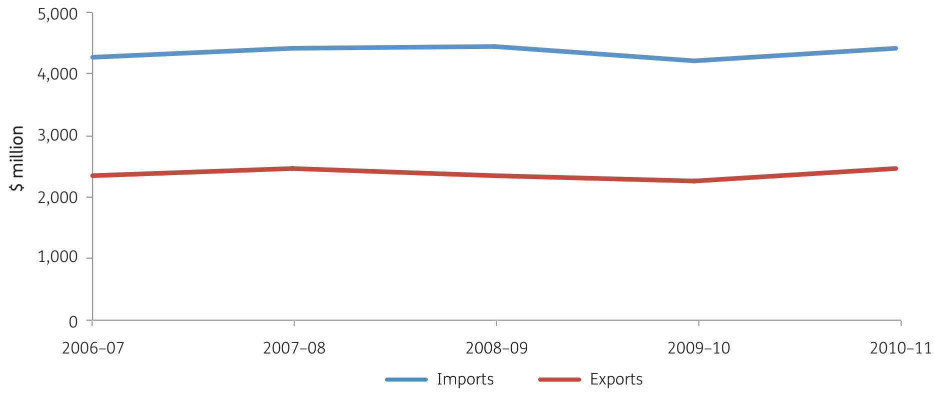
Trade performance

Australia is a net importer of wood and wood products. The total value of imported wood products increased from $4.3 billion in 2006–07 to about $4.4 billion in 2010–11 (Figure 6.21). Most of the increase was driven by an increased demand for sawn wood and wood-based panels. A significant slowdown in the United States housing market, and a strong Australian dollar, made the Australian market an attractive destination for sawn wood from other countries, for at least the second half of the reporting period (Burke and Townsend 2011).

The value of wood and wood product exports increased from $2.4 billion in 2006–07 to $2.5 billion in 2010–11, primarily as a result of growth in exports of recovered paper and roundwood. The trade deficit in wood products increased slightly, from $1.91 billion in 2006–07 to $1.93 billion in 2010–11.

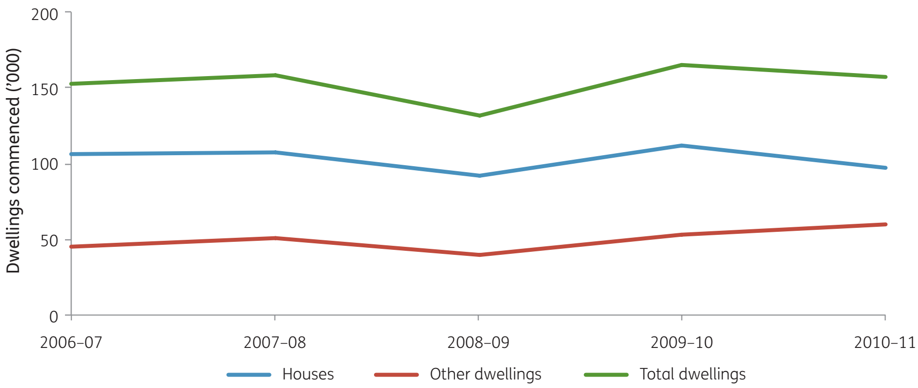
Australia's largest export wood product, by value, was woodchips (Table 6.17). Nevertheless, trade in this commodity declined in the wake of the slowdown that

Figure 6.21: Trade balance in wood and wood products, 2006–07 to 2010–11



Source: ABARES (2012g).

Figure 6.22: Dwellings and housing commencements, 2006–07 to 2010–11



Source: ABARES (2012g).

occurred in many advanced economies in 2007–08. The Japanese paper industry, Australia's largest export market for woodchips, contracted after 2008; a number of Japanese paper mills closed permanently, and production moved to countries with domestic supplies of wood fibre. To some extent, the decline in exports to the Japanese market was offset by an increase in exports to China.

Sawn wood

Softwood sawn wood is commonly used in housing construction for wall frames and roof trusses. Hence, one of the key factors influencing consumption of sawn wood is domestic housing demand (Burke and Townsend 2011). Annual dwellings commencements, which include high-rise apartment blocks, were about 3% higher in 2010–11 than in 2006–07, but housing commencements (excluding multi-dwellings such as apartments) fell by 9% (Figure 6.22).

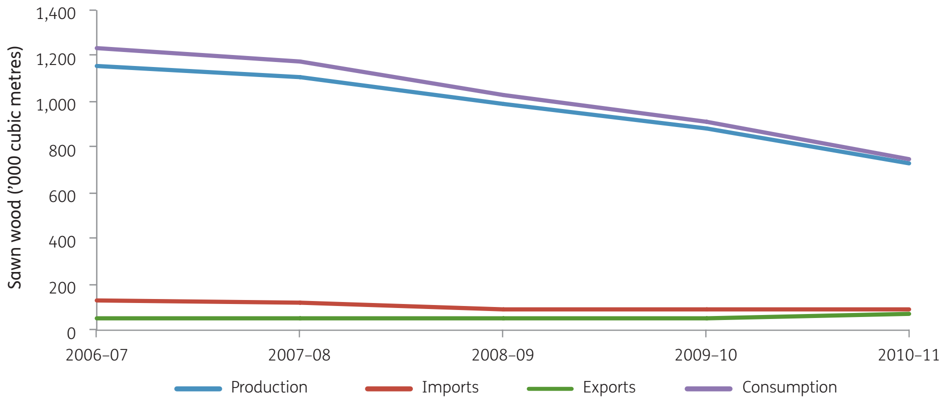
Hardwood sawn wood is generally used where strength is important and for decorative purposes—for example, for flooring, decking, joinery and furniture.

Table 6.17: Forest product exports, 2010–11

Product type	Export value ($ million)	Proportion (%)
Woodchips[a]	884.4	35.7
Roundwood	197.6	8.0
Recovered paper	240.0	9.7
Sawn wood		
Softwood sawn wood	71.7	2.9
Hardwood sawn wood	43.2	1.7
Wood-based panels		
Veneers	52.1	2.1
Plywood	1.7	0.1
Particleboard	2.4	0.1
Hardboard	2.1	0.1
Medium-density fibreboard	39.4	1.6
Softboard and other fibreboards	0.6	0.0
Paper and paperboard		
Newsprint	13.3	0.5
Printing and writing	88.4	3.6
Household and sanitary	94.0	3.8
Packaging and industrial	551.7	22.3
Other wood products	191.4	7.7
Total	**2,474.1**	**100.0**

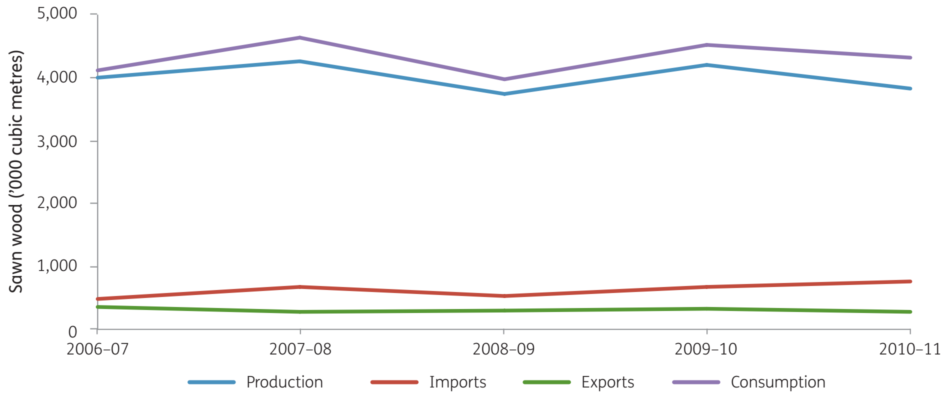
a See Indicator 6.1a.
Source: ABARES (2012g).

Figure 6.23: Hardwood sawn wood production, trade and consumption, 2006–07 to 2010–11



Note: Consumption = production plus imports less exports. Includes trade of roughsawn and dressed sawn wood.
Source: ABARES (2012g).

Figure 6.24: Softwood sawn wood production, trade and consumption, 2006–07 to 2010–11



Note: Consumption = production plus imports less exports. Includes trade of roughsawn and dressed sawn wood.
Source: ABARES (2012g).

Australia's consumption of sawn wood decreased by 6% between 2006–07 and 2010–11, from 5.3 million cubic metres to 5.0 million cubic metres. Consumption of hardwood sawn wood decreased by 39.2% between 2006–07 and 2010–11, from 1.23 million cubic metres to 748.2 thousand cubic metres (Figure 6.23). In comparison, the consumption of softwood sawn wood increased by 4.3%, from 4.1 million cubic metres to 4.3 million cubic metres (Figure 6.24).

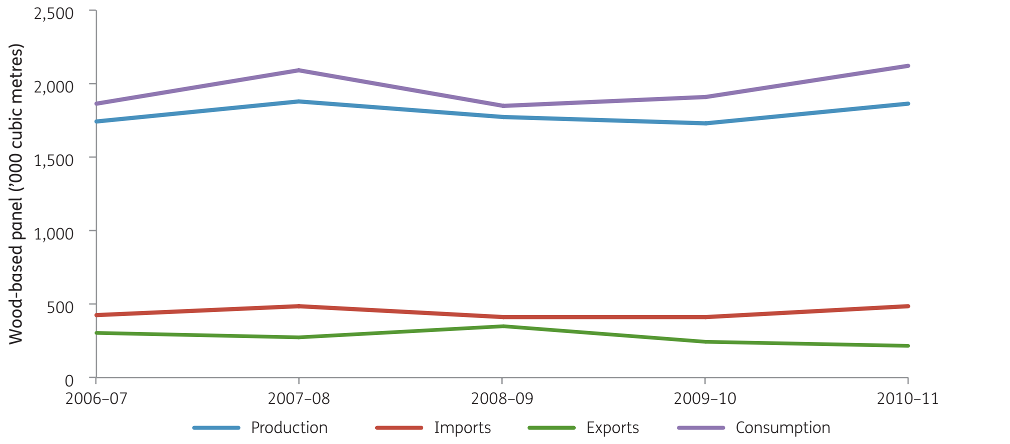
Wood-based panels

Wood-based panels are manufactured wood products such as medium-density fibreboard and particleboard. They have various applications, such as flooring, joinery (e.g. kitchen benches and cupboards), furniture and housing construction. The consumption of wood-based panels increased between 2006–07 and 2010–11 (Figure 6.25), from 1.9 million cubic metres to 2.1 million cubic metres. The increase in domestic demand was partly met by imports, which rose from 430 thousand cubic metres in 2006–07 to 480 thousand cubic metres in 2010–11.

The consumption of medium-density fibreboard increased by 31% in the period 2006–07 to 2010–11, from 447 thousand cubic metres to 585 thousand cubic metres (Figure 6.26). Production and export of medium-density fibreboard fell over the same period, partly as a result of competition arising from the continued expansion, after 2002, of the Chinese wood-based panel industry (Low et al. 2011).

The annual production and consumption of particleboard varied similarly between 2006–07 and 2010–11, while imports were relatively steady (Figure 6.27). The biggest fall was in exports of particleboard, which fell by 71%, from 18 thousand cubic metres in 2006–07 to six thousand cubic metres in 2010–11.

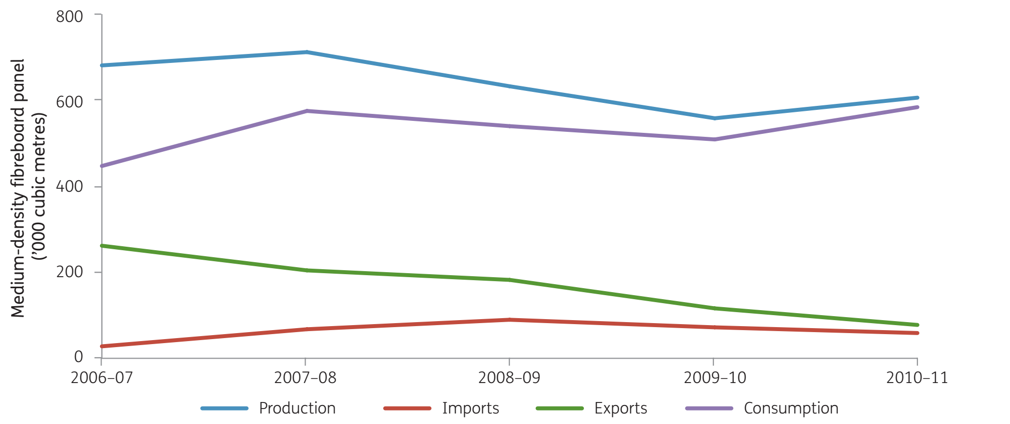
Figure 6.25: Wood-based panel production, trade and consumption, 2006–07 to 2010–11



Note: Estimate includes decorative veneer and veneer production, which is mainly for export for plywood production (commenced in 2007–08). It excludes veneer produced domestically for plywood production in integrated plywood mills and laminated veneer lumber production (confidential from July 2003). Consumption = production plus imports less exports.

Source: ABARES (2012g).

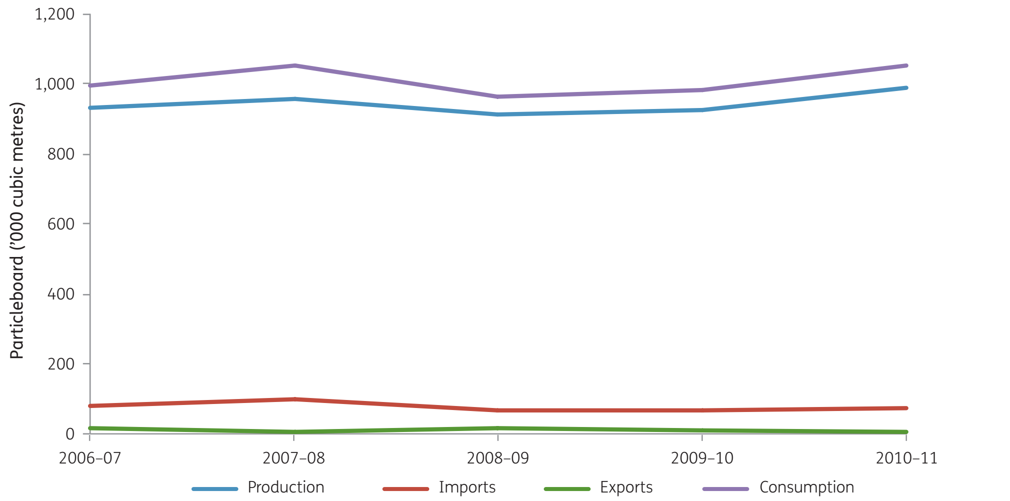
Figure 6.26: Medium-density fibreboard production, trade and consumption, 2006–07 to 2010–11



Note: Consumption = production plus imports less exports.

Source: ABARES (2012g).

Figure 6.27: Particleboard production, trade and consumption, 2006–07 to 2010–11



Note: Consumption = production plus imports less exports.

Source: ABARES (2012g).

Paper and paperboard

The paper and paperboard category of wood products includes newsprint, printing and writing paper, household and sanitary paper, and wrapping and packaging paper. It excludes recovered paper, and paper and paperboard products used for construction and special purposes (such as kraft and special thin papers). Packaging and industrial paper accounted for 69%, by volume, of Australia's total paper and paperboard production in 2010–11; the remainder comprised newsprint (14%), printing and writing paper (11%), and household and sanitary paper (6%).

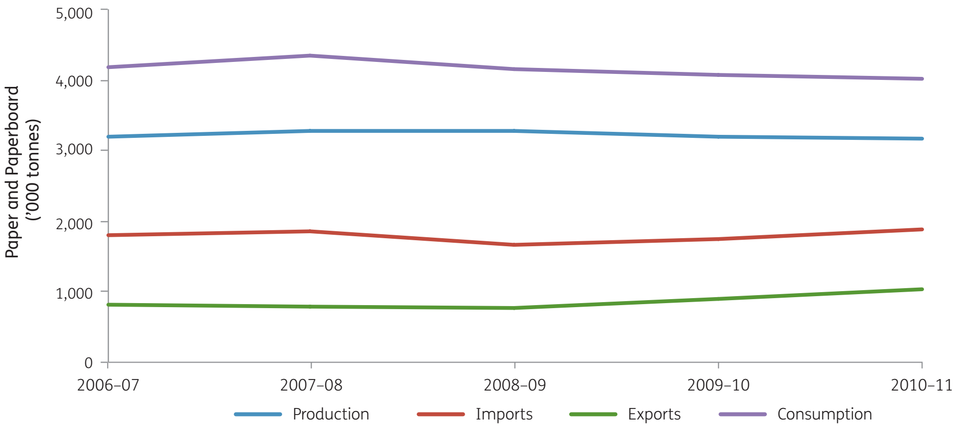
Australia produced 3.2 million tonnes of paper products in 2010–11, a decline of about 1.4% compared with 2006–07 (Figure 6.28). The consumption of paper products, which was about 4 million tonnes in 2006–07, also declined over the period (by 4.3%). However, consumption still exceeded domestic production.

Non-wood forest products

Non-wood forest products (NWFPs) include tree bark collected for paintings, sandalwood, seeds, bush flowers, furniture, native foods, bee products, water, minerals, and animal meat and skins (see also Indicators 2.1d and 6.1b). Several industries based on NWFPs have developed capacity to supply commercial markets. Case study 6.4 describes the native plant food industry, a proportion of which is based on forests.

In addition to provision of wood and non-wood forest products, forests provide a range of environmental services, such as carbon sequestration, visual amenity (of value, for example, to the ecotourism industry), soil conservation, water production, and the conservation of biodiversity and cultural heritage. See Indicator 6.1c for a further discussion on these environmental services.

Figure 6.28: Paper and paperboard production, trade and consumption, 2006–07 to 2010–11



Notes:
Consumption = production plus imports less exports.
Excludes recovered paper.

Source: ABARES (2012g).

Paper production.

CRITERION 6

Case study 6.4: Native plant food industry

The native plant food industry cultivates, or harvests in the wild, the fruits, leaves and seeds of plants that are native to Australia. Table 6.18 lists the main commercially used native plant foods associated with forests. Some are mainly cultivated (such as aniseed myrtle, lemon myrtle and riberry), while a significant component of other native plant foods is collected by wild harvest. Most native plant foods are sold frozen, dried or milled—there is only low market interest in native fresh fruit and herbs.

Table 6.18: Commercially used native plant foods associated with forests

Species name	
Aniseed myrtle	*Backhousia anisata*
Davidson's plum	*Davidsonia* spp.
Kakadu plum	*Terminalia ferdinandiana*
Lemon aspen	*Acronychia acidula* and *A. oblongifolia*
Lemon myrtle	*Backhousia citriodora*
Native citrus	*Citrus glauca*, *C. australasica* and other *C.* spp.
Native pepper	*Tasmannia lanceolata* and other *T.* spp.
Riberry	*Syzygium luehmannii*
Quandong	*Santalum acuminatum*
Wattle seed	*Acacia victoriae* and other *A.* spp.

Source: Salvin et al. (2008).

The native food industry had an estimated gross value of production of around $6.8 million in 2007, and there were about 500 active participants in the industry in 2008 (although this estimate excludes a large number of Indigenous Australian participants involved in the traditional cultivation and harvesting of native foods) (Foster 2009).

Various factors limit the further commercialisation of native foods, including high harvesting costs, a lack of reliability of harvests and sustainability issues. Some foods that are already intensively cultivated, such as lemon myrtle, lack sufficient market interest to justify further expansion. There is also a limited international market for Australian native plant foods (RIRDC 2008b, 2010).

Growers of native foods are typically widely dispersed and isolated from each other. Information about the financial performance and position of the native food industry is difficult to obtain, although organisations such as the Australian Native Food Industry Limited, the Queensland Bush Food Association and the South Australian Native Food Association Inc. provide industry representation (RIRDC 2008b, 2010).

Packaged native plant foods from the Northern Territory.

Sandalwood (*Santalum spicatum*) tree with nuts, Western Australia.

Indicator 6.1e

Degree of recycling of forest products

Rationale

This indicator measures the extent to which recycling or reuse of forest products occurs. As global demand for forest products increase, there is a growing need to meet societal demands for recycling of forest products.

Key points

- Australia produced about 14.2 million cubic metres of woodchips and particles, and about 2.5 million cubic metres of wood residue in 2011. Some of these products were exported: 8.7 million cubic metres of woodchips and particles and 67 thousand cubic metres of wood residue were exported, with an export value of $US791 million and $US82 million, respectively.
- The collection rate of recycled paper and paperboard products increased from 66.3% in 2006–07 to 77.4% in 2010–11. The utilisation rate of this recovered material also increased, but by a smaller amount—from 54.0% to 56.5%. An increase in exports of recovered paper, particularly to China, explains the difference between recovery and utilisation rates.
- Households reused and recycled more waste paper products in 2009 than in 2006. Australia-wide, household recycling and reuse increased from 91.5% to 95% over this period. The Northern Territory had the largest reported increase in household recycling and reuse, from 73.7% in 2006 to 93.1% in 2009.

This indicator measures the extent to which wood-based forest products such as structural timbers, pulp, paper and sawmill residue are recycled in Australia. Non-wood forest products may also be recycled or reused—for example, through composting for use in agriculture and floriculture—but the extent of this is not assessed in the indicator.

Industrial wood waste market

Industrial wood waste consists of wood residue left over after production. For example, sawmills process round logs to produce square or rectangular sawn wood, and so produce a range of by-products from this dimensional conversion process that can be either disposed of or reintegrated into the production cycle. Burns and Burke (2012) estimate that most of the residue produced in Australian sawmills is sold as woodchips. Some residue is also used as fuel in mill boilers for generation of heat and electricity, and for gardening, animal bedding or firewood.

The Food and Agriculture Organization of the United Nations (FAO) distinguishes two types of wood waste: woodchips and particles, and wood residue. 'Woodchips and particles' comprises wood waste that has deliberately been reduced to small pieces in the manufacture of other wood products, such as for pulping, engineered wood products such as particleboard and fibreboard, and fuel[136]. 'Wood residue' comprises wood waste that has not been reduced to chips or particles, such as sawdust, sawmill rejects, edging and trimmings, and veneer log cores and rejects. There is ongoing research to identify new applications for industrial wood waste, such as biomass for input to electricity production.

A total of 14.2 million cubic metres of chips and particles and 2.5 million cubic metres of wood residue was produced in Australia in 2011 (Table 6.19). These estimates include all exports of woodchips and particles, including those from forests grown specifically for pulpwood production. Some

136 This FAO's definition of woodchips and particle is thus wider than the ABARES definition of woodchips, which is confined to chips produced from logs (roundwood).

Table 6.19: Australian industrial wood waste production and trade, 2006–11

Product	2006	2007	2008	2009	2010	2011
Woodchips and particles[a]						
Production ('000 cubic metres)	16,563	17,181	19,679	18,088	13,696	14,178
Export quantity ('000 cubic metres)	11,524	12,191	12,282	9,549	10,404	8,732
Import quantity ('000 cubic metres)	14	13	39	22	28	40
Export value (US$ '000)	677,871	834,279	956,834	669,929	834,965	790,752
Import value (US$ '000)	1,514	908	1,879	1,044	1,232	1,929
Wood residue						
Production ('000 cubic metres)	2,633	2,300	2,300	2,300	2,577	2,466
Export quantity ('000 cubic metres)	3	5	3	11	59	67
Import quantity ('000 cubic metres)	4	4	3	2	3	4
Export value (US$ '000)	166	346	563	1,316	6,371	8,208
Import value (US$ '000)	1,514	908	1,879	1,044	1,232	1,929

Note: Estimates are subject to sampling and other errors.

[a] The FAO definition of woodchips and particles is wider than the ABARES definition of woodchips, which is confined to chips produced from logs (roundwood).

Source: FAO (2013).

residues derived from sawmilling were used for further processing, such as by panel and pulp manufacturers and woodchip exporters. Other wood waste that could not be used for further processing may have been sold for other products or disposed of by industry.

Paper recycling

Paper recycling is measured on the basis of 'collection rate' and 'utilisation rate'. The collection rate is the volume of recovered paper (recovered paper used for domestic paper production, plus recovered paper exported, less recovered paper imported) divided by the volume of paper and paperboard that is consumed domestically. The utilisation rate is the volume of recovered paper used in domestic paper production divided by the total volume of domestic paper production.

The consumption of paper and paper products was relatively stable in the period 2006–07 to 2010–11, and the collection rate increased from 66.3% to 77.4% (Figure 6.29). The utilisation rate also increased, but by a smaller amount—from 54.0% in 2006–07 to 56.5% in 2010–11. The difference in the collection and utilisation rates is explained by an increase in the export of recovered paper, particularly to China.

Household recycling and reuse patterns

Household recycling and reuse of waste paper, cardboard and newspaper products increased in all states and territories between 2006 and 2009 (Figure 6.30). Australia-wide, it increased from 91.5% to 95%. In this period for the Northern Territory, recycling or reuse of waste paper products increased from 73.7% to 93.1%.

Waste streams

In 2010, the then Environment Protection and Heritage Council identified three waste streams in Australia: municipal solid waste, commercial and industrial waste, and construction and demolition waste. It is estimated that, in 2007, paper and cardboard constituted about 15.5% of commercial and industrial waste and 13% of municipal solid waste sent to landfill (Table 6.20). Wood and wood waste accounted for 12.5% of commercial and industrial waste and 1% of municipal solid waste sent to landfill. In 2005, an estimated 1.1 million cubic metres of structural timber in the construction and demolition waste stream was either recycled or disposed of in landfill (EPHC 2010).

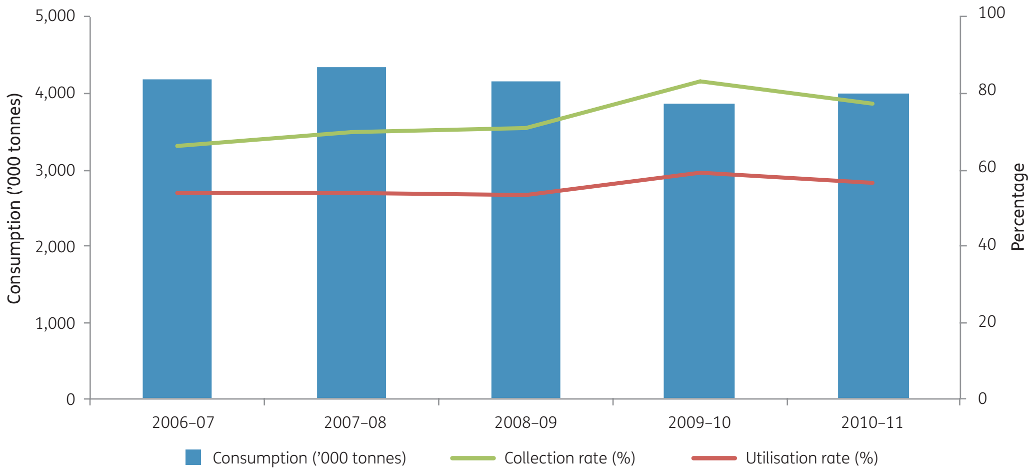
Waste is also disposed of as litter—for example, bottle corks, construction waste, cigarette packets, fast-food containers and tissues. Clean Up Australia estimated that paper, cardboard and wood comprised about 12.8% of all rubbish collected as a result of the Clean Up Australia Day initiative in 2011[137].

Initiatives to reduce wood waste

In November 2009, the environment ministers of the Australian, state and territory governments endorsed the National Waste Policy, which aims to reduce the amount of waste that is generated and disposed of by industry and households. The policy includes strategies to increase the recycling of waste products. For example, there are initiatives to change community attitudes so that people are more conscious about waste and recycling. There are also initiatives to introduce national standards and specifications for recycled construction, demolition and organic materials to encourage demand for recycled products (EPHC 2010). Box 6.1 shows that recycling of most forest products from commercial and industrial sources increased in Victoria over a three-year period.

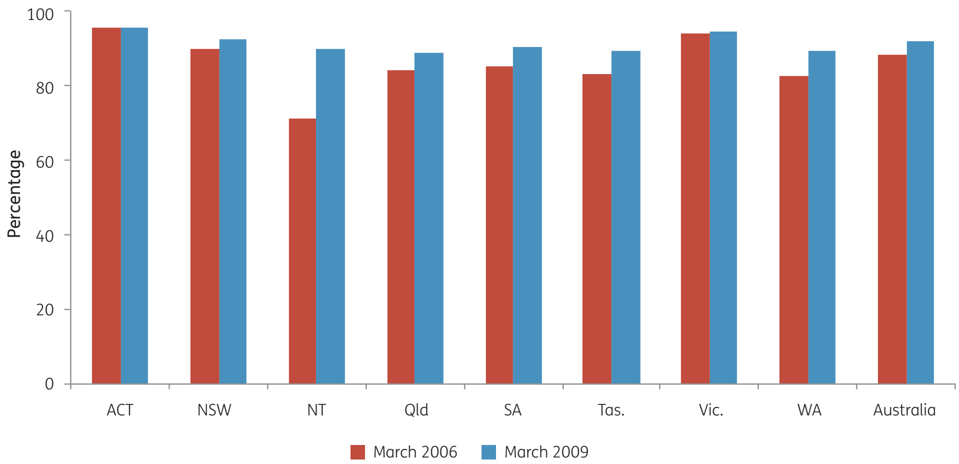
[137] http://www.cleanupaustraliaday.org.au/.

Figure 6.29: Consumption, collection rate and utilisation rate of paper and paper products, 2006–07 to 2010–11



Note: Estimates are subject to sampling and other errors.
Source: ABARES (2013c).

Figure 6.30: Proportion of waste paper products recycled or reused by households, March 2006 and March 2009



Note: Estimates are subject to sampling and other errors.
Source: ABS (2009).

Table 6.20: Major sources of rubbish in landfills in Australia, 2006–11

	Proportion (%)					
Type of rubbish	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Plastics	33.7	33.1	31.7	28.5	31.3	32.0
Foam and polystyrene	5.2	4.4	4.8	3.5	7.7	3.9
Glass	11.7	15.5	13.1	16.4	10.5	14.0
Rubber	1.8	2.3	1.7	1.4	1.1	1.2
Paper and cardboard	15.9	15.1	12.6	12.7	14.7	11.3
Metals	13.2	13.4	14.6	17.5	12.4	14.2
Wood	2.1	1.8	3.8	2.2	1.1	1.5
Not classified	16.4	14.4	17.7	17.8	21.2	22.0
Total	**100**	**100**	**100**	**100**	**100**	**100**

Note: Estimates are subject to sampling and other errors.
Source: CUAD (2011).

Box 6.1: Recycling of forest products in Victoria

Sustainability Victoria reported the recycling volumes of forest products between 2006–07 and 2008–09 (Table 6.21). The most widely recycled forest products in Victoria in this period were cardboard and paper packaging. Victoria also recycled 158 thousand tonnes of timber and 154.6 thousand tonnes of sawdust and other forestry residuals in 2008–09.

Table 6.21: Recycling of forest products in Victoria

Product type	2006–07	2007–08	2008–09
Paper-based products ('000 tonnes)			
Cardboard and paper packaging	389.2	422.2	468.4
Newsprint and magazines	121.8	131.9	160.0
Printing and writing paper	72.8	123.8	92.8
Telephone books	1.9	0.9	0.1
Other (mixed paper)	236.3	275.4	410.4
Other wood products ('000 tonnes)			
Timber	196.0	122.5	158.0
Sawdust and other forestry residuals	143.9	66.7	154.6

Notes:
'Timber' includes all wood and timber products (other than packaging and pallets) from commercial and industrial sources.
'Sawdust and other forestry residuals' includes bark (from forestry residues), sawdust and woodchips (rejected from export).

Source: Sustainability Victoria.

Indicator 6.2a

Investment and expenditure in forest management

Rationale

This indicator quantifies investment and expenditure in developing, maintaining, and obtaining goods and services from forests. It provides an indication of the long term and short term commitment to forest management, further processing and other forest uses.

Key points

- The Australian, state and territory governments undertake many activities that, together, constitute forest management. A range of state government data on forest management expenditure are presented, but the ability to compare these measures of investment is limited by differences in the classification of activities that constitute forest management, in accounting arrangements, and in reporting timelines. It is therefore also not possible to estimate national expenditure on forest management.
- Investment in new plantations, as well as re-establishment of harvested plantations, is important for future wood availability. The annual establishment rate of new hardwood and softwood plantations in Australia declined from 87 thousand hectares in 2006–07 to 10 thousand hectares in 2010–11. Declines occurred in all states, but there was a slight increase in the rate of establishment of new plantations in the Northern Territory. Investment in newly established plantations declined in parallel with the decline in area of new plantations established.
- Combined, the forestry and logging subsector, wood product manufacturing subsector, and pulp, paper and converted paper product manufacturing subsector accumulated about $6.0 billion of fixed capital between 2006–07 and 2010–11, including new plantations, equipment and buildings. Depreciation and amortisation expenses over the same period were estimated at $4.92 billion. Capital formation net of depreciation and amortisation was therefore estimated to be $1.08 billion.

This indicator provides an overview of investment in forest management for forests providing goods and services. This includes expenditure by state and territory governments, investment in establishment of new plantations and replanting of existing plantations, and investment in harvesting and in manufacturing involving forest products. Expenditure on management of conservation reserves or national parks is generally not included. Information on forest investment is scarce; in particular, investment by the private sector, both in native forest management and plantation establishment, is either not available or is treated as commercial-in-confidence and therefore not publicly available.

Expenditure by state and territory governments

The Australian, state and territory governments undertake many activities that, together, constitute forest management. These include management of weeds and pest animals; forest fire management; forest monitoring; inventory; biological surveys; provision of recreational opportunities; and silvicultural, post-harvest and wildlife-management practices. However, the states and territories vary in the way they classify activities that constitute forest management, in the detail they provide on expenditure, and in the methods used for accounting for the valuation and depreciation of assets. These differences limit the comparability of investments in forest management between jurisdictions. The data presented below for various agencies therefore vary widely, depending on the nature of the information available, and are generally not directly comparable.

In some states and territory jurisdictions, a proportion of native forest was progressively reassigned over the reporting period from multiple-use public forest (including public forest used for wood production) to public nature conservation reserves. The general lack of consistent data on expenditure on forest management, and the absence of data for some tenures (such as many conservation reserves), make it difficult to determine whether expenditure on forest management decreased as a result of such changes in tenure classification.

New South Wales

Forests NSW[138] is a state government agency that manages more than 2 million hectares of native and plantation forests in New South Wales. It undertakes a range of activities aimed at developing, maintaining, and obtaining goods and services from state forests; these include harvest supervision and assessment of environmental compliance, management of weeds and animal pests, fire management (including hazard reduction burning and wildfire fighting and prevention), and provision of recreational opportunities. Table 6.22 shows the expenditure by Forests NSW on these activities in the period 2006–07 to 2010–11.

Overall, expenditure on reported forest management activities in state forests in New South Wales was reasonably stable over the period. Expenditure on firefighting declined substantially as a result of a decrease in the proportion of the state forest estate affected by wildfire over the reporting period (from 3.9% in 2006–07 to less than 1% in 2010–11).

Queensland

The Department of Environment and Resource Management is responsible for managing Queensland's land, water and vegetation resources, including forest resources[139]. The rights to the state-owned plantations were sold in 2010 with the rights now held by HQPlantations Pty Ltd under a 99-year licence arrangement. Comprehensive information on forest-specific investment and expenditure is not available.

South Australia

In South Australia, ForestrySA primarily manages plantations but also has responsibility for some native forests managed for conservation purposes. The agency's total expenditure in 2010–11, including employee benefits, payments to contractors, investments in information technology, depreciation and amortisation, was $83.9 million, down slightly on the $86.7 million expended in 2009–10 (Table 6.23). The expenditure of ForestrySA on forest management activities is not separately reported.

Table 6.22: Expenditure on forest management in New South Wales state forests, 2006–07 to 2010–11

			($'000)		
Activity	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**
Harvest management					
Supervision and environmental compliance—native forests	6,219	5,164	5,561	5,454	5,184
Harvest planning and pre-harvest surveys	–	–	3,997	4,755	5,022
Other forest management activities					
Firefighting and fire prevention—wildfire	3,000	1,800	1,000	2,400	100
Hazard reduction burning	8,200	9,800	9,600	8,300	5,700
Weed management	779	597	899	1,125	1,019
Animal pest management	586	546	585	591	392
Recreation and tourism					
Recreation and tourism	2,721	2,092	2,437	2,547	2,408
Training and employee development					
Training	2,300	2,200	1,800	1,850	2,680

– = not available
Notes:
Data are for forests managed by Forests NSW only.
It is possible that the reported expenditure on the various aspects of forest management are not mutually exclusive, so figures cannot be summed.
Source: Forests NSW (2009, 2010b, 2011).

Table 6.23: Total expenditure by ForestrySA, 2005–06 to 2010–11

Activity	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11
Expenditure ($ million)	87.2	90.5	89.5	84.8	86.7	83.9

Note: Values are total expenditure of the agency, not just expenditure on forest management.
Source: SAFC (2007, 2008, 2009, 2010, 2011).

[138] From January 2013, the Forestry Corporation of NSW.
[139] From April 2012, the Queensland Department of Agriculture, Fisheries and Forestry is responsible for Queensland's forest resources.

Tasmania

In Tasmania, the Department of Primary Industries, Parks, Water and Environment (DPIPWE) has a number of programs for the management and protection of Tasmanian forests, including the valuation and protection of old-growth forests, and improvement of soil, air and water quality. Forestry Tasmania, a separate entity from DPIPWE, is responsible for the sustainable management of 1.5 million hectares of state forest for optimal community benefit, including the sustainable production and delivery of forest products and services; the facilitation of new forest-based industries; the conservation of natural and cultural heritage values; and the provision of education, recreation and tourism services. The expenditure of Forestry Tasmania on forest management activities is not separately reported. However, total operating costs, which include expenditure on forest management, research, and operational and other activities, were about $140 million annually over the reporting period (Table 6.24).

Victoria

In Victoria, the Department of Sustainability and Environment (DSE)[140] is responsible for managing state forests. VicForests is a separate, state-owned business that is responsible for the sustainable harvest, regeneration and commercial sale of wood from Victoria's public forests on behalf of the Victorian Government. Table 6.25 indicates the planned and actual budget for the management by DSE of state-run parks and forests in Victoria for 2009–10 and 2010–11. The difference between planned and actual expenditure is a result of various factors, including the 2011 Victorian floods.

Western Australia

In Western Australia, the Department of Environment and Conservation (DEC)[141] is responsible for protecting the environment, including forests, and conserving Western Australia's fauna and flora, including forest-dwelling species. Table 6.26 indicates the annual expenditure by DEC on nature conservation (including on non-forested land) and on sustainable forest management (in state forests and timber reserves) over the period 2006–07 to 2010–11. Total expenditure on nature conservation increased over the period. Expenditure on sustainable forest management was lower in total, but much higher on an area basis, and fluctuated from year to year.

Table 6.24: Total operating expenditure by Forestry Tasmania, 2006–07 to 2010–11

Activity	2006–07	2007–08	2008–09	2009–10	2010–11
Expenditure ($ million)	138.1	141.1	140.5	136.1	146.7

Note: Values are total expenditure of the agency, not just expenditure on forest management.
Source: Forestry Tasmania (2011a, Table 6.4).

Table 6.25: Planned and actual expenditure for management of state-run parks and forests, Victoria, 2009–10 and 2010–11

Activity	2009–10	2010–11
Planned expenditure ($ million)	156.7	187.4
Actual expenditure ($ million)	179.8	206.3

Note: Data are only for parks and forests managed by the Department of Sustainability and Environment.
Source: DSE (2010, 2011).

Table 6.26: Expenditure on nature conservation and sustainable forest management in state-owned parks and forests, Western Australia, 2006–07 to 2010–11

Activity		2006–07	2007–08	2008–09	2009–10	2010–11
Nature conservation[a]	Total expenditure ($ '000)	107,423	113,602	117,577	119,706	131,451
	Unit cost ($/hectare)	3.98	4.16	4.30	4.35	4.76
Sustainable forest management[b]	Total expenditure ($ '000)	48,981	40,539	53,627	46,360	48,539
	Unit cost ($/hectare)	37.74	31.24	41.33	35.73	37.41

a Includes non-forested land.

b The unit cost used for sustainable forest management is the accrual-basis average gross cost per hectare of managing state forests and timber reserves in accordance with the relevant management plan.

Note: Data are for parks and forests managed by the Department of Environment and Conservation only.

Source: DEC (2007, 2008b, 2009b, 2010b, 2011).

140 From April 2013, the Department of Environment and Primary Industries.
141 From July 2013, the Department of Parks and Wildlife.

CRITERION 6

Investment in plantations

Investment in the establishment of new plantations is one form of investment for obtaining wood from forest land. Australia-wide, there was a decline in the rate of establishment of new plantations between 2006–07 (when 86,600 hectares were established) and 2010–11 (when 9,600 hectares were established) (Table 6.27). Across this period, the new plantations that were established were predominantly hardwoods.

New South Wales

Table 6.28 indicates the plantation areas established or re-established by Forests NSW[142] in the period 2006–11, and the estimated annual costs associated with site preparation, planting, and post-planting fertilisation and management.

In 2006–07, Forests NSW established or re-established 8,149 hectares of plantation, most of which was softwood. The associated costs for that year were $15.8 million. In 2010–11, the area of plantations established or re established increased to 11,046 hectares, at a cost of $17.2 million.

Northern Territory

The size of the Northern Territory's predominantly hardwood public and private forest plantation estate was estimated at 40,200 hectares in 2010–11. Of this, 37,800 hectares were classed as hardwood plantations, and 2,400 hectares were softwood plantations (ABARES 2012h). About 11,300 hectares of new hardwood plantations were established in the five years to 2010–11, which represents a considerable expansion in tropical forestry in northern Australia.

Table 6.27: Area of new plantation establishment, 2006–07 to 2010–11

	Area ('000 hectares)								
Plantation type and year	**ACT**	**NSW**	**NT**	**Qld**	**SA**	**Tas.**	**Vic.**	**WA**	**Australia**
Hardwood									
2006–07	0.0	8.0	0.2	6.7	7.1	25.0	15.7	13.4	76.1
2007–08	0.0	11.1	3.6	9.9	3.5	18.0	9.8	10.3	66.0
2008–09	0.0	10.9	2.3	5.6	0.2	14.9	2.5	6.8	43.2
2009–10	0.0	1.0	3.0	3.0	0.0	3.9	2.3	7.8	21.0
2010–11	0.0	0.0	2.2	1.1	0.0	1.2	3.1	0.4	7.9
Softwood									
2006–07	0.0	5.7	0.0	1.0	0.2	1.4	0.6	1.6	10.5
2007–08	0.0	0.9	0.0	0.4	0.0	2.0	0.5	2.5	6.3
2008–09	0.0	2.3	0.0	1.2	0.5	0.1	0.5	1.8	6.4
2009–10	0.0	0.4	0.0	0.7	0.1	0.2	0.8	0.5	3.0
2010–11	0.0	0.3	0.0	0.8	0.1	0.4	0.0	0.0	1.7
Total									
2006–07	0.0	13.6	0.2	7.7	7.3	26.5	16.2	15.0	86.6
2007–08	0.0	12.0	3.6	10.3	3.5	20.0	10.2	12.8	72.3
2008–09	0.0	13.1	2.3	6.8	0.8	15.1	2.9	8.6	49.7
2009–10	0.0	1.4	3.0	3.6	0.1	4.0	3.1	8.3	23.5
2010–11	0.0	0.3	2.2	1.9	0.1	1.5	3.1	0.4	9.6

Notes:
Figures are areas of new public and private plantation.
Areas replanted as plantation following final harvest of a pre-existing plantation are excluded.
Totals may not tally due to rounding.

Source: ABARES (2012h).

Table 6.28: Area and cost of plantings in state-owned plantations, New South Wales, 2006–07 to 2010–11

Activity	2006–07	2007–08	2008–09	2009–10	2010–11
New plantation establishment (hectares)	1,350	370	1,596	472	352
Re-established plantations (hectares)	6,799	6,129	9,223	12,088	10,694
Total plantations established (hectares)	**8,149**	**6,499**	**10,819**	**12,560**	**11,046**
Cost ($ million)	15.8	13.7	20.8	20.9	17.2

Note: Data are for plantations controlled by Forests NSW only.
Source: Forests NSW (2012a,b).

[142] From January 2013, the Forestry Corporation of NSW.

Queensland

The estimated area of Queensland's public and private plantation estate varied over the period 2006–07 to 2010–11, and was 232,500 hectares in 2011. Of this area, 40,900 hectares is hardwood, 189,100 hectares is softwood, and the remaining 2,500 hectares is of unknown type (ABARES 2012h). New plantation establishment declined from 7,700 hectares in 2006–07 to 1,920 hectares in 2010–11.

South Australia

The estimated area of South Australia's public and private plantation estate increased over the period 2006–07 to 2010–11, and was 188,500 hectares in 2010–11. Of this, approximately 128,500 hectares (68% of the total) is softwood, while 59,700 hectares (32% of the total) is hardwood, and there is a small area (300 hectares) where the type is unknown (ABARES 2012h). The establishment of new plantations decreased substantially over the period, from 7,320 hectares in 2006–07 to 130 hectares in 2010–11.

ForestrySA manages South Australia's state-owned plantation estate. Table 6.29 presents the estimated cost and area of plantings undertaken by ForestrySA (including the re-establishment of plantations after harvesting) in the period 2006–07 to 2010–11. ForestrySA also reported the acquisition of new land for planting activities over the reporting period.

Tasmania

Tasmania's private and public plantation estate was estimated to be 310,700 hectares in 2010–11. Of this, 235,600 hectares was hardwood, and the remaining 75,100 hectares was softwood. The establishment of new plantations in Tasmania declined substantially from 26,480 hectares in 2006–07 to 1,540 hectares in 2010–11 (ABARES 2012h).

Forestry Tasmania manages state-owned forests, and the remaining plantations are controlled by the private sector. Information on plantation establishment and replanting costs was available for forests managed by Forestry Tasmania only. Forestry Tasmania planted or replanted 1,620 hectares of plantations in 2010–11, less than one-third of the area planted or replanted in 2006–07 (Table 6.30). The total investment in plantation establishment fell by nearly half, from $16.1 million to $8.1 million.

Victoria

Victoria's public and private plantation estate expanded in the period 2006–07 to 2010–11, reaching 432,900 hectares in 2010–11. Around 225,900 hectares were softwood plantations, and 205,800 hectares were hardwood (the remaining 1,200 hectares could not be identified as either hardwood or softwood) (ABARES 2012h). There was a decline in the establishment of new plantations, particularly hardwood.

Western Australia

The estimated area of public and private hardwood and softwood Industrial plantations (and therefore excluding sandalwood) in Western Australia varied over the reporting period, but increased overall to 412,600 hectares in 2010–11. Establishment of new plantations declined from nearly 15,000 hectares in 2006–07 to 440 hectares in 2010–11 (ABARES 2012h).

The Forest Products Commission (FPC) is responsible for the harvesting and sale of state-owned wood assets in both plantations and native forests. The commission was also involved in establishing sandalwood plantations from 2006–07 to 2010–11. Table 6.31 shows the FPC's planned and actual annual plantation establishment (including sandalwood and joint-venture plantations, and replanting existing plantations) on commission-controlled plantations on agricultural land in the period 2006–07 to 2010–11. The FPC's investment in new plantations (including re-established plantations and sandalwood) increased from $9.1 million in 2006–07 to a high of $18.6 million in 2009–10, before falling to a five-year low of $7.7 million in 2010–11.

Table 6.29: Area and cost of new plantings in state-owned plantations, South Australia, 2006–07 to 2010–11

Activity	2006–07	2007–08	2008–09	2009–10	2010–11
Plantation established (hectares)	3,033	4,159	3,307	3,287	2,762
Cost of new plantings ($ '000)	3,434	2,793	3,115	5,432	1,808

Notes:
Cost of new plantings is reported as standing value, which includes the value of the plantings and all costs associated with establishment.
Data are for plantations controlled by ForestrySA only.

Source: SAFC (2007, 2008, 2009, 2010, 2011).

Table 6.30: Area and cost of plantings in state-owned plantations, Tasmania, 2006–07 to 2010–11

Activity	2006–07	2007–08	2008–09	2009–10	2010–11
Total area planted and replanted (hectares)	5,216	5,561	4,083	2,381	1,620
Plantation establishment costs ($ '000)	16,147	14,433	12,094	8,070	8,094

Notes:
Costs include contractor expenses and replanting.
Area and costs include plantations established through joint ventures controlled by Forestry Tasmania.

Source: Forestry Tasmania (2008, 2009a, 2009b, 2010b, 2010c, 2011a, 2011b).

Table 6.31: Area and cost of plantation establishment under Forest Products Commission schemes, Western Australia, 2006–07 to 2010–11

Activity	2006–07	2007–08	2008–09	2009–10	2010–11
Planned area (hectares)	5,941	8,015	10,094	9,974	600
Actual area (hectares)	5,411	7,032	7,034	10,216	636
Cost ($ '000)	9,147	12,880	15,947	18,643	7,724

Notes:

For plantations controlled by Forest Products Commission only, including new and re-established plantations, joint-venture plantations and sandalwood. Cost for new plantations includes hardwood, softwood, joint-venture and sandalwood plantations.

Planned and actual area figures relate to December to February quarters for each financial year, as reported by Forest Products Commission.

Source: FPC (2007, 2008, 2009, 2010, 2011).

Investment in harvesting and manufacturing

Investment in the Australian forest industry has been estimated by the Australian Bureau of Statistics (ABS) for the following three subsectors taken from the 2006 Australian and New Zealand Standard Industrial Classification (Trewin and Pink 2006):

- forestry and logging
- wood product manufacturing
- pulp, paper and converted paper product manufacturing.

Four parameters have been used by the ABS to measure investment and expenditure in various areas of the economy. Estimates are based on random sampling of the industry and are subject to sampling and non-sampling errors. Moreover, changes in accounting methods adopted by industry, including approaches to asset valuation and depreciation, may affect the accuracy of estimates. The four parameters are:

- gross fixed capital formation (GFCF), which is the total value of fixed-asset acquisitions (such as establishment of new plantations, purchase of machinery, acquisition of goodwill and intellectual property rights) less any fixed-asset disposals
- depreciation and amortisation, which allocate the cost of an asset over its service life (Fraser and Ormiston 2010) and are considered expenses. Depreciation and amortisation do not include asset impairment, and therefore do not include revaluation of standing timber
- capital formation net of depreciation and amortisation, which is GFCF minus depreciation and amortisation, and reflects the net formation of new productive capacity
- inventories, which are intermediate goods (such as raw materials, fuels, containers), and goods held for sale or distribution. Reasons for accumulation of inventory can range from anticipatory investment to overinvestment, and reasons for reduction in inventory can range from increased sales to impairments in the value of inventory holdings.

Combined, the forestry and logging subsector, wood product manufacturing subsector, and pulp, paper and converted paper product manufacturing subsector accumulated about $6.0 billion of fixed capital between 2006–07 and 2010–11, including new plantations, equipment and buildings. Depreciation and amortisation expenses over the same period were estimated at $4.92 billion. Capital formation net of depreciation and amortisation was therefore estimated to be $1.08 billion.

Forestry and logging

Forestry and logging consists of enterprises that are mainly engaged in growing and harvesting wood for commercial benefit. This category also includes the gathering of other forest products, such as plant or animal products from a forest environment (Trewin and Pink 2006).

Table 6.32 presents estimates of investment and expenditure in the forestry and logging subsector for the period 2006–07 to 2010–11. GFCF was estimated at $207 million in 2010–11, and depreciation and amortisation was estimated at $130 million, giving capital formation net of depreciation and amortisation of $77 million in that year. Unlike many manufacturing sectors, the estimate of fixed capital formation in this subsector can include acquisitions of natural resource fixed assets, such as plantations, which can appreciate in value as trees grow. Reported inventory holdings in the forestry and logging subsector declined by $96 million between 2008–09 and 2010–11.

Wood product manufacturing

Wood product manufacturing comprises enterprises engaged in log sawmilling and timber dressing, woodchipping, timber re-sawing and dressing, and the production of engineered wood products.

Capital formation net of depreciation and amortisation in the wood product manufacturing subsector also varied substantially from year to year (Table 6.33) but was low compared with that of the forestry and logging subsector, as a result of the relatively high rate of aggregate depreciation and amortisation. Inventory holdings in the subsector grew each year in the period 2006–07 to 2010–11.

Table 6.32: Investment and expenditure in the Australian forestry and logging subsector, 2006–07 to 2010–11

	($ million)						
Parameter	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**	**Total 2006–11**	**Total 2006–11[a]**
Gross fixed capital formation	293	318	449	366	207	1,633	1,734
Depreciation and amortisation	130	226	164	176	130	826	877
Capital formation net of depreciation and amortisation	163	92	285	190	77	807	857
Change in inventory (over previous year/through period)	14	16	7	–88	–8	-59	-58

[a] Total adjusted for inflation to 2010–11 dollars. Other figures are not adjusted for inflation.
Source: ABS (2011a, 2012b).

Table 6.33: Investment and expenditure in the Australian wood product manufacturing subsector, 2006–07 to 2010–11

	($ million)						
Parameter	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**	**Total 2006–11**	**Total 2006–11[a]**
Gross fixed capital formation	346	486	433	450	302	2,017	2,141
Depreciation and amortisation	312	286	322	366	385	1,671	1,764
Capital formation net of depreciation and amortisation	34	200	111	84	–83	346	377
Change in inventory (over previous year/through period)	45	132	165	82	79	503	532

[a] Total adjusted for inflation to 2010–11 dollars. Other figures are not adjusted for inflation.
Source: ABS (2011a, 2012b).

Table 6.34: Investment and expenditure in the Australian pulp, paper and converted paper product manufacturing subsector, 2006–07 to 2010–11

	($ million)						
Parameter	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**	**Total 2006–11**	**Total 2006–11[a]**
Gross fixed capital formation	387	620	458	458	423	2,346	2,488
Depreciation and amortisation	403	465	458	577	521	2,424	2,558
Capital formation net of depreciation and amortisation	–16	155	0	–119	–98	-78	-70
Change in inventory (over previous year/through period)	24	24	–10	–166	86	-42	-43

[a] Total adjusted for inflation to 2010–11 dollars. Other figures are not adjusted for inflation.
Source: ABS (2011a, 2012b).

Pulp, paper and converted paper product manufacturing

The pulp, paper and converted paper product manufacturing subsector includes products such as newsprint, writing paper, paper pulp and wood pulp, as well as corrugated paper products such as cardboard boxes, paper bags, paper stationery and sanitary paper.

Depreciation and amortisation in the subsector was in excess of GFCF over much of the reporting period. The negative value for capital formation net of depreciation and amortisation suggests that investment in the subsector's fixed capital holdings is not sufficient to cover depreciation and amortisation. In comparison, inventory holdings increased in 2010–11 after declines in previous years. The increase in the value of inventory holdings reflects an increase in the value of the subsector's short-term capital (Table 6.34).

Containers made from pulp, paper and converted paper products.

CRITERION 6

Indicator 6.2b

Investment in research, development, extension and use of new and improved technologies

Rationale

This indicator monitors the investment in, and adoption of, new or improved technologies in forest management and in forest-based industries. It also quantifies the level of research and development. Significant investment in research, development and new technologies result in continual improvements to forest management practices.

Key points

- Australian Bureau of Statistics (ABS) data show that, between 2005–06 and 2008–09, total expenditure on research and development (R&D) reported by businesses in the forest and wood product sector declined from $164 million to $137 million. Only partial data on R&D expenditure are available from the ABS for 2009–10 and 2010–11.
- From 2005–06 to 2010–11, the ABS reported that business R&D expenditure increased from $15.6 million to $33.2 million in the forestry and logging subsector, but decreased from $76.3 million to $62.4 million in the wood product manufacturing subsector. Business R&D expenditure in the pulp, paper and converted paper product manufacturing subsector declined from $71.1 million in 2007–08 to $53.8 million in 2008–09.
- A separate survey of the forest and forest products sector, using a different definition of the sector from that used by the ABS, showed R&D expenditure of $106 million in 2007–08. Adjusted for inflation, expenditure on forestry and forest products R&D has declined by 13.4% between 1981–82 and 2007–08.

This indicator provides an overview of research and development (R&D) investment in the forest and wood products sector.

ABS survey data

The Australian Bureau of Statistics (ABS) collects data from businesses on their R&D expenditure across three forest and wood products subsectors: forestry and logging; wood product manufacturing; and pulp, paper and converted paper product manufacturing.

R&D is defined by the ABS as 'systematic investigation or experimentation involving innovation or technical risk, the outcome of which is new knowledge, with or without a specific practical application, or new or improved products, processes, materials, devices or services' (ABS 2012c). Accordingly, this category excludes expenditure that expands production capacity using existing technologies (e.g. silvicultural management), but includes expenditure on basic research ('research') and on ways of applying basic research in practice ('experimental development'). The ABS data include only intramural expenditure (expenditure undertaken within the sector) on R&D of $100,000 or more; extramural R&D (undertaken entirely by another entity outside this sector) is excluded.

R&D in the forestry and logging subsector can focus on ways to improve wood production and harvesting of wood products, or on identifying new markets for standing wood (such as a market for carbon emissions). Research in the wood product manufacturing subsector aims to identify new forest-based products and methods for processed forest products (excluding pulp, paper and cardboard), such as new applications for timber in construction (Bayne and Page 2009), new timber treatments, and the identification of new export markets. Research in the pulp, paper and converted paper product manufacturing subsector covers a range of areas, such as energy efficiency in the pulping and drying of wood, and the development of new wood-based products.

Table 6.35: Business R&D expenditure in the forest and wood products sector, and proportion of total business R&D expenditure, 2005–06 to 2010–11

Parameter	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11
Forestry and logging ($ million)	15.6	20.1	22.0	26.0	37.6	33.2
Wood product manufacturing ($ million)	76.3	55.2	51.3	57.1	57.5	62.4
Pulp, paper and converted paper product manufacturing ($ million)	72.2	70.7	71.1	53.8	–	–
Total research expenditure in forestry ($ million)	164	146	144	137	–	–
Total business expenditure in Australia ($ million)	10,434	12,639	15,047	17,264	16,685	17,880
Proportion of expenditure that is forestry expenditure (%)	1.6	1.2	1.0	0.8	–	–

– = not available
Note: Totals may not tally due to rounding.
Source: ABS (2011b, 2012d).

The total estimated R&D expenditure by forest-sector businesses in the three subsectors in 2008–09 was $137 million (Table 6.35; data are incomplete for 2009–10 and 2010–11). This is a decline of $27 million (16%) from 2005–06. Forest-sector business R&D expenditure declined as a proportion of total business R&D expenditure from 1.6% in 2005–06 to 0.8% in 2008–09.

Business R&D expenditure in the forestry and logging subsector more than doubled over the reporting period, while business R&D expenditure in the wood product manufacturing subsector decreased, as did business R&D expenditure in the pulp, paper and converted paper product manufacturing subsector over that part of the period for which data are available.

A review of investment needs in the pulp and paper industry, presented to the Australian Government, incorporates the R&D strategy for the Australian pulp, paper and converted paper product industry (Pulp and Paper Industry Strategy Group 2010). In the past, R&D by Australian companies has led to major improvements in the pulping and forming of paper, which have been taken up by the rest of the world (Pulp and Paper Industry Strategy Group 2010).

A research scientist examining native plant seeds under a microscope.

