Australian Government
Department of Agriculture, Fisheries and Forestry
Bureau of Rural Sciences

Australia's State of the Forests Report

Five-yearly report 2008

Prepared by the Montreal Process Implementation Group for Australia
on behalf of the Australian, state and territory governments

DEPARTMENT OF AGRICULTURE, FISHERIES AND FORESTRY

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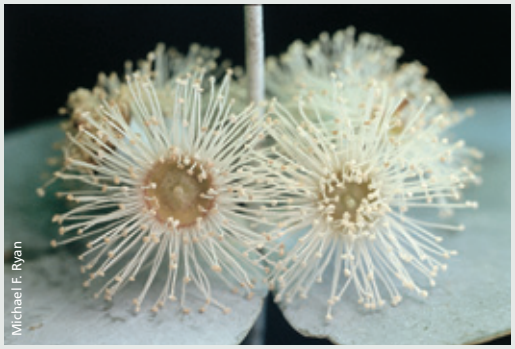

Argyle apple (*Eucalyptus cinerea*) blossom.

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Foreword

The nation's forests are valued for their role in conserving our unique wildlife, sequestering carbon, supplying fresh water and meeting many social and cultural needs. Moreover, forests provide the resource base for industries that employ thousands of people across Australia, particularly in rural and regional areas.

Australia's State of the Forests Report 2008 is the third report of its kind. It fulfils a commitment, made through the 1992 *National Forest Policy Statement*, to provide the Australian public with a forest sustainability report every five years and meets international reporting requirements under the Montreal process. It canvasses the situation in all the forests of Australia, including the tall forests of eastern and southwestern Australia and the open forests and woodlands of northern and interior Australia. It provides the most comprehensive review yet of the state of our forests.

This report highlights Australia's world-class forest conservation reserve network that helps to protect native forests, including more than 70% of known old-growth forests. Moreover, production forests outside this network are subject to a closely monitored sustainable forest management regime. This regime is supported by codes of practice for harvesting and environmental management and, increasingly, by the independent certification of high-quality forest management.

The report shows the important economic contribution from Australia's forests. The forestry and forest products industries are worth $19 billion yearly, and they directly employ more than 120,000 people nationwide. Other forest-related industries, such as honey production, ecotourism and handicrafts make substantial contributions to many rural economies. The evidence of the sustainability of these industries contained in this report should encourage us all to use Australian forest products with confidence and pride.

The report also alerts us to some of the challenges ahead. Predicted changes in climate, for example, could have profound effects on forests, forest production and the incidence and severity of fire, pests and diseases. The data presented here will help us deal with such challenges.

Australia's State of the Forests Report 2008 is the result of close collaboration among the governments of Australia. Data collated and published by state and territory agencies provide greater detail about the state of the forests in each jurisdiction and helped inform this report. I thank the many agencies and individuals who contributed.

I hope this report will enlighten community debate about the role, management and future of Australia's forests. I expect it to be an essential reference for policy makers and the wider community.

Dr Colin Grant
Executive Director
Bureau of Rural Sciences
May 2008

Acknowledgments

Montreal Process Implementation Group for Australia

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National Forest Inventory Steering Committee

The National Forest Inventory (NFI) Steering Committee compiled key datasets for SOFR 2008. Contributing members were Andrew Wilson (Co-chair, DAFF); Cain Trist (Co-chair, DSE, Victoria); Jenny Boshier (Australian Government Department of the Environment, Water, Heritage and the Arts – DEWHA); Adam Gerrand, Geoff Dunn and Mark Parsons (BRS); Margaret Kitchin (Australian Capital Territory Government Wildlife Research and Monitoring); Mike Welch (Forests NSW); Dave Howe (Northern Territory Department of Natural Resources, Environment and the Arts); Bruce Wilson (Queensland Environmental Protection Agency); Detlev Vogt (PIRSA); Martin Stone (Forestry Tasmania); and Martin Rayner (DEC).

SOFR 2008 Drafting Group

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Forest Industries Branch, Department of Agriculture, Fisheries and Forestry

The Forest Industries Branch of DAFF is responsible for forestry policy development and program delivery for the Australian Government, including national SOFRs. Contributions to SOFR 2008 were made by Jonathan Barker, Tim Bull, Simon Chinnock, Clair Dupont, Joanne Erskine, Garry Grant, Tony Hunn, Phil Link, Ben Pryor, Richard Mason, Tony Nicholson, Fintán O'Laighin and Andrew Wilson.

Bureau of Rural Sciences and expert authors

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Science editor

Alastair Sarre

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Contents

Executive summary

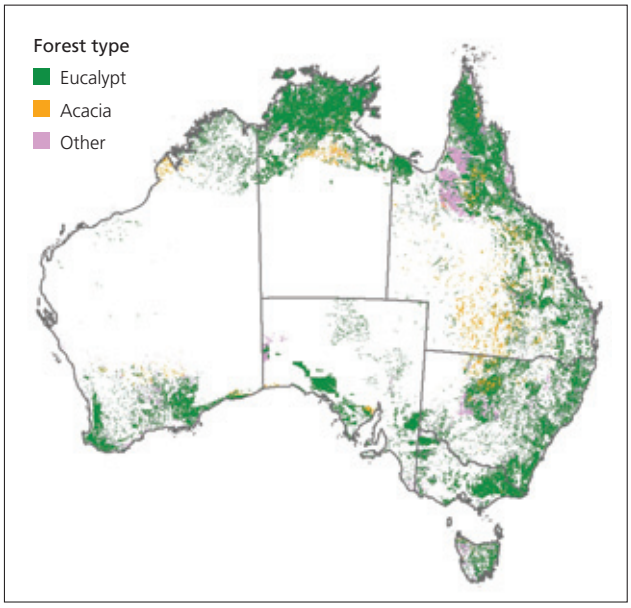
Australia's State of the Forests Report 2008 (SOFR 2008) is the third five-yearly report on Australia's forests. It presents data obtained from a wide range of sources, including the public and private sectors. Previous reports were published in 1998 and 2003.

In this report, 7 criteria and 44 indicators provide a framework and methodology for describing and evaluating progress towards forest sustainability at the national level. The criteria are:

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

These criteria are the same as 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, which comprises representatives of 12 governments, including the Australian Government. The national-level Montreal Process Implementation Group for Australia, which comprises representatives of the Australian, state and territory governments, devised the 44 indicators used to track progress across these criteria. The remainder of this summary synthesises major trends for the period from 2001–02 to 2005–06.

Australia's forests



149 million hectares of forest Australia-wide

Australia's ability to estimate its forest extent continues to improve with the increasing availability of high-resolution, remotely sensed data and improvements in methods for identifying forest types. This largely explains the revision of estimated total forest area from 164 million hectares reported in 2003 to 149 million hectares reported here; little of the change is due to real forest loss. Of the new total, 147 million hectares is native forest, dominated by eucalypt (79%) and acacia (7%) forest types. There is 1.82 million hectares of softwood and hardwood plantations.

The tall eucalypts in Tasmania's Styx Valley are a significant tourist attraction.

The forest-growing and wood-processing industries are important employers in Tumut, New South Wales.

Old-growth eucalypt forest, Tasmania.

An increased representation of forests in nature conservation reserves, continued high levels of old-growth forest reservation and a significant but declining rate of native forest clearing for agriculture and urban development

Since the 2003 report, the area of Australia's native forest in formal nature conservation reserves has increased by about 1.5 million hectares to 23 million hectares, from 13% to 16%. The area of multiple-use public forests, in which wood production is an objective, declined from 11.4 million hectares in 2000–01 to 9.4 million hectares in 2005–06. Seventy per cent of the total forest estate is privately managed, including private freehold, leasehold and Indigenous-managed lands.

Of the 23 million hectares of forest assessed for old-growth values, just over five million hectares (22%) is classified as old-growth. This is 200,000 hectares less than that reported in 2003, due mainly to the impact of severe fires, with younger forests replacing some old-growth forest, and also to some remapping. Over 70% of known old-growth forests are within nature conservation reserves.

Representation in formal nature conservation reserves increased for most forest types over the reporting period, with notable increases in some types, including rainforest (from 33% to 55%) and mangroves (from 13% to 18%). There has also been an increase in the area of privately managed forest (including private freehold, leasehold and Indigenous-managed lands) managed for conservation objectives through a variety of national and jurisdictional programs, although the extent of that increase is not well documented.

The net loss of woody vegetation (mostly forest) estimated by the Australian Greenhouse Office was 260,000 hectares (0.25%) per year between 2000 and 2004, due mainly to clearing for agriculture and urban development. The long-term rate of loss of woody vegetation is declining in response to changed land management practices and increased legislative controls. Legislation is in place in all states and territories to protect native plant and animal species.

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, those areas exhibit a relatively high level of fragmentation. A review of fragmentation in two regions 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. The cessation of broadscale clearing in much of Australia and increased forest protection have been critical in reducing forest fragmentation in recent times.

Some improvement in information on forest biodiversity, but substantial gaps remain

The number of known forest-dwelling species increased from 1998 to 2006, reflecting improved information. Comprehensive ecological information is available on at least 10% of mammal, bird and amphibian species, and partial ecological information is available on around 60% of known forest-dwelling vertebrate and vascular plant species. However, very limited information is available on forest-dwelling invertebrates, fungi, algae and lichens. A total of 1,287 forest-dwelling species are listed as vulnerable, endangered or threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth). Thirty-nine species or subspecies were removed from this list during the reporting period, and 67 were added.

The number of forest-dwelling species for which data on genetic variation are available has increased since the 2003 report but is still very small. Several studies have documented genetic variation and distribution patterns within existing populations of a relatively small number of forest-dwelling species. Conservation measures focus on increasing connectivity between isolated patches of native vegetation, increasing the area of forest contained in public and private nature conservation reserves, managing threats to native species, and assisting the recovery of threatened species.

Crimson rosella (*Platycercus elegans*).

Genetic resource conservation plans exist for more than 40 native timber and oil-producing species, a 70% increase on the number reported in 2003. The increase includes species used in farm forestry in drier environments. Tree-breeding and genetic improvement programs are expanding the scope for conserving native forest genetic resources, including of non-commercial endangered species.

Processes in place to maintain water quality and supply from forests

Over 30 million hectares of public forests (20% of the total forest area) is managed primarily for protection, including of soil and water values; most is in nature conservation reserves. In most jurisdictions, codes of practice or other instruments are applied to a wide range of activities that cause disturbances in forests, specifying measures to be taken to mitigate the contributions of such activities to soil erosion and their impacts on soil physical properties, and to maintain water quantity and quality.

Water reserve. Sign reads 'This is your drinking water. Swimming or any potential pollution activities within water reserves is strictly prohibited. Persons apprehended will be prosecuted.'

Difficulties in managing the effects of fire, drought and climate change in forested landscapes

Large areas of Australia were affected by severe drought over the reporting period, with significant regional impacts on tree health. Predicted changes in climate could have profound effects on forests, forest production and the incidence and severity of fire, pests and diseases. Several exotic organisms that pose a threat to Australian forests moved closer to Australia's shores during the reporting period, increasing the importance of effective quarantine. Fire, including some very intense fires in southern Australia, burnt an estimated 24.7 million hectares of forest in the period from 2001–02 to 2005–06. Of that total, an estimated 20 million hectares was burnt by unplanned fire (wildfire) and 4.7 million hectares by planned fire (e.g. prescribed burning).

The Australian Capital Territory's Corin Dam during the drought. A wildfire in the catchment in 2003 caused significant erosion, affecting water quality.

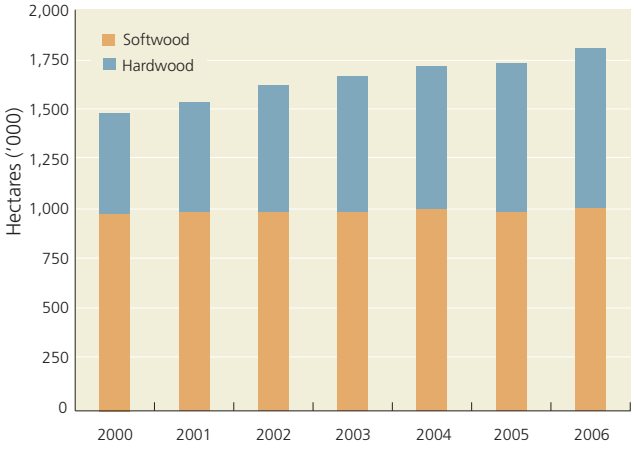
Major wildfires during the period led to soil erosion and affected water quality across forest tenures, increasing the challenges faced by managers of forest lands. The resulting natural regrowth is expected to reduce water yields in affected catchments for decades.

A 12% increase in the nation's plantation estate

The area of plantations increased from 1.63 million hectares to 1.82 million hectares over the reporting period. Nearly all the increase was in hardwoods (mostly for pulpwood), which grew from 503,000 hectares in 2000 to 807,000 hectares in 2006. Plantations now produce two-thirds of the country's log supply; that share is likely to grow due to the expansion of the plantation estate coupled with a long-term decline in the volume of timber harvested from native forests. The growing plantation estate is providing improved employment opportunities in some regions. Public concern has been raised about water consumption. Water use by plantations can have positive environmental effects by lowering saline watertables but can also affect water availability for other uses, such as irrigated agriculture, in some cases.

Second-rotation plantation of blue gums (*Eucalyptus globulus*).

Total plantation area, Australia, 2000 to 2006



An increased contribution by forests and forest industries to offsetting Australia's greenhouse gas emissions

Australia's forests sequester more greenhouse gases from the atmosphere than they emit and therefore help to offset Australia's contribution to global greenhouse gas emissions. Plantations offset about 3.5% and managed native forests about 5.5% of total national greenhouse gas emissions in 2005. Additional storage in wood products offset a further 1% of emissions. The net amount of carbon sequestered by managed native forests in 2005 was 43.5 million tonnes (carbon dioxide equivalent). Greenhouse gas emissions from deforestation, mainly for agriculture but also for urban development, declined from about 70 million tonnes carbon dioxide equivalent in 2002 to an estimated 53.3 million tonnes in 2005, which was about 9% of total national greenhouse gas emissions. The removal of carbon from native forests by timber harvesting stayed relatively constant and was compensated about three times over by sequestration. Extensive wildfires in native forests during the period released large amounts of greenhouse gases to the atmosphere. Over time, those emissions are expected to be offset by new forest growth. Several states passed legislation during the period to provide property rights for carbon sequestered in forests and other vegetation.

Sustainable levels of timber harvested in native public forests

In Tasmania, the sustainable sawlog yield from multiple-use public native forest fluctuated slightly in line with forest management strategies in the short term, but without adversely affecting long-term sawlog availability.

The volume of sawlogs harvested from multiple-use public native forests over the period from 1992–93 to 2005–06 was less than the prescribed sustainable level in New South Wales, Victoria and Western Australia.

In a number of jurisdictions, the total harvest volume declined over the period because of reductions in the area available for harvesting, increased forest restrictions, and revised downward estimates of sustainable yield. Harvesting in native multiple-use public forests is subject to substantial requirements to maintain non-wood values. The success rate in regenerating such forests after harvesting was high (above 85%) in those states for which data were available; remedial action was taken in areas where standards were not achieved.

Despite increased timber production, a continuing significant trade deficit in timber products

In the five years to 2006–07, the volume of logs harvested from native forests declined by 14% while the volume of logs harvested from plantations increased by 28%; the gross value of logs harvested from native forests and plantations both increased by 11%. Turnover of Australia's forest product industries increased in real terms by about 10% to more than $19 billion between 2000–01 and 2005–06. The trade deficit in timber products increased from $1.7 billion in 2001–02 to $1.9 billion in 2006–07. Tariffs on imported forest products are set in the range from zero to 5%; goods from all least-developed countries became tariff and quota-free from 1 July 2003.

Discarded paper and timber products contribute approximately 6.5 million tonnes to the waste stream annually. Recycling rates for paper and timber products are an estimated 53% and 30%, respectively. The volume of recovered paper exported increased by 250% to nearly 1.1 million tonnes, due mainly to increased demand from China.

Domestic sawn timber supplies have increased, reducing the need for imports.

Increased attention to the services provided by forests, including establishing a national carbon emissions trading scheme

Most jurisdictions are paying increased attention to forest-based services, implementing legislative and institutional reforms and establishing programs to support financial incentives for such services. Initiatives have been launched to establish a national carbon emissions trading scheme in Australia; such a scheme is likely to have a significant effect on Australian forestry.

Involvement of Indigenous people in forest management

Indigenous-managed land includes more than 21 million hectares of forest, which is 13% of Australia's total forest area. Australia has an Indigenous Forestry Strategy. Most state and territory land management agencies have targets for Indigenous employment, helping to build capacity in Indigenous communities. Legislative arrangements in all jurisdictions aim to ensure the identification and protection of Indigenous sites and places of significance. Mechanisms are being maintained to facilitate Indigenous participation in the forest sector and to provide economic benefits to Indigenous communities. The number of Indigenous people employed in government agencies responsible for nature conservation and commercial timber production increased over the period, and there was also a greater presence of Indigenous people in natural resource management committees and other forest stakeholder forums. Indigenous Australians continue to rely heavily on the use of non-wood forest products for customary purposes (such as food and medicine) and commercial uses (such as arts and crafts). The recognition of native title through mechanisms such as Indigenous land-use agreements strengthened the potential value of forests for Indigenous people and the resilience of Indigenous communities.


Richard Thackway

Indigenous people manage about 21 million hectares of forests, using them for a wide range of customary and commercial activities.

Investments in plantations, wood product manufacturing facilities and research

Investment in plantation expansion increased from 2002 to 2006, totalling an estimated $902 million, while investment in new or improved wood and wood product manufacturing facilities amounted to several billion dollars. Reported annual expenditure on national forest-related research and development decreased by $17.5 million to $198.5 million between 2000–01 and 2004–05; of this total, annual investment in manufacturing-related research increased from $79 million to $108 million. Investment in nationally reported research on forest growing for wood production and forest-related environmental research declined.


Michael F. Ryan

Export woodchip mill, Burnie, northeast Tasmania.

To improve overall collaboration and the coordination of forest research, Australian, state and territory agencies developed the following set of nationally critical research priorities: the impact of climate change on forest management; the role of forests in managing Australia's water resources; managing Australia's forests for multiple objectives; forest health and biosecurity; and forest products.

State and territory policies, such as disincentives for land-clearing, incentives for improving management practices in private native forests, and carbon-credit schemes, have encouraged investment in forest conservation and the forest growing and timber processing industries. Governments have also developed market-based mechanisms and incentives to promote reforestation and improved forest management as a way of protecting catchment values, particularly in agricultural landscapes. Six environmental assets are accounted for in national and sector balance sheets, including plantation timber and standing native timber available for harvesting. The values of those two assets grew at average annual rates of 5.6% and 3.8%, respectively, over the period from 1997 to 2005.

Forests are the subject of considerable community debate in Australia. The expansion of the plantation estate and the proposed development of new wood processing infrastructure, including pulp mills, have potentially significant employment benefits but are also accompanied by community concerns about their perceived social and environmental consequences.

Strategies in place to actively manage forest areas for recreation

Forest management agencies have strategies in place to actively manage forest areas of high recreation and tourism use. Most publicly owned multiple-use and nature conservation reserve forests are available to the general public for recreation and tourism, and many facilities such as visitor recreation centres and tree-top walks were established or improved during the period. For those forests for which data were available, the number of areas, tracks and sites available for recreation and tourism activities increased or remained the same over the reporting period.

Facilities like this boardwalk are available in many forest areas to assist ecotourism, recreation and nature education.

Regional changes in employment and improvements in safety in the wood and wood product sector

Total direct employment in wood and wood product industries increased marginally between 2001–02 and 2006–07. Total national employment in businesses dependent on growing and using timber in 2006 was estimated to be about 120,000 people. Total annual wages and salaries in the wood and wood product industries increased from $2 billion to $3 billion between 2000–01 and 2004–05. The rate of injuries and fatalities in wood and wood product manufacturing declined between 2000–01 and 2002–03, from 48.9 to 37.2 injuries or fatalities per 1,000 employees. Wood and non-wood forest product industries and forest contact industries (tourism, park management, etc.) generated considerable direct and indirect employment in some regional communities.

Dependence on the forestry industry as the primary source of employment declined in some regions (but not in areas of South Australia, East Gippsland and Tasmania). Populations in many forest-dependent regions were static or declining in line with a general trend in rural Australia, with the exceptions of Mount Gambier, Orbost, Oberon and Tumut, where populations increased marginally. The number of working-age people also declined in many regions.

Saw-doctoring is one of the specialist skills required by forest industries.

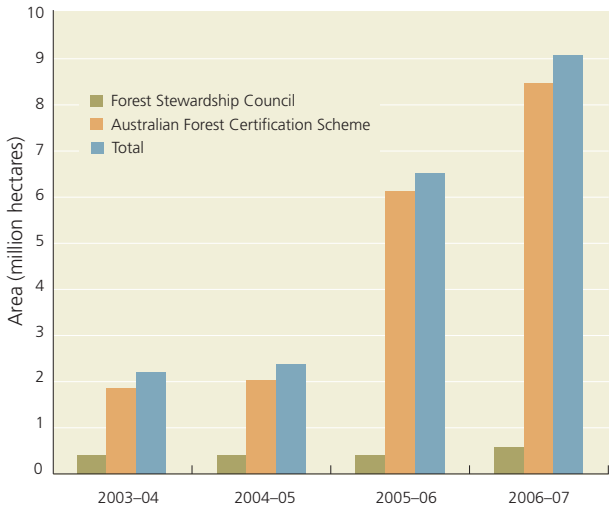
Strengthened regulation of forest management

The legal framework for achieving the conservation and sustainable management of forests was strengthened during the period through the continued implementation of regional forest agreements and new measures governing vegetation clearing and the allocation of water to land uses such as forestry. In most jurisdictions, codes of forest practice or other instruments underwent continuous improvement during the period and were applied to a wide range of activities that cause disturbances in forests.

Rapid expansion of third-party forest certification and auditing of forest management

The use of forest certification to demonstrate good forest management and maintain access to markets has grown rapidly to cover over nine million hectares of native forests and plantations by September 2007. Most multiple-use public forests and some private native forests are now managed in accordance with externally accredited environmental management systems, which provide a structured approach to the planning and implementation of forest management.

Forest certified in Australia by scheme, 2003–04 to 2006–07



Improved data availability and quality for multiple-use public forests and some public nature conservation reserves, but less so for leasehold and private forests

The capacity to report trends, while still variable, has generally improved since 2003. The best information is available for multiple-use public forests and some public nature conservation reserves. The biggest data gaps remain for leasehold and private native forests.

Introduction

This is the third report on the state of Australia's forests. Its purpose is to keep the public informed about Australia's forests, to show how they might be changing, and to indicate positive and negative trends. It also helps Australia to report the state of its forests to the world.

In 1992, the Australian Government and state and territory governments issued a National Forest Policy Statement[1], which set out a vision and goals, objectives and policies for Australia's forests and committed governments to prepare a national State of the Forests Report (SOFR) every five years. The first two such reports – referred to here as SOFR 1998 and SOFR 2003 – were published in 1998 and 2003. This report – *Australia's State of the Forests Report 2008* – is referred to as SOFR 2008.

Criteria and indicators

Forests are complex ecosystems that provide a wide and dynamic array of environmental and socioeconomic benefits and services. The essential aim of sustainable forest management is to maintain the broad range of forest values in perpetuity, but assessing progress towards this aim is difficult. Criteria and indicators are used to simplify the task by characterising the essential components of sustainable forest management. They are intended to provide a common understanding of what is meant by sustainable forest management and a common framework for describing, assessing and evaluating a country's progress towards sustainability at the national level.[2]

Most methods of sustainability assessment follow a broadly similar approach involving an analytical hierarchy, in which information is organised so that each individual component contributes to the understanding of a larger theme or question. The individual components ('indicators') may then be examined in terms of their contribution to key sustainability measures, which, in Australia's approach, consist of the following criteria:

- 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 socioeconomic benefits to meet the needs of societies
- legal, institutional and economic framework for forest conservation and sustainable management.

These criteria are the same as 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, known as the Montreal Process Working Group, which was formed in 1994 by countries with temperate and boreal forests. Members of the working group are Argentina, Australia, Canada, Chile, China, Japan, the Republic of Korea, Mexico, New Zealand, the Russian Federation, the United States of America and Uruguay; the Montreal Process indicators are therefore applied across 90% of the world's temperate and boreal forests.

Australia has accepted the criteria developed by the Montreal Process Working Group and adapted the indicators to better suit the country's unique forests. Seventy-four indicators were devised and used as the basis of reporting in SOFR 2003 (SOFR 1998 did not use the criteria-and-indicators approach). The indicators have been developed in the context of contemporary forest regulations, international agreements and current national and state policies,[3] such as the National Forest Policy Statement. Principles recognised in the development and implementation of the indicators include the precautionary principle; intergenerational equity; public participation; transparency and access to information; international good citizenship; and industry and regional development.

However, some of these indicators proved difficult to measure and some were repetitive. The national-level Montreal Process Implementation Group for Australia (MIG), reviewed the list of indicators in 2005 with the aim of eliminating duplication, ambiguity and gaps. As a result of that review, the list of indicators was reduced to 44.[4] The reduction in the number of indicators helps to streamline this report.

The criteria and indicators used in this report characterise the essential components of sustainable forest management. Measured over time, they can help to inform forest managers, owners and other stakeholders about the state of the forests and the benefits and risks associated with their management, and assist in measuring progress towards the 11 national goals set out in the National Forest Policy Statement (see box on next page).

1 Commonwealth of Australia (1992).

2 Montreal Process Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (1995).

3 Howell et al (2008).

4 Appendix A compares the indicators used in this report to those used in SOFR 2003 and lists the closest equivalent indicators of the international Montreal Process Working Group.

National goals set out in the National Forest Policy Statement

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, 11 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 11 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, heritage, Indigenous 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.

Boardroom table, silky oak (*Grevillea robusta*).

The reporting process

SOFR 2008 is the result of a collaborative effort by the Australian, state and territory governments coordinated by MIG, with inputs from the National Forest Inventory Steering Committee. In January 2007, the Bureau of Rural Sciences (BRS), an agency within the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF), requested data from each of the six Australian states and two mainland territories. On the basis of the responses to those requests and other information obtained from national agencies and other sources, BRS prepared summary tables, figures and text for each indicator, paying particular attention to changes and trends. The state and territory governments, MIG, and officers from DAFF and other Australian Government agencies, were invited

to participate in a drafting group, which met three times in 2007 to review manuscripts and provide supplementary information.

The draft report was approved by MIG in November 2007 and endorsed by the Forest and Forest Products Council in December 2007. The data contained in this report remain the property of the custodian, which is usually a state and territory agency or industry body, or a national organisation for those indicators for which nationally collected data were used. Data were not available for some indicators and for some jurisdictions; therefore, some tables, figures and textual information given in this report are not comprehensive.

Since – or coinciding with – SOFR 2003, many states and territories have prepared their own SOFRs and/or addressed forest-related issues in 'state of the environment' (SoE) or other reports. Victoria has committed to producing a SOFR every five years and published its first in 2005; that report contained data current to 2003 organised according to the seven criteria used in the national SOFR. Forests NSW has published an annual *Social, Environmental and Economic (Seeing) Report* since 2003 to document the outcomes of the agency's decision making in terms of social, environmental and economic goals. The Tasmanian and Australian governments published the *Sustainability Indicators for Tasmanian Forests 2001–2006* report in 2007. South Australia's fourth SoE report, published in 2003, addressed a number of forest-related issues, as did Western Australia's most recent SoE report, published in 2007. Some jurisdictions have other reports that complement and inform the forest reporting processes. For example, Victoria produces a five-yearly 'state of the parks' report, which analyses the condition of the state's nature conservation reserves; New South Wales produces its 'state of the parks' report every three years. The Australian Government publishes a five-yearly SoE report – most recently in 2006.

These reporting processes greatly assisted the provision of relevant data for the national-level SOFR 2008. Moreover, as the capacity of the states and territories to report against the Montreal Process criteria and indicators improves, so too does the national capacity, because data collected at the state and territory level increasingly feed directly into the national SOFR process.

The SOFR series

Australia's national SOFRs should be viewed as a series that, over time, constitutes a system for monitoring, assessing and reporting on the state of Australia's forests. Using such a system, it is possible to determine the direction of change in a range of parameters and the implications of such change for forest sustainability.

In general, SOFR 2008 reports data for the five-year period from 2001–02 to 2005–06 and compares these with those reported in SOFR 2003, which had a nominal reporting period of 1996–07 to 2000–01. Given the varied nature of the data sources, however, it was not always possible to collate information for the specified period; information on actual data coverage is provided in each indicator. The emphasis in this report is on change over the reporting period. In addition, some contextual information contained in SOFR 1998 and SOFR 2003 is summarised here; readers are directed to those reports for additional background information on the timber industry, the conservation movement and the development of plantations.

Mountain ash (*Eucalyptus regnans*), 1939 regrowth.

Context

What is a forest?

The definition of forest used in this report is the same as that used in SOFR 1998 and SOFR 2003:

> *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 two 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.*

Under this definition, a large part of Australia's mallee qualifies as forest, as do very large areas of tropical savanna and woodland, where trees are spread out in the landscape. What many people would traditionally regard as forests – expanses of tall, closely spaced trees – comprise a relatively small part of the country's total forest estate.

This report uses the National Forest Policy Statement definition of plantations:

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

Forest types

The distribution of forests across Australia is broadly determined by climate and soil properties, although other factors such as the fire regime are also important. Two-thirds of the country's forests have sparse crown cover, meaning

that, when viewed from above, tree canopies cover 20–50% of the ground surface (Figure 3, Indicator 1.1a).

Australia's forests are dominated by angiosperms (flowering plants); trees from this division of the plant kingdom are also called hardwoods. By far the most common forest type in Australia is eucalypt, followed by acacia and melaleuca; native conifers (also called softwoods) such as hoop pine (*Araucaria cunninghamii*), bunya pine (*Araucaria bidwillii*) and King Billy pine (*Athrotaxis selaginoides*) dominate some forests, but the total area of those forests is insufficient to constitute a major forest type. Indicator 1.1a reports on the nature and extent of Australia's forest types and changes in them compared to SOFR 2003.

Origins

The origins of Australia's forests can be traced to the beginning of the Cretaceous period, when the supercontinent Gondwana began to fragment into Africa, South America, India, Australia/Antarctica and many smaller islands. Although this happened at least 135 million years ago, similarities can still be found in the flora and fauna of these now widely separated lands.

But there are also large differences. Over the intervening millennia, Australia has evolved a new biota. About 38 million years ago, it broke away from Antarctica and shifted northwards, colliding with Asia about 13 million years ago. During Australia's northward journey, the climate became progressively warmer and drier, and the vegetation adapted accordingly. Cool and warm rainforests were replaced by sclerophyllous genera such as *Eucalyptus* and *Acacia* – plants that have hard, spiky or shiny leaves to reduce moisture loss, and are adapted to a regime of frequent fire. Gondwanan flora survived in isolated pockets, such as remnant cool temperate rainforests in eastern Australia, the wet tropical rainforests of northeastern Queensland, isolated areas of the Northern Territory, and the Kimberley, but over much of the continent, forests were replaced by non-forest vegetation and desert.

Over the past two million years, the forest estate has expanded and contracted as the climate has fluctuated between warm-and-wet and cool-and-dry periods. New species have also arrived, first from Asia and later from almost all parts of the world. Of all the newcomers, humans have undoubtedly had the biggest impact.

Indigenous Australians are thought to have occupied the continent for at least 60,000 years. Over millennia, their use of fire as a land-management and hunting tool probably had a major effect on vegetation structure and composition, including forests, although the extent of this effect is still debated.

Europeans began their settlement of Australia in 1788 when the British established a small colony on the east coast. In the decades that followed, colonists sought out and cleared land for agriculture and urban development, introduced intensive farming and grazing and many new plant and animal species, and altered forest fire regimes.

Much of Australia is now affected in some way by the impacts of European settlement.

It is difficult to know the extent of changes that have occurred in the area and distribution of forests since European colonisation. One estimate suggests that about 25% of the total forest estate existing before European settlement has been cleared.[5] Thus, Australia retains about three-quarters of its original forest estate, although in many cases in a modified form.

The jurisdictions

In 1901, the six British colonies of New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia formed a federation, becoming the component states of the Commonwealth of Australia. Today, the nation has three main levels of government: Commonwealth or federal (referred to in this report as the Australian Government or the national government), state/territory (two mainland territories, the Northern Territory and the Australian Capital Territory, are self-administered) and local. The traditional law-making and land management processes of Aboriginal and Torres Strait Islander people (referred to collectively in this report as Indigenous people) also apply in some areas. In this report, the term 'jurisdictions' is used to collectively denote the Australian, state and territory governments, or subgroups of them.

The Australian Constitution explicitly defines the areas of Australian Government, or federal, responsibility. In practice these cover foreign affairs and international agreements, defence, quarantine, the issuing of export licences for major resource developments, fiscal decisions and taxation. The management of land and natural resources, including forests, is largely the domain of the state and territory governments. However, the Australian Government is responsible for meeting the country's international obligations through the conventions and treaties to which it is party and has the constitutional power to make decisions on land management in fulfilment of those obligations. It rarely exercises this power, although it reserves the right to do so on matters of national importance.

Regional forest agreements

A key element of the approach adopted in the 1992 National Forest Policy Statement involved the negotiation of regional forest agreements (RFAs) between the Australian and certain state governments. RFAs are 20-year plans for the conservation and sustainable management of certain areas of Australia's native forests; they are designed to provide certainty for forest-based industries, forest-dependent communities and conservation. They use a science-based methodology to determine forest allocation for different uses and forest management strategies and are

5 ASEC (2006).

the result of substantial scientific study, consultation and negotiation covering a diverse range of interests.

Ten RFAs have been negotiated bilaterally between the Australian Government and four of the six state governments (New South Wales, Victoria, Western Australia and Tasmania – Figure 1). The Australian and Tasmanian governments are also party to the Tasmanian Community Forest Agreement, which complements the Tasmanian RFA. The protection provided by Australia's RFAs is given legal status through the *Regional Forest Agreements Act 2002* (Cwlth). The Australian and Queensland governments completed a comprehensive regional assessment for southeast Queensland but did not sign an RFA. Queensland has a 'statewide forests process' for the long-term assessment and planning of the public forest estate that will result in a significant expansion of conservation areas. The process involves key stakeholders and the community and is intended to result in forest agreements aimed at providing certainty to the forest industry, protecting environmental values and ensuring ecologically sustainable management of forests.

Land ownership and tenure

The question of tenure is important in forest management because the owner of the land (and in most cases the forest) has primary responsibility for its management. When the British arrived in Australia, they claimed all land as the property of government ('Crown land'). Over time, a large part of the Crown estate has been leased, sold or otherwise allocated by government to private use. Unassigned areas remain the property of state governments or the Australian Government under various designations, including multiple-use public forest (usually called 'state public forest'), timber reserves, nature conservation reserves (including national parks) and vacant Crown land.

The six tenure classes used for native forests in this report have been amalgamated from the wide range of classes used by various jurisdictions. The six classes can be further grouped as public and private:

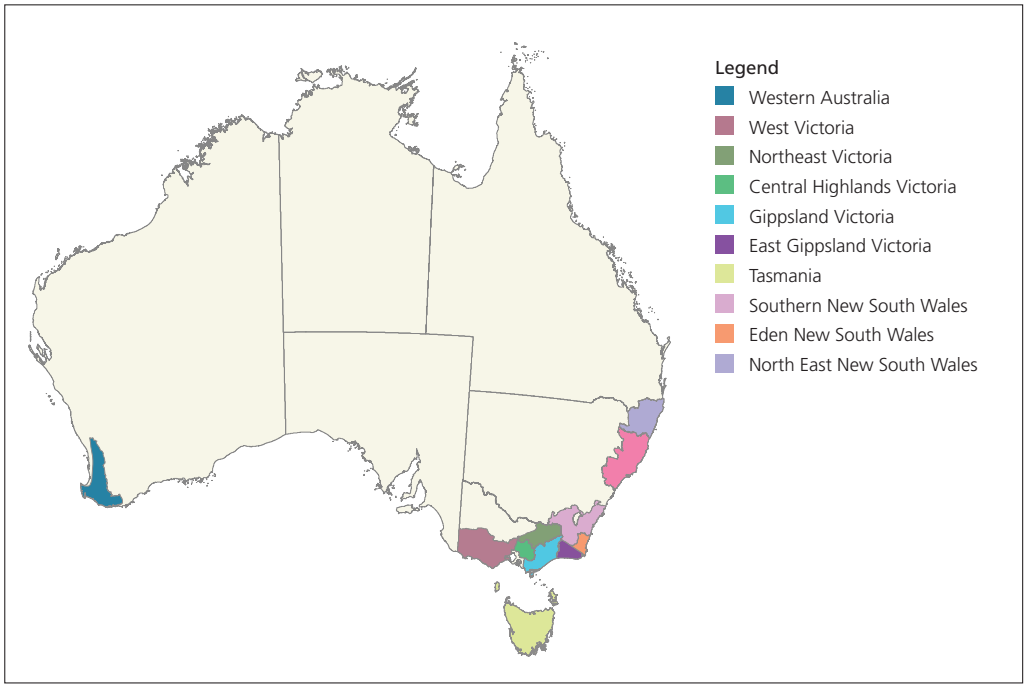
Public

Multiple-use public forests. Publicly owned state forest, timber reserves and other forest areas on which a range of forest values is managed, including timber harvesting, water supply, conservation of biodiversity, recreation and environmental protection. They are managed by state and territory agencies in accordance with state/territory Acts and regulations.

Nature conservation reserves. Crown lands that are formally reserved for environmental, conservation and recreational purposes. They include national parks, nature reserves, state and territory recreation and conservation areas, formal reserves in state forests, and Crown lands reserved to protect water-supply catchments. They do not include informal reserves and those pending gazettal. The harvesting of timber and non-timber forest products generally is not permitted.

Forest on 'other Crown land'. Forest on Crown land reserved for a variety of purposes including utilities, scientific research, education, stock routes, mining, use by the defence forces and use by Indigenous communities.

Figure 1: Regional forest agreement regions



Eucalypt tall open forest, southwestern Western Australia.

Private

Private forest. Forest on land held under freehold title and under private ownership. It includes land held under freehold title with special conditions attached for designated Indigenous communities.

Leasehold forest. Forest on Crown land held under leasehold title and generally regarded as privately managed. It includes land held under leasehold title with special conditions attached for designated Indigenous communities.

Unresolved tenure. Some forests where data are insufficient to determine ownership status.