Independent survey data

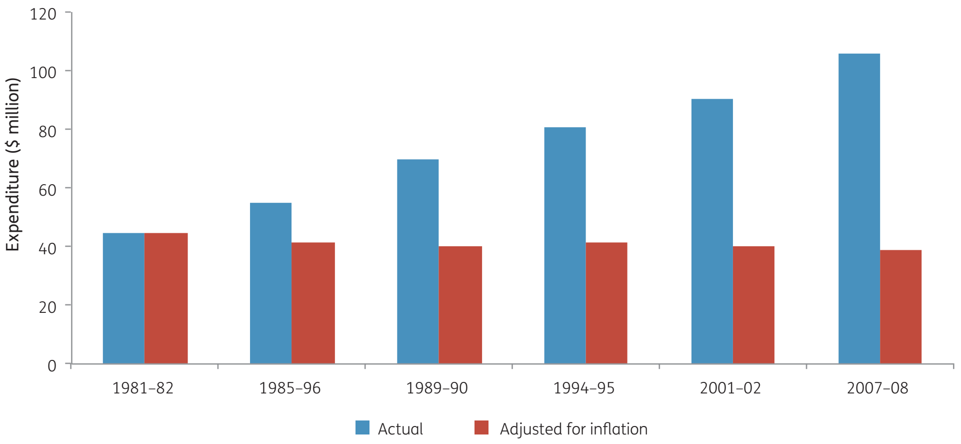
The ABS data are derived from self-reporting of R&D expenditure by business entities, and differ from other estimates of R&D expenditure in the forest and forest products sector, due in part to differing survey methodologies and definitions.

A series of surveys conducted by Turner and Lambert (2011) has used a consistent methodology to collect data on expenditure on R&D on forestry and forest products for two segments of the sector at intervals from 1981–82 to 2007–08. 'Forestry R&D' was defined by Turner and Lambert as including research relating to the commercial management and protection of forests, including environmental and ecological considerations, but not research on areas managed specifically for conservation (e.g. forest areas in public nature conservation areas such as national parks), or costs of monitoring growth, health, nutrition or biodiversity. 'Forest products R&D' was defined by Turner and Lambert as including R&D on value-adding to timber but not work on final product development (e.g. furniture production), production runs in mills, environmental monitoring or quality control assessment. For both segments, estimates included contributions from both public and private sources, and not just expenditure by business alone.

According to the results of the Turner and Lambert surveys, the estimated total expenditure on forestry and forest products R&D in 2007–08 was about $106 million (Figure 6.31). The data also show that, although expenditure on forest R&D increased in the period 1981–82 to 2007–08, when adjusted for inflation expenditure declined over the period by about 0.45% per year.

The difference between the estimates of Turner and Lambert ($106 million in 2007–08; Figure 6.31) and those of the ABS ($144 million in 2007–08; Table 6.35) may be explained by the inclusion in the ABS data of R&D on secondary wood products, by the underestimation of overheads by Turner and Lambert, and by the possibility that companies in the forest and wood product sector included a broader range of activities (such as production runs) in their definitions of R&D for the ABS survey (J Turner, pers. comm., July 2012).

Figure 6.31: Expenditure on forestry and forest product R&D, 1981–82 to 2007–08, actual and adjusted for inflation



Note: Figures were adjusted for inflation to 1981–82 prices using the consumer price index (ABS 2012a).
Source: Turner and Lambert (2011).

Hardwood veneer.

Indicator 6.3a

Area of forest available for public recreation/tourism

Rationale

This indicator measures the area of forest available for use by the community for recreation and tourism purposes. This provides an indication of the emphasis placed by society on the management of forest for recreation and tourism.

Key points

- Most publicly owned multiple-use and nature conservation forests in Australia are available to the general public for recreation or tourism purposes, with 30.8 million hectares available nationally for these uses. This figure comprises 10.1 million hectares of multiple-use forest and 20.7 million hectares of nature conservation reserve.
- Additional private forest areas are available, usually under commercial arrangements. Some substantial areas of reserved forest in northern Australia, such as in Kakadu National Park, are on private land tenure but available for recreation and tourism.
- Some forests that are generally available for public recreation and tourism may be closed temporarily, mainly to ensure the safety of the general public when certain forest management activities occur. Forest areas may also be closed permanently to recreation and tourism if these activities are likely to compromise, or are not compatible with, the primary objective of management for these forest areas.

This indicator reports the area of forest available for recreation and tourism in Australia. For the purpose of this indicator, an area of forest is considered to be available for recreation and tourism if there are no legal or other forms of prohibition on access to the forest for recreation and tourism activities. This includes areas where patrons may have to pay for public access to private land (e.g. a wildlife park).

Forests on public land

Most publicly owned forested lands designated for multiple use or nature conservation are available for general recreation and tourism purposes. Nationally, 30.8 million hectares of forest are available for general tourism and recreation across the public reservation and multiple-use forest estates (Table 6.36), as determined from the national forest coverage (Indicator 1.1a) and data provided by jurisdictional agencies on the proportions of forest on each tenure directly available for recreation and tourism. This figure comprises 10.1 million hectares of available multiple-use forest, and 20.7 million hectares of available nature conservation reserve.

Although various outdoor recreation and tourism activities may be undertaken in most public forests, some areas have exclusions or restrictions for visitor safety, or to protect specific scientific, natural, cultural or water supply values (IFA 2007). Publicly owned forest areas that are closed permanently to the public, and therefore not available for general recreation and tourism, include areas designated for scientific reference, study or research; conservation areas; some water catchment areas; significant Indigenous cultural heritage sites; and defence training areas.

Forests that are generally available for public recreation and tourism may be closed temporarily during wood harvesting, extreme fire weather or other climatic events, total fire bans, fuel reduction burning, control of feral animals or weeds, or special events (e.g. car rallies). Inadequate road, track or trail access, a lack of facilities and other practical considerations may also restrict or prevent public use of multiple-use and nature conservation forests. Some of these access restrictions (e.g. due to pest and weed control) are more likely to apply to Australia's publicly owned plantation forests than to multiple-use native forests. For particular forest areas, forest management plans may specify the types of visitor

Table 6.36: Area and proportion of forest available for general recreation and tourism on public land, by jurisdiction and tenure class

Jurisdiction	Multiple-use public forest			Nature conservation reserve			Total public land
	Total area[a] ('000 hectares)	Proportion available for recreation and tourism (%)	Area available for recreation and tourism ('000 hectares)	Total area[a,b] ('000 hectares)	Proportion available for recreation and tourism (%)	Area available for recreation and tourism ('000 hectares)	Area available for recreation and tourism ('000 hectares)
ACT	4	100[c]	4	115	99[c]	114	118
NSW	2,022	99[d]	2,002	5,581	88[e]	4,911	6,913
NT	0	n.a.	0	13	100[f]	13	13
Qld	2,905	99[g]	2,876	5,098	100	5,098	7,974
SA	20	100[h]	20	1,509	100[h]	1,509	1,529
Tas.	923	100[i]	923	1,240	100[i]	1,240	2,163
Vic.	2,994	99	2,964	3,313	97	3,214	6,178
WA	1,291	100[j]	1,291	4,610	100[j]	4,610	5,901
Australia	**10,159**	**99**	**10,080**	**21,478**	**94**	**20,709**	**30,789**

n.a. = not applicable

[a] See Indicator 1.1a.

[b] Does not include reserves on private or leasehold land. This particularly affects the NT, where much of the reserved forest estate available for recreation and tourism is on private or leasehold lands (e.g. Kakadu National Park).

[c] Data from ACT Environment and Sustainable Development.

[d] Data from Forests NSW.

[e] Data from Parks and Wildlife Group, NSW Office of Environment and Heritage.

[f] Availability of 100% assumed, as no data provided by jurisdiction.

[g] Data from SOFR 2008.

[h] Data from Primary Industries and Regions SA, Forestry, and based on all forest reserves in SA managed by ForestrySA, excluding non-forest areas.

[i] Data from FPA (2012).

[j] Data from WA Department of Environment and Conservation, and for the south-west forest region only; access to some forest areas for general recreation and tourism may be restricted due to the presence or potential spread of Phytophthora dieback, reservoir protection zones, or visitor safety requirements.

Note: Figures may differ from those reported in state and territory or regional reports on regional forest agreements as a result of different forest-type mapping or more recent data.
Totals may not tally due to rounding.

activities that are permissible and the conditions of use that apply. In forests not subject to forest management plans, the broad policies of the responsible forest management agency usually indicate the types of recreation and tourism that may take place.

A competitive mountain-bike rider in native forest, Wyena, Tasmania.

Forests on private and leasehold land

Public access for recreation and tourism to forests on private land is generally limited, although few data are available on this. If access is required, it would be on application to the private landowner or manager for permission to undertake specified activities in the forest area, unless specific commercial arrangements are advertised (e.g. a wildlife park). The same applies for forests on leasehold land, which is mostly privately managed under long-term pastoral leases that grant the lessee rights of custodianship of the land—these leases impart a level of responsibility for the management of the land.

Of the nearly 82 million hectares of forest on private and leasehold land (Indicator 1.1a), around 6 million hectares (7%) is in the National Reserve System (Indicator 1.1c). The Northern Territory contains more than 3.7 million hectares of reserved private or leasehold land, including reserved Indigenous land. Much of the land is available for recreation and tourism, including Kakadu National Park, which is private land leased to the Australian Government and which contains close to 900 thousand hectares of forest.

Indicator 6.3b

Range and use of recreation/tourism activities available

Rationale

This indicator assesses the range and number of recreation and tourism facilities provided in forests, their level of use and their contribution to the broader tourism sector. Appropriate and well managed facilities help to optimise visitor satisfaction as well as minimising environmental impacts associated with recreation and tourism.

Key points

- A wide range of forest-based recreation and tourism services are available in Australia to meet demand by the general public. The data reported here are for recreation and tourism on public land.
- For those forests for which data were available, the number of areas, tracks and sites available for recreation and tourism activities remained the same or increased over the reporting period.
- Forest management agencies have strategies in place to actively manage forest areas with high recreation and tourism use within their jurisdictions.

This indicator reports the range of recreation and tourism facilities available in forests and how much the facilities are used. Some facilities, such as walking or riding tracks, picnic sites and campgrounds, are provided solely for recreation or tourism. Other facilities, such as roads and vehicular tracks, are provided for a range of management purposes but are also available for use for recreation and tourism.

In each state and territory, forest management aims to provide a balanced range of opportunities for recreational pursuits—such as walking, running, cycling, climbing, fishing, camping, snow activities and water sports—consistent with demand, resources and environmental concerns, as well as facilities appropriate for each forest setting. As noted in the Institute of Foresters of Australia Forest Policy Statement no. 5.5 (IFA 2007):

> *The range of recreation and tourism activities that can be undertaken in Australia's forests also differ in their impact on the land, vegetation, wildlife and other forest values, such as water quality. Generally, any activity pursued occasionally and at a low level of intensity, and within management constraints, poses little threat to the environment. However, as the intensity and frequency increase, or when constraints are not followed conflicts and negative impacts on forest values can arise.*

State forests and national parks

Australia's state forests, also known as multiple-use public forests, are generally open to the broadest range of public recreation and tourism activities available in Australia's forests. State forests also have the fewest restrictions on public recreation and tourism activities (see Indicator 6.3a). Australia's national parks place greater limitations on recreation and tourism activities, because conservation is the management priority. The recreational opportunities in Australia's state forests complement those in national parks activities that are not allowed or are restricted in national parks—such as four-wheel driving, trail-bike riding, horse riding and hunting—and have a lower level of restriction with regard to companion dogs.

State forests also provide a range of recreational opportunities that are generally available free of charge to the public, including use of picnic and camping areas, and access to state forest roads for vehicular activities. Some national parks and facilities in national parks are accessed via an entrance gate with an entrance fee, and many national parks charge fees for overnight camping or require registration to access popular multi-day hiking trails. A proportion of these fees generally goes towards the ongoing maintenance of facilities and the management of national parks. Organised events and tourism activities in state forests and national parks are administered by permit systems and involve a cost to the public.

As an example of the spread of recreation and tourism activities in state forests, data on issued permits are presented for New South Wales (Table 6.37). In 2010–11, Forests NSW

Table 6.37: Number of permits issued by Forests NSW for organised recreational activities in New South Wales state forests, 2008–09 to 2010–11

Activity	2008–09	2009–10	2010–11
Bow hunting/archery	3	2	10
Bushwalking	5	8	7
Car and bike rallies/events	32	40	48
Ecotourism/four-wheel drive tours	21	7	14
Education/outdoor education schools	27	11	9
Fossicking[a]	116	152	320
Horse, trail and endurance rides	24	24	28
Mountain-bike rallies	51	38	42
Orienteering/mountain runs/triathlon	22	26	24
Training/exercises	35	34	56
Other	181	126	10
Total	**517**	**468**	**568**

a The number of fossicking permits has increased over time, partly because permits are now issued to individuals rather than groups; the actual number of participants may not have increased.

Source: Forests NSW.

Table 6.38: Tracks, sites and events provided for recreation and tourism in public multiple-use forests, 2005–06 and 2010–11

Activity	Unit	South Australia		Victoria	
		2005–06	2010–11	2005–06	2010–11
Walking or running	km of tracks	304	304	715	761
Cycling	km of tracks	232	252	170	320
Riding or walking animals	km of tracks	84	170	170	40
Driving[a]	km of roads	130	200	733	1,700
Cultural heritage appreciation	number of managed sites	1	20	34	42
Events or festivals	number of events	2	353	151	152
Fishing[b]	number of managed sites	1	1	25	33
Hunting	number of managed sites	0	–	–	–
Nature study	number of sites	11	11	–	–
Camping	number of sites	21	21	227	240
Picnicking and playing	number of sites	27	27	226	250
Watercraft (motorised)	number of sites	0	1	2	2
Watercraft (non-motorised)	number of sites	1	1	5	11

– = no data

a Victoria's data for driving refer to promoted two-wheel drive and four-wheel drive touring routes, a subset of the total available open public road network.

b For some activities such as fishing, there can be multiple locations for fishing in multiple-use forest; the recorded figures are for sites specifically promoted for fishing.

Note: Victorian data are derived from the Department of Sustainability and Environment's Recreation Facilities Database for multiple-use forests, and variations from SOFR 2008 may be due to better data capture.

Source: State agencies.

issued more than 500 special-purpose permits for activities in New South Wales state forests; the greatest number of permits was issued for fossicking. Other activities for which permits were issued included car rallies, adventure races, bike rallies, mountain-bike races, club sporting activities, and events such as dance parties and festivals.

Some state forest agencies conduct visitor surveys and have a good understanding of visitor needs and expectations; others provide sites and facilities in response to local demand and patterns of existing use. As examples, Table 6.38 presents data on tracks, sites and events available for forest-based recreation and tourism activities in public multiple-use forests in South Australia and Victoria. These data do not include sites and facilities managed by local governments or the commercial and private sectors, or sites in national parks.

Numbers of visitors

Visitor numbers in public forests (state forests, national parks and other reserves) are monitored by a mixture of counts and estimates by agency staff. Count data are based on entry fees, traffic counters, camping permits and surveys and are relatively accurate formal mechanisms for monitoring usage, whereas estimates are less accurate, informal mechanisms.

Usage is a difficult parameter to measure because most forests have many entry points and visitor use is dispersed. In addition, usage can vary dramatically according to the day of the week and the season, and increases greatly during school holidays. Sites that are well signposted and promoted in various media receive many more visits than lesser known sites, where usage is more dependent on word of mouth. Because of the free access to state forests and the many entrance points, data on usage levels are generally not collected. However, some specific locations do collect usage data—for example, Cumberland State Forest in Sydney's north-west, which attracts more than 100 thousand visitors per year (see Case study 6.5).

In Tasmania, climbing, abseiling, caving, nature observation, photography, swimming and other activities all take place in state forests, national parks and reserves. Hunting continues to be allowed in state forests and on some reserve classes—game reserves, conservation areas and regional reserves. No significant changes have been observed in the nature or level of these activities over the period 2006–2011. However, over the period 2006–2011, mountain-bike activity has increased in some parks and reserves. In response, special mountain-bike tracks have been developed.

Across Tasmania's national park system generally, the annual number of visitors remained relatively constant from 2005–06 to 2008–09, then declined (FPA 2012). The decline in visitor numbers was across the whole state, with no single park or forest destination showing a significantly greater decline than any other, and was in response to a combination of factors, including a stronger Australian dollar impacting on costs for international visitors.

Western Australian data from the Department of Environment and Conservation show that annual visitation to areas covered by the Western Australian *Forest Management Plan* reached 6.9 million visits in 2010–11—an increase of 2.1 million visits (43%) since 2003–04. Demand for use of land covered by the plan for recreation and tourism is expected to continue to grow in line with population growth in the south-west of Western Australia (CCWA 2012a).

In the Northern Territory, very little land is available for general recreation and tourism outside of national parks and reserves. Permission is required to visit all private land (Aboriginal freehold land and other freehold land, with the exception of Kakadu National Park) and leasehold land (pastoral land). This permission is given on request in most instances, but no member of the public is permitted to visit such areas unannounced. Annual visitor (vehicle) numbers to the main Northern Territory Government–managed forested parks and reserves decreased from 1.2 million in 2007 to 1.1 million in 2010.

In South Australia, just over 145,000 visitors were recorded in ForestrySA reserves in 2010–11. Because of limitations in data collection, such as multiple unmonitored access points and limited resources, it is estimated that actual numbers may be more than twice this recorded figure.

Diamond Tree fire tower, in karri (*Eucalyptus diversicolor*) tree near Manjimup, Western Australia.

Case study 6.5: Cumberland State Forest

Cumberland State Forest, located in West Pennant Hills, Sydney, is Australia's only metropolitan state forest. It contains 40 hectares of native forest. The original, privately owned land was cleared in 1908 and used for farming. In 1938, management of the land was taken over by the then NSW Forestry Commission, and the land was dedicated as a state forest in 1939. One-third was planted as an arboretum with native tree species from around Australia, while the rest was allowed to regenerate naturally.

Cumberland State Forest attracts more than 100 thousand visitors each year. A wide range of recreational activities are undertaken, including walking, picnicking and nature study. The arboretum, visitor centre, cafe and nursery are all areas of interest within the forest (Figure 6.32). Cumberland State Forest also offers a volunteer program that provides an opportunity for visitors to take part in revegetation and forest regeneration activities.

A forest school education program, run by Forests NSW[143], is also offered at Cumberland State Forest. The program includes excursions designed to match the curriculum of all levels of education up to high school. The excursions provide education about a wide range of sustainable land management issues. More than four thousand school children take part in excursions at Cumberland State Forest each year.

The Cumberland Forest Fair, a community event, attracts an additional five thousand visitors to the forest.

continued overleaf

[143] From January 2013, the Forestry Corporation of NSW.

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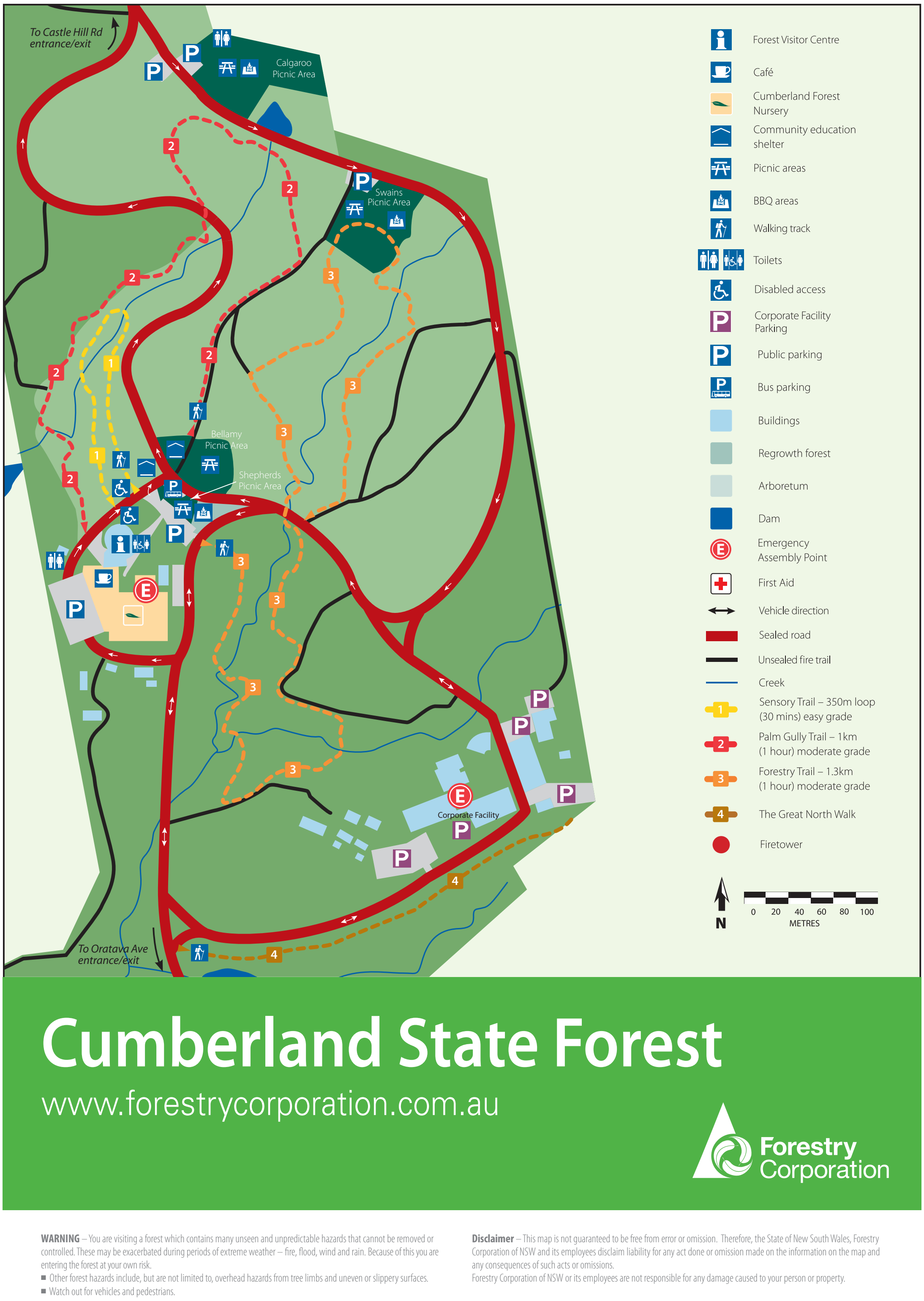
Case study 6.5: Cumberland State Forest continued

Figure 6.32 Cumberland State Forest map



Source: http://www.forestrycorporation.com.au/__data/assets/pdf_file/0007/440179/cumberland-sf-map.pdf

More details are available at: http://www.forestrycorporation.com.au/__data/assets/pdf_file/0007/440179/cumberland-sf-map.pdf

Indicator 6.4a

Area of forest to which Indigenous people have use and rights that protect their special values and are recognised through formal and informal management regimes

Rationale

This indicator monitors the degree to which land is placed under appropriate tenure classifications or management regimes to protect Indigenous peoples' values in forests. An acceptable level of accountability for the protection of Indigenous peoples' cultural, religious, social and spiritual needs and values is an essential part of forest management.

Key points

- Access, management and ownership are key parts of the relationship of Indigenous people with land. The Indigenous estate can be broadly divided into four land tenure and management categories: Indigenous owned and managed, Indigenous managed, Indigenous co-managed and Other special rights.
- Nationally, in 2011 there were 309.9 million hectares of land in the Indigenous estate, of which 41.9 million hectares was forested, corresponding to 34% of Australia's total forest area. This is an increase of 22.1 million hectares of forested land in the Indigenous estate over the figure reported in SOFR 2008. The increase has been driven primarily by improved availability of spatial information on Indigenous land tenure, as well as an increase in the area of land over which Indigenous people have legislated rights.
- Of the 41.9 million hectares of forested land in the Indigenous estate, 31.7 million hectares (76%) is in Queensland and the Northern Territory.
- The total area of forest located within sites with Indigenous heritage value registered on the Register of the National Estate in 2011 was 1.5 million hectares, of which 1.2 million hectares (81%) is in Queensland and the Northern Territory.

Indigenous land access, management or ownership

In SOFR 2008, information from the Indigenous Land Corporation was used to report on the area of forest over which Indigenous people had use and other rights that enabled the protection of special Indigenous values. This information provided a snapshot of all lands that were owned or managed by Indigenous community groups and agencies in 2003. However, it did not differentiate lands that were legally owned and controlled by Indigenous people from lands that were owned by other parties and managed by Indigenous people, such as Crown-owned leasehold lands.

Since 2003, the amount of Indigenous land tenure information accessible through government agencies at the national and state and territory levels has increased significantly. There has also been a significant increase in the area of land under formal management regimes over which Indigenous people have rights that enable them to protect their special values. Table 6.39 provides a list of the datasets collected for use in SOFR 2013 and other projects (including the National Indigenous Forestry Strategy[144]: DAFF 2005); more detailed descriptions of each land category and its importance to Indigenous people, history and usage are given in Indicator 6.4c.

[144] www.daff.gov.au/forestry/policies/nifs.

Table 6.39: Datasets compiled on areas of forest over which Indigenous people have use and rights

Title	Year of currency	Source agency and data availability
Indigenous owned and managed		
Indigenous Protected Areas	2011	DSEWPaC[a]; available at Discover Information Geographically website (www.environment.gov.au/metadataexplorer/explorer.jsp)
Northern Territory Aboriginal Lands Trust lands	2011	Northern Territory Department of Lands and Planning[b] (www.lands.nt.gov.au)
Indigenous Land Corporation owned and granted	2011	Indigenous Land Corporation (www.ilc.gov.au/Land-Acquisition/Land-Purchased/Land-Purchased-All-States)
Indigenous Land Corporation Indigenous estate[c]	2003	Indigenous Land Corporation (www.ilc.gov.au)
Queensland Deed of Grant in Trust	2009	Queensland Department of Environment and Resource Management[d] (http://dds.information.qld.gov.au/dds/)
Indigenous managed		
Western Australian Aboriginal Lands Trust	2009	Western Australia Department of Indigenous Affairs[e] (www.dia.wa.gov.au)
Western Australian Indigenous pastoral leases	2009	Western Australia Land Information Authority, trading as WA Landgate (www.landgate.wa.gov.au/corporate.nsf/web/index.html)
Leased-back nature reserves	2010	State and territory government conservation agencies, and the DSEWPaC[a] Collaborative Australian Protected Area Database 2010; available at Discover Information Geographically website (www.environment.gov.au/metadataexplorer/explorer.jsp)
Indigenous co-managed		
Nature conservation reserve memoranda of understanding	2010	State and territory government conservation agencies, and the DSEWPaC[a] Collaborative Australian Protected Area Database 2010; available at Discover Information Geographically website (www.environment.gov.au/metadataexplorer/explorer.jsp)
World Heritage Area memoranda of understanding	2010	State and territory government conservation agencies, and the DSEWPaC[a] Australian World Heritage Areas dataset; available at Discover Information Geographically website (www.environment.gov.au/metadataexplorer/explorer.jsp)
Other special rights		
Native title determinations	2011	National Native Title Tribunal (NNTT) (www.nntt.gov.au/Mediation-and-agreement-making-services/Geospatial-services/Pages/Spatial-Data.aspx)
Indigenous land use agreements	2011	National Native Title Tribunal (www.nntt.gov.au/Mediation-and-agreement-making-services/Geospatial-services/Pages/Spatial-Data.aspx)

DSEWPaC = Australian Government Department of Sustainability, Environment, Water, Population and Communities

a From September 2013, the Department of the Environment.

b From October 2012, the Department of Lands, Planning and Environment.

c There are some known errors in this dataset.

d From April 2012, the Department of Environment and Heritage Protection.

e From July 2013, the Department of Aboriginal Affairs (www.daa.wa.gov.au).

Source: Australian Bureau of Agricultural and Resource Economics and Sciences.

For reporting purposes, the information collected on Indigenous land tenure has been grouped into four categories (Table 6.39), which are shown on the map in Figure 6.33:

- Indigenous owned and managed —freehold lands that are both owned and managed by Indigenous communities
- Indigenous managed—lands that are managed but not owned by Indigenous communities (e.g. Crown reserves and leases); and lands that are owned by Indigenous people, but have formal shared management agreements with Australian and state and territory government agencies (e.g. leased-back nature conservation reserves)
- Indigenous co-managed—lands that are owned and managed by other parties, but have formal, legally binding agreements in place to include input from Indigenous people in the process of developing and implementing a management plan (e.g. nature conservation reserve memoranda of understanding)
- Other special rights—lands subject to native title determinations and active Indigenous land use agreements. These are independent of tenure and, in most cases, do not grant ownership or management rights of land to Indigenous communities. They can provide for the right to access areas of cultural significance, or a legal requirement for consultation with the local Indigenous community before any major development activities take place.

In all jurisdictions, government agencies responsible for the management of nature conservation reserves consult informally with Indigenous community groups and representatives as part of normal operations. Consultation with community groups, including Indigenous people, improves relations between these agencies and local communities and leads to a range of positive outcomes for agencies, community groups and the environment. However, since these arrangements are not identified explicitly as Indigenous co-management arrangements, they are not counted in Table 6.40 and not shown in Figure 6.33.

SOFR 2008 reported a total of 122 million hectares of land in the Indigenous estate, of which 20.8 million hectares was forested (14% of Australia's total forest area). In 2011, the national Indigenous estate contained 309.9 million hectares of land, of which 41.9 million hectares was forested (Table 6.40)—this is 34% of Australia's total forest area. Of the 41.9 million hectares of forested land in the Indigenous estate, 31.7 million hectares (76%) is in Queensland and the Northern Territory.

The 41.9 million hectares of Indigenous forested land comprises 13.5 million hectares of forested land that is Indigenous owned and managed, 2.4 million hectares of forested land that is Indigenous managed, 5.4 million hectares of forested land that has co-management arrangements in place with government agencies, and 20.6 million hectares of forested land over which Other special rights (including native title determinations and Indigenous land use agreements) have been granted.

Three major drivers are associated with the changes in estimated areas of forest in the Indigenous estate compared with the areas presented in SOFR 2008:

- the new method of estimating Australia's forest extent (Indicator 1.1a)
- improved availability and accessibility of spatial information on Indigenous land tenure from Australian and state and territory government agencies (Table 6.39)
- a real increase in the total area of land over which Indigenous people have legislated rights.

Figure 6.33: Forest on Indigenous owned and managed lands, Indigenous managed lands, Indigenous co-managed lands, and lands with Other special rights

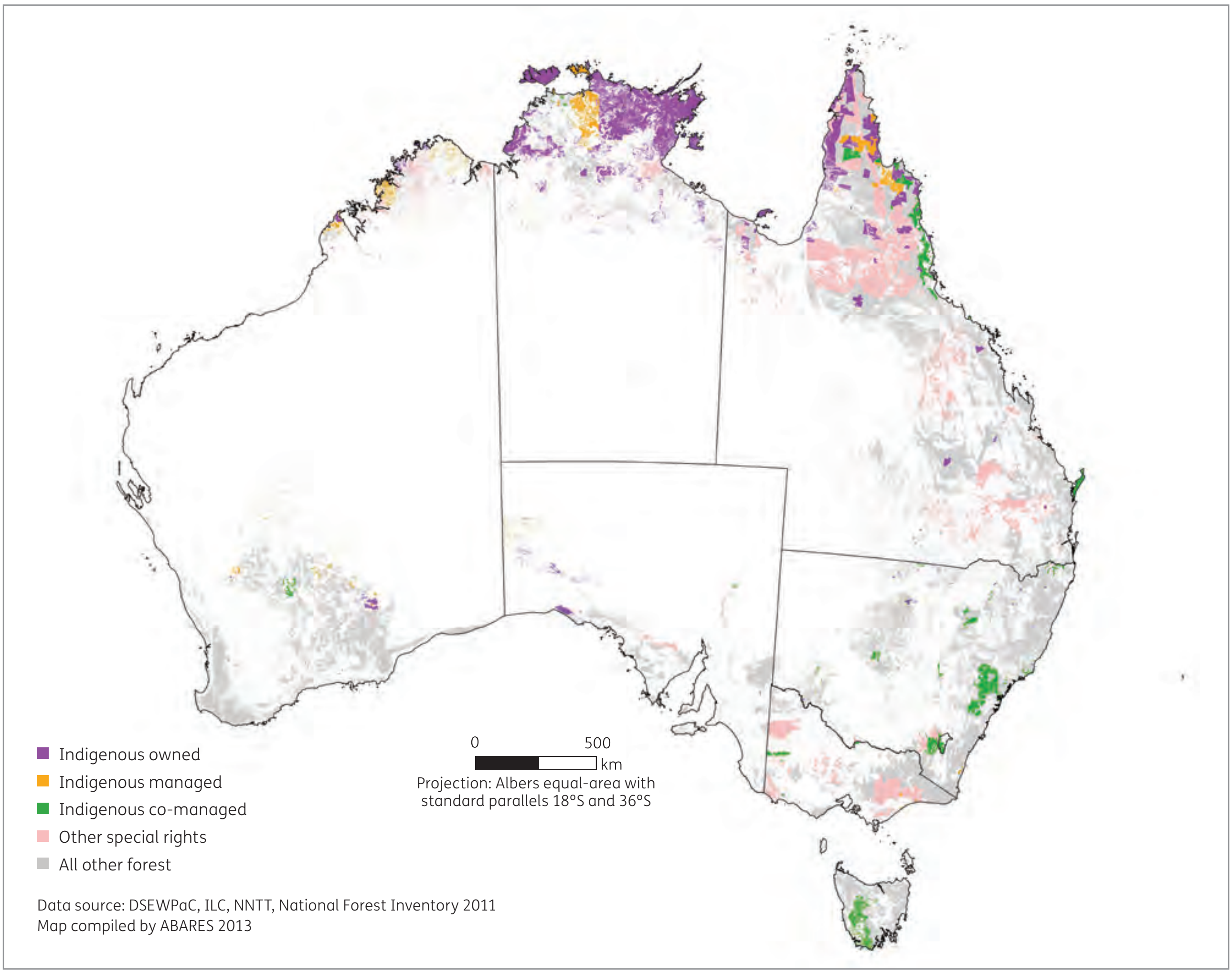


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Table 6.40: Area of land, including forest land, under Indigenous ownership and management, Indigenous management, Indigenous co-management and Other special rights

		Area ('000 hectares)								
Management category	**Land cover type**	**ACT**	**NSW**	**NT**	**Qld**	**SA**	**Tas.**	**Vic.**	**WA**	**Australia**
Indigenous owned and managed	All	0	434	64,068	4,997	20,351	62	11	16,109	106,032
	Forest	0	129	9,280	3,329	240	8	5	550	13,542
Indigenous managed	All	0	105	1,331	1,254	2,132	0	44	25,041	29,908
	Forest	0	28	461	1,002	74	0	27	808	2,400
Indigenous co-managed	All	106	2,920	196	2,436	3,077	1,383	222	5,494	15,834
	Forest	100	2,213	52	1,884	20	750	187	156	5,364
Other special rights	All	0	730	20,217	46,206	21,969	0	8,156	60,847	158,125
	Forest	0	366	691	15,045	371	0	2,857	1,293	20,622
Total	**All**	**106**	**4,189**	**85,812**	**54,894**	**47,529**	**1,445**	**8,432**	**107,492**	**309,899**
	Forest	**100**	**2,735**	**10,485**	**21,260**	**705**	**758**	**3,076**	**2,807**	**41,928**

Note: Totals may not tally due to rounding.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences.

A land parcel may be subject to more than one type of management. To avoid double-counting, land has been classified for this indicator into the highest applicable of the four Indigenous land tenure and management categories—for example, a land parcel that is a declared Indigenous Protected Area but is also subject to a native title determination is reported here as Indigenous owned and managed.

Indigenous heritage protection

The Commonwealth, state and territory laws that protect Indigenous cultural heritage in Australia are the:

- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Commonwealth)
- *Aboriginal Land Rights (Northern Territory) Act 1976* (Commonwealth)
- *Heritage Act 2004* (Australian Capital Territory)
- *National Parks and Wildlife Act 1974* (New South Wales)
- *Northern Territory Aboriginal Sacred Sites Act 1989* (Northern Territory)
- *Heritage Act 2011* (Northern Territory)
- *Aboriginal Cultural Heritage Act 2003* (Queensland)
- *Torres Strait Islander Cultural Heritage Act 2003* (Queensland)
- *Aboriginal Heritage Act 1988* (South Australia)
- *Aboriginal Relics Act 1975* (Tasmania)
- *Aboriginal Heritage Act 2006* (Victoria)
- *Heritage Act 1994* (Victoria)
- *Aboriginal Heritage Act 1972* (Western Australia).

All jurisdictions maintain Indigenous heritage site lists or registers. The legislation affords protection to all sites, including those situated in forests. It was not possible to collate these heritage lists spatially across each jurisdiction because of cultural sensitivities, privacy reasons and a lack of electronic spatial information for Indigenous heritage sites. Indigenous heritage sites are generally protected irrespective of their registration.

All states and territories have legislation, regulations, codes of practice and management prescriptions that govern the management of Indigenous heritage sites in forests. These instruments provide a level of protection for Indigenous heritage sites that are not yet included in the relevant Indigenous heritage site register.

Between 1975 and 2007, the Australian Government maintained the Register of the National Estate (RNE), a national list of places with historical, natural or Indigenous heritage significance. Each site was protected under the *Australian Heritage Commission Act 1975* (repealed in 2004) and the *Environment Protection and Biodiversity Conservation Act 1999*. The RNE was frozen in 2007 and ceased to be recognised as a statutory list in February 2012. Nevertheless, the RNE was still recognised in June 2011 (the end of the nominal reporting period for SOFR 2013), so the area of forest with Indigenous heritage significance listed on the RNE in June 2011 is reported here. Figure 6.34 shows the distribution of these areas across Australia.

The total area of forest located within sites with Indigenous heritage value registered on the RNE is 1.49 million hectares (Table 6.41), of which 1.2 million hectares (81%) is in Queensland and the Northern Territory. The forest types in the areas of forest with Indigenous heritage value registered on the RNE are predominantly Eucalypt medium open forest and Eucalypt medium woodland forest (70% of all forests on Indigenous sites; Table 6.41). SOFR 2008 reported 1.57 million hectares of forest within sites with Indigenous heritage value registered on the RNE. The difference between the values reported here and in SOFR 2008 is due solely to the new method of estimating Australia's forest extent (see Indicator 1.1a), since there has been no change in the total area or number of Indigenous sites on the RNE.

Figure 6.34: Forests on Indigenous sites on the Register of the National Estate

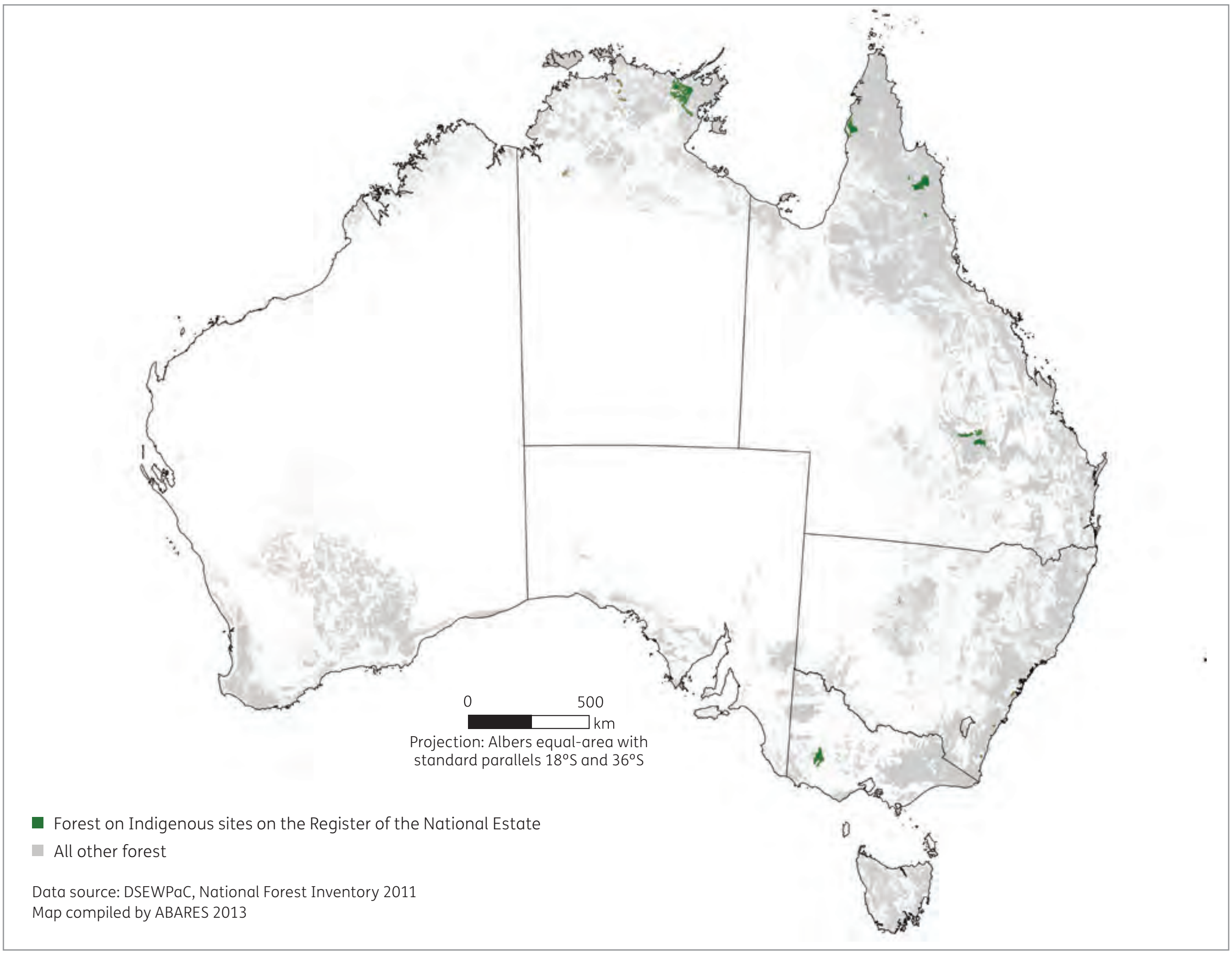


Table 6.41: Area of native forest on the Register of the National Estate for Indigenous values

	Area ('000 hectares)								
Forest type	**ACT**	**NSW**	**NT**	**Qld**	**SA**	**Tas.**	**Vic.**	**WA**	**Australia**
Acacia	0	10	0	47	0	0	1	1	59
Callitris	0	1	0	5	1	0	19	0	25
Casuarina	0	6	3	0	2	0	1	0	14
Eucalypt	0	56	439	525	12	1	134	3	1,173
Eucalypt mallee open	0	0	0	0	1	0	0	0	1
Eucalypt mallee woodland	0	0	0	0	7	0	1	2	10
Eucalypt low closed	0	0	1	0	0	0	0	0	1
Eucalypt low open	0	0	20	43	0	0	0	0	64
Eucalypt low woodland	0	4	13	12	2	0	0	1	33
Eucalypt medium closed	0	0	1	0	0	0	0	0	1
Eucalypt medium open	0	13	255	45	0	1	51	0	365
Eucalypt medium woodland	0	31	149	416	2	0	82	0	680
Eucalypt tall closed	0	1	0	0	0	0	0	0	1
Eucalypt tall open	0	7	0	9	0	0	0	0	17
Eucalypt tall woodland	0	0	0	0	0	0	0	0	0
Mangrove	0	1	2	13	0	0	0	0	16
Melaleuca	0	0	87	27	0	0	3	0	119
Rainforest	0	2	23	13	0	0	0	0	38
Other native forest[a]	0	9	10	16	0	0	15	0	50
Total	**0**	**85**	**566**	**646**	**16**	**3**	**174**	**3**	**1,493**

[a] Other native forest comprises a range of minor forest types, including Agonis, Atalaya, Banksia, Hakea, Grevillea, Heterodendron, Leptospermum, Lophostemon and Syncarpia (named after their dominant genera), as well as native forests where the type is unknown.

Notes: No plantation forests are on the Register of the National Estate for Indigenous values.

Totals may not tally due to rounding.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory.

Case study 6.6: Protection of Aboriginal heritage in forests in South Australia

In South Australia, the *Aboriginal Heritage Act 1988* provides for the identification, protection and preservation of Aboriginal (Indigenous) remains and archaeological sites and objects on all land, including forests, irrespective of land tenure. These sites and objects include:

- culturally modified trees (such as scar trees)
- burial mounds or sites
- middens or other sites used for camping or eating
- remnants of shelters
- cooking utensils or other tools
- stone flint sites or objects of technology
- cultural artefacts, paintings and carvings.

If Aboriginal remains and/or archaeological sites or objects exist at a site, including forest sites, a process is begun to develop a management plan to protect the area in consultation with regional Aboriginal authorities and communities.

To ensure that the forest industry is aware of its responsibilities under the *Aboriginal Heritage Act 1988*, Primary Industries and Regions South Australia (PIRSA) Forestry commissioned the publication of a fact sheet and internet video, *Aboriginal Heritage and Forestry*. In addition, PIRSA Forestry's *Guidelines for Plantation Forestry in South Australia 2009* outline the requirement to comply with the *Aboriginal Heritage Act 1988*.

The fact sheets and videos are available at: www.pir.sa.gov.au/forestry/publications_index/forestry_development_information/fact_sheets2/aboriginal_heritage_and_forestry.

Tiwi forestry worker pruning plantation trees, Melville Island, Northern Territory.

Indicator 6.4b

Registered places of non-Indigenous cultural value in forests that are formally managed to protect those values

Rationale

This indicator measures and monitors management regimes for non-Indigenous cultural values, such as historical, research, education, aesthetic, and social heritage values. Maintaining these values is integral to the protection of non-Indigenous peoples values associated with forests.

Key points

- A Non-Indigenous Heritage Sites of Australia dataset has been developed that compiles current non-Indigenous heritage lists and registers from all jurisdictions into a national dataset.
- Across all jurisdictions, the forest area on heritage-listed sites covers 7.3 million hectares. This is an overall increase of 6.8 million hectares of forest on heritage-listed sites since SOFR 2008, due to the use of the new dataset.

Australia's forests include many sites that provide evidence of the interactions between non-Indigenous people and forest landscapes, and the activities that have taken place on the continent since European settlement. A wide variety of historical, research, education, aesthetic and social heritage sites, features, structures and landscapes have cultural value at a local, regional, state, national and international level.

The Australian Government's Register of the National Estate (RNE) dataset was established in 1975 under the *Australian Heritage Commission Act 1975* (repealed in 2004) as a register of sites of local, state and national significance. This Act provided all registered sites with a basic level of statutory protection, limited to actions of the Australian Government and its agencies (see Indicator 1.1c).

In 1997, the Council of Australian Governments (COAG) agreed that it was more appropriate for heritage listing and protection to be the responsibility of the government agencies that were best placed to deliver agreed outcomes. This recognised that state and territory governments had passed their own legislation to protect sites that they considered to be significant at the state and territory level. To protect sites with national significance, the Australian Government created the National Heritage List (NHL) and the Commonwealth Heritage List in 2004, through amendments to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Australian sites registered on the UNESCO World Heritage List (WHL) are also protected under this Act (see Indicator 1.1c). The RNE was frozen in 2007 by amendments that flowed from the 1997 COAG agreement, and it ceased to be recognised as a statutory listing on 19 February 2012. Table 6.42 summarises all heritage registers that currently record sites of heritage significance at the national and state and territory levels.

In SOFR 2008 (Indicator 1.1c), the RNE dataset was used to report on the area of heritage sites on forested land that were registered for their historical and natural heritage values. For SOFR 2013, the electronic spatial versions of each of the databases listed in Table 6.42 have been collected from the relevant agencies and compiled at the national scale. Indigenous sites were removed from these registers, as this indicator focuses specifically on non-Indigenous cultural values; most states and territories record Indigenous sites on separate Indigenous heritage registers. This derived national dataset is referred to as the Non-Indigenous Heritage Sites of Australia (NIHSA) dataset. The RNE dataset that was used in SOFR 2008 was not an input to the new NIHSA dataset. Each dataset used to compile the NIHSA dataset was current as at June 2011, which is the end of the nominal reporting period for SOFR 2013.

The sites in the NIHSA dataset are afforded protection (under the relevant Acts) from disturbance by any person, while the sites on the RNE were only afforded protection from actions of the Australian Government.

It is recognised that heritage registers are also compiled at the local government level in some areas of Australia; however, it was not possible to compile the extensive list of such datasets for use in this report.

Table 6.42: Heritage registers by jurisdiction and relevant legislation

Heritage register	Jurisdiction	Relevant legislation	Agency responsible at June 2011	Description of register
World Heritage List	International. Maintained by UNESCO World Heritage Centre Secretariat	EPBC Act	DSEWPaC[a]	Sites of outstanding universal value that are registered on the UNESCO World Heritage List
National Heritage List	Australia	EPBC Act	DSEWPaC[a]	Sites of outstanding heritage value to the Australian nation
Commonwealth Heritage List	Australia	EPBC Act	DSEWPaC[a]	Sites of significant heritage value that are owned or controlled by the Australian Government
ACT Heritage Register	Australian Capital Territory	*Heritage Act 2004*	Environment and Sustainable Development Directorate	Significant heritage places and objects with historical relevance to the people of the Australian Capital Territory
New South Wales State Heritage Register	New South Wales	*Heritage Act 1977*	Department of Premier and Cabinet, Office of Environment and Heritage	Places of heritage significance to the New South Wales community
Northern Territory Heritage Register	Northern Territory	*Heritage Conservation Act 2011*	Department of Natural Resources, Environment, the Arts and Sport[b]	Places and objects with heritage significance to the Northern Territory
Queensland Heritage Register	Queensland	*Queensland Heritage Act 1992*	Department of Environment and Resource Management[c]	Sites of cultural heritage significance to Queensland
South Australian Heritage Places	South Australia	*Heritage Places Act 1993* and *Development Act 1993*	Department of Environment and Natural Resources[d]	Places of heritage significance to South Australia
Tasmanian Heritage Register	Tasmania	*Historic Cultural Heritage Act 1995*	Department of Primary Industries, Parks, Water and Environment	Places of historical cultural heritage significance to the whole of Tasmania
Victorian Heritage Register	Victoria	*Heritage Act 1995*	Department of Planning and Community Development	Victoria's most significant heritage places and objects
Western Australian State Register of Heritage Places	Western Australia	*Heritage of Western Australia Act 1990*	Department of Planning	Places of state cultural heritage significance

DSEWPaC = Australian Government Department of Sustainability, Environment, Water, Population and Communities; EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; UNESCO = United Nations Educational, Scientific and Cultural Organization

[a] From September 2013, the Department of the Environment.

[b] From October 2012, the Department of Lands, Planning and Environment.

[c] From April 2012, the Department of Environment and Heritage Protection.

[d] From July 2012, the Department of Environment, Water and Natural Resources.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences

Sites in the NIHSA dataset cover 61.6 million hectares across all jurisdictions, of which 7.3 million hectares are forested (Table 6.43; Figure 6.35). These 7.3 million hectares of forest on non-Indigenous heritage sites represent an increase of 6.8 million hectares over the area reported in SOFR 2008. This substantial increase was primarily driven by use of the new NIHSA dataset; the previous datasets did not include substantial areas of heritage-listed forest, such as the Wet Tropics of Queensland World Heritage Area.

Many of these registered heritage sites are not registered with the specific objective of protecting and conserving forests, although many of the larger sites are listed to protect landscapes that include forests and other wooded lands. Examples of these larger sites (and their heritage register category from Table 6.42) are Kakadu National Park in the Northern Territory (WHL), the Tasmanian Wilderness (WHL), Gondwana Rainforests of Australia in New South Wales and Queensland (NHL), Australian Alps National Parks and Reserves in the Australian Capital Territory, New South Wales and Victoria (NHL), High Conservation Value Old Growth Forests in New South Wales (New South Wales State Heritage Register) and the Grampians National Park in Victoria (Victorian Heritage Register).

Sites in the NIHSA dataset are located across all tenure types. The management approach for each site depends on which register it is listed under, its ownership and the type of heritage asset under management.

Under the EPBC Act, any site on the World, National and Commonwealth heritage lists owned or leased by the Australian Government is required to have a management plan that outlines how the heritage values of the site will be protected. Where the Australian Government does not have ownership, the owners (e.g. state or territory governments or private owners) can enter into agreements to develop and implement a management plan. Joint management plans can be developed for sites that extend across multiple tenures.

Sites listed on the state and territory heritage registers can be government owned or privately owned. Government-owned sites are managed by relevant state or territory government

Table 6.43: Area of forested land on sites included in the Non-Indigenous Heritage Sites of Australia dataset

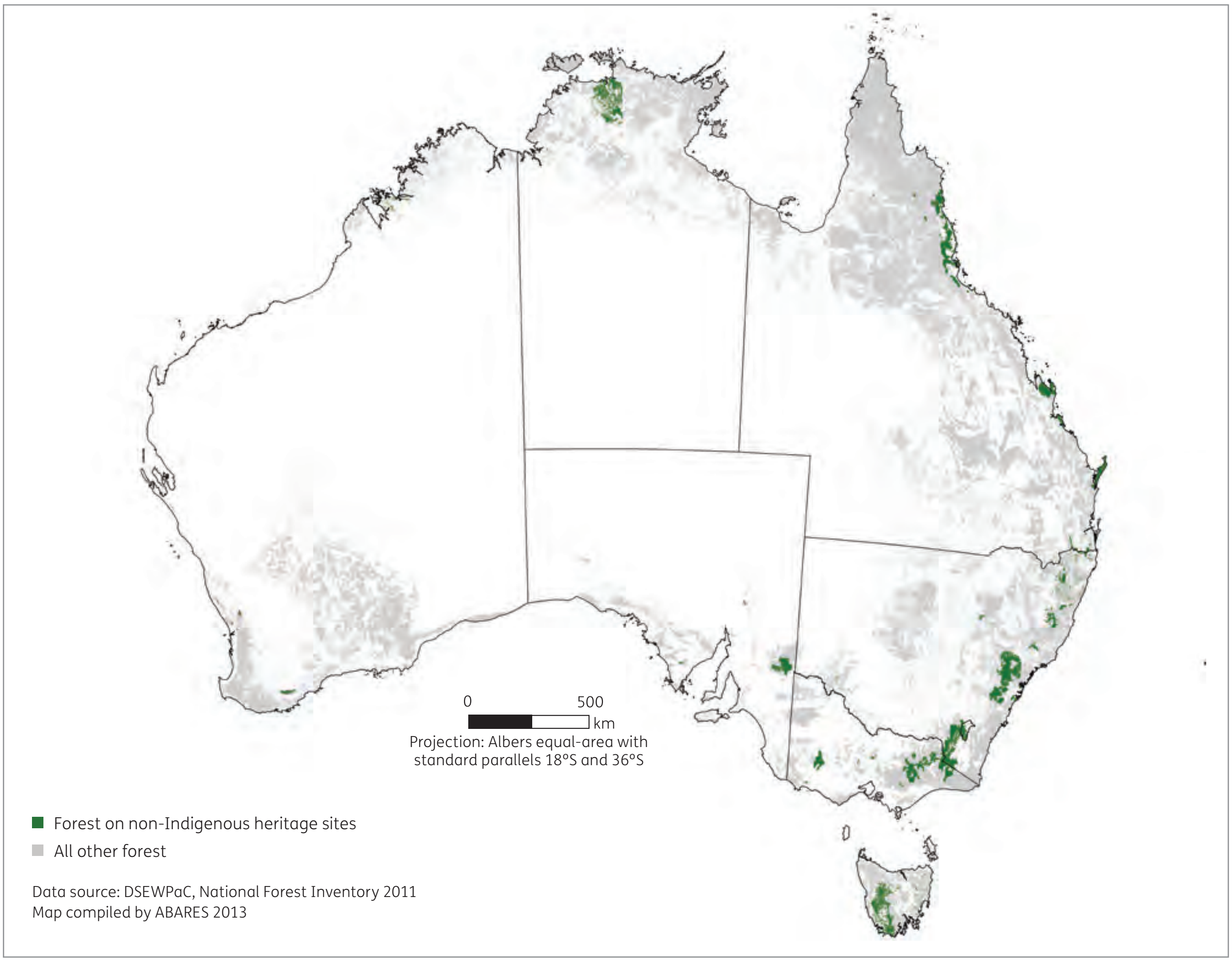
	Area ('000 hectares)								
Forest type	**ACT**	**NSW**	**NT**	**Qld**	**SA**	**Tas.**	**Vic.**	**WA**	**Australia**
Acacia	0	1	0	23	0	2	6	0	34
Callitris	0	2	0	0	2	0	19	0	22
Casuarina	0	68	0	30	3	0	1	0	102
Eucalypt	112	1,936	754	659	315	475	960	165	5,381
Eucalypt mallee open	0	9	0	0	3	0	0	0	12
Eucalypt mallee woodland	0	16	0	0	308	0	0	40	365
Eucalypt low closed	0	0	1	0	0	0	3	0	5
Eucalypt low open	0	12	41	17	0	43	21	1	136
Eucalypt low woodland	7	37	74	16	1	33	3	39	210
Eucalypt medium closed	0	0	2	9	0	0	8	0	20
Eucalypt medium open	82	1,087	276	304	0	88	554	2	2,394
Eucalypt medium woodland	23	568	360	273	3	142	257	81	1,707
Eucalypt tall closed	0	1	0	0	0	0	9	0	10
Eucalypt tall open	0	205	0	40	0	133	102	2	482
Eucalypt tall woodland	0	1	0	0	0	36	3	0	40
Mangrove	0	1	15	84	0	0	0	2	103
Melaleuca	0	2	93	60	0	9	4	1	168
Other	3	77	46	101	0	29	18	20	292
Rainforest	0	139	50	691	0	289	0	0	1,169
Plantation hardwood	0	0	0	0	0	6	0	0	7
Plantation softwood	4	0	0	0	0	0	0	0	5
Plantation mixed and unknown	0	0	0	0	0	0	0	0	1
Total	**119**	**2,225**	**959**	**1,648**	**321**	**814**	**1,009**	**190**	**7,285**

Note: Totals may not tally due to rounding.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences, National Forest Inventory.

agencies, and many have heritage management plans in place (e.g. conservation reserve management plans and state forest codes of practice). Private owners of heritage sites are required to submit development application plans to the relevant state agency or local government before any alteration of the site (including removal of trees), outlining how the heritage values will be preserved and maintained. Initiatives at local, state and territory, and national levels provide opportunities for funding for heritage conservation works.

Visitor facilities in forest above Mammoth Cave, a limestone cave containing ancient megafauna fossils, south-west Western Australia.

Figure 6.35: Forest on sites included in the Non-Indigenous Heritage Sites of Australia dataset



Nourlangie Rock, Kakadu National Park, Northern Territory.

Indicator 6.4c

The extent to which Indigenous values are protected, maintained and enhanced through Indigenous participation in forest management

Rationale

This indicator measures the extent to which Indigenous people participate in forest management. Active participation in forest management reflects the relationship between people and the land, and the integration of Indigenous peoples values with forest management practice, policy and decision making.

Key points

- Indigenous values can be divided into three broad but not mutually exclusive categories: heritage, contemporary and aspirational. Effective Indigenous participation can occur through a variety of direct or consultative mechanisms, but it is difficult to measure the exact scale of Indigenous participation through these mechanisms at the national scale.
- The degree of management control and influence that Indigenous people have over forests varies, depending on the type of land management arrangements in place and whether the land is Indigenous owned and managed, Indigenous managed, Indigenous co-managed or covered by Other special rights.
- Approximately 4.4 million hectares of forest are on Indigenous-owned lands where the legislated management intent is conservation. The tenure classifications for these lands are private, leasehold or other Crown land.

Indigenous people value forests for a range of cultural, social and economic reasons. This indicator discusses the relationship between the participation of Indigenous people in forest management and the protection, maintenance and enhancement of the values associated with forests.