There are notable differences in the ownership of different forest types. The drier, sparse woodland forests make up almost 100 million hectares, half of which is on leasehold land and another quarter on private land. There have also been significant recent changes in land tenure. In particular, as a result of decisions by courts recognising Indigenous land claims, significant areas of former Crown land are now owned by Indigenous people. In other areas, multiple-use public forests have been reassigned as nature conservation reserves, in most cases excluding extractive uses such as timber production (see Indicator 1.1a).

How to use this report

This report is organised by the seven criteria of forest conservation and management, within which various indicators address specific forest parameters. A summary of key points is given at the start of each indicator. At the head of each criterion, a short introduction explains the scope and lists some of the most important findings for that criterion, derived from the key points arising from the relevant indicators. Case studies are used to illustrate the indicators and to provide complementary information; additional case studies and resource material are available on the report's website (www.daff.gov.au/forestsaustralia).

A list of references and further reading is at the back of the report.

While the indicators are designed to be read as a suite, readers interested in particular aspects of Australia's forest estate and its management may wish to focus on specific indicators, which have been written in such a way that they can be read as stand-alone papers (although references have been grouped at the end of the report). Those looking for a quick overview of the state of Australia's forests should start with the executive summary at the front of the report.

Rainforest, far north Queensland.

Criterion 1

Conservation of biological diversity

Biological diversity is the variety of life forms: the different plants, animals and microorganisms, the genes they contain, and the ecosystems they form. It is usually considered at three levels: genetic diversity, species diversity and ecosystem diversity. The ultimate objective of the conservation of biological diversity is the survival of species and the genetic variability within those species.

The nine indicators in this criterion are divided into three subcriteria: ecosystem diversity, species diversity and genetic diversity. Ecosystem diversity indicators describe the range, extent and growth stages of Australia's forest types, the tenure systems within which they are managed, the level of forest clearing and the extent to which such clearing has fragmented native forests. Species diversity indicators are concerned with the number and variety of forest-dependent animal and plant species; indicators in this subcriterion identify forest-dwelling species, the level of information to support conservation strategies, and the role of forest management in protecting threatened and vulnerable species. Genetic diversity indicators examine the risk of genetic diversity loss in forests and the measures in place to minimise that risk.

Melaleuca leucadendra forest.

Key findings

Ecosystem diversity

- Australia has 149 million hectares of forest. Of this, 147 million hectares is native forest, dominated by eucalypt (79%) and acacia (7%) forest types. There is 1.82 million hectares of plantations, mostly comprising 1.0 million hectares of pine (softwood) and 0.81 million hectares of eucalypt (hardwood), an increase of 12% over the 1.63 million hectares reported in 2003.
- Australia's ability to estimate its forest area continues to improve with the increasing availability of high-resolution remotely sensed data and improvements in forest typing methods. This largely explains the revision of estimated total forest area from 164 million hectares in 2003 to 149 million hectares reported here; little of the change is due to real forest loss.
- Since 2003, the area of native forest in formal nature conservation reserves has increased by about 1.5 million hectares to 23 million hectares, from 13% to 16% of Australia's forests. The area of multiple-use public forests (in which wood production is an objective) declined from 11.4 million hectares in 2000–01 to 9.4 million hectares in 2005–06.
- Seventy per cent of the total forest estate is privately managed, including private freehold, leasehold and Indigenous-managed lands.
- The net loss of woody vegetation (mostly forest) estimated by the Australian Greenhouse Office (AGO) was 260,000 hectares (0.25%) per year between 2000 and 2004, due mainly to clearing for agriculture and urban development. The rate of loss of woody vegetation is declining in response to changed land management practices and increased legislative controls.

- Of the 23 million hectares of forest assessed for old-growth values, 5.03 million hectares (22%) is classified as old-growth. This is about 200,000 hectares less than that reported in 2003 (5.23 million hectares), due mainly to the impact of severe fires, with younger forests replacing some old-growth forest, and also to some remapping. Over 70% of known old-growth forests is now in nature conservation reserves.
- The area of forests in formal nature conservation reserves increased for most forest types over the reporting period, with notable increases in some types, including rainforest (from 33% to 55%) and mangroves (from 13% to 18%).
- There has been an increase in the area of privately managed forest (including private freehold, leasehold and Indigenous-managed lands) managed for conservation objectives through a variety of national and jurisdictional programs, but the extent of this increase is not well documented.
- 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, those areas exhibit a relatively high level of fragmentation.
- A review of fragmentation in two regions between 1972 and 2002 suggests that fragmentation can be dynamic, even in nature conservation reserves, with changing patch sizes and spatial arrangements of different forest types.
- The cessation of broadscale clearing in much of Australia and increased protection of forests have been critical in reducing forest fragmentation in recent times.

Species diversity

- The number of known forest-dwelling species increased from 1998 to 2006, reflecting improved information. Partial ecological information is available on around 60% of forest-dwelling vertebrate and vascular plant species and comprehensive ecological information is available on at least 10% of mammal, bird and amphibian species, but very limited information is available on forest-dwelling invertebrates, fungi, algae and lichens.
- A total of 1,287 forest-dwelling species are listed under the national *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) as vulnerable, endangered or threatened. Thirty-nine species or subspecies were removed from the list during the reporting period, and 67 were added.
- Most additions of forest-dwelling species to the national list of threatened species were made based on inherently small population sizes and ongoing impacts on habitat extent and quality, including the impacts of introduced species and unsuitable fire regimes. Most removals of forest-dwelling species from the list were made as a result of improved information.
- Birds are the taxonomic group with the largest number of programs in place to track population trends. State and territory efforts are supplemented by a large-scale investment by non-government groups.
- 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.

Genetic diversity

- While the number of forest-associated species for which data on genetic variation are available is still very small, it has increased since SOFR 2003. Then, data were available for one faunal and two floral species; now, data are available for more than 10 faunal and 13 floral species.
- Several studies have documented genetic variation and distribution patterns within existing populations of a relatively small number of forest-associated species. Several institutions have programs to measure genetic diversity in forest fauna, but nationally conclusive results are available for only a few species.
- Conservation measures focus on increasing connectivity between isolated patches of native vegetation, increasing the area of forest contained in public and private nature conservation reserves, managing threats to native species, and assisting the recovery of threatened species.
- Genetic resource conservation plans exist for more than 40 native timber and oil-producing plant species, a 70% increase on the number reported in SOFR 2003. The increase includes species used in farm forestry in drier environments.
- Tree-breeding and genetic improvement programs are expanding the scope for conserving native forest genetic resources, including non-commercial endangered species.

Selective harvesting in multiple-use public forest.

Indicator 1.1a

Area of forest by forest type and tenure

Rationale

This indicator uses the area of 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 affect forest biodiversity.

Key points

- Australia has 149 million hectares of forest. Of this, 147 million hectares is native forest, dominated by eucalypt (79%) and acacia (7%) forest types. There are 1.82 million hectares of plantations, mostly comprising 1.0 million hectares of pine (softwood) and 0.81 million hectares of eucalypt (hardwood).
- Australia's ability to estimate its forest extent continues to improve with the increasing availability of high-resolution, remotely sensed data and improvements in forest typing methods. This largely explains the revision of estimated total forest area from 164 million hectares in 2003 to 149 million hectares reported here; little of the change is due to real forest loss.
- The area of native forest in formal nature conservation reserves increased by about 1.5 million hectares to 23 million hectares over the reporting period, from 13% to 16% of Australia's native forests. The area of multiple-use public native forests (in which wood production is an objective) declined from 11.4 million to 9.4 million hectares.
- Seventy per cent of the total forest estate is privately managed, including private freehold, leasehold and Indigenous-managed lands.
- The net loss of woody vegetation (mostly forest) estimated by the AGO was 260,000 hectares (0.25%) per year between 2000 and 2004, due mainly to clearing for agriculture and urban development. The rate of loss of woody vegetation is declining in response to changed land-management practices and increased legislative controls.
- Australia's plantation area increased to 1.82 million hectares over the period, up 12% from the 1.63 million hectares in 2003.

Australia has 149 million hectares of forest,[1] which is 19% of the total land area. Of this, 147 million hectares is native forest, which is dominated by eucalypt (79%) and acacia (7%) forest types. There are also 1.0 million hectares of pine plantations (softwood) and 0.81 million hectares of eucalypt plantations (hardwood). The total forest area reported here is significantly different from that reported in SOFR 2003, mainly due to improved data resolution and better forest typing.

Forest types

The vast majority of Australia's native forest area is evergreen broadleaf. In general, and with the notable exception of mallee, forest distribution today is confined mainly to regions where average rainfall exceeds 500 millimetres per year. Most forests are in the northern, eastern and southwestern coastal zones, although woodland forests extend into drier areas in several parts of the country. With an estimated 4% of the world's forests, Australia has the world's sixth-largest forest estate and the fourth-largest area of forest in nature conservation reserves.

The eucalypt forest type (comprising the genera *Eucalyptus*, *Corymbia* and *Angophora*) is dominant across most of the country's forest area. The second most important forest type is acacia. Despite the overwhelming dominance of these two types, Australia's forests are very diverse. There are more than 700 species of eucalypts and almost 1,000 *Acacia*

1 Using the definition of forest given in the introduction to this report.

Warm temperate rainforest.

species, 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. Rainforests are particularly rich in floral and faunal biodiversity, even though they cover only 2% of the forest area.

For national reporting, forests are grouped into eight native forest types defined by dominant species and structure (Table 1). The first seven are eucalypt (divided into eleven subtypes), acacia, melaleuca, rainforest, casuarina, mangrove and callitris. The eighth group ('other') comprises forest types with relatively small total areas. Plantation forests are treated in two subcategories: hardwood and softwood. Figure 2 shows the distribution of these forest types across the continent and Table 2 shows it by jurisdiction.

Table 3 shows the percentage of total land area forested, by jurisdiction. Queensland has the largest area of forest (35% of the total), about half of which is classified as eucalypt medium woodland. The Northern Territory has about 20% of the forest estate, mostly low and medium eucalypt woodland and medium open eucalypt forest. Queensland and the Northern Territory also contain almost all (98%) of the melaleuca forest. About 18% of the total forest area is in New South Wales, including about 16 million hectares of tall and medium open forest. Tasmania has only 2% of Australia's forest estate.

Australia's plantation area expanded over the period. In 2006, it covered 1.82 million hectares, up 12% from 1.63 million hectares in 2003. Despite the increase, plantations account for only about 1% of the total forest area.

Further information describing Australia's forest types is provided in the Australian Forest Profile series.[2]

Table 1: Australia's forest area, by forest type

Forest type		Total ('000 ha)	% of total
Native forest	Acacia	10,365	7
	Callitris	2,597	2
	Casuarina	2,229	1
	Eucalypt	116,449	78
	Eucalypt low closed[a]	44	0.03
	Eucalypt low open	2,648	2
	Eucalypt low woodland	13,423	9
	Eucalypt mallee open	376	0.3
	Eucalypt mallee woodland	8,871	6
	Eucalypt medium closed[a]	254	0.2
	Eucalypt medium open	28,145	19
	Eucalypt medium woodland	56,187	38
	Eucalypt tall closed	123	0.1
	Eucalypt tall open	5,881	4
	Eucalypt tall woodland	497	0.3
	Mangrove	980	1
	Melaleuca	7,556	5
	Rainforest	3,280	2
	Other	3,942	3
Native forest total		*147,397*	*99*
Plantation[b]		1,818	1
Australian forest total		149,215	100

a New categories.

b Comprises both hardwood and softwood plantations. Plantation area as at 2006 from Parsons and Garvan (2007). May differ from state/territory estimates.

Note: Totals may not tally due to rounding.

Sources: NFI, National Plantation Inventory.

Young pine (*Pinus radiata*) (background) and bluegum (*Eucalyptus globulus*) plantations.

2 Compiled by the Bureau of Rural Sciences and available at www.daff.gov.au/forestsaustralia

Figure 2: Forest types and extent

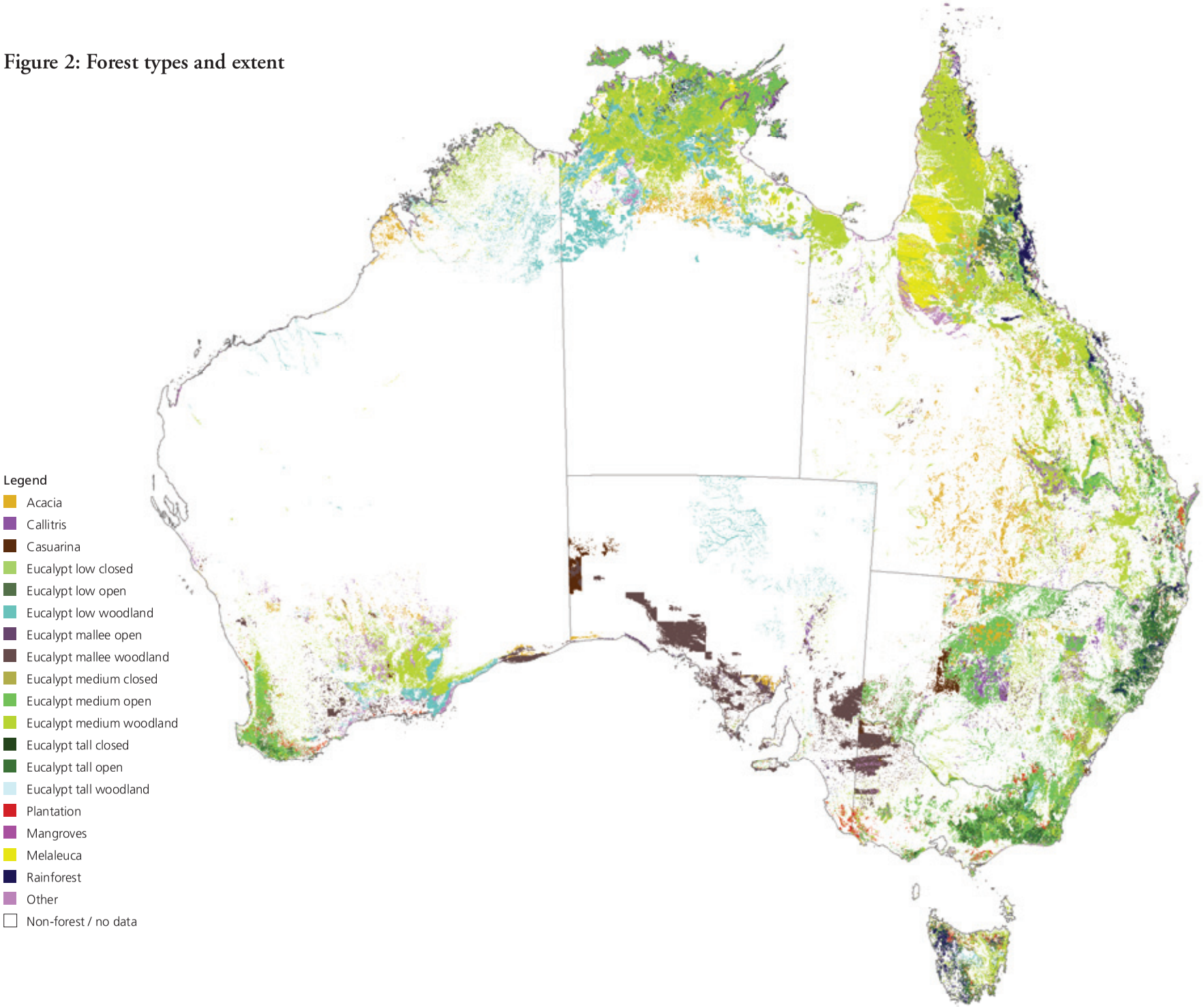
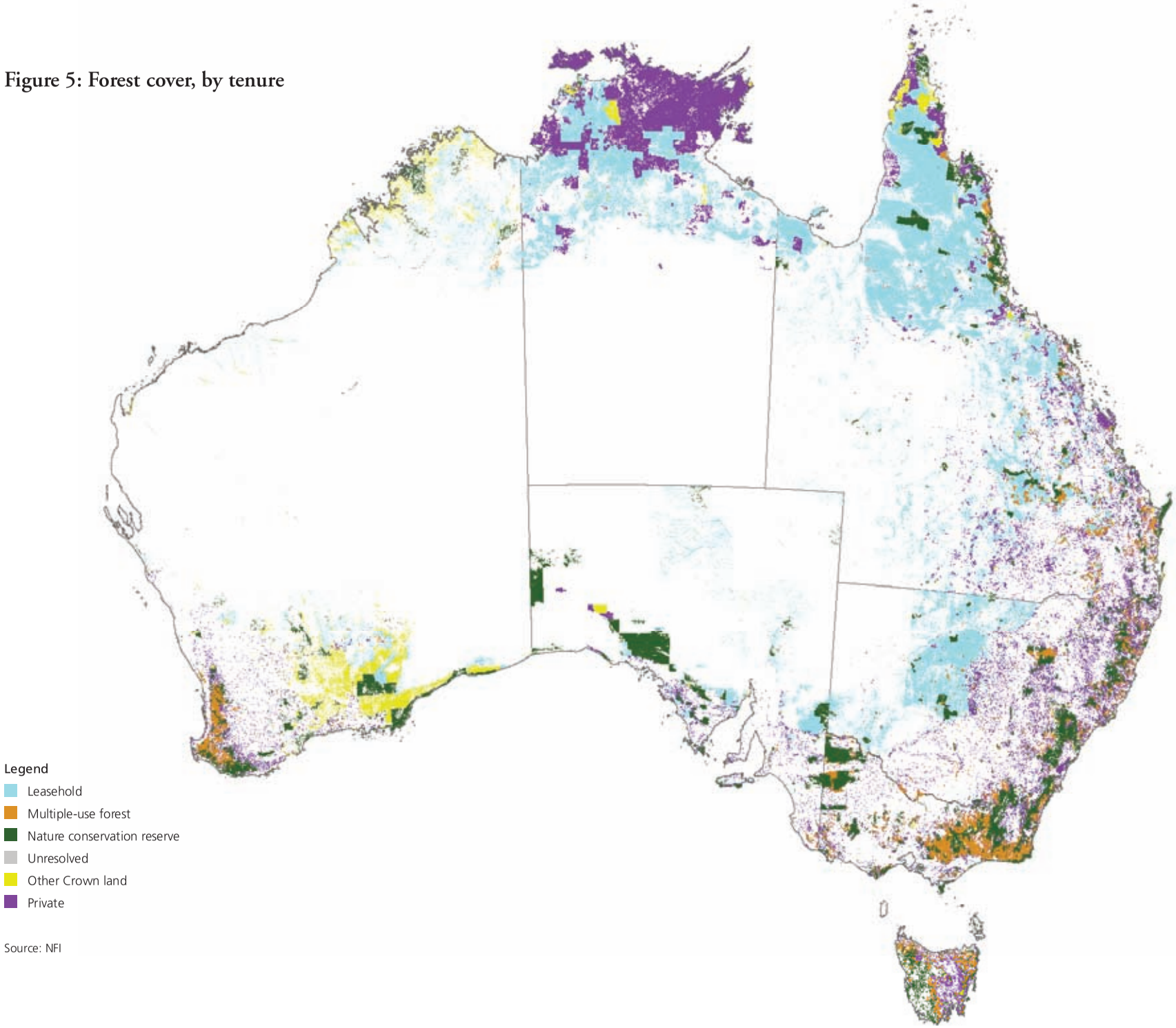


Figure 5: Forest cover, by tenure



Source: NFI

Table 2: Forest area, by forest type and jurisdiction ('000 hectares)

	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Australia
Acacia	–	1,333	1,496	6,060	239	72	41	1,123	10,365
Callitris	–	1,540	315	597	118	1	25	1	2,597
Casuarina	–	1,168	114	61	671	1	131	82	2,229
Eucalypt	116	21,147	26,389	36,466	7,792	2,430	7,281	14,827	116,449
Eucalypt low closed[a]	–	–	11	10	–	–	14	8	44
Eucalypt low open	4	31	592	1,739	8	–	70	204	2,648
Eucalypt low woodland	3	258	7,573	655	1,171	65	21	3,676	13,423
Eucalypt mallee open	–	53	–	–	318	–	–	5	376
Eucalypt mallee woodland	–	157	–	60	5,938	–	1,504	1,212	8,871
Eucalypt medium closed[a]	–	10	73	32	–	–	97	42	254
Eucalypt medium open	63	12,920	5,499	4,733	9	7	3,005	1,909	28,145
Eucalypt medium woodland	18	4,298	12,641	29,060	347	1,257	1,008	7,557	56,187
Eucalypt tall closed	–	–	–	–	–	–	117	6	123
Eucalypt tall open	28	3,319	–	156	–	814	1,372	193	5,881
Eucalypt tall woodland	–	102	–	21	–	287	73	14	497
Mangrove	–	5	359	436	14	–	2	164	980
Melaleuca	–	48	1,690	5,698	14	19	24	62	7,556
Rainforest	–	495	302	1,867	–	593	18	5	3,280
Other	7	473	344	1,397	7	–	314	1,400	3,942
Total native forest	*123*	*26,208*	*31,010*	*52,582*	*8,855*	*3,116*	*7,838*	*17,664*	*147,397*
Hardwood plantation	–	63	23	43	48	174	175	281	807
Softwood plantation	10	280	2	188	124	74	219	105	1,001
Mixed or unknown plantation	–	3	–	2	–	–	1	2	9
Total plantation[b]	*10*	*345*	*26*	*233*	*172*	*248*	*396*	*389*	*1,818*
Total forest 2007	132	26,554	31,035	52,815	9,027	3,364	8,234	18,053	149,215
% forested[c]	54	33	23	31	9	49	36	7	19

a New categories.

b Plantation areas as at 2006 from Parsons and Gavran (2007). May differ from state/territory estimates.

c Based on total land areas from ABS (2006a).

Note: Native forest data sourced from tables and forest type mapping provided by states and territories, nominally for data available as at June 2006. The date of mapping is earlier and may be different for some states or parts within a state (e.g. Queensland data are as at September 2003 and Tasmanian data are as at July 2005). Totals may not tally due to rounding.

Source: NFI

Table 3: Forest as a percentage of land area, by jurisdiction

	Native forest area[a] ('000 ha)	Plantation area[b] ('000 ha)	Total land area[c] ('000 ha)	Forest as % of jurisdiction	% of Australia's forest
ACT	123	10	243	54	<1
NSW	26,208	345	80,064	33	18
NT	31,010	26	134,913	23	21
Qld	52,582	233	173,065	31	35
SA	8,855	172	98,348	9	6
Tas.	3,116	248	6,840	49	2
Vic.	7,838	396	22,742	36	5
WA	17,664	389	252,988	7	12
Total	147,397	1,818	769,202	19	100

Sources:

a NFI

b Parsons and Gavran (2007)

c ABS (2006a)

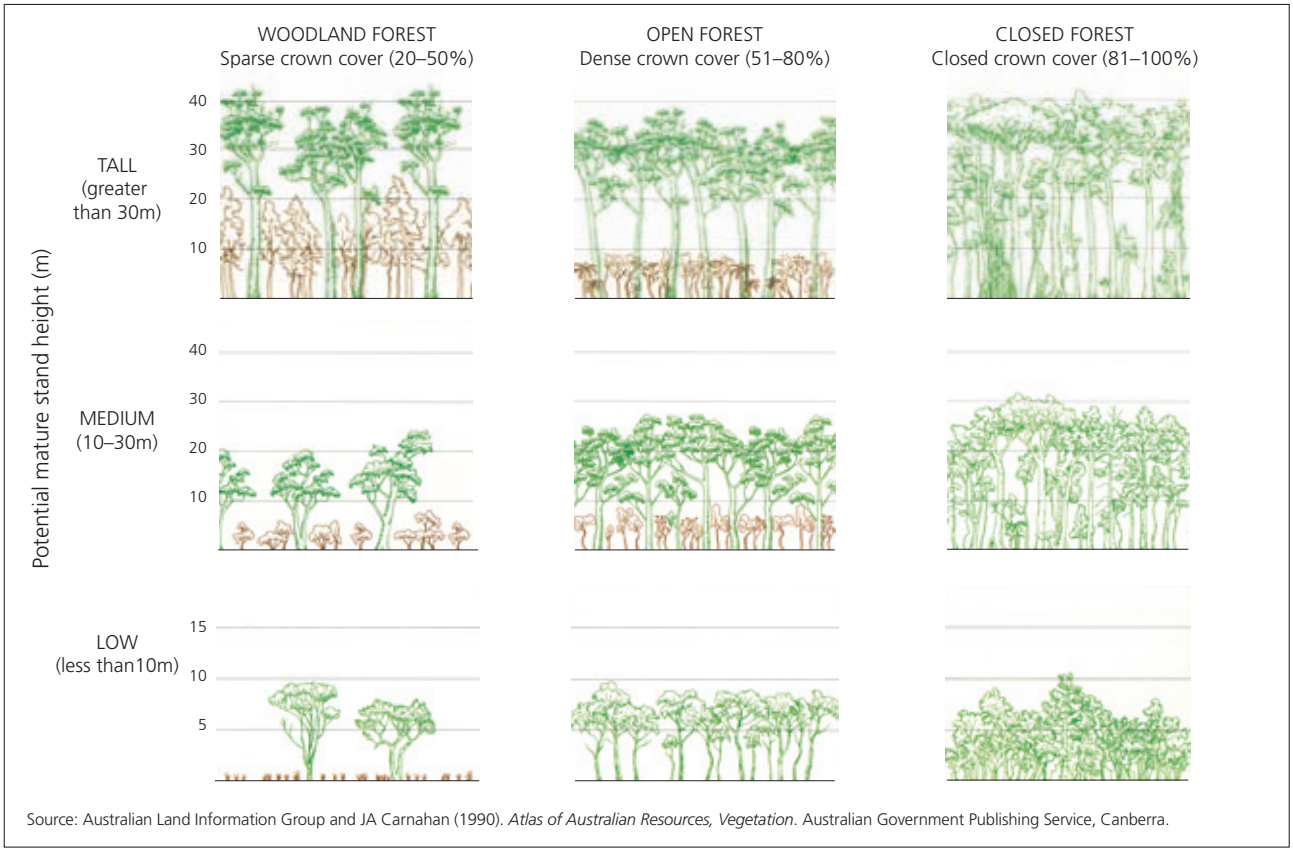
Note: Totals may not tally due to rounding.

Crown cover

Australia's native forests are classified into three crown cover classes – woodland, open and closed – and three height classes – low, medium and tall (Figure 3). Table 4 shows the area of each native forest type by crown cover class, and Figure 4 shows the spatial distribution of the classes across the continent. Table 5 shows the area of native forest in each crown cover class by state and territory. Forest type and cover are reasonably well mapped, but forest height is not well measured outside forests in which timber is harvested.

The distribution of the three crown cover classes varies across the states and territories depending on climate, soil type and land use; it is often related to the soil moisture regime, declining with lower water availability. Almost 100 million hectares, or two-thirds of the native forest estate, is classified as woodland and almost one-third as open forest. Production forestry occurs almost exclusively in the tall, denser forest types within regional forest agreement (RFA)

Figure 3: Crown cover and height classes



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

areas; lower, more open forests are often used for livestock grazing. The crown cover map created for this report has been improved by using data from the National Vegetation Information System to fill in data gaps for almost 10 million hectares of forest in Queensland and New South Wales that were classed as unknown crown cover in SOFR 2003.

Tenure

Forest ownership is reported in six tenure classes summarising the wide range of classes used by various jurisdictions (see Introduction). About 70% of Australia's forests is effectively under private management, with 44% on leasehold land and another 26% on land either held under freehold private title or managed by Indigenous communities (Table 6, Figure 5 – fold out map on the back of Figure 2). Leasehold land accounts for 65.1 million hectares of forest, about half of which is in Queensland; the Northern Territory and New South Wales also have significant areas of leasehold forest. More than 80% of forest classified as private is in Queensland, New South Wales or the Northern Territory, which includes large areas managed by Indigenous people.

Sixteen per cent of Australia's forest is now formally protected in public nature conservation reserves, a significant increase over the area reported in SOFR 2003 (see Indicator 1.1c). Multiple-use public forests, where timber harvesting is generally permitted, cover 9.43 million hectares, or about 6% of Australia's total native forest estate, down from 11.4 million hectares in SOFR 2003.

Table 4: Area of forest type, by crown cover class ('000 hectares)

Forest type	Woodland	Open	Closed	Australia
Acacia	7,059	3,306	–	10,365
Callitris	803	1,793	–	2,597
Casuarina	2,082	191	–	2,274
Eucalypt	79,878	37,050	421	117,349
Eucalypt low closed	–	–	43	43
Eucalypt low open	–	2,641	–	2,641
Eucalypt low woodland	13,427	–	–	13,427
Eucalypt mallee open	–	376	–	376
Eucalypt mallee woodland	8,869	–	–	8,869
Eucalypt medium closed	–	–	251	251
Eucalypt medium open	–	28,107	–	28,107
Eucalypt medium woodland	56,279	–	–	56,279
Eucalypt tall closed	–	–	119	119
Eucalypt tall open	–	5,803	–	5,803
Eucalypt tall woodland	494	–	–	494
Mangrove	99	331	552	980
Melaleuca	6,654	878	26	7,556
Rainforest	–	–	3,280	3,280
Other	3,240	693	–	3,942
Total	99,007	44,120	4,270	147,397

Note: Totals may not tally due to rounding.

Source: NFI

Figure 4: Native forest, by crown cover class

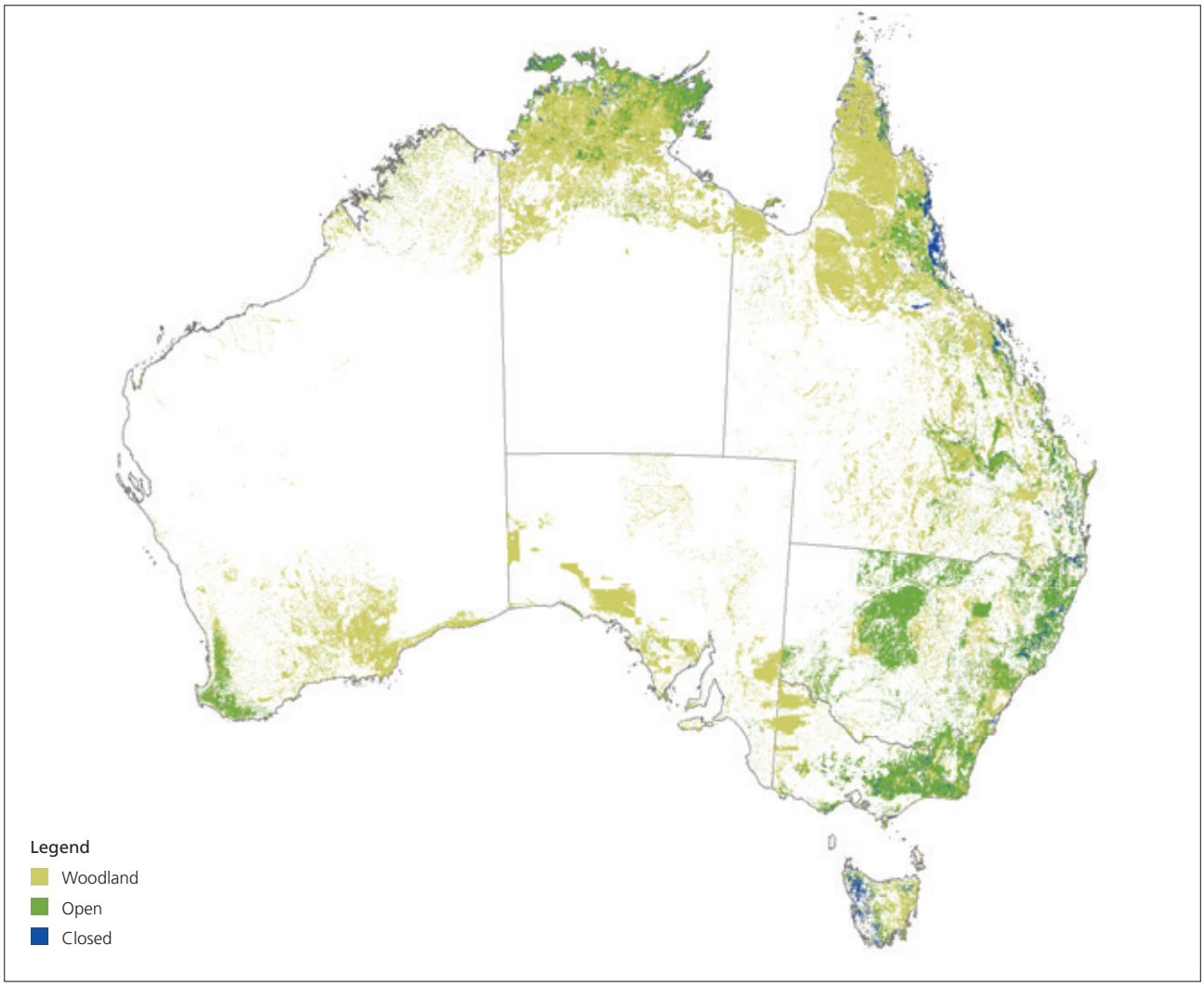


Table 5: Area of native forest, by crown cover class and state and territory ('000 hectares)

	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Australia	%
Woodland	37	6,480	22,905	41,172	8,494	1,610	3,177	15,130	99,007	67
Open	86	19,223	7,439	9,310	357	894	4,419	2,393	44,120	30
Closed	0	505	666	2,100	4	611	242	141	4,270	3
Total native forest	123	26,208	31,010	52,582	8,855	3,116	7,838	17,664	147,397	100

Note: Totals may not tally due to rounding.

Source: NFI

There are notable differences in the ownership of different forest types. The drier, sparse woodland forests make up almost 100 million hectares, half on leasehold land and another quarter on private land. The open forest types are distributed more or less evenly between public and private owners in most jurisdictions, while closed forests, comprising rainforest and mangroves, are mostly in public ownership.

Changes in forest mapping

The process used to collect data on forest extent for this and the previous two national reports (SOFR 1998 and SOFR 2003) involves the collation by Australia's National Forest Inventory (NFI) of forest-type maps produced by each state and territory. SOFR 2003 noted that imperfections in the process – such as the collection of data using different methods and at different scales – were the main reason for an apparent increase in forest area of about 7 million hectares between the 1998 and 2003 reports. Although the process used in compiling data for this 2008 report was similar to that used in 2003, the overall quality of the data

Table 6: Area of forest, by tenure and jurisdiction ('000 hectares)

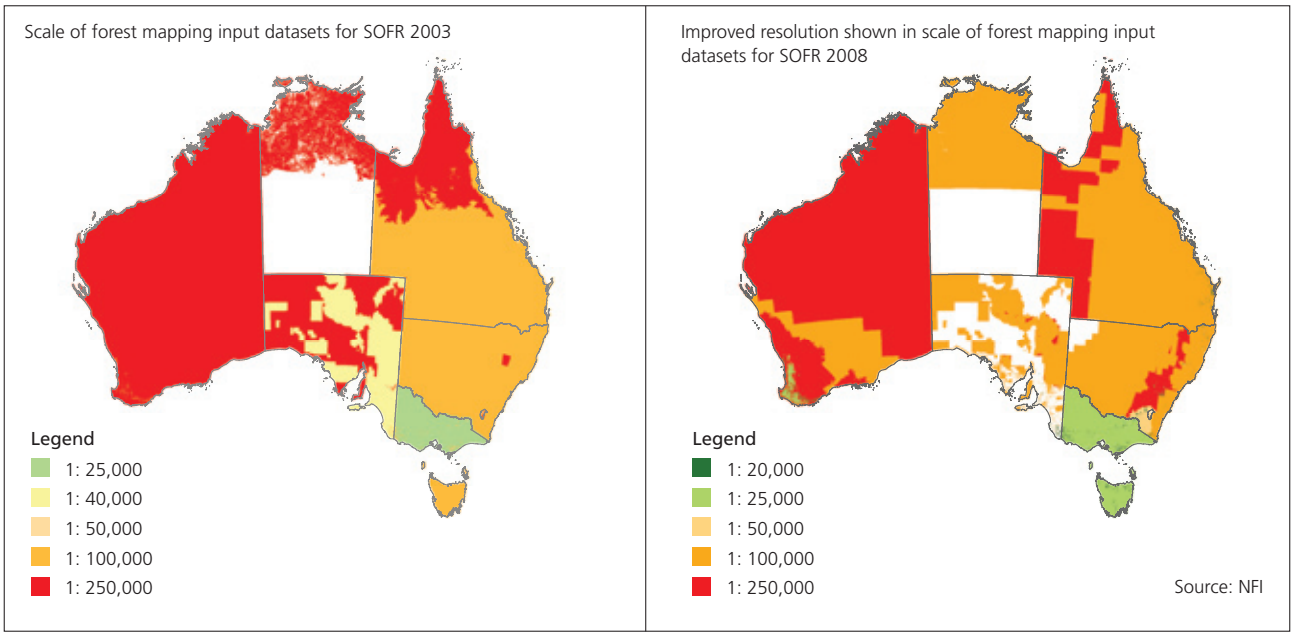
	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Australia	Tenure category as % of total native forest area
Leasehold forest	8	9,891	13,920	34,304	3,083	0	35	3,891	65,132	44
Multiple-use public forest	0	1,980	0	1,991	0	1,026	3,163	1,248	9,410	6
Nature conservation reserve	108	5,148	16	4,576	4,029	1,121	3,505	3,868	22,371	15
Other Crown land	7	943	674	1,598	277	85	109	7,169	10,862	7
Private land (including Indigenous)	0	8,076	16,317	8,908	1,399	885	1,025	1,489	38,099	26
Unresolved tenure	0	170	83	1,204	67	0	0	0	1,524	1
Total native forest	*123*	*26,208*	*31,010*	*52,581*	*8,855*	*3,116*	*7,837*	*17,665*	*147,397*	*99*
Plantations – all tenures[a]	10	345	26	233	172	248	396	389	1,818	1
Total forest	133	26,553	31,036	52,814	9,027	3,364	8,233	18,054	149,215	100

a The National Plantation Inventory classifies plantations by ownership classes that recognise land ownership, tree ownership and joint ownership. These cannot be aggregated into the tenure classes used for native forest.

Note: Totals may not tally due to rounding.