In the past, the forest sector has dealt with Indigenous issues mostly in terms of archaeological cultural heritage sites, placing less emphasis on the values associated with a spiritual attachment to the land. However, the forest sector's understanding of Indigenous forest values has changed significantly in recent years. In part, this is due to contemporary civil movements for social justice and land rights. In addition, larger numbers of Indigenous people are now employed in government agencies responsible for nature conservation and commercial wood production, and Indigenous people have a greater presence on natural resource management committees and in other forest-stakeholder forums.

Indigenous values

Indigenous values can be divided into three broad but not mutually exclusive categories: heritage, contemporary and aspirational.

Heritage

Heritage values are associated with Indigenous history and are important for connecting people with the landscape. Features with heritage value include the following.

- Archaeological sites—these provide tangible evidence of prior Indigenous presence. All jurisdictions protect archaeological sites through Indigenous heritage protection laws.

- Natural landscape features associated with Dreaming and creation stories—information about these features is often held by individuals and passed on orally, and may also be contained in historical records.
- Places associated with Indigenous history and culture—these places might not contain physical evidence of such associations. They can include places of teaching, resource collection and work. Most of this information is only available orally.
- Secret and sacred places—information on these places is held by particular knowledge holders and is released on a discriminatory basis according to customary laws. Most of this information is only available orally.

Contemporary

Indigenous people also value forests for contemporary reasons, including the following:

- Landscapes of reconciliation and empowerment—for example, native forest harvesting on the sacred mountains of Mumbulla and Gulaga (south-east New South Wales) was halted as a result of Indigenous protests in 1979 and 1990, respectively.
- Places where Indigenous beliefs and customs can be integrated with modern living—for example, customary knowledge can be applied in economic development to produce wood products for the arts and crafts industry.
- Economic independence—both planted and native forests may be valued by Indigenous people for their ability to contribute to economic independence.

Aspirational

Forests may also have aspirational value for Indigenous people. Most native forests are under public ownership, under which native title rights and interests may prevail; they can therefore potentially contribute to intergenerational equity. Native forests are valued as areas in which Indigenous people can gain greater autonomy and economic returns through a range of mechanisms, including ownership and management of country.

Indigenous participation

Effective participation and consultation are essential for the protection, maintenance and enhancement of Indigenous forest values. Participation and consultation can occur through a variety of mechanisms, including:

- forest ownership and management
- joint management of national parks and conservation reserves
- consultation by public forest management agencies
- direct employment in the forest sector
- community employment schemes
- cooperative research programs
- partnerships with government and industry.

It is difficult to measure the exact scale of Indigenous participation through these mechanisms at the national scale. Indicator 6.4a presents information on the areas of forest that are owned, managed or co-managed by Indigenous people or where other special rights allow Indigenous people to participate in forest management. Indigenous people have legislated rights over 41.9 million hectares of forest in Australia.

The degree of management control and influence that Indigenous people have over the forests on these lands varies, depending on the relevant Australian, state or territory legislation that applies in each case. The degree of management control that Indigenous people have over each of the land management types included in the dataset is described below; currency of the data for each sub-category is given in Table 6.39 (Indicator 6.4a).

Indigenous owned and managed lands

A total of 13.5 million hectares of forested land was Indigenous owned and managed as at 2011 (Indicator 6.4a), in the following sub-categories.

Indigenous Protected Areas

Indigenous Protected Areas (IPAs) are areas of land that are legally owned and managed by Indigenous people for the protection of biodiversity and cultural heritage values.

IPAs are established through voluntary agreements between the Australian Government and Indigenous land owners. All IPAs have management plans that are developed by the landowners when they apply for the IPA to be declared. These plans incorporate culturally significant traditional land-management practices with other land-management practices to protect the significant values of the area. On-ground implementation of the management plans is undertaken by the Indigenous landowners. Funding is available from the Australian Government for the Indigenous owners to develop, implement and monitor the effectiveness of the management plans (DEWHA 2009b).

Although a number of existing IPAs are located in non-forested regions in the arid centre of Australia, several are located in the wetter, forest-dominated regions of the north and east coasts. Approximately 2.4 million hectares of forest are located in IPAs. Eucalypt medium woodland forest and Eucalypt medium open forest make up 65% of all forests in this land category, and Rainforests make up 5%. Case study 6.7 describes how Indigenous values are protected, maintained and enhanced through the management of forests in the Kaanju Ngaachi Wenlock and Pascoe Rivers IPA on Cape York in Queensland.

Aboriginal Lands Trust lands, Northern Territory

Northern Territory Aboriginal Lands Trust lands have been granted or claimed under the *Land Rights Act 1976* (Northern Territory). The legal title of the land is held by an Aboriginal Lands Trust, which is made up of Indigenous people who hold the title for the benefit of all of the traditional landowners. The lands are inalienable freehold, which means that they cannot be acquired, sold, mortgaged or disposed of in any way (Central Land Council 2007).

The traditional landowners are the key decision makers for their land. As the owner, the Aboriginal Lands Trust can approve the use of the lands for Indigenous housing, Indigenous business activities and other community purposes. However, before any activities take place, the appropriate Aboriginal land council (Central, Northern, Anindilyakwa or Tiwi) provides advice and consults with the traditional landowners to ensure that they understand and agree with the proposal. Once agreement has been reached, the land council provides directions to the Aboriginal Lands Trust to carry out the proposal (Central Land Council 2007).

There are 9.1 million hectares of forest located across all Northern Territory Aboriginal Lands Trust lands. Eucalypt medium woodland forest and Eucalypt medium open forest make up 77% of all forests in this land category.

Indigenous Land Corporation–owned and Indigenous Land Corporation–granted lands

The Indigenous Land Corporation (ILC) was established in 1995 as an independent statutory authority of the Australian Government. The purpose of the ILC, as defined in the Commonwealth *Aboriginal and Torres Strait Islander Act 2005*, is to help Aboriginal persons and Torres Strait Islanders acquire and manage land to achieve economic, environmental, social and cultural benefits (ILC 2012).

Further information on the Land Acquisition and Land Management Programs of the ILC can be found in its National Indigenous Land Strategy.[145]

There are 1.2 million hectares of forest located across all ILC-owned and ILC-granted lands across Australia. Eucalypt medium woodland forests make up 66% of all forests in this land category.

ILC Indigenous estate

In 2003, the ILC funded the production of a dataset that was a snapshot of the extent of the Indigenous estate in Australia. It included all lands that were identified as being owned, managed or leased by Indigenous corporations, communities, trusts or agencies at the time of data collection.

This dataset has been used as a surrogate for Aboriginal Lands Trust and Aboriginal land council lands in a number of states and territories for which other data could not be collected within the required timeframe for use in this report. The dataset was used in SOFR 2008 to report on the area of forest that was owned and managed by Indigenous people, and therefore it provides a suitable baseline for use in SOFR 2013. There are some known errors in this dataset.

There are 15.0 million hectares of forest located on the 2003 ILC Indigenous estate. Eucalypt medium woodland forest and Eucalypt medium open forest make up 71% of all forests in this land category.

Deed of Grant in Trust, Queensland

Deed of Grant in Trust (DOGIT) lands are former reserves and missions that have been granted by the Queensland Government to Indigenous groups for the benefit of Indigenous inhabitants or for Indigenous purposes. The grants were made under the *Queensland Community Services (Torres Strait) Act 1984* and *Community Services (Aborigines) Act 1984* (DERM 2008).

Each trust area is owned by the Indigenous community and is managed as a local government area. Incorporated Aboriginal councils, which elect representatives every three years, manage the community's affairs. The councils are able to make by-laws and appoint community police, and are responsible for maintaining housing, infrastructure, the Community Development Employment Program, licences, and hunting and camping permits. All DOGIT lands are inalienable freehold, which means that they cannot be sold; however, they can be leased (DERM 2008).

There are 864 thousand hectares of forest located on all DOGIT lands. Eucalypt medium woodland forests make up 63% of all forests in this land category, and 'Other native forests' make up 12%.

Indigenous-managed lands

A total of 2.4 million hectares of forested land was Indigenous managed as at 2011 (Indicator 6.4a), in the following sub-categories.

Aboriginal Lands Trust, Western Australia

The Aboriginal Lands Trust (ALT) is a statutory body that was established under the Western Australian *Aboriginal Affairs Planning Authority Act 1972* (AAPA Act). The trust is made up of a board of Indigenous people appointed by the Western Australian Minister for Indigenous Affairs. The ALT, with assistance from the Department of Indigenous Affairs[146], is tasked with managing the ALT lands in a manner that will achieve social, cultural and economic advancement for Indigenous people. Any activities undertaken on ALT lands must be in accordance with the wishes of the local Indigenous community and in line with the ALT's land-use and development policy (DIA 2002).

Lands held by the ALT can be freehold, leasehold or Crown reserve lands that have been acquired through a variety of processes and held in trust for the use and benefit of

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145 www.ilc.gov.au/~/link.aspx?_id=8D4468C409DF44AAA4461918FCCFE67F&_z=z.

146 From July 2013, the Department of Aboriginal Affairs.

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Indigenous people. Freehold lands are owned by the ALT. Leasehold lands are Crown lands with leases granted under the Western Australian *Land Administration Act 1997* (LA Act). Leasehold land remains the property of the Crown and carries certain conditions or requirements relating to the way that it is used. Reserve lands are Crown reserves that have had management orders granted to the ALT to care for, control and manage the land for the use and benefit of Indigenous people, through either the LA Act or the AAPA Act. Lands declared under the AAPA Act have additional protection, which limits access to the lands by the general public and mining companies. Reserves make up the majority of the ALT estate (ALT 2009).

Any lands that are managed by the ALT can be granted to an Indigenous corporation to manage them.

There are 663 thousand hectares of forest located across all ALT lands in Western Australia. Eucalypt medium woodland forests make up 73% of all forests in this land category, and Eucalypt low woodland forests make up 18%.

Indigenous pastoral leases, Western Australia

Indigenous pastoral leases are lands with a pastoral lease granted to Indigenous corporations under the Western Australian LA Act. All pastoral leases that are held by Indigenous corporations are subject to the same rules and regulations that apply to non-Indigenous pastoral leases. The main activity that must be undertaken on these lands is the grazing of animals. Non-grazing activities cannot be undertaken without a permit from the Pastoral Lands Board; this includes clearing native vegetation and establishing plantations.

The Crown maintains ownership of these lands (DIA 2005).

There are 318 thousand hectares of forest located across all Indigenous pastoral leases in Western Australia. Eucalypt low woodland forest and Eucalypt medium woodland forest make up 55% of all forests in this land category, and Acacia forest makes up 42%.

Leased-back nature conservation reserves

The Australian, New South Wales, Northern Territory, Queensland, South Australian and Victorian governments have granted freehold ownership of several nature conservation reserves to Indigenous community groups, land trusts and land councils through Acts of parliament within their jurisdiction. The Indigenous owners have leased the reserves back to the relevant government environmental conservation agency, which in turn delegates the care, control and management of the reserve to a board of management.

The Indigenous owners of the reserves hold a majority of seats on the boards of management. Other stakeholders on the boards can include representatives of government agencies, conservation groups, local councils and other local landholders. The boards of management develop a management plan, which they implement and monitor using funds paid by the government agency as part of the lease agreement.

Leased-back nature conservation reserves have been classified in this report as Indigenous-managed lands because, although they are legally owned by Indigenous groups, these groups do not have sole management control over the land—control is often shared with non-Indigenous government and community representatives.

There are 2.0 million hectares of forest located across all leased-back nature reserves in Australia. Eucalypt medium woodland forest and Eucalypt medium open forest make up 65% of all forests in this land category; Melaleuca forest makes up 10%; and Rainforest makes up 9%.

Approximately 4.4 million hectares of forest are on Indigenous-owned lands where the legislated management intent is conservation. This includes the area of forest in Indigenous Protected Areas and leased-back nature conservation reserves. The formal land tenure classifications (see Indicator 1.1a) for these lands are private, leasehold or other Crown land.

Indigenous co-managed lands

A total of 5.4 million hectares of forested land had Indigenous co-management arrangements in place as at 2011 (Indicator 6.4a), in the following sub-categories.

Nature conservation reserve memoranda of understanding

Nature conservation agencies in all jurisdictions have negotiated memoranda of understanding (MOUs) with local Indigenous communities for the joint management of a number of nature conservation reserves. Under these MOUs, the Indigenous community may be involved in the development and implementation of reserve management plans to protect sites of Indigenous cultural significance.

The Crown maintains ownership and management control of these lands.

There are 3.6 million hectares of forest across Australia in nature reserves with co-management MOUs in place. Eucalypt medium woodland forest and Eucalypt medium open forest make up 65% of all forests in this land category, and Rainforest makes up 10%.

World Heritage Areas

Several of Australia's World Heritage-listed areas have Indigenous advisory committees that provide advice to the World Heritage Area management committee on the management of sites of Indigenous cultural significance.

World Heritage Areas can be owned by the Crown or by private parties and can exist on any land tenure type. Only areas that are owned by the Crown, or have co-management agreements with private landowners in place, have capacity for Indigenous co-management.

There are 4.3 million hectares of forest located across all co-managed World Heritage-listed areas across Australia. Eucalypt medium woodland forest and Eucalypt medium open forest make up 48% of all forests in this land category, and Rainforest make up 27%.

Lands with other special rights

Other special rights had been granted over a total of 20.6 million hectares of forested land as at 2011 (Indicator 6.4a), in the following sub-categories.

Native title determinations

Native title is the recognition, in Australian law, that some Indigenous people have rights to, and interests in, their land that come from their traditional laws and customs. Native title rights can include the right to live in, access and collect resources from an area, along with the right to visit and protect sites of cultural significance.

In some cases, native title includes the right to possess and occupy an area to the exclusion of all others. This includes the right to control access to, and use of, the area concerned. However, this right can only be recognised over certain areas, such as unallocated or vacant Crown land and some areas already held by, or for, Indigenous Australians (NNTT 2009).

Native title does not always grant legal title of an area to an Indigenous community group, but it does give the right to participate in decisions on how the land or waters are used by other people. Native title rights may co-exist with other rights not involving native title; however, in the event of conflict, the native title rights must give way to the non–native title rights (NNTT 2009).

There are 7.8 million hectares of forest across Australia located across all lands with native title determinations that have not been counted under any of the other Indigenous land ownership and management categories. Eucalypt medium woodland forest and Eucalypt medium open forest make up 57% of all forests in this land category; Eucalypt mallee woodland forest makes up 8%; and Eucalypt low woodland forest makes up 8%.

Case study 6.7: Kaanju Ngaachi Wenlock and Pascoe Rivers Indigenous Protected Area

The Kaanju Ngaachi Wenlock and Pascoe Rivers Indigenous Protected Area (IPA) is Australia's 25th IPA. It stretches across nearly 2,000 square kilometres of wet tropical forest and sand-ridge country between Lockhart River, Coen and Weipa on Cape York, Queensland. Like all of Australia's IPAs, it protects some of the nation's rare and fragile environments for the benefit of all Australians.

The IPA is managed by the Chuulangun Aboriginal Corporation and is a place of significant social, cultural, spiritual, historical and economic value for its traditional owners. Kaanju refers to 'upland' and Ngaachi to 'homelands' (traditional country).

Kaanju Ngaachi's forests are among the most diverse and unspoiled in the world and contain plant species that date back to the time of Gondwanaland. Through the vegetation along its rivers, the IPA provides an important habitat link between the closed forests on either side of Cape York.

The rivers that border the IPA contain many freshwater fish species. The IPA protects a wide range of animals, including nationally endangered southern cassowaries, fish eagles, yellow-faced whip snakes and quolls. Saltwater crocodiles can be found in the lower Pascoe River where salt water meets fresh water, and freshwater crocodiles live in the lagoons and tributaries of the upper Pascoe and Wenlock rivers.

A team of rangers helps look after the IPA, controlling weeds, maintaining traditional fire regimes, and fencing sensitive areas to exclude feral animals. Much of their work is funded by the Australian Government under the Caring for our Country initiative, through the Indigenous Protected Areas and Working on Country elements. Support also comes from the Queensland Government through the Wild Rangers program, and from Bush Heritage Australia, delivered by the Chuulangun Aboriginal Corporation.

Chuulangun also has a cooperation agreement with The Wilderness Society, which supports an environmental protection and homelands development agenda for Kaanju homelands and the IPA.

The declaration of Kaanju Ngaachi Wenlock and Pascoe Rivers IPA in June 2008 was made under International Union for Conservation of Nature (IUCN) Category V—Protected Area (Landscape/Seascape).

Like all IPAs, Kaanju Ngaachi is part of Australia's National Reserve System, a nationwide network of reserves especially set up to protect examples of Australia's unique landscapes, plants and animals for current and future generations.

For more information about the Kaanju Ngaachi Wenlock and Pascoe Rivers IPA and the activities of the Chuulangun Aboriginal Corporation, visit www.kaanjungaachi.com.au.

Source: Adapted from www.environment.gov.au/indigenous/ipa/pubs/kaanju-factsheet.pdf.

Indigenous land use agreements

The Commonwealth *Native Title Act 1993* allows for Indigenous land use agreements to be made between Indigenous people who hold or may hold native title and other interested parties (e.g. private companies or government agencies) about how land and waters in an area covered by the agreement will be used and managed. Indigenous land use agreements can be made as part of a native title determination, or separately from a native title claim.

Indigenous land use agreements do not equate to ownership of land. They deal with the use of land, and can cover a range of issues that may or may not relate to forests. For example, an Indigenous land use agreement may cover one or more of access to land for exploration or mining, change in land use, access to pastoral leases, terms and conditions of claim settlements, or joint management arrangements in relation to conservation areas. They can include assurances about protection of cultural heritage and the environment, employment and training opportunities, and communication between parties.

There are 21.0 million hectares of forest across Australia located across all lands with Indigenous land use agreements that have not been counted under any of the other Indigenous land ownership and management categories. Eucalypt medium woodland forest and Eucalypt medium open forest make up 56% by area of all forests in this land category, and Melaleuca forest makes up 11%.

Woodland forest on the south boundary of the Mission Aboriginal Area, New South Wales.

Tiwi forestry workers measuring native forest logs, Melville Island, Northern Territory.

Case study 6.8: Indigenous community engagement with Forests NSW[147]

Forests NSW works with Indigenous people to protect cultural heritage and empower people through participation in management programs and processes.

In the Forests NSW Central Region, a memorandum of understanding between Forests NSW and the Anaiwan elders led to Forests NSW funding improvements to forest sites.

In 2010–11, a co-management agreement was signed between Forests NSW Southern Region and the Ulladulla Local Aboriginal Land Council (LALC) relating to an area of state forest that contains significant art sites. The agreement opens the way for use of the area in an LALC ecotourism venture.

Forests NSW Southern Region also signed an agreement with the Eden LALC on a *Land & Sea Country Plan*. This will see the LALC develop a group of rangers for Forests NSW, the National Parks and Wildlife Service, the shire council, Landcare groups, and the Southern Rivers Catchment Management Authority. The intention is for these land management agencies to give a number of Indigenous people full-time work, such as weed clearing along rivers and beaches, hazard reduction burning for Forests NSW and the National Parks and Wildlife Service, and other works for Landcare and the council.

In another project, Eden LALC is working with Forests NSW and the National Parks and Wildlife Service on developing a walking track, known as the Bundian Way, that connects the coast at Eden to the high country around Mount Kosciuszko. The track is based on the travel route used by Indigenous people to connect the high country to the coast for trade; the route also allowed coastal people to travel to the high country to feast on bogong moths. It is hoped that this will bring tourists from around the country and the world to walk the track and visit LALC-owned areas along the route, providing tourism work and money to the local Indigenous and non-Indigenous people. The route was mapped in 2010–11, and work will continue on camping areas, signage and safety management systems in 2011–12.

Further information on Indigenous engagement and employment in Forests NSW can be found in the *Forests NSW Annual Report 2010–11* (Forests NSW 2011).

[147] From January 2013, the Forestry Corporation of NSW.

Indicator 6.4d

The importance of forests to people

Rationale

This indicator measures the range of attitudinal values that communities and individuals place on their forests. The importance of forests to society is exemplified through the value that people place on biodiversity, clean air and water, social equity or simply the knowledge that Australia's forests exist.

Key points

- Several surveys conducted between 2006 and 2012 have provided considerable insight into the attitudes of Australians to a range of forest-related issues.
- More than 40% of the respondents to an Australia-wide series of surveys agreed that Australia's native forests were being managed sustainably. The proportion of respondents who agreed that 'we should not be cutting down any trees for wood products' decreased between 2009 and 2012, and the proportion of respondents who agreed that 'we should use more wood because it is more environmentally friendly than alternative materials' increased.
- The level of understanding about the role of forests in carbon storage is high and increasing. In 2012, more than 90% of respondents to the same series of Australia-wide surveys agreed that trees absorb carbon dioxide, and 71% (up from 52% in 2008) agreed that 'carbon is stored in wood, even after the tree is harvested'.
- In south-west Western Australia and Tasmania, views are polarised on the acceptability of eucalypt plantations for pulp and paper, and pine plantations for timber.
- About 80% of respondents to a survey in south and central rural New South Wales indicated that they would consider planting trees for carbon sequestration, and nearly 70% indicated that being paid for carbon sequestration would increase the likelihood that they would plant trees for purposes such as reducing land degradation and providing shelter for stock.

Australia's forests are recognised as one of Australia's greatest natural assets and are highly valued for the wide range of environmental and socio-economic benefits and services that they provide. Over the past 35 years, societal values and attitudes towards the natural environment and the industries that affect it have changed (see Lacey et al. 2012 for an example). Understanding the importance of Australia's forests to people provides an insight into communities' acceptance and approval of activities relating to forest management.

SOFR 2008 reported a general lack of data for this indicator. In the period covered by SOFR 2013, however, considerable new data were generated by surveys of attitudes towards forest management (both native and plantation), wood products, and the potential role of forests and wood in climate change mitigation. The results provide insights into the knowledge and attitudes of the community and how these are changing over time.

Attitudes towards wood and forests

A series of nine national market research surveys conducted for Forest and Wood Products Australia[148] in the period 2008–12[149] explored the views of people towards forest-related environmental issues and the role of wood. People aged 18 years and over, living in Australia, were surveyed, with a sample size of greater than or equal to 1,000 per survey.

148 Forest and Wood Products Australia (FWPA) is a not-for-profit company that provides national integrated research and development services to the Australian forest and wood products industry (www.fwpa.com.au).

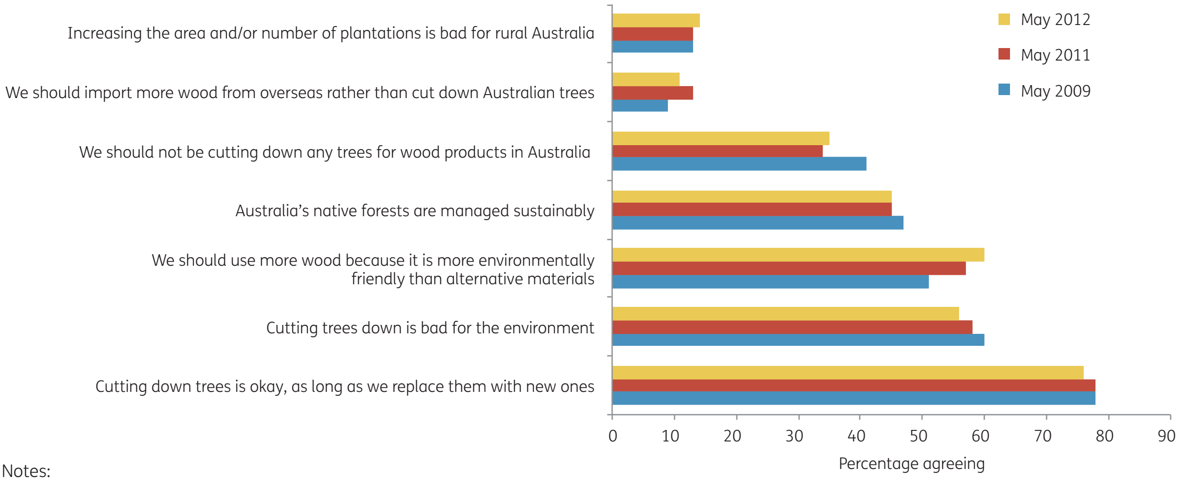
149 The most recent two surveys were in May 2012 and July 2012, outside the nominal reporting period for this report, but these data are included here because of their timeliness. Where practical, data for May 2011 (the most recent survey inside the nominal reporting period) are also provided.

In these surveys, almost 80% of people agreed with the statement 'cutting down trees is okay, as long as we replace them with new ones' (Figure 6.36). Over the same period, a smaller majority (56–60%) indicated that 'cutting down trees is bad for the environment'. However, only a small proportion (9–13%) agreed that we should import more wood from overseas rather than cut down trees in Australia. More than 40% of respondents agreed that Australia's native forests were being managed sustainably. The number of respondents who agreed with the statement 'we should not be cutting down any trees for wood products' declined from 41% in 2009 to 35% in 2012. Over the same period, the proportion of respondents who agreed that 'we should use more wood because it is more environmentally friendly than alternative materials' increased from 51% to 60%. The surveyed population therefore held a wide range of views about forests and wood.

Survey respondents perceived wood to be substantially more environmentally friendly than other common building materials (e.g. aluminium, plastic, concrete, steel and brick) (Figure 6.37). The surveys also indicated that the perception of wood as an environmentally friendly material increased substantially between 2008 and 2012.

The surveys found that fewer women than men agreed with the statements 'Australia's native forests are managed sustainably' and 'cutting down trees is okay, as long as we replace them with new ones' (Figure 6.38). More women than men agreed with the statements 'we should not be cutting down any trees for wood products in Australia' and 'cutting trees down is bad for the environment'.

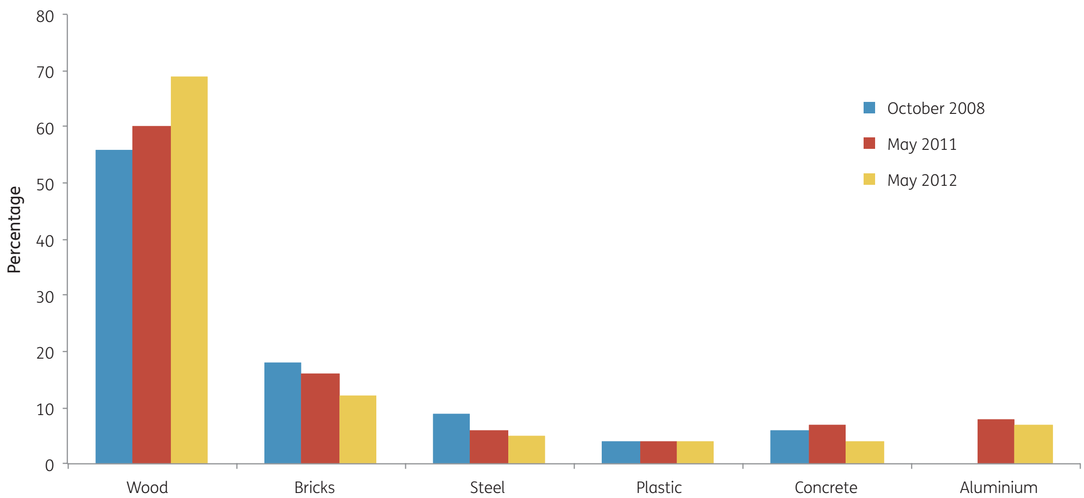
Figure 6.36: Proportion of people agreeing with statements relating to tree harvesting, native forest management and plantations, May 2009, May 2011 and May 2012



Notes:
'Agreeing' means a response of 'agree totally', 'agree strongly' or 'agree slightly'.
Sample sizes ≥ 1,000.
Total sample reliability = 95% ± 3%.

Source: FWPA (2013).

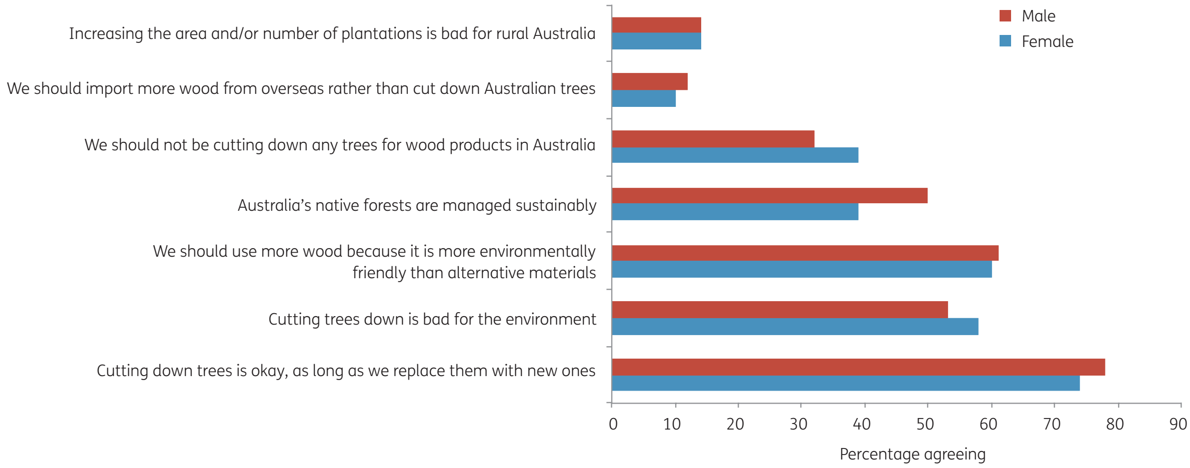
Figure 6.37: Perceptions of materials as environmentally friendly, October 2008, May 2011 and May 2012



Notes:
The histogram shows the percentage of respondents who associated the term 'environmentally friendly' with a given material.
Sample sizes ≥ 1,000.
Total sample reliability = 95% ± 3%.

Source: FWPA (2013).

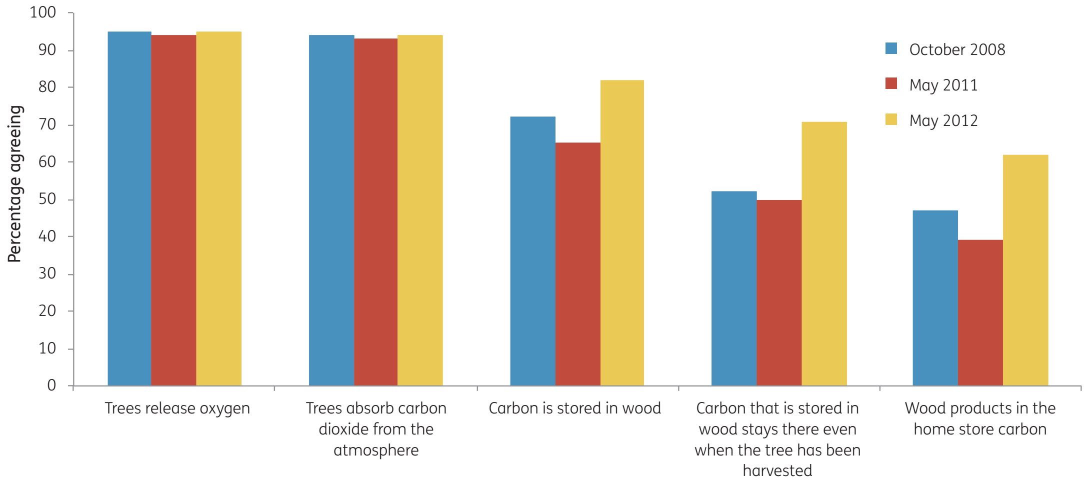
Figure 6.38: Proportion of females and males agreeing with statements related to tree harvesting, native forest management and plantations, May 2012



Notes:
'Agreeing' means a response of 'agree totally', 'agree strongly' or 'agree slightly'.
Sample sizes ≥ 1,000, comprising at least 500 females and 500 males.
Total sample reliability = 95% ± 3%.

Source: FWPA (2013).

Figure 6.39: Proportion of people agreeing with statements on trees and wood, October 2008, May 2011 and May 2012



Notes:
Participants were asked to respond 'true' or 'false' to each statement.
Sample sizes ≥ 1,000.
Total sample reliability = 95% ± 3%.

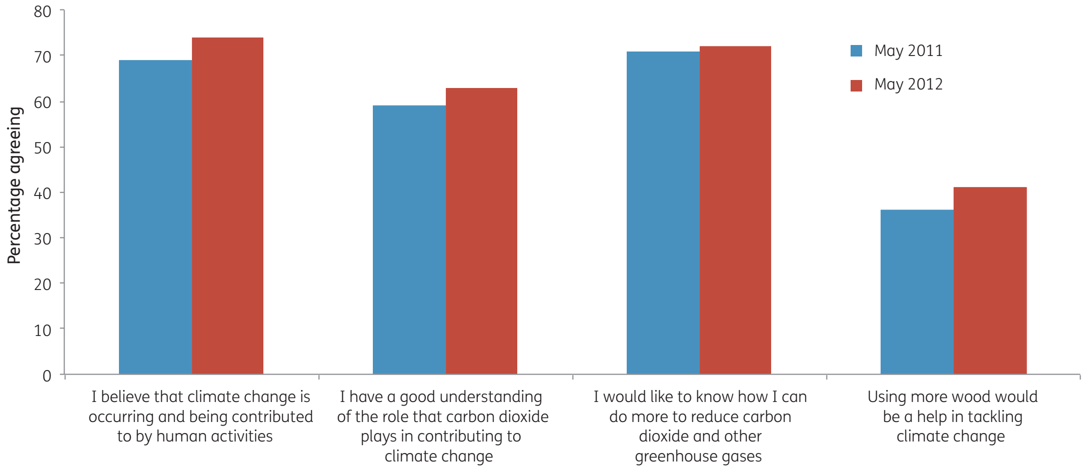
Source: FWPA (2013).

Forests, carbon and climate change

Public responses to statements on the role of forests and wood products in climate change were also assessed in the Forest and Wood Products Australia surveys. The level of understanding about the role of forests in carbon storage was generally high: in surveys conducted in 2008 and 2012, 94% of people thought that the statement 'trees absorb carbon dioxide from the atmosphere' was true (Figure 6.39). The level of understanding about the role of wood in carbon storage was somewhat lower, but increased over time. In 2008, 52% of people thought that the statement 'Carbon that is stored in wood stays there even when the tree has been harvested' was true, whereas 71% per cent of respondents thought that it was true in 2012 (Figure 6.39). Awareness of the role of wood in carbon storage increased between May 2011 and May 2012. This may have been the result of advertising campaigns held in February–April 2012 via television and the internet, which delivered the messages 'wood stores carbon for life' and 'wood—naturally better', or a range of other advertising campaigns.

Nearly three-quarters of survey respondents (74%) in May 2012 believed that climate change is occurring and being contributed to by human activities (Figure 6.40), and more than 70% 'would like to know more about what I can do to reduce carbon dioxide and other greenhouse gases'. An increasing proportion of respondents over time thought that 'using more wood would be a help in tackling climate change'.

Figure 6.40: Proportion of people agreeing with various statements relating to climate change, May 2011 and May 2012



Notes:

For the first three statements, 'agreeing' means a response of 'strongly agree' or 'agree'; for the fourth statement, 'agreeing' means a response of 'agree totally', 'agree strongly' or 'agree slightly'.

Sample sizes ≥ 1,000.

Total sample reliability = 95% ± 3%.

Source: FWPA (2013).

Public acceptability of plantation forestry

Understanding people's attitudes about plantation forests contributes to an understanding of the importance of forests to people. A survey of residents of Tasmania and south-west Western Australia (minimum sample size of 1,729) was undertaken between June and August 2008 to measure, among other things, the acceptability of eucalypt and pine plantations relative to other land uses (Williams 2009, Williams 2011).

On average, pine plantations and eucalypt plantations for timber and pulp production were viewed less positively than traditional agricultural land uses such as cropping and grazing, and less positively than 'green' land uses such as revegetation and wind farms, but more positively than rural residential development (Figure 6.41).

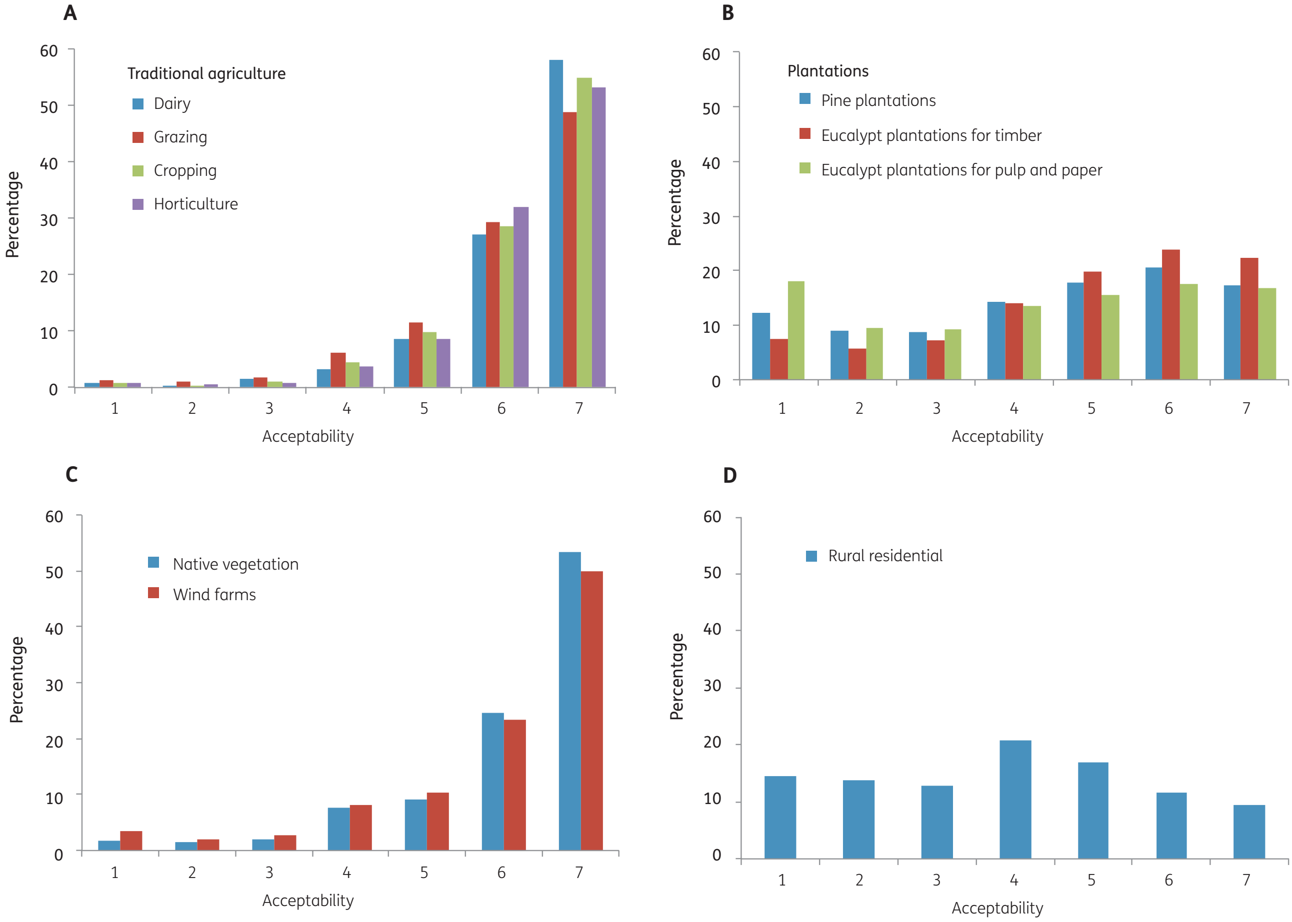
Both positive and negative views were expressed about plantations, especially with respect to eucalypt plantations for pulp and paper (Figure 6.41B). This polarisation was strongest in Tasmania, where there was both support for and strong aversion to pine plantations grown for timber production, and eucalypt plantations grown for pulp and paper. Conflict in the views of Western Australian respondents was less pronounced. Many respondents in Western Australia believed that plantations improved profit and management options for landholders, but fewer believed that plantations would lead to social benefits such as growth in regional populations and employment, community involvement and business for local traders.

Overall, plantations were viewed by respondents as having a mix of physical outcomes. For example, many believed that plantations would help protect soils from erosion, but many also considered plantations to have negative impacts on water availability (Williams 2009).

A follow-up survey conducted in 2011 (Williams 2012; minimum sample size of 1,094) found no significant change in attitudes between 2008 and 2011 among residents of south-west Western Australia with regard to acceptance of pine plantations grown for timber production, eucalypt plantations grown for timber, or eucalypt plantations grown for paper and pulp. However, residents in Tasmania had, over this period, become significantly more accepting of pine plantations grown for timber, eucalypt plantations grown for timber, and eucalypt plantations grown for pulp and paper (Figure 6.42). Nevertheless, the data again suggest conflicting views among residents of Tasmania with regard to both eucalypt plantations grown for paper and pulp, and pine plantations grown for timber: 12–15% of respondents expressed strong aversion to these forms of plantations, and 21–22% indicated strong support.

Recreational hikers in forest, Walhalla, Victoria.

Figure 6.41: Acceptability of various land uses to residents in Tasmania and south-west Western Australia, 2008



Notes:

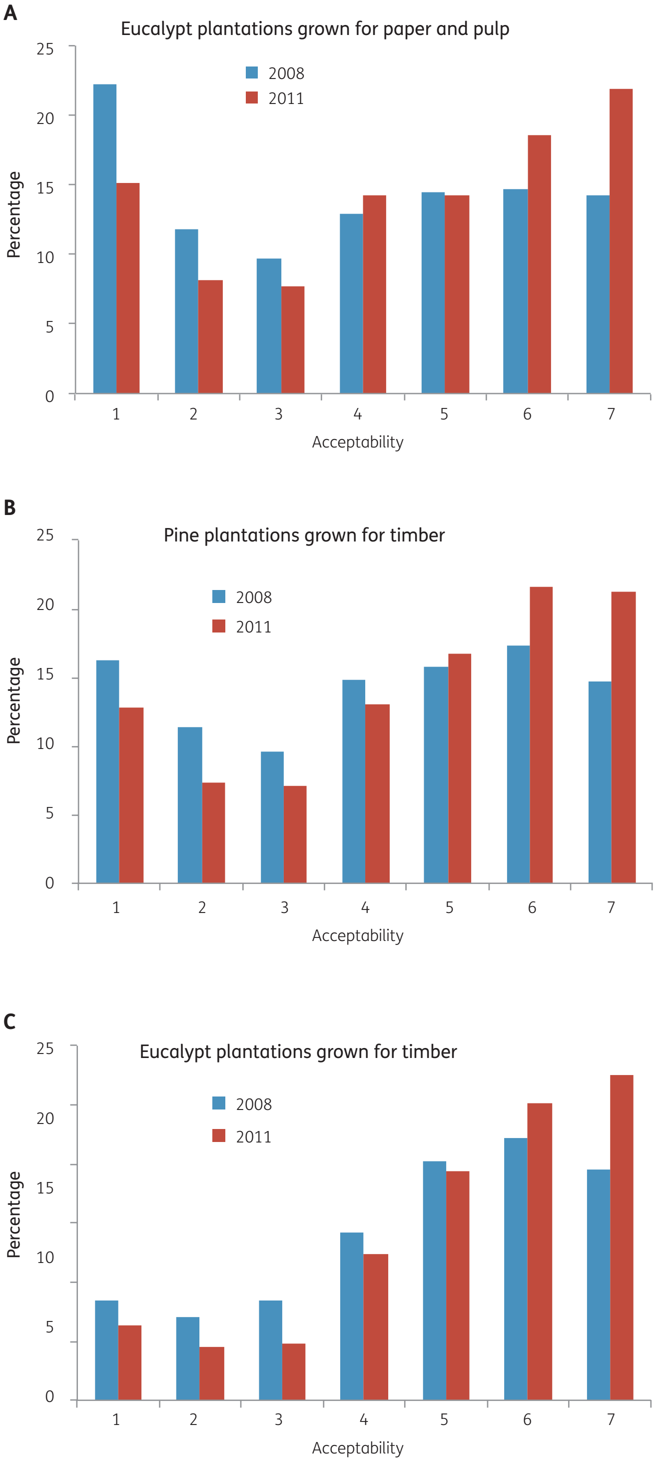
Distribution of acceptability ratings of (**A**) Traditional agricultural land uses, (**B**) Plantation land uses, (**C**) Native vegetation and wind farms as land uses, and (**D**) Rural residential development, as land uses. Acceptability is rated from 1 to 7, with a rating of 1 being 'Not acceptable' and a rating of 7 being 'Very acceptable'.

The histograms show the proportion of respondents with each acceptability rating. Combined data from respondents in Tasmania and south-west Western Australia. Sample sizes ≥ 1,000.

Source: Adapted from Williams (2009). See also Williams (2011).

Yellow-tailed black-cockatoos (*Calyptorhynchus funereus*) in pine (*Pinus radiata*) plantation, South Australia.

Figure 6.42: Acceptability of plantations to residents in Tasmania, 2008 and 2011



Notes:

Distribution of acceptability ratings of (**A**) eucalypt plantations grown for paper and pulp, (**B**) pine plantations grown for timber, and (**C**) eucalypt plantations grown for timber. Acceptability is rated from 1 to 7, with a rating of 1 being 'Not acceptable' and a rating of 7 being 'Very acceptable'.

The histograms show the proportion of respondents with each acceptability rating.

Sample sizes ≥ 1,000.

Source: Adapted from Williams (2012).

Tree planting for carbon sequestration

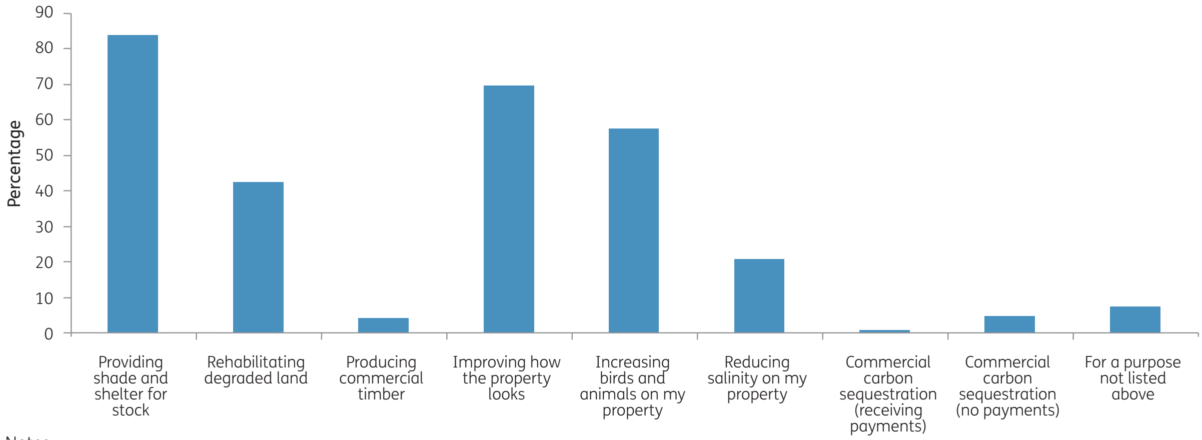
A survey conducted in July–September 2010 explored landholder perceptions of tree planting for carbon sequestration in south and central rural New South Wales (Schirmer and Bull 2011). Survey areas ranged from high-rainfall, traditional forestry regions, such as Tumut and Tumbarumba, to very low rainfall regions where tree planting is less common, such as Hay and Narrandera. Almost all respondents to the survey had previously engaged in tree planting, most commonly for shelter for animals but also for a wide range of aesthetic and environmental reasons (Figure 6.43).

About 80% of landholders responding to the survey indicated a desire to plant more trees on their properties, and almost 80% said that they preferred to plant species that were native to their local areas. More than 60% said that farmers had a responsibility to manage their lands to provide benefits for the wider community, and more than 70% said that they should be paid to do so.

About 80% of respondents also stated that they would consider planting trees for carbon sequestration in the future (Figure 6.44). Co-benefits were likely to be important in future tree-planting decisions: nearly 70% of respondents stated that being paid for carbon sequestration would increase the likelihood of their planting trees for purposes such as reducing land degradation and providing shade and shelter for stock. The main reasons limiting the uptake of tree planting for carbon sequestration appeared to be a lack of clarity in the rules governing carbon markets, the risk that future governments might change their minds on climate policy, current schemes not offering sufficient financial incentive, and carbon markets being too uncertain. More than 70% of respondents disagreed with the statement 'there is currently clear government legislation providing a good basis for a formal carbon market'. The survey was conducted before the enactment of the Commonwealth *Carbon Credits (Carbon Farming Initiative) Act 2011* (see Indicator 7.1a).

Environmental plantings on agricultural land. Large contiguous areas of environmental plantings that meet the definition of forest are recorded in the National Forest Inventory under the 'Other forest' category (Indicator 1.1a).

Figure 6.43: Proportion of landholders who planted trees for a given purpose, 2010



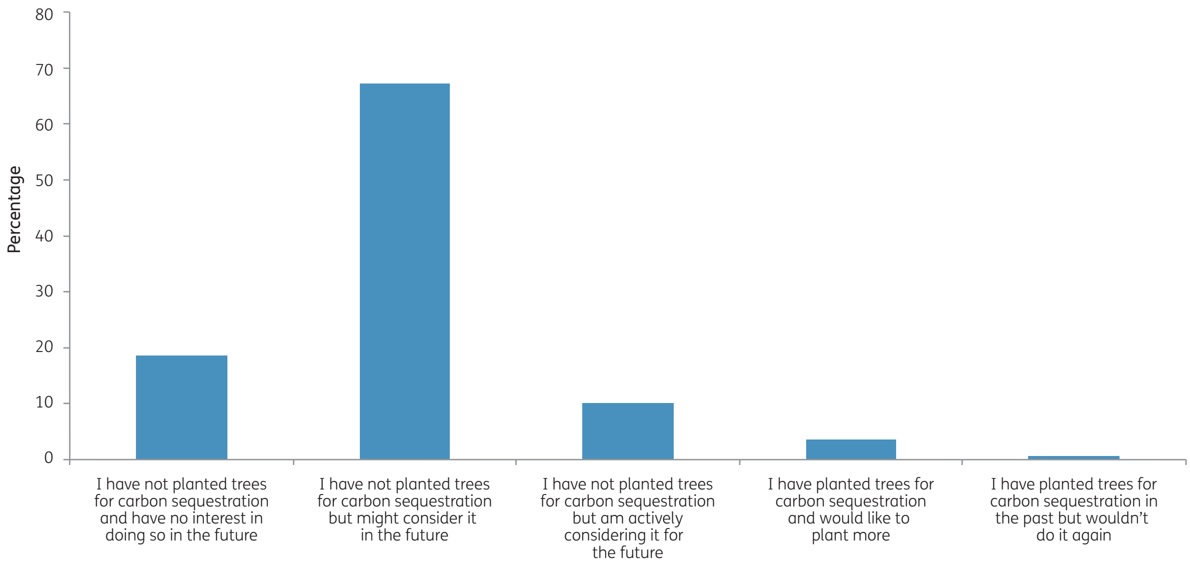
Notes:

The histogram shows the proportion of respondents stating each purpose. Respondents were able to state more than one purpose.

Sample size = 345.

Source: Schirmer and Bull (2011).

Figure 6.44: Adoption by landholders of tree planting for carbon sequestration, 2010



Notes:

The histogram show the proportion of respondents giving each response. Respondents could provide only one response.

Sample size = 345.

Source: Schirmer and Bull (2011).

Case study 6.9: Native vegetation management on agricultural land

More than 224 million hectares of native vegetation, including native forest as well as shrubland and grassland, occurs on agricultural land (ABS 2011c). Management of this native vegetation by farmers is particularly important for biodiversity protection, carbon sequestration, soil and water quality, and amenity and personal values.

A national telephone survey of farmers run by the Australian Bureau of Agricultural and Resource Economics and Sciences in 2011 (Harris-Adams et al. 2012) found that 85% of farmers were managing their native vegetation for production and/or on-farm environmental benefits (Table 6.44). Benefits include shelter belts, use of native pastures as stockfeed, and habitat for native species. Nearly one-quarter of farmers focused on improving connectivity between their patches of native vegetation and vegetation on neighbouring properties. Farmers were also interested in how their native vegetation fits within the landscape; 30% considered how their native vegetation management contributed to regional or landscape outcomes, including government regional plans.

Table 6.44: Focus of farmers' native vegetation management

Management focus	Proportion of responses (%)
On-farm benefits	85
Connectivity	22
Regional/landscape outcomes	30

Notes:

National results were calculated by weighting data collected from each sample farm.

Figures sum to more than 100% because respondents could choose more than one response.

Source: Harris-Adams et al. (2012).

More farmers were interested in improving the condition or increasing the extent of native vegetation than in clearing native vegetation (Table 6.45). Just over 30% of farmers intended to improve native vegetation condition, and 20% intended to increase the area of native vegetation on their farm; around 12% intended to do both.

Table 6.45: Future management intentions for native vegetation

Future management intentions	Proportion of responses (%)
Clear	10
Increase area	20
Improve condition	31
No change	56

Notes:

National results were calculated by weighting data collected from each sample farm.

Figures sum to more than 100% because respondents could choose more than one response.

Source: Harris-Adams et al. (2012).

Farmers therefore recognise the range of benefits produced by native vegetation on agricultural land and have a central role in managing Australia's native vegetation. Improving the management of native vegetation requires more flexible approaches that recognise its wider benefits.

Indicator 6.5a

Direct and indirect employment in the forest sector

Rationale

This indicator measures the level of direct and indirect employment in the forest sector. Employment is an important measure of the contribution of forests to viable communities and the national economy.

Key points

- Total direct employment in the forest sector was estimated at 73,267 people in 2011, down from 85,254 people in 2006. This decline in total direct employment was largely the result of a 14.3% fall in full-time direct employment in the forest sector between 2006 and 2011, from 69,930 to 59,896 employees.
- Direct employment declined from 2006 to 2011 in the forestry and logging subsector; wood product manufacturing subsector; pulp, paper and converted paper product manufacturing subsector; and timber wholesaling subsector. Direct employment in the forestry support services subsector increased.
- Limited data are available on indirect forest employment because of cross-linkages with other sectors of the economy.
- A study on Tasmania by the Cooperative Research Centre for Forestry used different employment categories, but showed that forest-related employment in Tasmania fell by 46.0% between 2006 and 2011, from 6,409 to 3,460 people. The number of forest-related businesses in Tasmania also fell over this time.

National data on forest-sector employment presented in this indicator are derived from the Australian Bureau of Statistics, and presented in five categories or subsectors: forestry and logging; wood product manufacturing; pulp, paper and converted paper product manufacturing; forestry support services; and timber wholesaling. The categories are from the 2006 Australian and New Zealand Standard Industrial Classification system (Trewin and Pink 2006). Estimates are for all people aged 15 years or over who worked for at least one hour for pay, profit, commission or payment in kind; employees working for one hour or more without pay in a family business or on a farm; and employers and employees who were on leave, on strike or away from work as a standard work or shift arrangement (ABS 2011d). 'Full-time' means workers who usually worked 35 hours or more in a week; 'part-time' means workers who usually worked fewer than 35 hours per week.

Tasmanian data on forest-sector employment from Schirmer et al. (2011) use different employment categories (Table 6.46).

Employment data for forest-dependent communities (including indirect forest employment) and Indigenous Australians are presented in Indicators 6.5c and 6.5d, respectively.

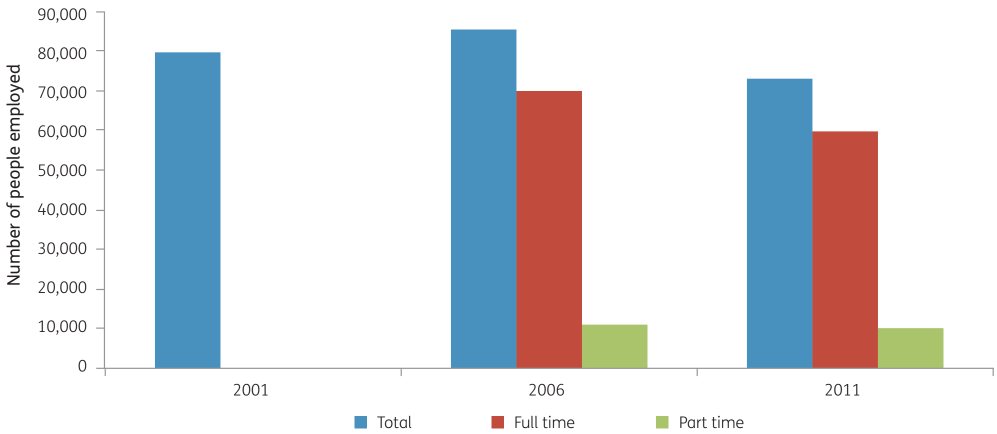
CRITERION 6

Direct employment in the forest sector

Total direct employment in the forest sector increased from 79,494 in 2001 to 85,254 in 2006 (Figure 6.45), in line with total national employment—direct forest-sector employment as a proportion of total national employment was 0.96% in both 2001 and 2006.

Total direct employment in the forest sector then fell by 14.0% to 73,267 employees in 2011 (Figure 6.45), and also declined as a proportion of total national employment, from

Figure 6.45: Total national employment in forestry, by employment status, 2001–11



Notes:

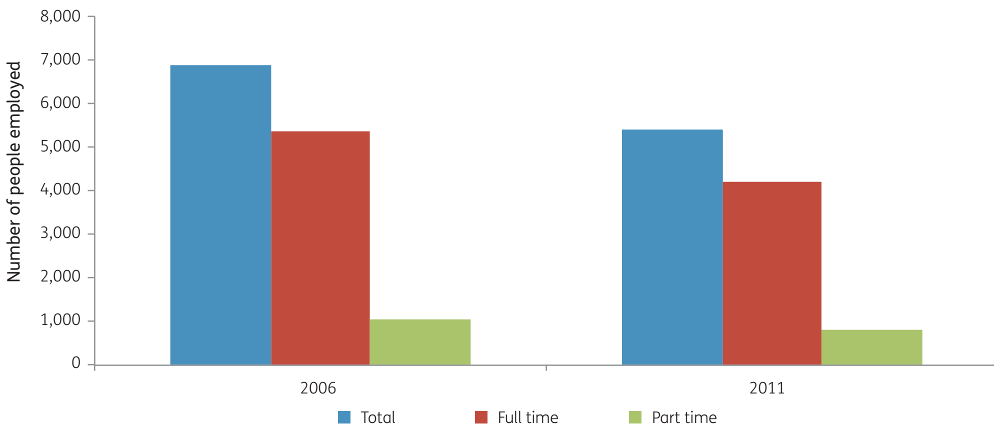
'Total' employment includes people employed full time and part time in forestry and logging; wood product manufacturing; pulp, paper and converted paper product manufacturing; forestry support services; and timber wholesaling. Total employment may be higher than the sum of full-time and part-time employment because total employment includes people who were 'employed, but away from work' but for whom hours worked were not given.

The national total direct employment of 73,267 employees comprised 501 employees in the Australian Capital Territory, 22,247 employees in New South Wales, 244 employees in Northern Territory, 12,845 employees in Queensland, 6,498 employees in South Australia, 3,526 employees in Tasmania, 21,826 employees in Victoria and 5,580 employees in Western Australia.

Estimates of full-time and part-time employment for 2001 are not available.

Source: ABS (2001, 2006, 2012e).