Sources: NFI, Parsons and Gavran (2007)

Figure 6: Improvements in national forest mapping 2003–08



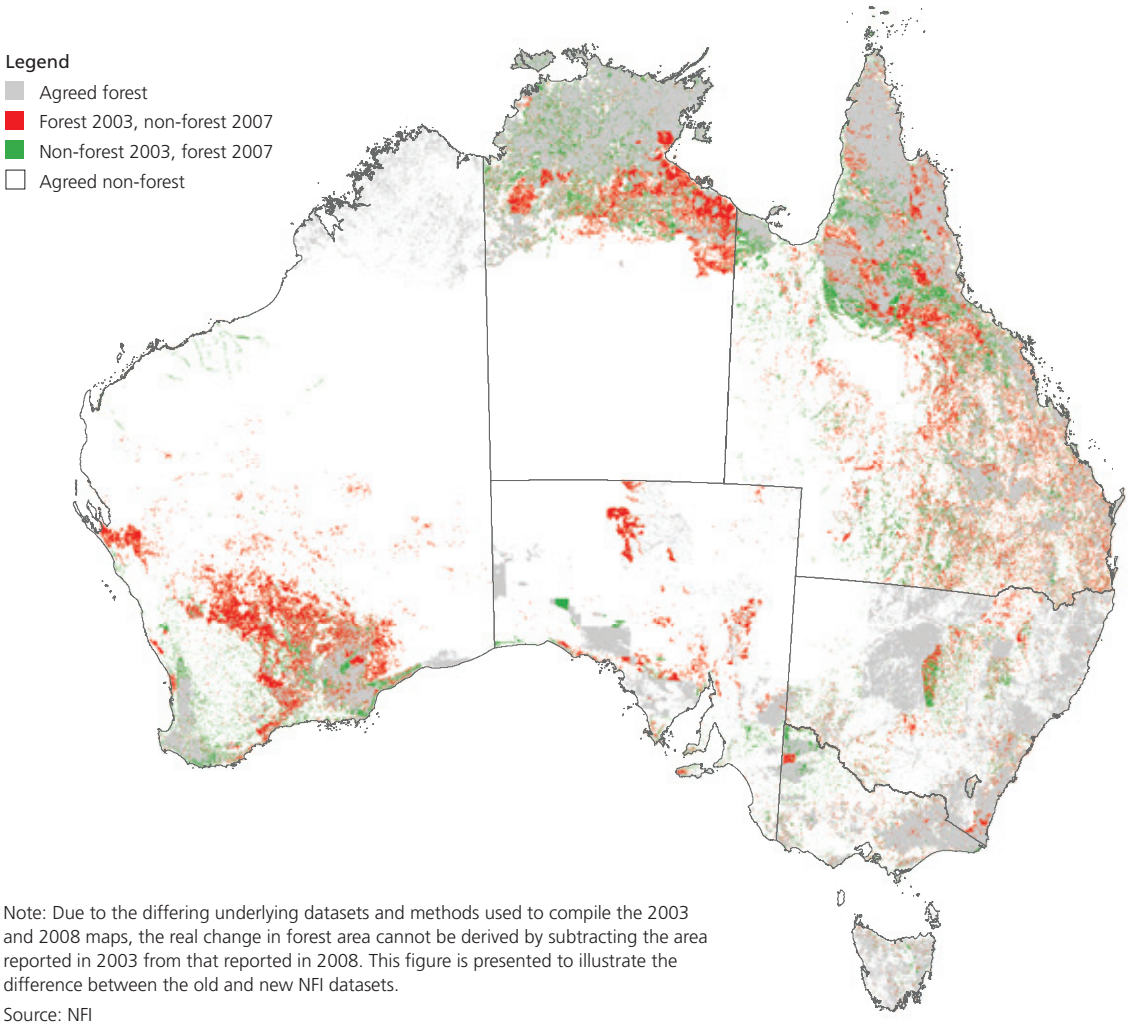
is much improved, due largely to increases in the resolution of remote sensing imagery. Figure 6 shows the distribution of the scale of data collection in SOFR 2003 and SOFR 2008.

One effect of improving data resolution is a reduction in the total apparent forest area, since it is now possible to detect small gaps in forest cover in areas that were previously treated as contiguous patches of forest. In contrast, some forest areas that were previously unknown have been detected using these high-resolution data (Figures 2, 5 and 6).

Many new or updated datasets – obtained mostly between 2004 and 2006 – were used in compiling SOFR 2008. The improvements in scale and currency of the data mean that the quality of mapping presented in this report is significantly improved from that in SOFR 2003. However, because of the different underlying datasets and methods used to compile the maps, the real change in forest area cannot be derived by subtracting the area reported in 2003 from that reported in 2008 (Figure 7). Most of the differences in forest cover between the two reports is due to new classifications of areas as shrublands or other non-forest vegetation.

The total native forest area is now considered to be more accurately estimated at slightly greater than 147 million hectares, compared to just less than 163 million hectares reported in SOFR 2003. Most of this change is due to changes in methodology and data resolution, rather than to a real change in forest cover. Data from other sources (see 'Changes in land cover') suggest that total native forest area is indeed declining, due largely to the clearing of open woodland forests for grazing and cropping, but by a much smaller amount.

Figure 7: Differences between national forest mapping in SOFR 2003 and SOFR 2008



Note: Due to the differing underlying datasets and methods used to compile the 2003 and 2008 maps, the real change in forest area cannot be derived by subtracting the area reported in 2003 from that reported in 2008. This figure is presented to illustrate the difference between the old and new NFI datasets.

Source: NFI

Almost half the national change in mapping is in Western Australia (mostly in the dry inland Goldfields region – Case study 1), which explains around 7.5 million hectares of the 15 million-hectare difference in forest extent between SOFR 2003 and SOFR 2008. Queensland accounts for another quarter of the change (some of which is due to land clearing – Case study 2). The Northern Territory and South Australia, combined, make up the remaining change, due mostly to changes in mapping rather than real forest conversion. New South Wales recorded little change in forest area; in its case, the underlying datasets have not been significantly updated. Victoria, Tasmania and the Australian Capital Territory have very stable mapped forest areas and together make up less than 1% of the total difference between 2003 and 2008.

Changes in land cover

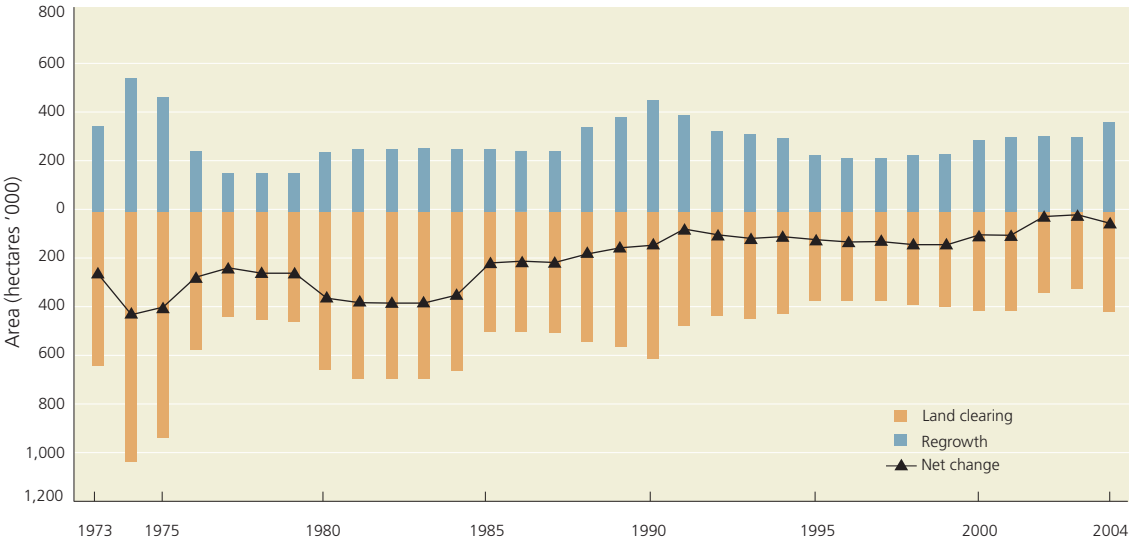
For various reasons (see earlier and box on page 14), the estimate of total forest extent presented here cannot be compared directly with those from SOFR 1998 and SOFR 2003 to determine the overall real change in forest cover over the periods covered by SOFRs. The 2006 Australian State of the Environment report discussed the net change in woody vegetation based on the AGO National Carbon Accounting System (NCAS – box on page 14 and Indicator 5.1a). The estimate of total woody vegetation cover derived by the NCAS methodology (108 million hectares) differs considerably from the estimate of total forest cover presented in this report. According to the NCAS, a net area of about 1 million hectares of woody vegetation (clearing minus regrowth) was cleared in Australia between 2000 and 2004, an average annual loss of about 260,000 hectares, or 0.25% of total woody vegetation.

A large part of this loss occurred in Queensland, due largely to the expansion of agriculture and urban development, although there is evidence that the rate of forest clearing is declining in that state (Case study 2). The net loss of woody vegetation (mostly forest) declined Australia-wide between 1973 and 2004 (Figure 8).

References and further reading

ABS (2006a), Accad et al (2006), AGO (2002), ASEC (2006), DNRM (2005), Kuhnell et al (1998), NFI (2007), Parsons and Gavran (2007) (list at the back of the report).

Figure 8: Net loss of woody vegetation (mostly forest), 1973 to 2004



Source: Adapted from ASEC (2006)

Case study 1: Changes in forest mapping in the Western Australian goldfields

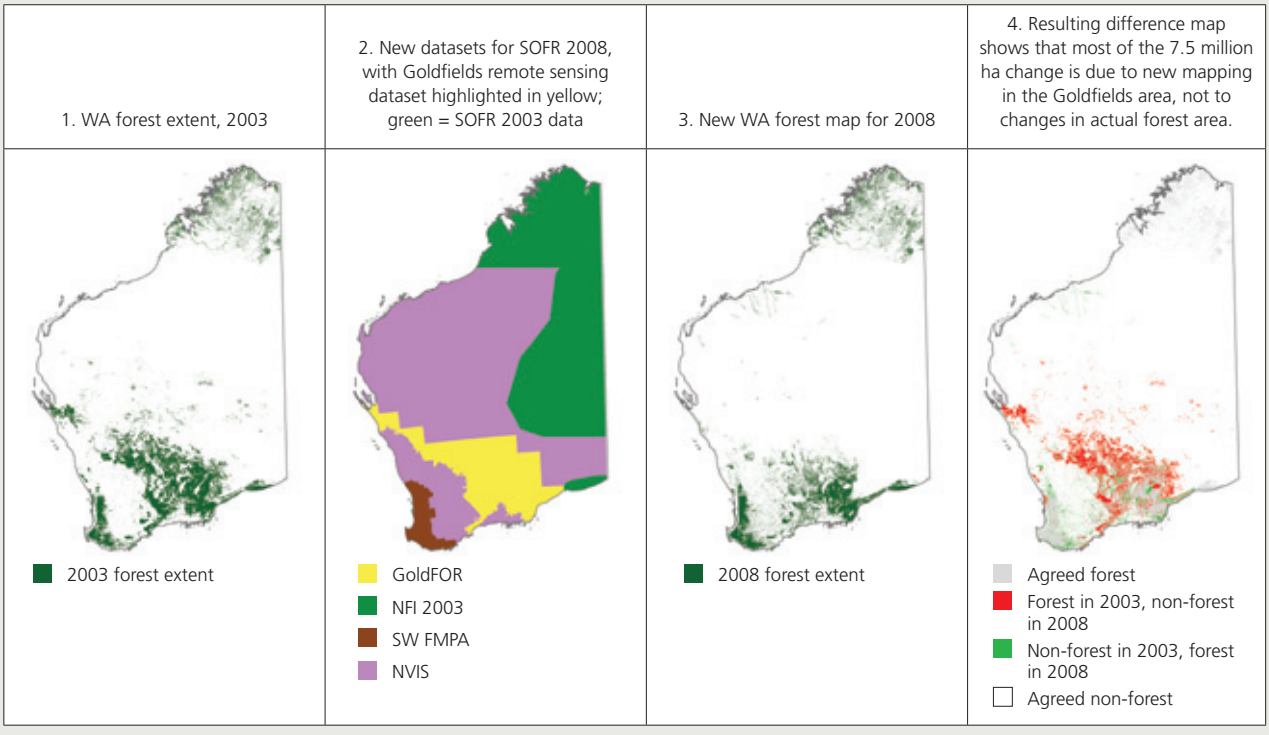
Approximately half of the 15 million-hectare difference in total forest extent between SOFR 2003 and SOFR 2008 can be attributed to changes in mapping across Western Australia, particularly in the Goldfields region.

Datasets used for SOFR 2008 are based on remote sensing data of higher resolution than previous spatial data available for the Southwest, Midwest, Goldfields and South Coast regions of Western Australia. This has enabled more accurate detection of forest cover in sparse woodland areas and resulted in the reclassification as shrublands of many areas that were previously recorded as forests.

Higher resolution data also improved the definition of forest boundaries and the identification of gaps in forest cover (Figure 9). As a consequence, the area mapped as forest in those regions, mostly the Goldfields region, has been reduced by 7.5 million hectares compared to the area reported in SOFR 2003.

Source: Department of Environment and Conservation (WA)

Figure 9: Differences in forest mapping for Western Australian goldfields, SOFR 2003 and SOFR 2008



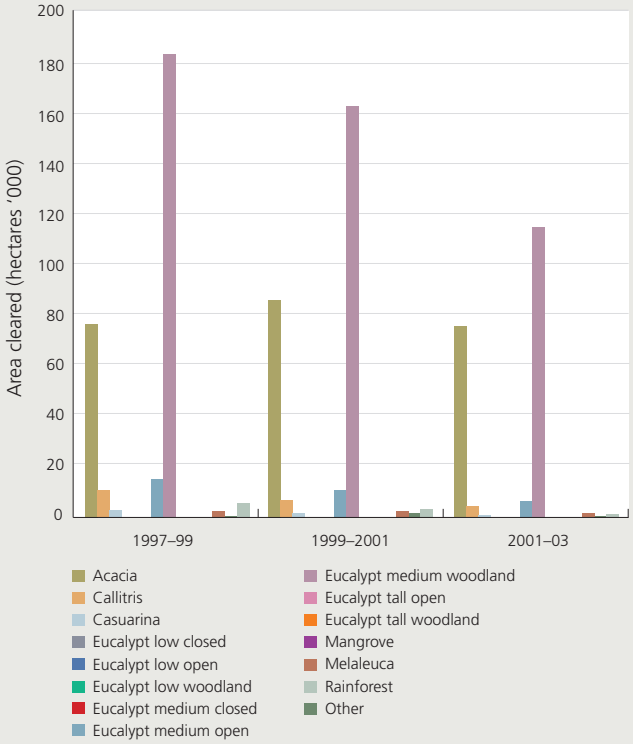
Case study 2: Forest clearing for agriculture in Queensland

The state of Queensland monitors the rate of change of woody vegetation cover and remnant native vegetation ecosystems. Figure 10 presents data from the regional ecosystem mapping program on the clearing of remnant vegetation over time in Queensland, by forest type. A total of just over 1.5 million hectares of forest was cleared over the period from 1999 to 2003, the rate declining from nearly 300,000 hectares per year in 1997–99 to around 200,000 hectares per year in 2001–03. Almost all (94%) of this clearing was in the drier open acacia and eucalypt medium woodland forest types (Figures 10 and 11), where forest was replaced by pasture for grazing or by other agricultural land uses. Clearing in most other forest types was much less or negligible.

The Queensland Government introduced a range of measures designed to phase out the broadscale clearing of remnant native vegetation in the state by the end of 2006 (Indicator 7.1a).

Sources: Accad et al (2006), DNRM (2005), Kuhnell et al (1998)

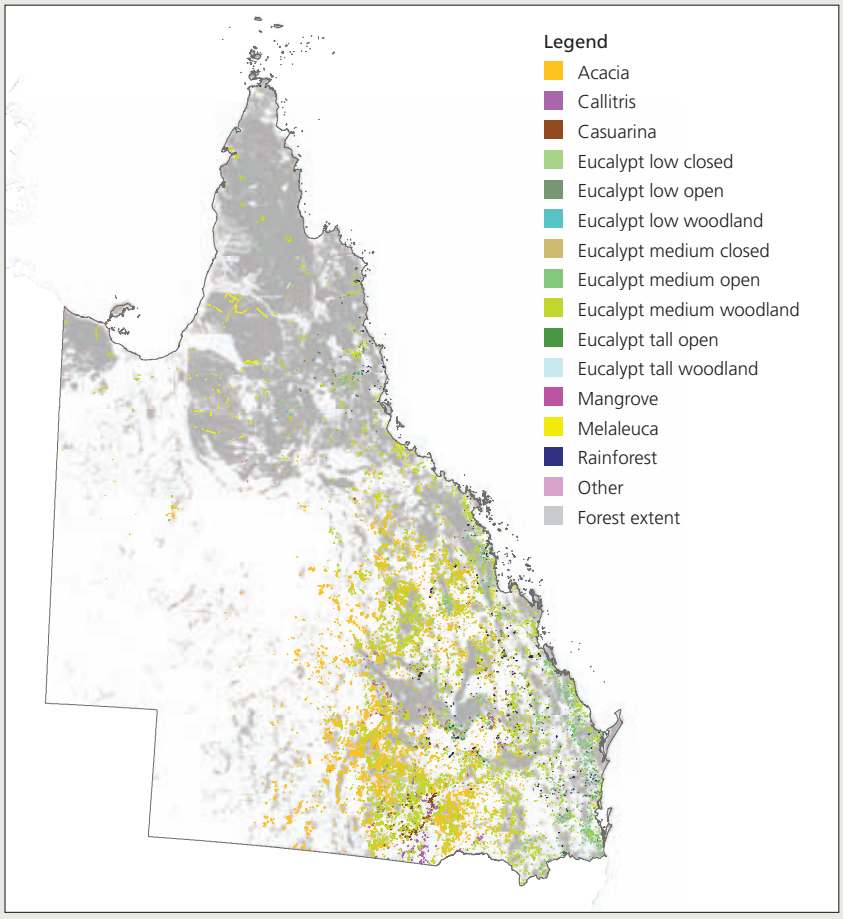
Figure 10: Forest clearing in Queensland, 1997–99 to 2001–03, by forest type



Note: Queensland regional ecosystem types have been converted to SOFR forest types.

Source: Data adapted from Accad et al (2006)

Figure 11: Extent and type of forest cleared in Queensland, 2003 to 2007



Differences between state and national forest mapping for SOFR 2008 and National Carbon Accounting System estimate of woody vegetation

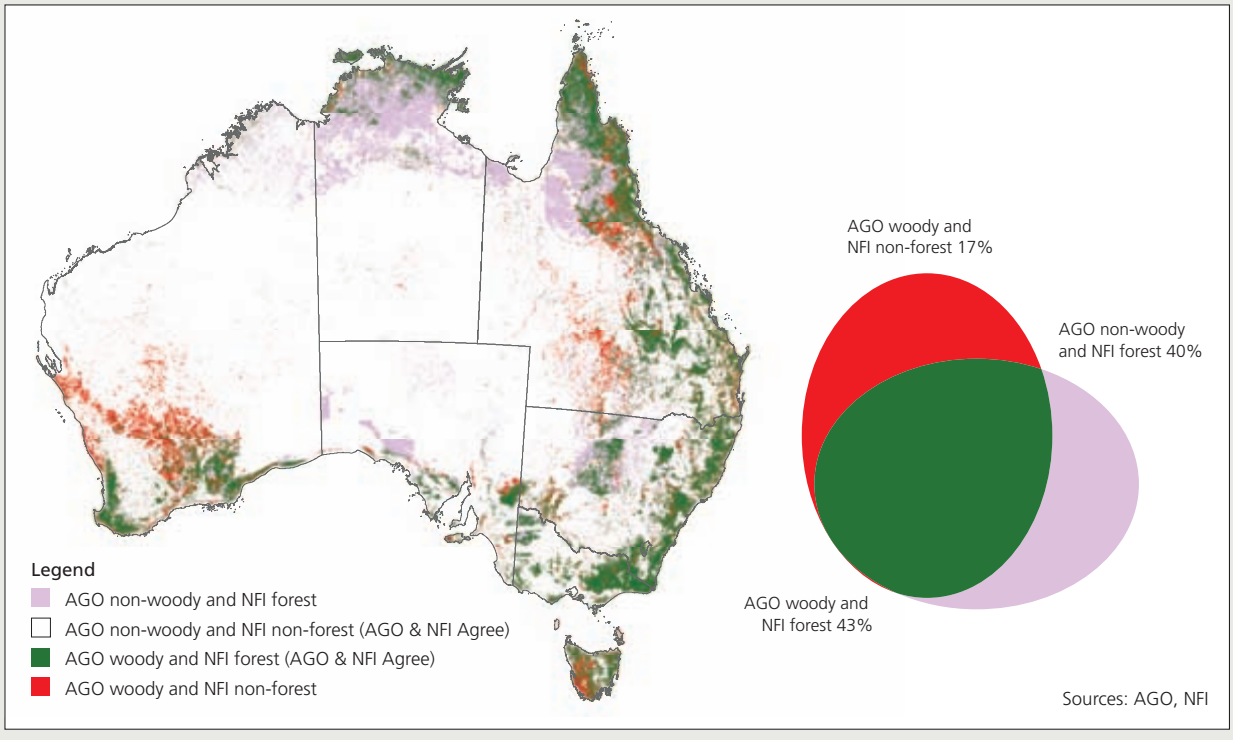
Each state and territory has its own method and sources of data for mapping and reporting on forest type and extent. The methods and data sources aim for a reliable, cost-effective estimate of forest type and cover appropriate to the needs of the jurisdiction. Historically, many jurisdictions have used aerial photography for developing forest-type maps combined with field validation, but satellite imagery of various time periods, scales and sources is increasingly used.

The NFI builds the national forest-cover map by compiling state and territory forest mapping information using eight agreed broad national forest types (including eucalypts with 11 subtypes). This map and its associated data are the accepted national data agreed by the Australian Government and the states and territories to be used for national and international reporting on Australia's forests. The NFI forest data incorporate the best available forest typing, floristic and structural information to make sure that vegetation counted as forest meets the national forest definition.

The AGO developed the National Carbon Accounting System (NCAS) for the purposes of reporting on Australia's carbon emissions. One part of the NCAS is a time-series of national woody-cover data layers based on Landsat satellite imagery from 1972 to the present; the primary end use of the final data is to determine vegetation cover change for the purpose of estimating net greenhouse gas emissions over time. The estimate of total woody vegetation cover derived by NCAS was 108 million hectares for 2005, which is considerably lower than the 149 million hectares total forest cover estimated in this report due to the different methodology used to compile the data. Neither dataset is right or wrong; both have been developed for and are best suited to specific purposes – the AGO dataset for tracking changes in woody cover and the NFI forest data, which include information on forest type, structure, height and extent, for reporting on a broader range of indicators for SOFR, including biodiversity and conservation values.

The NFI forest layer, which is used to report on total forest extent, overlaps the AGO NCAS woody-cover dataset on about half the NFI area (Figure 12). For dense forests, such as eucalypt tall open, eucalypt tall woodland and rainforest, there is a greater than 90% overlap; for softwood plantations there is a greater than 70% overlap. Some NFI forest types – particularly the open, drier forests across northern Australia, such as acacia, melaleuca, eucalypt medium woodland and eucalypt low woodland – are not well represented (<30% overlap) in the NCAS layer. The NCAS data also include dense woody vegetation that may have significant biomass but is not counted as forest in the NFI data. The AGO is currently developing a sparse woody vegetation layer that is expected to be larger in extent than the current NCAS dataset.

Figure 12: Differences between national forest mapping for SOFR 2008 and National Carbon Accounting System estimate of woody vegetation



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 are important in maintaining forest biodiversity.

Key points

- The growth stage of a forest provides an indication of its biodiversity and ecological values. Some growth stages, such as old-growth, provide specific habitat for particular species, wood products and a range of aesthetic and cultural values.
- Of the 23 million hectares of forest assessed for old-growth, 5.03 million hectares (22%) is classified as old-growth. This is about 200,000 hectares less than that reported in 2003 (5.23 million hectares); the difference is due mainly to the impact of severe fires, with younger forests replacing some areas of old-growth, and also to some remapping.
- Over 73% of known old-growth forests is now within formal or informal nature conservation reserves.
- Fire and disease represent the most significant threats to large areas of old-growth forests across all tenures. Logging is also a contentious issue, and several states have developed policies for the exclusion of harvesting from old-growth or for altered management prescriptions to reduce impacts.

Forests are dynamic ecosystems that go through stages of development following disturbances such as fire, storms and timber harvesting. Growth stage is an indicator of biodiversity in native forests[3] and also gives some indication of the balance of different age classes across the forest estate. The sustainable production of wood and the maintenance of values such as species diversity are often enhanced by a mix of areas in different age classes and a mosaic of growth stages.

The states and territories have developed various methods for describing forest growth stages or age classes. Four main growth stages in native forests can be identified: regeneration (less than 20 years since disturbance); regrowth (20–80 years); mature (80 or more years); and senescent (irregular crown form due to age) (Figure 13). These four categories work reasonably well for many eucalypt forests, which are often evenly aged. Substantial areas of forests are mixtures of one or more growth stages, especially forests dominated by other species.

Old-growth forests are of particular interest to the community for their habitat, conservation and aesthetic values, many of which are not found in forests in other stages of growth. However, old-growth is not a distinct growth stage; rather, it is a term that encompasses forest in the mature and senescent growth stages that has received minimal recent disturbance. The National Forest Policy Statement 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.*[4]

The National Forest Policy Statement gives high priority to the protection of old-growth forests, with specific provisions to protect more than 60% of identified areas. This target was intended to be applied flexibly to include representative

3 Plantation growth stages are reported by Parsons et al (2007a).

4 Commonwealth of Australia (1992).

Figure 13: 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 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.

examples of old-growth forest across the range, to ensure that high-quality habitat areas are included, and to take in the largest and least fragmented areas. To help achieve the National Forest Policy Statement target, national criteria were established for the conservation of old-growth forests in what is known as the JANIS report,[5] using a modified definition of old-growth:

> *Ecologically mature forest where the effects of disturbances are now negligible.*

Different jurisdictions use slight variations of this definition,[6] but all use the basic concept of identifying mature forest areas that have negligible disturbance. Old-growth forests generally have a layered structure, with large overstorey trees, a well-developed understorey of other tree species and shrubs, and ecological features such as dead standing trees and large logs on the forest floor. A number of wildlife species are reliant on these attributes because of the range of nesting hollows they provide and their greater structural complexity compared to forests in earlier stages of development. In addition, old-growth forests support a range of aesthetic and cultural values and provide tourism opportunities.

Mapping old-growth forests requires knowledge of both the growth stage and the disturbance history of the forest. The latter is often not well known and has to be interpreted from other information, such as the structure of the forest, and evidence of disturbance, such as tracks, stumps and fire scars. Some of these can be identified using aerial photographs, but in many cases expensive and labour-intensive on-the-ground inspection is required. Therefore, only a relatively small area of Australia's forests (mostly tall, wet forests) has been assessed for old-growth values. Old-growth forests are usually identified in patches larger than 2–3 hectares.

Other growth stages, such as regrowth (where the forest is younger and the trees are actively growing) are also important for habitat and conservation. Some wildlife species require more than one growth stage for their survival; for example, Leadbeater's possum (*Gymnobelideus leadbeateri*) requires one growth stage for nesting and another for feeding. Therefore, it is often important that a landscape includes a mosaic of growth stages.

The total area for which the growth stage of the forest is known is almost 15.4 million hectares, or 10% of Australia's 147 million-hectare native forest estate (Table 7). Growth stages are best known for multiple-use public forests used for wood production, as the mapping of growth stages in such forests is important for forest resource assessments. The largest gaps in the data are on private, leasehold and other Crown land tenures. Growth stage information is available for:

- 74% of forests in Tasmania
- 67% of forests in Victoria (mostly public land and some private)
- 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 (all public forest land in the Southwest Forest Management Plan area)
- 1% of forests in Queensland.

5 Joint Australian and New Zealand Environment Conservation Council/ Ministerial Council on Forestry, Fisheries and Aquaculture National Forest Policy Statement Implementation Sub-committee (JANIS 1997).

6 See Keenan and Ryan (2004).

Table 7: Area of forest type, by growth stage (where known) and tenure ('000 hectares)

Growth stage[a]	Leasehold	Multiple-use public forest	Nature conservation reserve	Other Crown land	Private	Unresolved tenure	Total
Regeneration	53	752	520	13	215	26	1,580
Regrowth	17	717	422	20	443	21	1,639
Mature[b]	87	2,563	2,820	135	1,354	28	6,986
Senescent	236	258	1,714	69	789	27	3,092
Uneven-aged[c]	3	1,282	678	49	86	0	2,099
Total	396	5,572	6,154	285	2,888	102	15,396
% by tenure	3	36	40	2	19	1	100

a Growth-stage definitions vary among states and have been translated to closest national category.

b Mature forest reported here includes both mature and senescent forest in Tasmania.

c Uneven-aged forests exist in all states but were not reported in SOFR 2003 and are included here using new data from Victoria and Western Australia.

Note: Totals may not tally due to rounding.

Sources: NFI, state agencies

In Western Australia, growth-stage information has been collected for 1.9 million hectares of forests in the southwest RFA area and reported in the region's Forest Management Plan 2004–13. This information, which was not available for SOFR 2003, includes spatial data for 331,000 hectares of old-growth forest on public land and has been added to the national dataset for the first time (Figure 14). In Tasmania and Victoria, some old-growth mapping has been updated to take into account harvesting, minor permanent conversion to other land uses, and fire since 2003. In South Australia, the Australian Capital Territory and the Northern Territory, native forest mapping does not collect forest growth-stage information. A mix of growth stages is likely to be present in most forests in those jurisdictions as a result of previous disturbances.

Most known growth-stage information pertains to eucalypt forests, as they are more easily classified into growth stages than some other forest types. Most of the eucalypt forests for which growth stage is known are considered to be mature forests (Table 8). Non-eucalypt communities, such as rainforest or drier open acacia woodlands, cannot easily be classified by growth stage. Those forests often occur as mixtures of several growth stages, including old-growth.

Manna gum (*Eucalyptus viminalis*), even-aged regrowth stand.

Extent of old-growth forest

Old-growth forests have historically provided an important resource for the timber industry in some parts of Australia, especially for high-quality sawn timber and veneer. Old-growth forests generally contain higher timber volumes than younger forests. Thus, old-growth forests planned for harvesting contribute a higher proportion to regional native forest wood supplies for industry in the short term than indicated by their areas. Reliance on these forests is declining in all states. The Western Australian Government's policy, which took effect in 2001, ended timber harvesting in old-growth forests. This increased the total area of old-growth on public land set aside from timber harvesting to 331,000 hectares (Figure 14) and contributed to a reduction in supply of first and second-grade jarrah and karri sawlogs to the timber industry from 457,000 cubic metres per year to 185,000 cubic metres per year. Tasmania also recently announced a program to reduce the clearfelling of old-growth forest on public lands: by 2010, no more than 20% of the small area of old-growth harvested each year will be clearfelled.

The framework to protect old-growth forest set out in the National Forest Policy Statement has largely been implemented in those areas covered by RFAs. A total of 5.03 million hectares of old-growth forest has been identified in the RFA regions. This is around 200,000 hectares less than that reported in 2003 (5.233 million hectares), due mainly to the impact of severe fires, which converted some areas of old-growth forest into younger age classes, and some remapping. About 73% (3.7 million hectares) of these old-growth forests are now in formal or informal nature conservation reserves, with some of the remaining 27% available for timber production.

Almost half of Australia's total identified old-growth forest is in New South Wales, and most of it is on public land (Table 9). The proportion of the forest estate that is old-growth varies widely by state; Tasmania has the highest (almost 40%).

Table 8: Area of forest type, by growth stage

	Area by growth stage ('000 ha)[a]						
Forest type	Regeneration	Regrowth	Mature	Senescent	Uneven-aged	Total	% of total known growth stage
Acacia[b]	1	0	15	0	2	20	0
Callitris[b]	7	0	19	22	1	48	0
Casuarina[b]	1	1	2	4	0	8	0
Eucalypt	1,478	5,569	6,830	2,966	2,085	14,929	97
Eucalypt low closed	3	5	5	0	1	14	0
Eucalypt low open	19	15	35	9	4	83	1
Eucalypt low woodland	2	35	77	75	2	192	1
Eucalypt mallee open	0	1	1	6	0	8	0
Eucalypt mallee woodland	3	0	35	1	1	40	0
Eucalypt medium closed	13	22	47	1	21	105	1
Eucalypt medium open	736	428	2,643	1,224	1,268	6,299	41
Eucalypt medium woodland	234	234	1,489	91	519	2,567	17
Eucalypt tall closed	24	29	48	1	22	123	1
Eucalypt tall open	414	744	2,187	1,538	231	5,114	33
Eucalypt tall woodland	29	56	264	21	15	385	3
Mangrove[b]	0	0	0	0	0	0	0
Melaleuca[b]	2	1	4	3	0	11	0
Rainforest[b]	68	55	35	59	2	219	1
Other[b]	23	13	81	36	8	161	1
Total	1,580	1,639	6,986	3,092	2,099	15,396	100
% of known growth-stage areas	10	11	45	20	14	100	

a Growth-stage class definitions vary between jurisdiction; national growth-stage classes are applied here.

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

Note: Data for RFA regions in New South Wales, Queensland, Tasmania, Victoria and Western Australia only. Totals may not tally due to rounding.

Sources: NFI, state agencies

Table 9: Area of old-growth forest in areas surveyed for regional forest agreements

	Native forest area in region ('000 ha)	Area of old-growth identified ('000 ha)	Area of old-growth as % of forest in region	Area of old-growth on public land ('000 ha)	Area of old-growth on private land ('000 ha)	Area of old-growth in formal and informal reserves[a] ('000 ha)	% old-growth in reserves
NSW[b]	8,989	2,536	28	1,892	644	1,742	69
Qld[b]	3,230	270	8	196	71	196	73
Tas.[c]	3,116	1,228	39	1,118	110	973[c]	79
Vic.	5,774	673	12	673	1	460	68
WA[d]	1,909	331	17	331	n/a	331	100
Total	23,018	5,039	22	4,209	826	3,702	73

a Includes nature conservation reserves and informal reserves on other tenures.

b Old-growth data for Queensland and New South Wales have not been updated since SOFR 2003. They do not include reserves established since 2003 and therefore 'area of old-growth in formal and informal reserves' is an underestimate.

c Includes new reserves established under the Tasmanian Community Forest Agreement on public land and 9,000 hectares of old-growth reserved on private land.

d Based on old-growth mapping for the RFA.

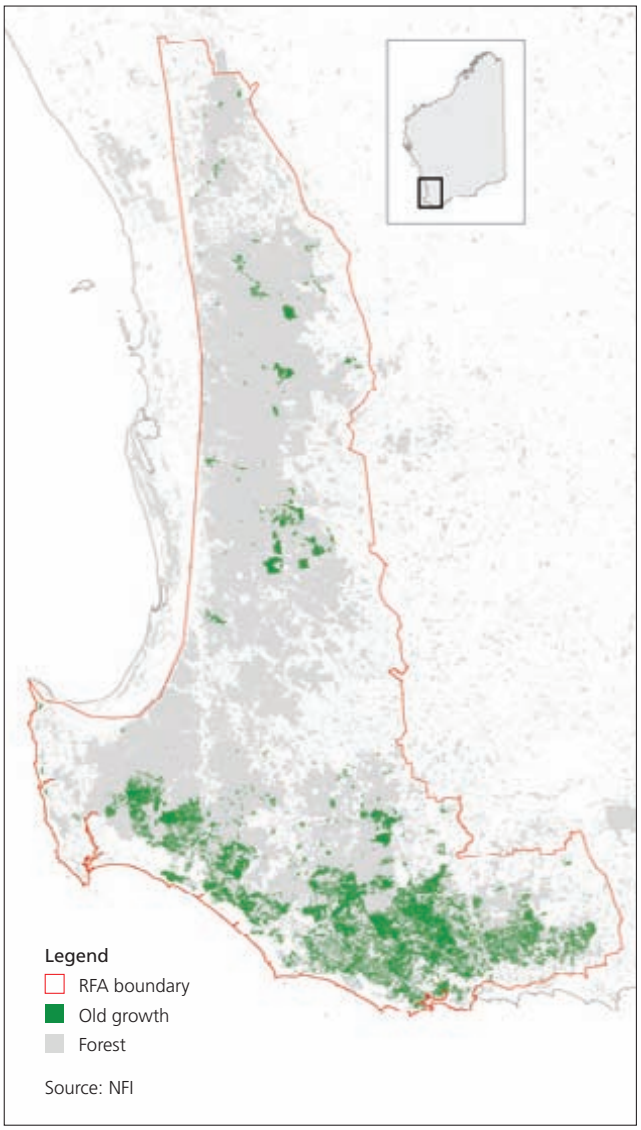
Note: Old-growth definitions vary among states. Old-growth forest has not been assessed in the Australian Capital Territory, Northern Territory or South Australia. Totals may not tally due to rounding.

Sources: NFI, state agencies

Old-growth forest also occurs outside RFA regions, but its extent is not well known. The classification of forests to a growth stage is difficult in areas where the age class is either mixed or not known or where the disturbance history is not known, which is often the case for drier, more remote forests. In Victoria, surveys have been conducted of old trees in red gum (*Eucalyptus camaldulensis*) forests, but those forests often do not meet the formal definition of old-growth forest.

Fire and disease are significant threats to old-growth forests across all tenures. In Victoria and New South Wales, large areas of old-growth have been burned and converted to regeneration and earlier growth stages since the completion of the RFA surveys, mostly in the 2003 fires, but the impact on the extent of old-growth areas has not been fully investigated. For jarrah forests to be classified as old-growth in Western Australia, they must be free of the *Phytophthora* root-rot disease, which is considered a form of disturbance.

Figure 14: Old-growth forest in southwest Western Australia's regional forest agreement area



References

Commonwealth of Australia (1992), JANIS (1997), Keenan and Ryan (2004), Parsons et al (2007a) (list at the back of the report).

Eastern jarrah (*Eucalyptus marginata*) mature growth stage near Dinningup, southwestern Western Australia.

Senescent (large tree, left foreground), mature and regenerating growth phases in eucalypt open forest.

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

- 23 million hectares of Australia's native forest is in formal nature conservation reserves, an increase of about 1.5 million hectares since SOFR 2003. There have also been significant increases to the informal reserve system on both public and private land.
- The representation of forests in Australia's forest reserve system is substantial, with most of the broad forest types protected above the targets recommended by the World Conservation Union.
- Representation in formal nature conservation reserves increased for most forest types over the reporting period, with notable increases in some types, including rainforest (from 33% to 55%) and mangroves (from 13% to 18%).
- Almost all of the increase in forest in nature conservation reserves has been achieved by reducing the area of multiple-use public forest (in which wood production is an objective) through the regional forest agreement (RFA) process and separate state processes.
- There has been an increase in the area of privately managed forest (including private freehold, leasehold and Indigenous-managed lands) managed for conservation objectives through a variety of national and jurisdictional programs, but the extent of that increase is not well documented.
- About 4.6 million hectares of Australia's native forests are within World Heritage-listed areas, a small increase over the area reported in SOFR 2003.

The National Forest Policy Statement[7] 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 RFAs followed this approach in the allocation of areas to the reserve system or to multiple-use public forests where wood production is also a management objective. Within the RFA areas, the reserve system comprises formal and informal reserves on both public and private land:

- **Formal reserves** are publicly managed land-tenures that cannot be revoked without parliamentary approval. Of these, *dedicated formal reserves* exclude mining.
- **Informal reserves** on public land are protected through administrative instruments by public authorities.
- **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, contractual agreements

7 Commonwealth of Australia (1992).

such as management agreements and covenants, and reserves set aside under independently certified forest management systems.

- In some areas, some *forest values may be managed by prescription* in a code of practice or management plan. These areas outside other reserves are not recorded as reserves for the purposes of this indicator.

The proportion of native forest formally protected in public nature conservation reserves has increased significantly over the past decade, from 11% (17.6 million hectares) reported in SOFR 1998, to 13% (21.5 million hectares) reported in 2003, to 16% (23 million hectares) reported in 2008 (Table 10). There have also been significant increases in the informal reserve system on both public and private land. There is a notable trend of increasing reservation on private property by a variety of secure legal mechanisms, such as covenants, but the full extent of that trend is not well documented.

A large part of the increase between the 1998 and 2003 reports arose from the RFA process and subsequent decisions taken by relevant states and territories. One of the key objectives of the RFA process was to use a set of nationally agreed criteria for the establishment of a CAR reserve system in Australia based on the JANIS[8] criteria to protect, in nature conservation reserves:

- 15% of the pre-1750 distribution of each forest type
- 60% of the existing distribution of each forest type, if vulnerable
- 60% of the existing old-growth forest
- 90% or more of high-quality wilderness forests
- all remaining occurrences of rare and endangered forest ecosystems (including rare, old-growth forests).

The process resulted in the transfer of more than 2 million hectares of forest from the broad tenure category of multiple-use public forest to nature conservation reserves; much of that change (1.7 million hectares) was reported in SOFR 2003 (page 42) and is not repeated here.

The 2005 Tasmanian Community Forest Agreement resulted in further increases in the area of forest in formal and informal nature conservation areas in Tasmania. Other states have made changes in forest tenure through departmental arrangements or passed legislation providing further protection to additional areas of forests. For example, New South Wales enacted the *Brigalow and Nandewar Community Conservation Area Act 2005*, which added 352,000 hectares of forest to nature conservation reserves stretching from Dubbo to the Queensland border. Western Australia developed a forest management plan for the southwest of the state covering the period from 2004 to 2013, which resulted in significant increases in the area of forest in nature conservation reserves; outcomes included placing all identified old-growth forest in reserves and altered management prescriptions in many other areas. In large part, the increase in nature conservation reserves has been at the expense of the multiple-use public forest estate (Figure 15).

Informal forest reserves and reserves on private land

Informal reserves are an integral part of the national forest reserve system. All states that undertook comprehensive regional assessments as part of the RFA process (New South Wales, Tasmania, Victoria, Queensland and Western Australia) have developed approaches to forest protection and conservation that include informal reserves, as reported in SOFR 2003.

Figure 15: Change in percentage of forest in formal nature conservation reserves on public land and multiple-use public forest available for wood production, 1997 to 2007

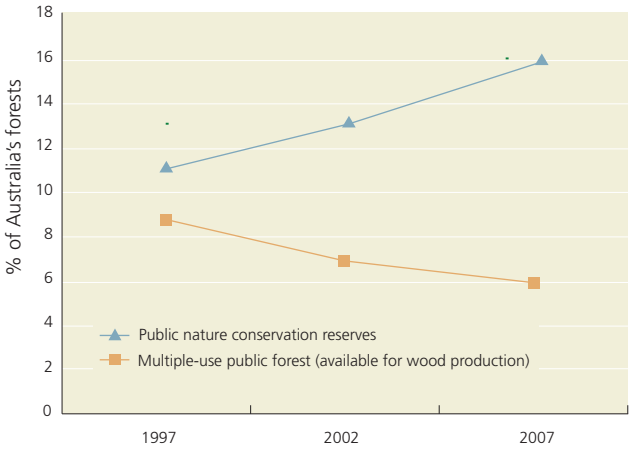


Table 10: Forest area reserved on public land as a percentage of total forest area, as reported in 1998, 2003 and 2008

	Forest area reported in SOFR 1998 (million ha)	% of total native forest area 1998	Forest area reported in SOFR 2003 (million ha)	% of total native forest area 2003	Forest area reported in SOFR 2008 (million ha)	% of total native forest area 2008
Forest in public nature conservation reserves[a]	17.6	11	21.5	13	23	16
All forest[b]	156	100	164	100	149	100

a Does not include informal reserves or private land.

b 'All forest' includes all forest types (native and plantation) on all tenures; it includes multiple-use public forest on public land where wood production is permitted, and forest on private, leasehold and other Crown land. Only relatively small proportions of those areas are used for wood production.

Note: Figures may differ from those reported in state and territory or regional RFA reports due to different forest-type mapping or more recent data.

8 JANIS (1997).

Although private CAR reserves are relatively small, they are important because they are most often selected to protect rare or endangered species or other important forest values that cannot be fully catered for by reservation on public land. There has been an increase in the area of privately managed forest (including private freehold, leasehold and Indigenous-managed lands) being managed for conservation objectives through a variety of national and jurisdictional programs. However, data on conservation areas on private land are not consistently reported and may not be complete.

Tasmania completed its second five-year review of the implementation of its RFA in 2007 and added areas both to the formal reserve system and to the informal system; it is the only state that is able to report comprehensively across both public and private land. Table 11 shows that 47% of the state's total forest area is in either formal or informal nature conservation reserves. It also demonstrates how informal (10% of total forest) and private (2%) reserves add about 350,000 hectares to the total area of forest in nature conservation reserves. Other states are at varying stages of their RFA reviews, and updated data from those states are not yet available.

The area of public land protected in three CAR reserve categories in Victoria is shown in Table 12. Data on CAR reserves on private land in the state are insufficient for reporting here, but it is known that the area of such reserves has increased. For example, in Victoria the Trust for Nature currently has in place more than 800 conservation covenants that offer legally binding protection to more than 35,000 hectares of native vegetation on private land, including a significant number on forested land. There are also conservation management agreements over 200,000 hectares of private land in Victoria, most of it forested. These management agreements, which are not binding on land titles, are associated with formal government programs including BushTender, the National Action Plan for Salinity and Water Quality, the Natural Heritage Trust and Land for Wildlife, which have been integrated into a new government program, Caring for our Country.

IUCN protected areas

The International Union for Conservation of Nature (IUCN) 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.*[9]

The IUCN classifies protected areas into the following protected area management 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.

In 1982, the IUCN recommended that at least 10% of each biome should be in reserve categories I–VI. Of Australia's 18 broad national forest types, 13 have reservation levels exceeding this; only acacia, callitris and eucalypt medium woodland forest types are represented below this level. In the RFA areas, the IUCN target has been significantly exceeded. The area of forest in IUCN categories I–VI is shown by jurisdiction in Table 13 and by type in Table 14. Nationally,

Table 11: Area of protected native forest in Tasmania, by CAR reserve type

	Dedicated formal reserves	Other formal reserves	Informal CAR reserves	Private CAR reserves	Total forest reserved
Forest area[a] ('000 ha)	635	479[b]	303	48	1,465
% total native forest[c]	20	15	10	2	47

a Forest areas in each reserve class are as at 30 June 2006.

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

c Total forest area in Tasmania as of first quarter 2005 was 3.12 million hectares.

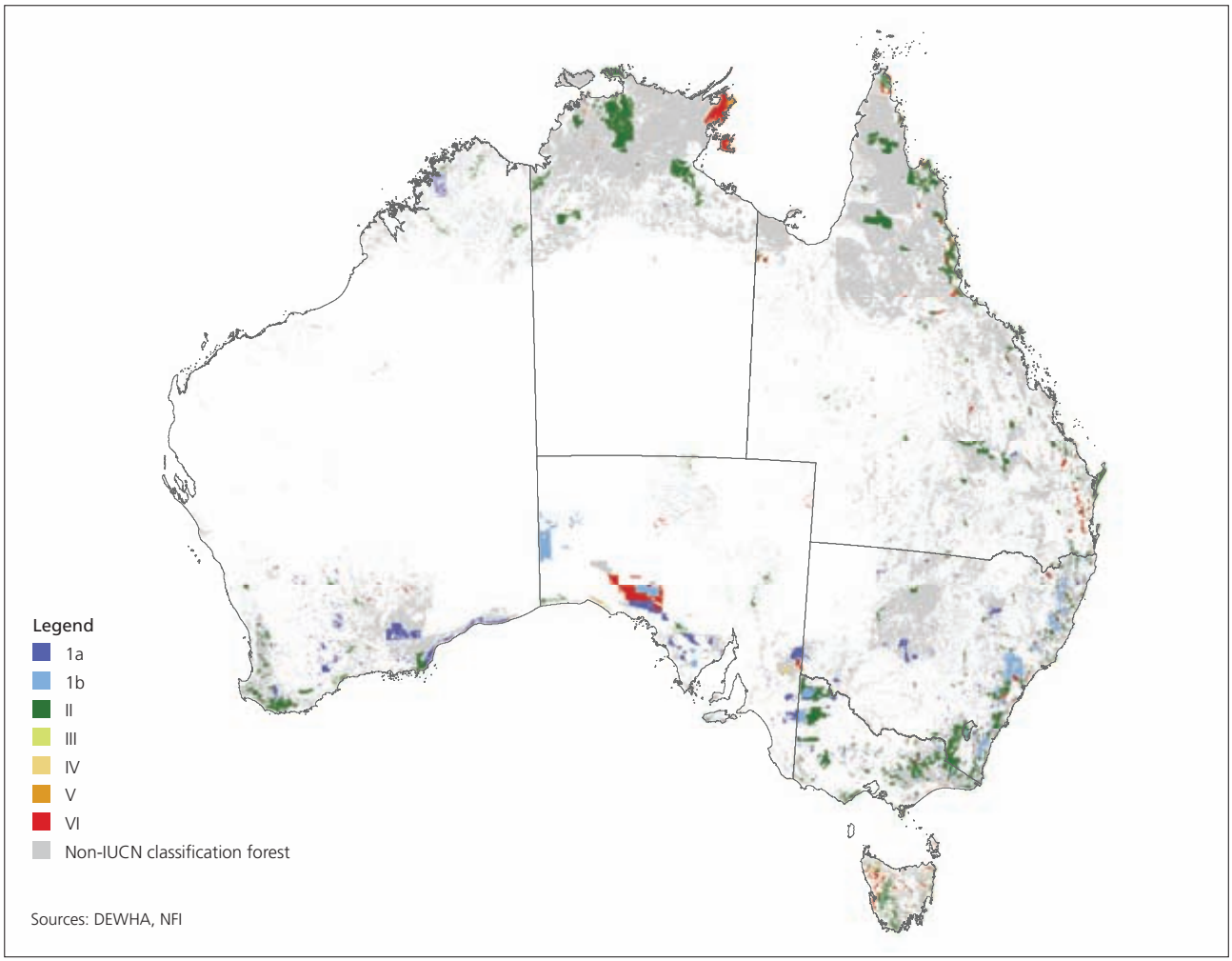
Table 12: Area of protected native forest on public land in Victoria, by CAR reserve type ('000 hectares)

	Dedicated formal reserves	Informal CAR reserves	Values protected by prescription	Private CAR reserves	Total forest reserved
Forest area[a] ('000 ha)	3,546	740	494	n/a	4,780
% total native forest[a]	45	10	6	–	61

a Total native forest area in Victoria of 7.84 million hectares.

9 www.iucn.org/themes/wcpa

Figure 16: Forest cover, by IUCN classification



18% of native forests are in IUCN protected area categories I–VI. In the main, categories Ia, Ib and II are equivalent to the nature conservation reserves reported elsewhere in this indicator; little forest area is contained in categories III, IV and V. Figure 16 illustrates the distribution of forest, by IUCN category.

National Estate

The Register of the National Estate is a national list of places of natural, historic and Indigenous significance. It was compiled and maintained by the Australian Heritage Commission from 1975 to 2003 and after that by the Australian Heritage Council. However, since February 2007 the council can no longer add places to the register or remove them from it. As a result of amendments to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), two new lists were created on 1 January 2004: the National Heritage List and the Commonwealth Heritage List.

In the past, a place may have been added to the Register of the National Estate if the statutory criteria were met to the appropriate degree, including if the place contained aspects of, or contributed to a greater understanding of, Australia's natural or cultural history, if it was aesthetically valued by the community, or if it was highly valued for social, cultural or spiritual reasons. The register lists sites under three broad categories of historic, Indigenous and natural values.

The register is now frozen but will continue to have statutory status until February 2012. This means that the Minister for the Environment, Heritage and the Arts is required to consider the register when making certain decisions under the EPBC Act. References to the register will remain in the *Australian Heritage Council Act 2003* (Cwlth) during this time, and it will continue to be available online.

Sites listed on the Register of the National Estate cover 66 million hectares in total, of which 22 million hectares is estimated to be forested (Table 15 and Figure 17). The vast majority (21 million hectares) of forest areas are listed for their natural values, and smaller but still significant areas (1.5 million hectares) are listed for Indigenous values and historical values (0.5 million hectares). The total area listed has not changed significantly since 2003, and any differences are most likely due to changes in forest mapping.

Table 13: Area of native forest in IUCN protected area categories, by jurisdiction ('000 hectares)

	IUCN protected area category										
	Ia	Ib	II	III	IV	V	VI[a]	Forest in IUCN categories I–IV	Forest in IUCN categories I–VI	Total native forest	% of forest in IUCN categories I–VI
ACT	–	28	84	–	–	–	–	112	112	123	91
NSW	672	1,636	2,184	–	16	7	215	4,506	4,730	26,208	18
NT	13	–	3,477	1	–	148	896	3,492	4,536	30,927	15
Qld	36	–	4,114	45	9	–	657	4,204	4,861	52,582	9
SA	1,194	1,306	340	111	103	41	1,059	3,054	4,155	8,855	47
Tas.	14	–	604	12	23	46	292	653	991	3,116	32
Vic.	387	781	2,187	49	30	30	66	3,434	3,531	7,838	45
WA	1,913	–	1,636	–	1	2	46	3,550	3,598	17,664	20
Total	4,229	3,752	14,626	218	182	274	3,232	23,005	26,514	147,311	18
IUCN areas as % of total forest	3	3	10	0.1	0.1	0.2	2	16	18		

a Multiple-use public forest could be classified under IUCN category VI; however, the Collaborative Australian Protected Areas Database, which provides estimates of forest areas in IUCN categories, does not do so if the multiple-use public forest is not principally managed for the conservation of biodiversity (see Dudley and Phillips 2006). Areas of forest in IUCN categories were calculated using the Collaborative Protected Area Database for IUCN data, except for Tasmania and Victoria, where state-supplied data were used for Table 13. This leads to slight differences in totals between Table 13 and Table 14.

Note: Totals may not tally due to rounding.

Sources: Collaborative Australian Protected Areas Database, Forestry Tasmania, Department of Sustainability and Environment (Vic.)

Table 14: Area of forest in each IUCN protected area category, by forest type ('000 hectares)

	IUCN protected area category									
Forest type	IA	IB	II	III	IV	V	VI[a]	Total protected	Total forest by type	% protected of type total
Acacia	67	4	388	9	13	2	26	510	10,364	5
Callitris	41	5	76	1	–	2	92	216	2,596	8
Casuarina	51	644	153	2	4	4	17	874	2,229	39
Eucalypt	3,751	2,526	11,601	190	284	235	2,672	21,261	116,413	79
Eucalypt low closed	–	–	11	1	–	–	–	12	44	27
Eucalypt low open	9	3	194	2	–	1	67	276	2,647	10
Eucalypt low woodland	334	7	1,309	7	3	7	91	1,758	13,416	13
Eucalypt mallee open	51	5	29	22	–	30	–	137	376	36
Eucalypt mallee woodland	1,634	1,003	849	66	105	8	1,014	4,681	8,871	53
Eucalypt medium closed	7	6	47	1	–	6	10	77	254	30
Eucalypt medium open	618	855	3,430	39	15	102	827	5,887	28,135	21
Eucalypt medium woodland	1,021	261	4,778	45	103	57	498	6,762	56,169	12
Eucalypt tall closed	1	–	18	–	–	–	1	21	123	17
Eucalypt tall open	75	383	879	6	49	20	140	1,552	5,881	26
Eucalypt tall woodland	1	3	57	1	9	4	24	98	497	20
Mangrove	30	1	102	7	–	8	23	172	936	18
Melaleuca	10	5	764	8	2	3	39	832	7,555	11
Rainforest	24	167	1,197	5	68	28	312	1,802	3,277	55
Other	202	99	593	1	1	–	58	956	3,942	24
Total	4,179	3,451	14,875	223	372	282	3,239	26,621	147,397	18

a Multiple-use public forest could be classified under IUCN category VI; however, the Collaborative Australian Protected Areas Database, which provides estimates of forest areas in IUCN categories, does not generally do so if the multiple-use public forest is not principally managed for conservation of biodiversity (see Dudley and Phillips 2006). Totals may not tally due to rounding. See also note under Table 13.

Sources: DEWHA Collaborative Australian Protected Areas Database for IUCN data, NFI for forest areas

Table 15: Area of forest on Australia's Register of the National Estate, by forest type (hectares)

	Historical	Indigenous	Natural	All values
Acacia	604	33,678	374,206	388,038
Callitris	99	101,467	99,655	175,734
Casuarina	318	17,566	835,887	849,536
Eucalypt	479,525	1,198,553	15,847,056	16,754,997
Eucalypt low closed	29	1,251	21,156	21,188
Eucalypt low open	1,543	61,811	282,483	337,426
Eucalypt low woodland	135,959	56,084	1,764,369	1,815,064
Eucalypt mallee open	69	1,046	56,689	57,666
Eucalypt mallee woodland	4,488	16,087	3,018,609	3,033,618
Eucalypt medium closed	64	1,164	52,077	52,585
Eucalypt medium open	205,513	389,349	4,259,079	4,542,238
Eucalypt medium woodland	49,103	657,568	5,242,951	5,724,927
Eucalypt tall closed	46	54	18,137	18,260
Eucalypt tall open	81,912	13,687	1,027,756	1,047,972
Eucalypt tall woodland	799	452	103,750	104,053
Hardwood plantation	1,225	155	7,542	8,906
Mangrove	199	7,551	339,793	352,613
Melaleuca	2,890	141,955	1,127,234	1,158,016
Other	492	34,607	816,584	828,924
Rainforest	1,062	38,321	1,811,317	1,824,064
Softwood plantation	811	66	9,481	10,956
Unknown plantation	2	–	313	313
Subtotal of forest areas	*487,227*	*1,573,919*	*21,269,068*	*22,352,097*
Non-forest or no data	*375,157*	*1,024,598*	*42,756,017*	*43,774,541*
Total[a]	862,384	2,598,517	64,025,085	66,126,638

a Areas registered as natural, historical and Indigenous overlap in some areas (e.g. Indigenous sites may be recorded in a national park that is also listed for its natural values). Therefore there is a difference between the total forest listed individually under each classification and the total forest listed under all values.

World Heritage

The World Heritage Convention 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 state and local laws still apply. However, as a signatory to the Convention, Australia has an obligation to identify, protect and conserve places on the list. Australia's 17 recognised World Heritage areas cover a total of 7.3 million hectares, of which about 4.6 million hectares is forested (Table 16, Figure 18). This is a small increase over the area reported in SOFR 2003, with a new listing for the sparsely forested areas in the Purnululu National Park in Western Australia. Other examples of forested World Heritage 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. A place may be included on both the Register of the National Estate and the World Heritage List, although the two use different criteria and therefore the boundaries of the two listings might not coincide.

Tropical rainforest, World Heritage Area, far north Queensland.

Figure 17: Area of forest listed on the Register of the National Estate

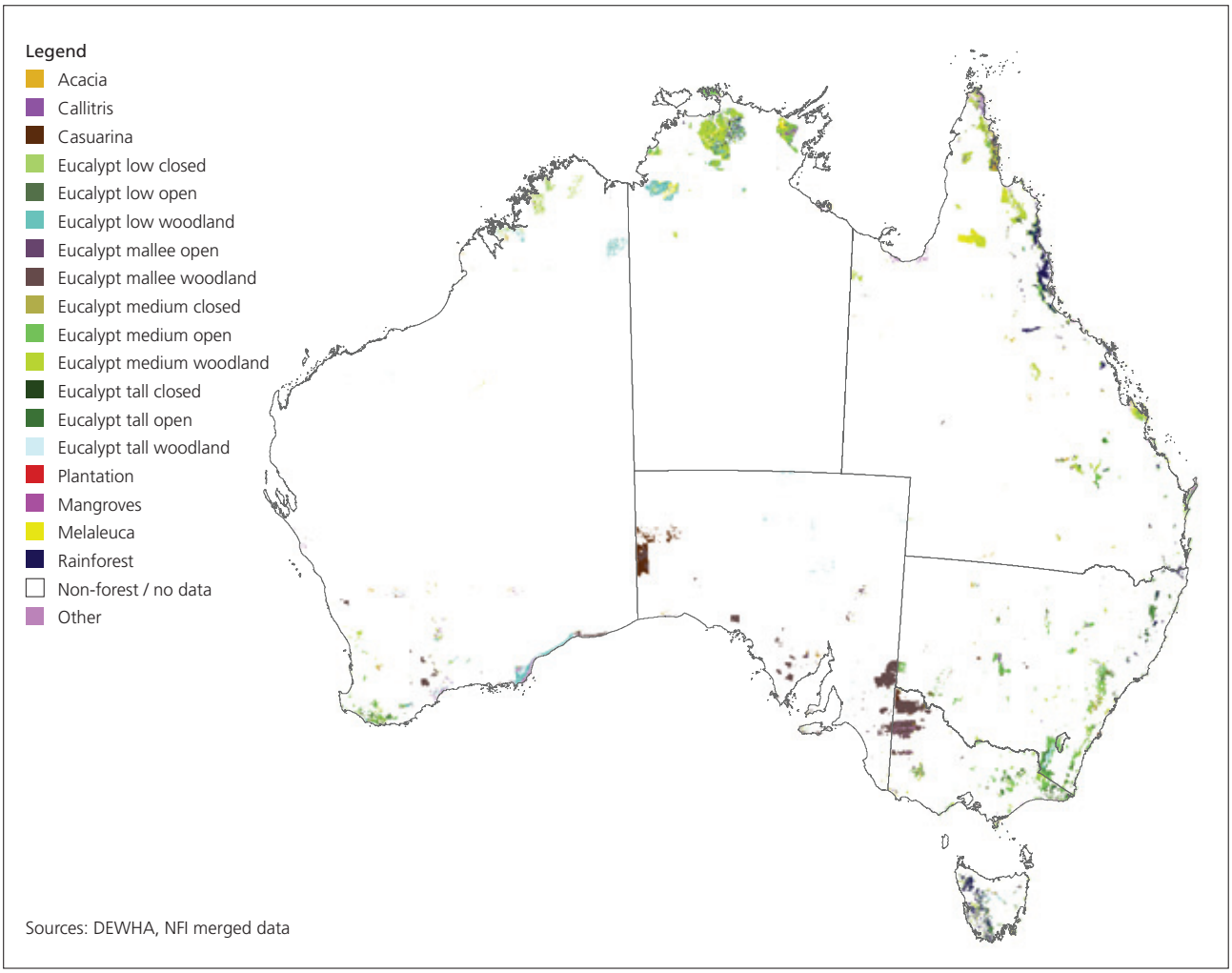
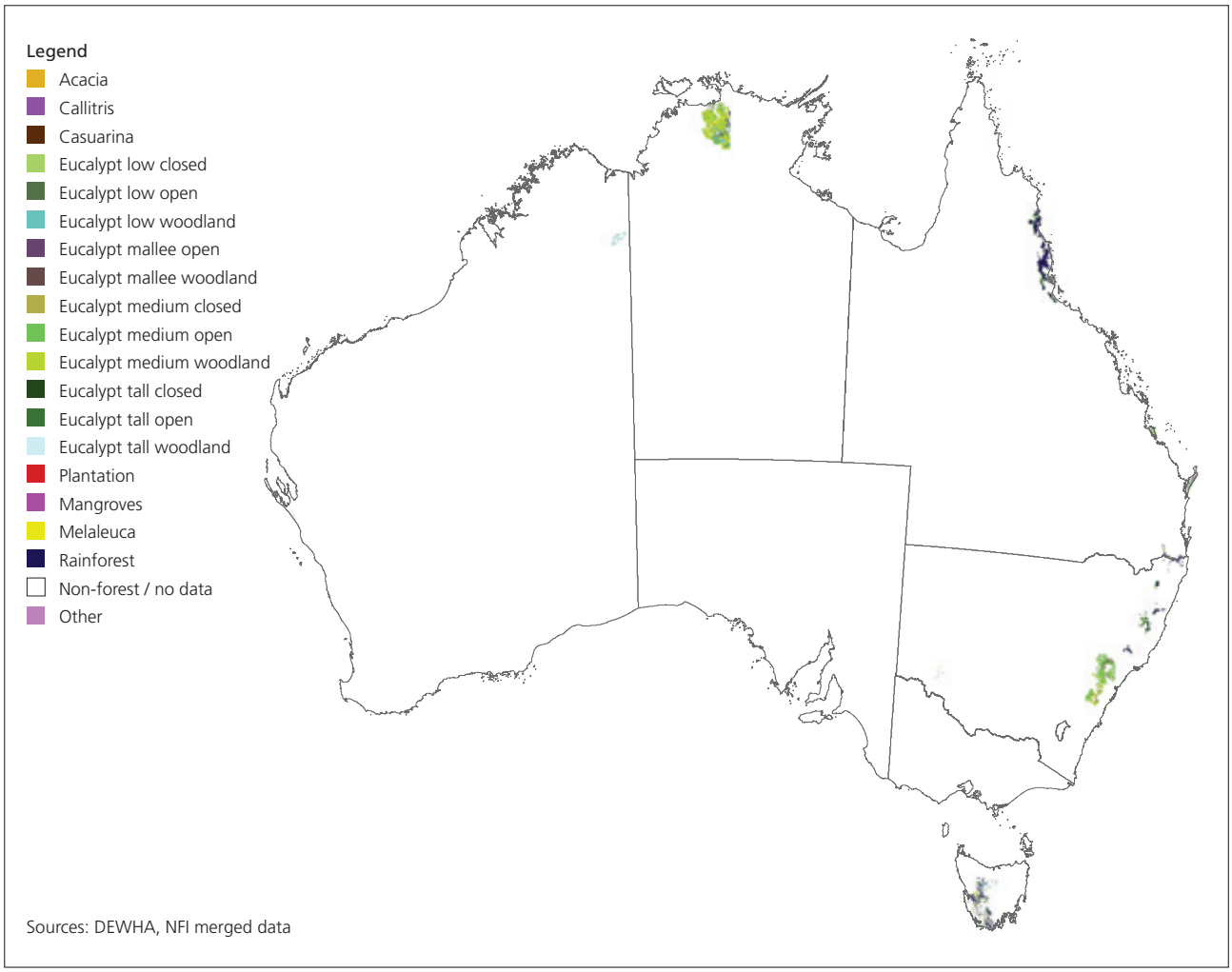


Table 16: Area of native forest in World Heritage areas ('000 hectares)

Forest type	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Australia
Acacia	–	–	–	11	–	2	–	–	13
Callitris	–	4	–	–	–	–	–	–	4
Casuarina	–	32	8	2	–	–	–	–	42
Eucalypt	–	1,003	1,433	396	–	278	–	59	3,170
Eucalypt low closed	–	–	1	–	–	–	–	–	1
Eucalypt low open	–	2	53	1	–	–	–	1	56
Eucalypt low woodland	–	–	137	1	–	34	–	58	230
Eucalypt mallee open	–	2	–	–	–	–	–	–	2
Eucalypt mallee woodland	–	7	–	–	–	–	–	–	7
Eucalypt medium closed	–	–	2	8	–	–	–	–	11
Eucalypt medium open	–	551	325	254	–	–	–	–	1,129
Eucalypt medium woodland	–	315	915	93	–	100	–	–	1,423
Eucalypt tall closed	–	–	–	–	–	–	–	–	–
Eucalypt tall open	–	126	–	40	–	114	–	–	279
Eucalypt tall woodland	–	1	–	–	–	31	–	–	32
Mangrove	–	–	11	52	–	–	–	1	64
Melaleuca	–	–	109	16	–	7	–	–	132
Rainforest	–	135	50	654	–	202	–	–	1,041
Other	–	68	–	64	–	–	–	8	140
Total	–	1,244	1,611	1,195	–	489	–	68	4,607

Figure 18: Forest areas with World Heritage status



References and further reading

ASEC (2006), Collaborative Australian Protected Area Database, Commonwealth of Australia (1992, 1997), Department of Natural Resources and Environment (Vic.) (2002), DEW (2007), Dudley and Phillips (2006), Government of Tasmania and Government of Australia (2007ab) (list at the back of the report).

Arve River, messmate (*Eucalyptus obliqua*) reserved forest, Tahune, Tasmania.

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, those areas exhibit relatively high levels of fragmentation.
- The cessation of broadscale clearing in much of Australia and increased protection of forests have been critical in reducing forest fragmentation in recent times.
- A review of fragmentation in two regions 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, or stable, particularly in regions where broadscale clearing has been limited.
- Where broadscale clearing is still occurring, the level of fragmentation is significant and may have increased between 1972 and 2002.

This indicator measures the level of fragmentation. It can be measured over a long time period (centuries) to take into account land clearing and land use change. It can also record and contrast change within forested areas in conservation reserves, multiple-use public forests and private forests in the shorter term (decades).

Fragmentation involving permanent clearing of land can cause a decline in habitat quality for many plant, mammal, reptile, bird and amphibian species found in Australian forests, although the impact varies considerably by species and community. An increase in forest fragmentation increases edge effects, reducing habitat quality for interior-adapted species and possibly improving it for edge and open-field species. When forests are divided into smaller patches, the capacity to provide habitat is reduced and the threat from non-native species, including weeds and predators, generally increases. Other ecosystem services may also be adversely affected.

Fragmentation caused by rock outcrops, lakes, streams, rivers and successional changes within forest boundaries or driven by climate change and fire has always been a feature of Australian forests. However, the main cause of forest fragmentation over the past 200 years has been land-use change, primarily for agriculture. 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. The cessation of broadscale clearing in much of southern Australia (Indicator 1.1a) and increased protection of forests (Indicator 1.1c) have been critical in reducing further forest fragmentation. An exception is occurring in the Northern Territory, where forest land is being cleared for new agricultural settlement (Case study 3). Clearing north–south in a linear fashion in the territory is resulting in reduced east–west connectivity between areas of formerly contiguous forest.

In some localities, native trees and shrubs have been planted in corridors to re-establish connectivity in landscapes (Case study 4).

Measuring fragmentation

The measurement of fragmentation involves analyses of the configuration, connectivity and composition of native forest patches, where configuration addresses patch size and shape, connectivity addresses the dispersion pattern of patches within the landscape, and composition addresses the variation of disturbance within patches.

Increasingly sophisticated software is available for analysing fragmentation using satellite imagery. Satellite-based remote sensing data obtained from the Australian Greenhouse Office and the FRAGSTATS computer program supported fragmentation analyses, by tenure, in a study area of two regions over a 31-year period (1972–2002). The study area comprised those parts of the landscape in which tenure did not change over the period. Seven parameters of fragmentation were examined for the entire study area (Table 17). The results of the analyses for Tasmania, where there has been little broadscale clearing in recent decades (Figure 19), and southeastern Queensland (Figure 20), where land clearing is known to have occurred in recent decades, demonstrate key changes in forest fragmentation (Appendix B). Analyses were conducted using subregions as categorised in the Interim Biogeographic Regionalisation of Australia (IBRA), which divides the Australian continent into 85 bioregions and 404 subregions.[10]

Tasmania

The representation of forest types in the fragmentation analyses varies by tenure (Table 18). Rainforests are prominent in nature conservation reserves, eucalypt tall open forests in multiple-use public forests and eucalypt medium woodlands in private forests.

Nature conservation reserves

In nature conservation reserves, fragmentation decreased in the period from 1972 to 1992 (i.e. the mean number of patches decreased, mean patch size increased, and distance

Figure 19: Sub-IBRA regions analysed for trends in forest fragmentation in Tasmania

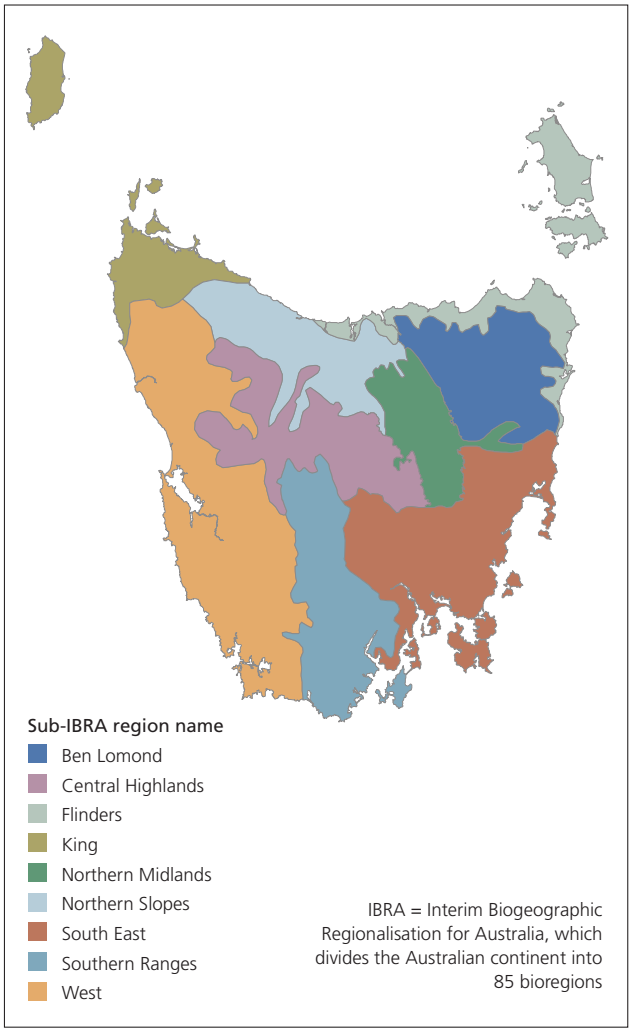


Table 17: Parameters of landscape fragmentation examined, SOFR 2008

Term	Definition and interpretive value
Forest type area	The area sum (hectares) of all patches in a forest type. A measure of the abundance of each forest type in the landscape.
Percent of landscape	The percentage of the landscape area composed of a particular forest type or class. A measure of landscape composition, as it quantifies 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 (hectares) 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, fine 'grain' is a mosaic of small patches.)
Mean nearest neighbour	The average distance, in metres, between nearest neighbouring patches based on patch edge-to-edge distance. A measure of isolation where 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 (metres per unit area). Measures landscape configuration.

10 www.environment.gov.au/parks/nrs/ibra/index.html, accessed February 2008

Figure 20: Sub-IBRA regions analysed for trends in forest fragmentation in Queensland

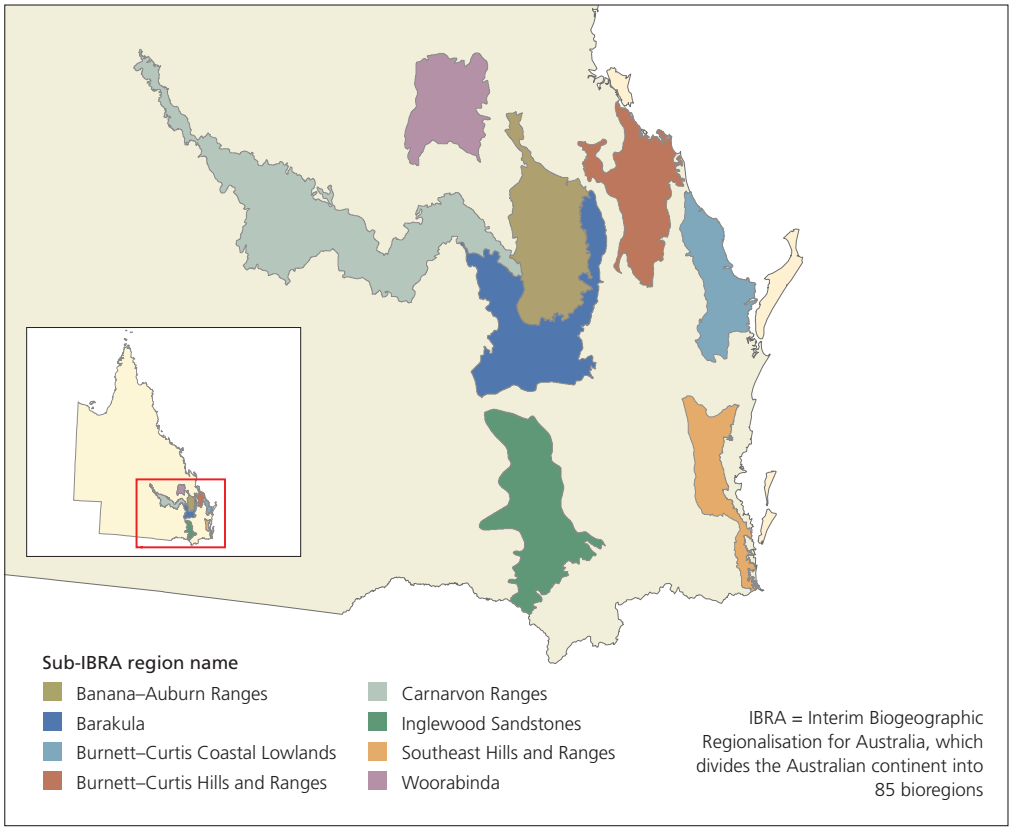


Table 18: Principal forest types examined in fragmentation analyses, Tasmania

	Forest type classes (% of all types)					
Tenure	Acacia	Eucalypt low woodlands	Eucalypt medium woodlands	Eucalypt tall open forests	Eucalypt tall woodlands	Rainforests
Nature conservation reserves	0.3	6.0	26.1	23.2	6.7	35.9
Multiple-use public forests	3.3	0.8	22.1	45.5	10.2	9.1
Private forests	2.1	0.7	60.9	12.4	10.6	2.2

Source: BRS

Table 19: Principal forest types examined in fragmentation analyses, Queensland

	Forest type classes (% of all types)				
Tenure	Acacia	Eucalypt medium open forests	Eucalypt medium woodlands	Callitris	Rainforests
Nature conservation reserves	3.9	11.4	63.4	1.2	4.2
Multiple-use public forests	1.8	9.6	71.7	7.4	2.5
Private forests	3.1	35.0	51.8	0.5	4.6

Source: BRS

to nearest neighbour decreased), then increased to 2002 in the Central Highlands, King and West regions. The early decrease was particularly large in King. Fragmentation decreased between 1972 and about 1998 and then increased to 2002 in the Northern Slopes, South East and Southern Ranges regions. The early decrease was particularly large in the last two regions. The reasons for the reversal 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 regions over the period from 1972 to 2002, most markedly in the South East region. Fragmentation increased in the Southern Ranges region to about the mid 1990s and then decreased. In the West region, fragmentation increased between 1972 and 1980 but decreased significantly thereafter. One region, Northern Midlands, experienced increasing fragmentation throughout the entire period.