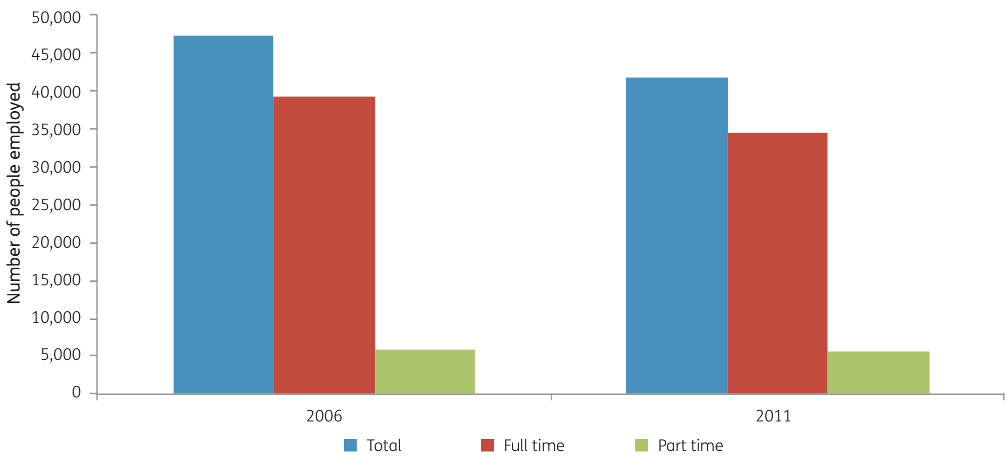
Figure 6.46: Employment in the forestry and logging subsector, 2006–11



Note: 'Total' employment may be higher than the sum of full-time and part-time employment because it includes people who are 'employed, but away from work' where hours worked are not given.

Source: ABS (2006, 2012e).

Figure 6.47: Employment in the wood product manufacturing subsector, 2006–11



Note: 'Total' employment may be higher than the sum of full-time and part-time employment because it includes people who are 'employed, but away from work' where hours worked are not given.

Source: ABS (2006, 2012e).

0.96% in 2006 to 0.75% in 2011. This decline was primarily the result of a 14.3% decline in total full-time employment, from 69,930 full-time employees in 2006 to 59,896 in 2011. Total part-time employment in the forest sector also fell over the period, but only by 8%, from 11,116 to 10,198 people.

Direct employment in the forestry and logging subsector

The forestry and logging subsector includes the workforce employed in growing trees in both native and plantation forests, and workers employed in logging activities, such as felling trees and cutting logs. It also includes the growing and harvesting of some non-wood forest products.

Total employment in the forestry and logging subsector declined between 2006 and 2011, from 6,872 to 5,399 people (Figure 6.46). The decrease in full-time employment was larger than the decrease in part-time employment. Monthly employment data (not shown) confirm a downward trend from February 2006 to February 2012, with strong seasonal variability (ABS 2012f).

Direct employment in the wood product manufacturing subsector

Wood product manufacturing includes activities relating to log sawmilling, timber dressing, woodchipping, and engineered and secondary wood products.

Employment in the subsector decreased by approximately 12% between 2006 and 2011, from 47,312 to 41,672 people (Figure 6.47). The decline was also evident in monthly employment data for the period February 2006 to February 2012 (not shown), although with seasonal fluctuations (ABS 2012f).

Direct employment in the pulp, paper and converted paper product manufacturing subsector

Employment estimates for the pulp, paper and converted paper product manufacturing subsector include workers engaged in the manufacture of wood pulp, paper and paperboard products.

From 2006 to 2011, employment in this subsector declined by 17.6%, from 23,485 to 19,356 people (Figure 6.48). The decline in full-time employment, from 19,468 to 16,171 people, was larger than the decline in part-time employment. Monthly employment data for the period February 2006 to February 2012 (not shown) showed a similar downward trend, with some seasonal variability (ABS 2012f).

Direct employment in the forestry support services subsector

Forestry support services include silvicultural activities such as planting, pruning, thinning, conservation and plant maintenance. This subsector may overlap with the forestry and logging subsector, which also covers activities relating to forest-growing operations.

Employment in the forestry support services subsector increased by about 5.6% between 2006 and 2011. The number of people employed full time in this subsector remained almost constant, but part-time employment increased from 616 to 755 people (Figure 6.49). Data on intervening years (not shown) show yearly variability and a slight upward trend between 2006 and 2011.

Direct employment in the timber wholesaling subsector

Timber wholesaling includes all wholesaling activities of wood except for firewood. Between 2006 and 2011, employment in the timber wholesaling sector decreased by 15.5%, from 5,534 to 4,674 people (Figure 6.50). There were declines in both full-time and part-time employment.

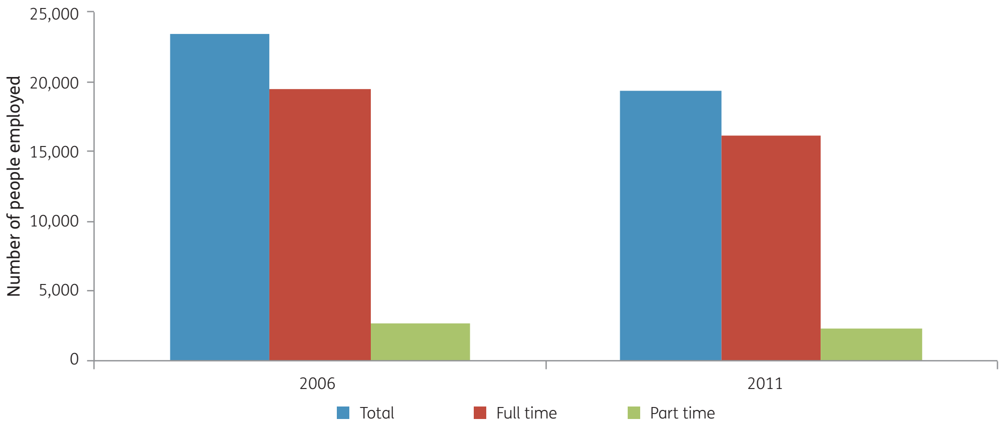
Indirect forest employment

Indirect employment includes activities that are generated from direct employment in the forest sector. Examples of indirect employment are wholesale and retail trade; legal services; accounting; marketing and business services; motor vehicles; rail, pipeline and other transport services (parts, equipment, maintenance and repairs); electricity, gas and water supply; education; scientific research; technical and computer support; government administration; and media services. Limited data are available on indirect forest employment because of extensive cross-linkages with other sectors of the economy.

Victorian forest officers conducting an audit of harvesting operations.

CRITERION 6

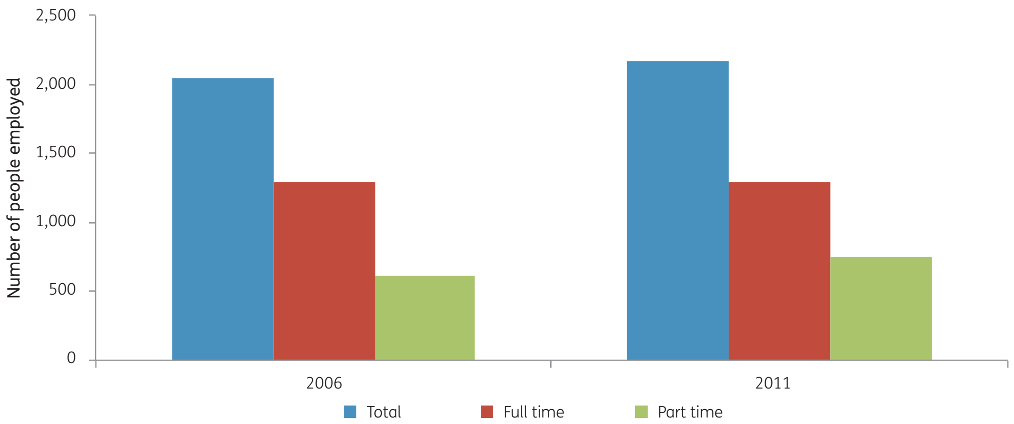
Figure 6.48: Employment in the pulp, paper and converted paper product manufacturing subsector, 2006–11



Note: 'Total' employment may be higher than the sum of full-time and part-time employment because it includes people who are 'employed, but away from work' where hours worked are not given.

Source: ABS (2006, 2012e).

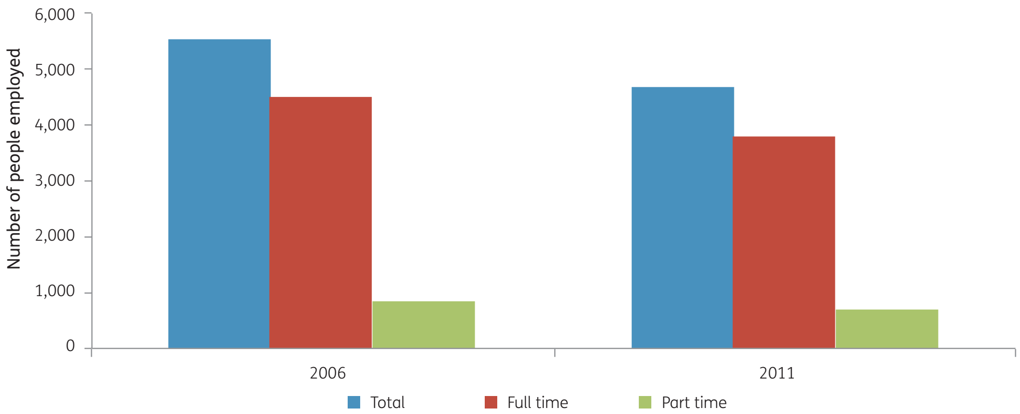
Figure 6.49: Employment in the forestry support services subsector, 2006–11



Note: 'Total' employment may be higher than the sum of full-time and part-time employment because it includes people who are 'employed, but away from work' where hours worked are not given.

Source: ABS (2006, 2012e).

Figure 6.50: Employment in the timber wholesaling subsector, 2006–11



Note: 'Total' employment may be higher than the sum of full-time and part-time employment because it includes people who are 'employed, but away from work' where hours worked are not given.

Source: ABS (2006, 2012e).

Tasmanian forest industry employment and trends

Schirmer et al. (2011) report a study on the Tasmanian forest industry by the Cooperative Research Centre for Forestry. The employment categories used this study are summarized in Table 6.46, as they are different from those used in ABS (2006, 2012e).

Table 6.46: Forest-related employment in Tasmania—inclusions and exclusions

Included
Processors of wood up to finished wood products domiciled in Tasmania
Harvest and haulage contractors
Silviculture and road contractors
Nurseries and seed suppliers
Forest and/or plantation growers and managers
Woodcraft sector
Excluded
Processors who use Tasmanian wood but are based outside Tasmania
Firewood cutters and sellers
Researchers focused on forestry
Forest industry groups and regulatory agencies, including industry lobby groups, industry associations and government regulators

Source: Schirmer et al. (2011).

Forest-related employment in Tasmania fell by almost half (46.0%) between 2006 and 2011, from 6,409 to 3,460 employees (Figure 6.51). This was a result of business closures driven by the global financial crisis, appreciation of the Australian dollar and other factors. The estimated number of forest-related businesses operating in Tasmania declined from 510 to 372 between 2006 and 2011 (Figure 6.51). Further declines in employment may occur following the appointment of administrators to Gunns Limited in 2012.

Forest growing and nurseries

The forest-growing and nurseries subsector includes people who are employed in managing native forest and plantations, as well as those who grow and collect seedlings for commercial planting.

In Tasmania, employment in the subsector declined by 43.1% between 2006 and 2011. Employment declined for both forest growers, and nurseries and seed suppliers (Figure 6.52). The fall in employment in the subsector coincided with a sharp decline in plantation establishment in Tasmania (see Indicators 6.2a and 2.1b).

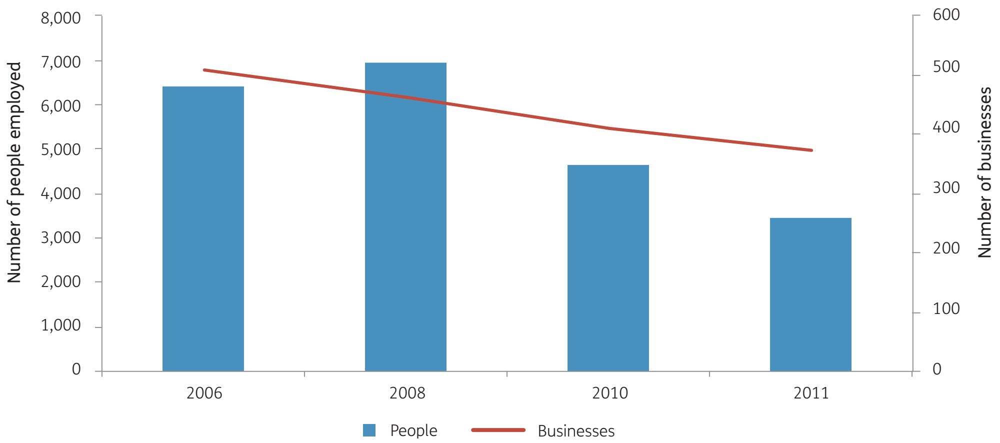
Wood processing

Wood processing includes all businesses involved in the manufacture of primary wood products, including woodchips, sawn timber, and engineered wood products such as veneer. Between 2006 and 2011, employment in the Tasmanian wood-processing industry declined by 46.5%, from 3,034 to 1,622 employees (Figure 6.53). The strong Australian dollar and reduced domestic demand were two drivers of this decline.

Forest contractors

The forest contractors subsector, consisting of people employed in silviculture, harvest and haulage, and roading and earthmoving, experienced a downturn in employment between 2006 and 2011 (Figure 6.54). The number of contractors working in harvest and haulage declined by 41.0% from 1,394 to 823; in silviculture, there was a decline of 76.3% from 668 to 158.

Figure 6.51: Number of people employed in the forest industry, and number of forest-related businesses, Tasmania, 2006–11



Notes:
Categories of forest industry employment are given in Table 6.46.
Data for 2007 and 2009 are unavailable.

Source: Schirmer et al. (2011).

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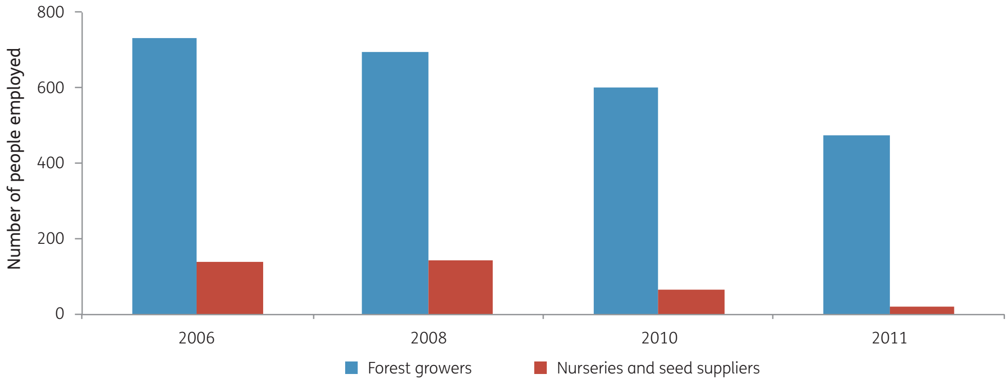
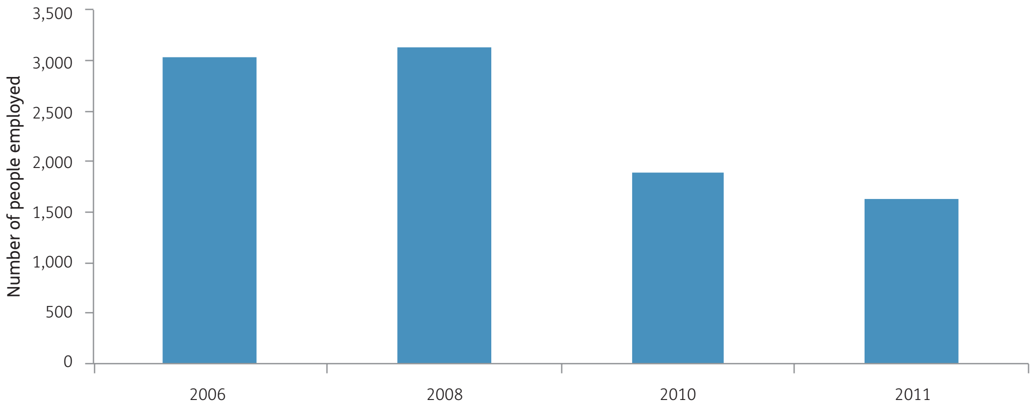
Figure 6.52: Employment in the forest-growing and nurseries subsector, Tasmania, 2006–11



Notes:
Includes people employed in both native and plantation estates, but excludes people employed on a contractual basis.
Data for 2007 and 2009 are unavailable.

Source: Schirmer et al. (2011).

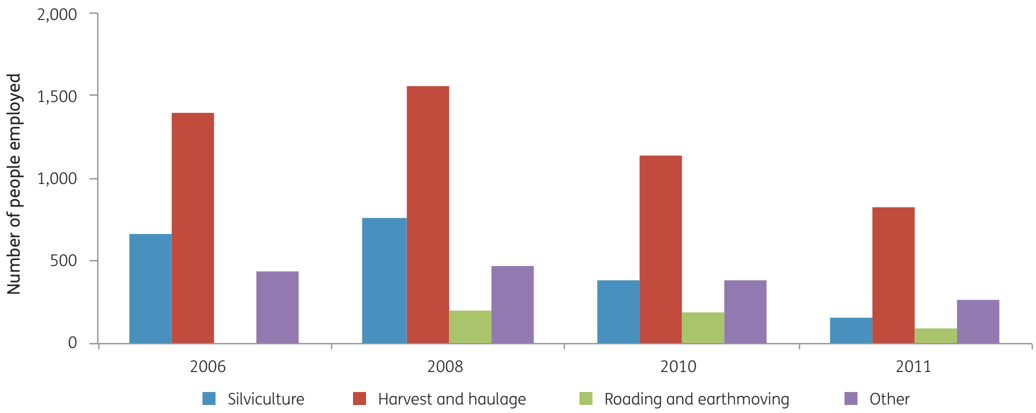
Figure 6.53: Employment in the wood-processing subsector, Tasmania, 2006–11



Note: Data for 2007 and 2009 are unavailable.

Source: Schirmer et al. (2011).

Figure 6.54: Employment in forest contracting, Tasmania, 2006–11



Notes:
Data for 2007 and 2009 are unavailable.
Data on employment in roading and earthmoving were unavailable for 2006.

Source: Schirmer et al. (2011).

Indicator 6.5b

Wage rates and injury rates within the forest sector

Rationale

This indicator measures the level of wage and injury rates in the forest sector. A sustainable industry will ensure high levels of workforce health with welfare and wage rates comparable with national averages for other occupations.

Key points

- Total wages and salaries in the wood and wood product industries have been between $3.8 billion and $4.2 billion from 2005–06 to 2010–11. Over the period, the average wage (not adjusted for inflation) has been increasing in the forestry and logging subsector, in wood product manufacturing, and in the pulp, paper and converted paper product subsector.
- Average annual wages in the forestry and logging subsector were estimated to be $34,467 in 2010–11. This is high compared with most other primary sectors, including agriculture and aquaculture, but low compared with the mining sector.
- The average wage in the wood product manufacturing sector was estimated to be $48,568 in 2010–11, which is lower than in most other manufacturing industries. In comparison, average annual wages in the pulp, paper and converted paper product subsector were estimated to be $72,381 in 2010–11.
- The number of serious injury claims in both the forestry and logging and the wood and paper product manufacturing subsectors have been declining in recent years. However, the decline in the incidence rate of serious claims is more modest in wood and paper products manufacturing than in the forestry and logging subsector.
- Between 2003–04 and 2009–10, there were 25 reported compensated fatalities in the forestry and logging subsector and 21 compensated fatalities in the wood and paper product manufacturing subsectors.

This indicator compares wage and salary rates in the forestry and logging, wood product manufacturing, and pulp, paper and converted paper product manufacturing subsectors with those of other primary and manufacturing sectors. This indicator also examines death and injury rates in those subsectors.

Wage rates

Estimates of wage rates were derived by dividing the total wages and salaries reported in a sector or industry by the number of full-time and part-time employees in that sector or industry. Wages and salaries include abnormal payments, such as severance, termination, redundancy and bonus payments, and provision expenses for employee entitlements, such as leave. They exclude payments to self-employed labourers such as consultants, contractors and those working on commissions. Withdrawals of equity from a business by proprietors and partners are also excluded.

Total wages and salaries in the wood and wood product industries have ranged from $3.7 to $4.2 billion between 2005–06 and 2010–11 (Table 6.47). Some industry sectors showed increases in wages and salaries, and some showed decreases. Businesses classified under 'other wood product manufacturing' constituted the largest component of total wages and salaries (35.7%) in 2010–11. This category includes industries engaged in the manufacture of prefabricated buildings, engineered wood products such as veneer and plywood, wooden structural fittings, and other types of wood products not classified elsewhere, such as ornamental woodworking, picture frames and wood pallets. It excludes timber used in making furniture, such as tables and chairs.

The average wage for workers was higher in the forestry and logging subsector than in many other primary sectors in the period 2005–06 to 2010–11 (Table 6.48; employment categories used for the intersectoral comparisons are shown in Box 6.2). Workers in agriculture had the lowest average wage relative to other primary sectors, due partly to the large part-time labour force that is typically recruited during harvesting seasons. The high average annual wage in the mining sector is largely a result of the sector's location in remote areas of Australia—requiring higher wages to attract labour to the industry (Connolly and Orsmond 2011)—and the strong global demand for minerals over the reporting period.

Table 6.49 shows the annual average wage in wood product manufacturing and selected other manufacturing sectors between 2005–06 and 2010–11. The average wage in wood product manufacturing is generally lower than in most other manuacturing sectors. However, the pulp, paper and converted paper product manufacturing subsector was estimated to have an average annual wage of $72,381 in 2010–11, which was higher than in most other reported sectors except for the petroleum and chemical manufacturing sector.

Table 6.47: Wages and salaries, wood and wood products industries, 2005–06 to 2010–11

	($ million)					
Subsector	**2005–06**	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**
Forestry and logging	611	509	500	568	540	517
Wood product manufacturing	1,851	2,082	2,246	2,137	2,224	2,137
Pulp, paper and converted paper product manufacturing	1,294	1,470	1,530	1,468	1,459	1,520
Total	**3,756**	**4,061**	**4,276**	**4,173**	**4,223**	**4,174**

Notes:

Estimates for the timber wholesaling and forestry support services subsectors could not be presented because of aggregation limitations with the source data.

Employment categories for 2006–07 to 2010–11 are from the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006 (Trewin and Pink 2006) (see Box 6.2). Categories for the 2005–06 estimate are from ANZSIC 2003; data were not available for all categories for 2005–06.

Source: ABS (2007, 2012b).

Box 6.2: Employment categories used for the intersectoral comparisons

The employment categories used in Tables 6.48 and 6.49 to compare forest-sector wage rates to the wage rates in other sectors use slightly different employment categories from those used in Indicators 6.5a–d.

Agriculture, forestry and fishing support services

For 2006–07 to 2010–11, agriculture, forestry and fishing support services relate to Division A, subdivision 05 under the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006. This includes silvicultural services, crop spraying, irrigation services and other activities that support agriculture, forestry and fishing.

Forestry and logging

For 2005–06, forestry and logging relates to Division 3 of the ANZSIC 2003 classification. For 2006–07 to 2010–11, forestry and logging relates to Division A, Subdivision 03 in the ANZSIC 2006 classification. This includes activities relating to the harvesting of forest products, both standing trees and non-timber products. It excludes silvicultural activities, which are covered under agriculture, forestry and fishing support services.

Wood product manufacturing

For all periods, this category relates to Division C, Subdivisions 14 and 15 of the ANZSIC 2006 classification. It includes activities relating to sawmilling and timber dressing, the construction of engineered wood products, pulp and paper activities, and other paper products. It excludes activities relating to printing services, such as book-binding services, photocopying, digital printing, and services relating to the reproduction of recorded media.

See Trewin and Pink (2006) for further detail.

Table 6.48: Estimated annual wage, selected primary sectors, 2005–06 to 2010–11

	($ per person)					
Sector	**2005–06**	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**
Agriculture	8,800	10,260	10,290	10,531	10,478	10,116
Agriculture, forestry and fishing support services	13,000	17,860	18,604	15,044	16,319	16,940
Aquaculture	–	28,143	25,625	28,286	30,286	30,000
Forestry and logging	23,144	26,789	27,778	28,400	30,000	34,467
Fishing, hunting and trapping	13,000	16,500	20,286	19,857	18,000	16,308
Mining	85,622	101,085	103,813	118,926	115,271	118,882

– = not available

Note: Employment categories for 2006–07 to 2010–11 are from the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006 (Trewin and Pink 2006); some categories are aggregated. Categories for the 2005–06 estimates are from ANZSIC 2003. Box 6.2 gives more detail of the forestry-related categories.

Source: ABS (2007, 2012b).

Table 6.49: Estimated annual wage, selected manufacturing sectors, 2005–06 to 2010–11

	($ per person)					
Sector	**2005–06**	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**2010–11**
Food beverages and tobacco	46,929	43,321	41,632	44,656	46,498	48,685
Metal and non-metal minerals	49,747	54,657	57,694	59,646	59,288	61,951
Petroleum and chemical	58,161	68,365	72,692	77,353	84,340	84,216
Textiles, clothing and footwear	32,184	31,185	32,577	38,021	36,591	34,795
Wood products	43,802	40,824	42,377	43,612	46,333	48,568
Pulp, paper and converted paper product	43,802	61,250	66,522	69,905	69,476	72,381
Other	46,782	51,166	53,917	55,155	54,519	57,270

Note: Employment categories for 2006–07 to 2010–11 are from the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006 (Trewin and Pink 2006); some categories are aggregated. Categories for the 2005–06 estimates are from ANZSIC 2003. Box 6.2 gives more detail of the forestry-related categories.

Source: ABS (2007, 2012b).

Injury rates

Injury and fatality rates in the forest sector reflect occupational health and safety standards, as well as the inherent danger of the sector. The number of serious claims in both forestry and logging and wood and paper product manufacturing declined between 2003–04 and 2009–10 (Table 6.50). The incidence rate of serious claims in the forestry and logging subsector fell from 32.4 per 1000 employees in 2003–04 to 21.4 per 1000 employees in 2009–10. In comparison, the incidence rate of serious claims in the wood and paper product manufacturing industry fell more modestly, from 33.5 per 1000 employees to 32.8 per 1000 employees over the same period.

The number of compensated fatalities in the forestry and logging subsector has also fallen over the same period, with a similar trend in the incidence rate of compensated fatalities (Table 6.50).

Table 6.50: Number of serious claims and compensated fatalities, 2003–04 to 2009–10

	2003–04	**2004–05**	**2005–06**	**2006–07**	**2007–08**	**2008–09**	**2009–10**	**Total 2003–10**
Number of serious claims								
Forestry and logging	375	345	350	290	315	290	270	**2,235**
Wood and paper products	2,460	2,420	2,190	2,140	2,185	1,905	1,830	**15,130**
Incidence rate of serious claims (number per 1000 employees)								
Forestry and logging	32.4	30.5	32.1	27.3	26.1	23.8	21.4	**n.a.**
Wood and paper products	33.5	35.4	33.3	31.9	35.4	34.3	32.8	**n.a.**
Number of compensated fatalities								
Forestry and logging	8	8	5	0	3	1	0	**25**
Wood and paper products	2	2	0	7	4	5	1	**21**
Incidence rate of compensated fatalities (number per 1000 employees)								
Forestry and logging	0.69	0.71	0.46	0.00	0.25	0.08	0.00	**n.a.**
Wood and paper products	0.03	0.03	0.00	0.10	0.06	0.09	0.02	**n.a.**

n.a. = not applicable

Notes:

'Wood and paper products' includes wood product manufacturing and pulp, paper and converted paper product manufacturing.

It is not possible to present estimates for timber wholesaling or forestry services because data are not available.

Source: Calculated from data in Safe Work Australia (2010, 2011, 2012).

Indicator 6.5c

Resilience of forest dependent communities to changing social and economic conditions

Rationale

This indicator provides a measure of the extent to which forest dependent communities are able to successfully respond and adapt to change. Resilient forest dependent communities will adapt to changing social and economic conditions, ensuring they remain viable into the future.

Key points

- A reduction in the harvest of native forests, lower investment in new plantations, reduced demand for wood products, and the closure of large-scale mills have had significant impacts on Australia's forest and wood products industries and forest-dependent communities over the period from 2006 to 2011.
- In 2011, there were 28 Statistical Local Areas (SLAs) where 4% or more of the working populations were employed in forest and wood products industries (the level used to show medium-to-high relative community dependence on forests). Of these 28 SLAs, only 10 showed a decline in total employment over the period from 2006 to 2011, but 24 showed a decline in employment in the forest and wood products industries over this period. Dependence on forest and wood products industries as a source of primary employment therefore decreased in most regions in the period from 2006 to 2011. Exceptions include Kyogle in the north coast region of New South Wales and Colac in western Victoria.
- Of the SLAs with relatively high employment dependence on forest and wood products industries, several had relatively low rankings in an adaptive capacity index.
- An increased number of people with training qualifications and skills, higher incomes, higher community participation levels and regional industry diversity may contribute in some communities to a higher adaptive capacity and resilience to industry change, through a transition to, and growth of, other industries.

A clear measure of the resilience of communities in adapting to change is not available. In this indicator, information is presented about the characteristics of communities and workers in forest and wood products industries that may affect their capacity to adapt, and that informs our understanding of community resilience.

The concept of resilience in a community in a socio-economic context is conceptualised and measured in different ways, sometimes interchangeably with adaptive capacity (ABARE–BRS 2010). Maguire and Cartwright (2008) clarify that resilience can occur in three different ways: as recovery, as stability and as transformation. The relationship between adaptive capacity and resilience is complementary: increasing adaptive capacity will increase community resilience.

The Australian forest and wood products industries[150] have undergone significant structural changes in recent years, such as a reduced harvest in native forests (Indicator 2.1a), reduced investment in new plantations (Indicator 6.2a), reduced demand for wood products from both domestic and international markets due to global economic conditions (Indicator 6.2a), and decommissioning of several old and uncompetitive processing facilities (Indicator 6.2b).

Such changes can have economic and social implications for forest-dependent communities and workers in the forest and wood products industries. The impacts will depend on factors such as community size, structure, location and history. Some communities adapt to change through transformation and taking opportunities, which enables them to 'bounce back' from stressors, adjust to unknown situations or create a buffer against stressors through continual improvement. For other communities, change may have damaging consequences (Australian Social Inclusion Board 2009). This indicator considers only the dependence of communities on the forest and wood products industries, and not on other forest activities such as tourism or grazing.

150 Defined here as the Australian and New Zealand Standard Industrial Classification categories of forestry and logging; forestry support services; wood product manufacturing; pulp, paper and converted paper product manufacturing; and timber wholesaling.

The capacity of forest-dependent communities, and workers in forest and wood products industries, to accommodate change is influenced by their level of economic dependence on these industries, and by the level of resources they can draw on to assist their response to change; these resources can be described collectively as 'adaptive capacity'. The resources represented by adaptive capacity can contribute to a community's resilience. Dependence and adaptive capacity are discussed below, and the derivation and application of these terms are discussed in more detail in Schirmer et al (2013).

Dependence on forest and wood products industries

The proportion of people directly employed in an industry can indicate the level of a community's economic dependence on that industry. However, beyond those directly employed in the forest and wood products industries, it is difficult to determine the economic dependence on forests of forest users such as apiarists, graziers, ecotourism operators, training providers and transport contractors, and potentially some personnel involved in forest management. Since these categories are not included in this assessment of forest dependence, forest-related employment is potentially underestimated by the available figures.

Communities are considered to show medium-to-high relative community dependence on forest and wood products industries when employment in the sector is at least 4% of total community employment. Table 6.51 shows the characteristics of the 28 Statistical Local Areas[151] (SLAs) that in 2011 had more than 4% employment dependence on the forest and wood products industries and more than 20 workers employed in these industries; these SLAs are also shown in Figure 6.55.

In 2011, there were eight SLAs where 10% or more of the working populations were employed in forest and wood products industries (four in New South Wales, two in South Australia, one in Victoria and one in Western Australia).

Only 10 of the 28 SLAs dependent on forest and wood products industries showed a decline in total employment over the period from 2006 to 2011. However, 24 of these 28 SLAs (all except for two each in New South Wales and Victoria) showed a decline in employment in the forest and wood products industries over this period—in 10 of these 24 SLAs, the decline was more than 20%. This decline may be due to several factors, including the changing nature of the forest and wood products industries.

Of the 28 SLAs, 14 had an increase in employment in forest and wood products industries from 2001 to 2006, while 11 had declines over both consecutive five-year periods to 2011. In Tasmania, several SLAs with more than 4% employment dependence on the forest and wood products industries in 2006 showed a decline to dependence levels below 4% in 2011 (Figure 6.54) and hence do not appear in Table 6.51.

Community adaptive capacity

Community adaptive capacity is affected by the diversity and magnitude of resources available to people in a community. These resources are commonly described in terms of social, human, institutional, physical, natural and economic capital (ABARE–BRS 2010, Wall and Marzall 2006). The assessment of adaptive capacity presented here uses an indicator approach to construct sub-indices from selected Australian Bureau of Statistics (ABS) data from the Census of Population and Housing for forest-dependent SLAs (see Box 6.3). Sub-indices for human capital, social capital and economic diversity are combined to create an overall adaptive capacity index (not incorporating natural or physical capital).[152] Information on the level of dependence of a community on forest and wood products industries, and its adaptive capacity, can help indicate areas where communities adapting to change might require assistance.

Of the SLAs with relatively high employment dependence on forest and wood products industries, several had relatively low rankings in the adaptive capacity index in 2006 (Table 6.51). In particular, Bombala and Tumbarumba in New South Wales, Dorset in Tasmania, and Wattle Range in South Australia depend on these industries for close to, or more than, 10% of employment, but using 2006 data had an adaptive capacity ranking of 'lower'.

Community adaptive capacity is a complex concept, and a single metric cannot capture the full experience of specific communities undergoing rapid change. Using census data reveals only part of the story and, given this limitation, it is important to further validate indicator results with specific information about each community.

Tumut shire in New South Wales, an area with high employment in the forest and wood products industry.

[151] A Statistical Local Area (SLA) is one of the base spatial units at which the Australian Bureau of Statistics collects and publishes statistics across Australia (www.abs.gov.au/ausstats/abs@.nsf/0/4BF2827AC128BF62CA256AD4007F680C?opendocument).

[152] For further details, see Stenekes et al. (2012).

Table 6.51: Characteristics of Statistical Local Areas with more than 4% employment dependence on, and more than 20 workers employed in, the forest and wood products industries

SLA[a]	Number of people employed in forest and wood products industries, 2011	Proportion of workforce employed in forest and wood products industries, 2011 (%)	Change in forest and wood products industries employment, 2001–06[b] (%)	Change in forest and wood products industries employment, 2006–11[c] (%)	Change in total employment, 2006–11 (all industries) (%)	Adaptive capacity ranking, 2006[d]
New South Wales						
Oberon	394	17.45	8.65	–7.73	–0.66	Middle
Bombala	163	15.22	–0.64*	4.49*	–1.47	Lower
Tumut Shire	717	15.22	1.65	–3.24	4.06	Middle
Tumbarumba	185	13.08	2.56*	–7.50	–5.35	Lower
Clarence Valley—Balance	113	5.30	7.19*	–24.16	5.33	Lower
Clarence Valley—Grafton	412	4.81	27.83	–6.58	4.92	Middle
Kyogle	135	4.03	–46.85	14.41	0.72	Lower
Queensland						
Gympie—Cooloola	412	4.79	–0.48*	–0.24*	17.21	Middle
Gympie—Gympie	320	4.61	–1.10*	–10.86	9.54	Middle
South Australia						
Wattle Range—West	451	12.23	–5.39	–30.62	–2.33	Lower
Mount Gambier	1,239	11.02	–3.51	–17.95	6.66	Middle
Grant	362	9.41	0.63*	–25.05	–2.71	Middle
Wattle Range—East	100	6.43	–20.75	–40.48	–1.95	Lower
Tasmania						
Dorset	227	8.78	–1.50*	–50.54	–6.91	Lower
Derwent Valley—Part B	103	7.93	13.08	–14.88	12.37	Middle
Circular Head	241	6.69	11.45	–17.47	–1.75	Lower
Derwent Valley—Part A	156	6.43	–4.13*	–32.76	4.34	Middle
Central Highlands	41	5.07	6.38*	–18.00*	–2.06	Lower
Launceston—Part C	60	4.51	–16.83	–28.57	5.14	Middle
Victoria						
Alpine—West	200	10.33	–12.20	–22.78	0.36	Middle
Latrobe—Traralgon	749	5.47	8.18	–14.20	14.03	Middle
Wellington—Alberton	119	5.33	25.00	19.00	–0.62	Lower
Colac-Otway—Colac	259	5.22	–7.35	14.10	5.95	Middle
East Gippsland—Orbost	168	5.08	–43.27	–13.40	5.55	Middle
Latrobe—Balance	65	5.00	38.18	–14.47	1.01	Middle
Western Australia						
Nannup	60	10.31	102.94	–13.04*	9.81	Middle
Manjimup	274	6.55	–43.71	–23.46	1.97	Middle
Bridgetown—Greenbushes	98	5.14	3.23*	–38.75	8.72	Middle
Australia[e]	**73,267**	**0.75**	**7.2**	**–14.1**	**9.7**	

SLA = Statistical Local Area

a 2001 and 2006 comparative data are based on 2006 SLA boundaries, and 2011 data are based on 2011 SLA boundaries. There are no significant boundary differences for the SLAs listed.

b, c Percentage change calculated from change in absolute employment numbers between census years. Changes of 10 or fewer individuals are indicated by *.

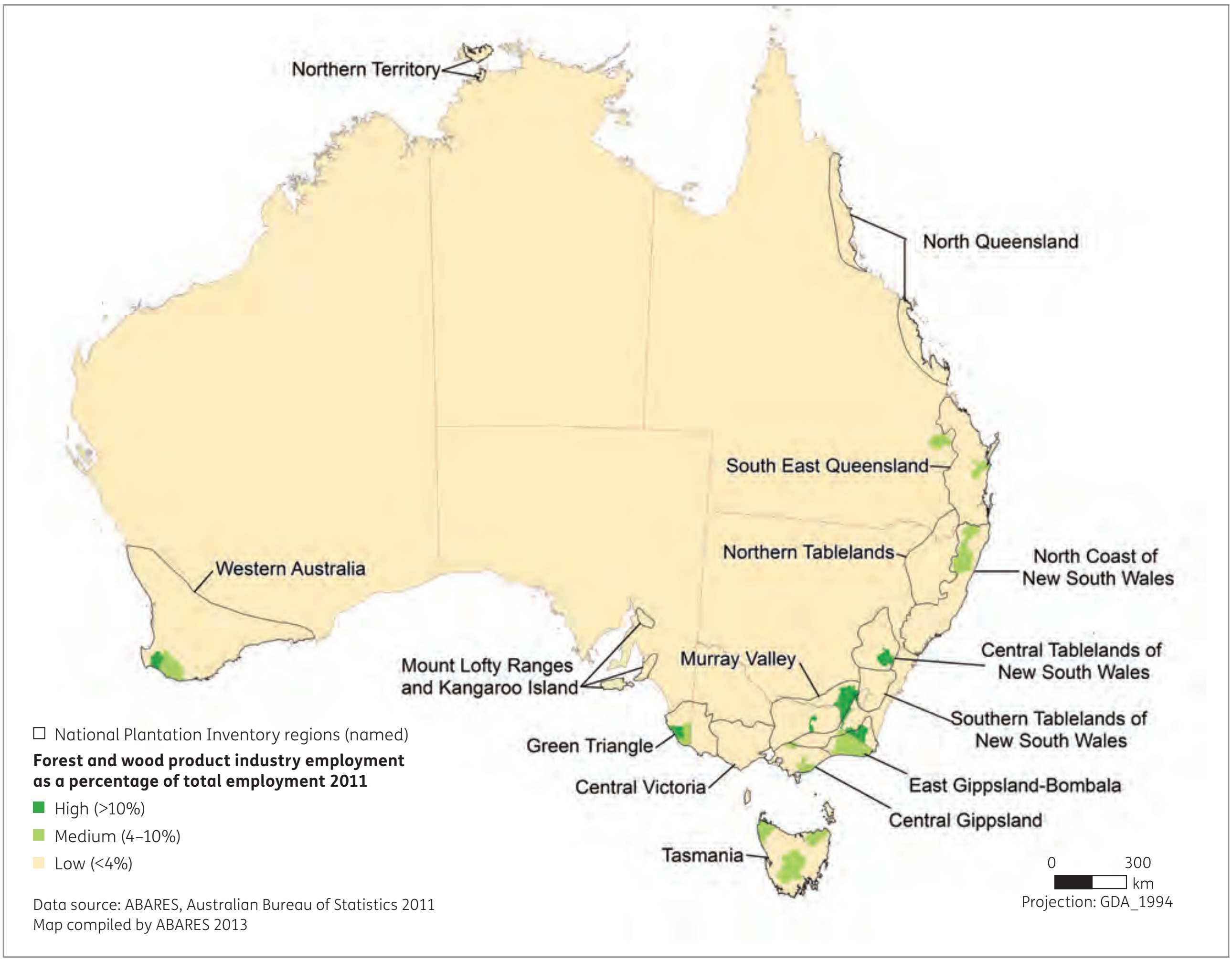
d Adaptive capacity ranking is only currently available from 2006 census data. 'Lower', 'middle' and 'higher' refer to the adaptive capacity index relative to all SLAs with 20 or more forest-sector workers. The adaptive capacity index combines sub-indices for human capital, social capital and economic diversity.

e Data based on total aggregated SLAs across Australia.

* Indicates changes of 10 or fewer individuals.

Source: ABS (2011e).

Figure 6.55: Employment dependence on forest and wood products industries by Statistical Local Area, 2011



Source: ABS (2011e).

Box 6.3: Sub-indices of adaptive capacity

Human capital

Human capital comprises factors that influence the productivity of labour, including education, skills and health. Human capital was calculated using Australian Bureau of Statistics data for age of residents, employment rates, level of education and qualifications, financial position, household structure (such as the proportion of lone-person households) and population mobility.

Social capital

Social capital describes relationships, networks and connections between people, and hence the degree of support people can draw on in the face of challenges. Methods for measuring social capital are less established than those used to measure human capital. The index used here includes two measures of social capital: the percentage of adults undertaking voluntary work, and the percentage of the female workforce in non-routine occupations.

Several other factors can increase social capital, such as business funding, facilitation of community initiatives, and people's attitudes and values, which shape how changes are perceived and decisions are made. These factors cannot be measured using readily available data sources and are not included in the index.

Economic diversity

Economic diversity is the variety of employment sectors in a local economy relative to the Australian economy. High economic diversity provides multiple income streams to a local economy and alternative employment for displaced workers, thereby potentially increasing community resilience to changes in the industry on which they depend.

Worker characteristics

Changes in forest and wood products industries may affect workers at a personal level. An individual's ability to adapt to change is difficult to quantify and can be independent of the broader community's adaptive capacity. Individual adaptive capacity is influenced by many factors; Table 6.52 presents some of the characteristics of workers in forest and wood products industries that could contribute to individual adaptive capacity, using 2006 and 2011 ABS data.

Older employees can find it more challenging than younger people to find alternative employment. In 2011, the median age of forestry workers in most SLAs was 41–47 years, with a small increase in the median age between 2006 and 2011 (Table 6.52).

Qualifications and formal skills recognition can increase opportunities for workers. Nationally, 48% of forestry workers had non-school qualifications in 2011, compared with 59% in the total workforce; however, forestry worker education levels have increased in most communities since 2006 (Table 6.52).

Workers on lower incomes and in unskilled occupations may have fewer financial resources to assist them to adapt to change. In many SLAs of high dependence on forest and wood product industries, up to one-third of forest workers were employed in unskilled jobs in 2011, and nationally 8% were low-income earners (Table 6.52). These proportions decreased in the five years to 2011.

Case study 6.10: Potential adaptive capacity and contribution of forestry to the Tumut community

Adaptive capacity can be applied not only to understand a community's ability to 'bounce back' from an impact, but also its ability to take advantage of opportunities. Tumut in southern New South Wales provides a good example of a community that has been able to take advantage of embodied local resources—natural, physical, human and social capital—to attract significant investment in the local forestry sector.

The expansion of forestry in the region since 1991 has contributed to stable economic growth, and to population stability in towns that otherwise would have been likely to experience population decline (Schirmer et al. 2005).

Tumut is ranked 'middle' in terms of its potential adaptive capacity relative to other forest-dependent localities in Australia (Table 6.51). Tumut's degree of adaptive capacity is a result of moderate levels of human capital and economic diversity, and a slightly lower level of social capital than other forest-dependent localities. This indicates that Tumut could be expected to respond reasonably well to 'shocks' affecting the community, and to be able to take advantage of investment opportunities that may derive from other economic, geographic or biophysical factors.

Plantations of radiata pine (*Pinus radiata*) were first established in Tumut Shire in the 1920s, with large-scale processing occurring in the area since the 1950s (Schirmer et al. 2005). In 2000, the consistent quantity and quality of the timber produced in the area (natural capital), the proximity of major road transport infrastructure (Hume Highway) and existing processing infrastructure (physical capital), and the strength of the community and an available skilled workforce (social and human capital) attracted substantial investment by Visy Industries, which selected Tumut from a host of international contenders as the location for its kraft paper mill.

Wood production and associated manufacturing in Tumut have diversified the declining regional economy, and their combined value currently exceeds $600 million per year. The forest and wood products industries have underpinned significant employment in Tumut, and directly employed 15.2% of the working population in 2011. Although there was a small drop in forest-sector employment from 2006 to 2011 (741 to 717 employees), there was a 4% rise in total employment across all industries (Table 6.51). Flow-on employment has also been generated by, for example, several Tumut-based enterprises that provide engineering and technical services to the Visy paper mill and to forest and wood product industries across New South Wales. Accredited training courses, delivered via the Tumut campus of TAFE NSW, have been established to service the training needs of a range of plantation-sector employees.

The forest and wood products industries have also contributed to the broader Tumut community by supporting community initiatives. For example, Visy Industries has provided funding for local building improvements, and for tree planting and other environmental projects.

Source: ABS (2011e), FWPRDC (2005), Tumut Shire Council (2010), Visy (2011).

Table 6.52: Forestry worker characteristics in Statistical Local Areas with more than 4% employment dependence on, and more than 20 workers employed in, the forest and wood products industries, 2006 and 2011

SLA[a]	Median age (years)		Workers with non-school qualification[b]		Unskilled workers[c]		Low-income earners[d]	
	2011	2006	2011 (%)	2006–11 (% change)	2011 (%)	2006–11 (% change)	2011 (%)	2006–11 (% change)
New South Wales								
Oberon	41	39	39.3	5.1	23.4	–0.8	2.5	–0.7
Bombala	41	38	30.1	7.0	28.2	–8.3	1.8	–3.9
Tumut Shire	44	41	47.6	5.2	20.2	–5.0	5.0	–1.9
Tumbarumba	41	37.5	49.7	11.7	22.2	–11.8	1.6	–2.9
Clarence Valley—Balance	45	44	34.5	2.3	38.1	1.8	10.6	1.9
Clarence Valley—Grafton	42	39	30.6	1.3	35.4	0.3	8.3	0.8
Kyogle	45	44	38.5	6.3	43.7	3.9	11.1	5.2
Queensland								
Gympie—Cooloola	46	44	40.0	2.8	28.6	–6.0	4.9	–3.4
Gympie—Gympie	43	42	42.2	3.2	23.8	–3.8	5.3	–3.9
South Australia								
Wattle Range—West	45	43	37.7	4.3	25.3	–1.2	2.9	–1.9
Mount Gambier	43	40	44.2	7.3	20.1	–6.3	3.3	–1.7
Grant	44	41	47.8	2.7	18.5	–4.3	6.1	0.7
Wattle Range—East	45	41	24.0	0.2	31.0	–9.5	3.0	–2.4
Tasmania								
Dorset	39.5	37	42.7	6.6	29.1	–6.9	7.0	–2.3
Derwent Valley—Part B	40	41	39.8	10.1	30.1	2.0	10.7	1.6
Circular Head	42	40	20.7	0.9	38.2	–1.6	6.2	–6.1
Derwent Valley—Part A	47	42	39.1	5.1	19.9	–3.0	3.2	–2.0
Central Highlands	34	33	29.3	17.3	22.0	–14.0	7.3	–10.7
Launceston—Part C	44	39	28.3	–3.8	28.3	10.5	8.3	1.2
Victoria								
Alpine—West	47	42	38.0	1.7	35.0	–4.0	4.0	–0.6
Latrobe—Traralgon	46	44	56.2	6.0	21.2	–3.4	2.0	–0.7
Wellington—Alberton	40	39	29.4	–7.6	44.5	–4.5	10.9	–10.1
Colac-Otway—Colac	36	41	33.2	1.0	28.6	–8.9	4.6	–2.9
East Gippsland—Orbost	43	42.5	39.9	7.9	33.3	2.4	7.7	–1.0
Latrobe—Balance	47	41	60.0	0.8	23.1	15.2	4.6	–0.6
Western Australia								
Nannup	52	44.5	31.7	11.4	65.0	7.0	11.7	–2.8
Manjimup	47	44	32.1	3.1	32.5	–9.4	5.8	–0.9
Bridgetown—Greenbushes	47	44	28.6	7.9	46.9	3.2	8.2	0.0
Australia—forest workers[e]	**42**	**40**	**48.6**	**5.4**	**15.9**	**–2.1**	**8.0**	**–3.3**
Australia—all workers[f]	**40**	**40**	**58.9**	**6.0**	**9.4**	**–1.0**	**15.9**	**–5.0**

SLA = Statistical Local Area

a Comparative data are based on 2006 SLA boundaries. There are some minor differences with 2011 SLA boundaries, but no significant differences for the SLAs listed.

b Workers holding a qualification at the level of certificate, diploma or advanced diploma, bachelor degree, graduate certificate or graduate diploma, or postgraduate degree.

c Workers who identified their occupation as 'labourer'.

d Workers whose median weekly income was less than $400.

e Whole-of-workforce comparison figures (forest and wood products industries) for all SLAs in Australia.

f Whole-of-workforce comparison figures, all industries.

Source: ABS (2006, 2011e).

CRITERION 6

Indicator 6.5d

Resilience of forest dependent Indigenous communities and forestry workers to changing social and economic conditions

Rationale

This indicator provides a measure of the extent to which forest dependent Indigenous communities are able to respond and adapt to change successfully. Resilient forest dependent Indigenous communities will adapt to changing social and economic conditions, ensuring they prosper into the future.

Key points

- Access to native forests enables Indigenous people to practise and maintain cultural values, leading to an improved sense of well-being, and personal and community resilience. However, measuring Indigenous cultural dependence on forests or economic dependence on forest-based activities is difficult.
- The financial and educational resources developed through engagement with commercial forest management activities can help build the capacity of Indigenous peoples to manage change and increase broader community resilience. In 2011, the forest and wood products industries directly employed 1,110 Indigenous people nationally. In a number of regions across Australia, more than 1% of the Indigenous workforce was employed in the forest and wood products industries.
- The proportion of Indigenous workers who had non-school qualifications or had completed secondary school increased between 2006 and 2011. There were a total of 169 completions of ForestWorks vocational courses by Indigenous students in 2011.
- Successful Indigenous forest-sector projects can deliver both social and economic benefits, strengthening the resilience of Indigenous communities in the face of social and economic change.

In the same way as Indicator 6.5c, this indicator examines community resilience by considering community capacity and resources to adapt to changes. Although no single measure for resilience is possible, the information presented here informs an understanding of resilience—it includes community adaptive capacity, dependence on forests and the characteristics of Indigenous workers.

Indigenous communities include both Aboriginal and Torres Strait Islander communities. 'Indigenous forestry' can be defined as the range of forest and forest-related activities that deliver social and economic benefits to Indigenous people (Feary 2007). Many Indigenous people place strong cultural significance on native forests (Feary 2008); Indigenous forestry can therefore have different dimensions from that of the mainstream forest sector. The various ways in which Indigenous people and their communities use forest resources, and the range of social, cultural and economic benefits they may gain through this use, can increase personal and community resilience in times of social and economic change.

Oral histories suggest that the timber industry was a major employer of Indigenous people in the mid-20th century in New South Wales, Queensland and Victoria, with a decline in Indigenous employment later in the century. Over the reporting period, there has been an increase in opportunities for Indigenous communities to use or maintain their use of native forests and participate in the forest sector. This increase is the result of the recognition of native title, land rights legislation and other processes (Indicators 6.4a and 6.4c; see also Pollack 2001). Currently, 15.9 million hectares of forest are Indigenous owned and managed or Indigenous managed (refer to Indicator 6.4a).

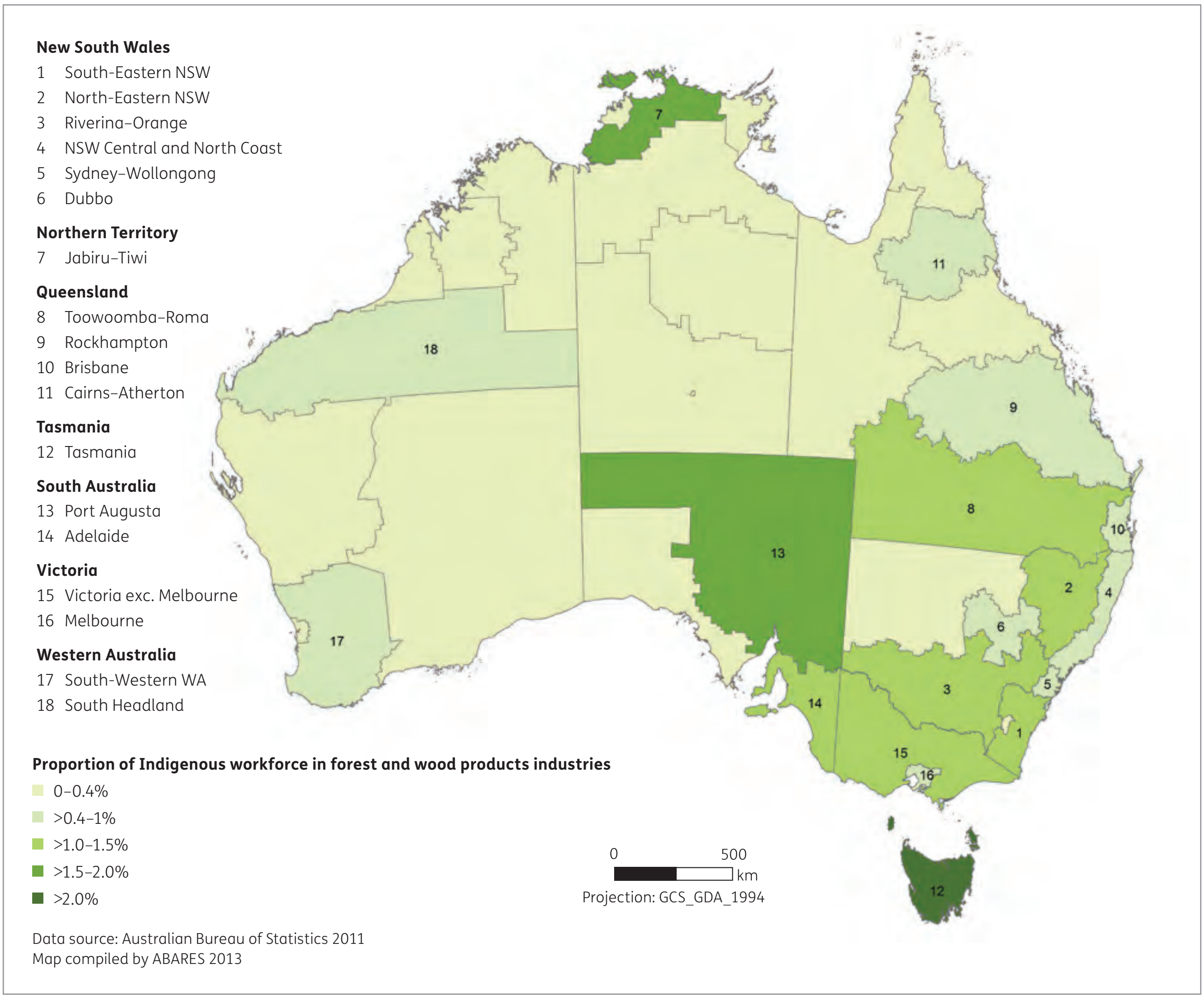
Forest dependence

Dependence of Indigenous communities on native forests has social, cultural and economic aspects that vary in intensity depending on the local context, and the connections and values of each Indigenous community. Many Indigenous communities have cultural dependence on forests; especially where the forest is part of the country for which a particular community has customary responsibility, access to native forests enables Indigenous communities to engage in cultural activities, contributing to improved health and wellbeing (Ganesharajah 2009).

Measuring cultural dependence is complex and not readily done using census data. In addition, census data do not capture aspects of resilience that relate to the Indigenous cultural context, such as traditional skills and knowledge, kinship networks and other aspects of Indigenous culture. The area of land managed under the Indigenous estate is a measure that can suggest opportunities for strengthening both cultural connectedness and economic benefits (see Indicators 6.4a and 6.4c).

Indigenous economic dependence on forest-based activities is also difficult to quantify because of a lack of data on Indigenous involvement in the forest sector. The number of people directly employed in forest and wood products industries[153] is used here as an indicator of the economic dependence of Indigenous communities on these industries. Indigenous communities are geographically defined using ABS Indigenous Regions (Figure 6.56); data on the level of involvement of different Indigenous Regions in the forest and wood products industries are shown in Table 6.53. Nationally consistent data on the economic benefits from employment in tourism, ecotourism, conservation (including national parks) or other non-commercial forest management were unavailable.

Figure 6.56: Indigenous Regions and level of Indigenous workforce employment in forest and wood products industries, 2011



Note: Numbered and listed regions are regions with more than 0.4% of their Indigenous workforce employed in the forest and wood products industries.
Source: ABS (2011e).

[153] www.daff.gov.au/forestry/policies/nifs.

Table 6.53: Characteristics of Indigenous communities and workers, in Indigenous Regions with more than 0.4% of the Indigenous workforce employed in forest and wood products industries, 2011

Indigenous Region[a]	Community characteristics—employment dependence				Characteristics of Indigenous workers in forest and wood products industries				Land tenure	
	Number of Indigenous people employed in forest and wood products industries	Proportion of Indigenous workforce employed in forest and wood products industries (%)	Change in number employed, 2006–11[b] (%)	Indigenous people in population (%)	Median age (years)	Secondary school qualification[c] (%)	Non-school qualification (%)	Unskilled workers (labourers) (%)	Indigenous-owned or managed land ('000 hectares)[d]	Forest on Indigenous-owned or managed land ('000 hectares)[d]
New South Wales										
South-Eastern NSW	37	1.38	–0.48	3.5	41	11.1	44.7	34.2	28	27
North-Eastern NSW	42	1.13	–0.34	8.8	27	26.7	17.1	43.9	21	14
Riverina–Orange	51	1.08	–0.28	4.6	27	25.0	46.0	44.2	47	14
NSW Central and North Coast	128	0.96	–0.24	3.8	35	31.7	25.6	41.6	28	22
Sydney–Wollongong	113	0.71	–0.03	1.3	29	28.4	41.0	25.6	3	3
Dubbo	17	0.64	–0.22	13.7	16	35.7	33.3	17.6	3	2
Northern Territory										
Jabiru–Tiwi	36	1.67	1.33	78.9	25	27.6	38.5	7.9	7,754	4,435
Queensland										
Toowoomba–Roma	46	1.27	–0.19	4.8	41	22.7	27.3	54.2	239	97
Rockhampton	43	0.88	–0.86	4.5	31	23.4	27.7	62.5	51	24
Brisbane	111	0.68	–0.30	1.9	35	35.8	28.0	32.1	1	0
Cairns–Atherton	23	0.47	–0.29	11.3	55	50.0	30.4	16.7	603	489
South Australia										
Port Augusta	26	1.67	1.67	9.3	29	21.4	23.1	25.0	11,771	9
Adelaide	55	1.07	–0.32	1.5	36	19.0	23.3	33.9	20	4
Tasmania										
Tasmania	146	2.36	–0.96	4.1	36	8.6	32.1	41.4	61	8
Victoria										
Victoria excluding Melbourne	59	1.23	–0.51	1.5	36	23.7	31.5	29.3	65	40
Melbourne	46	0.77	–0.46	0.5	34	31.3	31.1	20.8	0	0
Western Australia										
South-Western WA	16	0.71	–0.79	3.0	19	26.3	31.6	33.3	25	8
South Hedland	10	0.47	0.47	14.2	30[e]	0.0	0.0	0.0	8,567	2
Australia[f], 2011	**1,110**	**0.79**	**–**	**2.68**	**33**	**25.0**	**30.2**	**33.2**	**135,149**	**16,455**
Australia[f], 2006	**1,073**	**0.93**	**–**	**2.29**	**33**	**21.5**	**26.4**	**39.5**	**101,657[g]**	**20,867[g]**
Australia[f], 2001	**985**	**1.03**	**–**	**2.28**	**–**	**–**	**–**	**–**	**–**	**–**

– = not available

a Indigenous Regions are geographical units used by the Australian Bureau of Statistics in place of the Aboriginal and Torres Strait Islander Commission regions that were used for reporting before the 2006 census. They are based on Indigenous Coordination Centre (ICC) regions and Torres Strait Regional Authority areas; 39 Indigenous Regions cover the whole of Australia. Indigenous Regions are aggregated from one or more Indigenous Areas, which in turn are aggregated from one or more Indigenous Locations (which generally represent small Aboriginal and Torres Strait Islander communities with a minimum population of 90 Aboriginal and Torres Strait Islander usual residents). Indigenous Regions are grouped by state and then listed in order of the percentage of the Indigenous workforce employed in the forest sector. Regions with fewer than 10 forest sector workers are not included because of data unreliability due to ABS randomisation.

b Difference in percentage employed from 2006 to 2011.

c Secondary school qualification is defined as Year 12 or equivalent as highest year of school completed.

d Includes indigenous-owned land and Indigenous-managed land as described in Indicators 6.4a and 6.4c. Indigenous co-managed land and land with other special rights have not been included because they are less suitable for the forest and wood products industry, due to restrictions on resource extraction based on tenure type or land ownership.

e Median age calculated from fewer than 10 workers.

f Totals cover the whole of Australia, not just the Indigenous Regions listed.

g Figures as presented in Table 96 of SOFR 2008. These were calculated using the Indigenous Land Corporation's Indigenous Estate dataset and the SOFR 2008 forest extent.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences, Australian Bureau of Statistics.

Yellow box (*Eucalyptus melliodora*) and Blakely's red gum (*Eucalyptus blakelyi*) woodland forest, New South Wales.

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In 2011, the forest and wood products industries directly employed 1,110 Indigenous people nationally—0.79% of the Indigenous workforce. The highest level of Indigenous employment in the forest and wood products industries (measured as the percentage of the Indigenous workforce employed in these industries) was in the Indigenous Region of Tasmania, followed by the Indigenous Regions of Port Augusta in South Australia, Jabiru–Tiwi in the Northern Territory and South-Eastern New South Wales.

Although absolute numbers of Indigenous people employed in the forest and wood products industries have increased nationally since 2001, the proportion of Indigenous employment in forest and wood products industries decreased nationally over this period and in most of the listed Indigenous Regions (Table 6.53); exceptions include Port Augusta (South Australia) and Jabiru–Tiwi (Northern Territory), which had zero or very low employment in these industries in 2006. The decrease in proportion employed may be due to a combination of factors, such as changes in the forest and wood products sector as a whole, more efficient technology requiring less employment per unit of production, the availability of alternative sources of income for Indigenous communities, and possible impacts of the global financial crisis on employment and training opportunities for Indigenous communities.

Of Indigenous people directly employed in the forest and wood products industries in 2011, nationally 67% were employed in wood, pulp and paper product manufacturing, 10% were employed in forestry and logging, and 18% were employed in forestry support services (ABS 2011d). Compared with 2006, in 2011 a greater proportion of Indigenous employment in forest and wood products industries was in support services, and a lower proportion was in manufacturing.

Community and worker resilience

Resilience refers to the capacity of communities and individuals to 'bounce back' from stressors and to cope with unknown situations (Australian Social Inclusion Board 2009). It varies spatially and over time (Maguire and Cartwright 2008) and can be shaped by a range of cultural, social and economic factors.

The cultural use of native forests allows Indigenous people to connect with ancestral landscapes through traditional activities such as hunting and gathering, and social ceremonies. Native forests are places where new generations of Indigenous people can learn about values and maintain cultural identity. This can strengthen mental health and personal wellbeing (Feary 2008) and so improve individual resilience.

Business opportunities that draw on traditional activities can deliver both cultural and economic outcomes. For example, collection of bush food and the creation of traditional artefacts for tourist markets can enable Indigenous communities to generate income while maintaining customary activities and values. Generally, the most resilient Indigenous communities are those in which economic development incorporates customary laws and values (SOFR 2008).

Ownership of native forests can enable Indigenous communities to establish forest-based enterprises, provide training and employment (see Case study 6.11), pursue economic independence on country, maintain social connections and fulfil cultural obligations to care for country. This may be particularly important in remote communities with limited access to other commercial industries. Moreover, the skills and work experience gained in Indigenous forest-based enterprises can assist Indigenous people to obtain employment in other forest-sector enterprises and in other industries (although Indigenous people often face significant barriers in obtaining employment—see Case study 6.12). Some Indigenous-owned and Indigenous-run business models do not revolve around maximum financial gain (e.g. Nanum Tawap, described in SOFR 2008 and Feary 2008) and have other prime objectives of addressing social and family obligations.

In 2005, the National Indigenous Forestry Strategy was launched to broker partnerships between Indigenous communities and forest and wood products industries, and to build the capacity of Indigenous people and communities to run forest-based ventures (DAFF 2005). The strategy has funded a range of Indigenous forestry projects across Australia, ranging from the purchase of portable forestry equipment to the engagement of an economic development officer for an Indigenous ecotourism project[154] (Case study 6.11).

Indigenous worker characteristics

Demographic information, together with employment data about Indigenous people employed in the forest and wood products industries (Table 6.53), can be used to indicate resilience to changes in these industries and identify regional differences.[155] Demographic and employment data provide the following information for Indigenous Regions with more than 0.4% of the Indigenous workforce employed in forest and wood products industries in 2011:

- The median age of Indigenous workers employed in forest and wood products industries Australia-wide was 33, unchanged from 2006. Younger employees can find it easier than older people to adapt to change. The regions of Dubbo and South-Western Western Australia had median worker ages substantially lower than the national median age.
- In the Dubbo (New South Wales), Cairns–Atherton (Queensland) and Melbourne (Victoria) regions, the combination of higher rates of secondary school completion and lower proportions of unskilled workers, compared with other regions and national figures, may positively influence resilience.

154 www.daff.gov.au/forestry/policies/nifs.

155 www.daff.gov.au/forestry/policies/nifs. Note that Indigenous workers may be living away from home and not necessarily employed in their local communities.

Table 6.54: Indigenous student enrolments in the ForestWorks Forest and Forest Products Training Package

Year	NSW	NT	Qld	SA	Tas.	Vic.	WA	Total enrolments
2007	102	0	143	0	34	84	2	365
2008	155	5	204	0	34	82	13	493
2009	110	10	165	2	22	72	32	413
2010	111	26	336	1	30	85	18	607
2011	105	9	500	0	41	83	9	747

Note: Enrolments do not indicate whether students completed qualifications. However, students commonly aim to complete units of competencies, rather than entire qualifications.

Source: ForestWorks (2012a).

Table 6.55: Completions of ForestWorks course qualifications by Indigenous students, 2011

Level	NSW	NT	Qld	SA	Tas.	Vic.	WA	Total completions
Certificate II	3	0	70	0	0	2	0	75
Certificate III	2	0	87	1	2	1	0	93
Certificate IV	0	0	0	0	1	0	0	1
Diploma or higher	0	0	0	0	0	0	0	0
Total	**5**	**0**	**157**	**1**	**3**	**3**	**0**	**169**

Note: Courses focus on vocational skills in forest growing and management, harvesting, haulage and sawmilling, and processing (for occupations such as tree felling, loading, nursery operation, timber grading and kiln operation).

Source: National Centre for Vocational Education Research (www.ncver.edu.au/).

- Workers in the South-Eastern New South Wales, Riverina–Orange (New South Wales), Sydney–Wollongong (New South Wales) and Jabiru–Tiwi (Northern Territory) regions had the highest levels of non-school qualifications. This could indicate a greater capacity to take opportunities in forestry, or potentially other sectors, although workers in South-Eastern New South Wales also had a low level of secondary school completion.
- Nationally, Indigenous workers had lower rates of non-school qualifications such as certificates and diplomas (30%) than the forest-sector workforce as a whole (49%—see Indicator 6.5c). However, the proportion of Indigenous workers who had non-school qualifications or had completed secondary school increased between 2006 and 2011. Higher levels of formal education are typically associated with increased rates of employment and tend to indicate a greater capacity to respond to workplace change. However, traditional skills and knowledge, which may also increase resilience, are not measured by these data.
- As for the general forestry workforce, the proportion of Indigenous workers in unskilled (labourer) occupations fell nationally from 2006 to 2011. In the remote and northern Indigenous Regions of Jabiru–Tiwi, South Hedland and Port Augusta, the proportion of Indigenous workers in skilled professional occupations was higher than in capital city and southern regions (ABS 2011d). Forest-sector employment in Jabiru–Tiwi, South Hedland and Port Augusta was concentrated in forestry support services, rather than in manufacturing.

Training and skills development

Training in practical forest-sector skills can increase future employment opportunities and enhance personal resilience. ForestWorks, a not-for-profit provider of learning and skill development in forest and wood products industries, offers a Forest and Forest Products Training Package, which provides training in skills such as tree felling, machine and kiln operation, and timber grading (ForestWorks 2012a). Since 2007, Indigenous enrolments in this training package have risen nationally, with the majority of enrolments being from Queensland (Table 6.54). In 2001, course completions by Indigenous students were mostly at Certificate II and Certificate III levels (Table 6.55).

It is difficult to measure the connection between training and employment—training may not lead to a job in the sector. Similarly, it is difficult to measure the number of people who obtain employment in other industries because of the transferable skills they obtain by undertaking forest-sector training courses. Nevertheless, the availability of such training and training participation by Indigenous people, especially in Queensland, New South Wales and Victoria, is likely to help build individual and community resilience.

Case study 6.11: Indigenous training and enterprise development

In 2008, the Batemans Bay Local Aboriginal Land Council (BBLALC), located on the south coast of New South Wales, established a locally owned and operated timber enterprise project. Major goals were to create training and employment opportunities for Indigenous people, and increase the economic base of the BBLALC. This project gained support through Forests NSW[156] and the Australian Government (under the National Indigenous Forestry Strategy) for feasibility assessments and equipment, and through private organisations for training delivery.

In 2011, as part of the project, 15 local unemployed Indigenous people completed a pre-employment program in competencies based on the Certificate III in Harvesting and Haulage, incorporating training in basic workplace skills, chainsaw use, occupational health and safety, and first aid. The skills obtained in the course are transferable beyond the forest and wood products industries—for example, to the agricultural sector and natural resource management.

The BBLALC intends to create 25 new jobs in the future by expanding firewood operations using mechanical harvesting, and by value-adding through portable mills and bagging operations. The project reflects the integration of Indigenous people's values with forest management practice, policy and decision making, and successful partnerships between the BBLALC, private industry and government.

Source: M MacCallum, Batemans Bay Local Aboriginal Land Council, pers. comm., February 2012.

Case study 6.12: Barriers to Indigenous employment in forestry

Although a national shift has occurred towards more service-based employment for Indigenous and non-Indigenous workers, together with positive signs in terms of worker education levels, participation of Indigenous Australians in the forest sector has decreased slightly in recent years. Barriers to increased Indigenous employment in the sector include the following:

- **Traditional recruitment processes that fail to identify effective Indigenous jobseekers.** Indigenous people with low levels of literacy may find it difficult to prepare written job applications, and traditional interviews that focus on applicants presenting themselves well can be daunting.
- **Balancing responsibilities and Indigenous and non-Indigenous cultures.** Some Indigenous people experience strong pressures in balancing their cultural responsibilities as custodians of the land with the practices of commercial forestry.
- **A lack of skills and experience.** The increasing mechanisation of the forest sector requires acquisition of new skills by forest workers. In many Indigenous communities, particularly in remote areas, locally based training opportunities are lacking, and apprenticeships and traineeships suitable for low entry skill levels are not widely available.
- **The future of the industry.** Some Indigenous people feel that the forestry industry has a limited future and lacks job security.

Source: DAFF (2004), ForestWorks NSW (2011), Loxton (2007), Loxton et al. (2012), Pearson and Helms (2011).

[156] From January 2013, the Forestry Corporation of NSW.

Criterion 7

Legal, institutional and economic framework for forest conservation and sustainable management

Plantation and native forest, Queensland. iStockphoto

Victorian forest officers assessing harvest operations at a log landing.

Criterion 7
Legal, institutional and economic framework for forest conservation and sustainable management

The five indicators in this criterion report on the extent to which the legal, institutional and economic framework supports sustainable forest management, specifically the conservation, maintenance or enhancement of the forest attributes described in Criteria 1–6, and the extent to which it supports the capacity to monitor change and to conduct and apply research and development to forest management. The indicators can be arranged into three groups.

Legal, institutional and economic frameworks

Effective legal, institutional and economic frameworks are critical for sustainable forest management. The legal system defines and allocates legal and regulatory responsibilities, and provides for public participation and the protection of conservation values. Institutions provide mechanisms for policy-making and decision-making, and for the engagement of the wider community in continuous improvement in sustainable management of forests. Government economic policies on investment, taxation and trade influence the level of investment in forest conservation, forest growing and wood processing.

Capacity to measure and monitor changes

A comprehensive measurement and monitoring program provides the basis for planning to support sustainable forest management. The extent to which relevant and up-to-date information about forest condition is available to forest managers provides a measure of the capacity to demonstrate sustainable forest management. Reporting on the capacity to measure change provides forest managers with the opportunity to revise and prioritise data collection so that future measurement and monitoring are more relevant and informative.

Capacity to conduct research and development and apply the results

A scientific understanding of the characteristics and functions of forest ecosystems is needed to underpin their sustainable management. Research and development (R&D) provide the basis for biological and wood inventories, forest health surveillance, improvements in operational forest management and silviculture, and the development of methods for assessing sustainable forest management. High-quality R&D and expert advice are required to inform decision-making and policy development. Changes in the institutional capacity for, and the magnitude of, investment in R&D can indicate changes in research investment priorities and delivery mechanisms.

Key findings

Key findings are a condensed version of the Key points presented at the start of individual indicators in this criterion.

Legal, institutional and economic frameworks

- All states and territories and the Australian Government have legislation to support the conservation and sustainable management of Australia's forests. This is underpinned by a well-established policy environment guided by a *National Forest Policy Statement*.
- Twenty-eight million hectares of Australia's forests (22% of the area of forest) are covered by management plans relating to their conservation and sustainable management. Nationally, 14.8 million hectares of forest in the National Reserve System (56% of the area of forest in the NRS) has management plans in place.
- Codes of forest practice vary in their legal status and coverage but generally provide specific operational guidance on sustainable forest management practices in public and private forest available for wood production, including plantations. The codes of forest practice, as well as externally accredited environmental management systems and forest certification schemes, provide forest managers with a structured approach to forest planning and management, including protection of the environment. In 2011, 10.7 million hectares of native forests and plantations were certified for forest management under independent, third-party schemes (either the Australian Forest Certification Scheme or the Forest Stewardship Council scheme).
- Legislation covering carbon credits (the Carbon Farming Initiative) and illegal logging was introduced at the national level in 2011 and 2012, respectively.
- A range of options for training and educational qualifications is available in Australia in all areas relevant to sustainable forest management. However, the number of students entering and graduating from forestry-specific university degrees declined over the reporting period.
- The value of benefits from forests other than wood, such as biodiversity, carbon sequestration, production of water, and soil protection, is generally not integrated into an economic framework for forest conservation or management.
- Managed investment schemes have become a less important financial mechanism for plantation expansion since the global financial crisis.

Capacity to measure and monitor changes

- The Australian Government and all states and territories, except the Northern Territory, publish 'State of the Environment' reports at regular intervals, varying from three to five years. Tasmania and Victoria publish five-yearly 'State of the Forests' reports, based on a framework of criteria and indicators similar to *Australia's State of the Forests Report*.
- Australia's five-yearly state of the forests reporting uses a framework of criteria and indicators developed under the international Montreal Process, which provides a mechanism for presenting disparate data in a consistent and repeatable format. Some data are collected nationally, and others are provided by the states and territories.
- Compared with SOFR 2008, the quality of data in SOFR 2013 has improved for almost half (21) of the 44 national reporting indicators. The data available for SOFR 2013 were assessed as comprehensive (the highest possible rating) in each of coverage, currency and frequency for 17 of the indicators, and comprehensive in any two of these aspects for a further 10 indicators. Capacity has been developed to report trends over time in 16 of the 44 indicators.
- The ability to measure, monitor and report on forests varies considerably by tenure. The most reliable information continues to be available for multiple-use public forest and some public nature conservation reserves. Significant gaps in data collection and monitoring remain for leasehold and private forests.

Capacity to conduct research and development and apply the results

- The number of staff engaged in forestry-related R&D activities fell over the reporting period. About 635 researchers and technicians were involved in forestry and forest products R&D in 2007–08. A recent sector-wide survey estimated that this number had decreased to 396 in 2011, with the decline occurring across the public and private sectors, including state and territory governments, CSIRO and academic institutions.
- Changes in funding and delivery models by the Australian Government reduced forest-related R&D capacity across a number of national organisations, including several for which government funding or support ceased. Some of these organisations were replaced under new funding arrangements. Changes in funding and delivery models by state and territory governments generally reduced forest R&D capacity in their forest management agencies.

Indicator 7.1a

Extent to which the legal framework supports the conservation and sustainable management of forests

Rationale

This indicator outlines the support that the legal system gives to the sustainable management of forests. A legal system that ensures transparency and public participation in policy and decision-making processes supports the continuous improvements in sustainable forest management.

Key points

- All states and territories and the Australian Government have legislation to support the conservation and sustainable management of Australia's forests.
- Australia's public native forests, including those held in nature conservation reserves and those available for wood production, are governed and managed under state or territory regulatory frameworks and management plans, many of which are prescribed in legislation. Management of forests on private land is also regulated under various native vegetation Acts. Twenty-eight million hectares of forest (22% of Australia's forests) are covered by management plans relating to their conservation and sustainable management.
- Codes of forest practice vary in their legal status and coverage, but generally provide specific operational guidance for sustainable forest management practices in public and private forests available for wood production, including plantations. In Tasmania, there is a code of practice for the management of nature conservation reserves, including forested nature conservation reserves.
- Legislation covering carbon credits (the Carbon Farming Initiative) and illegal logging was introduced at the national level in 2011 and 2012, respectively.

This indicator provides an overview of the support that the regulatory framework provides for the conservation and sustainable management of Australia's forests. An effective framework of legislation and legal mechanisms ensures transparency in land ownership, management planning and operational implementation, and enables public participation and the inclusion of Indigenous perspectives in policy development and decision-making processes. An effective regulatory framework also promotes continuous improvement in the sustainable management of forests across tenures.

Legislation

In Australia, primary responsibility for land management, including forest management, lies at the state and territory level, while the Australian Government also has certain powers and responsibilities at the national level. All states and territories have Acts, and dependent Regulations, that are designed to ensure the conservation and sustainable management of forests. Some of this legislation is administered jointly by, and requires coordination between, state or territory and local governments, statutory authorities and regional management authorities. In the states and territories, comprehensive legislative provisions cover planning and review, public participation, and the regulation of forest management activities in multiple-use public forests, public nature conservation reserves and, to a lesser extent, private and leasehold forests. Table 7.1 lists examples of major pieces of legislation at the national and state and territory levels relating to the conservation and sustainable management of Australia's forests.

Table 7.1: Major pieces of legislation relating to the conservation and sustainable management of Australia's forests, by jurisdiction, active during the SOFR reporting period 2006–11

Jurisdiction	Legislation	Purpose
National	*Environment Protection and Biodiversity Conservation Act 1999*	To provide a legal framework to protect and manage, among other things, nationally and internationally important flora, fauna, ecological communities and heritage places—defined in the Act as matters of national environmental significance.
	Regional Forest Agreements Act 2002	To give effect to certain obligations of the Commonwealth under Regional Forest Agreements, which are 20-year plans for the conservation and sustainable management of Australia's native forests in the regions in which they apply; and to provide legislative recognition of the existence and work of the Forest and Wood Products Council. The legislation also requires the establishment of a comprehensive and publicly available source of information for national and regional monitoring and reporting in relation to all of Australia's forests, to support decision-making in relation to all of Australia's forests.
ACT	*Nature Conservation Act 1980*	To protect native flora, fauna and habitats, especially threatened species; and to provide management authority for national parks and nature reserves.
	Environment Protection Act 1997	To establish an environmental duty of care in relation to water quality and other environmental pressures, and to protect soil and water quality during harvesting through the application of a pollution control licence.
NSW	*Forestry Act 1916*	To provide an adequate supply of timber and protect environmental values; and to provide for the administration, by the Environment Protection Authority, of the environment protection licence issued to Forests NSW (Note: After the end of the SOFR 2013 reporting period, the *Forestry Act 1916* was replaced by the *Forestry Act 2012* that *inter alia* established the Forestry Corporation of NSW).
	National Parks and Wildlife Act 1974	To conserve nature, including threatened species; conserve objects, places and features of cultural value; and foster public appreciation, understanding and enjoyment of nature and cultural heritage and their conservation.
	Forestry and National Park Estate Act 1998	To transfer certain state forest and other Crown lands to the national parks estate and to Aboriginal ownership, and to provide for forest agreements and integrated forestry operations approvals for licensing operations in state forests for a 20-year period.
	Native Vegetation Act 2003	To regulate the clearing of native vegetation (including trees) on private and some Crown lands, by requiring consent or compliance with a regional vegetation management plan or code of practice.
NT	*Environment Assessment Act 1994*	To provide for the assessment of the environmental effects of development proposals and for the protection of the environment.
	Territory Parks and Wildlife Conservation Act 2006	To provide for the establishment and management of parks and reserves (including sanctuaries and joint management parks or reserves), and the study, protection, conservation and sustainable use of wildlife.
Qld	*Forestry Act 1959*	To provide for forest reservations; the management, silvicultural treatment and protection of state forests; the sale and disposal of forest products and quarry material, which are the property of the Crown in state forests and timber reserves, and on other lands; and to grant exclusive rights to state plantation forests through a plantation licence.
	Nature Conservation Act 1992	To conserve nature using an integrated and comprehensive conservation strategy for the whole of Queensland.
	Vegetation Management Act 1999	To regulate the clearing of vegetation in a way that conserves remnant vegetation, conserves vegetation in declared areas, ensures that clearing does not cause land degradation, prevents the loss of biodiversity, maintains ecological processes, manages the environmental effects of clearing and reduces greenhouse gas emissions.
SA	*Forestry Act 1950*	To provide for the creation, management and protection of state forest reserves, including the conservation, development and management of native forest reserves.
	National Parks and Wildlife Act 1972	To provide protection measures for endangered and vulnerable plants and animals, and to provide for the establishment of reserves for public benefit and recreation.
	Native Vegetation Act 1991	To preserve native vegetation, including through legislative controls on native vegetation clearance.
	Natural Resources Management Act 2004	To promote the sustainable and integrated management of the state's natural resources and make provision for the protection of the state's natural resources, including the control of significant plantation water use through licensing or a forest permit system.

continued overleaf

Table 7.1: Major pieces of legislation relating to the conservation and sustainable management of Australia's forests, by jurisdiction, active during the SOFR reporting period 2006–11 continued

Jurisdiction	Legislation	Purpose
Tas.	*Forestry Act 1920*	To establish a forestry corporation with a commitment to sustainable forest management and multiple use, and to provide for the better management and protection of forests.
	Forest Practices Act 1985	To establish the *Forest Practices Code* and forest practices system to provide for the sustainable management of forests on any land subject to forest operations; and to enable the establishment of private timber reserves on private land to provide security of long-term forestry use for landowners.
	Nature Conservation Act 2002	To provide for the declaration of national parks and other reserved land, and set out the values and purposes of each reserve class with respect to the conservation and protection of fauna, flora and geological diversity.
	National Parks and Reserves Management Act 2002	To provide for the management of national parks and reserves under the *Nature Conservation Act 2002*, according to management objectives for each reserve class.
Vic.	*Forests Act 1958*	To consolidate the law for the management and protection of state forests, including timber harvesting and fire management; and to require that timber harvesting complies with a code of practice.
	National Parks Act 1975	To provide a framework for the establishment and management of national parks, and to make provision for certain other parks, including harvesting in selected parks.
	Conservation, Forests and Lands Act 1987	To provide a framework for a land-management system and to make necessary administrative, financial and enforcement provisions.
	Flora and Fauna Guarantee Act 1988	To provide the framework for the conservation of threatened species and ecological communities and management of processes threatening Victoria's native flora and fauna.
	Sustainable Forests (Timber) Act 2004	To provide a framework for sustainable forest management and sustainable timber harvesting in state forests.
WA	*Conservation and Land Management Act 1984*	To make provision for the use, protection and management of certain public lands and waters, and their flora and fauna, and to establish responsible authorities.
	Environmental Protection Act 1986	To provide for the assessment of the environmental impacts of forest management proposals, and to allow the minister to set conditions on implementation of proposals to moderate adverse impacts; and to provide offences for unlawful environmental harm, including the clearing of native vegetation.

Source: State, territory and Australian Government agencies.

Table 7.2: Examples of management plans prescribed in legislation for the conservation and sustainable management of Australian forests

Plan	Purpose	Coverage
Management plans for all national parks	To provide a framework of objectives, principles and policies to guide the long-term management of the broad range of values contained in national parks.	All state, territory and nationally managed national parks.
NSW's regional Ecologically Sustainable Forest Management Plans	To publicly document the broad strategies, ecological principles, performance indicators and measurable outcomes for forest management.	NSW state forests or other Crown timber lands covered by Regional Forest Agreements.
South Australia's State Natural Resources Management Plan	To establish direction for South Australia in its management of natural resources by providing the framework for regional Natural Resource Management (NRM) boards working with state government agencies to develop regional NRM plans and programs.	Statewide natural resources in South Australia.
South Australia's regional Natural Resource Management Plans	To set the direction for NRM in each region to improve the management of regional natural resources.	Region-by-region natural resources in South Australia.
Victoria's regional Forest Management Plans	To ensure that state forest is managed in an environmentally sensitive, sustainable and economically viable manner, while being responsive to changing community expectations and expanding knowledge of the forest ecosystem.	State forests in Victoria's 12 Forest Management Areas.
Western Australia's *Forest Management Plan 2004–2013*	To set out the actions to be taken to conserve biodiversity; sustain the health, vitality and productive capacity of ecosystems; and produce the social, cultural and economic benefits valued by the community, taking account of the principles of ecologically sustainable forest management.	Forests on public land in the south-west that is vested in the Conservation Commission of Western Australia.

Source: State, territory and Australian Government agencies.

Management plans and codes of practice

Australia's public native forests, including those held in nature conservation reserves and those available for wood production, are governed and managed under state or territory regulatory frameworks and management plans, many of which are prescribed in legislation. Only a small number of nature conservation reserves are governed and managed by the Australian Government under Commonwealth legislation and management plans prescribed in that legislation. Australia's publicly managed plantation forests are also governed and managed under state or territory regulatory frameworks and management plans. Management plans provide guidance for sustainable forest management practices. Examples of management plans prescribed in legislation for the conservation and sustainable management of forests are listed in Table 7.2 and described in Case study 7.1.

Twenty-eight million hectares (22% of Australia's forests) are covered by management plans relating to their conservation and sustainable management (Table 7.3). A forest area with a management plan is an area for which there is a long-term, documented and periodically reviewed management plan containing defined management goals. Management plans can take many forms, such as the examples listed in Table 7.2, as well as natural resource, environment and water catchment management plans that cover forests, and the strategic management planning systems required for forest certification.

Case study 7.1: Forest Management Plans in Western Australia

The Conservation Commission of Western Australia is the controlling body in which Western Australia's terrestrial conservation estate is vested, including national parks, conservation parks, nature reserves, state forests and timber reserves.

Under Western Australia's *Conservation and Land Management Act 1984*, the public forests in the south-west of Western Australia are managed according to a forest management plan (FMP). The FMPs provide a framework for managing these forest areas for a range of environmental, social and economic uses. The plans are based on a modified set of Montreal Process criteria of sustainability as the framework for identifying management actions in line with the principles of ecologically sustainable forest management. The criteria used are conservation of biodiversity, maintenance of productive capacity, maintenance of ecosystem health and vitality, conservation and maintenance of soil and water, maintenance of forests' contribution to the global carbon cycle, maintenance of heritage and maintenance of socio-economic values (CCWA 2004).

The Conservation Commission's overall objectives in formulating Western Australia's *Forest Management Plan 2004–2013* were for biodiversity to be conserved; the health, vitality and productive capacity of ecosystems to be sustained; and the social, cultural and economic benefits valued by the community to be produced in a manner that takes account of the principles of ecologically sustainable forest management. Western Australia's Department of Environment and Conservation[157] and the Forest Products Commission managed the land to which the FMP applied. A new FMP is being developed for the period January 2014 to December 2023.

Source: CCWA (2004).

The forest management plan for 2004–2013 for Western Australia.

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[157] From July 2013, the Department of Parks and Wildlife.

Table 7.3: Area of Australia's forests covered by a management plan

	Area ('000 hectares)								
Areas by plan type	**ACT**	**NSW**	**NT**	**Qld**	**SA**	**Tas.**	**Vic.**	**WA**	**Australia**
Forest area with a management plan	113	6,028	3,479	4,696	1,038	2,277	6,265	3,863	27,758
primarily conservation[a]	109	4,424	3,160	1,001	837	1,420	3,952	2,344	17,249
primarily production[b]	0	1,539	15	2,242	167	841	1,201	1,226	7,231
multiple or other values[c]	4	66	303	1,452	34	16	1,111	293	3,279
Forest area without a management plan	25	16,653	11,735	46,340	3,527	1,429	1,925	15,359	96,994
Total	**138**	**22,681**	**15,214**	**51,036**	**4,565**	**3,706**	**8,190**	**19,222**	**124,752**

a 'Primarily conservation' includes forest areas in the Collaborative Australian Protected Areas Database (CAPAD) covered by existing management plans, certified forests zoned for biodiversity conservation, and forest areas managed by the Department of Defence zoned for biodiversity conservation.

b 'Primarily production' includes net harvestable area of multiple-use public native forests covered by existing management plans or certification, and areas of plantation (Industrial plantations and Other forest) that are certified.

c 'Multiple or other values' includes forest areas covered by either a management plan or certification and not allocated to either of the previous two categories, plus forest areas managed under a water or natural resources management plan, plus forest areas managed by the Department of Defence.

Source: State, territory and Australian Government agencies, including the Australian Government Department of Sustainability, Environment, Water, Population and Communities (CAPAD 2010) and Department of Defence; includes data updated for Qld and the ACT (Table 7.12 in Indicator 7.1d), ABARES data, and publicly accessible data on Australian certified forests from Australian Forestry Standard Ltd (www.forestrystandard.org.au) and Forest Stewardship Council (http://info.fsc.org).

Codes of practice provide specific guidance for sustainable forest management practices in wood production forests. The codes cover a range of issues, such as forest planning; forest access and roading; forest harvesting; the conservation of non-wood values; pest, weed and fire management; and the harvesting of non-wood forest products. Codes of forest practice vary in their legal status and coverage. In Tasmania and Victoria, codes are prescribed in legislation, and cover public and private native and plantation production forests. In New South Wales, the *Forest Practices Code* is backed by legislation, and covers native and plantation production forests managed by Forests NSW[158]. In August 2007, a *Private Native Forestry Code of Practice* came into effect in New South Wales under the state's *Native Vegetation Act 2003*. This code establishes a regulatory framework for the sustainable management of private native forests by ensuring that operations improve or maintain environmental outcomes. It is reviewed periodically as part of a statutory review process.

In the Australian Capital Territory, Queensland and Western Australia, codes of forest practice on public land are prescribed at the agency level only. In Queensland, the *Code Applying to a Native Forest Practice on Freehold Land* allows for commercial wood production in private native forests while satisfying the purposes of the state's *Vegetation Management Act 1999*.

Plantation codes of practice are referred to in Regulations concerning the export of unprocessed plantation wood under the *Export Control Act 1982*. Under this Act, the Export Control (Unprocessed Wood) Regulations provide for the removal of the requirement for licensing of exports of some plantation-sourced wood. Such a decision can be made by the minister, subject to a satisfactory assessment of a state or territory's plantation forestry code of practice against the National Plantation Principles.[159] Under the Regulations, a plantation code of practice covers the establishment, management and harvesting of all plantations in a state or territory, whether or not these practices are contained in a single document. All state and territory plantation codes of practice were assessed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) between late 2010 and 2012.[160]

Tasmania is the only Australian jurisdiction with a code of practice for the management of nature conservation reserves. The *Tasmanian Reserve Management Code of Practice* (2003) complements other forest management codes of practice, including the Tasmanian *Forest Practices Code 2000*. It provides information and guidance for best-practice operational standards for activities in the state's nature conservation reserves. It applies to all land-based reserves managed under the *National Parks and Reserves Management Act 2002*, forest reserves managed under the *Forestry Act 1920*, and certain public reserves managed under the *Crown Lands Act 1976*. The code applies to reserves with significant natural and cultural values that are still in a largely natural condition; it does not apply to public reserves that have been highly modified and developed, such as school grounds. The code is the result of a commitment under the 1997 Tasmanian Regional Forest Agreement to develop and implement a code of practice to cover all environmental practices in reserves.

Regional Forest Agreements

Regional Forest Agreements (RFAs) are 20-year plans for the conservation and sustainable management of Australia's native forests in the regions in which they apply. Ten RFAs were negotiated bilaterally between the Australian Government and four of the six state governments (New South Wales, Tasmania, Victoria and Western Australia), and commenced between 1997 and 2001. A map (Figure I.vi) in the Introduction shows the 10 regions to which RFAs apply.

158 From January 2013, the Forestry Corporation of NSW.

159 National Principles Related to Wood Production in Plantations, available at www.daff.gov.au/forestry/australias-forests/plantation-farm-forestry/principles or www.daff.gov.au/__data/assets/pdf_file/0007/37609/principles_wood_production.pdf.

160 Further information on the assessments is available at www.daff.gov.au/forestry/australias-forests/plantation-farm-forestry/principles.

Each RFA was the result of a Comprehensive Regional Assessment (CRA) involving substantial scientific study, consultation and negotiation, covering a diverse range of stakeholder interests. Information was gathered on the social, economic, environmental, and cultural and natural heritage values of each region's forests, and a science-based methodology was used to determine forest allocation for different uses and forest management strategies. RFAs are designed to provide stability for forest-based industries, certainty for forest-dependent communities, and conservation through a Comprehensive, Adequate and Representative (CAR) reserve system. The *Regional Forest Agreements Act 2002* gives effect to certain obligations of the Commonwealth under RFAs, including public reporting.

In addition to the 10 RFAs, a CRA was completed for south-east Queensland, but an RFA was not signed for that region. The Queensland Government, industry and environmental groups developed a South East Queensland Forest Agreement, although this is not recognised as an RFA by the Australian Government.

Under the *Regional Forest Agreements Act 2002*, five-yearly RFA reviews reporting the performance of each RFA are to be tabled in the Australian Parliament by the Australian Government minister with responsibility for forestry. The first and second five-yearly reviews have been undertaken for the Tasmanian RFA, with the second completed in 2008. The first and second five-yearly reviews for the five Victorian RFAs were conducted as a combined review between 2009 and 2010. The first five-yearly review for the three New South Wales RFAs was conducted in 2009.

As part of the third five-yearly review of each RFA, the state concerned and the Australian Government will jointly determine the process for extending the agreement beyond 20 years. The 20-year periods of the 10 RFAs expire between 2017 and 2021.

In addition, two sets of regulations made under the *Export Control Act 1982*—the Export Control (Hardwood Wood Chips) Regulations 1996 and the Export Control (Regional Forest Agreements) Regulations—provide for the unlicensed export of wood and wood chips sourced from native forests in a region covered by an RFA.

Environment Protection and Biodiversity Conservation Act 1999

Australia's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which came into effect in July 2000, applies to matters of national environmental significance, such as World Heritage properties and Natural Heritage places, wetlands of international importance, nationally listed threatened species and ecological communities, internationally listed migratory species, water resources and Commonwealth marine areas.

The EPBC Act only refers specifically to forests in relation to RFAs. Part 4, Division 4, section 38(1) states that 'Part 3 does not apply to an RFA forestry operation that is undertaken in accordance with an RFA'. This provision recognises that RFAs have already met the normal requirements for assessment and approval of operations, as a result of the CRAs of conservation values that were undertaken before each RFA was signed. RFAs therefore provide an equivalent level of protection to that provided by Part 3 of the EPBC Act. The requirements for assessment and approval under the EPBC Act apply to forests outside an RFA region.

An independent review of the EPBC Act was undertaken by Dr Allan Hawke in 2009. Among other things, this review recommended 'that the current mechanisms contained in the Act for RFA forest management be retained, but be subject to rigorous independent performance auditing, reporting and sanctions for serious non-compliance' (DEWHA 2009c). In its response to the independent review, the Australian Government stated that it 'remains committed to RFAs as an appropriate mechanism for effective environmental protection, forest management and forest industry practices in regions covered by RFAs', and that it was also 'committed to working with state governments to improve the review, audit and monitoring arrangements for RFAs' (DSEWPaC 2011).

Illegal logging

The *Illegal Logging Prohibition Act 2012* was passed by the Australian Parliament and came into effect in November 2012. The Act aims to support the trade in legally harvested wood and wood products by giving consumers and businesses greater certainty about the legality of the wood products they purchase.

The Act prohibits the importation of illegally logged timber and the processing of domestically grown raw logs that have been illegally logged. Criminal penalties apply for contraventions of the Act.

The Illegal Logging Prohibition Amendment Regulation 2013 that supports the Act was developed with stakeholders and was tabled in the Australian Parliament on 3 June 2013. The Regulation, which will commence on 30 November 2014, prescribes due diligence requirements to minimise the risk of sourcing illegally logged wood, and lists the wood products subject to those requirements. The due diligence requirements are intended for importers of the listed wood products and processors of domestically grown raw logs.

Carbon farming initiative

The *Carbon Credits (Carbon Farming Initiative) Act 2011* was passed by the Australian Parliament in August 2011. The Carbon Farming Initiative (CFI) commenced in December 2011, and is designed to provide economic opportunities for farmers, forest growers and landholders, while reducing greenhouse gas emissions and storing carbon in the landscape. Farmers and land managers can potentially gain benefits through a range of activities under the CFI, including avoided deforestation, improved forest management, reforestation and revegetation.

Indicator 7.1b

Extent to which the institutional framework supports the conservation and sustainable management of forests

Rationale

This indicator examines the institutional frameworks that support sustainable forest management. Institutional frameworks provide mechanisms for engagement of the wider community in the process of continuous improvement and sustainable forest management.

Key points

- A well-established policy framework, guided by a *National Forest Policy Statement*, supports the conservation and sustainable management of Australia's forests, both nationally and at state and territory levels.
- Codes of forest practice and externally accredited environmental management systems are used by forest managers to provide a structured approach to the planning and management of protection of the environment.
- A full range of training and education qualification options continues to be available in Australia across all areas relevant to sustainable forest management. Despite this, the number of students entering and graduating from forestry-specific university degrees has declined, and there are ongoing shortages in skilled workers across Australia's forest industry.
- In 2011, about 10.7 million hectares of native forests and plantations were certified for forest management under either the Australian Forest Certification Scheme or the Forest Stewardship Council scheme. Some forest areas have been certified under both schemes.

Australia's forest policy framework

The management of Australia's forests is guided by a *National Forest Policy Statement* (Commonwealth of Australia 1992), which was signed by the Australian Government and all mainland state and territory governments in December 1992 and by the Tasmanian Government in April 1995. The statement outlines 11 broad national goals (see Introduction, Box 1.i). The three goals that are most relevant to this indicator are integrated and coordinated decision making and management; employment, workforce education and training; and public awareness, education and involvement. Through this statement and other regulatory mechanisms, Australia's national, state and territory governments are committed to the sustainable management of all Australia's forests, whether the forest is on public or private land, or within a conservation reserve or a production forest.

At the national level, the Standing Council on Primary Industries (SCoPI) was launched by the Council of Australian Governments in September 2011 as part of a new ministerial council system. SCoPI subsumed parts of two previous ministerial councils: the Primary Industries Ministerial Council and the Natural Resource Management Ministerial Council. SCoPI is supported by the Primary Industries Standing Committee, which in turn is supported by the Productivity and Regulatory Reform Committee and its subcommittee the Forestry and Forest Products Committee (FFPC), to coordinate and facilitate forest policy and planning, and their review, across Australia's states and territories. These committees consist of representatives from the Australian Government and each state and territory government. The FFPC provides a significant forum for government agencies responsible for sustainable forest management to consider national issues relevant to forests and forestry.

Most of the state and territory government organisations and agencies that are responsible for forest management operate under long-term national and state or territory frameworks that relate to sustainable management of Australia's forests. Table 7.4 lists the major non-legislative policies, strategies and charters that influence the sustainable management of Australia's forests, by jurisdiction. The extent to which these arrangements provide for sustainable forest management—through forest management planning, and public and Indigenous participation—varies among states and territories. Generally, these arrangements are accommodated in management of public forests (except those under leasehold), but to a lesser extent in management of private and leasehold forests.

Much of Australia's privately owned production native forests and plantation forests are owned and/or managed by large organisations. These organisations also operate under forest management systems, using policies, guidelines, protocols and other instruments that promote the sustainable management of forests and the engagement of the wider community. Their policies are stated publicly and generally relate to sustainability, forest stewardship and environmental awareness. These policies guide private organisations in their forest management planning and practices, and establish responsibility and accountability to the public for the forests that the organisations manage. Frequently, the policies and the management practices they underpin form the basis for certification of forest lands by independent certification bodies.

Public participation and awareness

In addition to those prescribed in legislation, Australia has well-established non-legislative mechanisms for public participation and for raising awareness of forest management planning. These mechanisms include the provision of information on forest resources, impacts, uses and values; discussion papers on alternative plans; invitations to provide comment or written submissions; and discussion forums and public meetings.

The *National Forest Policy Statement* (Commonwealth of Australia 1992) calls for public awareness and involvement in the management of Australia's public forests through consultation processes and the availability of forest

Table 7.4: Major non-legislative policies, strategies and charters that influence the sustainable management of Australia's forests, June 2011

Jurisdiction	Non-legislative policy, strategy or charter	Purpose
National	*National Forest Policy Statement 1992*	Outlines agreed objectives and policies for Australia's public and private forests, based on 11 national goals to be pursued within a regionally based planning framework that integrates environmental and commercial objectives so that provision is made for all forest values.
	Plantations for Australia: the 2020 Vision	Seeks to enhance regional wealth creation and international competitiveness through a sustainable increase in Australia's plantation resources.
	National Indigenous Forestry Strategy 2005	Encourages Indigenous participation in the forest industry and contributes to the overall sustainable development of Indigenous land and communities, addressing areas such as natural resource management, business development, cultural heritage, education, employment and training.
	Australia's Biodiversity Conservation Strategy 2010–2030	Provides a guiding framework for conserving Australia's biodiversity over the coming decades for all sectors—government, business and the community.
	Australia's Strategy for the National Reserve System 2009–2030	Provides national guidance for improved cross-jurisdictional coordination, and supports collaborative action by protected area managers and key stakeholders to enhance the National Reserve System.
	Farm Forestry National Action Statement 2005	Outlines the objectives and actions agreed by the Australian, state and territory governments and the forest and wood products industry to develop farm forestry.
	The Australian Forestry Standard for Forest Management (AS 4708-2007)	Provides criteria and requirements which allow a forest manager to demonstrate sustainable forest management through independent, accredited, third-party certification.
ACT	*ACT Nature Conservation Strategy* 1998	Provides a framework for a coordinated and strategic approach to protection of biological diversity and the maintenance of underpinning ecological processes.
	ACT Lowland Woodland Conservation Strategy (Action Plan No. 27)	Seeks to maintain and improve the natural integrity of remaining lowland woodland ecosystems, including encouraging community participation in the conservation of lowland woodland and component species.
NSW	*Forests NSW*[a] *Forest Management Policy*	Provides a commitment to sustainably manage the forest estate of Forests NSW and the supply of timber to the community, in conjunction with a range of environmental, social and economic benefits.
	Farm Forestry Strategy for NSW 2003	Aims to build a vision for the future of farm forestry in New South Wales.
NT	*Northern Territory Agribusiness Industry Strategy 2011–2015*	Provides an overarching strategy for the future development of the Northern Territory's animal and plant industries.
	Territory 2030 Strategic Plan	Provides a framework for the government's strategic plans and policy initiatives, including the management of natural resources according to the principles of ecologically sustainable development.

continued overleaf

CRITERION 7

Table 7.4: Major non-legislative policies, strategies and charters that influence the sustainable management of Australia's forests, June 2011 continued

Jurisdiction	Non-legislative policy, strategy or charter	Purpose
Qld	DERM Forest Products[b] *Forest Management Policy Statement*	Provides a commitment to a range of measures, including the responsible management of state land allocated to native forest production.
	Statewide Forest Process[c]	Aims to progressively pursue solutions for management and industry development of state-owned native forest.
	Queensland Timber Plantation Strategy 2020[c]	Articulates the Queensland Government's policy objective of securing sustainable growth in the timber plantation sector to deliver a range of economic, social and environmental benefits
	Building Nature's Resilience: A Biodiversity Strategy for Queensland	Establishes policy directions for conserving the state's biodiversity, covering the marine, freshwater and terrestrial environments.
SA	*Forest Industry Strategy: Vision 2050 Strategic Directions 2011–2016*	Sets out a vision and targets, articulates key directions and strategies, and identifies major opportunities for industry to work with government and the community to strengthen the development of a sustainable future for the forest industry in South Australia.
	ForestrySA Policy for Sustainable Forest Management	Provides for a commitment to sustainable forest management, a safe environment for employees, and compliance with relevant legislative requirements, standards and codes.
	No Species Loss: A Nature Conservation Strategy for South Australia 2007–2017	Promotes strategic and creative thinking by government, industry and urban, rural and Indigenous communities about how best to achieve biodiversity conservation and sustainable management in South Australia.
Tas.	*Permanent Native Forest Estate Policy*	Sets minimum levels of native forest for the maintenance of a permanent native forest estate by forest communities at both the bioregional and state levels.
	Forestry Tasmania's *Sustainable Forest Management Policy and Sustainability Charter* (*Forest Management Plan 2008*)	Provides a commitment to continual improvement and to ensuring that the forest resource is managed sustainably through practices that are environmentally sound, socially acceptable and economically viable.
Vic.	*2009 Timber Industry Strategy*[d]	Provides a framework and long-term direction for the Victorian timber industry for the next 20 years.
	Sustainability Charter for Victoria's State Forests	Sets objectives for the sustainability of public native forests and of the timber harvesting industry on public land in Victoria, and promotes community involvement in how state forests are managed to enhance their diverse values and uses.
	Environmental Sustainability Framework	Establishes three fundamental directions to drive environmental sustainability in Victoria: maintaining and restoring natural assets, using resources more efficiently, and reducing everyday environmental impacts.
WA	Forest Products Commission *Forest Management Policy*	Commits the Forest Products Commission to ensuring that renewable timber resources are managed sustainably through the implementation of forest management practices that are environmentally sound, socially acceptable and economically viable.
	Western Australia's Strategy for Plantations and Farm Forestry: 2008–2012	Aims to ensure that the forestry industry is well placed to contribute to Western Australia's environmental and economic sustainability.

[a] In January 2013, Forests NSW became a state owned corporation, the Forestry Corporation of New South Wales.

[b] In April 2012, the roles performed by the Queensland Department of Environment and Resource Management (DERM) were transferred to a number of agencies. The role of DERM Forest Products was transferred to the newly formed Queensland Department of Agriculture, Fisheries and Forestry.

[c] The Statewide Forest Process in Queensland was discontinued in March 2012. In December 2012, the Forest and Timber Industry Plan Working Group, comprising representatives from Timber Queensland, other industry stakeholders and the Queensland Department of Agriculture, Fisheries and Forestry, released the *Queensland Forest and Timber Industry Plan*. The Queensland Government response to this plan is being developed and may supercede the *Queensland Timber Plantation Strategy 2020*.

[d] In December 2011, the Victorian Government released the *Timber Industry Action Plan* (TIAP), which builds on the *2009 Timber Industry Strategy*. TIAP actions are designed to provide the conditions for a productive, competitive and sustainable Victorian timber industry.

Source: Australian Government Department of Agriculture, Fisheries and Forestry; Australian Government Department of Sustainability, Environment, Water, Population and Communities; state and territory agencies.

Children participating in forest learning activities.

information. Accordingly, all public forest management agencies publish forest-related information, such as annual reports and technical papers on research and matters of interest. At the national level, the Australian Government coordinates *Australia's State of the Forests Report* and the *Australia State of the Environment* report, which provide periodic status updates based on available information. The Australian Government also maintains the Forests Australia website[161], which contains up-to-date information about Australia's forests. Some states and territories publish their own state of the forests (or equivalent) reports (see Indicator 7.1d).

Some state and territory agencies responsible for forest management also run forest education and awareness programs:

- The Cumberland Forest Visitor Centre in Pennant Hills, a suburb of Sydney, New South Wales, provides an extensive school holiday and activities program, along with a forest school education program and the opportunity to participate in its volunteer program (see Case study 6.5).
- The Australian Forest Education Alliance, a network of forest educators and forestry communication specialists across Australia covering government, industry and other organisations, maintains a website that provides school teachers, educators, children and the public with information on Australian forests and forest-based products, and access to forestry teaching resources. It is supported by links to key government and industry organisations and educational service providers.
- The Forest Education Foundation, based in Tasmania, aims to develop community knowledge and understanding of forest environments and their management, forest products and their processing, and human interaction with forest environments.
- The Toolangi Forest Discovery Centre in Victoria was established in 1994, and offered programs for primary, secondary and tertiary students, as well as programs for community groups such as U3A (University of the Third Age), Probus and international visitor groups. The centre closed in 2012.
- As an example of a specific program, between 2009 and 2012 Victoria's Department of Sustainability and Environment and Parks Victoria staff hosted a Biodiversity Campout at Warby–Ovens National Park in Victoria's north-east. This free community event showcased local wildlife, native flora, forest ecosystems and Indigenous cultural heritage through a range of interactive activities, including learning about plants and the forest ecosystem, and the importance, uses and value of forests.

Indigenous community participation and awareness

Raising awareness and increasing Indigenous community participation in forest management is encouraged as a key aim of the National Indigenous Forestry Strategy (see also Indicator 6.4c). The strategy specifically encourages Indigenous community participation in the forest and wood products industry by forming business partnerships that provide long-term benefits to Indigenous communities and to the forest and wood products industry. The first step is raising awareness in Indigenous communities of the possibilities for participation in the forest and wood products industry. This is to be accomplished through regional planning forums and networks, which are intended to bring together Indigenous communities, industry and all levels of government.

Forest practice codes and systems, and monitoring of compliance

The monitoring of compliance with forest management codes of practice, and with the regulatory framework deriving from state and territory legislation, is generally conducted by regionally based officers and field staff within an agency that has responsibility for enforcement and compliance. The highest levels of monitoring occur for wood harvesting in Australia's multiple-use public forests.

State agencies responsible for wood production from native forests give high priority to compliance with legislation, regulations and codes of practice in their management of multiple-use public forests. Accordingly, compliance is generally high. In addition, most of these agencies are externally regulated.

Forests NSW[162] has legal instruments in place to monitor and penalise operators, contractors or forest visitors in cases of non-compliance, and is externally regulated by the NSW Office of Environment and Heritage, the main compliance monitoring body in New South Wales.

161 http://daff.gov.au/forestsaustralia/.
162 From January 2013, the Forestry Corporation of NSW.

The Office of Environment and Heritage, which works with the Environment Protection Authority (EPA), has wide monitoring and compliance responsibilities under the NSW *Native Vegetation Act 2003* (see Case study 7.2), while under the *Forestry Act 2012* the EPA administers NSW Forestry Agreements and Integrated Forestry Operations Approvals (IFOAs) that were established under the *Forestry and National Park Estate Act 1998*. The results of compliance audits are tabled annually in the New South Wales Parliament. Forests NSW also undergoes independent external auditing for compliance with the Australian Forestry Standard (AS 4708-2007) and environmental management systems (ISO 14001:2004).

Tasmania's forest practices system operates with the objective of achieving sustainable management of public and private forests, with due care for the environment, and includes Tasmania's *Forest Practices Code 2000*. The forest practices system was set up through the *Forest Practices Act 1985*. Tasmania's Forest Practices Authority (FPA), an independent statutory body established under this Act, is responsible for monitoring compliance under Tasmania's forest practices system, and taking appropriate enforcement action, as required. Monitoring of compliance under Tasmania's forest practices system is carried out at three levels:

1. Routine monitoring of operations is undertaken by Forest Practices Officers[163] employed by forest managers. This level of monitoring is often included in formal environmental management systems and forest certification, which also involve third-party audits.
2. Formal reporting on compliance is required for all Forest Practices Plans (FPPs) under section 25A of the *Forest Practices Act 1985*. This is performed by Forest Practices Officers.
3. Independent monitoring of a representative sample of FPPs, in accordance with section 4E(1)(b) of the *Forest Practices Act 1985*, is performed annually by the FPA (FPA 2011).

In Victoria, the Department of Sustainability and Environment (DSE)[164] was the environmental regulator responsible for conducting audits of commercial wood harvesting activities in Victoria's state forests from 2008. A previous forest audit program was administered by the Victorian Environment Protection Authority from 2003 to 2007. The current process covers harvesting operations managed by VicForests in eastern Victoria, and harvesting operations managed by the Department of Primary Industries (DPI)[165] in other parts of the state. DSE had the responsibility for ensuring that all wood harvesting operations were undertaken in compliance with relevant legislation and with Victoria's *Code of Practice for Timber Production 2007*. Compliance is required under the *Sustainable Forests (Timber) Act 2004*.

The current Victorian forest audit program was developed in 2009 and finalised in 2010. It is designed to allow for the independent examination of a range of activities associated with wood harvesting. The audit program is based on seven modules—two overview modules and five modules structured around the elements of the forest production lifecycle: tactical planning, operational planning, harvesting and closure, harvesting performance, and regeneration and finalisation. The audit program also aims to assess the effectiveness the state's regulatory framework and the effectiveness of the DSE as the regulator.

In Western Australia, the means for monitoring compliance in forest management is prescribed in the *Forest Management Plan 2004–2013*, which is prepared under the *Conservation and Land Management Act 1984* for land vested in the Conservation Commission of Western Australia. Under the plan, the Western Australian Department of Environment and Conservation and the Forest Products Commission, in consultation with the Conservation Commission, develop an annual audit program to monitor the extent to which land to which the plan applies is managed in accordance with the plan.

The Conservation Commission of Western Australia also undertakes independent audits to assist it in assessing the extent to which land to which the plan applies is managed in accordance with the plan. In auditing, it gives priority to assessing, among other things:

- management of old-growth forest in informal reserves
- protection of stream zones and less well reserved vegetation complexes
- selection and management of fauna habitat zones
- dieback hygiene
- protection of significant flora and understorey species
- soil management.

Cradle Mountain as seen across Lake Lilla, Cradle Mountain–Lake St Claire National Park, Tasmania.

163 The FPA accredits Forest Practices Officers, who have legislative authority under the *Forest Practices Act 1985* to undertake compliance and enforcement activities across all tenures under the Act or the *Forest Practices Code 2000*.

164 From April 2013, the Department of Environment and Primary Industries (DEPI).

165 From April 2013, the Department of Environment and Primary Industries (DEPI).

Case study 7.2: Monitoring and compliance of forest management in New South Wales

Monitoring and compliance of native vegetation management in New South Wales

The New South Wales Office of Environment and Heritage (OEH) is responsible for promoting, monitoring and enforcing compliance with the New South Wales *Native Vegetation Act 2003*, a key piece of legislation protecting native vegetation in New South Wales. Amongst other things, the *Native Vegetation Act* and Regulation require private native forestry to be conducted in accordance with the Private Native Forestry Code of Practice.

The OEH works with state government agencies, local government, industry sectors and land management groups to provide information to help the community understand and comply with the native vegetation management framework and Private Native Forestry Code of Practice. Although achieving voluntary compliance is preferable, the organisation has a regulatory obligation to monitor, investigate and respond to issues of non-compliance with the *Native Vegetation Act* and take enforcement action where serious breaches are detected.

An annual Compliance and Enforcement Report Card is available as part of OEH's annual Native Vegetation Report Card, published at: www.environment.nsw.gov.au/vegetation/reports.htm.

Monitoring and compliance of forestry operations on State forests and private land in New South Wales

Data on monitoring and compliance activities specific to forestry on State forests and private land in New South Wales from 2007–08 to 2010–11, including activities conducted by OEH and Forests NSW, are presented in Table 7.5. The guidelines for reporting non-compliance incidents (NCIs) changed after 2007–08: incidents able to be resolved within 24 hours and not relating to systematic failures were no longer recorded in the Non-Compliance Incident Reporting system. The number of NCIs reported as "Other NCI issues (e.g. safety)" decreased further in 2010-11, which can be partly attributed to better supervision and training. The very low numbers of fines and prosecutions compared to the numbers of NCIs recorded is consistent with very few of the NCIs being major incidents.

Table 7.5: New South Wales forestry monitoring and compliance, 2007–08 to 2010–11

Compliance item	2007–08	2008–09	2009–10	2010–11
Number of compliance check sheets conducted	4,720	3,998	3,764	3,407
Number of audits undertaken by regulators				
NSW OEH audits	12	11	25	28
DTIRIS (Fisheries) audits	n.r.	1	2	1
DTIRIS (Office of Private Forestry) audits	n.r.	n.r.	7	13
Number of non-compliance incidents recorded by Forests NSW supervision for corrective action				
NCIs related to soil erosion and water quality	318	28	143	135
NCIs related to flora and fauna	89	93	93	103
NCIs related to fish habitat and passage	0	0	38	67
Other NCI issues (e.g. safety)	689	434	319	72
Total	**1,096**	**555**	**593**	**377**
Number of fines (penalty infringement notices) issued to Forests NSW by regulators				
Fines relating to the *Threatened Species Conservation Act 1995*	2	1	5	1
Fines relating to the *Protection of the Environment Operations Act 1997*	2	0	0	11
Fines relating to the *Fisheries Management Act 1994*	0	0	2	2
Total	**4**	**1**	**7**	**14**
Number of prosecutions recorded against Forests NSW				
Prosecutions under the *Threatened Species Conservation Act 1995*	0	0	0	1
Prosecutions under the *Protection of the Environment Operations Act 1997*	0	0	0	0
Prosecutions under the *Fisheries Management Act 1994*	0	0	0	0
Total	**0**	**0**	**0**	**1**

DTIRIS = New South Wales Department of Trade and Investment, Regional Infrastructure and Services (also known as NSW Trade & Investment); NCI = non-compliance incident; n.r. = not recorded; NSW OEH = New South Wales Office of Environment and Heritage

Source: Forests NSW (2011).