Private forests

Fragmentation in private forests fluctuated within fairly narrow limits across all regions, with no apparent trend over the period from 1972 to 2002.

Southeast Queensland

For southeast Queensland, the representation of forest types in the fragmentation analyses varies among tenures (Table 19). Eucalypt medium woodlands are prominent in nature conservation reserves and multiple-use public forests. Eucalypt medium woodlands and eucalypt medium open forests are 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 regions; the number of patches decreased and patch size increased (but connectivity was lower). The Barakula and Southeast Hills and Ranges regions also showed decreased fragmentation, but the magnitude was smaller. Fragmentation fluctuated over the period from 1972 to 2002 in the Carnarvon Ranges region.

Multiple-use public forests

In multiple-use public forests, fragmentation decreased in the Baracula, Burnett–Curtis Coastal Lowlands and Burnett–Curtis Hills and Ranges regions, but usually also with lower connectivity. A particularly large decrease was observed in the Carnarvon Ranges region. Fragmentation fluctuated in the Banana–Auburn Ranges, Southeast Hills and Ranges and Woorabinda regions.

Private forests

Fragmentation in private forests decreased in the Burnett–Curtis Hills region, increased in Woorabinda and fluctuated in all other regions.

References and further reading

Governments of Tasmania and Australia (2007ab), NLWRA (2001), Rankmore and Price (2004), Thackway and Lesslie (2006) (list at the back of the report).

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

Case study 3: Land clearing in the Northern Territory

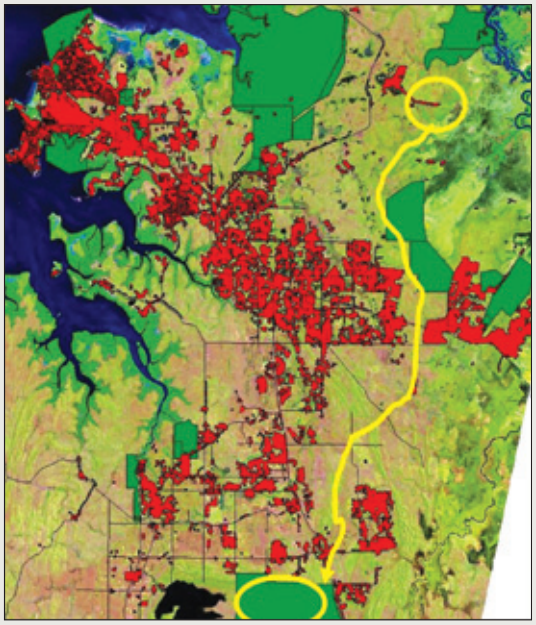
The extent of land clearing is generally lower in the Northern Territory than in southern parts of Australia: 35,000 hectares (6%) of the greater Darwin region; 202,000 hectares (10%) of the Daly Basin.

In both the greater Darwin region and the Daly Basin, clearing is concentrated in certain areas and is carried out in a linear fashion, north–south along the main drainage lines. The biggest problem is to ensure east–west connectivity through cleared areas between significant areas of contiguous forest (see Figures 21 and 22). Research in these regions has shown that biodiversity responds to the extent of clearing of forest habitat in the landscape, the size of patches retained and the degree of connectivity among patches. Of 75 bird, mammal, frog or reptile species, only a small proportion (25%) used modified land, but most (69%) were recorded in corridors. No species could confidently be classified as an edge specialist (i.e. preferring the interface between woodland and modified land).

Three variables were found to have a strong positive influence on animals occurring in a fragment: the size of the fragment; the total amount of woodland within a 4-kilometre radius of the fragment; and connectivity, or the extent of corridors linking the fragment to other large woodland tracts. The fire regime and the density of trees were identified as having important effects in determining the animals present in fragments.

Source: Rankmore and Price (2004)

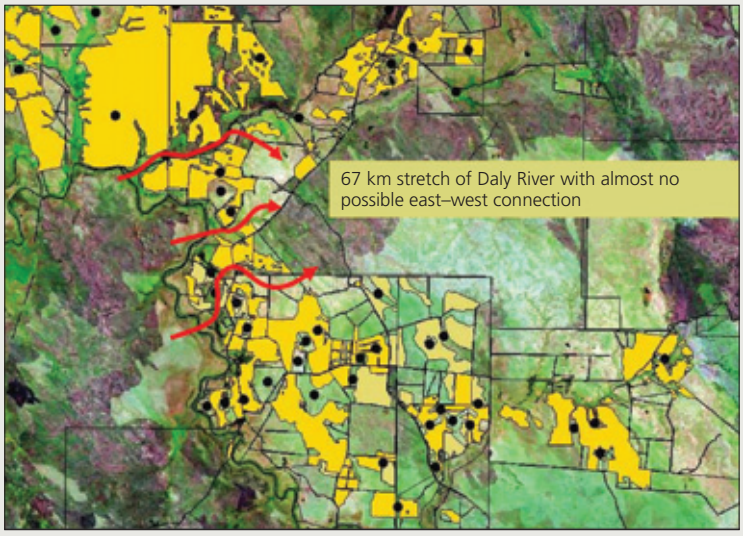
Figure 21: Land clearing and remaining connectivity options in the greater Darwin region



Red = land clearing; yellow = remaining connectivity options

Note: Solid green areas are nature conservation reserves.

Figure 22: Land clearing and remaining connectivity options in the Daly Basin



Yellow = land clearing; red = remaining connectivity options

Case study 4: Biodiversity corridors in the Green Triangle

ForestrySA manages a total of 13,500 hectares of native vegetation in the Green Triangle in the state's southeast, as well as significant areas of forest plantations, particularly radiata pine (*Pinus radiata*). It has set aside more than 70 hectares of productive plantation land for the development of biodiversity corridors that link native vegetation remnants. Some native species are able to move from one remnant to another through plantations and grazing land, but many others cannot. The fragmentation of native vegetation is considered a key threat to such species.

ForestrySA and the Department of Primary Industries and Resources South Australia (PIRSA) Forestry have undertaken modelling to determine priority locations for corridors. As ForestrySA radiata pine plantations are harvested, strategic strips of land are being direct-seeded with local understorey species and a canopy is established by the hand-planting of native tree species.

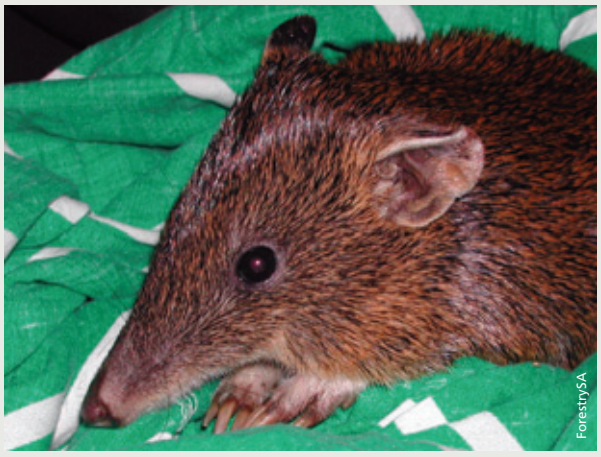
Each corridor is designed to create specific resources for target species. Elements such as a diverse and thick understorey for predator protection, a linked tree canopy, hollows and nesting boxes, logs, rocks and leaf litter are all incorporated in corridors to cater for species such as the southern brown bandicoot, sugar gliders, crested shrike tits, painted button quails and splendid ochre butterflies.

Seed collection, hand-planting and ongoing monitoring of flora and fauna provide opportunities for community involvement by individuals and groups such as schools, environmental interest groups and ForestrySA's Friends of the Forests volunteers.

Other owners of land identified in the project's modelling are being approached to set aside land, to undertake fauna surveys, and to prepare sites and select species for revegetating their own biodiversity corridors. PIRSA Forestry, South Australia's Department of Environment and Heritage and ForestrySA have also begun a program of bird monitoring to look at changes in diversity in corridors compared to adjacent land.

Source: ForestrySA

Planting in a biodiversity corridor after harvest of a pine plantation.



Southern brown bandicoot (*Isoodon obesulus*).

Indicator 1.2a

Forest dwelling species for which ecological information is available

Rationale

This indicator examines 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 the Northern Territory have developed lists of forest-dwelling vertebrates and vascular plant species. The lists show that the number of forest-dwelling species generally increased over the period from 1998 to 2006, reflecting improved information.
- Partial ecological information is available on around 60% of forest-dwelling vertebrate and vascular plant species, and comprehensive ecological information is available on at least 10% of mammal, bird and amphibian species.
- Significantly better information is available for species in regions subject to formal assessment processes, such as comprehensive regional assessments.
- Information is very limited on forest-dwelling invertebrates, fungi, algae and lichens.

Echidna (*Tachyglossus aculeatus*).

Knowledge of the species present in a forest, and increases or decreases in their number, 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 remains a precondition for the effective management of forest ecosystems. Nevertheless, the changes in numbers reported in this indicator reflect improvements in the data on which the lists are based and not actual changes in forest ecosystem diversity.

Australia is home to between 600,000 and 700,000 species, many of which are found nowhere else in the world. About 84% of plants, 83% of mammals and 45% of birds are endemic – that is, they are found only in Australia.[11] An important indicator of forest ecosystem diversity is the number of forest-dwelling species, which are species that use forest habitat for all or part of their lifecycles. This is a broader set of species than forest-dependent species, which are those species that are dependent on forest habitat for all or part of their lifecycles.

All states and territories except the Australian Capital Territory have developed lists of forest-dwelling plant and animal species (Table 20). In New South Wales, the Northern Territory, South Australia, Tasmania and Victoria the number of species reported increased from those in SOFR 2003 because of improved information. However, Western Australia reported a significant decrease in forest-dwelling species in its southwest forest region. The decrease reflects a change in the methodology for identifying forest-dwelling species in Western Australia; the methodology now includes a more focused subset of data, derived in part from a new forest monitoring process called ForestCheck (Indicator 1.2c).

11 Chapman (2006).

Table 20: Number of forest-dwelling vertebrate species, by taxon and jurisdiction

	NSW	NT	SA	Tas.	Vic.	WA[a]
Fish	75	–	–	11	–	10
Amphibians	74	38	22	9	37	20
Reptiles	191	232	182	15	117	53
Birds	317	87	311	69	272	112
Mammals	103	83	59	33	87	31
Total	760	440	574	137	513	226

a Southwest Western Australia only.

Note: No data available for the Australian Capital Territory or Queensland.

Source: State and territory agencies

Grey-headed flying foxes (*Pteropus poliocephalus*).

Table 21 shows the number of known forest-dwelling vascular plant species, by jurisdiction. Compared to SOFR 2003, the number of species reported increased by 109 (about 10%) in Tasmania, increased marginally in New South Wales, and decreased slightly in South Australia. In the Northern Territory, the number reported decreased by 72 (about 2%). All changes reflect improved information, rather than real changes in forest composition.

Table 21: Number of forest-dwelling vascular plant species, by jurisdiction

	NSW	NT	SA	Tas.	Vic.	WA[a]
Species	7,461	3,970	2,306	1,017	2,853	3,000

a Southwest Western Australia only.

Note: No data available for the Australian Capital Territory or Queensland.

Sources: SOFR 2003, state and territory agencies

The comprehensive regional assessments carried out as part of the regional forest agreement process (Indicator 7.1a) and specific species surveys of rare, threatened or endangered species have been important in increasing knowledge of forest-dwelling species. The number of species considered to be adequately known is also increasing as a result of scientific studies and regional planning exercises, especially for species that are considered under threat (Case study 5). As more surveys are undertaken, it is likely that species will be found in areas where they were previously unknown and, in rare cases, species previously unknown to science might be discovered.

There are no comprehensive lists of the invertebrate fauna, fungi, lichens and algae that occur in forests, and the overall level of knowledge about them is low. There are probably well over 100,000 terrestrial invertebrate species, of which only a small fraction has been described. Non-vascular plants

Table 22: Assessed level of ecological knowledge on forest-dwelling species, by taxonomic group

	Assessed knowledge level[a] (% of species)		
Taxonomic group	Minimal or inadequate information is available to inform management decisions	Partial information is available but some crucial information may be absent or limited	Information is comprehensive or adequate to inform management decisions
Arthropods: insects[b]	85.0	11.0	4.0
Arthropods: other[b]	90.0	7.5	2.5
Non-arthropods[b]	89.5	8.0	2.5
Fish[b]	0.0	32	68.0
Amphibians	34.0	51.2	14.8
Reptiles	39.5	50.5	10.0
Birds	35.0	39.2	25.8
Mammals	30.3	55.7	14.0
Vascular plants	37.3	52.2	10.5
Non-vascular plants[b]	85.0	15.0	0.0

a Comprehensive/adequate = knowledge of life history parameters, habitat requirements and distribution and population status and trends; Partial = knowledge of at least broad habitat requirements and population trends; Minimal/inadequate = information limited to species taxonomic identification, with no or very limited knowledge of past and present distribution and population trends. Each jurisdiction was asked to assess the level of knowledge available for species by taxonomic group according to these descriptions. A score of 100 would mean that the knowledge level applies to 100% of species in that taxonomic group. The figures presented in the table are the mean of all responses received and are indicative only.

b Information based on only two or three jurisdictions. Non-arthropods are invertebrates without jointed limbs, segmented body and exoskeleton. Non-vascular plants are plants without tissues that transport sugars, water and salts: algae, lichens, fungi and mosses.

Note: No data available for the Australian Capital Territory and Queensland.

Sources: State and territory forest agencies, analysis by BRS

are also poorly known; for example, only 5,000 of an estimated 250,000 species of fungi have been formally described. Western Australia is collecting comprehensive information on lesser studied fauna and flora groups through ForestCheck; over time, this should result in the development of a more comprehensive list of forest-dwelling invertebrates and non-vascular plants in the southwest of the state.

Table 22 illustrates the level of ecological knowledge about forest-dwelling animal and plant species. Such knowledge varies markedly across taxa. At least partial (limited to adequate) information is available for the majority of vertebrate and vascular plant species; confidence in the level of information was greatest for species occurring in areas where comprehensive regional assessments have been undertaken. All jurisdictions reported that their confidence in the level of knowledge for invertebrates and non-vascular plants was low. In contrast, the level of knowledge on amphibians increased as a result of heightened concerns about declines in the populations of several frog species.

For all taxa for which ecological information is inadequate, risk assessments are necessarily based on information about better studied, closely related taxa in similar ecological niches. Management strategies are reliant on general conservation measures, such as additions to the reserve system, additional environmental protection measures and the maintenance of ecosystem processes.

Reference

Chapman (2006) (list at the back of the report).

Brush-tailed rock wallaby (*Petrogale penicillata*). The species is vulnerable at the national level and critically endangered in Victoria.

Case study 5: Changes to the list of forest species in Tasmania

In Tasmania, improved information has brought about significant changes in the list of threatened forest-dwelling vascular plant species. For example, between 2002 and 2006 the number of new listings increased by 10, with 42 species added and 32 removed. These changes were based on new information gathered largely during the preparation of *Threatened Flora of Tasmania*, a database on threatened flora listed on the schedules of the Tasmanian *Threatened Species Protection Act 1995* and the national *Environment Protection and Biodiversity Conservation Act 1999*.

In 2004, a forest-dwelling fauna species, the Miena jewel beetle (*Castiarina insculpta*), was rediscovered in Tasmania. The beetle was previously known only from two specimens, one collected in 1934 and the other in 1965; both were collected in the Great Lake district of the state's Central Plateau.

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

- In total, 1,287 forest-dwelling species are listed as vulnerable, endangered or critically endangered under the national *Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act).
- Thirty-nine species or subspecies were removed from the national list of threatened species during the reporting period, and 71 were added.
- Most additions of forest-dwelling species to the national list were made based on inherently small population sizes and ongoing impacts on habitat extent and quality, including the impacts of introduced species and unsuitable fire regimes.
- Most removals of forest-dwelling species from the national list were made as a result of improved information.

The EPBC Act, with subsequent amendments, is the Australian Government's principal piece of environment legislation. It is designed to protect Australia's native species and ecological communities by providing for:

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

The Act requires the establishment of a national list of threatened species. As of December 2006, 1,287 extant forest-dwelling species were listed under the Act as critically endangered, endangered or vulnerable, and 50 species (including subspecies) were listed as having become extinct (Table 23).

Table 23: Number of forest-dwelling species listed as extinct, critically endangered, endangered or vulnerable under the EPBC Act, by taxon

	Extinct	Critically endangered	Endangered	Vulnerable	Total
Mammals	8	1	16	18	43
Birds	4	3	18	13	38
Reptiles			6	14	20
Amphibians	4	1	10	9	24
Fish		1	5	9	15
Invertebrates		3	2	5	10
Flora (higher plants)	34	49	474	630	1,187
Total	50	58	531	698	1,337

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

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

Changes in conservation status

An addition to the 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 the protection of additional habitat. However, because many listings (or non-listings) reflect information deficiencies, changes in this indicator need to be assessed with caution.

Since SOFR 2003, a number of changes in the national listing of threatened forest-dwelling species has occurred, including both additions (Table 24, Case study 6) and removals (Table 25, Case study 7). Fewer species were removed from the list (Table 26) than were added (Table 27), reflecting better information on the conservation status of many species as well as taxonomic revisions. Most newly listed species were added because of their small population size and/or restricted range and because of threats caused by land clearing, habitat degradation and unsuitable fire regimes (Case study 6). Overgrazing (for plants) and predation by introduced species (for animals) were often factors. A total of 16 forest-dwelling fauna species and 34 vascular plant species are known to have become extinct since European settlement, but none are known to have become extinct during the reporting period.

Bird-eating spider (*Selenocosmia* sp.) found in rainforest, Kimberley, Western Australia.

Table 24: Forest-dwelling species added to the national list of threatened species during the reporting period

	Extinct	Critically endangered	Endangered	Vulnerable	Total
Vertebrate fauna	–	5	6	6	17
Invertebrate fauna	–	3	1	–	4
Vascular plants	–	19	17	14	50

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

Source: www.environment.gov.au/biodiversity/threatened/index.html

Table 25: Forest-dwelling species removed from the national list of threatened species during the reporting period

	Extinct	Critically endangered	Endangered	Vulnerable	Total
Vertebrate fauna	1	–	–	3	4
Vascular plants	2	–	10	23	35

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

Source: www.environment.gov.au/biodiversity/threatened/index.html

Table 26: Reasons for the removal of forest-dwelling species from the national list of threatened species during the reporting period

Reason	Number	%
Revised taxonomy/no longer considered valid species	12	31
Lack of data to justify original listing	8	20
No longer considered to be in decline	9	23
No identified threat	10	26
Total	39	100

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

Source: www.environment.gov.au/biodiversity/threatened/index.html

Table 27: Reasons for the addition of species to the national list of threatened species during the reporting period

Reason	Extinct	Critically endangered	Endangered	Vulnerable	Total
Fauna					
Very small population	–	8	6	–	14
Competition from introduced fauna	–	3	2	3	8
Disease/pathogens	–	3	2	1	6
Land-use change/habitat loss	–	7	7	4	18
Predation by introduced fauna	–	4	1	2	7
Unsuitable fire regime	–	5	5	–	10
Overexploitation/mortality agents	–	1	1	3	5
Flora					
Very small population	–	4	4	4	12
Weeds	–	–	1	1	2
Pathogens	–	1	–	–	1
Land-use change/mechanical disturbance	–	1	4	1	6
Overgrazing/overbrowsing	–	1	2	1	4
Unsuitable fire regime	–	1	1	2	4
Over-harvest	–	–	1	–	1
Moved from higher threat category – better data	–	–	–	1	1

Note: Multiple reasons may be given for individual species. Assessment of flora based on a random sample of five species in each threat category (excluding 'extinct', which had no occurrences).

Source: www.environment.gov.au/biodiversity/threatened/index.html

Protecting listed threatened species

Once a species is listed under the EPBC Act, its recovery is promoted using conservation advice, recovery plans, and the Act's assessment and approval provisions. Recovery plans set out the research and management actions necessary to stop the decline and support the recovery of listed threatened species or threatened ecological communities. The aim of a recovery plan is to maximise the long-term survival in the wild of the species or ecological community. The regional forest agreement process has also provided specific protections in relation to forest-dwelling species.

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

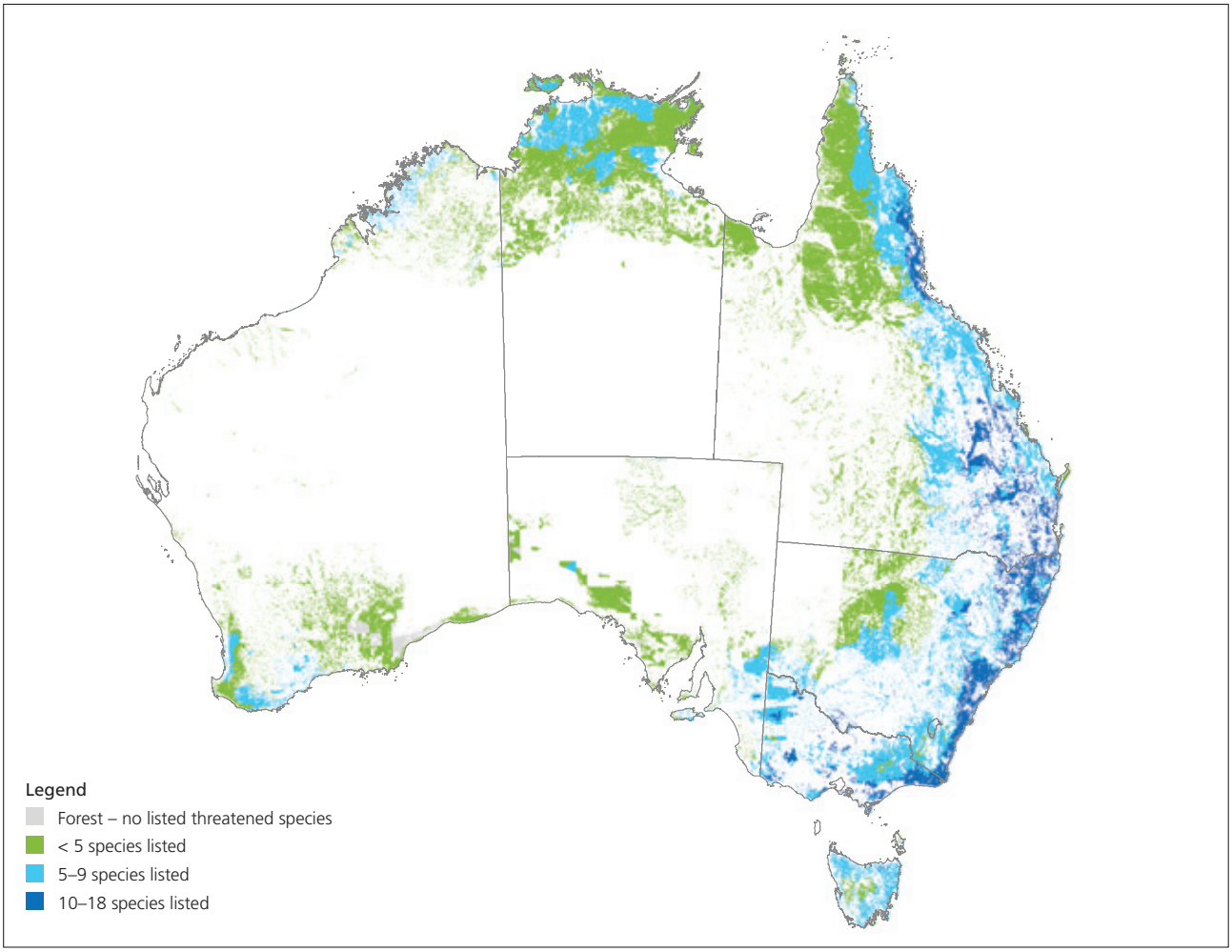
The central north burrowing crayfish. General body length is usually under 10 cm. It is believed to eat rotting wood, detritis, root material and occasionally animal matter.

Case study 6: The central north burrowing crayfish

The central north burrowing crayfish (*Engaeus granulatus*), a small crustacean, is listed as endangered under the Tasmanian *Threatened Species Protection Act 1995*. It occurs in a triangular area in central north Tasmania (southwest from Port Sorell to the Railton area and north to Quoiba, near Devonport) and inhabits seeps, wetlands and stream banks. The species is confined to seven geographically isolated areas, with a minimum of 5 kilometres separating each area. Precise population figures for an invertebrate species such as this are difficult to determine, and estimates vary considerably.

To date, the crayfish has not been recorded in any secure nature conservation reserve, and it may be subject to a number of ongoing threats, including activities that alter water quality or quantity, such as clearing of riparian and seepage-way vegetation, ploughing, dam construction, unrestricted stock grazing, and competition from an introduced species. No specific assessments have been conducted of potential threats, and it is difficult to determine the extent to which such threats are jeopardising the species' survival in the wild. Nevertheless, its geographical distribution is so restricted as to make its survival precarious. For this and other reasons, the species was considered to be eligible for listing as endangered under the EPBC Act, and it was added to the list in November 2005.

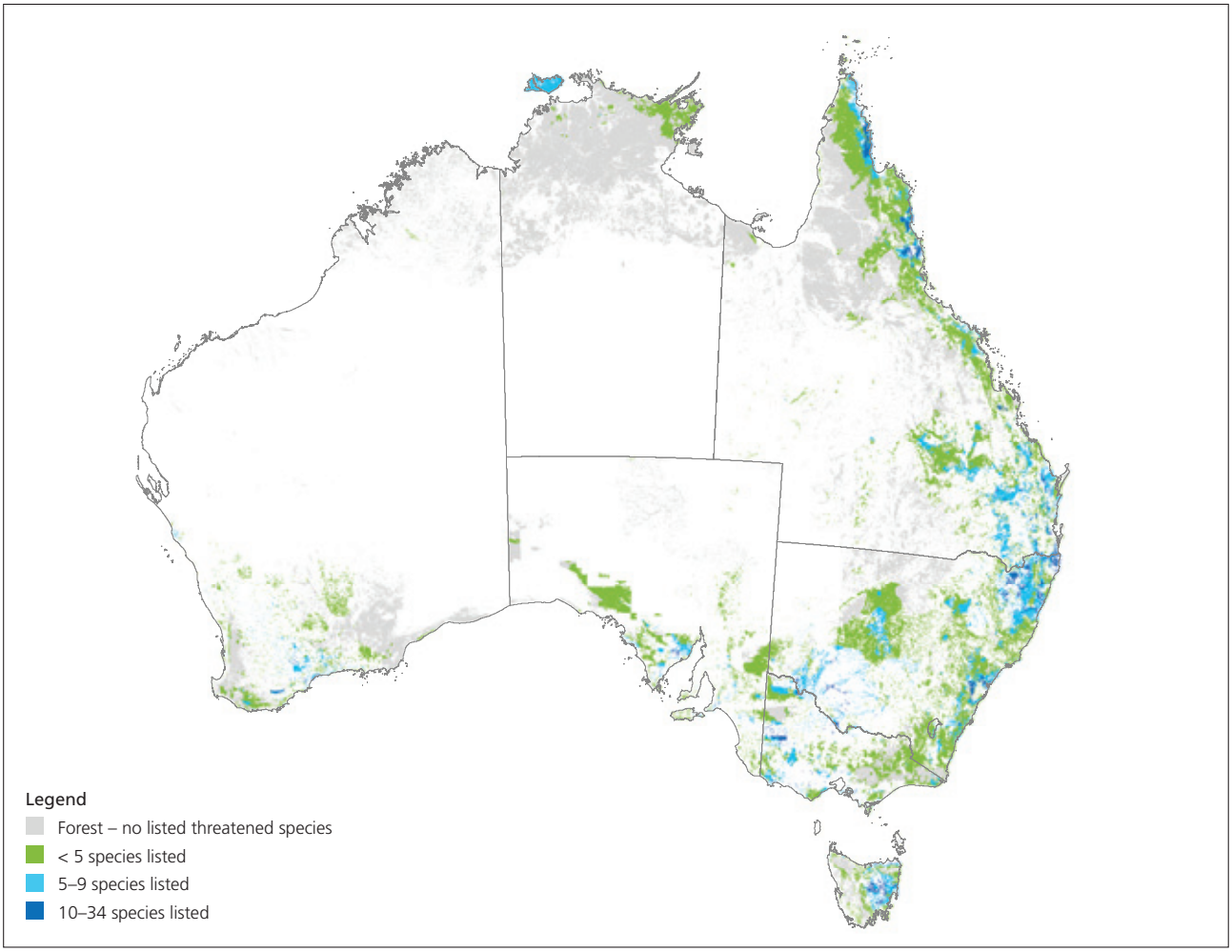
Figure 23: Distribution of rare and threatened forest-dwelling fauna species



Distribution of threatened forest-dwelling species

Figures 23 and 24 show the distribution of threatened forest-dwelling fauna and flora species. The number of listed species per forest area is highest in the wet coastal areas, where species diversity is also high. The mallee and Grampian regions in Victoria are also 'biodiversity hotspots'.

Figure 24: Distribution of rare and threatened forest-dwelling flora species



Case study 7: The Eprapah wattle

The Eprapah wattle was previously considered to be a species (*Acacia perangusta*) in its own right but is now considered to be an extreme form of the Brisbane golden wattle (*A. fimbriata*). The Brisbane golden wattle is a small tree or rounded shrub that grows up to 7 metres high and 6 metres across. It has profuse yellow, ball-shaped flowers in spring.

In 1980, *A. perangusta* was recognised as a separate species that was restricted to the banks of small streams in an area south and southeast of Brisbane and on the Burrum River north of Maryborough; it was listed as vulnerable under the EPBC Act. However, collections of plants since then have indicated that *A. perangusta* represents natural variation within *A. fimbriata* and is therefore part of that species. *A. fimbriata* is a widespread plant in eastern Australia, occurring between Rockhampton in Queensland and Nowra in New South Wales, and is not listed as threatened under Australian legislation. *A. perangusta* was removed from the list of threatened species under the EPBC Act in November 2005.

The Eprapah wattle.

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 the maintenance of forest biodiversity.

Key points

- Efforts to monitor forest-dwelling species vary across jurisdictions.
- Birds are the taxonomic group with the largest number of programs in place to track population trends. State and territory agency efforts are supplemented by a large-scale investment by non-government groups.
- 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 the 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. Such 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. Individual jurisdictions monitor forest-dwelling species to meet requirements specified by legislation; therefore, priorities at the state and territory level may differ from those set at the national level.

Table 28 indicates the extent to which monitoring programs are in place for representative species in various taxonomic groups, by state and territory. The table is based on reporting by individual state agencies and therefore might not include all existing programs.

At the national level, the most comprehensive monitoring is in place for bird fauna, driven by a national volunteer program coordinated by Birds Australia and supplemented by agency-specific programs. While birds are usually reasonably visible and hence amenable to direct monitoring, that is not the case for all species, so innovative monitoring approaches are also needed (for example, Case study 11). A similar community-partnership program has been developed for amphibians through FrogWatch, which is now active in most states and territories. In both the bird and frog-monitoring approaches, a non-government organisation is working in collaboration with government agencies to develop comprehensive monitoring programs using public participation.

Frogs are often considered good environmental indicators because they use both land and water and because their permeable skin makes them more susceptible to changes in the environment. Monitoring frog populations, therefore, offers an opportunity to test the impacts of habitat change using an organism that should be quite sensitive to such change. Long-term trends are essential to understanding population processes and threats. For example, in New South Wales, frog populations have been monitored at the Watagan Mountains and around Dorrigo over the past 5–10 years to determine whether populations of pond frogs are stable within a general forestry environment (including roading, logging and fire). The data show no change in populations overall and no obvious signs that any activities in these areas have affected the frogs significantly. Importantly, a few species appear to be increasing in numbers again, possibly recovering from outbreaks of the chytrid fungus in the 1980s.

Recognising the value of a structured, broad-based monitoring program in assisting long-term management, Western Australia recently established ForestCheck, a comprehensive approach to the monitoring of species in the

state's southwestern forests. ForestCheck is one of only a few programs in the world collecting regional-scale information on mosses, lichens, fungi and invertebrates as well as the more well-known components of forest biodiversity (vertebrates and vascular plants). Sustainable forest management requires an understanding of ecological trends over long timescales; long-term monitoring programs such as ForestCheck will deliver some of that information and thereby contribute to the continuous improvement of the forest management regime. Other such programs include projects to monitor fire in Eden, New South Wales (Case study 8), the swift parrot in Tasmania (Case study 9), barking owls in New South Wales (Case study 10), Tasmanian devils (Case study 11), and wildlife in mountain ash forest in Victoria (Case study 12).

Table 28: Taxonomic groups for which representative species are being monitored, by jurisdiction

	Mammals	Birds	Reptiles	Amphibians	Invertebrates	Vascular plants	Non-vascular plants
NSW	✓	✓		✓		✓	
NT	✓	✓				✓	
SA	✓	✓					
Tas.[a]	✓	✓			✓	✓	
Vic.	✓	✓		✓		✓	
WA[b]	✓	✓	✓	✓	✓	✓	✓
National[c]		✓		✓			

a Government of Tasmania and Government of Australia (2007a), www.warra.com/warra

b www.naturebase.net/content/view/2388/482

c www.birdata.com.au; frogs.org.au/frogwatch

Note: No data are available for the Australian Capital Territory and Queensland. A tick indicates that at least one species of the taxonomic group is being monitored to detect changes in population size at a scale relevant to forest management.

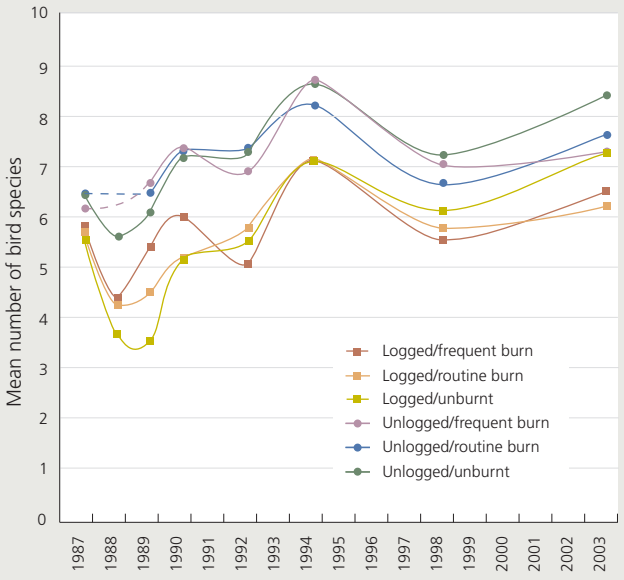
Sources: As noted, and state and territory agencies

Case study 8: Eden, NSW, burning study

Biological data have been collected in the Eden Burning Study Area in southeastern New South Wales over two decades. In one study, bird populations in six logging and prescribed burning treatments (three replicates of six treatments = 18 coupes) have been surveyed using the same sampling methods for the past 20 years. In 1987, all sites were unlogged and not recently burned. Logging occurred in 1988 within coupes scheduled for that treatment. Prescribed burning (depending on treatment) occurred in 1988, 1990, 1992, 1996, 2001 and 2003. Figure 25 shows that the number of bird species fluctuated in treated and untreated coupes over time but was generally lowest at sites that were logged and burned frequently and higher in unlogged sites.

The study also collected data on the effects of fire and logging on understorey and overstorey vegetation. The prescribed burns were found to be extremely patchy, and are likely to have significantly lower ecological impacts than homogeneous burns because refuges are provided for fire-sensitive species and newly burned areas for colonising species. Logging (but not fire) was associated with higher species richness in the shrub understorey. In contrast, fire (but not logging) had a significant impact on ground vegetation diversity and richness. The results of this study will allow the identification of species or groups of species that are more susceptible to logging and fire disturbances.

Figure 25: Bird species observed in surveys in the Eden Burning Study Area under various treatments, 1986 to 2003



Source: Forests NSW

Case study 9: Swift parrot

The swift parrot (*Lathamus discolor*) breeds only in Tasmania and 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. In Tasmania, the bird's breeding range is mostly restricted to the east coast within the range of the Tasmanian blue gum (*Eucalyptus globulus*). The breeding season coincides with the blue gum's flowering, when the tree's nectar provides the parrot with its main food source.

Populations of the swift parrot were monitored annually in Tasmania from 1999 to 2005 during the bird's breeding season. Results were strongly affected by the blue-gum flowering event. In years of poor flowering (2000 and 2002), both the number of swift parrots observed and the number of sites at which they were observed were very low. In years of moderate-to-heavy flowering (1999, 2001, 2003, 2004 and 2005), swift parrots were recorded at 25–30% of sites. Excluding the poor flowering years of 2000 and 2002, the swift parrot population appears to have been reasonably steady over the period. These results are inconclusive, however, because they cover a relatively short period and were influenced by the temporal and spatial variability in blue-gum flowering patterns.

Surveys conducted during the 2004–05 and 2005–06 breeding seasons found 134 swift parrot nests; previously, only 40 had been recorded throughout Tasmania. Many of the nests were in breeding aggregations of up to 50 nests covering about 100 hectares.

The information collected from known nest sites and from additional surveys targeting both nesting and foraging habitat is being integrated into the management of breeding habitat and used to identify potential nesting habitat.

The forest practices system provides protection to two of the swift parrot's key habitats in Tasmania – grassy *E. globulus* forest and shrubby *E. ovata* forest – from clearing and conversion on both public and private land. Prescriptions for the management of swift parrot nesting and foraging habitat are currently under review, 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.

Source: Swift Parrot Recovery Team (2000)

Case study 10: Ecology of barking owls in managed forests

Many vertebrate species occur so rarely in the wild that it is not possible to assess their sensitivity to logging using standard fauna survey techniques. Instead, species-specific research programs are needed to obtain information useful for those species' conservation and management. Scientists working for the New South Wales Department of Primary Industries conducted a radio-tracking study of nine barking owls (*Ninox connivens*), a vulnerable species, in the state's Pilliga forests to determine key elements of habitat required by the species and to provide appropriate guidelines for forest managers.