The Conservation Commission of Western Australia undertakes comprehensive mid-term and end-of-term audits of the extent to which land to which the *Forest Management Plan 2004–2013* applies has been managed in accordance with the plan. This includes consideration of the extent to which key performance indicator targets have been achieved.

Monitoring of the management of nature conservation reserves, recreational use of public lands, and native forest harvesting on private lands in New South Wales, Queensland, Tasmania and Victoria is generally less extensive than monitoring for multiple-use public forests. However, stringent monitoring and compliance controls are exercised under legislated codes of forest practice. The exception is Tasmania, which is the only state or territory with a code of practice for the management of nature conservation reserves—the *Tasmanian Reserve Management Code of Practice* (2003) (see Indicator 7.1a). Enforcement of legislation and regulations on reserved land in Tasmania is primarily conducted by authorised officers in the Tasmanian Parks and Wildlife Service, who coordinate compliance activities throughout the state with respect to breaches of legislation on reserved land.

Human resources and education

A full range of options for training and educational qualification continues to be available in Australia across all areas relevant to sustainable forest management. The levels of training and education available include operational competency certificates, coursework certificates and diplomas, and graduate and postgraduate degrees.

However, while the range of qualification options remains available, there has been a significant reduction in the availability of forestry-specific undergraduate university degrees, and a greater emphasis on broader natural resource management degrees, some of which contain forestry-related units.

Tertiary education

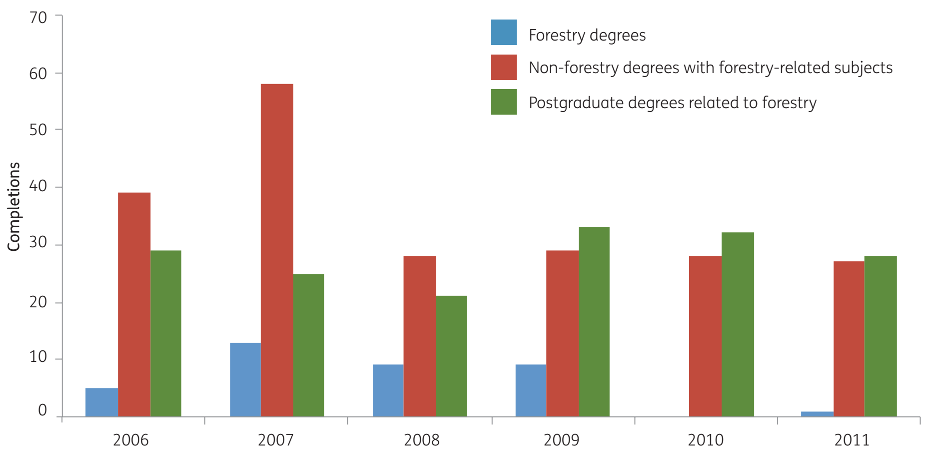
Since 2007, undergraduate degrees in forestry have closed at two of Australia's leading universities, and only Southern Cross University (based in Lismore, NSW) continues to offer a dedicated undergraduate forestry degree in 2012. This change has been partly driven by the steady decline in undergraduate enrolments in forestry degrees in the past decade or so, which has also resulted in a decline in forestry degree graduates (Figure 7.1). Another factor in the closure of undergraduate forestry degrees was the relatively high cost of field-based teaching, which is unsustainable at lower levels of enrolment.

Forestry-related subjects remain available in some undergraduate degrees in sustainable resource management, environmental science and agricultural science. In some of these degrees, graduates who complete specific forestry subjects are able to obtain professional recognition as qualified forest managers. These degrees and postgraduate degrees (including graduate diplomas) continued to deliver graduates in forestry-related study areas (Figure 7.1).

Broader study areas outside forestry-specific degrees and courses also contribute to delivering graduates who gain employment in areas of forest management beyond the forestry industry. For example, Table 7.6 shows the completion levels for a range of broader undergraduate degrees in South Australia that may lead to employment in forest management. These completion levels have remained relatively steady over time.

Despite the decline in availability of forestry-specific degrees in Australia since 2007, there has been an increase in the demand for qualified professional foresters over this period. The domestic shortfall in graduates with professional forestry and related qualifications over this period has been largely filled through the recruitment of suitably qualified international graduates, particularly from New Zealand and South Africa (de Fégely 2010).

Figure 7.1: Australian university forestry and forestry-related degree completions, 2006–11



Note: 'Postgraduate degrees related to forestry' includes graduate diplomas.

Source: Australian Government Department of Industry, Innovation, Science, Research and Tertiary Education, Higher Education Statistics Collection, 2012.

In 2007, a National Forestry Masters Program was instigated in Australia to provide relevant, accessible and practical training for production of professional foresters, and thus address the domestic shortfall in graduates with forestry-specific degrees. The program is offered through five Australian universities[166] and to graduates from any background, and was developed in partnership with employers, industry groups and government bodies. The forest industry has also been trying to overcome the shortage of forestry graduates through scholarships, marketing campaigns and community engagement.

Fellowships and awards provide professional development opportunities in the forest industry. The Joseph William Gottstein Memorial Trust Fund was established in 1971 as a national education trust to promote the development of Australia's forestry and forest products industry. The fellowship and award programs provided by the Gottstein Trust enable people working in the forestry and forest products industry to acquire knowledge and skills that benefit themselves, their employers and the industry as a whole. The Gottstein Forest Industry Scholarship is for undergraduate or postgraduate students studying approved courses in forestry, forest science or wood science.[167]

Vocational education and training

The ForestWorks Industry Skills Council (ForestWorks) assists in learning and skills development in the forest, wood, paper and timber products industry. ForestWorks is also contracted by the Australian Government to develop, maintain and continuously improve the Forest and Forest Products Training Package, and the Pulp and Paper Manufacturing Industry Training Package. These packages offer vocational education and training in technical qualifications, 25 at certificate level and 7 at diploma level.

National completions in vocational education and training from 2006 to 2010 (Table 7.7) demonstrate a sustained level of interest in improved skills in the workforce.

Despite the availability of training and qualification options, shortages in skilled workers and gaps in the skill level of the existing workforce have been identified across the forest industry in Australia (ForestWorks 2012b). In some regions, the shortage of skilled workers has been exacerbated by competition from the growth in demand for skilled workers in Australia's rapidly expanding mining sector. The increased reliance on plantation timber is also increasing the need for skilled workers in plantation establishment, maintenance, harvesting and timber processing.

Certification of forest management

Forest certification is the voluntary, independent assessment of forest management activities and operations in a particular area of forest against a credible standard that has criteria, requirements and indicators encompassing environmental, economic, social and cultural values. Certification schemes typically require forest management practices that are more stringent than provided for by law alone. Forest certification provides consumers, governments and enterprises with an assurance that the forest and wood products they buy are sourced from legally harvested and sustainably managed forests. It also provides for community consultation in the management of forests covered by certification.

The certification of a forest area is carried out by an accredited, third-party certification body against standards set out by a certification scheme. Two forest certification schemes

Table 7.6: University degree completions in South Australia in areas that may lead to employment in forest management, 2006–11

Degree	2006–07	2007–08	2008–09	2009–10	2010–11
Natural resource management	87	89	94	106	104
Spatial analysis	34	35	24	33	13
Environmental management	81	67	67	63	67
Environmental science (including biodiversity and conservation)	46	5	25	16	27

Source: Department of Primary Industries and Regions South Australia.

Table 7.7: National completions in vocational education and training, 2006–10

Qualification	Qualification level	2006	2007	2008	2009	2010
Forest and Forest Products	Diploma	3	2	10	12	42
	Certificate	419	309	338	324	522
Pulp and Paper Manufacturing Industry	Diploma	0	0	0	0	0
	Certificate	1	8	45	7	5
Total		**423**	**319**	**393**	**343**	**569**

Note: Figures are indicative only, because the National Centre for Vocational Education Research relies on providers to supply data.
Source: National Centre for Vocational Education Research.

166 The Australian National University, Southern Cross University, the University of Melbourne, the University of Queensland, and the University of Tasmania.

167 www.gottsteintrust.org/index.htm.

operate in Australia: the Australian Forest Certification Scheme and a scheme operated by the Forest Stewardship Council. Both have forest management standards and chain-of-custody standards. Forest management standards support sustainable forest management through a range of economic, social, environmental and cultural criteria and requirements for wood production in native and plantation forests. A chain-of-custody standard is a process for tracking wood and forest products originating in certified forests through all phases of ownership, transportation and manufacturing, from a defined forest area to the final product and delivery to the end consumer.

The certification of forest management practices expanded rapidly during the reporting period for SOFR 2008. The current reporting period has seen a steady increase in forest management area certified (Figure 7.2), from just over 9 million hectares in 2006–07 to about 10.7 million hectares in 2011[168]. There has also been a rapid increase in the number of chain-of-custody certificates issued under the Australian Forest Certification Scheme and by the Forest Stewardship Council during this time (Figure 7.3).

In addition to forest certification, most multiple-use public forests and some private forests and plantations are managed in accordance with codes of forest practice (see Indicator 7.1a), as well as environmental management systems (EMSs). EMSs are independently certified by accredited, third-party certification bodies to International Organization for Standardization (ISO) standard 14001:2004 (*Environmental Management Systems—Requirements with Guidance for Use*). An EMS under ISO 14001 is a tool for managing the impacts of an organisation's activities on the environment, and provides a structured approach to the planning and implementation of environmental protection measures. Several major private forestry companies have EMSs in place.

Chain of Custody labels on logs from forests certified under the Australian Forest Certification Scheme.

Institute of Foresters of Australia, Registered Professional Forester scheme, and Association of Consulting Foresters of Australia

Established in 1935, the Institute of Foresters of Australia (IFA) is a professional body with more than 1,350 members. Membership represents all segments of the forestry profession, including public and private practitioners engaged in many aspects of forestry, nature conservation, resource and land management, research, administration and education. The institute has developed more than 30 policies[169], representing the consensus view of Australian professional foresters on a wide range of contemporary forestry issues—these cover sustainable forest management, and the processes and practices that translate these principles into outcomes. The IFA publishes the *Australian Forestry* journal.

The Registered Professional Forester scheme is a formal registration system that offers quality assurance on forestry expertise. The scheme is administered by the IFA and is available to members and non-members of the IFA.

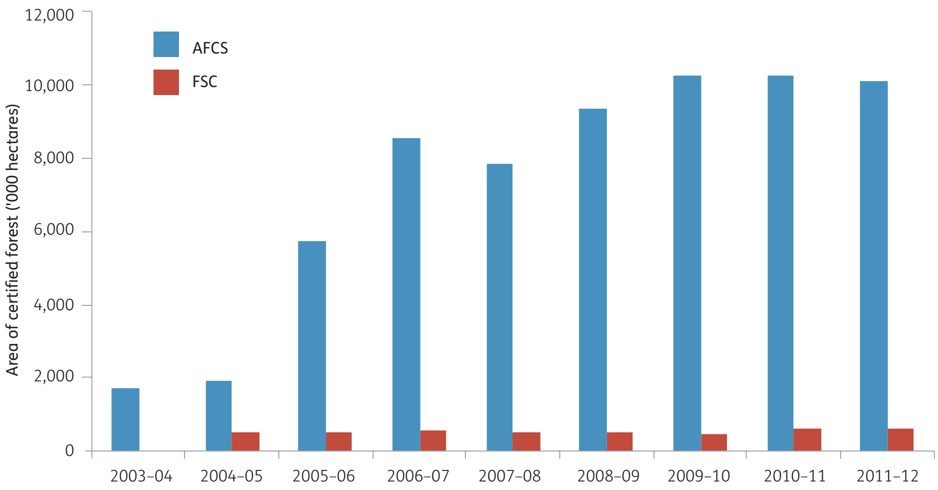
The Association of Consulting Foresters of Australia was established in 1978 in response to the need to promote and protect the credibility and competence of Australia's consulting foresters.[170] The association is now a division of the IFA.

168 The area under Forest Stewardship Council certification increased by around 342,000 hectares to 965,000 hectares in March 2012 (after the reporting period for SOFR 2013 and after the period graphed as '2011–12' on Figure 7.2), as a result of the certification of the Hancock Queensland Plantations estate.

169 www.forestry.org.au/publications/ifa-policy-statements.

170 www.forestry.org.au/consulting-foresters.

Figure 7.2: Area of certified forest management in Australia, 2003–12



AFCS = Australian Forest Certification Scheme; FSC = Forest Stewardship Council

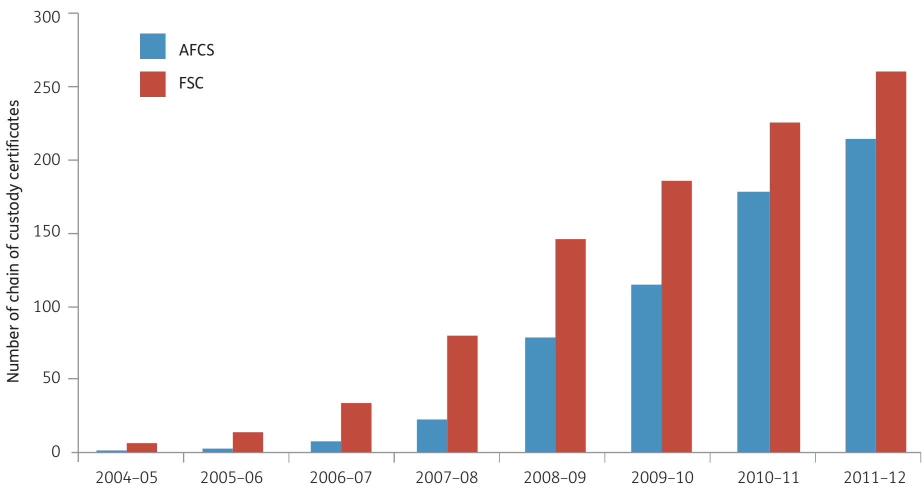
Notes:

FSC numbers are for March 2004, January 2005, February 2006, March 2007, January 2008, January 2009, January 2010, January 2011 and January 2012.

Some areas of forest have both AFCS and FSC certification.

Source: Australian Forestry Standard Limited (Australian Forest Certification Scheme), Forest Stewardship Council Australia.

Figure 7.3: Chain-of-custody certificates issued in Australia, 2004–12



AFCS = Australian Forest Certification Scheme; FSC = Forest Stewardship Council

Note: FSC numbers are for January 2005, February 2006, March 2007, January 2008, January 2009, January 2010, January 2011 and January 2012.

Source: Australian Forestry Standard Limited (Australian Forest Certification Scheme), Forest Stewardship Council Australia.

Indicator 7.1c

Extent to which the economic framework supports the conservation and sustainable management of forests

Rationale

This indicator examines the extent to which government policies support the conservation and sustainable management of forests. Government policies on investment, taxation and trade influence the level of investment in forest conservation, forest establishment and timber processing.

Key points

- The *Australia State of the Environment 2011* report assessed Australia as having effective to very effective policies relating to managing production forests and conservation reserves. Some aspects of policies relating to managing bushfires and Indigenous forest land were assessed as only partially effective.
- The value of the wood in Australia's native forest (the 'standing timber') was estimated as $1.8 billion in June 2011, and the value of plantation wood ('standing timber') as $9.5 billion. These values cannot be compared because they were calculated using different timeframes and discount rates. The monetary value of benefits from forests other than wood, such as biodiversity, carbon sequestration and soil protection, is not included in these figures, and in general is not integrated into an economic framework for forest conservation or management.
- Australia's National Competition Policy has led to several reforms that affect the competitive climate for Australian forest-based industries, including that commercial state-owned forest entities be competitively neutral with the private sector.
- Managed investment schemes have become a less important financial mechanism for plantation expansion since the global financial crisis.
- The Australian Government introduced the Carbon Farming Initiative, which allows land managers to earn carbon credits for storing carbon or reducing greenhouse gas emissions. The Australian Government has also made investments which aim to promote sustainable management of privately owned forests.

In this indicator, 'economic framework' refers to the economic commitments and policy mechanisms of governments that promote the conservation and sustainable management of forests. 'Conservation' refers to the protection of forests to allow ongoing ecosystem functions and maintain the forests' natural and cultural significance (State of the Environment 2011 Committee 2011), and 'sustainable management' refers to the use of natural resources in a way that does not adversely affect the needs and interests of future generations.

Effectiveness of the economic framework

The *Australia State of the Environment 2011* report, published by the Australian Government Department of Sustainability, Environment, Water, Population and Communities, estimated the effectiveness of government policies in promoting conservation and sustainable management in the period 2006–11. It found, overall, that understanding, planning, inputs/resources, processes, outputs and outcomes were either very effective, effective or partially effective for production forests, bushfire, conservation reserves and Indigenous-managed lands (Table 7.8). Against that background, however, was a declining level of inputs/resources, outputs and outcomes for conservation reserves, and declining inputs/resources for Indigenous-managed lands (Table 7.8).

Table 7.8: Status of understanding, planning, inputs/resources, processes, outputs and outcomes associated with conservation and sustainable management of forests, 2006–11

Category	Production forests		Bushfire		Conservation reserves		Indigenous-managed lands[a]	
Understanding	Very effective	↑	Effective	↑	Very effective	→	Effective	↑
Planning	Very effective	→	Effective	↑	Effective	↑	Partially effective	→
Inputs/resources	Effective	→	Partially effective	↑	Effective	↓	Partially effective	↓
Processes	Effective	→	Very effective	→	Very effective	→	Effective	→
Outputs and outcomes	Effective	↑	Effective	→	Effective	↓	Partially effective	↑

↑ = improving at time of assessment; → = stable at time of assessment; ↓ = declining at time of assessment

a Indigenous-managed lands in this instance refer to 'Indigenous owned and managed' and 'Indigenous managed' lands (see Indicator 6.4a and 6.4c for further information on these categories).

Source: Condensed from State of the Environment 2011 Committee (2011), pp. 348–351.

Table 7.9: Value of Australia's environmental assets

	Value ($ billion)				
Date	**Rural land**	**Subsoil oil and gas**	**Other subsoil**	**Native standing timber**	**Plantation standing timber**
June 2003	143	123.1	44.8	1.9	10.1
June 2004	178	140.7	56.7	2.0	10.1
June 2005	200	153.2	70.2	2.1	10.0
June 2006	207	173.4	114.2	2.0	9.7
June 2007	222	182.4	147.9	2.0	10.3
June 2008	243	226.0	217.0	2.0	11.6
June 2009	254	307.0	413.6	1.8	10.4
June 2010	263	280.2	388.9	1.7	9.8
June 2011	263	288.5	415.7	1.8	9.5

Notes:
'Subsoil oil and gas', and 'Other subsoil' are derived series. 'Subsoil oil and gas' is the combined value of four categories (petroleum [recoverable]—crude oil; petroleum—natural gas; liquefied petroleum gas [LPG]—naturally occurring; petroleum—condensate) presented in ABS (2012g). 'Other subsoil' is total subsoil minus 'Subsoil oil and gas'.
Figures are not adjusted for inflation.
Source: ABS (2012g).

Value of Australia's environmental assets

The value of Australia's environmental assets increased in the period 2006–11. The Australian national balance sheet recorded $10.1 trillion in assets on 30 June 2011, of which $4.4 trillion (44%) was classed as environmental assets (ABS 2012g). The values of some of these assets are listed in Table 7.9.

The Australian Bureau of Statistics (ABS) assesses the asset value of wood ('standing timber') in Australia's native forests and, separately, Australia's plantations. The valuation for native forests is based on the net present value of the future stream of income from the estimated net area of native forest available for production on private and public land, over the estimated rotation cycle of the forests and using a discount rate based on the average cost of forest industry borrowing. On this basis, Australia's native standing timber decreased in value from $2.0 billion to $1.8 billion between June 2006 and June 2011; changes in a number of economic parameters could have led to this re-valuation. The valuation for plantations is based on a insured asset value, derived from plantation forest area and planting data from ABARES, and relevant industry insurance schedules compiled by Australian Forest Growers[171]. On this basis, the value of Australia's plantation standing timber increased from $9.7 billion in June 2006 to $11.6 billion in June 2008, before decreasing to $9.5 billion in June 2011. These valuations of native forest and plantation standing timber cannot be compared to each other because of the different methodologies and assumptions used in the calculations.

The values in the ABS balance sheet for native standing timber and plantation standing timber include the value of wood available for harvesting, but not the value of other benefits from forests, such as maintaining biodiversity, carbon sequestration or preventing soil erosion.

171 http://www.afg.asn.au/.

Overview of the economic framework

The World Bank publishes indicators of the general investment environment across countries. These apply to the economy as a whole and use various regulatory and financial measures, such as property registration, ease of obtaining credit, and the institutional capacity to enforce contracts. On the basis of these indicators, Australia was ranked 15th out of 183 countries in 2011 for the ease of doing business (World Bank 2012). This is higher than several other member countries of the Organisation for Economic Co-operation and Development, including Japan, Germany and France, but lower than Singapore, New Zealand and the United States of America.

Australia's strong economic framework can partly be attributed to reforms that increase the competiveness of Australian products. A key reform was the introduction of Australia's National Competition Policy (NCP) in 1995, which is a package of Commonwealth, state and territory legislation aimed at promoting 'good' competitive behaviour. Governments signed three agreements as part of the NCP: the Competition Principles Agreement, the Conduct Code Agreement, and the Agreement to Implement the National Competition Policy and Related Reforms (NCC 2012).

The NCP introduced several reforms that affect the competitive climate for Australian forest-based industries. For example, since the introduction of the NCP, commercial state-owned forest entities such as sawmills are subject to the principle of competitive neutrality (Ferguson et al. 2010), which requires state entities competing with the private sector to be exposed to similar expenses and costs. Before the introduction of this principle, state entities were not subject to commercial obligations such as business taxes and dividends, which may have discouraged the entrance of private-sector entities into the market.

Version 2.0 of the Australian Forest Valuation Standard was released in 2008, followed by Version 2.1 in 2012 (Leech and Ferguson 2012). The standard provides guidelines for conducting forest valuation of commercial goods or services of native forests and plantations.

Trade policy

Australia's trade policy focuses on trade liberalisation, to improve access for Australian exports in global markets, as well as Australian access to imports. Improved market access is facilitated both through global and multilateral efforts and through the use of free trade agreements (FTAs). Australia is a member of the World Trade Organization (WTO), which facilitates multilateral trade negotiations and ensures that the rules of international trade are correctly applied and enforced. FTAs reduce barriers to the trade of goods—for example, by eliminating tariffs and simplifying compliance measures, such as the need to apply for export licences—and liberalise services such as intellectual property protection, investment and the movement of people.

Australia has signed two FTAs since 2008, one with Chile (effective March 2009) and the other with the Association of Southeast Asian Nations (effective January 2010). An Australia–Malaysia FTA was signed in May 2012 but is not yet implemented. In addition to bilateral trade negotiations, the Australian Government is advocating a reduction in trade barriers for non-agricultural goods, including those produced in the forest sector, in the WTO Doha Round negotiations (DFAT 2011).

Plantation investment

Until recently, forest-sector managed investment schemes were important financial mechanisms for plantation expansion. New taxation arrangements for managed investment schemes came into effect on 1 July 2007, with the aims of encouraging expansion of the plantation estate, and supporting investment in long-rotation plantations by allowing trading of managed investment scheme investments (DAFF 2012a). Since the global financial crisis, however, managed investment schemes have become a less important proportional driver of plantation expansion (see Case study 7.3). In 2008, about 81% of new plantations established were funded by managed investment schemes (Table 7.10), whereas in 2010–11 managed investment schemes funded only 24% of plantation expansion (which itself had slowed considerably—see Indicator 6.2a). Some investments were taken over by other private investors, and others were written off (Gavran 2012).

Table 7.10: Investment in new plantations, by investor type, 2008 and 2010–11

Investor type	Proportion of investment (%)	
	2008	2010–11
Managed investment schemes	81	26
Institutional investors	–	42
Timber industry companies	–	23
Farm foresters and other private owners	–	4
Government organisations	14	5

– = not available but deduced to total 5%

Note: '2008' refers to the calendar year; '2010–11' refers to the 2010–11 financial year.

Source: Gavran (2012), Gavran and Parsons (2009).

The House of Representatives Standing Committee on Agriculture, Resources, Fisheries and Forestry produced a forest-sector inquiry report in 2011 that made several recommendations in relation to plantations (SCARFF 2011). For example, it recommended that the Australian Government lead a process through the Council of Australian Governments to create a national plan for plantations, to ensure selection of appropriate species and planting locations and that there is appropriate infrastructure to support those plantations. It also recommended that the managed investment scheme mechanism be assessed for its appropriateness in meeting policy objectives.

Case study 7.3: Managed investment schemes (MIS)

Managed investment scheme companies faced many challenges during the reporting period, including the global financial crisis, reduced investor confidence in managed investment schemes generally, an inability to raise further debt, and regulatory changes that had the potential to affect sales of managed investment scheme products.

On 13 May 2010, the Australian Government amended the four-year holding period tax law for forest-sector managed investment schemes. The aim of this change was to ensure that investors will not have their previously claimed tax deductions denied if they fail to hold their forest-sector investments for four years for reasons genuinely beyond their control.

The collapse of a number of forest-sector managed investment scheme companies led to the strengthening of related prudential arrangements. In November 2011, the Australian Securities and Investments Commission (ASIC) released new financial requirements for responsible entities of managed investment schemes. Under the changes, responsible entities must prepare 12-month cash-flow projections, which must be approved at least quarterly by directors. New net tangible asset capital requirements and a liquidity requirement were also introduced. In January 2012, ASIC released five benchmarks and five disclosure principles for agribusiness schemes that will help retail investors understand the risks, assess the rewards being offered, and decide whether investment in these products is suitable for them.

The changes introduced by ASIC were designed to ensure that investors are well informed before making investment decisions and to bolster investor confidence in Australia's investment markets, leading to a more secure future for Australia's forest-based industries.

Tasmanian forest-based industries

In November 2010, the Australian Government announced \$22.4 million in funding to help the Tasmanian forest-sector industries re-position for the future (Ludwig and Green 2010). This commitment was delivered through two programs: the \$17 million Tasmanian Forest Contractors Exit Assistance Program, administered by the Australian Government Department of Agriculture, Fisheries and Forestry; and the \$5.4 million Tasmanian Forest Contractors Financial Support Program, administered by the Tasmanian Government. Assistance was aimed at Tasmania's native forest harvest and haulage contracting businesses, 29 of which accepted exit assistance under this program (DAFF 2011a).

Further assistance for Tasmania was agreed in the Tasmanian Forests Intergovernmental Agreement, which was signed by the Prime Minister and the Tasmanian Premier on 7 August 2011. This agreement aimed to provide certainty for Tasmania's forest-based industries, support local jobs and communities, and protect the state's forests. Of the \$277 million committed under the agreement, \$45 million was set aside for the Tasmanian Forests Intergovernmental Agreement Contractors Voluntary Exit Grants Program. This funding was allocated for grants and associated delivery costs, for voluntary exits from operations in Tasmania's public native forests, for haulage, harvest and silvicultural contractors in the 2011–12 financial year (DAFF 2012b). A total of 61 applicants were offered exit grants with a combined total of \$43 million.

Investment in timber processing

Current investments in timber processing in Australia are largely driven by changes in resource availability resulting from changes in forest access and forest management practices, linked to economies of scale. For example, increased sourcing of wood from plantations and a reduction in the availability of logs from native forests have led to a consolidation of sawmilling operations in larger mills (Burns and Burke 2012). These larger mills are capable of processing logs at a lower unit cost than earlier, smaller mills, thereby helping to maintain competitiveness. The \$450 million expansion of Visy's pulp and paper mill at Tumut in New South Wales was successful in doubling the production capacity of the mill (Visy 2011).

In January 2009, the Australian Government launched its \$9 million Forest Industries Development Fund, a competitive grants program to boost the international competitiveness of Australian forest products. The fund encouraged increased investment in measures designed to add value to Australia's forest resources. Supported industry initiatives included an Australia-wide project for the design and delivery of modular wood-based Indigenous housing for rapid deployment in remote areas, a new facility to process the timber of highland species into high-value timber flooring products, a project to optimise softwood processing efficiency, and a project to automate a product grading process to improve recovery and add value to forest resources. This funding is estimated to have leveraged investments worth more than \$20 million from the private sector and other sources (DAFF 2011b).

Investment in environmental services

In August 2011, the Australian Parliament passed the *Carbon Credits (Carbon Farming Initiative) Act 2011*. The Act establishes the Carbon Farming Initiative, which allows farmers and land managers to earn carbon credits for storing carbon or reducing greenhouse gas emissions on their land (see Indicator 5.1a - Box 5.1, and Indicator 7.1a).

Australia also has programs at state and territory level that promote other types of environmental services from forests. For example, the Sawlogs for Salinity pilot project, part of the Victorian Government's Plantation Incentive Strategy, provided $650,000 in incentive payments to landowners to plant trees that can be used to produce sawlogs on land where there will be environmental benefits, particularly relating to salinity. The project used a science-based framework, the Catchment Analysis Tool, to predict the nature and extent of certain services, including environmental services, provided by plantations. About 743 hectares of new plantations were established through this project in the west Gippsland and Corangamite regions.

Farm trees planted for stock shelter and wood production, Mount Lofty Ranges, South Australia. Large contiguous areas of farm trees that meet the definition of forest are recorded in the National Forest Inventory under the 'Other forest' category (Indicator 1.1a).

Investment to improve management of privately owned forests

Australian landholders are increasingly aware of the benefits associated with maintaining forests and native vegetation to manage salinity and erosion (State of the Environment 2011 Committee 2011). Governments and industry groups have implemented a range of programs to support natural resource management on privately held lands.

These programs include Caring for our Country, an Australian Government grants-based program to help meet national priorities relating to the environmental management of Australia's natural resources. This program focuses on six national priority areas: the National Reserve System; biodiversity and natural icons; coastal environments; sustainable farm practices; natural resource management in northern and remote Australia; and community skills, knowledge and engagement. It supports regional natural resource management groups; local, state and territory governments; Indigenous groups; industry bodies; land managers; farmers; Landcare groups and communities.

The Caring for our Country program, which began in 2008, will involve a total investment of just over $2 billion in the five years to 2013. Since this investment is not all for specific areas, it is difficult to estimate the total investment in forest management. However, a significant proportion of the total funding will benefit forests—for example, through the Environmental Stewardship Program, which involves a total investment of $63.3 million and has secured more than 47,500 hectares of nationally threatened ecological communities, including forests.

State and territory governments have also developed programs to encourage private and community-based natural resource management within their jurisdictions. In particular, extension programs encourage private-sector and community participation in natural resource management activities through education, technology transfer and support programs.

Industry groups such as the Australian Forest Products Association, as well as government departments at the national, state and territory levels, also provide the community with information on sustainable natural resource management.

Indicator 7.1d

Capacity to measure and monitor changes in the conservation and sustainable management of forests

Rationale

This indicator examines the capacity of forest owners and agencies to measure and monitor changes in the forest and the impact of forest activities. A comprehensive measurement and monitoring programme provides the basis for forest planning to support sustainable management.

Key points

- The ability to measure, monitor and report on forests varies considerably by tenure. The most reliable information continues to be available for multiple-use public forests and some public nature conservation reserves. Significant gaps in data collection and monitoring remain for leasehold and private forests.
- Australia's states and territories vary in their levels of forest and environmental data collection, monitoring and reporting. Tasmania and Victoria each publish five-yearly 'state of the forests' reports, based on a framework of criteria and indicators similar to Australia's national State of the Forests report.
- Use of a framework of criteria and indicators, developed under the Montreal Process[172], for Australia's five-yearly state of the forests reporting provides a mechanism for presenting disparate data in a consistent and repeatable format. The quality of data have improved for almost half (21) of the 44 national reporting indicators in SOFR 2013 compared with SOFR 2008. The data available for SOFR 2013 were assessed as comprehensive (the highest possible rating) in each of coverage, currency and frequency for 17 of the indicators, and comprehensive in any two of these aspects for a further 10 indicators. The capacity has been developed to report trends over time for 16 of the 44 indicators.
- Although the SOFR 2013 report is wide-ranging, few of the 44 national reporting indicators are measured easily, and the availability, coverage and currency of data vary considerably. Some data are collected nationally, and others are provided by the states and territories.
- The Australian Government and all states and territories, except the Northern Territory, also publish 'state of the environment' reports at regular intervals, which vary from three to five years. These reports provide information on the condition of the broader natural environment and, where possible, indicate trends or changes for a range of measures relating to the environment.
- Australia's strategy for the National Reserve System stipulates that the effectiveness and performance of protected area management must be monitored and evaluated against conservation goals. Nationally, 14.8 million hectares of forest in the National Reserve System (56% of the area of forest in the National Reserve System) has management plans in place.

[172] The Montreal Process Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests – see www.montrealprocess.org.

The opening paragraph of Indicator 7.1d in SOFR 2008 remains pertinent for SOFR 2013:

> *The extent to which relevant and up-to-date information about forests is available for reporting provides a measure of the capacity to demonstrate sustainable forest management. Reporting on the capacity to measure change, in turn, offers an opportunity for forest managers to review and prioritise data collection to make future measurement and monitoring more timely and relevant. If a reporting system is to measure change in Australia's forests successfully, it must be underpinned by adequate and ongoing data collection.*

Monitoring and reporting by tenure

State and territory agencies and some private forest owners and managers collect primary forest inventory data, but the frequency and scope of such data collection vary across jurisdictions and by tenure. The most reliable information is available for multiple-use public forests and a few public nature conservation reserves for which governments require reporting. Reliable information is also available for Industrial plantations on both public and private land.

In publicly managed native forests—especially those managed for multiple uses, including wood production—data are available for reporting on a range of indicators, and inventories and assessments are undertaken regularly for management purposes and to monitor and report on performance. State forest management agencies are also committed to reporting regularly on forest management in multiple-use public forests in relation to environmental, economic and social values. Their reporting processes provide the level of detail required for their jurisdictions, while the national State of the Forests reporting process provides a whole-of-nation overview and is the basis for meeting legislated national and international obligations.

In contrast to government data collection and reporting requirements, private landowners and managers (including leaseholders) are rarely required, and often have little incentive, to collect data on their forests or to make such data publicly available. As a result, the most significant gaps in information on Australia's forests are for privately managed and leasehold forests. Another area with large gaps in information across all tenures and jurisdictions is non-wood forest values (see Indicators 2.1d, 4.1a–e, 5.1a, 6.1b and 6.1d).

State and territory forest measurement, monitoring and reporting

Australia's states and territories vary in the levels of forest and environmental reporting that they publish. Of the states and territories, Tasmania and Victoria are the only ones to publish state of the forests reports (SOFRs) that cover all forests, regardless of type or tenure. These reports are based on the same framework of 7 criteria and 44 indicators for sustainable forest management as used in Australia's national SOFR, and are also published at five-yearly intervals. New South Wales (annually) and Western Australia (five-yearly) publish regular indicator-based reports on the sustainable management of production forests on public land. ForestrySA (South Australia) publishes an annual report covering plantation forests on public land.

Tasmania's SOFR provides information on the state of Tasmania's public and private forests, as required under *Tasmania's Forest Practices Act 1985*; the most recent report was released in 2012 (FPA 2012).

Under Victoria's *Sustainable Forests (Timber) Act 2004*, the Victorian Government is required to produce a SOFR every five years, with a 2013 version the next to be released. *Criteria and Indicators for Sustainable Forest Management in Victoria* (DSE 2007b) sets out the range of environmental, economic and social indicators that will be monitored in the state. These are closely aligned with the Montreal Process and Australia's national framework, with the seven criteria the same as those used for Australia's SOFR 2008 and SOFR 2013. In addition, VicForests, the state-owned business that is responsible for the sustainable harvest, regeneration and commercial sale of wood from Victoria's native public forests, produces an annual *Sustainability Report*. This presents information on the activities performed by VicForests to achieve environmental, social and economically sustainable outcomes, including long-term monitoring of threatened species, retained trees and water quality.

The four states with Regional Forest Agreements (RFAs)—New South Wales, Tasmania, Victoria and Western Australia—are required to produce five-yearly independent reviews assessing the progress and performance of each RFA. The review processes vary slightly for each RFA, but generally they independently assess the results from monitoring the 44 Montreal Process sustainability indicators used in Australia, and from monitoring the RFA milestones and obligations agreed by the states with the Australian Government. Five-yearly RFA reviews have been completed in New South Wales, Tasmania and Victoria.

In New South Wales, progress on the implementation of four State-based forest agreements and integrated forestry operations approvals (IFOAs) is reported annually. The reports provide a snapshot of the results of monitoring ecologically sustainable forest management criteria and indicators; wood supply; compliance with integrated forestry operations approvals for each region; and achievement of milestones defined in the four forest agreements and the IFOAs.

All states and territories, except the Northern Territory, also produce 'state of the environment' (SoE) reports at regular intervals, which vary from three to five years. SoE reports are generally designed to communicate credible, timely and accessible information about the condition of the environment to decision makers and the community, and, where possible, to indicate trends or changes in the environment. A summary of the status of SoE reporting in the jurisdictions is as follows:

- The Australian Capital Territory produces an SoE report every four years. An objective of these reports is to provide accurate, timely and accessible information to the community and government on the condition of, and trends in, the environment; underlying pressures; and sustainability trends. SoE reporting in the Australian Capital Territory is a requirement of the *Commissioner for the Environment Act 1993*.
- New South Wales publishes an SoE report every three years to provide information on the status of the main environmental issues facing the state. The most recent report, published in 2012, was prepared by the Environment Protection Authority in accordance with the *Protection of the Environment Administration Act 1991*.
- The latest four-yearly Queensland SoE report was released in 2011. It includes an assessment of the state of major environmental and cultural assets, the identification of significant trends, and a review of the significant programs, activities and achievements of public authorities in the protection, maintenance, restoration and enhancement of the state's environment. SoE reporting in Queensland is a statutory requirement under both the *Environmental Protection Act 1994* and the *Coastal Protection and Management Act 1995*.
- The next five-yearly SoE report from South Australia, due for release in 2013, aims to provide an assessment of efforts to deal with significant environmental issues. South Australia's SoE reporting is a legislative requirement under the *Environment Protection Act 1993*.
- Tasmania's SoE report for 2012 summarises environmental condition, trends and changes, and provides recommendations for future management of the environment in Tasmania. Tasmania's SoE reports are a legislative requirement under the *State Policies and Projects Act 1993*.
- Victoria's next five-yearly SoE report is due for release in 2013, and will be based on a new framework for environmental reporting. The report is intended to inform the Victorian community about the health of the natural environment and influence government to achieve environmental, social, cultural and economic sustainability. Production of the report is a statutory role of the Commissioner for Environmental Sustainability under the *Commissioner for Environmental Sustainability Act 2003*.
- The most recent SoE report from Western Australia was released in 2007 by the Environmental Protection Authority, Western Australia. These reports are designed to communicate credible, timely and accessible information about the condition of the environment to decision makers and the community, focusing on major environmental issues.

SOFR 2008 reported that two states published 'state of the parks' reports between 2003 and 2008: New South Wales in 2004 and Victoria in 2007. No state of the parks report has been subsequently published by a state or territory. However, the New South Wales Office of Environment and Heritage produced the *Management of the NSW Park System—2010* report.[173] This report, which reflects the New South Wales park system at June 2010, provides a broad overview and assessment of the approaches used to manage the system.

A wide variety of measurement and monitoring activities support state and territory reporting. Examples for Victoria and Western Australia are provided below.

Victoria

After the release of Victoria's State of the Forests Report 2008, the state assessed its ability to report on its forests, including the costs and barriers associated with reporting. As a result, the Victorian Department of Sustainability and Environment[174] now undertakes a range of activities for monitoring and reporting changes in the extent, state, condition and sustainable management of Victoria's public forests and parks. These activities are known collectively as the Victorian Forest Monitoring Program (VFMP[175]), formerly known as the Forests and Parks Monitoring and Reporting Information System.

The VFMP aims to provide a continuously updated, tenure-blind public forest description, using a combination of permanent plots, aerial photography and satellite imagery. Its development and full implementation is expected to take 5–7 years (Wallace 2010). In total, 786 ground plots are being established and will be measured once every five years (Figure 7.4). By 2012, about 250 of these plots had been established and measured across Victoria's public forests and parks.

The VFMP will provide Victoria with the capability to produce consistent statewide data for its public forests and parks—that is, not limited to state forest areas available for wood production. Ongoing remeasurement will allow the state to better monitor changes in its forests over time. The data and information generated will be an input to land management policy and decision making and will support state and national reporting of sustainable forest management through *Victoria's State of the Forests Report*.

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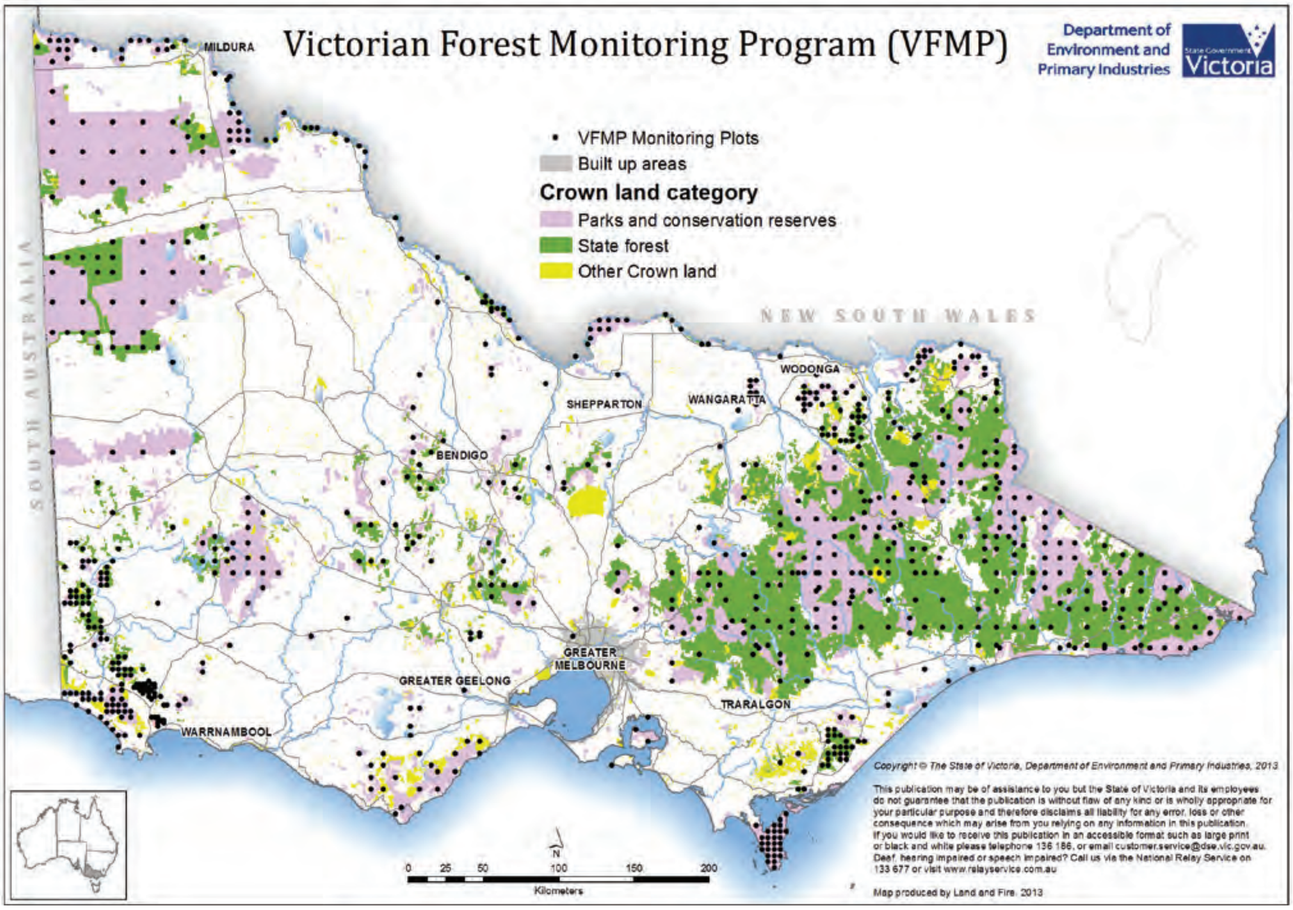
173 www.environment.nsw.gov.au/sop10/index.htm.

174 From April 2013, the Department of Environment and Primary Industries.

175 http://www.depi.vic.gov.au/forestry-and-land-use/forest-management.

Figure 7.4: Distribution of forest monitoring plots in the Victorian Forest Monitoring Program



Western Australia

Western Australia's *Forest Management Plan 2004–2013*, produced by the Conservation Commission of Western Australia, specifies a number of monitoring and auditing actions, some of which are also ministerial requirements (CCWA 2004). The Conservation Commission undertakes comprehensive mid-term and end-of-term audits of the extent to which land to which the plan applies has been managed in accordance with the plan, including the extent to which key performance indicator (KPI) targets have been achieved. The Conservation Commission submitted the mid-term and end-of-term audit reports to the Environmental Protection Authority on 24 December 2008 and 30 March 2012, respectively (CCWA 2012b).

The Western Australian Department of Environment and Conservation, in consultation with the Conservation Commission, developed protocols for addressing each KPI in the plan, identifying data to be collected, assessing the extent to which each KPI has been achieved, and specifying who is responsible for collecting and analysing the data. These protocols are contained in the document *Protocols for Measuring and Reporting on the Key Performance Indicators of the Forest Management Plan 2004–2013*.

During this reporting period, the Conservation Commission has given priority to auditing:

- management of old-growth forest in informal reserves
- protection of stream zones and less well reserved vegetation complexes
- selection and management of fauna habitat zones
- marri (*Corymbia calophylla*) retention
- dieback hygiene
- protection of significant flora and understorey species
- soil management.

Western Australia also runs the Forestcheck project, which monitors biodiversity in jarrah forest managed for sustainable wood production (see Case study 1.3 in Indicator 1.2a).

National forest monitoring and reporting

The National Forest Inventory (NFI) in the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), Australian Government Department of Agriculture, Fisheries and Forestry[176], compiles data supplied by states and territories, and integrates these data into national classification schemes and databases. Data compilation for Industrial plantations is undertaken annually at the state and territory level, and every five years at the national level (Gavran and Parsons 2011). The NFI has primary responsibility for national forest reporting in Australia, including coordinating the preparation of the five-yearly SOFRs. Australia remains one of the few industrialised forested countries yet to introduce a national sample-based forest monitoring system.

The production of *Australia's State of the Forests Report* gives effect to a requirement in the *National Forest Policy Statement* 'to produce and publish a "state of the forests" review every five years' (Commonwealth of Australia 1992). The state and territory governments agreed to the *National Forest Policy Statement* with the Australian Government in 1992 (Tasmania in 1995). Publication of *Australia's State of the Forests Report* also gives effect to a statement in the Commonwealth *Regional Forest Agreements Act 2002*, which specifies that 'the Minister must cause to be established a comprehensive and publicly available source of information for national and regional monitoring and reporting in relation to all of Australia's forests'.

Australia's state of the forests reporting is based on a framework of 7 criteria and 44 indicators that are closely aligned with the international Montreal Process (MIG 1998). This framework provides a mechanism for presenting Australia's disparate forest data in a consistent and repeatable format, in spite of varying state and territory data collection processes, classification systems and standards. The coverage and currency of data, frequency of data collection, and capacity to report on trends also vary considerably among indicators, and few indicators are capable of easy measurement.

Table 7.11 summarises Australia's capacity to report against the 44 indicators for SOFR 2013, including the reporting of trends, based on the coverage, currency and frequency of data available for each indicator. The table also notes changes over the period 2006–2011 in the quality of the data that contribute to the reporting.

Overall, the data available for SOFR 2013 were comprehensive in each of coverage, currency and frequency for 17 of the indicators, and comprehensive in any two of these aspects for a further 10 indicators. Trends over time could be reported for 16 of the 44 indicators for SOFR 2013, and there has been an overall improvement in the quality of data for almost half (21) of the indicators, compared with SOFR 2008. The availability of national data and the capacity to report for one indicator (1.1b) were particularly deficient, and three indicators (1.1b, 1.1d and 6.3b) have seen an overall decline in the quality of data since SOFR 2008. For 20 indicators, the overall quality of data have not changed.

New datasets reported in SOFR 2013

A number of new social, economic and environmental datasets have been compiled, analysed and presented in SOFR 2013, including the development of nationally consistent datasets from new national data. These include:

- development of an updated National Forest Inventory dataset of Australia's forest cover, type and tenure, resulting from using a Multiple Lines of Evidence process to integrate states and territories data with a variety of remotely sensed data
- improvement of the reporting of protected forest areas by use of the National Conservation Lands Database that lists private land protected by covenant, identifying private forest reserves
- updated and comprehensive lists of vertebrate species found in forest
- compilation of new national databases for the reporting of threatened fauna and flora species
- use of a new national forest commerciality database to identify spatially the area of forest available and suitable for harvesting
- compilation and reporting of firewood and fuelwood usage data
- compilation of a new national database on silvicultural systems in multiple-use public native forests from information from state forest management agencies
- compilation of nationally consistent public data on Indigenous land tenure, including spatial information, which allowed the Indigenous estate to be divided into four land tenure and management categories
- development of a Non-Indigenous Heritage Sites of Australia dataset, that compiles current non-Indigenous heritage lists and registers from all jurisdictions into a national dataset
- use of employment and demographic data from the Australian Bureau of Statistics 2011 Population and Housing census in socio-economic indicators
- presentation of time-series data on the resilience and adaptability of forest-dependent communities, including forest-dependent Indigenous communities
- incorporation of quantitative data on the importance of forests to people, from surveys of community attitudes towards native and plantation forest management, wood products and the potential role of forests and wood in climate-change mitigation.

[176] From September 2013, the Department of Agriculture.

Table 7.11: Quality of data coverage, currency, frequency and capacity to report trends, and overall change since SOFR 2008, for each indicator addressed by SOFR 2013

Indicator		Data quality				
		Data coverage	Data currency	Data update frequency	Capacity to report trend	Change in data quality since SOFR 2008
Criterion 1: Conservation of biological diversity						
1.1a	Area of forest by forest type and tenure—*forest type*[a]	Green	Yellow	Yellow [b]	Yellow	—[c]
	Area of forest by forest type and tenure—*tenure*[a]	Green	Green	Green	Yellow	↗
1.1b	Area of forest by growth stage	Yellow	Red	Red	Red	↙[d]
1.1c	Area of forest in protected area categories	Green	Green	Green	Green	↗[e]
1.1d	Fragmentation of forest cover	Yellow	Yellow	Yellow	Yellow	↙[f]
1.2a	Forest dwelling species with ecological information	Green	Green	Yellow	Green	↗[g]
1.2b	Status of forest dwelling species at risk	Green	Green	Yellow	Green	↗[h]
1.2c	Representative species monitored	Yellow	Yellow	Yellow	Yellow	↗[i]
1.3a	Species at risk of loss of genetic variation	Yellow	Yellow	Yellow	Yellow	↗[j]
1.3b	Genetic resource conservation mechanisms in place	Yellow	Green	Green	Yellow	↗[k]
Criterion 2: Maintenance of productive capacity of forest ecosystems						
2.1a	Native forest available for wood production	Green	Green	Green	Green	↗[l]
2.1b	Age class and growing stock of plantations	Green	Green	Green	Green	—
2.1c	Annual removal of wood products compared with sustainable volume	Green	Green	Green	Green	—[m]
2.1d	Annual removal of non-wood forest products compared with sustainable level	Yellow	Green	Yellow	Yellow	—
2.1e	Effective forest regeneration and plantation re-establishment	Green	Green	Green	Green	↗[n]
Criterion 3: Maintenance of ecosystem health and vitality						
3.1a	Scale and impact on forest health and vitality	Yellow	Yellow	Green	Yellow	↗[o]
3.1b	Forest burnt by planned and unplanned fire	Green [p]	Green	Green	Yellow	↗[q]
Criterion 4: Conservation and maintenance of soil and water resources						
4.1a	Forest managed primarily for protective functions	Yellow	Yellow	Green	Yellow	—[r]
4.1b	Management of the risk of soil erosion	Yellow	Yellow	Red [s]	Yellow	—[r]
4.1c	Management of the risks to soil physical properties	Yellow	Yellow	Red [s]	Yellow	—[r]
4.1d	Management of the risks to water quantity	Yellow	Yellow	Red [s]	Yellow	—[r]
4.1e	Management of the risks to water quality	Yellow	Yellow	Red [s]	Yellow	—[r]
Criterion 5: Maintenance of forest contribution to global carbon cycles						
5.1a	Contribution to global greenhouse gas balance	Green	Green	Green	Green	—
Criterion 6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies						
6.1a	Value and volume of wood and wood products	Green	Green	Green	Green	—[t]
6.1b	Values, quantities and use of non-wood forest products	Green	Green	Yellow	Yellow [u]	↗[v]
6.1c	Value of forest-based services	Yellow	Green	Yellow	Yellow	—[w]
6.1d	Wood and non-wood product production and consumption	Green	Green	Green	Green	—[x]
6.1e	Recycling of forest products	Green	Green	Yellow	Green	↗[y]
6.2a	Investment and expenditure in forest management	Green	Green	Green	Green	↗[z]
6.2b	Investment in research, development and extension, and new technologies	Green	Green	Green	Yellow	—[aa]
6.3a	Area of forest available for public recreation/tourism	Green	Green	Green	Green	—
6.3b	Recreation/tourism activities available	Yellow	Green	Green	Yellow	↙[bb]
6.4a	Area to which Indigenous people have use and rights	Yellow	Green	Yellow	Yellow	↗
6.4b	Registered places of non-Indigenous cultural value	Green	Green	Green	Yellow	↗
6.4c	Protection of Indigenous values	Yellow	Green	Red	Red	—
6.4d	Importance of forests to people	Yellow	Green	Green	Yellow	↗
6.5a	Direct and indirect employment	Green	Green	Green	Green	—[cc]
6.5b	Wage rates and injury rates	Green	Green	Green	Green	—[dd]

Table 7.11: Quality of data coverage, currency, frequency and capacity to report trends, and overall change since SOFR 2008, for each indicator addressed by SOFR 2013 continued

Indicator		Data quality				
		Data coverage	Data currency	Data update frequency	Capacity to report trend	Change in data quality since SOFR 2008
6.5c	Resilience of forest dependent communities					↗
6.5d	Resilience of forest dependent Indigenous communities					↗
Criterion 7: Legal, institutional and economic framework for forest conservation and sustainable management						
7.1a	Legal framework					—
7.1b	Institutional framework					↗
7.1c	Economic framework					↗ [ee]
7.1d	Capacity to measure and monitor					—
7.1e	Capacity to conduct and apply research and development					—

Key:

Rating	Data coverage	Data currency	Data update frequency	Capacity to report trend
	Whole country assessed	Current data (data since 2006)	Annual to five-yearly	Capacity to report trends across all or most tenures
	Incomplete national data	Mixed current and historical data	Less frequently than five-yearly	Partial capacity
	No data; case studies only	Historical data (pre-2006 data only)	Occasional or once only	No capacity
↗	Overall data quality has improved since SOFR 2008			
↙	Overall data quality has declined since SOFR 2008			
—	Overall data quality is unchanged since SOFR 2008			

a 1.1a has been split in order to separately report data status/quality for forest type and tenure.

b Some states and territories are developing datasets and systems that will be updated more frequently (e.g. annually).

c Although overall data quality is unchanged, estimation of the extent of Australia's forest cover is more robust because of the 'Multiple Lines of Evidence' approach (Indicator 1.1a) used for SOFR 2013, which uses and validates multiple datasets and gives increased confidence in the estimate.

d Sufficient, consistent and coordinated data have not been collected at the state and territory level since 2008 to enable satisfactory data-based reporting against this indicator (see Table 1.13). Available data is therefore increasingly out of date.

e Reflects improvements in data on tenure of private forest reserves.

f Fragmentation metrics derived from National Carbon Accounting System data for SOFR 2008 were not recalculated for SOFR 2013.

g Reflects significant improvement in capacity to report vertebrate fauna and vascular plants.

h Reflects significant improvement in capacity to report listed invertebrate and non-vascular plants.

i Variable across states and territories. Very good in Tasmania and Western Australia.

j Data remain patchy across species and jurisdictions, but are improving over time for targeted threatened species.

k Publication of *Status of Australia's Forest Genetic Resources* (Singh et al. 2013) made a broader range of data available for SOFR 2013.

l Capacity to report on private forests is still limited.

m Capacity to report on private forests is still limited.

n Capacity to report on private native forests is limited.

o Reflects a wider availability of data through published sources and consultation.

p Complete MODIS data (500-metre resolution) provide coarse coverage only.

q SOFR 2008 used MODIS thermal anomalies at 1000-metre resolution, whereas SOFR 2013 uses MODIS burnt area bands of 500-metre resolution.

r The overall quality of data remains the same as SOFR 2008, although the ratings for data coverage, currency and frequency more accurately reflect data quality.

s Data are collected from some sites in multiple-use forest and nature conservation reserves more frequently than annually as part of regular monitoring programs.

t Data in SOFR 2013 and SOFR 2008 were sourced from Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) *Australian Forest and Wood Products Statistics*, which is released twice yearly.

u Very limited capacity to report trend.

v Data are for 2006 only, but for all of Australia.

w Data are current (2006 onwards) but not updated periodically. Ability to identify trends is limited.

x Data in SOFR 2013 and SOFR 2008 were sourced from ABARES *Australian Forest and Wood Products Statistics*, which is released twice yearly.

y Data for this indicator use information from regular reports from the Food and Agriculture Organization of the United Nations, the Australian Bureau of Statistics (ABS) and ABARES. These information sources were not used in SOFR 2008, which primarily used research reports that were not part of a series.

z Data are sourced from financial reports published by state government agencies, ABS and ABARES (*Australian Forest and Wood Products Statistics*), which are updated regularly and at the national scale. Numerical data provided in SOFR 2013 were not published in SOFR 2008.

aa Information is current (2006 onwards) and at the national scale. Most data are updated regularly (within five years). It is possible to identify trends, although some series are not continuous. A similar approach was used for SOFR 2008.

bb Data coverage is limited to public tenures where data are collected (and publicly available), and data collection is declining.

cc Data are sourced from the ABS Census, which is undertaken every five years at the national scale. The latest ABS Census information is for 2011. Trend analysis is possible (in five-yearly periods). A similar approach was used for SOFR 2008.

dd Data are from the ABS and Safe Work Australia. The data are at the national scale and updated regularly (within five years). A similar approach was used for SOFR 2008.

ee Indicator uses information from *Australia State of the Environment 2011*, which provided an assessment for forestry. This information was not used for SOFR 2008. Other information is used in a similar way to SOFR 2008.

CRITERION 7

Gaps in SOFR 2013 data

There remain a number of ongoing national gaps in the data compiled for SOFR 2013. These include:

- Australia does not have a national sample-based forest monitoring system, such as a Continental Forest Monitoring Framework (Wood et al. 2006), to act as a nationally consistent system to underpin reporting across a number of indicators of forest condition
- few of the national reporting indicators can be measured directly, and the availability, coverage and currency of data vary considerably. Some data are collected nationally, and other data are provided by states and territories
- quantitative information is not equally available across environmental, economic and social indicators
- native forest growth-stage data are not collected routinely by state and territory jurisdictions
- nationally meaningful data on forest fragmentation and on soil and water parameters are deficient
- there are gaps in regard to species lists for invertebrate fauna, fungi, lichens, algae or micro-organisms in forests and the overall understanding of their key roles in ecological processes
- data on the use of forests for tourism and recreation are patchy
- information on the production, consumption and trade of non-wood forest products is difficult to obtain
- data are lacking on the management performance of the Comprehensive, Adequate and Representative (CAR) reserve system against conservation values, and on the condition of protected areas in the National Reserve System.