The owls were trapped, released and radio-tracked for one year. The study identified important aspects of the ecology of the species, enabling the development of guidelines for conserving it in timber-producing forests. The research showed that barking owl pairs in the Pilliga forests live year-round in non-overlapping home ranges of about 2,000 hectares. The owls used most of the forest vegetation types available in their home ranges, but preferred particular subsets of tree species associations for hunting, nesting and roosting.

A feature of the owls in the Pilliga is their diet of native prey species, including sugar gliders, bats, birds and insects; in some other locations, European rabbits form the main component of their diet. Perhaps for this reason, forest edges were not as important an element of habitat for barking owls in the Pilliga as they appear to be elsewhere. The Pilliga forests have a long history of selective logging, but there appeared to be no evidence of owls avoiding logged areas within their home ranges. Most pairs of owls attempted to breed during the study but only half were successful, each producing two or three young. Nest predation by goannas appeared to be a significant cause of nest failure for the other pairs.

Management guidelines arising from this study are being incorporated in the negotiated outcomes of recent land-use decisions for the Brigalow and Nandewar regions.

Source: Forests NSW

Barking owl (*Ninox connivens*).

Case study 11: Tasmanian devil

In recent years, the Tasmanian devil (*Sarcophilus harrisii*) has been severely affected by devil facial tumour disease (DFTD). Long-term monitoring of the species indicates that, while its population has fluctuated, numbers were relatively stable until about five years ago (Figure 26).

DFTD has now been confirmed in Tasmanian devils across more than half of the Tasmanian mainland (Figure 27) and has been demonstrably linked to a 41% decline in the population over the past 10 years. This cancerous disease takes the form of tumours on the head of the devil; the tumours may spread to other parts of the body. Death occurs within months of the first signs. DFTD appears to be a new, infectious disease, typically affecting only adults. The cancerous cells are thought to be the agent of infection; no viruses or other disease agents have been identified, despite extensive investigation. While wildlife diseases rarely cause extinction, there is so far no evidence to suggest that DFTD will not continue to spread across Tasmania, or that populations can recover once infected. No local extinctions have been detected to date, and Tasmanian devils still exist in all rural habitats throughout the mainland of the state. However, the population has declined by 89% in the region where DFTD signs were first reported.

The first clear indications of the impact and wide distribution of the disease emerged in 2003, and in response the DFTD Program was established in 2004. The program's key focal areas are:

- **population monitoring**: gathering data in the field to clarify disease distribution and impacts, and using those data to help determine conservation strategies
- **disease diagnostics**: a laboratory-based investigation of the disease, which includes defining the disease and exploring its transmission and possible causes
- **wild management**: establishing methods for managing the impact of the disease in the wild
- **captive management**: assembling captive breeding populations using devils from disease-free areas.

Source: Forest Practices Authority (Tasmania) (2007)

Figure 26: Changes in population of the Tasmanian devil, 1985 to 2005

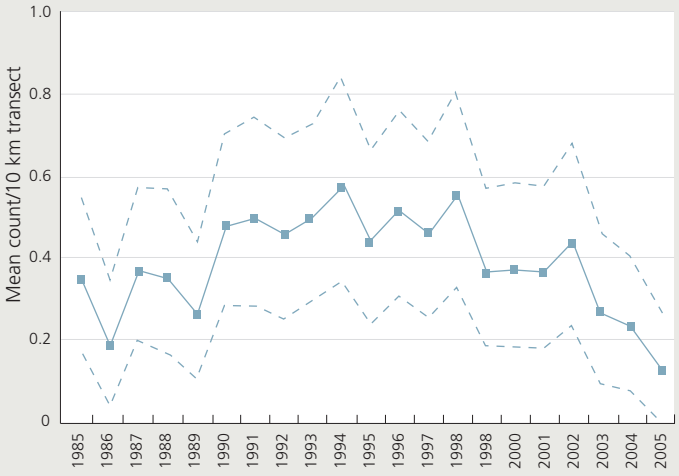
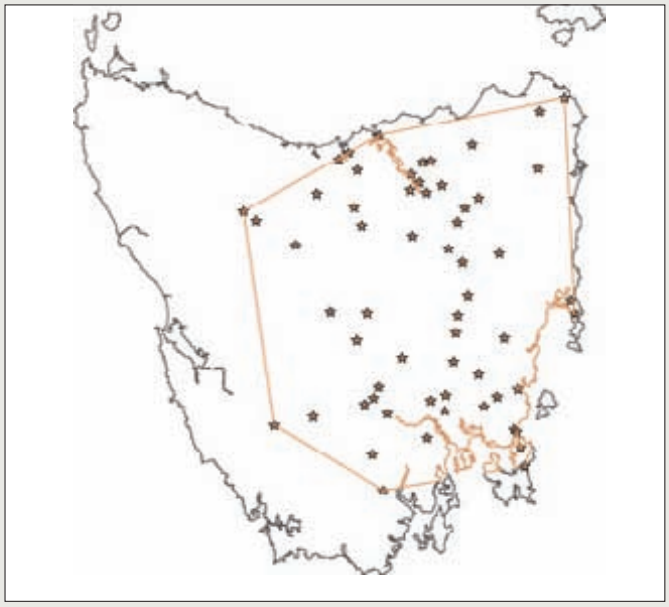


Figure 27: Locations at which the presence of devil facial tumour disease had been confirmed by November 2006



The Tasmanian devil (*Sarcophilus harrisii*) now found in the wild only in Tasmania, is the largest carnivorous mammal in the world. It is vicious when feeding and is known to hunt prey and scavenge carion. Although usually solitary, devils sometimes eat together.

Case study 12: Long-term species monitoring and research program in the Victorian mountain ash forests

Since 1983, the Victorian Department of Sustainability and Environment has supported a long-term monitoring and allied research program in the mountain ash (*Eucalyptus regnans*) forests of the Central Highlands of Victoria (Figure 28). To date, over 50 major projects have been completed, 6 books and 130 scientific articles have been published, and many field workshops and other extension activities have been conducted.

This is one of the most significant and longest running forest monitoring and research programs of its type in the world. The value of the data, the new insights gained and the relevance and importance of the work to indicators of sustainability strengthen with each additional year of work.

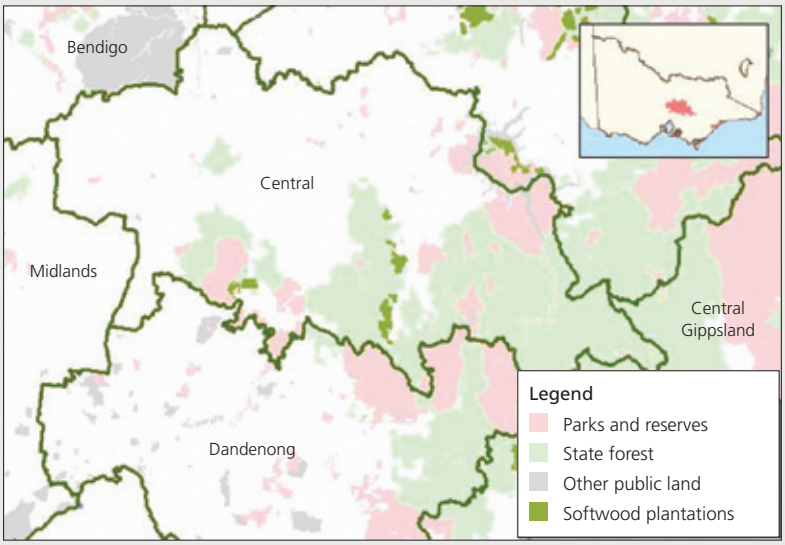
A suite of projects is ongoing, and several key strategically important new projects have been established. The primary focus is the long-term monitoring of arboreal marsupials, such as Leadbeater's possum (*Gymnobelideus leadbeateri*) and the mountain brushtail possum (*Trichosurus cunninghami*). The study is considering the effectiveness of various forest management prescriptions.

The monitoring program currently comprises:

- long-term ecological monitoring of landscape cover and composition (logged/unlogged mosaic) effects on arboreal marsupials, forest owls and diurnal birds
- monitoring falls of large hollow trees
- nest-box use and occupancy patterns of hollow-dependent fauna
- fauna surveys (mammals, birds and reptiles) of dry and mixed-species forest patches in the Upper Yarra catchment (32 sites in the Yarra Ranges National Park)
- a variable retention harvest system experiment
- small-mammal population dynamics – relationships between forest floor architecture (logs, ground cover, etc.) and populations of three species of small mammals
- long-term population dynamics of the mountain brushtail possum.

Source: DSE, Victoria

Figure 28: Victorian Central Highlands study area



Leadbeater's possum (*Gymnobelideus leadbeateri*).

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 decreased ability to adapt to future environmental change, and thus a higher risk of extinction.

Key points

- While the number of forest-associated species for which data on genetic variation are available is still low, it has increased since SOFR 2003. Then, data were available for one faunal and two floral species; now, data are available for more than 10 faunal and 13 floral species.
- Several studies have documented genetic variation and distribution patterns within existing populations of a relatively small number of forest-associated species. Several institutions have programs to measure genetic diversity in forest fauna, but nationally conclusive results are available for only a few species.
- Conservation measures therefore focus on increasing connectivity between isolated patches of native vegetation, increasing the area of forest contained in public and private nature conservation reserves, managing threats to native species, and assisting the recovery of threatened species.

Spider orchid (*Caladenia behrii*).

The distributions of Australian species before European settlement are needed for definitive assessments of genetic variation. Evidence of major changes in the past few decades can assist. Historical records, expert opinion and analysis and incidental observations have been used to compile maps or to model the former distributions of species. For example, the regional forest agreements provided pre-1750 estimates of the extent of forest ecosystems within the main production forest estate.

Species with low genetic variation are widely held to be less able to withstand unexpected threats and so face a higher risk of extinction. In practice, it is difficult to demonstrate the level of genetic variation that has been lost in a species. However, it is possible to identify whether certain threatened species are becoming endangered by the increased isolation of populations arising from habitat loss, fragmentation and threatening biotic factors such as predators and disease.

Efforts are being made to improve long-term conservation outcomes, for example by increasing connectivity among patches of native vegetation. In South Australia, ForestrySA is implementing biodiversity corridor programs across its (mostly pine plantation) land in the southeast of the state and in the Mount Lofty Ranges to link areas of isolated native forest with strips of revegetation (Case study 4 in Indicator 1.1d). Most jurisdictions have threat abatement plans in place to reduce the impacts of predators and diseases on threatened species.

Several institutions have programs to measure genetic diversity in forest fauna, but nationally conclusive results are available for only a few species. Changes in the genetic diversity of forest-associated flora have also been little measured, although several studies have documented genetic variations and distribution patterns within existing populations. Those studies suggest that a reduction in range is less likely to cause a significant loss of genetic variation in species with a high level of diversity within populations and

a low level of diversity between populations. A reduction in range is more likely to reduce genetic variation in species that exhibit low genetic diversity within populations and high variability among populations. The former applies to most of the limited number of tree species that have been surveyed, but the latter applies to species with naturally restricted ranges – such as the 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 the blue gum (*E. globulus*).

The number of species for which data on genetic variation are available has increased since SOFR 2003, when data were available for one faunal and two floral species. Data are now available for more than 10 faunal and 13 floral species (Appendix C).

Threatened species

The states and territories and the Australian Government maintain lists of threatened species, the Australian Government at the national level (Indicator 1.2a). For example, Table 29 shows threatened forest-associated species in New South Wales by broad taxonomic group and the reasons for their listing. Many taxa in Table 29 are the subject of priority action statements prepared by the New South Wales Department of Environment and Climate Change, which describe the actions required for the conservation and recovery of the species.

Table 30 shows the number of forest-associated species potentially at risk in Tasmania from isolation and the loss of genetic variation. Measures in place to address the risk of loss of genetic variation in the state's threatened species include recovery plans, habitat restoration, seed-collecting programs and the management of habitat and populations under the forest practices system.

Table 30: Tasmanian forest-associated species potentially at risk from isolation and the loss of genetic variation as a result of past human-induced or natural events, by taxon

Group	Potential high and moderate risk	Potential low risk	Unknown risk	Total
Fish	3	3	–	6
Amphibians	1	1	–	2
Reptiles	–	1	1	2
Birds	6	5	–	11
Mammals	3	2	1	5
Plants[a]	104	116	50	270
Total	117	128	52	296

a Includes dicotyledons, monocotyledons, pteridophytes and gymnosperms.

Source: Forest Practices Authority (Tasmania) (2007)

Fragmentation

Forest fragmentation (Indicator 1.1d) caused principally by land clearing and loss of habitat can contribute to a loss of genetic variation. Native populations at greatest risk and of greatest concern are those that are small or fragmented and at the same time have high conservation value. For example, the rare species swamp peppermint (*Eucalyptus rodwayi*) may be at risk where outlying populations exist near shining gum (*E. nitens*) plantations in southern Tasmania because of the possibility of hybridisation between them. Case studies 13 and 14 examine several species with highly restricted distributions.

Climate change

A change in climate, such as that being predicted due to the enhanced greenhouse effect (see Indicator 3.1a), may contribute to a loss of forest genetic variation. For example, a reduction in rainfall is believed to be the cause of widespread mortality over the past decade in some Gunns white gum (*E. gunnii*) populations on Tasmania's Central Plateau. *E. gunnii* is one of the most frost resistant of all

Table 29: Threatened forest-associated species in New South Wales with conservation and recovery plans in place, by taxon

	Reasons for listing species as threatened			
Group	Low population	Hybridisation	Low genetic diversity	Other[a]
Plants[b]	265	2	8	20
Reptiles	11	–	–	–
Birds	17	1	–	–
Mammals	4	–	1	2
Amphibians	3	–	–	–
Invertebrates	–	–	–	1

a Includes too-frequent fire, grazing pressure, weed competition, low seed viability, germination difficulties and stochastic events.

b Includes dicotyledons, monocotyledons, pteridophytes and gymnosperms.

Source: Department of Environment and Climate Change (Parks and Wildlife Group) (NSW)

eucalypts. The greatest mortality has been in some of its most frost-resistant populations, so an important part of the species' gene pool is being lost (see Case study 18 in Indicator 1.3b for information on efforts to conserve this species). Another possible example of the effects of climate change is the mortality occurring in the small population of Tasmania's rarest eucalypt species, Morrisby's gum (*E. morrisbyi*), in the East Risdon Flora Reserve as a result of drought.

Increases in nature conservation reserves

There has been an increase in the area of public and private forests in formal and informal nature conservation reserves (Indicator 1.1c). These reserves are being managed for nature conservation objectives under a variety of national and jurisdictional programs, helping to address the risk to biodiversity caused by isolation and the loss of genetic variation. In private forests, forest purchases by governments and non-government organisations and management covenants are being used to help conserve threatened species and habitats.

References and further reading

Butcher et al (2005), Forest Practices Authority (2007), Lindenmayer et al (2003ab) (list at the back of the report).

Web resources

Case study 13: Recovery plans in South Australia

Case study 14: *Eucalyptus benthamii*

Southern Emu-wren (*Stipiturus malachurus intermedius*) Mount Lofty Ranges, South Australia.

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

- Most states and territories have guidelines and management plans for the conservation of the genetic diversity of forest timber species of commercial significance.
- Genetic resource conservation plans exist for more than 40 native timber and oil-producing species, a 70% increase on the number reported in SOFR 2003. The increase includes species used in farm forestry in drier environments.
- Tree-breeding and genetic improvement programs are expanding the scope for conserving native forest genetic resources, including non-commercial endangered species.

There are significant ongoing activities for the conservation of native forest species and communities. For forests covered by regional forest agreements (RFAs), governments have developed a set of criteria that includes broad benchmarks for the in-situ conservation of forest biodiversity (Indicator 1.1c). In the RFA regions, significant additional areas of forest were included in nature conservation reserves and in reserves in multiple-use public forests to meet those criteria. There were relatively high reservations of rainforests (35% of the pre-1750 distribution), mangroves (32%), eucalypt tall open forests (29%) and eucalypt low open forests (29%).

In addition to these reservations, ex-situ seed orchards and conservation plantings have been made for several rare and endangered species, including Miena cider gum (*Eucalyptus gunnii* subsp. *divaricata* – Case study 18 on the SOFR website), Camden white gum (*E. benthamii*), Brooker's gum (*E. brookeriana*), Risdon peppermint (*E. risdonii*), varnished gum (*E. vernicosa*), spinning gum (*E. perriniana*) and Morrisby's gum (*E. morrisbyi*) in Tasmania.

Most states and territories have guidelines and management plans for conserving the genetic diversity of native forest timber species of commercial significance. In the regeneration of native production forests, the aim is to maintain local gene pools and the approximate composition and spatial distribution of the species (including non-timber and understorey species) that were present before harvesting. Plans include specifications for seed collection and the selection of seed trees of good form and health.

Codes of forest practice, such as those in Victoria and Tasmania, require native forests to be sown with species that approximate the natural mix of a site's canopy trees, while allowing for those species that will regenerate naturally. Seed to be sown should be collected either from the stand to be felled or from the nearest similar ecological zone. In Western Australia, silvicultural guidelines specify the seed sources to be used in the rehabilitation of cleared areas in jarrah forest (Case study 15).

The Australian Tree Seed Centre in Canberra, ACT, maintains a national collection of more than 900 species in some 75 mainly Australian genera, including over 240 species of *Acacia*, 19 *Allocasuarina*, 11 *Casuarina*, 25 *Corymbia*, 330 *Eucalyptus* and 38 *Melaleuca*. This seed bank provides a high-quality, representative, ex-situ sample of Australia's tree and shrub genetic diversity. Originally, the centre collected and stored seed mostly on a population or provenance basis, but the emphasis has increasingly shifted to individual parent trees. These genetically distinct acquisitions are important for ex-situ genetic resource conservation. In addition to the national collection, various tree-growing communities and forest and research agencies maintain their own forest seed collections. Several of these organisations are listed in Table 31, which shows that tree-breeding and genetic conservation and/or improvement programs are in place for more than 25 native species, most of which are commercially important.

Australia is a partner in the Millennium Seed Bank Project run by the United Kingdom's Royal Botanic Gardens at Kew, the largest ex-situ conservation project ever conceived. By 2010, project partners will have banked seed from 10% of the world's wild plant species, including many of the rarest, most threatened and most useful plant species known.

Base populations for breeding

While breeding populations are maintained mainly for improving commercial wood production, they have an important spinoff in conserving genetic resources. Plant-breeding strategies require a base population with wide-ranging genetic diversity. Normally, seeds are collected from natural forests 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. A part of this genetic material for blue gum (*E. globulus*) and shining gum (*E. nitens*) is held in existing Australian plantations and special-purpose field trials, many of which are approaching harvest age and some of which have already been felled. Plans are urgently required to collect seed from these mature stands to provide the basis for the next generation of ex-situ plantation genetic resources.

The Southern Tree Breeding Association, formed in 1983, runs cooperative national tree improvement programs for *E. globulus* (Case study 17 on the SOFR website) and *E. nitens*. The program for *E. globulus* has been running since the 1994 amalgamation 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 at Mount Gambier, South Australia, which was launched in August 2005. Control-pollinated *E. globulus* seed is collected and stored in refrigerators, and diversity is maintained in 32 field trials spread across temperate Australia. The TREEPLAN® genetic evaluation system is being used to update genetic values in *E. globulus* and *E. nitens*.

Forests NSW manages its 40-year-old hardwood tree improvement and breeding program from the Grafton Forest Technology Centre, which opened in August 2005. Specialised clonal propagation and breeding facilities have been constructed. Clonal seed orchards of key species – *E. dunnii*, *E. nitens*, *E. pilularis* and *Corymbia citriodora* subsp. *variegata* – have been established. Clonal propagation of eucalypts by cuttings commenced in 2004 and should reach full commercial production by 2010. Hybrid eucalypts are being produced in a pot-based arboretum; these involve

Table 31: Principal native genera and species in genetic resource conservation and improvement programs in Australia

Organisation	Principal native genera and species
CSIRO Australian Tree Seed Centre (Canberra)	*Acacia, Casuarina, Corymbia, Eucalyptus*
Southern Tree Breeding Association and National Genetic Resource Centre (Mount Gambier, South Australia)	Blue gum (*Eucalyptus globulus*), shining gum (*E. nitens*)
Cooperative Research Centre for Forestry (Hobart, Tasmania)	Blue gum (*E. globulus*), shining gum (*E. nitens*), mountain ash (*E. regnans*), messmate stringybark (*E. obliqua*)
Forestry Tasmania	Blue gum (*E. globulus*), shining gum (*E. nitens*), blackwood (*Acacia melanoxylon*), mountain ash (*E. regnans*), messmate stringybark (*E. obliqua*), alpine ash (*E. delegatensis*), Brooker's gum (*E. brookeriana*), red tingle (*E. johnstonii*)
University of Tasmania	Blackwood (*Acacia melanoxylon*), myrtle beech (*Nothofagus cunninghamii*), manna gum (*E. viminalis*), swamp gum (*E. ovata*)
Department of Primary Industries and Fisheries (Queensland)	Spotted gum (*Corymbia citriodora* subsp. *variegata*), Gympie messmate (*E. cloeziana*), blackbutt (*E. pilularis*), western (Chinchilla) white gum (*E. argophloia*), large-fruited (broad-leaved) red mahogany (*E. pellita*), flooded gum (*E. grandis*), mangium (*Acacia mangium*), red cedar (*Toona ciliata*), silky oak (*Grevillea robusta*), hoop pine (*Araucaria cunninghamii*), Wollemi pine (*Wollemia nobilis*)
Forests NSW Grafton Forest Technology Centre (New South Wales)	Dunn's white gum (*E. dunnii*), shining gum (*E. nitens*), blackbutt (*E. pilularis*), spotted gums (*C. citriodora* subsp. *variegata, C. citriodora* subsp. *citriodora, C. henryi* and *C. maculata*), cadaga (*C. torelliana*), large-fruited (broad-leaved) red mahogany (*E. pellita*), flooded gum (*E. grandis*), Gympie messmate (*E. cloeziana*), Sydney blue gum (*E. saligna*), flooded gum (*E. grandis*), grey gum (*E. longirostrata*)
Collaborative programs, some from the former Australian Low Rainfall Tree Improvement Group	Blue-leaved mallee (*E. polybractea*), mulga (*E. sideroxylon*), red ironbark (*E. tricarpa*), river red gum (*E. camaldulensis*), spotted gums (*C. citriodora* subsp. *variegata* and *C. maculata*), sugar gum (*E. cladocalyx*), swamp yate (*E. occidentalis*), oil mallees (*E. kochii* and *E. horistes*)
Department of Environment and Conservation (Western Australia)	Jarrah (*E. marginata*), karri (*E. diversicolor*), WA flooded gum (*E. rudis*), York gum (*E. loxophleba*), coojong (*Acacia saligna)*

many of the main commercial species and also species that are more suited to marginal sites, tolerant of frost and/or able to grow on heavier soils (e.g. blackbutt (*E. pilularis*) with stringybark (*E. macroryncha*)) or that combine useful wood properties with rapid growth (e.g. red mahogany (*E. pellita*) with flooded gum (*E. grandis*)).

The Department of Environment and Conservation in Western Australia runs provenance trials of karri (*E. diversicolor*) and associated timber species used for site-restocking after timber harvesting. Range-wide collections of west-Australian flooded gum (*E. rudis*) are under way, and limited trials are testing the heritability of the species' natural resistance to disease.

Gene flow from plantations

Gene flow from rapidly expanding native-tree plantations (see Indicator 2.1b) into surrounding native forests (a phenomenon sometimes called 'introgression') is a potential risk, diminishing the full range of variation within local native tree populations. Breeding strategies and genetic resource management plans aim to maintain the genetic diversity of commercially utilised native species and avoid gene flow that could damage the overall genetic resource. Strategies include the careful selection of species and provenances, the genetic 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 (see Case study 16 on the SOFR website).

Shining gum (*E. nitens*) was introduced to Tasmania from Victoria and New South Wales, and about 100,000 hectares of plantations have been established. Spontaneous hybridisation between *E. nitens* plantations and native swamp gum (*E. ovata*) and manna gum (*E. viminalis*) populations has been documented. The results of research by the University of Tasmania and the Cooperative Research Centre for Forestry are influencing guidelines for plantation establishment.

Further reading

Dieters et al (2007), Harwood et al (2007), Henson and Smith (2007), Lee (2007), Pilbeam and McRae (2007), Potts et al (2001), Smith and Henson (2007) (list at the back of the report).

Web resources

Case study 16: Gene flow studies for *Acacia saligna* and *Eucalyptus loxophleba*

Case study 17: Breeding *Eucalyptus globulus* in the Southern Tree Breeding Association

Case study 18: *Eucalyptus gunnii* subsp. *divaricata* ex-situ seed orchard and conservation plantings in Tasmania

Case study 15: In-situ and ex-situ genetic resource conservation of jarrah in Western Australia

In Western Australia, the Department of Environment and Conservation (formerly the Department of Conservation and Land Management) provides the Forest Products Commission with guidelines on seed collection zones for the rehabilitation of cleared areas and for the species mix to be used in the regeneration of native forests.

The ecologically sustainable rehabilitation and regeneration of timber-harvesting areas requires plants that are adapted to local site conditions. Provenance trials are being conducted for jarrah (*Eucalyptus marginata*) and associated understorey species to identify seed collection zones for genetic material that suits the rehabilitation requirements of particular sites. Under the silvicultural guidelines, seedlings for planting should be grown from seed sourced from a seed zone appropriate to the species' genetic management.

Genetically based resistance to the fungal pathogen *Phytophthora cinnamomi* (also called 'dieback') has been demonstrated in jarrah. Under a long-term selection and screening program, inoculation trials have been carried out and field validation trials have been established to prove the selections. Individuals showing the highest resistance have been propagated and multiplied by tissue culture. The resulting clonal lines have been used in further validation trials, in field plantings, and to establish seed orchards for the production of dieback-resistant jarrah for future operational forest rehabilitation planting.

The department's Sustainable Forest Management Guideline No. 1 (*Silvicultural Practice in the Jarrah Forest, 2004*) describes measures that must be taken to retain jarrah trees that show resistance to *P. cinnamomi*; such trees form an important genetic resource and are a potential source of seed.

Ex-situ conservation stand of cider gum (*Eucalyptus gunnii*), Tasmania.

Criterion 2

Maintenance of productive capacity of forest ecosystems

The five indicators in this criterion canvass the forests available for timber production, the volumes of timber harvested against the calculated sustainable yield, the volumes and types of non-timber forest products extracted, and the regeneration of harvested native forests and plantations. The indicators also consider the role of wood production in native forests and plantations and the sustainability of harvesting.

Key findings

Native forests

- In 2005–06, 112.6 million hectares of native forest was in tenures in which timber harvesting is allowed, compared to 119.8 million hectares in 2000–01. While large, much of the available area contributes little to timber supply.
- The area of multiple-use public native forests declined from 11.4 million hectares in 2000–01 to 9.4 million hectares in 2005–06.
- With the exception of Tasmania, the sustainable level of harvest from multiple-use public native forests continued to decline, due to reductions in the area allocated to harvesting, further restrictions on harvesting, and revised downward estimates of sustainable yield.
- In Tasmania, the sustainable sawlog yield from multiple-use public native forest fluctuated slightly in line with forest management strategies in the short term, but without adversely affecting long-term sawlog availability.
- The volume of sawlogs harvested from multiple-use public native forests over the period from 1992–93 to 2005–06 was less than the prescribed sustainable level in New South Wales, Victoria and Western Australia.
- The success rate in regenerating multiple-use public native forests after harvesting was high (above 85%) in those states for which data were available; remedial action was taken in those areas where standards were not achieved.

Plantation forests

- The area of plantations increased from 1.63 million hectares in 2003 to 1.82 million hectares in 2006. Nearly all the increase was in hardwood (mostly pulpwood) plantations, from 503,000 hectares in 2000 to 807,000 hectares in 2006.
- Plantations produce about two-thirds of Australia's log supply, by volume.
- Based on current plantings, wood production from softwood plantations is expected to plateau by 2010, while production from hardwood plantations will increase substantially, to over 14 million cubic metres per year by 2010.
- The reported success rate in restocking harvested plantations with replacement seedlings was generally over 90%.

Non-wood forest products

- A number of non-wood native forest species are subject to commercial harvesting regimes, some of which are significant in terms of value, quantity or both.
- Indigenous Australians rely to varying degrees on the use of non-wood forest products for customary (e.g. food and medicine) and commercial (e.g. arts and crafts) purposes.
- Approaches to assessing the sustainability of the Australian non-wood forest product sector are being developed. Adaptive management plans are in place for native species subject to significant harvest to assist regulators in managing for sustainability.

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 2005–06, 112.6 million hectares of native forest was in tenures in which timber harvesting is allowed, compared to 119.8 million hectares in 2000–01. The area of multiple-use public forests declined from 11.4 million hectares in 2000–01 to 9.4 million hectares in 2005–06, while the area of public nature conservation reserves increased from 21.5 million hectares to about 23 million hectares over the same period.
- Multiple-use public native forests continue to provide most of the native forest wood and wood product harvest. Leasehold and private tenure forests are also potentially available, subject to landholder intent, markets and environmental constraints.
- Harvesting in multiple-use public native forests is subject to substantial requirements to maintain non-wood values.
- The increased capacity of industry to use small-diameter logs as a feedstock has, to some extent, offset the impact of decreases in the area available for harvesting in multiple-use native forests.

The area of native forests available for timber harvesting[1] affects the forest sector's capacity to meet domestic and export demand for native timbers and wood products and the level of sustainable yield. In Australia, the area available for harvesting is a function of tenure, codes of practice and requirements to manage for multiple values.

Native forest area available for harvesting

The major source of Australia's native timber and wood 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. Timber harvesting is not permitted in nature conservation reserves.

In 2000–01, the area of forest not legally restricted from timber harvesting was 119.8 million hectares; this declined to 112.6 million hectares or 76% of Australia's native forests in 2005–06 (Table 32). In practice, much of the available area currently contributes little to timber supply because it comprises leasehold land predominantly used for grazing, does not contain marketable species, is too far from

1 Under the Montreal Process, the emphasis of this indicator is to report on the area of native forests in which harvesting is not legally restricted.

Table 32: Area of forest not legally restricted from timber harvesting in 2005–06, by jurisdiction ('000 hectares)

Tenure	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Australia
Leasehold forest	8	9,891	13,920	34,304	3,083	–	35	3,891	65,132
Multiple-use public forest	–	1,980	–	1,991	2	1,026	3,163	1,248	9,410
Private land (including Indigenous)	–	8,076	16,317	8,908	1,399	885	1,025	1,489	38,099
Total	8	19,947	30,237	45,203	4,484	1,911	4,223	6,628	112,641

Table 33: Area of multiple-use public native forest available for harvesting, New South Wales ('000 hectares)

	1999–2000	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06[a]
Area	1,368	1,190	1,187	1,172	1,164	983	846

a The reduction in the area available for harvesting in the period from 2004 to 2006 was due to the finalisation of the Western Regional Assessment and the Southern Icon areas; the resulting tenure changes affected most Forests NSW management zones.

Source: Forests NSW (various)

Table 34: Gross and net forest areas available for wood production, Tasmania, 30 June 2006 ('000 hectares)

Tenure	Gross forest area	Net native forest area
Public	2,335	607
Private	1,018	Not available

Source: Forest Practices Authority (2007)

markets, or is not operationally feasible. For example, there is relatively limited commercial native forest harvesting in the Northern Territory and none in South Australia or the Australian Capital Territory. Moreover, the Queensland Government has signalled a significant phase-out of native forest harvesting on public land across that state in favour of hardwood plantations in areas where they can be developed.

Leasehold, private and multiple-use public forests are managed for a range of values as well as timber production, and in some cases are dedicated to water protection, flora and fauna protection and other key values. This has contributed to major reductions in the availability of multiple-use public forests for timber harvesting that are not apparent in data on tenure changes.

The area of forests not legally restricted from timber harvesting declined from 11.4 million hectares in SOFR 2003 to 9.4 million hectares in 2005–06, a decrease of 17.5%. This reduction is complemented by an increase in the area of forest in public nature conservation reserves, from 21.5 million hectares in SOFR 2003 to about 23 million hectares in 2005–06.

The overall decline in the area available for timber harvesting occurred across jurisdictions. In New South Wales, for example, the area of multiple-use native forest available for timber harvesting declined from 1.37 million hectares in 1999–2000 to 846,000 hectares in 2005–06, a reduction of 38% (Table 33). The area of multiple-use native forests set aside from harvesting in state forest reserves and special protection zones increased over the period.

In Tasmania, the area of public native forest land potentially available for timber production decreased by about 15% between 2001 and 2006, to 607,000 hectares (Table 34), partly due to the transfer of land from multiple-use public forest to the conservation reserve system as a result of the 2005 Tasmanian Community Forest Agreement.

Available growing stock

'Growing stock' is the total volume of wood in all living trees in a forest at a particular time. Changes in growing stock – whether it is increasing or decreasing – can indicate (among other things) the sustainability of resource use. In multiple-use public forests, assessments of the growing stock of merchantable timber (i.e. timber of saleable quality) and tree growth rates are used to estimate sustainable harvesting levels.

In recent years, the wood processing industry has adopted technologies and developed markets that have increased its ability to use small-diameter timber that was previously often unused. Provided that it is within sustainable limits, this increased resource-use efficiency is one way in which the timber industry can maintain its timber supply even as the area of forest available for timber harvesting decreases. The increased use of small-diameter timber also provides an incentive to improve the management of regeneration in forests previously regarded as relatively unproductive, improving long-term productivity and sustainable yield. In the past, the absence of markets for small-diameter timber has strongly affected long-term productivity under selective felling regimes. Sustainable yield is further considered in Indicator 2.1c.

With the exception of data for Tasmania, few or no data are available on growing stock, potential sustainable yield or owners' management intentions in private native forests.

References

Forests NSW (various), Forest Practices Authority (2007) (list at the back of the report).

Assessing trees in native forest prior to harvest, southeast New South Wales.

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 plantations increased from 1.63 million hectares in 2003 to 1.82 million hectares in 2006, with almost all of the increase achieved by planting on cleared agricultural land.
- Of the total area of plantation estate, 55% is softwood and 45% is hardwood.
- While the area of softwood plantations has been stable for several years, the area of hardwood plantations has increased substantially, from 503,000 hectares in 2000 to 807,000 hectares in 2006.

Plantation forestry has come to dominate Australia's forestry and timber industries. Growing and harvesting logs and processing them into sawn timber, paper, panels and other products provides substantial employment, especially in rural areas. Although plantations provide the raw material for major rural industries, they occupy a small part of the rural estate.

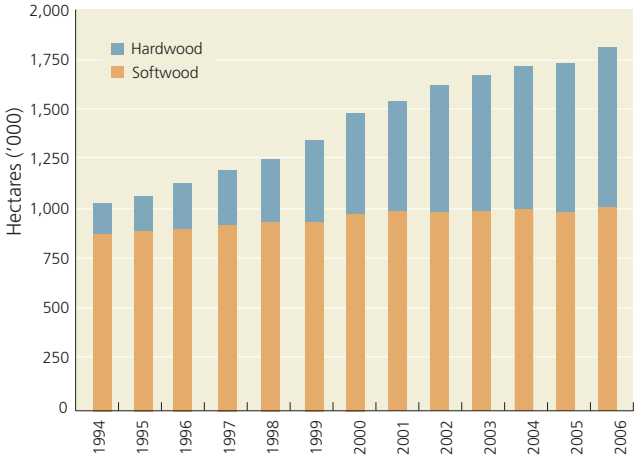
The Montreal Process Working Group identifies 'growing stock' – the total volume of wood in all living trees in a forest at a particular time – as an indicator of potential wood supply from plantations. However, growing stock is not usually measured in Australia. Instead, the National Plantation Inventory develops forecasts of plantation log supply every five years. The 2007 forecast is summarised in Indicator 2.1c.

Most plantations established in Australia until the 1990s were pines and other softwoods grown to produce sawn timber. Many were planted on land where there had previously been native forests; however, the clearing of native vegetation (including native forests) for plantation development is now prohibited or restricted by state and territory policies and legislation, and new plantations are now almost exclusively established on cleared agricultural land.

Plantation areas and values

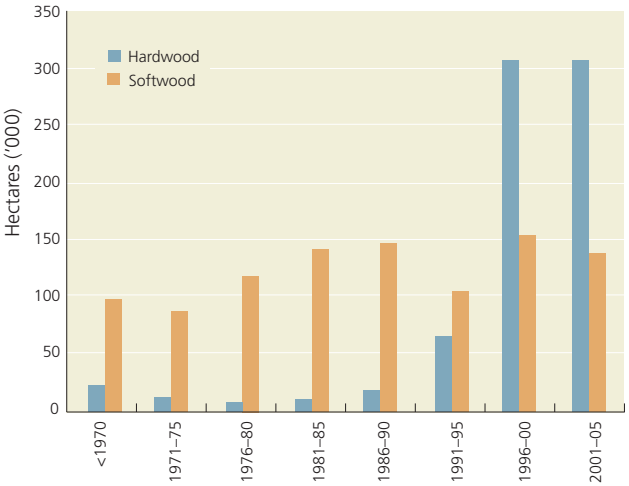
Australia's plantations have expanded rapidly since the National Plantation Inventory began collecting data in 1993. Supportive policies and programs such as *Plantations for Australia: the 2020 Vision* were important in removing impediments to plantation development. The inventory's first comprehensive map-based report showed in 1994 that Australia had 1,042,600 hectares of plantations. SOFR 2003 reported a plantation estate of 1.63 million hectares; by 2006 it had reached 1.82 million hectares (Figure 29). About 55% of the total area is softwood plantations (mainly exotic pines) and 45% is hardwood plantations (mainly eucalypts). Figure 30 shows the planting year distribution of these plantations.

Figure 29: Total plantation area, Australia, 1994 to 2006



Source: National Plantation Inventory

Figure 30: Plantation planting year distribution to 2005



Source: National Plantation Inventory

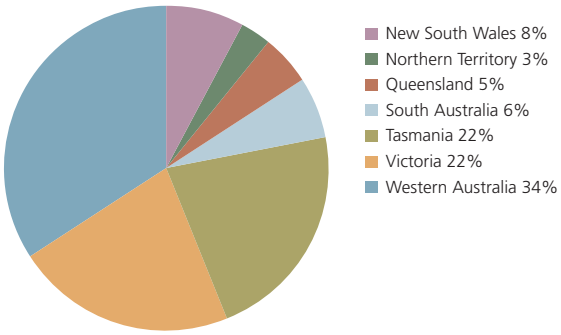
Figures 31 and 32 show the distribution of hardwood and softwood plantations, respectively, by jurisdiction. Victoria has the largest plantation area, with 22% of the national total of both hardwood and softwood plantations, closely followed by Western Australia with 21% (34% of all hardwoods and 11% of all softwoods) and New South Wales with 19% (8% of hardwoods and 28% of softwoods).

After 1990, there was a shift from mainly government investment in plantations of exotic softwoods towards private sector planting of a wide range of native and exotic hardwoods. Table 35 shows the main types of plantation and the main uses for the timber they produce.

Further reading

Parsons et al (2007a), Parsons and Gavran (2007), Parsons et al (2006) (list at the back of the report).

Figure 31: Total hardwood plantations, 2006, by jurisdiction



Source: National Plantation Inventory

Figure 32: Total softwood plantations, 2006, by jurisdiction

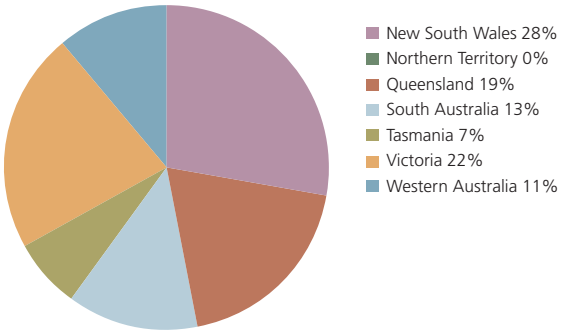


Table 35: Types of plantation, by region

Region	Main species	Main uses
Tropical – high rainfall	Mangium (*Acacia mangium*)	Paper products, veneer and sawn timber
Subtropical – medium rainfall	Flooded gum (*Eucalyptus grandis*), Dunn's white gum (*E. dunnii*)	
Temperate – medium-to-high rainfall	Blue gum (*E. globulus*), shining gum (*E. nitens*)	
Tropical – high rainfall	African mahogany (*Khaya senegalensis*), teak (*Tectona grandis*), some native species	Sawn timber for furniture, flooring and other high-value uses
Several regions	Various eucalypts	Sawn timber for building and furniture
Temperate – medium rainfall	Radiata pine (*Pinus radiata*)	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 (*P. caribaea*), slash pine (*P. elliottii*) and hybrids	
Temperate – low-to-medium rainfall	Maritime pine (*P. pinaster*)	
Tropical, subtropical – high rainfall	Hoop pine (*Araucaria cunninghamii*)	

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

- The volume of sawlogs harvested from multiple-use public native forests in the period from 1992–93 to 2005–06 was within the prescribed sustainable level in New South Wales, Victoria and Western Australia.
- In New South Wales, Victoria and Western Australia, the prescribed sustainable yield in multiple-use public native forests declined between the SOFR 2003 and SOFR 2008 reporting periods due to reductions in the area allocated to harvesting, further restrictions on harvesting, and revised estimates of forest growth and yield.
- In Tasmania, the sustainable sawlog yield from multiple-use public native forest fluctuated slightly in line with forest management strategies in the short term, without adversely affecting long-term sawlog availability.
- Plantations produce about two-thirds of Australia's log supply. Hardwoods make up 45% of plantation-grown pulp logs; softwoods provide 55% of the plantation pulp log supply and 98% of sawlogs.
- Based on current plantings, total wood production from softwood plantations is nearing its maximum potential and is expected to plateau by 2010, while total production from hardwood plantations will increase substantially, to over 14 million cubic metres per year by 2010.

This indicator examines the extent to which a sustainable harvest of timber and wood products is being achieved in native forests. It reports the average annual sustainable and actual harvests in multiple-use public forests, the actual harvest on private land, and plantation harvesting rates and projected future yields. Indicator 2.1a describes the impact of changes in tenure and forest reservation on the area available for the harvesting of wood products.

This indicator reports only on those states where there is significant ongoing native forest harvesting: New South Wales, Queensland, Tasmania, Victoria and Western Australia. The main primary wood products harvested in native forests are veneer logs, sawlogs and pulpwood (the last comprising logs used for paper and wood-based panel products). Other wood products harvested in native forests include posts and poles, bush sawn/hewn timber, firewood, specialty timber and sleepers. The data presented under this indicator pertain mainly to sawlogs (including veneer logs) and pulpwood.

Native multiple-use public forests provide most of Australia's native timber and wood products. Harvesting is subject to a

Loading redgum sleepers, Horsham, Victoria.

regulatory framework designed to maintain environmental values and the productive capacity of forests. Harvesting volumes are set according to a calculated sustainable yield, which is the estimated volume of timber that can be removed each year while ensuring the functioning of the forest system continues as a whole.

Sustainable yield from native forests

Those jurisdictions in which native forest harvesting occurs have formal processes, backed by legislation or codes of forest practice, to calculate sustainable sawlog yields for publicly managed native forests, primarily multiple-use forests.[2] The volume of timber available for harvesting is calculated based on 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 and pulpwood are also harvested from native forests, usually as a residual product of sawlog and veneer log harvesting; therefore, sustainable yields are not determined for low-quality sawlogs or pulpwood.

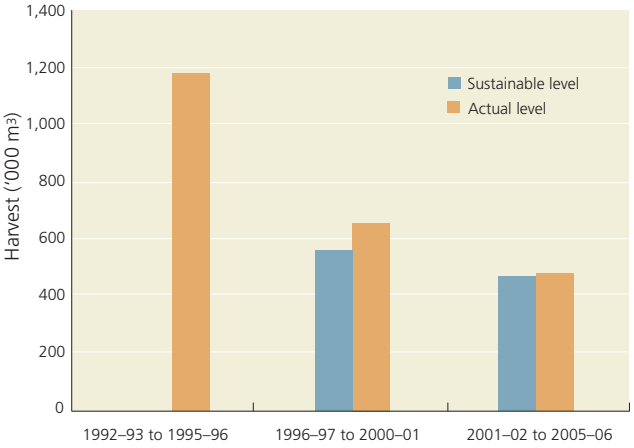
Sustainable volumes vary over time according to management strategies, improved resource data and utilisation standards, and the area of land available for harvesting. Estimates are therefore reviewed periodically, usually every five years. For a range of reasons, annual harvesting levels are likely to fluctuate around the sustainable volume, but overcuts in some years must be at least balanced by undercuts in others.

Figures 33–37 show the reported average volume of harvesting from native multiple-use public forests averaged across the periods covered by the three SOFR reports: 1992–93 to 1995–96 (SOFR 1998), 1996–97 to 2000–01 (SOFR 2003) and 2001–02 to 2005–06 (SOFR 2008). For all states except New South Wales, harvested volumes were, on average, lower than the prescribed sustainable yields for each of the periods. In New South Wales, the actual harvest was slightly higher than the sustainable yield in some years of the SOFR 2008 reporting period (Figure 33). Under state forest agreements, industry in New South Wales is permitted to vary its actual cut by ±5% of the allowable cut, which allows it to take into account previous undercuts to its allocations when required.

Average sustainable yield declined in all states except Tasmania between SOFR 2003 and SOFR 2008, due mainly to reductions in the area of native forest available for harvesting and improved information on forest yields. In Tasmania, the sustainable sawlog yield from multiple-use public native forest fluctuated slightly in line with forest management strategies in the short term, but without adversely affecting long-term sawlog availability. The actual annual harvest volume from public forest in the SOFR 2008 reporting period was generally slightly below the estimated sustainable sawlog yield; the harvest from private forests also declined over the period.

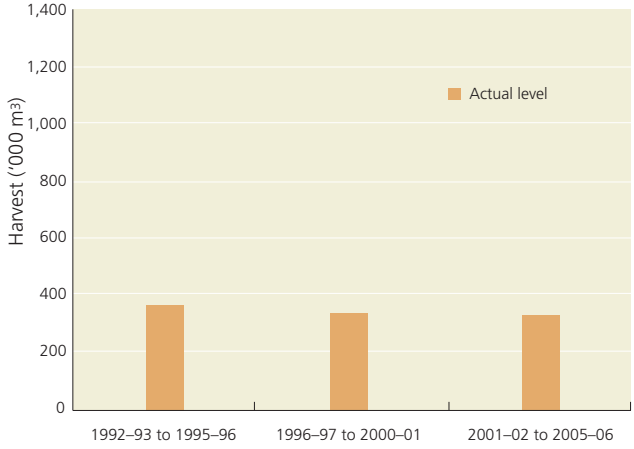
In Queensland, the state government agreed in 1999 to a 25-year transition in which public native forests in the state's southeast – its major timber-producing area – will be withdrawn from timber harvesting and recategorised as nature conservation reserves. For this reason, Figure 34 does not show a sustainable yield volume, although it does show that timber harvest volumes are declining. Hardwood plantations are being established in the region to provide an alternative timber resource. Other areas of the state are the subject of the Statewide Forests Process, in which decisions are being made progressively on future harvesting levels and conservation areas.

Figure 33: Average annual sustainable harvest level in native multiple-use public forests in New South Wales, by SOFR reporting period



Sources: Forests NSW, NFI (2003)

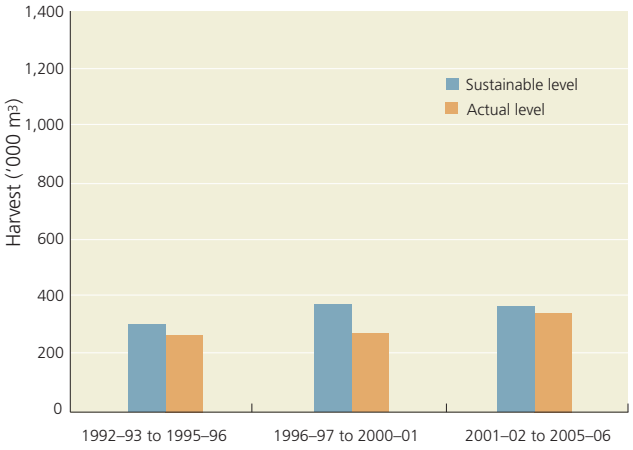
Figure 34: Average annual harvest level in native multiple-use public forests in Queensland, by SOFR reporting period



Sources: Department of Natural Resources and Environment (Qld), NFI (2003)

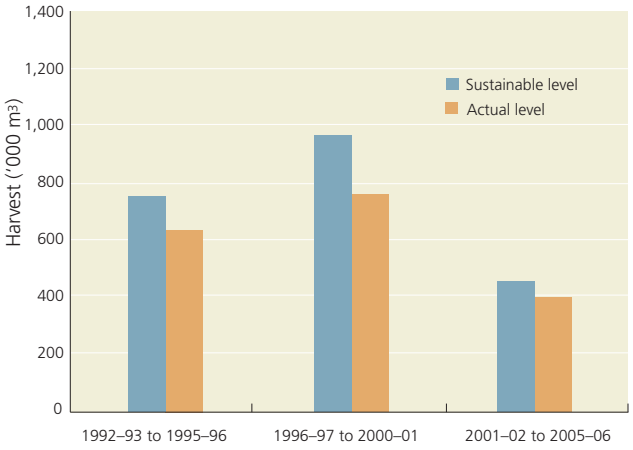
2 Sustainable sawlog volumes are calculated using data on forest type and age class, standing timber volumes, terrain, accessibility, timber growth and yield, recreational use, water and conservation. Estimates also take into account restrictions on harvesting imposed by codes of practice and other regulations. Once calculated, the sustainable volumes are used to produce harvesting schedules and forecasts of the future spatial and temporal characteristics of the forest.

Figure 35: Average annual sustainable harvest level in native multiple-use public forests in Tasmania, by SOFR reporting period



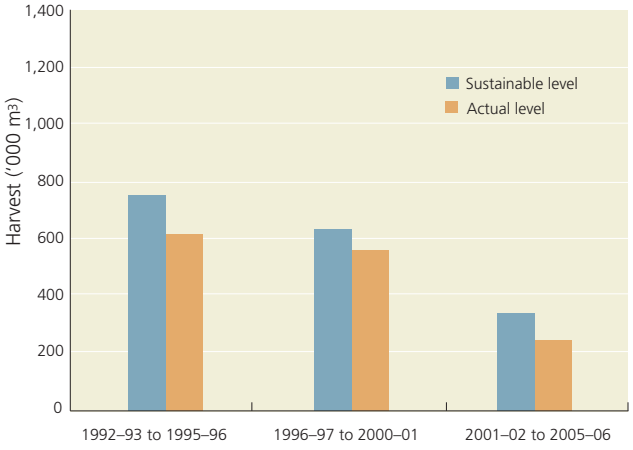
Sources: Forestry Tasmania, NFI (2003)

Figure 36: Average annual sustainable harvest level in native multiple-use public forests in Victoria, by SOFR reporting period



Sources: Department of Sustainability and Environment (Vic.), NFI (2003)

Figure 37: Average annual sustainable harvest level in native jarrah and karri multiple-use public forests in southwestern Western Australia, by SOFR reporting period



Sources: Department of Environment and Conservation (WA), NFI (2003)

The general decline in sustainable yield and harvesting in Western Australia and Victoria is further highlighted in Case studies 19 and 20, respectively. The case studies also illustrate the assessment processes undertaken to provide the basis for sustainable yields.

Private native forests

The supply of sawlogs from private native forests is significant in New South Wales, Queensland and Tasmania (Figure 38). In Tasmania, this supply declined markedly in the SOFR 2008 reporting period compared to the supply reported in SOFR 2003; for other states, recent data on private sawlog supply were not available.

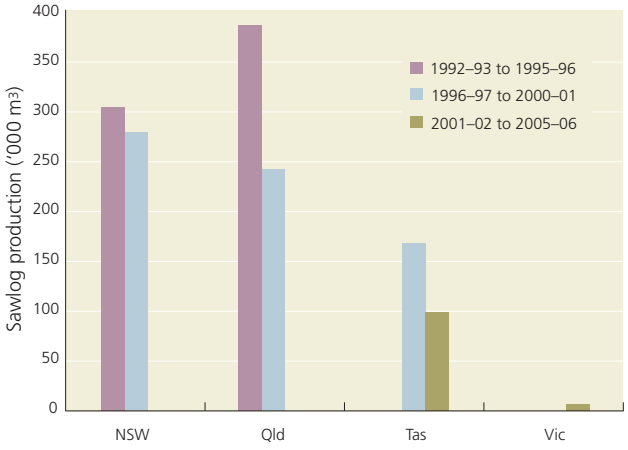
While there is no calculated sustainable yield for wood production in native forests on private land, private-forest harvesting operations face substantial and increasing restrictions. In practice, most private forest managers make limited use of their forests for wood production, responding to immediate needs and opportunities in the market.

The Queensland Timber Board and the Australian Government jointly commissioned an assessment of timber and some non-timber values for private native forests in southeast and central western Queensland. That work, which was completed in 2003, provided timber resource estimates for private native forests in those regions. The work also provided assessment methods that can be applied to private native forests in other regions.

Pulpwood

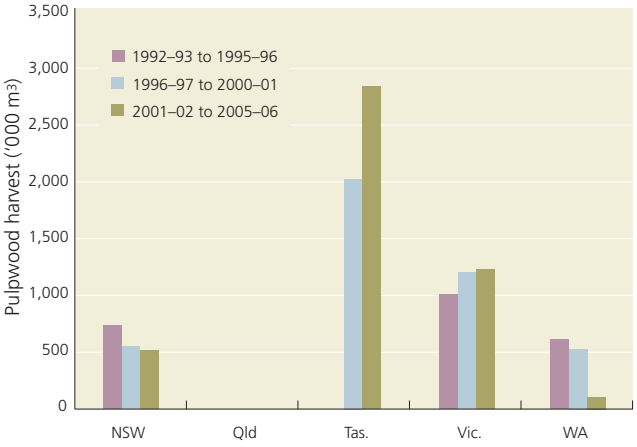
The volume of pulpwood harvested on public land increased in Tasmania and Victoria and declined in New South Wales between the SOFR 2003 and SOFR 2008 reporting periods (Figure 39). Tasmania is the country's major provider of private pulpwood; at the national level, however, available data for the pulpwood harvest in private native forests are insufficient to show volume trends.

Figure 38: Average annual sawlog production from private native forests, by SOFR reporting period



Source: State agencies

Figure 39: Average annual pulpwood harvest from multiple-use public native forests, by SOFR reporting period



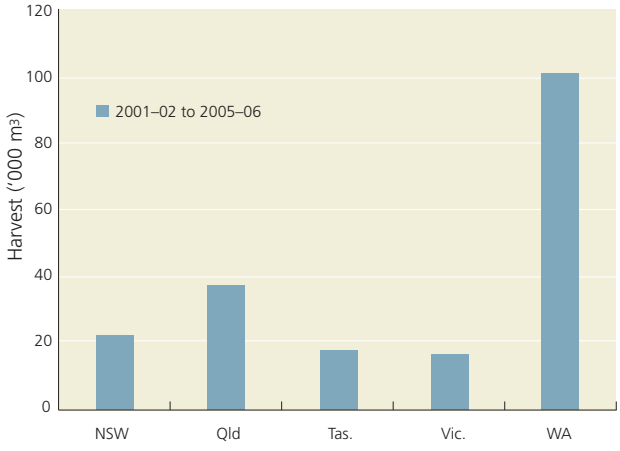
Note: No pulpwood is harvested from public native forests in Queensland.

Source: State agencies

Other wood products

The supply of minor and other wood products, such as posts and poles, bush sawn/hewn timber, specialty timber and sleepers, is often opportunistic. They are generally harvested in relatively small quantities compared to sawlogs and pulpwood and are not always factored into sustainable yield calculations. Figure 40 shows estimates of harvest rates for all these products combined for the period from 2001 to 2006; it does not include firewood, which is discussed next. About three-quarters of the volume shown for Western Australia comprises wood used to make charcoal for silicon smelting.

Figure 40: Average annual 'other wood products' harvest from native multiple-use public forests, 2001–02 to 2005–06



Source: State agencies

3 Driscoll et al (2000).

4 ANZECC (2001).

5 The forecast is based mainly on plantation areas as at 2005, combined with assumptions about the yield of log products per unit land area. The forecast assumes that all plantation sites harvested are replanted.

Firewood

One of the most commonly used forest products is firewood. Excluding industrial uses, Australian households use an estimated 4.5–5.5 million tonnes of firewood per year, with New South Wales and Victoria accounting for over half of this.[3] The five most common tree species used are river red gum (*Eucalyptus camaldulensis*, 1.10 million tonnes), jarrah (*E. marginata*, 0.61 million tonnes), red box and yellow box (*E. polyanthemos* and *E. melliodora*, 0.54 million tonnes combined) and ironbark (*E. sideroxylon*, 0.47 million tonnes).

Approximately half of the wood burned in households is collected by the residents, and 84% is obtained on private property. Sixty per cent of firewood is purchased through small suppliers; this component is worth about $240 million.

Firewood collection is an important segment of the forest sector, particularly in regional communities. It is regulated in many jurisdictions through permit systems, controls on the clearing of native vegetation, and voluntary codes of practice among commercial operators; several jurisdictions developed firewood strategies over the period. A national approach has also been developed to increase the effectiveness of existing controls and to protect threatened species and ecological communities from the impacts of firewood collection.[4] In October 2005, the Firewood Association of Australia was created. This is a not-for-profit organisation that certifies the compliance of firewood suppliers with a national, voluntary code of practice for sustainable firewood suppliers.

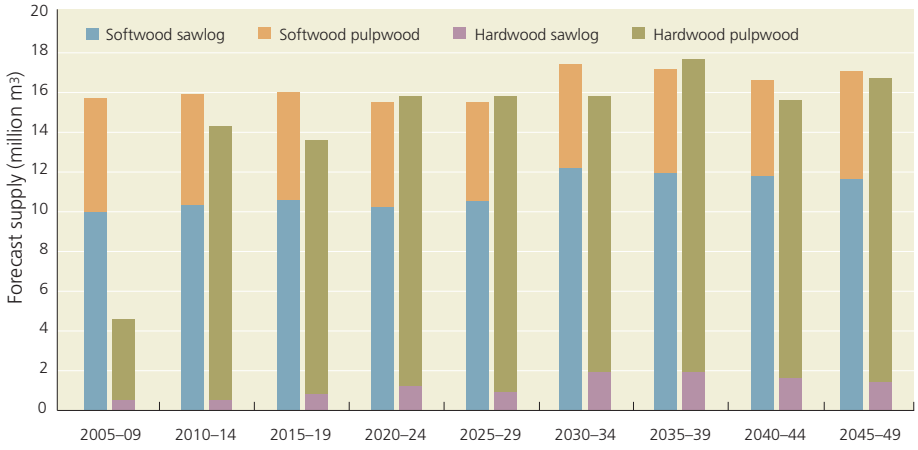
Forecast plantation log supply

Plantations now produce about two-thirds of Australia's total log supply (half of the logs are pulplogs and half sawlogs). Hardwoods make up 45% of plantation-grown pulp logs; softwoods provide 55% of the plantation pulp log supply and 98% of sawlogs. Plantations are developed mainly for timber production and managed as businesses, so the timing and volume of harvest are determined primarily by market forces.

The National Plantation Inventory has developed a forecast of potential future timber supply from existing plantations (Figure 41).[5] 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 are less reliable. The proportion of the total volume suitable for sawlogs is particularly difficult to estimate accurately.

Total wood production from softwood plantations is expected to plateau by 2010. Most of the hardwood plantations are immature: wood production from them will increase substantially in the next few years from about 2 million cubic metres per year in the period to 2004 to over 14 million cubic metres per year from 2010.

Figure 41: Forecast plantation log supply, Australia, 2005 to 2049



Source: National Plantation Inventory

References

ANZECC (2001), Driscoll et al (2000), EPA WA (2007), Forestry Tasmania (2007), NFI (2003) (list at the back of the report).

Web resources

Case study 19: Reduction in sustainable yield in Western Australia (including Figures 42–44)

Case study 20: Responding to sustainable yield challenges in Victoria

Victoria has continued to develop its capacity to adapt to changes in sustainable yield caused by reduced resource availability arising from changes in tenure, other management restrictions, wildfire and improved resource information.

In response to an independent analysis of timber resources,[6] the Victorian Government released a policy statement called *Our Forests, Our Future* in February 2002 to ensure the sustainability of the state's native forests and the timber industry communities they support. The major components of the initiative are:

- a 31% reduction in logging across the state
- an $80 million assistance package, which includes funding for a voluntary licence reduction program and a workers' assistance package
- new legislation to ensure resource security
- independent forest auditing
- the establishment of a new commercial entity, VicForests, to help separate commercial forestry objectives from the policy and regulatory functions of government and to ensure that the logging industry is managed efficiently.

Legislation developed under *Our Forests, Our Future* came into effect in 2004 as the *Sustainable Forests (Timber) Act 2004*. Among other things, the Act provided for the development of a Sustainability Charter in 2006. The charter sets out objectives, consistent with both the Montreal Process for sustainable forest management and the National Principles of Ecologically Sustainable Development, for the sustainability of public native forests and the sustainability of the timber-harvesting industry on public land.

The charter sets the future direction for sustainable public native forest management in Victoria and commits the Department of Sustainability and Environment and VicForests to respond to and support the objectives set out in the charter.

VicForests, which is responsible for sustainable timber harvesting and commercial sale in eastern Victoria, will develop initiatives and targets to ensure that progress is made in conforming to the charter, include the initiatives and targets in its statement of corporate intent, and report on their outcomes as part of its normal business reporting. In this way, both the department and VicForests will work towards achieving the government's vision for sustainable forest management.

Our Forests, Our Future and other initiatives, such as *Growing Victoria Together*, *Our Environment, Our Future* (Victoria's environmental sustainability framework created in 2005) and the *Sustainable Forests (Timber) Act*, demonstrate and strengthen the Victorian Government's commitment to regional communities and the sustainable management of Victoria's state forests. Performance will be communicated through five-yearly state of the forest reports and regular third-party auditing.

Source: DSE (Vic.)

6 www.dse.vic.gov.au/DSE/nrenfor.nsf/FID/-1D47A25DE8DAA3C24A256B670015BEED?OpenDocument

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

- A number of non-wood native forest species are subject to commercial harvesting regimes. Some species are significant in terms of value, quantity or both.
- Permits are usually required to harvest native plant and animal products from forests, although the requirements for permits may differ by jurisdiction and land tenure. All Australian states and territories have legislation restricting the harvest of threatened species.
- Indigenous Australians rely to varying degrees on the use of non-wood forest products for customary (e.g. food and medicine) and commercial (e.g. arts and crafts) purposes.
- Approaches to assessing the sustainability of the Australian non-wood forest product sector are being developed. Adaptive management plans are in place for native species subject to significant harvesting to assist regulators in managing for sustainability.


Michael F. Ryan

Stripping cork bark.

This indicator examines the extent to which sustainable harvest of non-timber products from forests is being achieved. It also discusses the legislative process related to non-wood harvest.

Non-wood forest products (products of biological origin other than wood derived from forests) include hundreds of products that are generated directly or indirectly from organisms living in forest ecosystems. They include landscape and garden products, health and personal care products, food products, and decorative and aesthetic products. For convenience, wood-based products, such as wood carvings and aromatic items produced from sandalwood (*Santalum spicatum*), are also considered in this indicator.

The sustainable management of non-wood forest products is essential both for the conservation of the species subject to harvesting and for maintaining the livelihoods of people dependent on them. Research on the ecological sustainability of the non-wood forest product harvest has grown rapidly over the past two decades, but mostly in the form of studies specific to certain species or regions. Approaches to assessing the sustainability of the Australian non-wood forest product sector are being developed.

Direct harvest of forest flora and fauna

Table 36 gives examples of the kinds of non-wood products harvested from Australian forests. These products provide income for many Australians; moreover, communities of Indigenous people in the Northern Territory may be at least partly dependent on them as a source of food and income.[7]

7 Altman and Taylor (1989).

Table 36: Examples of non-wood forest products produced and used in Australia

Category	Examples
Landscape and garden products	Transplants (tree, shrubs, wildflowers, grasses), mulches, soil amendments, seed
Health and personal care products	Essential oils, herbal health products, fragrances
Food products	Mushrooms, herbs, berries, seeds, teas, flavouring agents, honey
Animal products	Meat, skins, eggs
Decorative and aesthetic products	Specialty wood products, Christmas trees, foliage, cones, wildflowers, tannins, dyes
Indigenous products	Bark paintings, wooden sculpture, weaving, pigments and dyes, subsistence products

Permits are usually required to harvest native plant and animal products from forests, although the requirements for permits differ between jurisdictions and across the various land tenures within each jurisdiction. All Australian states and territories have legislation restricting the harvest of threatened species across all land tenures (see Appendix E). Threatened species of national environmental significance are also protected under Australia's *Environment Protection and Biodiversity Conservation Act 1999*. Among other things, the Act regulates the commercial export from Australia of most wild-harvested native plants and animals and their derivatives. The export of some species, such as cycads, and crocodile products are also subject to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

The natural abundance of several species, such as sandalwood in Western Australia, has been reduced by clearing for agriculture and pastoral activities (specifically, grazing by introduced herbivores). Other species, such as the saltwater crocodile and cycad species, have been listed in CITES appendixes because of poor management practices in the past or the unsustainable management of similar species internationally. In Australia, the management of certain species has enabled their continued harvest without deleterious effects on the species as a whole. Indicators 6.1b and 6.1d include case studies on saltwater crocodiles and sandalwood, respectively.

Flora

The removal of native plant products from Australian forests for commercial purposes is subject to regulations enforced by government agencies. Factors that influence harvest sustainability 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 timber production or grazing); variations in harvest methods; remoteness from human settlements; and variations in land-use context or environmental factors.

A growing number of non-wood plant product industries are subject to sustainability assessments. In Tasmania, for example, tree or man ferns (*Dicksonia antarctica*) have been harvested for many years for transplanting in public and private gardens. This practice was largely unregulated until 2002, when the Tree Fern Management Plan was formulated and additions were made to Tasmania's *Forest Practices Act 1985* to improve the sustainability of the industry. As a result, harvested tree ferns must now be tagged with a 'Tasmanian tree fern' tag. The fees levied on the tags are used to fund the industry's self-regulation and monitoring, as well as research into the sustainable management of the species.

Case study 21 describes the approach being taken to the harvesting of cycads in the Northern Territory.

Fauna

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 those species considered to be common, and in most cases requires a permit. Permits are usually only issued for a species after a detailed sustainability analysis. The 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 likely to adversely affect the species.

Many species of kangaroo are harvested commercially for meat and skins. Annual national quotas are set for each species by the relevant state agencies and endorsed by the Australian Government Department of the Environment, Water, Heritage and the Arts under delegated authority provided via approved species management plans approved by the responsible minister. The annual harvest quotas are percentages of the estimated populations based on direct population monitoring. In some states, subquotas are then set regionally and allocated to individual property holders on a permit basis. In all states, a sealed tag must be attached to each carcase before it can be processed.

Exotic fauna species are also harvested in Australia for meat and skins. Many of these species, such as pigs, goats and water buffalo, are officially declared pests that adversely affect forest health. For these species, the harvesting rate is usually determined by forest management rather than by ecological sustainability criteria. The live export of water buffalo from Arnhem Land is the subject of a case study in Indicator 6.1d.

Indigenous harvest, including traditional use

Indigenous Australians harvest wildlife for both traditional and commercial purposes. Non-wood Indigenous forest products include carvings, bark paintings, wooden sculpture, weaving, pigments and dyes, and subsistence products used for food and ceremonial purposes.

The sustainable use of non-wood forest products 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.[8] Despite the importance of the non-wood forest product harvest to the conservation of particular species and the livelihoods of many Indigenous communities, few studies have attempted to assess its size and impact. However, one survey that looked at the Indigenous use of wood for carving in central Arnhem Land found the practice to be sustainable despite a steep increase in output.[9] Indicator 6.1b includes a case study on the Indigenous arts and crafts industry.

References and further reading

Altman (1987), Altman and Taylor (1989), Belcher et al (2005), Davies (2005), Griffiths et al (2003), Koenig (2007), Marrfurra et al (1995), Puruntatameri et al (2001), PWCNT (1997), PWSNT (2003, 2007), Raymond et al (1999), Russell-Smith et al (1998) (list at the end of the report).

Case study 21: The sustainable harvesting of cycads

Researchers in Arnhem Land in the Northern Territory assessed the wild harvest of the native cycad (*Cycas arnhemica*), an understorey plant in tropical eucalypt savannas. All Northern Territory cycads are listed in CITES Appendix II, which means that they can only be traded under an approved management plan that meets specified standards for impacts on wild populations. In 1997, the Parks and Wildlife Commission of the Northern Territory introduced a management program for cycads that allows seed and leaf harvest and makes provision for the limited harvesting of adult stems. The plan was modified in 2000 to allow experimental non-salvage harvests of a number of native cycad species, including *C. arnhemica*.

Based on this management program, replicated harvest treatments were monitored for two years to determine the effects of wild harvest and environmental factors such as fire frequency and disturbance by feral animals on cycad survival, recruitment and stem growth. Researchers suggested that the wild harvest of the species would have minimal impact if it focused on juvenile stems and if the return time (the time before next harvest) was extended to 15–40 years.

The outcomes of this and other research were taken into consideration by the Northern Territory Government in formulating the management program for cycads for the period from 2003 to 2008, allowing annual wild harvests not exceeding 5% of the population, assessed on a case-by-case basis.

Sources: Griffiths et al (2003), PWCNT (1997), PWSNT (2003, 2007)


John Davidson

Tree or man ferns (*Dicksonia antarctica*).

8 Altman and Taylor (1989).

9 Koenig (2007).

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

- Relevant jurisdictions have codes of forest practice and other regulations 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.
- Reported regeneration success rates in multiple-use public native forests are high. In plantations, success rates are generally above 90%.
- Remedial action is carried out in areas where specified standards are not achieved.
- The regeneration rates reported for Victoria and Tasmania are equal to or exceed those reported in SOFR 2003, but no comparisons were possible for other jurisdictions.

The term 'forest regeneration' usually refers to new trees that establish in a forest after timber harvesting, fire or other causes have removed some or all trees from the forest overstorey. This indicator provides information on the area of native forest regenerated each year after harvesting, the proportion of the total area of harvesting this represents, and the success of the regeneration effort for Tasmania, Victoria, New South Wales and Western Australia, where significant volumes of wood are harvested in native forests. It also reports on the area of plantations replanted after harvesting and the success of the replanting effort.

Native forest regeneration

The relevant jurisdictions 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 harvest, although the period is longer in some jurisdictions. Further treatments are carried out if regeneration standards are not met. The definition of, and standard for, effective regeneration varies between jurisdictions, but all aspire to the full stocking of the site.

Managers of multiple-use public forests are required by codes of forest practice and other regulations to measure the effective regeneration (e.g. by stocking, density and species composition) of areas harvested for timber production and to report the results publicly. Regional differences in forest type, climatic and biophysical conditions and management objectives mean that each jurisdiction has its own method for assessing the success or effectiveness of regeneration. While assessment techniques are well developed in even-aged native forests, they are less so in multi-aged stands, where there may be trees of markedly varying age and height. Prescribed fire and site disturbance are employed to encourage regeneration in many multiple-use public native forests.

In New South Wales, the effective regeneration for the period from 2000–01 to 2004–05 was generally over 80% (Table 37). The impact of drought has been a significant factor in the regeneration of some forests because successful regeneration requires adequate soil moisture for seedling establishment. Wildfires have also affected regeneration in some forests. Further silvicultural treatment is undertaken to meet specified standards wherever feasible.

Table 37: Area of multiple-use public native forest effectively regenerated, New South Wales, 2001–02 to 2005–06

Year	Total area effectively regenerated (ha)	Proportion of total harvested area effectively regenerated (%)
2001–02	5,215	68
2002–03	10,076	87
2003–04	10,044	86
2004–05	4,670	83
2005–06	3,870	74

Source: Forests NSW

In Victoria, the area of even-aged multiple-use public native forest regenerated after harvesting is reported only up to 2000–01 because of a 4–5-year lag between regeneration treatment and assessment. Table 38 shows results from initial regeneration treatments for the period from 1996–97 to 2000–01; under the state's code of forest practice, a harvesting coupe that does not meet the minimum standard is re-treated so that, over time, the harvested area is effectively restocked. The data in Table 38 compare favourably to those reported in SOFR 2003 for the period from 1993–94 to 1996–97.

In Western Australia, the Forest Management Plan 2004–13, which covers all the main timber production areas in the state's southwest, and supporting guidance documents such as the *Silvicultural Guidelines* require that regeneration success and effective stocking rates be monitored in publicly owned forests. In the mixed-age jarrah 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 will require remedial action. Similarly, in karri 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 given standards. Key performance indicators have been developed for the public reporting of the timeliness and effectiveness of regeneration.

Forestry 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, 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. In the period from 1998–99 to 2005–06, the standard was achieved on 95% or more of regenerated areas (Table 39), well above the target of 85%. These results are similar to or slightly better than those reported in SOFR 2003 for the period from 1994–95 to 1997–98.

Under the Tasmanian code of forest practice, sowing and planting mixtures must approximate the natural composition of the canopy trees of the harvested forest. 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 standard are considered.

Table 38: Area of even-aged multiple-use public native forest effectively regenerated, Victoria, 1996–97 to 2000–01

Year	Total area treated (ha)	Total area effectively regenerated (ha)	Proportion of total harvested area effectively regenerated (%)
1996–97	6,650	5,050	76
1997–98	5,590	5,140	92
1998–99	6,730	5,820	86
1999–2000	5,820	5,210	90
2000–01	2,350	2,150	92

Source: Department of Sustainability and Environment (Vic.)

Table 39: Percentage of regenerated native forest meeting stocking standards in Tasmanian multiple-use public native forest, 1998–99 to 2005–06

Reporting year	Regeneration year – eucalypt clearfelling and partial logging	Regeneration year – rainforest/blackwood swamp	Total area treated (ha)	Total area that achieved standard (ha)	% area meeting standard
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

Source: Forestry Tasmania

Certified native forest regrowth stand, Tasmania.

Plantation re-establishment

The size of Australia's plantation estate is increasing as areas are replanted after harvesting and new plantations are established, almost all on cleared agricultural land. The decision to re-establish plantations depends on factors such as site suitability, grower intent, market availability and alternative land uses, particularly for plantations funded through private investment.

In Tasmania, conditions for plantation re-establishment were generally favourable over the reporting period. About 40,700 hectares of harvested plantations was replanted and only 1,730 hectares was converted to other uses, a conversion rate of about 4% (Table 40).

The choice of species deployed in re-established or new plantations varies. In 2006, hardwood plantations accounted for 86% of new plantation areas established in Australia.

State agencies and most private growers have internal management systems to assess plantation regeneration or re-establishment stocking levels and prescribe remedial treatment. Where plantations are re-established, the level of stocking is usually close to 100%: for example, in South Australia the proportion of plantations restocked effectively was 98–100% between 2001–02 and 2004–05 (Table 41). Results in other jurisdictions and in private plantations vary but are consistently high for both softwood and hardwood plantations.

References

Forest Practices Authority (1996–2006), Forestry Tasmania (2001–2005) (list at the back of the report).

Table 40: Area of public and private plantation forest harvested and proposed for re-establishment or converted to non-forest land use, Tasmania, 2000–01 to 2005–06 (hectares)

Year	Clearfelled, followed by plantation re-establishment	Clearfelled, followed by conversion to non-forest use
2000–01	5,230	90
2001–02	5,350	360
2002–03	7,740	130
2003–04	8,250	420
2004–05	6,550	220
2005–06	7,590	510
Total	40,710	1,730

Source: Forest Practices Authority (Tas.)

Table 41: Softwood plantation establishment in South Australian public plantations, 2001–02 to 2004–05

Year	Total area treated (ha)	Total area effectively replanted (ha)	Proportion effectively 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

Source: ForestrySA

New plantations established during the reporting period are mainly hardwood eucalypts. Stocking levels achieved are usually above 90%.

Criterion 3

Maintenance of 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, including pests, diseases, salinisation, soil acidification and climate change. The second assesses the area of forest burnt by planned and unplanned fire.

Key findings

Threatening processes

- Drought affected large areas of Australia during the reporting period, with significant impacts on forest health in several regions. Drought contributed to a series of intense wildfires that affected large areas of forest in southeastern Australia.
- Predicted changes in climate, including increased temperatures and lower moisture availability, could make forests more susceptible to pests, diseases, fire and other pressures.
- Damage to forest ecosystems from most native insect pests and pathogens is usually widespread and of low severity. Occasional outbreaks and epidemics occur and the resultant damage can adversely affect commercial values, particularly in plantations.
- Several exotic organisms that pose a threat to Australian forests have moved closer to Australia's shores, increasing the importance of effective quarantine.