Data variation across tenures and jurisdictions

The ability to measure, monitor and report on forests varies considerably by tenure. The most reliable and comprehensive information across a range of parameters continues to be available for plantations, and for native forests in multiple-use public forestss and a few nature conservation reserves; data are more limited for native forests in other tenure categories, including many nature conservation reserves and, especially, in leasehold and private forests.

In the preparation of SOFR 2013, data were received from New South Wales, the Northern Territory, South Australia, Tasmania and Victoria for all indicators for which state and territory data were relevant, although these data were of variable quality; data were received for only some indicators from the Australian Capital Territory, Queensland and Western Australia, with these data again being of variable quality. For other indicators, national-level data were used from national government departments or organisations, including ABARES (biophysical, production and socio-economic data); the Australian Bureau of Statistics (socio-economic data); the Australian Government Department of Climate Change and Energy Efficiency (carbon data); the Australian Government Department of Industry, Innovation, Science, Research and Tertiary Education (socio-economic data); the Australian Government Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (biodiversity and conservation data); Forests and Wood Products Australia (socio-economic data); and ForestWorks (socio-economic data).

Other national reporting relevant to forests

In addition to Australia's five-yearly SOFR, regular national reports that include updated information on Australia's forested environments include the five-yearly SoE report (State of the Environment 2011 Committee 2011), and the annual state of the parks report (Director of National Parks 2011) (for Australian Government–managed national parks).

The purpose of national SoE reporting is to capture and present key information on the state of the Australian environment, and provide an overall assessment of the outlook for the environment. Examples of issues faced in SoE reporting that also are faced in SOFR reporting include the following:

– *Assessing the state of Australia's environment is inherently difficult. Australia is a big country, with a wide variety of ecosystems and heritage. There are many unconnected means by which we (Australia) gather and store information on our environment, and accessing this information at a national scale is tremendously complicated and not always possible.*

– *The difficulties we face with a national SoE report in terms of inadequate data are in part a symptom of a lack of national coordination. Australia is a federation with nine major jurisdictions and hundreds of local authorities, plus thousands of individual government departments and nongovernment organisations.*

(State of the Environment 2011 Committee 2011)

The annual state of the parks reports present systematic and consistent background information on each Commonwealth reserve proclaimed under the *Environment Protection and Biodiversity Conservation Act 1999*. The report includes information on the major monitoring efforts for the year in each reserve.

Australia's National Carbon Accounting System (NCAS; now known as the National Greenhouse Gas Inventory) also provides for the regular measurement and monitoring of Australia's forests. The focus is on measuring and monitoring changes in carbon stocks, emissions and sequestration across the landscape, including detecting changes in forest carbon stocks. Indicator 5.1a gives more information about the NCAS and the carbon cycle in Australia's forests.

International forest reporting and monitoring

Australia is a member country of the Montreal Process, which reports on forests using an internationally agreed framework of criteria and indicators (the C&I process) for monitoring sustainable forest management in temperate and boreal forests. SOFR is Australia's reporting mechanism to the Montreal Process.

Global Forest Resources Assessments (GFRAs) are produced by the Food and Agriculture Organization of the United Nations (FAO) every five years as a consistent description of the world's forests and how they are changing. The FAO also prepares *State of the World's Forests* reports on the status of forests and key issues concerning the forest sector. SOFR is the primary source of data for Australia's country report used in GFRA and *State of the World's Forests* reports. The FAO was also scheduled to prepare a *Status of the World's Forest Genetic Resources* report in 2013 using national reports, including *Status of Australia's Forest Genetic Resources* (Singh et al. 2013).

The Montreal Process, the International Tropical Timber Organization, Forest Europe, the FAO and the Observatory for the Forests of Central Africa have developed a new Collaborative Forest Resources Questionnaire that better aligns global data collection schedules and requirements for reporting on forests through GFRAs with data collected, monitored and reported within international C&I processes such as the Montreal Process.[177]

SOFR data are also used to report to the United Nations Convention on Biological Diversity and other international agencies. NCAS data are used for reporting carbon-related forest information, including data on forest change, to the United Nations Framework Convention on Climate Change, including for its Kyoto Protocol.

Effectiveness of monitoring the national forest reserve system

The National Reserve System (NRS) represents the collective efforts of Australian governments and non-government organisations to achieve an Australian system of protected areas, as a major contribution to the conservation of Australia's native biodiversity (NRMMC 2004). The area of the forest component of the NRS is reported in Indicator 1.1c across all tenure categories.

Australia's strategy for the NRS has national targets for a comprehensive, adequate and representative (CAR) system that meets regional, national and international goals. It also stipulates that the effectiveness and performance of protected area management must be monitored and evaluated to provide a measure of the achievement of conservation goals in a manner that is open to public scrutiny (NRMMC 2009). Assessment includes evaluating the coverage of protected area systems and the extent to which biodiversity is represented, evaluating the adequacy and appropriateness of management systems and processes, and assessing the condition of protected areas and trends in specific conservation values. To monitor the currency and development of the NRS, the Australian Government collects information from state and territory governments and other protected area managers about the location and management of protected areas, and collates and stores this information as the Collaborative Australian Protected Area Database (CAPAD).

The NRS therefore helps Australia to meet international obligations and goals under the United Nations Convention on Biological Diversity, including for implemented management plans and management effectiveness assessments; these are to be incorporated into a global database maintained by the World Conservation Monitoring Centre[178] as part of the United Nations Environment Programme.[179]

Leverington et al. (2010) reported that 10–30% of Australia's protected areas had been assessed for management effectiveness (primarily in New South Wales, Queensland and Victoria), comprising 30–50% of the area of protected areas nationally. Australia overall was judged at a basic standard of effective management—a significant reason for this rating was the status of management plans, and an inability to monitor and report on protected area values, objectives and management outcomes.

Nationally, 14.8 million hectares of forest in the NRS has management plans in place, which is 56% of the area of forest in the NRS; 30% is covered by transitional management arrangements; and the remaining 14% has no management planning documentation (Table 7.12). More than 75% of the area of forest in the NRS in the Australian Capital Territory, the Northern Territory, Tasmania and Victoria is managed under an existing management plan. The majority of forest area in the NRS in Queensland and South Australia is not covered by existing management plans as identified in CAPAD. However, many areas of forest in the NRS in Queensland are managed under pre-existing management plans rated as transitional. In addition, while South Australian state legislation requires NRS areas to have management plans, processes may not have commenced or have been completed to allow all of these to be described as existing under CAPAD requirements (Table 7.12).

Monitoring for a range of conservation values and objectives in public forests in the NRS in Victoria has commenced through the VFMP. In New South Wales, monitoring has commenced through a state of parks assessment system (Hockings et al. 2009). Nationally, however, information is deficient or unavailable on the management performance against values of the CAR reserve system and on the condition of protected areas in the NRS.

177 See www.un.org/esa/forests/pdf/national_reports/unff10/Montreal%20Process.pdf.

178 See www.unep-wcmc.org. The World Conservation Monitoring Centre Protected Areas Programme manages the World Database on Protected Areas (www.protectedplanet.net), develops and supports the scientific basis for the valuation of protected areas, assesses the management and ecological effectiveness of these areas, and monitors this performance at a global level.

179 See Parties to the Convention on Biological Diversity COP 10 Decision X/31, https://www.cbd.int/decision/cop/default.shtml?id=12297.

Table 7.12: Status of management plans covering forests in the National Reserve System

	Proportion of area of forest in National Reserve System with management plans of given status (%)							
Status	**ACT**	**NSW**	**NT**	**Qld**	**SA**	**Tas.**	**Vic.**	**WA**	**Australia**
None	5	10	0	33	30	1	11	2	14
Transitional	0	22	16	55	34	22	0	37	30
Exists	95	68	84	12	36	77	89	61	56

None = no form of management documentation identified in the Collaborative Australian Protected Area Database (CAPAD).
Transitional = planning documentation identified in CAPAD is in preparation or in draft, or intent is documented, or old plans exist that require updating.
Exists = planning documentation identified in CAPAD is in statutes or plans formally adopted after consultation, with strategies and implementation actions.
Forest areas in the National Reserve System are given in Table 1.23.

Source: Australian Government Department of Sustainability, Environment, Water, Population and Communities (CAPAD 2010), including data updated for Qld and the ACT; forest area data from the National Forest Inventory.

Forest condition

The Montreal Process[180] underpinned development of the 7 criteria and 44 indicators of sustainable forest management against which the state of Australia's forests is reported every five years. This process deliberately does not score, rank or aggregate individual indicators, allowing users of the report (researchers, policy makers, forest owners or managers) to make their own interpretation of the meaning and causes of changes in forest parameters, and the overall condition of any particular forest area.

Other forest indicator frameworks have been created with different rationales and for other purposes. An example of a framework that has been developed specifically to track change in vegetation condition over time, and can be applied to forests, is the Vegetation Assets States and Transitions (VAST[181]) framework. This framework scores various indicators at a site of interest, then combines the individual indicator scores into scores for species composition, vegetation structure and regenerative capacity. Aggregated scores for each of these three groups can then be plotted against a time series of natural and management events that may have affected vegetation condition (see Case study 7.4). The VAST framework is increasingly used by managers at the site level to understand the historical basis of current forest condition and the nature of resilience in forest ecosystems, and to obtain insights into future management options.

Image taken during a field survey of native vegetation condition near Darwin, Northern Territory.

180 www.montrealprocess.org.
181 http://data.daff.gov.au/brs/brsShop/data/vast_report.pdf.

Case study 7.4: Tracking change and trend in native forest condition

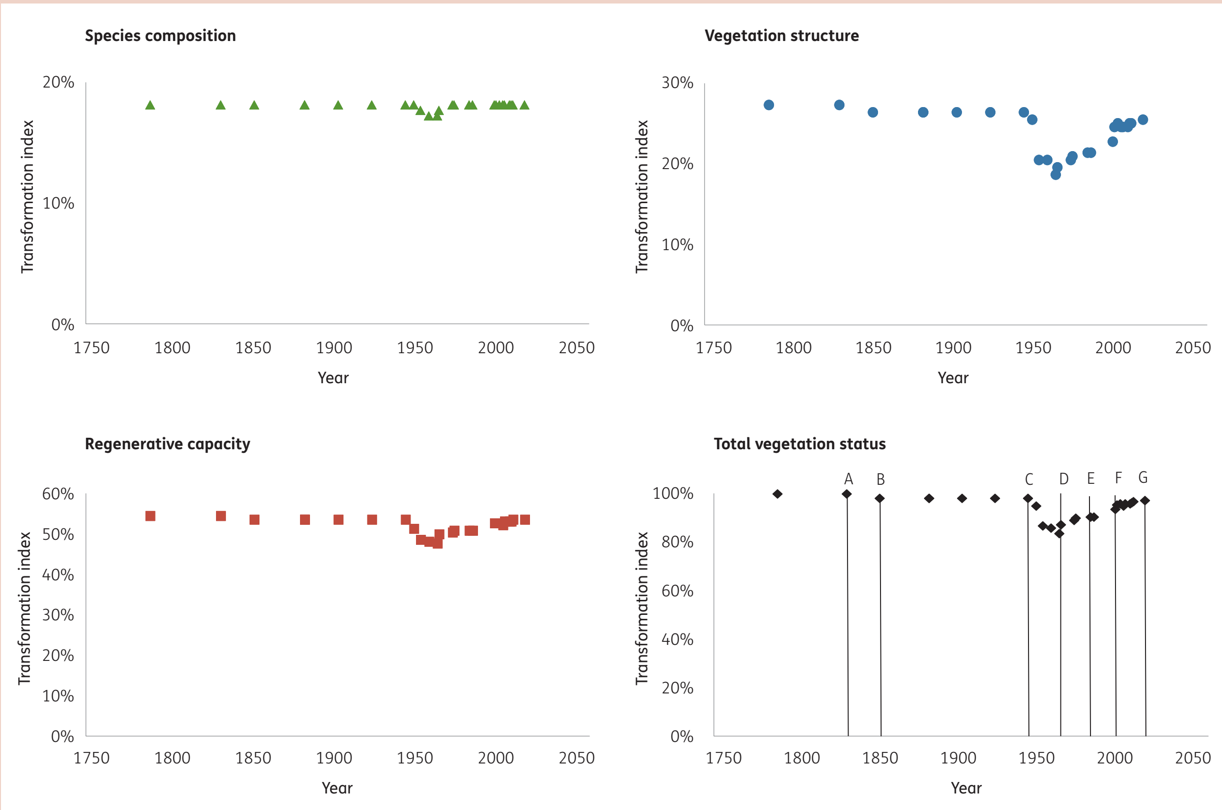
The condition of native vegetation communities reflects the effects of contemporary and (to a lesser extent) historical land management practices, and can be assessed using plant species affected by management practices. However, tracking vegetation transitions gives different information from mapping vegetation states: it provides decision makers with information on changes and trends in the resource base due to environmental and anthropogenic changes, allows land managers to monitor the outcomes of management interventions, and indicates to all stakeholders the link between forest use and management and observed changes in forest condition over time.

The Vegetation Assets States and Transitions framework assesses the effects of site forest management practices using reference sites that are assumed to have had homogeneous plant communities before European influence. Scores for species composition, community structure and regenerative capacity for each site are calculated for different time periods. The scores are weighted 20:30:50 to reflect their relative importance in maintaining resilience and integrity of plant communities, and summed to give a total vegetation transformation index (expressed as a percentage). The index is put into one of five score classes: Unmodified (80–100%), Modified (60–80%), Transformed (40–60%), Replaced/Adventive (20–40%) and Replaced/Managed (0–20%). The timeline of changes in the plant community at a site is then set alongside historical and contemporary records, and relationships are established via a set of ecological attributes.

This approach provides a format for systematic assemblage and correlation of historical and environmental records across a range of Australian vegetation types. The resulting insight into the origins of the current status of sites can then be used to inform decision making about restoration and regeneration.

The changes plotted in Figure 7.5 for spotted gum (*Corymbia maculata*) forest in South Brooman State Forest, New South Wales, and in Figure 7.6 for Cumberland State Forest, New South Wales, provide examples of the insight that can be gained at the site level using this approach.

Figure 7.5: Changes in spotted gum forest, South Brooman State Forest, Batemans Bay, New South Wales



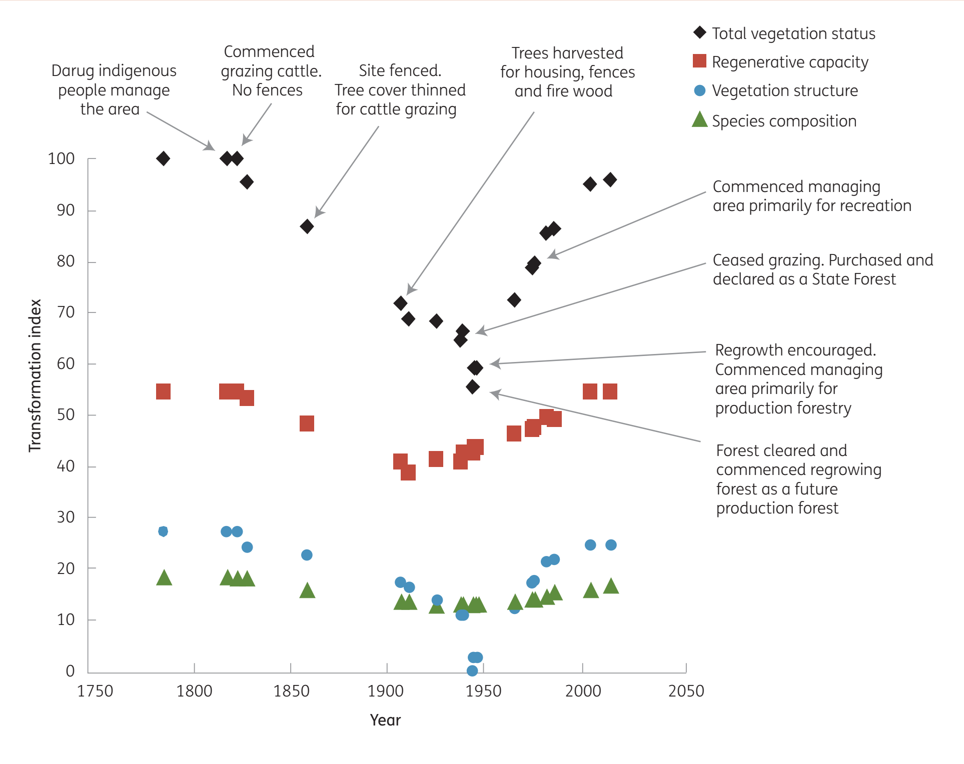
Key management practices: A = Indigenous management; B = site picked over for high-quality sawlogs, fire suppressed and/or excluded; C = site again picked over for high-quality sawlogs; D = sawlogs harvested over 85% of site, removing 50% of canopy; E = site rehabilitated naturally; F = wildfire burnt 100% of site; G = site rehabilitated naturally

Source: http://aceas.org.au/portal Vegetation Transformation Study Sites.

continued overleaf

Case study 7.4: Tracking change and trend in native forest condition continued

Figure 7.6: Changes in Cumberland State forest, West Pennant Hills, compartments 8b, 9a and 9b



Source: http://aceas.org.au/portal Vegetation Transformation Study Sites.

Indicator 7.1e

Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services

Rationale

This indicator reports on the scientific understanding of Australian forest ecosystem characteristics and functions needed to underpin sustainable forest management. Research, inventory and the development of assessment methodologies provide the basis for sustainable forest management.

Key points

- Changes in research and development (R&D) capacity since 2007 have occurred at the national, state and territory levels of government and within academic institutions. Generally, numbers of staff engaged in R&D activities have fallen over the reporting period.
- One of the notable changes since 2007 has been the increase in R&D relating to climate change, some of which is directly relevant to forests. However, the level of other forest-related R&D has fallen.
- As an indication of Australia's forest R&D capacity, about 635 researchers and technicians were involved in forestry and forest products R&D in 2007–08. That number has declined since then—a recent sector-wide survey estimates the number to be 396 in 2011, with the decline occurring across the public and private sectors, including CSIRO and universities.
- Changes in funding and delivery models by the Australian Government reduced forest R&D capacity across a number of national organisations, including several for which government funding or support ceased. Some of these organisations were being replaced under new funding arrangements.
- Changes in funding and delivery models by state and territory governments generally reduced forest R&D capacity in their forest management agencies.

A scientific understanding of the characteristics and functions of Australian forest ecosystems is needed to underpin their management. Research and development (R&D) provides the basis for biological surveys and standing wood inventories, forest management, the silviculture of harvested forests, forest health surveillance, and the development of methods for assessing sustainable forest management. This indicator examines the institutional capacity for forest-related R&D; Indicator 6.2b quantifies investments in R&D by three industry subsectors.

'Forestry' R&D covers research in relation to commercial management and protection of forests, including environmental and ecological considerations. It does not cover research on areas managed specifically for conservation (e.g. forest areas in nature conservation reserves), or programs monitoring growth, health, nutrition and biodiversity. 'Forest products' R&D covers research on value-adding to wood in its broadest sense, but not work on final product development (e.g. furniture production), production runs in mills, environmental monitoring or quality control assessment. These categories have been stable across a number of surveys and reporting periods. For both types of research, estimates include contributions from both public and private sources.

Australia has gained a good level of scientific understanding of the characteristics and functions of its unique forest ecosystems, based on more than 100 years of research in a broad range of forest areas. This knowledge is required to underpin sustainable forest management. However, since 2007, Australia's capacity to conduct and apply R&D to improve the scientific understanding of forests and delivery of forest products has progressively decreased. Significant changes in R&D capacity have occurred at the national, state and territory levels of government, and within CSIRO and academic institutions. Many of these changes reflect either general changes in overall government priorities or specific changes in government priorities for scientific R&D. For example, there has been an increase in R&D relating to climate change, some of which is directly relevant to forests.

National-level forest research and development capacity

Over the period 2006 to 2011, Australia's capacity to conduct and apply forest R&D at the national level has been coordinated and delivered through a number of organisations, including:

- the Research Priorities and Co-ordination Committee; and the Forest and Wood Products Research, Development and Extension Forum
- the Commonwealth Scientific and Industrial Research Organisation
- Forest and Wood Products Australia
- the Cooperative Research Centre for Forestry
- the Bushfire Cooperative Research Centre
- the Terrestrial Ecosystem Research Network
- the Australian Bureau of Agricultural and Resource Economics and Sciences
- the Rural Industries Research and Development Corporation
- Land & Water Australia.

As an indication of the extent to which these organisations enhanced Australia's capacity to conduct and apply forest R&D, their activities are briefly described below, along with the changes in their R&D capacity since 2007.

Research Priorities and Co-ordination Committee, and Forest and Wood Products Research, Development and Extension Forum

Until June 2011, the Research Priorities and Coordination Committee (RPCC) played a role in coordinating forest research conducted by the state, territory and Australian governments—for example, by producing a strategic research directions document (Forestry and Forest Products Committee 2008). The RPCC reported to the Forestry and Forest Products Committee (see Indicator 7.1b), advising the committee on research-related issues, research needs and technology transfer relevant to maximising forest productivity and to managing a range of forest values within the context of sustainable forest management. The RPCC played a research coordination role, rather than a research planning or research policy role (FWPA 2010b). The RPCC also managed a number of research working groups comprising key researchers drawn from government agencies, universities and other non-government research providers. Reforms to the ministerial council system were announced by the Council of Australian Governments in February 2011, and the formal role of the RPCC in forest research coordination ended in June 2011.

This change coincided with the proposal to establish a national-level Forest and Wood Products Research, Development and Extension Forum (FWP RD&E Forum). The Forum was proposed under the RD&E Strategy for the Forest and Wood Products Sector, part of the National Primary Industries RD&E Framework developed under the Primary Industries Ministerial Council, with the roles of improving research coordination and identifying overall research priorities and more collaborative research structures (FWPA 2010b). Among other things, it was planned that the FWP RD&E Forum would 'monitor and work to maintain forest and wood products sector research, development and extension (RD&E) capability, including by defining the research capability needed in the sector and developing mechanisms to deliver this' (FWPA 2010b). It was also planned that the FWP RD&E Forum, once established, would comprise funding bodies, research providers, and users of RD&E in the forest and wood products sector.

Commonwealth Scientific and Industrial Research Organisation

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia's national science research agency. CSIRO maintains forest research capacity to support national and international priorities, including sustainable production of wood fibre, reducing greenhouse gas emissions and energy use, adapting forest management to climate change, addressing degradation of natural resources, conserving biodiversity, and water security. It performs forest and forest products research for the entire forestry value chain. Since 2007, CSIRO has restructured its operations in response to budget pressures, resulting in a reduction in the number of forest research positions (FWPA 2010a). The work of the previous Forest Biosciences division (and of the previous Forestry and Forest Products division) is now spread across a number of other research divisions.

Since the restructure, forest research programs at CSIRO have mostly been delivered under the Sustainable Agriculture Flagship, which aims to secure Australian agricultural and forest industries by increasing productivity and reducing the intensity of carbon emissions. CSIRO also undertakes forest research under the Climate Adaptation Flagship, which aims to equip Australia with practical and effective adaptation options to respond to climate change and climate variability. CSIRO research is mostly performed in collaboration with other national, state and territory research agencies, universities and research institutions, as well as international research agencies.

Forest and Wood Products Australia

Forest and Wood Products Australia (FWPA) Ltd was declared Australia's industry-owned forest R&D company in August 2007 under the *Forestry Marketing and Research and Development Services Act 2007*. FWPA replaced the Forest and Wood Products Research and Development Corporation (FWPRDC), which had been established in 1994 as a statutory authority under the *Primary Industries and Energy Research and Development Act 1989*.

FWPA was established as a not-for-profit company, jointly funded by the forest and wood products sector (through levies) and the Australian Government. The company invests in R&D projects relevant to the Australian forest and wood products sector, and undertakes promotional and marketing activities for the sector.

FWPA invests in and coordinates R&D to improve industry productivity and competitiveness, inform industry's climate change response, increase investment, increase forest usage, and ensure that the sustainability of forests, wood products and services are effectively communicated (FWPA 2011). Research in wood product manufacturing aims to identify new products and methods for processed forest products (excluding pulp, paper and cardboard)—for example, new applications for timber in construction, new timber treatments and new export markets. FWPA also aims to grow industry's capacity and capability through effective technology transfer, and education activities that support the industry and its products.

Forest research areas funded by FWPA have included growth and yield modelling, wood quality, forest health management, silviculture, water use, soil quality, plant disease, tree genetics, tree breeding and resource evaluation. Broader issues that have been addressed under FWPA research funding include forest management strategies for climate change and maximising the greenhouse advantages of forest products.

Cooperative Research Centre for Forestry

The Cooperative Research Centre (CRC) for Forestry has been an Australia-wide joint venture supported by the forest industry, research organisations, state agencies and the Australian Government. It is being succeeded by the National Centre for Future Forest Industries, based at the University of Tasmania in Hobart.

The mission of the CRC for Forestry was to support a sustainable and vibrant Australian forest industry through research, education, communication and collaboration. The CRC's research was organised around four programs: managing and monitoring for growth and health, high-value wood resources, harvesting and operations, and trees in the landscape. By 2012, the CRC for Forestry had developed into a broadly based research organisation with 31 partners across Australia. It performed research along the whole value chain of production forestry, including social, environmental and regional economic considerations, and focused on research outcomes for adoption by industry end users.

Case study 7.5 summarises the research outputs of the CRC for Forestry.

One of the four CRC for Forestry research programs was Harvesting and Operations.

Bushfire Cooperative Research Centre

In Australia, bushfires often affect forests and the communities associated with them.

The Bushfire CRC conducts research that builds a better understanding of the complex and interacting social, economic and environmental aspects of bushfires. Its overall objective is to improve the management of bushfire risk to the community and to firefighters, in an economically and ecologically sustainable way. It also aims to provide a research framework that improves the effectiveness of bushfire management agencies, including forest management agencies.

Following the Black Saturday bushfires of February 2009 in Victoria, the Australian Government granted the Bushfire CRC an extension of funding to examine national issues arising from the tragedy. This led to a new three-year research program for the Bushfire CRC, from 2010 to 2013. The new research builds on outputs from the CRC's first seven years of research, to give communities and fire managers a solid basis to better prepare for, manage and respond to severe bushfires. The new research focuses on understanding the risks associated with bushfires, how to better communicate these risks to the public, and how to better manage the direct threat of bushfires when they occur.

The Bushfire CRC has a strategy of integrating research into the areas where it will be used and so maximising research impact. The strategy also aims to build on successful partnerships with industry, while seeking to engage with other identified groups.

Terrestrial Ecosystem Research Network

The Terrestrial Ecosystem Research Network (TERN) was created in 2009 as an overarching and integrated network to service ecosystem research in Australia. It was established by the Australian Government Department of Innovation, Industry, Science and Research through the National Collaborative Research Infrastructure Strategy, and the Queensland Government. TERN builds on significant past research on understanding Australian ecosystems, including forests, by focusing on collating, calibrating, validating and standardising existing datasets. TERN also funds new research infrastructure and collection systems, expands observation and monitoring programs into unrepresented ecosystems, and builds digital infrastructure to store and publish this information in a form that can be searched and accessed freely under licences that acknowledge the data provider(s).

TERN is designed to connect ecosystem scientists, enabling them to collect, contribute, store, share and integrate data across relevant disciplines. Collectively, this increases the capacity of the Australian ecosystem science community to advance science and contribute to effective management and sustainable use of ecosystems. TERN operates as a network of nine facilities that each contribute to achieving TERN's goals. The facilities are run in partnership with a range of research institutions and government agencies. It is intended that TERN's legacy is a sustainable long-term ecosystem research network for Australia, with shared access to research data for improved understanding and management of ecosystems (TERN 2012).

Case study 7.5: Outputs from the CRC for Forestry

The Cooperative Research Centre (CRC) for Forestry[a] operated from 2005 to 2013, following the previous CRC for Temperate Hardwood Forestry (1991–97) and the CRC for Sustainable Production Forestry (1997–2005). Research outputs from the forestry CRCs supported the Australian forest industry through a time of transition, during which the size of the Australian plantation estate doubled to 2 million hectares, almost entirely through establishment of hardwood plantations funded by private-sector investment. This rapid expansion of the plantation estate and the consequent future increased harvest of wood from this source required research on improved risk management, wood quality, harvesting and supply-chain efficiency. Over the same period, an array of environmental services, such as biodiversity conservation, carbon sequestration and improved water quality, grew in significance and public profile; this led to a need for research on integration of the provision of environmental services into production forest estates.

Important CRC innovations include:

- a portable near-infrared (NIR) scanner that predicts cheaply and accurately the internal wood properties of a tree, including cellulose content and pulp yield, and thus its commercial value
- the FastTRUCK software system for optimising forest transport and log-production operations, which can significantly reduce industry transport costs
- a guide for selection of on-board computer systems that increase machine efficiency during harvesting operations
- an Industry Pest Management Group that provided technical support, ran collaborative workshops for information exchange, and disseminated baseline plantation health data and advice on alternative pest management methods
- the Blue-gum Productivity Optimisation System, a web-based decision-support system driven by *Eucalyptus globulus* growth and nutrition models, which helps plantation managers assess potential plantation performance across different market conditions, climates and site characteristics
- improvements in operations and coupe design for variable retention silviculture in wet eucalypt forests, maximising biodiversity benefits without compromising the productivity of the regenerating forest
- applications that extract informative datasets, such as tree height, from the large stream of information collected by LiDAR remote sensing ; these applications have resulted in major changes to inventory, mapping and planning of forest operations (see Case study 7.6)

Eucalypt flowers. Detailed knowledge of the pollination biology and breeding systems of eucalypts underpinned development of tree improvement programs in the CRC for Forestry.

- a handbook of practical guidance for forest managers on undertaking successful and effective community engagement—an important part of cultivating the best possible relationships with the communities in which forestry companies operate
- a remote-sensing product that uses weekly or fortnightly data acquired from the MODIS satellite to detect changes in forest condition and monitor forest health at reduced cost
- protocols for assessing and monitoring the genetic risk to native forest of pollen flow from nearby plantations, based on groundbreaking research into the genetic consequences of large-scale commercial forestry
- establishment of a world-leading tree breeding program for *Eucalyptus globulus,* with solid analytical techniques and economic objectives, ensuring that genetic gains are rapidly and efficiently transferred to the expanding plantation estate
- new silvicultural options for producing eucalypt sawlogs in plantations, through control of initial stand density, pruning, thinning and fertilising, and based on a thorough understanding of the physiology of tree growth and development.

More than 170 research students have graduated from CRC-supported PhD and Masters by Research programs since 1991. The series of forestry CRCs have thereby also shaped the long-term human resource capacity of the forestry sector for future innovation.

[a] www.crcforestry.com.au.

Source: Adapted from CRC for Forestry (2012).

Australian Bureau of Agricultural and Resource Economics and Sciences

In 2010, two of Australia's national research agencies—the Australian Bureau of Agricultural and Resource Economics (ABARE) and the Bureau of Rural Sciences (BRS)—merged to form the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) within the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF)[182]. ABARES was formed to provide integrated economic and scientific research previously carried out separately by ABARE and BRS for strategic policy development.

ABARES role in delivering integrated economic, social and scientific forest research for policy development also contributes to R&D aimed at improving forest management and the delivery of forest goods and services. For example, ABARES coordinates the preparation of the *Australia's State of the Forests Report* series, publishes the *Australian Forests and Wood Products Statistics* series, and undertakes other nationally relevant research on Australia's forests.

Rural Industries Research and Development Corporation

The Rural Industries Research and Development Corporation (RIRDC) is a statutory authority established under the *Primary Industries and Energy Research and Development Act 1989*. It was one of 15 rural research and development corporations established by the Australian Government in 1990. The RIRDC was established to work with industry to invest in R&D for a more profitable, sustainable and dynamic rural sector. Through its five-year corporate plans, the RIRDC aligns its investment in R&D with the Australian Government's rural research priorities. Under its Corporate Plan 2007–12 (RIRDC 2007c), the RIRDC was involved in R&D that addressed natural resource management and sustainability issues of national importance. It invested in a range of research areas, including agroforestry systems and the impact of climate change and variability, with topics such as:

- bioenergy in forest industries
- the productivity of oil mallee agroforestry systems
- the bio-economic potential for agroforestry in northern cattle grazing
- agroforestry feedstocks for biofuels and bioenergy to mitigate and adapt to climate change.

Much of this research was coordinated by the RIRDC through the Joint Venture Agroforestry Program when Agroforestry and Farm Forestry were listed by the RIRDC as 'National Rural Issues'. RIRDC investment in agroforestry-related research decreased significantly after the reporting period for *Australia's State of the Forests Report 2013*.

Land & Water Australia

Land & Water Australia (LWA) was also established by the Australian Government in 1990 (as the Land and Water Research and Development Corporation) under the same legislation as the RIRDC. LWA was the only research and development corporation to focus on 'public good sustainability' (LWA 2009). Under its unique charter, LWA invested in generating and managing new knowledge, with the aim of achieving the sustainable management and use of Australia's natural land and water resources, including forests. It developed an integrated portfolio of research investments focused on productivity growth balanced with sustainability, working in partnerships with industry, universities and CSIRO. It also acted as a leading research broker, organising collaborative R&D programs. LWA's operations ended on 30 June 2009 when government funding ceased.

Long-term ecological research in Australia's forests

Long-term ecological research (LTER) sites are dedicated to multidisciplinary, long-term, site-based ecological research; some LTER sites are dedicated to forest research. Long-term research is critical to the understanding of ecosystem processes and to formulating policy to establish and maintain sustainable forest management.

Networks of LTER sites existed in Australia and around the world during the reporting period. In 2012, several of Australia's forested LTER sites were also brought together under TERN's Long-Term Ecological Research Network (LTERN) to establish a new coordinated and collaborative approach across forest types (including tropical rainforests, tall eucalypt forests and mallee woodlands), land tenures and land uses (including plantation forestry, conservation, restoration, tourism and agriculture).

One of the LTERN sites is an LTER site dedicated to native forest research at Warra in southern Tasmania (see Case study 1.8, and www.warra.com). The Warra LTER site was established in 1995 to facilitate understanding of the ecological processes of Tasmania's wet eucalypt forests. The site contains both working forests and conservation reserves, managed under different regimes, and provides for ecological and silvicultural research experiments. Research areas include forest biodiversity, hydrology, fire, climate change, fauna, harvesting practices and social impacts. Warra is also a member of the Australian Supersites Network, another part of the TERN infrastructure. The network comprises a number of 'Supersites' located across the country, each representative of a different ecosystem type.

[182] From September 2013, the Department of Agriculture.

Other nationally coordinated research

Over the period 2006–2011, the Australian Government has directly supported measures that contributed to boosting Australia's capacity to conduct and apply forest R&D. These measures were focused on climate change and the forest industry, and included:

- the National Climate Change and Commercial Forestry Action Plan 2009–12 developed by the Primary Industries Ministerial Council
- the Forest Industries Climate Change Research Fund.

The National Climate Change and Commercial Forestry Action Plan 2009–12 responded to climate change through adaptation and mitigation, underpinned by R&D and communication. This plan guided action by the forest industry with the support of the state, territory and Australian governments. Covering forests intended for commercial production (representing 12% of Australia's forest cover), the plan identified knowledge gaps and proposed actions to assist the forest industry to respond to climate change, including developing practical strategies and actions to manage the risks and to take advantage of opportunities brought about by climate change.

The Forest Industries Climate Change Research Fund funded 24 climate change–related research projects. The outcomes from these projects have helped the forestry and forest products industries to better understand the implications of climate change and to build capacity in the areas of adaptation, mitigation, bioenergy, and inventory and data collection.

National research capacity surveys

A series of surveys conducted by Turner and Lambert on expenditure on R&D for forestry and forest products has also collected data on R&D capacity, using a consistent methodology, at intervals in the period 1981–82 to 2007–08 (Turner and Lambert 2011). The definitions of 'Forestry R&D' and 'Forest Products' R&D used by Turner and Lambert are detailed in Indicator 6.2a.

Turner and Lambert calculated that there were about 635 researchers and technicians involved in forestry and forest products R&D in 2007–08, together with additional support staff and external contractors. This represented steady declines since about 1990 in the Commonwealth and state sectors, not fully compensated by increases in the university and private sectors. These increases in university and private sector research capacity were due to more organisations reporting research, rather than an expansion of any particular research group.

The number of researchers and technicians involved in forestry and forest products R&D is likely to have declined further since 2007–08; the most recent of this series of sector-wide surveys (currently unpublished) estimates the number of researchers and technicians to have declined to 396 in 2011 (J Turner and M Lambert, pers. comm., 2012). The continued decline has occurred across the public and private sectors, including CSIRO.

The expertise of each researcher was not recorded for these surveys, but discussions with employing organisations indicated that there has been a decline in some areas of research (for example, forest health, silviculture and forest hydrology) compared with others. The overall reduction in research capacity presents a risk for industry, especially when capacity in key areas is greatly diminished. Table 7.13

Table 7.13: Full-time-equivalent employees engaged in forest-related research and development in Australia

Organisation category	1985	2008	2011
CSIRO			
Scientists	145	75	38
Technical staff	132	81	39
States			
Scientists	180	117	77
Technical staff	206	109	71
Private companies			
Scientists	6	59	30
Technical staff	3	57	30
Universities[a]			
Scientists	11	90	72
Technical staff	10	47	39
Total			
Scientists	**342**	**341**	**217**
Technical staff	**351**	**294**	**179**
Total of all scientists and technical staff	**693**	**635**	**396**

[a] Excludes postgraduates.

Source: Turner and Lambert (2011), J Turner and M Lambert, pers. comm. 2012.

summarises the data on forestry and forest product research capacity for the various categories of R&D organisation, as compiled in these surveys from 1985 to 2011 (estimates of researcher numbers do not take into account changes in facilities and infrastructure).

University-based forest research capacity

Capacity for forest research is maintained at a small number of Australia's universities. The general framework for forest research at Australia's universities is based on research programs in Honours degrees (one year), Masters degrees (two years) and Doctorates of Philosophy (PhDs) (generally three or more years). These programs are supervised by qualified experts who direct and contribute to the delivery of high-quality, peer-reviewed research outcomes that add to the scientific understanding of Australia's forests needed to underpin sustainable forest management. Much of the development of assessment methodologies contributing to our scientific understanding of Australia's forests occurs in universities. Many of these academic institutions contribute to the forest research programs (discussed above) established under the research agencies funded by the Australian Government, as well as research agencies funded by state and territory governments (discussed below).

State and territory forest research and development capacity

The capacity of Australia's states and territories to conduct and apply forest R&D is led by the government agencies that are responsible for forest management and conservation. Changes in their capacity to conduct and apply forest R&D have occurred in the five years since SOFR 2008, largely as a result of changes in government priorities and funding. Much of the forest research effort is conducted in collaboration with other organisations, including national organisations such as CSIRO and CRCs, as well as universities.

Limited information is available on forest research capacity in individual states and territories. Some information is presented below for the Australian Capital Territory, New South Wales, South Australia, Tasmania, Victoria and Western Australia.

Australian Capital Territory

The Conservation, Planning and Research section of the Environment and Sustainable Development Directorate of the Australian Capital Territory Government supports forest management and facilitates research on forested areas. It undertakes research on local flora and fauna, prepares scientific advice on the environment and natural resource management, conducts ecological surveys, monitors biodiversity, and prepares and guides implementation of threatened species action plans.

New South Wales

Forest R&D by government agencies in New South Wales is undertaken by Forests NSW (the state's manager of publicly owned production forests)[183], by the Department of Primary Industries and through collaborative research arrangements. New South Wales forest R&D has focused on resource development, sustainability and the enhancement of the environment within the state. Priority fields of research have been those that add value to planted forests, commercial services and native forest businesses in New South Wales.

The number of full-time-equivalent (FTE) positions in forest-related R&D at Forests NSW decreased from 36 in 2006–07 to 25 in 2010–11 (Table 7.14), indicating an overall decline in research capacity, as well as changes in research priority. Decreases in capacity occurred across a number of research areas, including silviculture and agroforestry. The decrease in staff numbers in tree breeding, timber use, fire behaviour and fire ecology meant that direct capacity for research in those areas no longer remained in 2010–11. However, increases in FTE position numbers occurred in forest pathology (from 2 to 3 positions) and climate change (from 1 to 3 positions), and there were several areas in which the number of FTE positions did not change.

Table 7.14: Full-time-equivalent employees engaged in forest-related research and development in Forests NSW

Research area	Number of FTE employees	
	2006–07	2010–11
Silvicultural research	3	1
Tree breeding (not horticultural)	3	0
Forest hydrology	1	1
Timber use	3	0
Fire behaviour	1	0
Forest pathology	2	3
Agroforestry	7	3
Fauna ecology	8	8
Fire ecology	1	0
Forest entomology	3	3
Flora ecology	1	1
Non-timber forest products	1	1
Climate change	1	3
Statistical analysis	1	1
Total	**36**	**25**

FTE = full-time-equivalent
Note: Data are for plantation and native forest R&D combined.
Source: Forests NSW.

[183] From January 2013, the Forestry Corporation of NSW.

South Australia

Forest R&D in South Australia is focused on outcomes relating to plantation forestry, climate change and the environment. Primary Industries and Resources South Australia (PIRSA)[184] Forestry supports targeted research, which provides information to guide both policy development and forest and forest ecosystem management. For example, with funding provided by PIRSA Forestry, ForestrySA commissioned CSIRO to undertake research into the consequences of predicted climate change on plantation forestry in South Australia. This led to publication of *Climate Change and South Australia's Plantations: Impacts, Risks and Options for Adaptation* (Pinkard and Bruce 2011). The report provides recommendations for climate change adaptations, and covers many aspects of forest establishment and management in South Australia. PIRSA Forestry and ForestrySA also collaborate with other agencies to undertake research into crosscutting issues, such as management of *Phytophthora cinnamomi.*

Table 7.15 presents the number of FTE employees engaged in forest-related R&D for ForestrySA for 2006–07 and 2010–11. Research capacity for plantation forests has been stable over this time. ForestrySA's capacity for R&D in native forests is limited—this reflects ForestrySA's plantation focus and South Australia's *Native Vegetation Act 1991*, which strongly constrains the harvesting and clearing of native vegetation in South Australia.

Table 7.15: Full-time-equivalent employees engaged in forest-related research and development in ForestrySA

Research area	Number of FTE employees			
	Plantations		Native forest	
	2006–07	2010–11	2006–07	2010–11
Silvicultural research	13.0	13.0	0	0
Tree breeding (not horticultural)	0.5	0.5	0	0
Forest hydrology	0.5	0.5	0	0
Timber use	0.5	0.5	0	0
Fire behaviour	0.25	0.25	0	0
Forest pathology	0.25	0.25	0	0
Agroforestry	0.25	0	0	0
Fauna ecology	0	0	0.4	0.4
Fire ecology	0.25	0.25	0	0
Forest entomology	0.2	0.2	0	0
Flora ecology	0	0	0.4	0.4
Climate change	0.25	0.25	0	0
Statistical analysis	0.1	0.1	0	0
Total	**16.05**	**15.8**	**0.8**	**0.8**

FTE = full-time-equivalent
Source: ForestrySA.

184 From October 2011, Primary Industries and Regions South Australia.

Tasmania

Forest R&D capacity in Tasmania declined between 2005–06 and 2010–11 (Table 7.16). Large reductions in FTE research positions occurred in the public and private sectors, while the academic sector experienced a slight increase in forest R&D capacity.

State government agencies performing forest R&D in Tasmania include the Department of Primary Industries, Parks, Water and Environment (DPIPWE), the Forest Practices Authority and Forestry Tasmania. Forestry Tasmania's Division of Forest Research and Development undertakes research into native forest silviculture, plantation silviculture, biology and conservation. Together with the Parks and Wildlife Service of DPIPWE, the division also manages the Warra LTER site in southern Tasmania. At least one-third of Forestry Tasmania's research expenditure is devoted to development and extension work involved in the strategic or operational uptake of research. The Forest Practices Authority employs scientists who undertake forest monitoring and research programs in areas related to archaeology, botany, geomorphology, soils science, visual landscape and zoology, as well as contributing to the scientific knowledge underpinning the Tasmanian Forest Practices Code 2000 and associated specialist manuals (FPA 2012).

Much of Tasmania's forest-related research effort over the reporting period occurred through the CRC for Forestry (FPA 2012). Academic forest research in Tasmania included collaborations with CRCs (principally the CRC for Forestry, but also the Bushfire CRC), CSIRO and the University of Tasmania. However, the number of researchers employed in private companies decreased, partly as a result of outsourcing to CRCs and other external research providers (FPA 2012).

The majority of Tasmanian forest researchers worked in flora and fauna ecology, and silviculture (Table 7.17). The greatest reductions in forest R&D capacity over the reporting period occurred in plantation research (silviculture, tree breeding, fauna ecology and fire behaviour); smaller reductions occurred in native forest research (flora ecology, hydrology and pathology). Some research areas showed a modest increase in forest R&D capacity; these included climate change, silviculture, fire behaviour and tree breeding in native forest research, and hydrology, entomology and climate change in plantation research.

The Australian and Tasmanian governments jointly funded research into alternatives to clearfelling in Tasmania's old-growth forests. This funding facilitated acceleration of existing research programs based at the Warra LTER site in southern Tasmania, and enabled the expansion and application of these programs in other parts of Tasmania. The final report on this five-year research and extension program was delivered in October 2010 (Tasmanian Community Forest Agreement Technical Support Group 2010). The research program covered silviculture, biodiversity, forest health, safety, productivity, and social and economic issues. A key outcome was the delivery of a Variable Retention Manual, describing the variable retention harvesting and thinning technique as an alternative to clearfell harvesting in Tasmania's wet eucalypt forests. This research program

Table 7.16: Tasmanian forest and forestry research and development effort, 2005–06 and 2010–11

Period	Number of FTE employees				
	Government agencies	Private companies[a]	Academia[b]		Total
			Staff	Students[c]	
2005–06	69.0	10.4	38.4	36.3	**154.1**
2010–11	43.6	2.5	40.2	41	**127.3**

FTE = full-time-equivalent

[a] The number of FTE researchers is an estimate only, due to data availability.

[b] 'Academia' includes Tasmanian-based CRC activities (principally the CRC for Forestry but also the Bushfire CRC), CSIRO Sustainable Ecosystems, and various schools of the University of Tasmania.

[c] 'Students' are higher-degree students engaged full time in research, on projects often determined in collaboration with the CRC for Forestry or private forestry companies.

Source: Tasmanian Forest Practices Authority.

Table 7.17: Full-time-equivalent employees engaged in forest-related research and development in Tasmania

Research area	Number of FTE employees			
	Plantations		Native forest	
	2005–06	2010–11	2005–06	2010–11
Silvicultural research	21.6	9.8	3.6	6.9
Tree breeding (not horticultural)	12.7	8.2	0	1.3
Forest hydrology	3.8	6.2	4.5	2.4
Timber use	2.4	2.3	0.4	0.1
Fire behaviour	1.0	0	0	1.6
Forest pathology	6.5	5.0	2.0	1.0
Fauna ecology (including genetics)	16.6	12.8	23.5	25.0
Fire ecology	0	0	1.1	1.1
Forest entomology	0	0.8	1.6	1.3
Flora ecology (including genetics)	5.7	5.5	32.8	21.1
Non-timber forest products	0	0.1	0.4	0.1
Climate change	1.1	1.6	0.7	4.6
Statistical analysis	1.2	0.1	1.2	0.1
Other	1.5	6.1	0.9	2.2
Total	**74.0**	**58.5**	**72.7**	**68.8**

FTE = full-time-equivalent

Note: This table does not allocate 7.4 FTE sector R&D employees for 2005–06.

Source: Tasmanian Forest Practices Authority.

provided assurance that variable retention silviculture can be safely and effectively implemented in old-growth forests and is supported by soundly based science, validated by peer-reviewed papers.

Victoria

Most of Victoria's forest R&D capacity is held in academia, supported by investment by the Victorian Government. This is shown in Table 7.18, which presents the number of FTE employees engaged in forest-related R&D in Victoria for 2006–07 and 2010–11. Significant increases in forest R&D capacity occurred in the research areas of climate change, fire behaviour and fire ecology; in general, capacity declined for plantation research and increased for native forest research. Over the reporting period, there was a shift to a landscape-based approach to fire ecology monitoring and research (Table 7.18), and a stronger strategic focus on achieving state-wide applicability in data development.

In 2010–11, the Victorian Department of Sustainability and Environment established a further three-year research program with the University of Melbourne. The aims of the program are to develop an improved capacity and evidence base to manage impacts of fire (natural and managed), climate variability and climate change; and investigate forest management regimes relating to water quantity and quality, biodiversity values, carbon assets, other social and economic values, and the vulnerability and resilience of Victoria's public forests. This involves:

- integrated understanding of multiple forest values for adaptive forest management
- understanding the effects of fire, climate and management on the vulnerability and resilience of Victorian forests
- understanding and managing Victoria's forest carbon

- understanding water security from Victoria's forested catchments in the face of climate variability, climate change and fire
- understanding interactions between fire, landscape pattern and biodiversity
- assessing social, economic and community safety values of forests in fire-prone landscapes.

Western Australia

The number of FTEs employed by the Western Australian Department of Environment and Conservation (DEC) in research relevant to sustainable forest management varied between 20 and 25 during the period 2005–11. A decline from 2008 to 2010 (Figure 7.7) resulted from the retirement of permanent staff who were not replaced. The increased FTE from 2010 to 2011 reflects updated staff allocations that better align with work requirements within the Science Division of DEC—for example, in the area of climate science (CCWA 2012b).

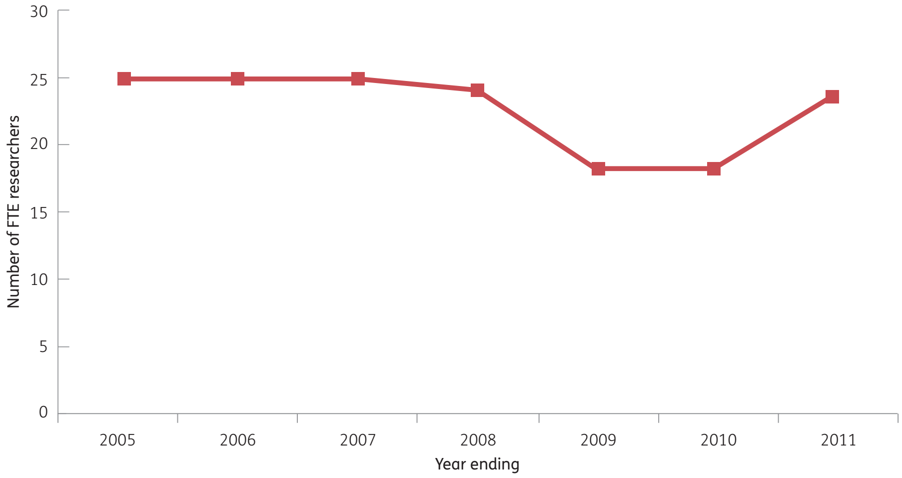
Key disciplinary areas of forest research were biodiversity, ecosystem health and vitality, and soil and water. Research effort on jarrah and karri forest ecosystems was broadly proportional to the areas of each forest ecosystem, and in addition to research at the whole-of-forest scale (CCWA 2012b). Some of DEC's forest research effort also went towards achieving, and demonstrating the achievement of, the objectives of Western Australia's *Forest Management Plan 2004–2013*, and into the development of the draft *Forest Management Plan 2014–23* (DEC 2012b).

Table 7.18: Full-time-equivalent employees engaged in forest-related research and development in Victoria

Research area	Number of FTE employees							
	Government agencies				Academia			
	Plantations		Native forest		Plantations		Native forest	
	2006–07	2010–11	2006–07	2010–11	2006–07	2010–11	2006–07	2010–11
Silvicultural research	1.5	0.6	0	0	0	0	0	0
Tree breeding	1.4	0.6	0	0	0	0	0	0
Forest hydrology	0	0	0	0	0	0	5.15	4.0
Timber use	0.4	0	0	0	0	0	0	0
Fire behaviour	0	0	0.35	1.35	0	0	0.65	2.25
Forest pathology	0	0	0	0	0	0	0	0
Agroforestry	0.5	0.1	0	0	0	0	0	0
Fauna ecology	0.2	0.1	0	0	0	0	0	0
Fire ecology	0	0	0	1.0	0	0	6.35	7.5
Forest entomology	0	1.0	0	0	0	0	0	0
Flora ecology	0	0	0	0	0	0	0	0
Non-timber forest products	0.3	0.2	0	0	0	0	0	0
Climate change	0	0	0	3.4	0	0	2.6	4.5
Other (forest industries)	0.1	0	0	0	0	0	0	0
Other (sustainable forest management)	0.1	0	3	3	0	0	6.95	5.5
Other (plantations and health)	1.5	2.5	0	0	3.6	0	0	0
Total	**6.1**	**5.1**	**6.35**	**11.75**	**3.6**	**0**	**21.7**	**23.75**

FTE = full-time-equivalent
Source: Victorian Department of Sustainability and Environment, Victorian Department of Primary Industries.

Figure 7.7: Number of full-time-equivalent employees in research relating to sustainable forest management, Western Australian Department of Environment and Conservation



FTE = full-time-equivalent
Source: Conservation Commission of Western Australia.

Case study 7.6: LiDAR research and development

In the past, most features within forests, such as tree heights and the location of streams and roads, were mapped using a combination of aerial photographic interpretation and ground-based surveys. Most of Australia's state and territory forest managers are now turning to airborne and ground-based laser scanning technology to replace traditional methods of forest mapping in native and plantation forests.

Light aircraft equipped with 'light detection and ranging' (LiDAR) equipment are flown over forests while emitting high-repetition, short-duration pulses directed at the target forest, and measuring the return reflection time to gauge target distance and bearing. Ground-mounted LiDAR sensors are also being developed to measure structural features within forests. As a direct sampling tool, LiDAR can capture a range of terrain and forest measures more rapidly, objectively and cost-effectively than current ground-based survey techniques (Turner 2007).

Over the past 10 years, LiDAR technology has been researched and tested in Australia's forests. It can accurately measure tree and forest heights, and determine features such as drainage lines, roads and slopes, leading to digital elevation maps. The development of LiDAR from a research tool to a fully operational assessment tool allows LiDAR to contribute to many areas of forest management, including forest mapping, topographic mapping, catchment management, reserve planning and mapping, carbon accounting, wood resource assessment, harvest planning, forest health and fuel-load assessments, and monitoring of mechanical harvesting operations and illegal logging activities.

Direct applications of LiDAR include determining forest canopy height and cover, forest stand density and basal area, forest growth stage, forest and vegetation classification, vertical and horizontal forest structure, forest fuel characteristics and regeneration success rates. The simultaneous measurement of vertical and horizontal forest structure can now provide an accurate three-dimensional representation of a forest's structure (Figure 7.8). By 2012, LiDAR technology had been adopted operationally across Tasmania's forests and in public production forests in New South Wales and South Australia.

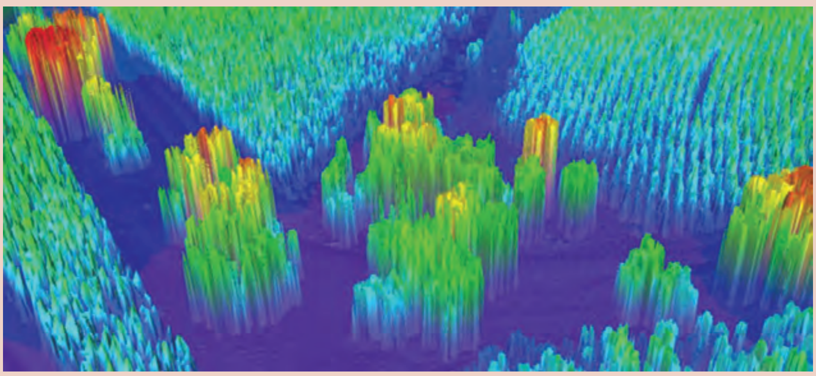


Figure 7.8: Airborne LiDAR 'virtual forest' image of uniform stands of *Pinus radiata* plantation forest surrounding remnant patches of taller *Eucalyptus* trees

Source: ForestrySA.

CRITERION 7

Oliver Creek, Daintree forest, Queensland.

Appendix A

Comparison of international Montreal Process indicators with Australia's national indicators

In reporting on the state of its forests, Australia uses the seven criteria developed in 1995 by the international-level Montreal Process Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montreal Process Working Group 2009a, 2009b). Indicators are nested under each of these criteria.

In 1998, the national-level Montreal Process Implementation Group for Australia (MIG), which comprises representatives of the Australian Government and state and territory governments, adapted the Montreal Process set of indicators to better suit reporting on Australia's unique forests. However, some of Australia's original set of indicators proved difficult to measure, and some overlapped. In 2006, MIG reviewed the indicators and reduced the list used in Australia to 44 (Commonwealth of Australia 2008). This set of 44 national indicators underpinned SOFR 2008 and again underpins SOFR 2013.

Table A1 shows the alignment of Australia's 44 national indicators with the 54 international indicators of the Montreal Process.

Table A1: Alignment of the international Montreal Process indicators with Australia's national indicators used in SOFR 2013

International Montreal Process criteria and indicators		Australian indicator(s) with which each Montreal Process indicator aligns		Australia's criteria and indicators		Montreal Process indicator(s) with which each Australian indicator aligns	
Indicator number	Indicator name	Strong alignment	Partial alignment	Indicator number	Indicator name	Strong alignment	Partial alignment
Criterion 1 Conservation of biological diversity							
1.1	**Ecosystem diversity**			**1.1**	**Ecosystem diversity**		
1.1.a	Area and percent of forest by forest ecosystem type, successional stage, age class, and forest ownership or tenure	1.1a	1.1b	**1.1a**	Area of forest by forest type and tenure	1.1.a	–
1.1.b	Area and percent of forest in protected areas by forest ecosystem type, and by age class or successional stage	1.1c	1.1b	**1.1b**	Area of forest by growth stage	–	1.1.a 1.1.b
1.1.c	Fragmentation of forests	1.1d	–	**1.1c**	Area of forest in protected area categories	1.1.b	–
				1.1d	Fragmentation of forest cover	1.1.c	–
1.2	**Species diversity**			**1.2**	**Species diversity**		
1.2.a	Number of native forest associated species	–	1.2a	**1.2a**	Forest dwelling species for which ecological information is available	–	1.2.a
1.2.b	Number and status of native forest associated species at risk, as determined by legislation or scientific assessment	1.2b	–	**1.2b**	The status of forest dwelling species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment	1.2.b	–
1.2.c	Status of on site and off site efforts focused on conservation of species diversity	–	–	**1.2c**	Representative species from a range of habitats monitored at scales relevant to regional forest management	–	1.3.b
1.3	**Genetic diversity**			**1.3**	**Genetic diversity**		
1.3.a	Number and geographic distribution of forest associated species at risk of losing genetic variation and locally adapted genotypes	1.3a	–	**1.3a**	Forest associated species at risk from isolation and the loss of genetic variation, and conservation efforts for those species	1.3.a	1.3.c
1.3.b	Population levels of selected representative forest associated species to describe genetic diversity	–	1.2c	**1.3b**	Native forest and plantations of indigenous timber species which have genetic resource conservation mechanisms in place	–	1.3.c
1.3c	Status of on site and off site efforts focused on conservation of genetic diversity	–	1.3a 1.3b				

Table A1: Alignment of the international Montreal Process indicators with Australia's national indicators used in SOFR 2013 continued

International Montreal Process criteria and indicators		Australian indicator(s) with which each Montreal Process indicator aligns		Australia's criteria and indicators		Montreal Process indicator(s) with which each Australian indicator aligns	
Indicator number	Indicator name	Strong alignment	Partial alignment	Indicator number	Indicator name	Strong alignment	Partial alignment
Criterion 2 Maintenance of productive capacity of forest ecosystems							
2.a	Area and percent of forest land and net areas of forest land available for wood production	2.1a	–	**2.1a**	Native forest available for wood production, area harvested, and growing stock of merchantable and non-merchantable tree species	2.a 2.b	–
2.b	Total growing stock and annual increment of both merchantable and non-merchantable tree species in forests available for wood production	2.1a	–	**2.1b**	Age class and growing stock of plantations	2.c	–
2.c	Area, percent, and growing stock of plantations of native and exotic species	2.1b	–	**2.1c**	Annual removal of wood products compared to the volume determined to be sustainable for native forests and future yields for plantations	2.d	–
2.d	Annual harvest of wood products by volume and as a percentage of net growth or sustained yield	2.1c	–	**2.1d**	Annual removal of non-wood forest products compared to the level determined to be sustainable	2.e	–
2.e	Annual harvest of non-wood forest products	2.1d	–	**2.1e**	The area of native forest harvested and the proportion of that effectively regenerated, and the area of plantation harvested and the proportion of that effectively re-established	–	–
Criterion 3 Maintenance of ecosystem health and vitality							
3.a	Area and percent of forest affected by biotic processes and agents (e.g. disease, insects, invasive species) beyond reference conditions	3.1a	–	**3.1a**	Scale and impact of agents and processes affecting forest health and vitality	3.a 3.b	–
3.b	Area and percent of forest affected by abiotic agents (e.g. fire, storm, land clearance) beyond reference conditions	3.1a 3.1b	–	**3.1b**	Area of forest burnt by planned and unplanned fire	3.b	–
Criterion 4 Conservation and maintenance of soil and water resources							
4.1	**Protective function**						
4.1.a	Area and percent of forest whose designation or land management focus is the protection of soil or water resources	4.1a	–	**4.1a**	Area of forest land managed primarily for protective functions	4.1.a	–
4.2	**Soil**						
4.2.a	Proportion of forest management activities that meet best management practices or other relevant legislation to protect soil resources	4.1b 4.1c	–	**4.1b**	Management of the risk of soil erosion in forests	4.2.a	–
4.2.b	Area and percent of forest land with significant soil degradation	–	–	**4.1c**	Management of the risks to soil physical properties in forests	4.2.a	–
4.3	**Water**						
4.3.a	Proportion of forest management activities that meet best management practices, or other relevant legislation, to protect water related resources	4.1d 4.1e	–	**4.1d**	Management of the risks to water quantity from forests	4.3.a	–
4.3.b	Area and percent of water bodies, or stream length, in forest areas with significant change in physical, chemical or biological properties from reference conditions	–	–	**4.1e**	Management of the risks to water quality in forests	4.3.a	–
Criterion 5 Maintenance of forest contribution to global carbon cycles							
5.a	Total forest ecosystem carbon pools and fluxes	5.1a	–	**5.1a**	Contribution of forest ecosystems and forest industries to the global greenhouse gas balance	5.a 5.b	5.c
5.b	Total forest product carbon pools and fluxes	5.1a	–				
5.c	Avoided fossil fuel carbon emissions by using forest biomass for energy	–	5.1a				

Table A1: Alignment of the international Montreal Process indicators with Australia's national indicators used in SOFR 2013 continued

International Montreal Process criteria and indicators		Australian indicator(s) with which each Montreal Process indicator aligns		Australia's criteria and indicators		Montreal Process indicator(s) with which each Australian indicator aligns	
Indicator number	Indicator name	Strong alignment	Partial alignment	Indicator number	Indicator name	Strong alignment	Partial alignment
Criterion 6 Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies							
6.1	**Production and consumption**			**6.1**	**Production and consumption**		
6.1.a	Value and volume of wood and wood products production, including primary and secondary processing	6.1a	–	**6.1a**	Value and volume of wood and wood products	6.1.a	–
6.1.b	Value of non-wood forest products produced or collected	6.1b	–	**6.1b**	Values, quantities and use of non-wood forest products	6.1.b	–
6.1.c	Revenue from forest based environmental services	6.1c	–	**6.1c**	Value of forest based services	6.1.c	–
6.1.d	Total and per capita consumption of wood and wood products in round wood equivalents	6.1d	–	**6.1d**	Production and consumption and import/export of wood, wood products and non-wood products	6.1.d 6.1.e 6.1.f 6.1.g	6.1.h
6.1.e	Total and per capita consumption of non-wood products	6.1d	–	**6.1e**	Degree of recycling of forest products	6.1.i	–
6.1.f	Value and volume in round wood equivalents of exports and imports of wood products	6.1d	–				
6.1.g	Value of exports and imports of non-wood products	6.1d	–				
6.1.h	Exports as a share of wood and wood products production and imports as a share of wood and wood products consumption	–	6.1d				
6.1.i	Recovery or recycling of forest products as a percent of total forest products consumption	6.1e	–				
6.2	**Investment in the forest sector**			**6.2**	**Investment in the forest sector**		
6.2.a	Value of capital investment and annual expenditure in forest management, wood and non-wood product industries, forest-based environmental services, recreation and tourism	6.2a	–	**6.2a**	Investment and expenditure in forest management	6.2.a	–
6.2.b	Annual investment and expenditure in forest-related research, extension and development, and education	6.2b	–	**6.2b**	Investment in research, development, extension and use of new and improved technologies	6.2.b	–
6.3	**Employment and community needs**			**6.5**	**Employment and community needs**		
6.3.a	Employment in the forest sector	6.5a	–	**6.5a**	Direct and indirect employment in the forest sector	6.3.a	–
6.3.b	Average wage rates, annual average income and annual injury rates in major forest employment categories	6.5b	–	**6.5b**	Wage rates and injury rates within the forest sector	6.3.b	–
6.3.c	Resilience of forest-dependent communities	6.5c	–	**6.5c**	Resilience of forest dependent communities to changing social and economic conditions	6.3.c	–
6.3.d	Area and percent of forests used for subsistence purposes	–	6.5d	**6.5d**	Resilience of forest dependent Indigenous communities to changing social and economic conditions	–	6.3.d
6.3.e	Distribution of revenues derived from forest management	–	–				
6.4	**Recreation and tourism**			**6.3**	**Recreation and tourism**		
6.4.a	Area and percent of forests available and/or managed for public recreation and tourism	6.3a	–	**6.3a**	Area of forest available for public recreation/ tourism	6.4.a	–
6.4.b	Number, type, and geographic distribution of visits attributed to recreation and tourism and related to facilities available	6.3b	–	**6.3b**	Range and use of recreation/ tourism activities available	6.4.b	–

Table A1: Alignment of the international Montreal Process indicators with Australia's national indicators used in SOFR 2013 continued

International Montreal Process criteria and indicators		Australian indicator(s) with which each Montreal Process indicator aligns		Australia's criteria and indicators		Montreal Process indicator(s) with which each Australian indicator aligns	
Indicator number	Indicator name	Strong alignment	Partial alignment	Indicator number	Indicator name	Strong alignment	Partial alignment
Criterion 6 Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies continued							
6.5	**Cultural, social and spiritual needs and values**			**6.4**	**Cultural, social and spiritual needs and values**		
6.5.a	Area and percent of forests managed primarily to protect the range of cultural, social and spiritual needs and values	6.4a 6.4b 6.4c	–	**6.4a**	Area of forest to which Indigenous people have use and rights that protect their special values and are recognised through formal and informal management regimes	6.5.a	–
6.5.b	The importance of forests to people	6.4d	–	**6.4b**	Registered places of non-Indigenous cultural value in forests that are formally managed to protect those values	6.5.a	–
				6.4c	The extent to which Indigenous values are protected, maintained and enhanced through Indigenous participation in forest management	6.5.a	–
				6.4d	The importance of forests to people	6.5.b	–
Criterion 7 Legal, institutional and economic framework for forest conservation and sustainable management							
7.1.a	Legislation and policies supporting the sustainable management of forests	7.1a	7.1b	**7.1a**	Extent to which the legal framework supports the conservation and sustainable management of forests	7.1.a	7.3.a 7.3.b
7.1.b	Cross-sectoral policy and programme coordination	–	7.1a 7.1b	**7.1b**	Extent to which the institutional framework supports the conservation and sustainable management of forests	–	7.1.a 7.4.a 7.5.b
7.2.a	Taxation and other economic strategies that affect the sustainable management of forests	7.1c	–	**7.1c**	Extent to which the economic framework supports the conservation and sustainable management of forests	7.2.a	–
7.3.a	Clarity and security of land and resource tenure and property rights	–	7.1a	**7.1d**	Capacity to measure and monitor changes in the conservation and sustainable management of forests	7.5.c	–
7.3b	Enforcement of laws related to forests	–	7.1a	**7.1e**	Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services	7.4.b	–
7.4.a	Programmes, services and other resources supporting the sustainable management of forests	–	7.1b				
7.4.b	Development and application of research and technologies for the sustainable management of forests	7.1e	–				
7.5.a	Partnerships to support the sustainable management of forests	–	–				
7.5.b	Public participation and conflict resolution in forest-related decision making	–	7.1b				
7.5.c	Monitoring, assessment and reporting on progress towards sustainable management of forests	7.1d	–				

– = no such alignment

Glossary

Numbers separate alternative definitions or uses.

Term	Definition and use in SOFR 2013
Abiotic	Used in reference to the non-biological components of the environment (e.g. climate, soil and water).
Above-ground biomass	All living biomass above the soil, including stump, stem, bark, branches, foliage and seeds, and attached material such as dead branches. See *Below ground biomass, Biomass*.
Acacia	As a national forest type, forest dominated by trees of the genus *Acacia*.
Acidification	Increasing levels of acidity—for example, in soil—that can damage soil and vegetation.
Adaptive capacity (human)	Ability, or potential, of a community or individual to modify or change their characteristics or behaviour to cope better with change or stresses.
Afforestation	Establishment of forest on land not previously forested. The Kyoto Protocol and initiatives such as the Carbon Farming Initiative use specific definitions of afforestation. See *Deforestation, Forest, Reforestation*.
Age class	Group of trees of a similar age; for example, plantations established between 1990 and 1994 are in a five-year age class.
Aggregated retention	A silvicultural system in which clumps or clusters of trees are retained in forest stands harvested for wood. A form of variable retention. See *Silvicultural practices / systems, Variable retention*.
Agroforestry	See *Farm forestry*.
Amortisation	Allocation of the cost of an intangible asset (such as goodwill) over its service life.
Apical dominance	Growth habit of a shoot whereby growth and development of lateral buds are suppressed.
Arboretum	A collection of living trees brought together at a single site at least partly for observation and scientific study. Plural: arboreta.
Below-ground biomass	All biomass of live roots in the soil. (Fine roots are often excluded from measurement because it is difficult to separate these from soil organic matter.) See *Above ground biomass, Biomass*.
Biodiversity; Biological diversity	The variety of all life forms, plants, animals and microorganisms, their genes and the ecosystems they inhabit. See *Ecosystem diversity, Genetic diversity, Species diversity*.
Bioenergy	A form of energy derived from biomass, when biomass is used to generate electricity or heat or to produce liquid fuels for transport. See *Biofuel, Biomass*.
Biofuel	An energy source based on organisms and their products such as wood and plant matter, algae, or animal fats. See *Bioenergy*.
Biogeographic	Relating to the study of the distribution of living things.
Biological diversity	See *Biodiversity*.
Biomass	1. Material of biological origin (plant and other). 2. Organic material located both above-ground and below-ground, and both living and dead—for example, trees, grasses, litter, roots and soil organic matter (for purposes of carbon accounting).
Biome	A large, regional ecological unit, usually defined by some dominant vegetative pattern.
Bioregion	A large, geographically distinct area that has a common climate, geology, landform, and vegetation and animal communities. See *IBRA*.
Biotic	Used in reference to the biological components of the environment (e.g. plants, animals and other organisms).

Term	Definition and use in SOFR 2013
Broadscale clearing	Clearing of large tracts of native vegetation. See *Forest clearing, Land clearing*.
Bushfire	Fire started naturally (such as by lightning), accidentally or deliberately (such as by arson), but not in accordance with planned fire management prescriptions. See *Unplanned fire, Wildfire*
Bushland	A general term in Australia for natural vegetation, covering any kind of habitat from open, shrubby country with scattered trees, to tall, closed forests.
Callitris	As a national forest type, forest dominated by trees of the genus *Callitris*.
Canopy	Uppermost layer of a forest comprising tree crowns, branches and leaves.
CAR reserve system	A reserve system based on the three principles of Comprehensiveness, Adequacy and Representativeness, and which include: the full range of vegetation communities (comprehensive); ensuring that the level of reservation is large enough to maintain species diversity, as well as community interaction and evolution (adequate); and conserving the diversity within each vegetation community, including genetic diversity (representative). The CAR reserve system is made up of dedicated reserves, informal reserves and areas where values are protected by prescription. Dedicated, or formal, reserves are set aside for conservation through areas such as national parks. Informal forest reserves are areas set aside for conservation purposes in forests that are otherwise production forests, such as special protection zones in state forests. Areas where values are protected by prescription within production forests are those that cannot be practically protected by formal or informal reservation (e.g. riparian vegetation or rare and dispersed values). See *Vegetation community*.
Carbon accounting	Estimation of the amount of carbon stored in an ecosystem and changes in this amount.
Carbon credit	A tradable certificate, permit or legal instrument, deriving from a verified reduction of one unit (one tonne) of carbon dioxide emissions (or equivalent), and tradable to offset one unit (one tonne) of carbon dioxide emissions (or equivalent).
Carbon sequestration	Removal of carbon from the atmosphere and its storage in vegetation, soils or elsewhere.
Carbon sink	A carbon reservoir or pool that has the capacity to accumulate carbon.
Carbon source	A carbon reservoir or pool that has the capacity to release carbon.
Carbon stock	Quantity of carbon in a carbon reservoir or pool.
Carbon store	A carbon reservoir or pool.
Casuarina	As a national forest type, forest dominated by any of four genera in the family Casuarinaceae; in practice, forest dominated by trees of the genera *Allocasuarina* or *Casuarina*.
Certification	See *Forest certification*.
Certified forest	A forest that has been certified by a third party to comply with the requirements of a credible and recognised forest management standard. See *Forest certification*.
Chain of custody	A process of verifying the origin and supply of wood or timber product through the supply chain to a point of market. Generally, this applies to products from forests with forest certification or where products are legally harvested. See *Forest certification*.
Chlorosis	Yellowing or whitening of leaf tissue due to a lack of chlorophyll, typically caused by disease, changed drainage, plant nutrient deficiencies, or damage to or compaction of roots.
Clearfelling	A silvicultural system in which all (or nearly all) trees in an area are harvested in one operation, such that more than half of the harvested area is greater than one tree height from a retained forest edge. See *Silvicultural practices / systems*.
Clone	Identical copies of a plant produced by tissue culture or vegetative reproduction.
Closed forest	Forest in which the tree crown cover ranges from 80% to 100%. See *Crown cover*.
CO_2-equivalent (CO_2-e)	Measurement unit for the effect in the atmosphere of greenhouse gases relative to the effect of a unit of carbon dioxide (CO_2).
Code of forest practice	A set of principles, procedures, guidelines and standards that defines and prescribes minimum acceptable practices in harvesting and associated forestry operations.
Commerciality	The expected volume yield of commercial sawlog or veneer log (or high-value equivalents) that is available over the long term, based on good silvicultural practices. Derives from the combination of merchantability and productivity.

Term	Definition and use in SOFR 2013
Community	1. Biological: a naturally occurring group of species inhabiting a particular area and interacting with each other, especially through biological relationships, relatively independently of other communities. 2. Human: a group of people associated with a particular place.
Community adaptive capacity (human)	See *Adaptive capacity, Community (definition 2).*
Community resilience (human)	The capacity of an individual, community or human system to absorb and respond to shocks while sustaining an acceptable level of function, structure, and identity. See *Community (definition 2).*
Compaction	See *Soil compaction.*
Compliance audit	An audit of compliance to an environmental standard, silvicultural practice, or code of practice prescriptions. See *Code of forest practice, Forest certification.*
Conifer	Taxon in the order Pinales (formerly Coniferales), a group of gymnosperms with characteristic reproductive structures called cones; includes Araucariaceae (araucaria family), Cupressaceae (cypress family), Pinaceae (pine family) and Podocarpaceae (podocarp family). See *Pine, Softwood.*
Connectivity	The degree of vegetation structural links between forest patches in a landscape, which facilitate or impede species movement across habitat within the landscape context.
Conservation reserve	Area of land specially set aside to protect some inherent environmental value. Development in, and use of, conservation reserves is usually restricted to activities that are compatible with conservation of the environmental values for which the reserve was declared. Conservation reserves include national parks, conservation parks and nature reserves, and informal reserves. See *Nature conservation reserve (Public).*
Consumer Price Index (CPI)	Index that measures changes in the price of a 'basket' of goods and services that account for a high proportion of expenditure by a CPI population group (e.g. metropolitan households).
Consumption	Production plus imports minus exports of a commodity or group of commodities.
Cording	The practice of placing large (5–30 centimetre diameter) woody material on extraction tracks before harvesting, to minimise soil erosion. See *Matting.*
Criterion	A category of conditions or processes by which sustainable forest management may be assessed. A criterion is characterised by a set of related indicators that are monitored periodically to assess change. Plural: criteria. See *Indicator, Montreal Process.*
Critically endangered species / ecological community	Native species / ecological community facing an extremely high risk of extinction in the wild in the immediate future. One of the categories of threatened species / ecological communities defined in sections 179 and 182 of the *Environment Protection and Biological Conservation Act 1999*. See *Ecological community, Endangered species / ecological community, Extinct, Extinct in the wild, Threatened ecological community, Threatened species, Vulnerable species / ecological community.*
Crown cover	The area of ground covered by tree canopies, ignoring overlaps and gaps within individual canopies.
Crown density	Measure of crown cover.
Crown land	Land belonging to the Crown, being a national, state or territory government, including Crown land under private leasehold title. See *Leasehold land, Other Crown land, Public land.*
Deforestation	1. A type of land clearing involving the permanent removal of tree cover. 2. The direct, human-induced removal of forest cover and replacement with pasture, crops or other uses on land that was forest on 01 January 1990 (relates to the Kyoto Protocol).
Degradation	1. Destruction of specific aspects of a forest ecosystem, such as a decrease in tree cover, changes in structure, a reduction in the number of species, or the loss of habitat characteristics that support the requirements of species or communities, short of being defined as deforestation. 2. Reduction in the capacity of a forest to provide a range of goods and services.
Dieback	A symptom of disease agents or environmental factors in which foliage dies progressively from the extremities and trees exhibit loss of vigour; commonly used in reference to native forests affected by cinnamon fungus (*Phytophthora cinnamomi*), woodland forests affected by salinity, forest affected by drought or changed nutrient or water regimes or fire regimes, or trees subjected to overgrazing.

Term	Definition and use in SOFR 2013
Direct employment	The number of jobs in public and private agencies and firms relating to the process of producing a good or service. Any secondary economic activity resulting from the primary activity is included in indirect employment. See *Indirect employment.*
Dry forest / dry sclerophyll forest	Typically, eucalypt-dominated sclerophyll forest associated with water-limited or nutrient-limited conditions, and with an understorey (if present) of sclerophyll trees or shrubs. Ground cover can be bare, litter, grassy or heathy. See *Eucalypt, Sclerophyll, Wet forest / wet sclerophyll forest.*
Ecological community	A group of plants, animals and other organisms that are interacting in a habitat. See *Community (definition 1).*
Ecological and/or ecosystem resilience	See *Resilience.*
Ecologically mature	Displaying a range of structural, function and compositional attributes associated with the ecological processes characteristic of forests in their mature or senescent growth stages. See *Mature, Old-growth.*
Ecologically sustainable forest management	The integration of commercial and non-commercial values of forests so that the welfare of society (both material and non-material) is improved, while ensuring that the values of forests, both as a resource for commercial use and for conservation, are not lost or degraded for current and future generations. See *Sustainable forest management.*
Ecologically sustainable use	Use of natural resources within their capacity to sustain natural processes, while maintaining the life-support systems of nature and ensuring that the benefit of the use to the present generation does not diminish the potential to meet the needs and aspirations of future generations.
Ecosystem	A dynamic complex of plant, animal and microorganism communities and their non-living environment, interacting as a functional unit.
Ecosystem diversity	The diversity of different ecological communities formed by living organisms and the relations among them. See *Biodiversity, Genetic diversity, Species diversity.*
Ecosystem services	The provision of benefits (goods and services) that society obtains from ecosystems, and the contributions that ecosystems make to human well being, arising from both biotic and abiotic processes and their interaction.
Ecotourism	Tourism that features places of ecological interest, such as forests, and experience of the environment.
Edge effect	1. The effect of non-forest environmental influences on adjoining forest land. 2. The effect of forest environmental influences on adjoining non-forested land.
Endangered species / ecological community	Native species / ecological community facing a very high risk of extinction in the wild in the near future. One of the categories of threatened species/ ecological communities defined in sections 179 and 182 of the *Environment Protection and Biological Conservation Act 1999*. See *Critically endangered species / ecological community, Ecological community, Extinct, Extinct in the wild, Threatened ecological community, Threatened species, Vulnerable species / ecological community.*
Endemic	Species of plant or animal that occurs naturally only in a specified region or country. See *Exotic, Indigenous (of species), Introduced species.*
End-use market	The final market in which a product or service is ultimately consumed.
Environmental asset	1. A part or feature of the natural environment that provides environmental or ecosystem functions or services. 2. In Australia's System of National Accounts, one of four environmental assets (land, significant subsoil assets, plantation timber, or native standing timber available for exploitation) that are under the control of an economic agent, and measurable (valued in monetary terms). See *Ecosystem services.*
Environmental compliance	Conforming to specified requirements in environmental laws, regulations, environmental management systems, management plans, planning specifications, codes of practice, standards and prescription guidelines. See *Code of forest practice, Environmental management system.*
Environmental management system	A framework for the systematic management of an organisation's environmental obligations and objectives.

Term	Definition and use in SOFR 2013
Environmental planting	In a forest context, trees established for environmental benefit (not industrial benefit) by direct seeding or planting that have the potential to attain a crown cover of at least 20% and a height of at least 2 metres. See *Industrial plantation, Other forest, Plantation.*
Environmental service	*See Ecosystem services*.
Eucalypt	1. Any member of three genera (*Angophora*, *Corymbia* and *Eucalyptus*) of trees or large shrubs in the family Myrtaceae, mostly native to Australia. 2. As a national forest type, forest dominated by any of the three genera *Angophora*, *Corymbia* and *Eucalyptus*.
Even-aged forest	Forest in which all trees are about the same age or of the same age class, even though they may vary in size because of their different rates of growth. See *Uneven-aged forest.*
Exclusion zone	Forest excluded from harvest or management operations as a result of the application of a prescription in a code of practice (for fire, forest or reserve management).
Exotic	Species of plant or animal that does not occur naturally in a region or country. See *Indigenous (of species), Introduced species.*
Ex-situ conservation	The conservation of species and genetic components of biological diversity outside their natural habitats. See *In-situ conservation.*
Extinct	A species for which there is no reasonable doubt that the last individual has died, or for which exhaustive surveys in known or expected habitats throughout its historical range have failed to record an individual over a timeframe appropriate to its lifecycle and form. One of the categories of threatened species defined by sections 179 of the *Environment Protection and Biological Conservation Act 1999*.
Extinct in the wild	A species known to survive in only cultivation, in captivity or as a naturalised population well outside its past range, and that has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form. One of the categories of threatened species defined by sections 179 of the *Environment Protection and Biological Conservation Act 1999*.
Farm forestry	Establishment and/or management of trees or forests on agricultural landscapes for commercial, aesthetic and/or environmental reasons. Also known as agroforestry.
Fibreboard	A category of reconstituted wood-panel products made from pulpwood and/or wood-processing residues such as woodchips, sawmill shavings and sawdust plus a resin or binder, pressed into panels. Types of fibreboard (in order of increasing density) include particleboard, medium-density fibreboard (MDF), high-density fibreboard and hardboard.
Fire regime	The frequency, intensity, seasonality and scale of burning of an area or vegetation type over a period of time. The history or forecast of fire events or fire use in a particular area or vegetation type.
Firewood	Wood used for residential heating. See *Fuelwood.*
Floriculture	Cultivation of flowering and ornamental plants.
Floristics	Study of the distribution and relationships of plants over a geographic area.
Forest	An area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding 2 metres and with existing or potential crown cover of overstorey strata about equal to or greater than 20%. This includes Australia's diverse native forests and plantations, regardless of age. It is also sufficiently broad to encompass areas of trees that are sometimes described as woodlands.
Forest certification	A process whereby the quality of sustainable forest management is assessed and certified by a third party, against the criteria of a credible and recognised forest management standard. See *Certified forest.*
Forest clearing	Conversion of forested land to agricultural, urban or other non-forest land uses. See *Broadscale clearing, Land clearing.*
Forest-dependent community (human)	A community having an identified dependence on the forest and wood products industries. *See Community (definition 2).*
Forest-dependent species	A species that requires a forest habitat for at least part of its lifecycle, and that could not survive or reproduce in the absence of this habitat.
Forest-dwelling species	A species that may use a forest habitat for at least part of its lifecycle.
Forest health	The sum of the ecosystem processes (energy, nutrient, hydrological and biological processes) that together maintain the vitality of a forest ecosystem.

Term	Definition and use in SOFR 2013
Forest land	Land carrying forest. See *Forest*.
Forest management	A system of practices for conservation, stewardship and productive use of forest land, aimed at fulfilling relevant ecological, economic and social functions and objectives of the forest.
Forest management plan	A long-term, documented plan for a forest area that contains defined management goals, objectives and outcomes, which are monitored and periodically reviewed, and that expressly includes the management of forest. Management plans can take many forms, including forest management plans; natural resource, environment and water catchment management plans that cover and include a focus on forests; and strategic management planning systems required for forest certification.
Forest operations	Operational forest management activities, independent of forest type or tenure.
Forestry operations	Operational forest management activities related to wood production.
Formal reserve	See *CAR reserve system*.
Fragmentation	1. The degree of loss of spatial connectivity between forest areas. 2. The process of loss of spatial connectivity between forest areas. See *Connectivity*.
Free-on-board value	The value of goods to the seller at the point of loading goods onto transport to overseas markets, excluding transport and insurance costs.
Fuel load	The total amount of combustible material in a defined area.
Fuelwood	Wood or wood products used as industrial fuel or for bioenergy production. See *Bioenergy, Firewood*.
Gall	A proliferation of modified plant tissue caused by various parasites, from fungi and bacteria to insects and mites.
Genetic diversity	The diversity of genetic information within and between individual species. See *Biodiversity, Ecosystem diversity, Species diversity*.
Genetic resources	Material of plant, animal, microbial or other origin that contains functional units of heredity and that has actual or potential value for humanity.
Genotype	The genetic constitution or makeup of an organism.
Geographic information system (GIS)	A system for capturing, storing, analysing and managing data and associated attributes that are spatially referenced to the surface of the Earth.
Geospatial	Relating to the relative position of features on the surface of the Earth.
Girder	A specialised, large-dimensioned timber product, usually in squared-end form, that is used in building bridges, wharves and the framework of large buildings.
Global carbon cycle	The movement of carbon between different parts of the Earth and its atmosphere, including the storage of carbon in those parts.
Graft	A method of plant propagation, whereby a bud, shoot or tissue of one plant is joined with another plant.
Greenhouse gas	Gas that affects the temperature of the Earth's surface and climate, including water vapour, ozone, chlorofluorocarbons, carbon dioxide, methane and nitrous oxide. National inventories report anthropogenic emissions and removals of greenhouse gases not controlled by the Montreal Protocol on Substances that Deplete the Ozone Layer.
Green Triangle	A region comprising in whole or in part 17 local government areas straddling the state border in south-west Victoria and south-east South Australia, and containing significant areas of plantation and dependent wood-processing facilities.
Greenwood	1. Wood freshly harvested that has not been dried. 2. Wood from live sandalwood that meets a specified quality standard and size.
Gross domestic product	The total market value of goods and services produced in a country in a given period, after deducting the cost of intermediate goods and services used in production (but not deducting allowances for the consumption of fixed capital, or depreciation). 'Gross domestic product' is the sum of the value added by each industry across the economy. 'Industry value added' is the value added by a particular sector. See *Industry value added.*
Gross value of production	Value placed on production at the wholesale prices realised in the marketplace (where the marketplace refers to local consumption, export, or a point before value-adding by a secondary industry). Gross value of production provides a value for products that do not have a final market price.

Term	Definition and use in SOFR 2013
Group selection	A silvicultural system in which groups (small patches or stands) of trees are harvested, allowing for subsequent regeneration and leading to a forest comprising patches of differently aged trees. See *Selection logging, Silvicultural practices / systems.*
Growing stock	The living tree component of the standing volume in a forest at a given time. See *Standing volume*.
Gymnosperm	A plant, such as a cycad or conifer, the seeds of which are not enclosed within an ovary. See *Conifer*.
Habitat	The environment where a plant, animal or ecological community normally lives or occurs. See *Ecological community.*
Hardwood	Wood or wood products from flowering trees (broadleaved tree species), such as eucalypts, irrespective of the physical hardness of the wood; also used to refer to the trees that have such wood, and plantations of such trees.
Harvested wood products	Wood products originating from harvested trees and removed from harvest areas for use or further processing.
Harvesting	1. As part of forest management, cutting (felling) of trees to produce wood products. 2. Collection (gathering) of non-wood forest products.
Heathland	A shrubland habitat found mainly on low-quality acidic soils and characterised by open low-growing woody vegetation. It forms extensive and highly diverse communities across Australia in humid and sub-humid areas. Heathland above 2 metres tall can also be classified as other woody vegetation. See *Other woody vegetation, Shrubland*.
Hybridisation	The process of crossing different breeds or cultivars of a single plant species, or crossing plants of different taxa (subspecies, species or genera). Hybridisation can occur naturally between closely related species.
IBRA (Interim Biogeographic Regionalisation for Australia)	A set of 85 bioregions within the Australian landmass, used as the basis for the National Reserve System's planning framework and some state-based reporting.
Indicator	A measure or measurement of an aspect of a criterion. A quantitative or qualitative variable that can be measured or described and that, when observed periodically, demonstrates trends. See *Criterion, Montreal Process.*
Indigenous (of people)	Of Aboriginal or Torres Strait Islander descent.
Indigenous (of species)	Species of plant or animal that occurs naturally in a specified region or country. See *Endemic, Exotic.*
Indigenous co-managed (of lands)	Lands that are owned and managed by non-Indigenous parties, but have formal, legally binding agreements in place to include Indigenous people in the process of developing and implementing management plans. See *Indigenous managed (of lands), Indigenous owned and managed (of lands), Other special rights (of lands)*.
Indigenous estate (land or forest)	Land or forest that is Indigenous owned and managed, Indigenous managed, Indigenous co-managed, or subject to Other special rights.
Indigenous Land Use Agreement	A voluntary agreement between Native Title parties and other people.
Indigenous managed (of lands)	Lands that are managed but not owned by Indigenous communities (e.g. Crown reserves and leases), and lands that are owned by Indigenous people, but have formal shared management agreements with Australian or state and territory government agencies. See *Indigenous co-managed (of lands), Indigenous owned and managed (of lands), Other special rights (of lands)*.
Indigenous owned and managed (of lands)	Freehold lands that are both owned and managed by Indigenous communities. See *Indigenous co-managed (of lands), Indigenous managed (of lands), Other special rights (of lands)*.
Indigenous Protected Area	An area of Indigenous-owned land or sea where traditional owners have entered into an agreement with the Australian Government to promote biodiversity and cultural resource conservation. See *Protected area.*
Indirect employment	The number of jobs in secondary economic activity resulting directly from a primary economic activity, in provision of materials, supplies, goods and services to support the primary activity, and generated or supported in retail and service sectors by the spending of salaries and wages of individuals and families included in direct employment. See *Direct employment*.
Industrial plantation	Hardwood or softwood plantation supplying log resources to the wood-processing industries as reported through the National Plantation Inventory. See *Other forest, Plantation.*

Term	Definition and use in SOFR 2013
Industry value added	The value added by an industry to the inputs used by that industry; the contribution of that industry to Gross domestic product. For SOFR 2013, 'Industry value added' excludes some downstream parts of the forestry, wood and paper products industries, particularly wholesaling, retailing and value-adding (including the manufacturing of some commodities). See *Gross domestic product*.
Informal reserve	Reserve on public land protected through an administrative instrument by a public agency. See *CAR reserve system*.
In-situ conservation	The conservation of species and genetic components of biological diversity in their natural habitats. See *Ex-situ conservation*.
Integrated pest management	A pest control strategy that uses an array of complementary methods, such as natural predators and parasites, pest-resistant varieties, cultural practices, biological controls, various physical techniques and chemicals.
Introduced species	A species of plant or animal occurring outside its natural range (past or present) and dispersal potential—that is, outside the range it occupies naturally or could occupy without direct or indirect introduction or care by humans. See *Exotic, Indigenous (of species)*
Introgression	The movement of a gene or genes from the gene pool of one species into the gene pool of another by hybridisation or cross-breeding. See *Hybridisation*.
Jurisdictions	The Commonwealth, states and territories of Australia, in each of which its own system of laws has authority.
Key threatening process	A threatening process listed under the *Environment Protection and Biodiversity Conservation Act 1999*. See *Threatening process*.
Land clearing	Removal of vegetation to convert land to another land use. See *Broadscale clearing, Forest clearing*.
Land tenure	Formal title, ownership or occupancy of land. See *Crown land, Leasehold forest, Multiple-use public forest, Nature conservation reserve, Other Crown land, Private forest, Unresolved tenure*.
Leasehold forest	Forest on Crown land held under leasehold title for a specific term and purpose and generally regarded as privately managed, including land held under leasehold title with special conditions attached for designated Indigenous communities. See *Crown land, Leasehold land, Leasehold title*.
Leasehold land	Crown land held under leasehold title for a specific term and purpose and generally regarded as privately managed, including land held under leasehold title with special conditions attached for designated Indigenous communities. See *Crown land, Leasehold title*.
Leasehold title	Land title held under a contract by which one party conveys the land to another for a specified time and purpose, usually in return for a periodic payment.
LiDAR (Light Detection and Ranging)	A technology that uses laser (light) pulses from (most commonly) an aircraft to collect information on terrain and vegetation features (such as tree height), based on the return time of pulses back to the sensor.
Litter	The uppermost layer of the forest floor consisting chiefly of fallen leaves, wooden debris and other decaying organic matter.
Log landing	A cleared area where harvested logs are laid or piled in stacks after being gathered from the site or sites of felling, and before transport to the wood processing facility.
Mallee	1. A woody plant, usually a eucalypt, that is multi-stemmed from ground level, and without a prescribed upper or lower height limit. 2. A forest dominated by mallee species.
Managed investment scheme (MIS)	Scheme associated with primary production (e.g. plantation forestry) that satisfies the definition of 'managed investment scheme' in s. 9 of the Corporations Act 2001 and fulfils associated regulatory requirements.
Managed losses	Losses of carbon directly from forests to the atmosphere that are associated with the management of forests—for example, prescribed burns, post-harvest burnings, and burning of debris associated with land-clearing.
Management effectiveness	A measure of how well a protected area, or system of protected areas, is being managed in terms of protecting values and achieving goals and objectives, based on an audit process or evaluation.

Term	Definition and use in SOFR 2013
Mangrove	1. A tree, shrub, palm or ground fern that normally grows above mean sea level in the intertidal zone of coastal environments and estuarine margins. 2. The tidal habitat comprising mangrove trees and shrubs. 3. A national forest type comprising mangroves.
Matting	The practice of placing small (less than 5 centimetre diameter) woody material on extraction tracks before harvesting to protect soil against heavy vehicle traffic and minimise soil erosion. See *Cording.*
Mature	1. A native forest growth stage in which trees are at maximum height and the crowns at full lateral development. 2. A native forest growth stage, generally taken as 80 or more years since disturbance. One of four growth stages used at the national level to describe the age of trees and stands of trees. See *Apical dominance, Ecologically mature, Regrowth, Senescent.*
Medium-density fibreboard (MDF)	See *Fibreboard.*
Melaleuca	As a national forest type, forest dominated by trees of the genus *Melaleuca*.
Merchantability	The suitability of a tree species for pulp, sawlog, or speciality wood products. An emphasis is placed on commercial production of sawlogs or high-value equivalents.
Merchantable tree species	A tree species or provenance with known commercial uses for wood products, based on standards, technology or market conditions. See *Non-merchantable tree species.*
MODIS (Moderate-resolution Imaging Spectroradiometer)	A remote-sensing technology carried on two Earth Observing System satellites, capturing data covering the visual and infrared spectrum and imaging the entire Earth every 1–2 days.
Monitoring	The periodic and systematic measurement and assessment of a value, attribute or indicator.
Montane	Ecosystems associated with mountain landscapes, alpine environments or higher elevations.
Montreal Process (the Montreal Process Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests)	An initiative by the Montreal Process Working Group of (currently 12) countries, which has developed and is implementing a comprehensive set of criteria and indicators for the conservation and sustainable management of temperate and boreal forests. Australia is a member of the working group. See *Criterion, Indicator.*
Mosaic (of vegetation)	Vegetation composed of patches of different types, perhaps arising from periodic disturbance (such as fire or wood harvesting) or related to differences in soil or landform.
Multi-leaders (of trees)	A condition in trees where the apical dominance of the shoot at the top of the plant is lost, allowing lateral buds to grow into two or more stems or leaders. See *Apical dominance.*
Multiple Lines of Evidence approach	Compilation of data from a range of different sources, followed by assessment and validation to arrive at a best-possible dataset.
Multiple-use public forest	Publicly owned state forest, timber reserves and other forest areas on which a range of forest values—including provision of wood for harvest, water supply, conservation of biodiversity, recreation and environmental protection—are managed by state and territory government agencies in accordance with relevant Acts and regulations.
National forest type	Any one of eight broad forest types in which Australia's forests are categorised in the National Forest Inventory for the purpose of reporting and analysis (Acacia, Callitris, Casuarina, Eucalypt, Mangrove, Melaleuca, Rainforest, and Other native forest).
Native	Of a species, located within its natural range. See *Non-native.*
Native forest	Forest that is dominated by the suite of native tree species naturally associated with forest in that location and located within their natural range, and that is not a plantation.
Nature conservation reserve (Public)	Crown land that is formally reserved for environmental, conservation and recreational purposes, including national parks, nature reserves, state and territory recreation and conservation areas, and formal reserves in state forests. It does not include informal reserves and those pending gazettal. The commercial harvesting of wood and non-wood forest products is generally not permitted. See *Conservation reserve, Crown land.*
Non-forest	Vegetation communities and habitats that are not forest, including marine environments, alpine meadows, other woody vegetation (including open woodland, heathland and shrubland), grassland, non-forest waterways and wetlands, rock outcrops, mudflats and farmland. See *Forest, Habitat, Other woody vegetation, Vegetation community.*

Term	Definition and use in SOFR 2013
Non-forest land	Land that does not carry forest. See *Forest land*.
Non-merchantable tree species	A tree species or provenance with no currently known commercial uses for wood products, based on standards, technology or market conditions. See *Merchantable tree species*.
Non-native	Of a species, located outside its natural range. See *Native*.
Non-production native forest	Native forest that is not managed for commercial wood production.
Non-vascular plant	A plant without a water-conducting system, including algae, liverworts and mosses.
Non-wood forest product	A product of biological origin, other than wood, derived from forests, including game animals, seeds, berries, chemical products, mushrooms, oils, foliage, medicinal plants, flowers, fodder, and wood and non-wood Indigenous artefacts.
Old-growth forest	Ecologically mature forest where the effects of disturbances are now negligible. See *Ecologically mature, Mature*.
Open forest	Forest in which tree crown cover ranges from 50% to less than 80%. See *Crown cover*.
Other Crown land	Crown land reserved for a variety of purposes, including utilities, scientific research, education, stock routes, mining, water-supply catchments, and use by Indigenous communities. Excludes Leasehold Forest, Nature Conservation Reserve, and Multiple-Use Forest. See *Crown land*.
Other forest	Non-industrial plantations and planted forests that are not reported through the National Plantation Inventory but satisfy the definition of forest; it includes farm forestry and agroforestry plantations, sandalwood plantations, environmental plantings, plantations within the reserve system, and plantations regarded as not commercially viable. Non-planted forests dominated by introduced species are also included in this category. See *Forest, Industrial plantation, Plantation*.
Other native forest	A national native forest type comprising forest types of minor extent such as Agonis, Atalaya, Banksia, Hakea, Grevillea, Heterodendron, Leptospermum, Lophostemon and Syncarpia (named after their dominant genera), as well as native forests where the type is unknown. See *Forest, Native forest*.
Other special rights (of lands)	Lands subject to Native Title determinations and active Indigenous Land Use Agreements. These are independent of tenure and, in most cases, do not grant ownership or management rights of land to Indigenous communities. They can provide for the right to access areas of cultural significance, or a legal requirement for consultation with the local Indigenous community before any major development activities take place. See *Indigenous co-managed (of lands), Indigenous managed (of lands), Indigenous owned and managed (of lands)*.
Other woody vegetation	A non-forest vegetation type: open woodland, heathland or shrubland generally containing a tree component with actual or potential tree height greater than 2 metres, but *either* actual or potential tree canopy crown cover of 5–20% *or* combined cover of shrubs and trees greater than 10% but cover of trees less than 20%. See *Crown cover, Heathland, Shrubland*.
Overstorey	1. The uppermost layer of foliage in a forest. 2. Trees occupying the uppermost layer in a forest of more than one layer (storey).
Parasitoid	An organism that spends a significant proportion of its life attached to or within a single host organism, which it ultimately kills (and often consumes).
Particleboard	A panel product made by compressing wood particles (usually from softwood) and resin under heat and pressure, commonly used in flooring and joinery. See *Fibreboard*.
Patch	Basic unit of a landscape mosaic.
Pattern	The spatial arrangement or configuration of forest across the landscape.
Peeler log	A pulpwood or low-quality sawlog meeting specifications for peeling—that is, suitable for rotary peeling to produce veneer for structural-grade plywood.
Photosynthesis	A process in plants in which energy from sunlight and carbon dioxide from the air are used to produce plant matter, releasing oxygen.
Pile	A specialised round wood product that meets specified durability requirements and is used principally for wharves and to support the framework of buildings in a marine environment.

Term	Definition and use in SOFR 2013
Pine	1. A tree of the genus *Pinus* in the family Pinaceae. 2. Also refers to a tree of other conifer families, e.g. Araucariaceae, Cupressaceae and Podocarpaceae. See *Conifer, Softwood.*
Planned fire	Fire started in accordance with a fire management plan or planned burning program, such as fuel-reduction burning. See *Prescribed burn.*
Plantation	Intensively managed stand of trees of either native or exotic species, created by the regular placement of seedlings or seeds. See *Environmental planting, Industrial plantation, Other forest*.
Plant community	See *Community (definition 1), Vegetation community*.
Planted forest	Forest comprising planted trees. The 'Industrial plantation' and 'Other forest' categories (excluding forests of naturalised exotic species) comprise Australian 'planted forest'.
Plywood	A panel product made by gluing together veneers of wood under heat and pressure, commonly used in construction and joinery. See *Veneer.*
Pole	A specialised round wood product generally treated with preservatives that is used to support transmission lines or as structural members in pole-frame building construction.
Post	A specialised wood product from durable hardwood or treated softwood species that is used in an upright support role and meeting specifications for a range of functions.
Prescribed burn	Fire started in accordance with a fire management plan or planned burning program, such as fuel-reduction burning. See *Planned fire.*
Private forest	Forest on land held under freehold title and typically under private ownership. It excludes leased Crown land, and includes land held under freehold title with special conditions attached for designated Indigenous communities.
Privately managed forest	Forest that is managed under private ownership (including private land managed by the Crown), as well as privately managed leasehold forest and Indigenous managed forests.
Productivity	1. Capacity of an ecosystem to grow, produce or yield products. 2. Amount of growth or product yield per unit area per unit time. 3. Potential annual volume growth of trees per unit area at peak mean annual increment in fully stocked forest stands.
Protected area	1. General definition: a geographically defined area that is designated or regulated and managed to achieve specific conservation objectives (Article 2, Convention on Biological Diversity). 2. Specific definitions for reserve system: an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means (IUCN definition); a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (revised IUCN definition). See *Indigenous Protected Area.*
Provenance	1. The place of origin of a plant or animal. 2. A set of individuals of a plant or animal species that originate from a particular location.
Public forest	See *Publicly managed forest*.
Public land	Land belonging to the Crown, i.e. a government, but excluding leasehold Crown land. See *Crown land, Leasehold land.*
Publicly managed forest	1. Forest on public land for which management responsibility has generally been delegated to government agencies, including multiple-use forests, nature conservation reserves and other Crown land, but excluding leasehold forest. 2. Any forest on Crown land for which management responsibility has been delegated to government agencies, local governments or other instrumentalities. See *Crown land, Public land.*
Pulplog	A log harvested from a plantation or native forest stand that does not meet sawlog quality specifications and is designated to produce pulpwood.
Pulpwood	Wood used to manufacture pulp or paper products.
Rainforest	A national forest type that is dominated by rainforest species, typically in moist to wet or sheltered environments, and with broad-leaved species. Can include areas with up to 30% cover of non-rainforest species, typically as emergents, but where rainforest species dominate the character of the site.

Term	Definition and use in SOFR 2013
Reconstituted wood products	Products manufactured from reconstituted wood fibres or flakes, originating from sources such as woodchips, sawdust, wood shavings or sawmill off-cuts. Includes fibreboard (particleboard, medium-density fibreboard, high-density fibreboard and hardboard) and laminated products (but not laminated veneer).
Recycling	The collection, separation and processing of previously used and recovered wood fibre and wood and paper products for manufacture into raw materials or new products.
Reforestation	Establishment of forest on land that historically contained forest but was converted to some other use, such as agriculture. The Kyoto Protocol and initiatives such as the Carbon Farming Initiative use specific definitions of reforestation. See *Forest*.
Regeneration	1. A native forest growth stage that includes juvenile and sapling stages, where trees are very small and crowns exhibit apical dominance. 2. A native forest growth stage generally taken as less than 20 years since disturbance. One of four growth stages used at the national level to describe the age of trees and stands of trees. 3. New trees arising naturally or with human assistance after harvesting, fire or other causes have removed all or some of the overstorey. See *Apical dominance, Mature, Regrowth, Senescent.*
Regional Forest Agreement	An agreement between the Australian Government and a state government about the long-term management and use of forests in a region that meets the requirements now listed in the *Regional Forest Agreements Act 2002*.
Regrowth	1. A native forest growth stage in which trees generally have well-developed stems with crowns of small branches and are actively growing in height and diameter, but are below mature stand height. Apical dominance is apparent in vigorous trees. 2. A native forest growth stage generally taken as 20–80 years since disturbance. One of four growth stages used at the national level to describe the age of trees and stands of trees. See *Apical dominance, Mature, Regeneration, Senescent.*
Remote sensing	Practice of acquiring and using data from satellites or aircraft to infer or measure land cover, land use and vegetation parameters. May be used in combination with ground surveys to check the accuracy of interpretation.
Re-sawing	Cutting timber along the grain to reduce larger boards into smaller sections.
Research and development	Investigative work conducted to acquire knowledge, apply knowledge, develop or implement new products or procedures, or make significant improvements to existing products or procedures.
Resilience (ecological and ecosystem)	The capacity of an ecological system to absorb and respond to shocks while retaining essentially the same function, structure and feedbacks, and therefore identity.
Resilience (human-community)	See *Community resilience (human).*
Resolution (image)	Measurement of the output quality or detail of an image, usually given as pixel size (the size of the square areas recorded). Higher resolution means more image detail and smaller pixels; for example, an image with 1 m × 1 m pixels is of higher resolution than an image with 1,000 m × 1,000 m pixels.
Riparian zone	The interface between land and a flowing water body such as a stream or river. Plant communities along perennial watercourses are called 'riparian vegetation'. See *Community (definition 1), Vegetation community*.
River regulation	The control or modification of the natural flow of a river or stream, most commonly by the use of dams.
Rotation	The planned number of years between regeneration or establishment of a stand of trees, and final harvesting. Rotation length is used in forest management planning to determine sustainable yield. See *Harvesting, Regeneration*.
Roundwood	Wood in round form, e.g. sawlogs, pulplogs, poles, piles, girders and posts.
Rural dieback	See *Dieback*.
Rut	A depression or groove worn into a snig track, path or road by machinery or erosion by water. Typically, rutting is reported in terms of rut depth. See *Snig Track*.
Salinity / salinisation	The amount of salt in water or soil. Salinisation is the process of increasing salinity levels, such as occurs in soils and streams when saline groundwater rises towards the surface following clearing of forests for farmland.
Salvage harvesting	The harvest of trees that are dead or dying as a result of insect attack, disease, drought, fire or other factors.
Sandalwood	A native tree (e.g. *Santalum spicatum*, *S. lanceolatum*) or exotic tree (e.g. *S. album*) in the family Santalaceae, which yields fragrant timber and oil.

Term	Definition and use in SOFR 2013
Sawlog	Log used to manufacture sawn timber. High-quality sawlogs are sawlogs meeting specified size and grade specifications (including amount of permissible defect). Low-quality sawlogs are sawlogs not meeting high-quality sawlog specifications.
Sawmill	A wood-processing facility in which logs are sawn by specialised machinery into timber such as boards.
Sawn timber	Timber produced by sawing logs into particular sizes; also called 'sawn wood'.
Sawn wood	See *Sawn timber*.
Sclerophyll	A description of plants or vegetation that have tough leaves, such as eucalypts and acacias, adapted to dry or nutrient-poor conditions.
Seed orchard	A stand planted and managed especially for the production of abundant superior seeds.
Seed tree	A tree left standing in a harvested area for the purpose of providing seed for regeneration.
Seed-tree silviculture	A silvicultural system in which trees are retained in a harvested area to provide seed for natural regeneration. See *Silvicultural practices / systems.*
Selection logging	A silvicultural system in which trees, typically above a certain specified size or growth stage, are removed singly or in groups, while regrowth, pole timber or habitat trees are retained to maintain an uneven-aged forest. See *Group selection, Silvicultural practices / systems, Single-tree/small group selection.*
Senescent	1. A native forest growth stage older than mature, when irregular crowns form. 2. A native forest growth stage at various ages after 80 years since disturbance. One of four growth stages used at the national level to describe the age of trees and stands of trees. See *Apical dominance, Mature, Regeneration, Regrowth*.
Sensu lato (s.l.)	In the broad sense (of a taxon). See *Taxon*.
Shelterwood	A silvicultural system of securing natural tree regeneration under a partially harvested overstorey, which is subsequently removed by successive harvest(s) to allow seedlings and young regeneration to occupy the site. See *Silvicultural practices / systems.*
Shrubland	A non-forest vegetation type dominated by woody plants that are multi-stemmed or single-stemmed. Shrubland above 2 metres tall can also be classified as 'other woody vegetation'. See *Heathland, Other woody vegetation.*
Siltation	Deposition of silt (fine soil and mineral matter), usually related to the degradation of watercourses due to soil erosion.
Silvicultural practices / systems	Methods used in managing forest establishment, composition and growth. See *Aggregated retention, Clearfelling, Group selection, Seed-tree silviculture, Selection logging, Shelterwood, Silviculture, Single tree / small group selection, Variable retention.*
Silviculture	The art, science and technology of managing forest establishment, composition, health, wood quality and growth, wildlife habitat and water quantity to achieve specified forest management objectives.
Single tree/small group selection	A silvicultural system in which single trees or small groups of trees of various ages are harvested; a method suitable for promoting regeneration of shade-tolerant species, or growth of preferred species or individual trees. See *Selection logging, Silvicultural practices / systems.*
Skeletal soils	Shallow soils, usually on ridges or steep slopes.
Slash	Tree debris left on site following harvesting events.
Snig track	A track along which logs are pulled or conveyed from the felling point (place where the tree is felled) to a nearby log landing or point of loading. Also known as an extraction track.
Softwood	Wood or wood products from conifers, irrespective of the physical softness of the timber; also used to refer to the trees that have such wood, and plantations of such trees. See *Conifer.*
Soil compaction	A reduction in soil volume without loss of soil, leading to poor soil aeration, reduced drainage and root deformation.
Soil degradation	Any phenomenon that lowers the current and/or future capacity of the soil to support existing forest vegetation and ecosystems.
Soil erosion hazard	The susceptibility of soil to erosion, combining soil properties, site and climate factors, and management practices. Site factors can include slope, aspect, vegetation and drainage.
Soil moisture regime	The spatial distribution and annual variation in water availability in a soil profile..

Term	Definition and use in SOFR 2013
Species diversity	The variety of species in an ecosystem. See *Biodiversity, Ecosystem diversity, Genetic diversity*.
Standing volume	The volume (excluding branches) above stump height of living or dead standing trees.
Statistical local area (SLA)	Base spatial unit at which the Australian Bureau of Statistics collects statistics across Australia.
Stocking	Stand density measured in a number of ways: number of trees, basal area, volume, or percentage of crown closure. Can apply to stocking of retained trees after harvest, or to adequacy of seedlings, regeneration or planted stock to establish stands of trees.
Streamflow	Movement of water along streams, rivers and other watercourses, especially expressed as volume of flow.
Subspecies	A taxonomically recognised subdivision of a species.
Sustainable development	Development that meets current needs without compromising the ability of future generations to meet their own needs.
Sustainable forest management	1. A set of objectives, activities and outcomes consistent with maintaining or improving the forest's ecological integrity and contributing to people's wellbeing now and in the future. 2. The practice of stewardship and use of forests and forest lands in such a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity and vitality, and their potential to fulfil, now and in the future, relevant ecological, economic and social functions at local, national and global levels, and that does not cause damage to other ecosystems. See *Ecologically sustainable forest management*.
Sustainable yield	Yield of forest products (e.g. wood, water) that ensures that the functioning of the forest ecosystem as a whole is maintained and the flow of products continues indefinitely under a given management strategy and suite of sustainable-use objectives.
Taxon	A taxonomic unit in the classification of plants or animals (e.g. a subspecies, species or genus). Plural: taxa.
Tenure	Title to land as controlled by legislation. See *Land tenure*.
Threat	A natural, human-induced or human-exacerbated factor or process that increases the risk to a species of population reduction or extinction, or that creates a significant risk to the persistence or integrity of an ecological community. See *Ecological community, Threatening process*.
Threatened ecological community	An ecological community listed in any one of the following categories defined in section 182 of the *Environment Protection and Biodiversity Conservation Act 1999*: critically endangered, endangered or vulnerable. See *Critically endangered species / ecological community, Ecological community, Endangered species / ecological community, Vulnerable species / ecological community*.
Threatened species	A species of native flora or fauna that is listed in any one of the following categories defined in section 179 of the *Environment Protection and Biodiversity Conservation Act 1999*: extinct, extinct in the wild, critically endangered, endangered or vulnerable. See *Critically endangered species / ecological community, Endangered species / ecological community, Extinct, Extinct in the wild, Vulnerable species / ecological community*.
Threatening process	1. A process that threatens, or may threaten, the survival, abundance or evolutionary development of a native species or ecological community (section 188 of the *Environment Protection and Biodiversity Conservation Act 1999*). 2. A natural, human-induced or human-exacerbated process that increases the risk to a species of population reduction or extinction, or is a significant risk to the persistence or integrity of an ecological community. 3. A process identified as a historical, current or future threat in listing or conservation advice of a threatened ecological community or species. See *Ecological community, Key threatening process, Threat*.
Timber	Products square or rectangular in cross-section that are sawn from logs of variable lengths, and conform to industry grades, standards or specifications.
Translocation	The deliberate transfer of plant material from one area to another for the purpose of conservation. The plant material may be in the form of plants, seeds, cuttings or propagated seedlings.
Turbidity	The degree to which the clarity of water is reduced by suspended solids, silt, sediments or organic matter.
Turnover	Sales and service income: the total value of sales of all goods and services, whether or not manufactured by the business (exclusive of goods and services tax, and not deducting the costs of inputs or intermediate goods and services).
Understorey	Layer or layers of vegetation beneath the main canopy of a forest.

Term	Definition and use in SOFR 2013
Uneven-aged forest	Forest with trees of more than one age or age class present on the same site. See *Even-aged forest.*
Unplanned fire	Fire started naturally (such as by lightning), accidentally or deliberately (such as by arson), but not in accordance with planned fire management prescriptions. See *Bushfire, Wildfire.*
Unresolved tenure	Areas where tenure is unknown or for which there are no tenure data.
Value-adding	The process of converting timber or forest products into one or more higher-valued products.
Variable retention	Retention of trees in a harvested area in forests harvested for wood, with the amount and configuration of retention dependent upon silvicultural objectives; an alternative to clearfelling. See *Aggregated retention, Clearfelling, Silvicultural practices / systems.*
Vascular plant	A plant with conducting tissue that transports water, mineral salts and sugars; includes clubmosses, horsetails, ferns, gymnosperms (including conifers) and angiosperms (flowering plants).
Vegetation community	A naturally occurring group of plant species inhabiting a particular area and interacting with each other, especially through biotic relationships, relatively independently of other plant communities. See *Community (definition 1).*
Veneer	Thin slices of wood, usually thinner than 3 millimetres, which can be glued and pressed to make plywood, or glued and pressed onto core panels (typically wood, particleboard or medium-density fibreboard) to produce flat panels.
Veneer logs	Logs used to produce sliced veneers or plywood. Excludes peeler logs used to produce rotary-peeled veneer.
Vulnerable species / ecological community	Native species / ecological community facing a high risk of extinction in the wild in the medium-term future. One of the categories of threatened species / ecological communities defined in sections 179 and 182 of the *Environment Protection and Biological Conservation Act 1999*. See *Critically endangered species / ecological community, Ecological community, Endangered species / ecological community, Extinct, Extinct in the wild, Threatened ecological community, Threatened species.*
Water yield	The amount of water that flows out of a catchment (drainage basin).
Watershed	The dividing line between two catchments (drainage basins).
Watertable	The underground level at which the ground is saturated with water, where the water pressure is equal to atmospheric pressure.
Wet forest / wet sclerophyll forest	Typically, eucalypt-dominated forest (not dry forest or rainforest) associated with moist conditions, and with an understorey (if present) dominated or co-dominated by rainforest species or non-sclerophyll shrubs. See *Dry forest / dry sclerophyll forest, Eucalypt, Rainforest, Sclerophyll.*
Wetland	Land consisting of swamps, marshes or mangroves. Forest wetlands are wetland ecosystems where forests are present. See *Mangroves.*
Wild harvest	Commodity harvested from the wild, including farming of wildlife and feral animals.
Wilderness	Land that, together with its plant and animal communities, has not been substantially modified by, and is remote from, the influences of European settlement, or is capable of being restored to such a state; is of sufficient size to make its maintenance in such a state feasible; and can provide opportunities for solitude and self-reliant recreation.
Wildfire	1. A large destructive forest fire that spreads rapidly. 2. Fire started naturally (such as by lightning), accidentally or deliberately (such as by arson), but not in accordance with planned fire management prescriptions. See *Bushfire, Unplanned fire.*
Wildlife corridor	An area or strip of suitable habitat design to connect or reconnect wildlife populations that have been separated by human activities.
Wildling	A wild plant of a tree species that has escaped from plantations.
Windthrow	Trees uprooted or broken as a result of severe wind associated with storms.
Wood	The hard, fibrous, underbark component of the stem and/or branches of a tree, often suitable for conversion into products.
Woodchips	Wood converted from logs into small chips for use in fibre products or conversion to pulp for paper manufacture.
Woodland forest	Forest in which the tree crown cover ranges from 20% to less than 50%. See *Crown cover, Other woody vegetation.*

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Above: View of the Atherton Tablelands, Queensland.




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