Fire

- The estimated area of forest burnt in the period from 2001 to 2006 was 24.7 million hectares; an estimated 20.0 million hectares was burnt in unplanned fires and 4.7 million hectares was burnt in planned fires.
- Fire is an important forest management tool in Australia because many forested ecosystems are ecologically adapted to fire and require it for regeneration.
- There is evidence that global climate change may exacerbate the risk of fire and cause the window of opportunity for planned fires to shift and narrow in southeastern Australia.

Fire in a pine plantation near a log dump, Tumut, New South Wales, December 2006.

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

- Drought affected large areas of Australia during the reporting period, with significant impacts on forest health in several regions. Drought contributed to a series of intense wildfires that affected large areas of forest in southeastern Australia.
- Predicted major changes in climate, including increased temperatures and lower moisture availability, could make forests more susceptible to pests, diseases, fire and other pressures. The productive capacity of the principal timber production forests (both native and plantation) could decline in the medium term.
- Several exotic organisms that pose a threat to Australian forests have moved closer to Australia's shores, increasing the importance of effective quarantine. The European house borer, which infests seasoned coniferous timber and can cause structural damage to houses, has been detected in Perth and steps have been taken to control its spread.
- Damage to forest ecosystems from most native insect pests and pathogens is usually widespread and of low severity. Occasional outbreaks and epidemics occur and the resultant damage can adversely affect commercial values, particularly in plantations.
- Chemical pest and disease control methods used in forest plantations are highly regulated, and the quantity of pesticides used is estimated to be less than 1% of the total Australian market.

This indicator addresses the factors affecting the health and vitality of Australia's native forests and plantations and considers the impacts of vertebrates, invertebrates, pathogens, weeds, drought, soil acidification, climate change and other potentially damaging agents. The active management of these agents in forests is directed principally towards protecting commercial values in multiple-use public and private native and planted forests and, in all forests, biodiversity and other forest values. Many pests and diseases, particularly native ones, show cyclical patterns of impact and are generally of minor concern.

Limiting the introduction of new exotic pests and pathogens is the goal of biosecurity and quarantine measures. Specific plans have been prepared for several threats, including fire ants, guava rust and pine pitch canker (Case study 23 refers to red fire ants).

As with most agricultural enterprises, plantation forestry uses pesticides for crop protection and to improve production under the same system of regulation that applies to all other Australian chemical pesticide users. In 2003–04, the Australian forestry plantation sector was estimated to constitute less than 1% of the total Australian chemical pesticide market, including household and agricultural use.

Where chemicals are used to control pests and diseases, only authorised chemical ingredients are used and manufacturers' instructions on mixing and application are required to be strictly followed. Chemicals are applied using both ground-based and airborne application systems. To minimise spray drift, strict guidelines determine when spraying can be carried out. Forest management agencies are working continuously towards minimising chemical use and finding more targeted and environmentally benign active ingredients or non-chemical methods of control.

River regulation, extreme climatic events, salinisation, soil acidification and climate change also affect Australia's forests and are sometimes precursors to poor forest health.

Vertebrates

Animals can damage forests, for example by browsing and ringbarking juvenile and mature vegetation, contributing to soil erosion, competing for food and habitat, and predating on native fauna. Table D1 in Appendix D lists, by jurisdiction and tenure, the vertebrate animals that have destructive impacts in Australian forests and estimates the severity of those impacts.

Native species

Kangaroos, wallabies and possums can 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 South Australia, the impact of kangaroos has increased compared to the SOFR 2003 reporting period, the impact of wallabies has declined and the impact of possums has remained the same.

Exotic species

At least 80 introduced animal species have established wild populations in mainland Australia. Some of those species, such as rabbits, foxes, pigs and cats, have become major pests in forests and the environment generally.[1] Foxes have a high adverse impact in forests in all mainland states and territories except the Northern Territory, while cats are also a significant problem in many jurisdictions. Pigs continue to have an adverse impact in Western Australia. Cane toads continue to be a problem in Queensland and have moved westwards into the Northern Territory and southwards into northern New South Wales. Exotic birds are a problem in the Australian Capital Territory and Queensland.

Invertebrates

Australia's native forests and eucalypt plantations are regularly browsed by a wide range of native insects, including leaf-chewing chrysomelid beetles, scarab beetles, sawflies, leaf skeletoniser moth larvae, and sapsucking psyllids. Infestations are sometimes severe and repeated, but control programs have generally been conducted only in plantations where attacks may result in reduced growth and poor form. Eucalypts are generally resilient and able to rejuvenate their foliage once infestation subsides, often as a result of native predator activity. Many outbreaks are also cyclical. Table D2 in Appendix D lists, by jurisdiction and tenure, the invertebrate animals that have destructive impacts in Australian forests and estimates the severity of those impacts.

Species of the chrysomelids *Paropsis* and *Paropsisterna* (formerly *Chrysophtharta*) cause damage in eucalypt forests and plantations Australia-wide. Their prevalence appears to have increased since SOFR 2003 in South Australia, Victoria and Western Australia, probably at least partly due to the growth in the total area of eucalypt plantations. Integrated pest management programs have been developed to minimise the effects of these pests.

Autumn gum moths (*Mnesampela privata*) are present in most states and territories and cause widespread damage to juvenile or young adult eucalypt foliage: young larvae skeletonise the leaf and older larvae eat the whole leaf, rapidly defoliating trees. Since SOFR 2003, autumn gum moths have become more of a problem in Victoria and South Australia. Broad-spectrum insecticides are sometimes used to control this insect in young plantations, but also reduce populations of beneficial predator insects.

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 as a result. Regional outbreaks tend to occur on a 5–10-year cycle. In plantations, impacts are not usually severe and control measures are generally unnecessary. The episodic impact of this insect increased in Western Australia in the SOFR 2008 reporting period compared to SOFR 2003.

Wingless grasshoppers can cause total defoliation in young eucalypt plantations, particularly during periods of drought, and have been significant pests in several states; recent prolonged drought led to an upsurge in severity in Western Australia and South Australia. The Australian plague locust had a widespread and severe impact in New South Wales during the SOFR 2008 reporting period.

Pests of exotic pine plantations that can reduce commercial productivity include the pine-killing wood wasp (*Sirex noctilio*), the Monterey pine aphid (*Essigella californica*), and the five-spined bark beetle (*Ips grandicollis*). *Sirex* usually attacks stressed trees, and numbers high enough to cause significant damage generally do not develop in vigorous, healthy stands. In the past, however, serious *Sirex* outbreaks have killed several million trees in *Pinus radiata* plantations in several states. The National Sirex Control Strategy encourages an integrated pest management approach that aims to keep *Sirex* wasp populations low by maintaining and releasing virulent strains of the nematode *Beddingia siricidicola*, as well as a range of parasitoid wasps, as biological controls, and by encouraging optimal

Common brushtail possum (*Trichosurus vulpecula*).

1 Hart and Bomford (2006).

plantation thinning practices and site selection to minimise the occurrence of stressed trees in areas at risk. Since it first entered Tasmania in the 1950s, *Sirex* has spread slowly through Victoria, South Australia, New South Wales and the Australian Capital Territory but has not yet been observed in Western Australia, Queensland or the Northern Territory. The extent and severity of *Sirex* attacks increased in New South Wales and Victoria during the SOFR 2008 reporting period compared to SOFR 2003. Regular trapping and surveillance programs monitor *Sirex* levels, and controls are implemented to avoid major outbreaks. Only a small number of individual, already suppressed trees are killed by *Sirex* under the optimal control practices in place in major plantations. Under the recent drought conditions, the incidence of *Sirex* and *Ips*-related tree deaths began to increase in southeastern Australia.

The Monterey pine aphid, which infests a range of pine species, was first observed in Australia in 1998 but was probably already in the country for some time by then. It has since been detected in most pine-growing areas in all states, but the biggest impacts have been in Victoria and New South Wales. In Victoria, the aphid is now widespread and having an adverse impact. Aphid levels are regularly monitored in most states using standard foliage-beating methods during surveys.

The five-spined bark beetle is the most serious pest among several exotic pine bark beetles that have been introduced accidentally from the northern hemisphere; it is able to infest all plantation pine species grown in Australia. The beetle has been present in Australia for at least 60 years and occurs in all mainland states and the Australian Capital Territory but is absent from Tasmania and the Northern Territory. Pheromone traps are used in some states to monitor beetle presence and numbers. Population levels build primarily on fresh logging debris or in damaged (e.g. after fire) or severely stressed standing trees. 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*. A range of parasitoids has been introduced into Australia to limit beetle numbers. Western Australia reports that the severity of *Ips* infestation has increased since SOFR 2003.

Australian sawfly (*Perga* sp.) larvae.

The European house borer (*Hylotrupes bajulus*) was first detected in Western Australia in 2004. This insect is a destructive pest of seasoned coniferous timber, including pine and oregon, and can cause major structural damage to buildings. Several measures are being taken to contain and, if possible, eventually eradicate this pest. For example, regulations were introduced in Western Australia in 2006 to control the movement of seasoned pine. Surveys are conducted regularly to detect new infestations, ways to better detect the pest are being developed, infested materials are removed and destroyed, and a communication program is under way to inform the general public and the building industry about the pest.

Fire ants (*Solenopsis invicta*) are another serious potential pest in Australia. Since they were first detected in Queensland in 2001, a major program has successfully controlled their spread (Case study 23).

Weeds

Species such as blackberry (*Rubus fruticosus*, *Rubus* spp.), lantana (*Lantana camara*) and brome grasses (*Bromus* spp.) compete with native flora and can become locally dominant, reducing biodiversity and other values; they can also interfere with commercial forest plantations impacting on access as well as tree growth and product yield. Table D3 in Appendix D lists, by jurisdiction and tenure, the exotic plants that are regarded as weeds in Australian forests and estimates the severity of their impact. Several exotic plants common in Australian forests are included in the Weeds of National Significance Program under the National Weeds Strategy.

Blackberries occur in all Australian states and the Australian Capital Territory and are the single most widespread pest plant threat across southern and eastern Australia, mainly in regions with an annual rainfall of more than 750 millimetres. The area of forest affected by this weed is not known nationally. Blackberry in forests is mostly controlled by herbicides.

Lantana is a shade-tolerant invasive pest plant which develops dense shrubby thickets that can overwhelm native species. It affects over 4 million hectares of land, predominantly in coastal forests extending from far north Queensland to southern New South Wales but also, to a lesser extent, in parts of the Northern Territory, Western Australia and Victoria. The weed is gradually spreading inland, and its impact in both multiple-use native forests and nature conservation reserves in New South Wales is now particularly severe. Whole ecosystems and many species are affected and some are threatened by this species. It causes major reductions in invertebrate and avian biodiversity and, among other things, can lead to a reduction in the recruitment of native plant species. Integrated pest management measures include the use of biological control agents such as introduced sap-sucking insects and a fungal leaf rust.

The invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*) and boneseed (*C. monilifera* subsp. *monilifera*) is listed as a key threatening process in New South Wales. Bitou bush primarily invades dune vegetation systems and is found along more than 80% of the state's coastline. However, it also encroaches on coastal forest and woodland communities on the sand-dune fringes, where it affects numerous threatened species, plant communities and native animal habitats. Biological methods have proved to be of limited value in controlling the infestation of the bush, which has no known effective predators. A management regime being tested in southern New South Wales includes a spray–burn–spray cycle. In Queensland, the only significant occurrence of bitou bush is in areas in the southeast; control programs generally consist of removal by hand. The closely related boneseed is more widespread across different environments; it is found in southern New South Wales, Victoria, Tasmania and southeastern South Australia. Boneseed is an invader of a range of forest types and is spread by seed. Biological controls have so far been unsuccessful in Australia, and eradication efforts tend to involve uprooting and burning.

Willows (*Salix* spp.) have invaded many forested parts of southern Australia, mainly along watercourses; the Australian Capital Territory, New South Wales, Tasmania and Victoria are the jurisdictions most affected. Guidelines for the identification and eradication of particular willow species from inappropriate environments have been prepared in a range of jurisdictions and programs are under way. Camphor laurel (*Cinnamomum camphora*), which was introduced to Australia in 1822 as an ornamental tree, is especially invasive of moist stream banks and disturbed rainforest in eastern Australia, reducing light penetration and crowding out native species.

Measuring the effects of pest plants on forest productivity and biodiversity on a regional, state or national scale is still problematic. Coordinating data collection across jurisdictions and forest types, and separating forest and non-forest data remain major challenges.

Pathogens

With the exception of the soilborne and waterborne root-rotting pathogen *Phytophthora cinnamomi*, which is widely considered to be introduced, native forests and plantations of native tree species are affected significantly only by indigenous plant pathogens, whereas the most damaging agents in exotic plantations are usually exotic (Table D4 in Appendix D). *P. 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 more than 600 millimetres of annual rainfall. The pathogens' most significant impacts are on the biodiversity of flora and fauna, but quantitative nationwide data are limited in their capacity to distinguish the area and impacts in forests from those in non-forest vegetation types, such as heathlands. As many as 2,000 of the estimated 9,000 native plant species in southwestern Western Australia

Myrtle wilt (*Chalara australis*) is a fatal disease of myrtle beech (*Nothofagus cunninghamii*).

are susceptible to *P. cinnamomi*. *Phytophthora* is listed as a 'key threatening process' in the *Environment Protection and Biodiversity Conservation Act 1999*, and a national threat abatement plan for the pathogen was released in 2001. *P. cinnamomi* spread is controlled with hygiene protocols to limit the movement of soil and water and the use of management zones for the protection of threatened flora. Forestry, national park and local agencies in many jurisdictions have implemented plans to restrict pathogen spread. In Western Australia, intensive monitoring is undertaken to identify the distribution of the disease in commercial forests and conservation areas and to help in the designation of 'disease risk areas' in which special measures apply to minimise the risk of infection.

A wide range of chronic or episodic crown dieback syndromes, often causing significant tree mortality and associated impacts on ecosystems, occur to some degree in native forests in all states and territories. They are usually caused by combinations of factors such as climatic stress, poor 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 *Cryphonectria 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 problematic 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 southeast 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; recent work suggests

that the symptoms of Mundulla yellows are actually the symptoms of a lime-induced chlorosis.[2]

Defoliating diseases have become more prevalent as the native hardwood plantations have expanded. Outbreaks tend to be cyclical in response to such factors as local climatic conditions, age and the genetic composition of plantations. While few fungal leaf diseases of eucalypts are economically damaging in commercial or environmental plantations, significant exceptions include several species of the native genus *Mycosphaerella*, the most serious being *M. cryptica* and *M. nubilosa* in young blue gum (*Eucalyptus globulus*) and shining gum (*E. nitens*) plantations in southern Australia, *Cylindrocladium quinqueseptatum* in young eucalypt plantations in northern Queensland, and *Quambalaria pitereka* in young spotted gum (*Corymbia* spp.) plantations in humid areas of New South Wales and Queensland. Such diseases are less debilitating in natural forests, where inoculum levels are usually low. Control measures in plantations include selecting genotypes for their genetic resistance to these foliar pathogens.

Root and butt rots caused by *Armillaria* species, most significantly *A. luteobubalina*, in eucalypt forest in southern Australia and southwestern Western Australia cause small patch deaths of a range of plant species. Similarly, *Rigidoporus vinctus* and *Phellinus noxius* kill 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. However, the distribution of these pathogens is usually localised and limited control measures are being implemented.

Various species of native gall or phyllode rust fungi (*Racospermyces* and *Uromycladium*) affect *Acacia* species across a wide range of land tenures and forest ecosystems, sometimes with severe defoliation and effects on form as well as tree death. The effects in natural stands are usually ephemeral; on the other hand, impacts in plantations such as those of *A. mangium* in northern Australia have led to investigations into disease resistance.

In areas where climatic, topographic and stand conditions are suitable, the exotic needle-cast fungus *Dothistroma septospora* can cause severe needle loss in radiata pine (*Pinus radiata*) plantations up to 15 years of age and can have a significant impact on tree growth. First recorded in Australia in 1975, the fungus is most prevalent in the Walcha district of New South Wales and small areas of southeastern Queensland, but is sometimes also significant in parts of Tasmania. Stand thinning is used as an ameliorative measure, but aerial spraying with low concentrations of fungicide is also occasionally carried out. The disease has not been observed in South Australia and has had little impact in Western Australia. The incidence of needle blight has been relatively low for the past decade because of drought conditions over much of the radiata pine estate. Disease-resistant stock is being used to reduce disease impacts in highly prone locations in northern New South Wales. In most jurisdictions, the fungus *Diplodia pinea* (formerly *Sphaeropsis sapinea*) is associated with dying crowns and occasionally significant mortality in radiata pine, usually on drought-prone sites. Needle-cast associated with the fungus *Cyclaneusma minus* also occurs in pine-growing regions, including in New South Wales and South Australia.

River regulation

River regulation – controlling or modifying the natural flow of a river or stream – is a widespread practice in Australia, most commonly through the use of dams. It occurs for a number of reasons, including to store water for irrigation, hydropower generation and urban and rural water supply, and to divert water to other catchments. Regulation can have long-term ecological impacts on wetlands; for example, it affects normally periodically inundated forest lands such those populated by river red gum (*Eucalyptus camaldulensis*). The health of large stands of *E. camaldulensis* in the Deniliquin region has been affected by significant moisture deficits caused by a combination of drought and water regulation.

Salinisation

Dryland salinity is a widespread and growing problem in Australia. It affects biodiversity, agricultural and forest productivity, and regional and urban infrastructure such as water supply, roads and buildings.

Dryland salinisation occurs predominantly on cleared agricultural land and also affects adjacent forests. A contributing factor is the widespread clearing in the past of deep-rooted native tree species, which has caused watertables to rise, thereby mobilising salt in the soil. Increased concentrations of salt and the waterlogging of soils adversely affect plant growth and survival and can affect animal populations. Biodiversity is under threat in some areas as a result of salinisation, but catchments that are still largely forested are probably at less risk.

Salinity monitoring programs exist in most states. Rehabilitation and salinity management are often a joint effort between government and communities and may involve various strategies such as tree planting, the regeneration and maintenance of native vegetation, and strategic water usage and redirection, including pumping.

Soil acidification

In natural ecosystems, the acidification of soils is a gradual process. Australia's soils are old and highly weathered and can be naturally quite acidic, both at the surface and deep in the profile; surface and subsoil acidity occurs in all Australian states and territories and affects an area up to nine times that affected by dryland salinity. The largest areas of acid soils are in New South Wales, Western Australia, Victoria and Queensland.[3]

2 Parsons and Uren (2007).

3 NLWRA (2000).

Cyclone damage, Northern Territory.

Accelerated soil acidification is a serious soil degradation problem. When soils and sediments containing iron sulfides are drained or disturbed, sulfuric acid is formed. The rate of soil acidification increases when land is developed for agriculture or forestry because such development involves both disturbance and changes to the nitrogen and carbon cycles. The impact of forest plantations on soil acidity has yet to be examined in detail.

The National Strategy for the Management of Coastal Acid Sulfate Soils, which was released in 2000, involves risk mapping; avoiding disturbance of coastal acid sulfate soils; educating stakeholders in the agricultural sectors; policy; planning and development strategies; mitigating impacts when disturbance is unavoidable; and remediation in the form of acid neutralisation, the revegetation of acid scald areas and the modification of drains and floodgates.

Generally, there are insufficient monitoring sites or measurements in soil profiles within forested lands to obtain baselines or trends in soil acidity in forests.

Climatic events and climate change

Drought

Australia is the driest inhabited continent on Earth and has a highly variable rainfall regime. Drought occurs in a cyclical pattern and can extend over several years. In economic terms, it is probably the most costly of all the country's climatic phenomena: it not only causes production losses in native and exotic timber plantations, but often contributes to the severity of fires, dust storms and general land degradation. Additionally, drought-stressed flora are more susceptible to disease and to infestations of insects such as stem borers, and face increased browsing pressure when food sources for fauna become scarce in affected regions. Significant areas of Australia were in severe drought from 2003 to the end of the SOFR 2008 reporting period.

For example, much of the Murray–Darling Basin, the coastal zone of southwestern Western Australia, southern New South Wales, most of Victoria and parts of South Australia experienced serious rainfall deficiencies over a three-year period from January 2004 to December 2006, with some areas receiving the lowest rainfall on record during that period. The drought contributed to the severity of several major fires in eastern Australia (Indicator 3.1b). In addition, stress caused by rainfall deficits has been shown to contribute to tree death in eucalypt savanna in central Queensland,[4] although the scale of drought-related tree death is not known at the national level. Drought also affects the water yield of forests (Indicator 4.1d).

Wind and storm damage

There are no formal means of collecting information on wind damage to forests across Australia, although damage in forest plantations is monitored through systematic forest health surveys. In addition to catastrophic incidents of wind damage caused by cyclones, thunderstorms, winter gales and tornados, the young growing shoots of trees can be blown out, resulting in bud loss, flattened crowns, forks and multiple leaders. This is particularly prevalent at higher altitudes and in exposed areas in winter when there is a combination of snow loading and strong winds.

Climate change

Australia has widely varied climates and ecosystems, including deserts, rangelands, rainforests, coral reefs and alpine areas. The nature of predicted climate change in Australia is complex when spatial and inter-annual variability are taken into account.[5] The climate is strongly influenced by the surrounding oceans: the El Niño – La Niña – Southern Oscillation phenomena produce a sequence of floods and prolonged droughts, especially in eastern Australia. Floods and droughts do not necessarily alternate, and each can occur during longer episodes of the other. The continent is vulnerable to a possible change towards a more El Niño-like state, which is one of the scenarios outlined by the Intergovernmental Panel on Climate Change (IPCC).[6]

Increases in the frequency and severity of tropical cyclones, mid-latitude storms, heavy rain events and droughts are predicted under several climate change scenarios. The IPCC estimates that annual average temperatures in Australia will increase by 1°C by 2030 compared to 1990 and by up to 5°C by 2070, with associated increases in potential evaporation and heatwaves and fewer frosts.

Annual rainfall in the country's southwest could change by between –20% and +5% by 2030 and by between –60% and +10% by 2070; in southeastern Australia, rainfall is projected to change by between –10% and +5% by 2030 and by between –35% and +10% by 2070. In northern Australia and parts of eastern Australia, average rainfall could increase or decrease, depending on locality. When changes in rainfall are combined with increases in potential evaporation due to temperature rises, a general decrease in

4 Fensham and Fairfax (2007).

5 CSIRO and Bureau of Meteorology (2007).

6 CSIRO and Bureau of Meteorology (2007).

Table 42: Definitions of the four main health surveillance and monitoring activities carried out by forest managers in Australia

Activity	Definition
Forest health surveillance	Damage-focused and optimised to detect and then quantify damage (rate incidence and severity in delineated area). Introduced to Australia in 1996–97.
Health/condition monitoring	Tree/forest-focused and optimised to describe the condition of trees and detect change.
Pest population monitoring	Pest-focused and optimised to measure populations of the target pest.
Ad hoc detection	Damage-focused and designed to incur the least cost (for detection). The term 'guided ad hoc detection' is used if forest workers receive training to focus attention on specific pest and disease issues.

Source: Wardlaw et al (2007)

Table 43: Status of health surveillance and monitoring in Australian forests, by jurisdiction

State	Softwood plantations	Hardwood plantations	Multiple-use public native forests	Public nature conservation reserves
Qld	FHS, PM	Ad hoc	Ad hoc	
NSW	FHS, PM	FHS, Ad hoc	FHS, Ad hoc	HM, PM, Ad hoc
Vic.	HM, PM	HM, PM, Ad hoc	HM	
Tas.	FHS, PM	FHS, PM, Ad hoc	Ad hoc	
SA	PM	PM, Ad hoc	Not applicable	
WA	PM	PM, Ad hoc	PM, HM	

Ad hoc = ad hoc detection; FHS = Forest health surveillance; HM = health and condition monitoring; PM = pest population monitoring; (See Table 42 for an explanation of these categories.)

Source: T Wardlaw, pers comm, 2007

available soil moisture is projected across Australia, with droughts likely to become more severe. There is some evidence to suggest that the observed warming trend in Australia has already contributed to an increased severity of drought through higher evaporation and water demand.

Climate change of the magnitude described here could have a profound effect on forests and forest production in Australia. Native forests in many locations are expected to experience more stress due to increased temperatures and lower moisture availability; such forests are likely to become more susceptible to pests, diseases, fire and other pressures.[7] The productive capacity of the principal forest areas (both native and plantation) may decline in the medium term, requiring a restructuring and adjustment of the industry and possibly its geographical relocation.

Forest health surveillance

In many jurisdictions, forest health surveillance is carried out regularly to identify the severity and extent of problems mainly in planted forests where pests, diseases, vertebrates, nutrients and weeds limit growth or affect tree survival. Table 42 lists the four main health surveillance and monitoring activities carried out by forest managers in Australia; Table 43 gives the status of those activities for the main forest types, by jurisdiction. Surveillance is carried out in plantations and multiple-use public forests in three states: Queensland, New South Wales (see Case study 22) and Tasmania. Less intensive monitoring is conducted in South Australia, Victoria and Western Australia. The main monitoring of forest health in public nature conservation reserves in New South Wales is conducted as part of three-yearly 'state of the parks' surveys and on a case-by-case basis. The area of pine plantation subject to forest health surveillance is stable but that of eucalypt plantation has fallen; there has been little uptake by the private sector except in Tasmania. Although forest managers now have a clearer understanding of the purpose of forest health surveillance and its costs are well known, the benefits have not been quantified.[8]

ForestCheck plot, Western Australia.

7 Chakraborty (2005), Garrett et al (2006).

8 Wardlaw et al (2007).

Cane toads (*Bufo marinus*) have expanded their range from Queensland westwards into the Northern Territory and southwards into northern New South Wales.

Outcomes of surveillance

One aim of pest and disease surveillance is to identify resistant/susceptible genotypes. Blue gum provenances with relatively high resistance to damage from autumn gum moths are planted in some regions.

Surveillance indicates that infestations of Christmas beetle (*Anoplognathus* spp.) occur at the interface of forest and cleared land, particularly in river red gum communities in Victoria, but also in blue gum and flooded gum plantations in eastern Australia.

The use of DNA 'fingerprinting' has enabled the detection of a wide range of blackberry genotypes across Australia and will help in the use of biocontrols as part of integrated reduction and control programs. Observations of the Monterey pine aphid suggest that there are differences in genetic predisposition to infestation by the aphid among individual trees.

References and further reading

Chakraborty (2005), CSIRO and Bureau of Meteorology (2007), Fensham and Fairfax (2007), Garrett et al (2006), Hart and Bomford (2006), NLWRA (2000), Parsons and Uren (2007), Wardlaw et al (2007) (list at the end of the report).

Web resources

Case study 24: Guava rust

Case study 25: Pine pitch canker

Case study 22: Forest health surveillance by Forests NSW

Forests NSW regularly carries out forest health surveillance in its plantation forests. Softwood plantations in all regions were surveyed in June–September 2005. Sixty state forests or plantations were surveyed by helicopter, with the majority receiving follow-up ground surveys. The data collected can be used to predict pre-harvested wood volumes in affected stands, adjust management regimes for 'unhealthy' stands (e.g. bringing thinning forward in drought-affected stands), apply fertilisers or weed control to improve the establishment, growth and survival of young trees, control-spray for *Dothistroma*, and increase trap-tree plots in *Sirex*-infested areas.

Routine forest health surveys of hardwood plantations were conducted in the summer and autumn of 2006. Over 110 plantations were surveyed from the ground, some twice, as part of the monitoring program for the psyllid insect *Creiis* sp. Over 50 plantations were surveyed by helicopter in May 2006 and again in July. Such surveys identify important pests and diseases that may be limiting the growth and establishment of eucalypt plantations and that may need further research, as well as certain sites and areas that may have increased health problems. Continued forest health surveys are essential to increase knowledge of known pests and diseases and factors influencing damaging outbreaks of these problems, as well as to increase the ability to detect new diseases and pests (including exotic species).

Source: Forests NSW

Assessing forest health, Badja State Forest, New South Wales.

Case study 23: Red fire ants

The fire ant (*Solenopsis invicta*) was first discovered in southeastern Queensland in 2001 but had clearly entered the country some years earlier. Queensland's Department of Primary Industries and Fisheries found colonies over almost 30,000 hectares of land – and spreading fast.

The fire ant is considered by some ecologists to be the greatest ecological threat to Australia since the introduction of the rabbit and potentially worse than the cane toad. The World Conservation Union lists it among the world's top 100 pest species.

Fire ants have a coppery brown head and body and a darker abdomen. A distinguishing feature of the ant is size variation: a single nest will contain ants ranging in length from 2 millimetres to 6 millimetres. Nests form dome-shaped mounds, up to 40 centimetres high, or occur next to or under objects on the ground, such as rocks, logs and timber. The tops of the nests have no obvious entry or exit holes.

Fire ants pose such a serious threat to the Australian economy and environment and to people's lifestyles that they have been declared a notifiable pest under Queensland's *Plant Protection Act 1989*. A cost–benefit analysis estimated that the ant would cost the Australian economy $8.9 billion over 30 years.

To combat the threat, the $175 million National Fire Ant Eradication Program, funded by all states and the Australian Government, was launched in September 2001. As fire ants have been found almost entirely around the Greater Brisbane area (with a small outbreak near Gladstone), the Queensland Department of Primary Industries and Fisheries has primary responsibility for the program. In other states, high-risk areas such as ports and airports are under active surveillance. The program is the largest of its type ever mounted in Australia and at its peak in the mid 2000s employed close to 650 staff.

The first three years of the program were spent finding the ants and stopping their spread – that is, treating known infestations, detecting new or previously unknown infestations, and minimising the risk of spread to new areas. A massive baiting and surveillance program began with 400 ant-control officers spreading bait on 100,000 properties in Brisbane. The hormone bait targeted the queen, the only ant in the colony that can reproduce.

A recent survey found that 99.5% of all known previously infested properties are now fire ant free. In 2001 it was estimated that there were 65,000 colonies; in 2006 only about 100 colonies were found. Treatment has ceased in some areas but continues in others. All properties in the fire ant infested area are surveyed several times a year. The target area has been reduced to 14,000 hectares.

The final two years of the program will be spent monitoring the treated areas and eradicating small infestations, but total eradication may be some way off.

Source: www2.dpi.qld.gov.au/fireants (accessed July 2007)

Indicator 3.1b

Area of forest burnt by planned and unplanned fire

Rationale

This indicator provides 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 2001 to 2006, the estimated total area of forest burnt was 24.7 million hectares. This estimate was determined using a combination of data on fire extent derived from satellite imagery (for the Northern Territory, Queensland and northern Western Australia) and data supplied by state agencies in New South Wales, South Australia, Tasmania, Victoria and Western Australia.
- Of the total area affected by fire, an estimated 19.5 million hectares was in northern Australia and 5.2 million hectares was in southern Australia.
- From 2000 to 2006, unplanned fires burnt an estimated 20.0 million hectares and planned fires burnt 4.7 million hectares of forest.
- Fire is an important forest management tool in Australia because many forested ecosystems are ecologically adapted to fire and require it for regeneration.
- There is evidence that global climate change may exacerbate the risk of fire and cause the window of opportunity for planned fires to shift and narrow in southeastern Australia.

This indicator reports on the area of planned and unplanned fires in forested landscapes. Unplanned fire is defined as fire started naturally (such as by lightning), accidentally or deliberately (such as by arson) that is not in accordance with planned fire management prescriptions; the terms 'unplanned fire', 'bushfire' and 'wildfire' are used interchangeably here. Planned fire is fire started in accordance with a fire management plan or some other type of planned burning program or bushfire-response procedure, such as fuel reduction (prescribed) burning.

Tools for capturing information on fire management and reporting are increasingly available in some jurisdictions 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 of whether they are planned or unplanned. To support the reporting of this indicator, a nationwide analysis of fire using satellite imagery has been compiled for the first time; it has been used here to estimate fire occurrence in forests in northern Australia, complementing data provided by some states for forests in southern Australia.

Aftermath of a mega-fire, Namadgi National Park, Australian Capital Territory.

Fire as a factor in Australian forests

Fire has been an important factor in Australian ecosystems for millions of years. Many of our plants and animals have evolved to survive fire events, and most Australian ecosystems have developed highly specialised relationships with fire.

The extent and intensity of forest fires vary with latitude and seasonal rainfall. In northern Australia, low-intensity fires may burn over large areas. In the southeastern and southwestern corners of Australia, hot, dry and windy conditions in summer mean that bushfires are often intense and difficult to control. Such fires (sometimes called 'mega-fires') can result in the loss of human life and destroy community assets such as buildings, fences, bridges and power lines; water supplies and standing timber can also be affected. Increased summer temperatures and declining rainfall – such as have been observed during the recent drought – exacerbate the risk of fire and increase the challenges associated with fire management. Fire is rare in the tropical rainforests of northern Australia and in the temperate rainforests, mixed rainforests and wet sclerophyll forests in parts of Tasmania and Victoria, but even those forests can dry out during prolonged droughts and will then burn if ignited.

Impacts on ecological values

The long-term effects of fire on landscapes and biodiversity rarely arise from a single fire, but vary according to the sequence of fire events; this is often called the 'fire regime'. Fire regimes are determined by three factors: intensity (how severe fires are), frequency (how often fires occur) and season (the times of the year in which fires occur).

Plant communities vary in their response to the period of time between fires, as do individual species and plants. Some, such as mountain ash (*Eucalyptus regnans*), may not survive if fires are too frequent because trees are unable to reach maturity and produce sufficient seed before the next fire. Infrequent fires may displace plants that require fire to assist their regeneration, such as most heath species.

Regeneration post-2003 fires, Swifts Creek, Victoria.

However, mega-fires can have a dramatic ecological impact, including the replacement of a multi-aged forest structure with even-aged regeneration, the loss of species that prefer frequently or mildly burnt forest, and the degradation of soils and waterways.

The structure and composition of the savanna forests of the Northern Territory, northwestern Queensland and Western Australia's Kimberley region appear to be the result of a very frequent fire regime, especially where the understorey is dominated by native cane grass *(Zygochloa* sp.). Variations in fire frequency and season in these forests are associated with shifts in structure and the composition of the forest understorey.

There are still many gaps in the understanding of forest fire ecology, partly because of the complexity of the interactions between fire regimes and forest types and the long timeframe over which ecological changes can occur. Most is known about the impacts of fairly frequent (<10-year interval), low-intensity fires in southern eucalypt forests; least is known about the long-term impacts of infrequent, very high intensity fires.

Fire management

Australian bushfire scientists and anthropologists generally agree that, before European settlement, Indigenous people carried out frequent, regular and wide-scale burning, especially in the drier forest types. The net result was a mosaic of burnt and unburnt vegetation patches that limited the extent and intensity of fire under severe weather conditions. European settlers, particularly in southern Australia, attempted to deal with the fire threat with a policy of fire exclusion, under which bushfires were identified rapidly and suppressed where feasible. In some forest areas, that policy was accompanied by strategic burning to reduce accumulated forest fuels in narrow strips adjacent to railway lines, roads, farms and settlements.

A fire-exclusion policy remains in some agricultural districts in southern Australia where the main assets are crops, pasture and domestic stock. In general, however, it has proved unsuccessful in forests. This is partly because ignition (by lightning or humans) is inevitable and partly because bushfires in long-unburnt forests are often impossible to control, even under relatively mild weather conditions and with a large and expert firefighting force.

The lack of success of a fire-exclusion policy led Australian forest managers to adopt prescribed burning as a means of systematically reducing forest fuels in zones across the forest. Many studies in temperate Australia and elsewhere illustrate the effectiveness, within limitations, of prescribed burning in reducing fuel loads, ameliorating subsequent bushfire behaviour and assisting management operations. Other studies have led to modifications in burning practices to maximise their value to biodiversity or to protect particular species or forest types, and to ensure that smoke from prescribed burning does not cause haze in urban areas. While the application of prescribed burning is increasingly

sophisticated, it has also become more costly, and the opportunities for prescribed burns may in future be reduced due to increased climate variability (especially in Western Australia, Victoria and New South Wales). On its own, prescribed burning does not constitute a fire management system; it is only effective as part of a holistic approach that also includes fire prevention and suppression; education and training; research; and law enforcement.

In the tropical savanna, open 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; most areas burn at least once every three years. If fire is suppressed, reduced fire frequency can lead to increased tree and shrub invasion and thickening, 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, and Indigenous land managers are being encouraged to employ traditional early wet season burning techniques that result in reduced fire intensity.

Fire management has been the subject of intense scrutiny in recent years following several severe, large-scale bushfires in southern Australia. Major public inquiries were conducted into fires that occurred in Sydney in 2001; in New South Wales, Victoria and the Australian Capital Territory in 2002–03; and in Victoria in 2006. The severity of the 2002–03 fire season prompted an inquiry into bushfire mitigation and management by the Council of Australian Governments. Among other things, that inquiry recommended the adoption of a bushfire risk management framework and a national program of fire regime mapping.

There is evidence that global climate change may exacerbate the risk of fire and cause the window of opportunity for prescribed burning to shift and narrow in southeastern Australia.[9] Continued scrutiny of fire management regimes can be expected, given the increasing number of people living in bushfire-prone areas and the possible effects of climate change on bushfire occurrence and severity. The continued development of sustainable fire management strategies is therefore both critical and challenging.

Fire and the urban population

Nearly 75% of Australians live in or within 50 kilometres of a coastal city. In recent years there has been an increase in the number of people living at the urban–forest interface, often in areas prone to unplanned forest fire. Therefore, the management of fire in these zones both for biodiversity and for the protection of built assets has become a major challenge for Australian forest and fire managers, particularly on the east coast. Many jurisdictions now require that the risk of bushfire be considered in urban planning and in the design of houses and other buildings.

Reporting on fire impacts

A number of innovative programs are now in place to carry out fire mapping and to monitor fire regimes more closely. For example, the Victorian Department of Sustainability and Environment has established IFIS (the Integrated Fire Information System), and the Western Australian Department of Environment and Conservation records planned and unplanned fires in its centralised FIRE SYSTEM database. Forests NSW recently upgraded its wildfires database to a centralised system for rapid input and access to data and for better integration with the fire reporting systems of other agencies.

Fire in Australia's forests, 2001 to 2006

In Australia's northern forests, several satellite-based platforms can be used to derive meaningful wildfire datasets, including Advanced Very High Resolution Radiometer, Moderate-resolution Imaging Spectroradiometer (MODIS) and Landsat.[10] Such datasets are useful for detecting fires in more open forests, such as tropical savannas, but are less effective in closed forests, such as many forests in the southern mesic rainfall zone (Figure 45). In Australia's southern forests, particularly those managed for timber production, state agencies use a combination of ground-based approaches and high-resolution aerial photography to estimate the extent and distribution of wildfire.

In this analysis, data on the extent and seasonality of fire in Australia's southern forests were supplied by state agencies, while the extent of fire in Australia's northern forests was determined for the period from February 2000 to December 2006 with the aid of MODIS satellite imagery.[11]

Synthesis of southern and northern fire estimates

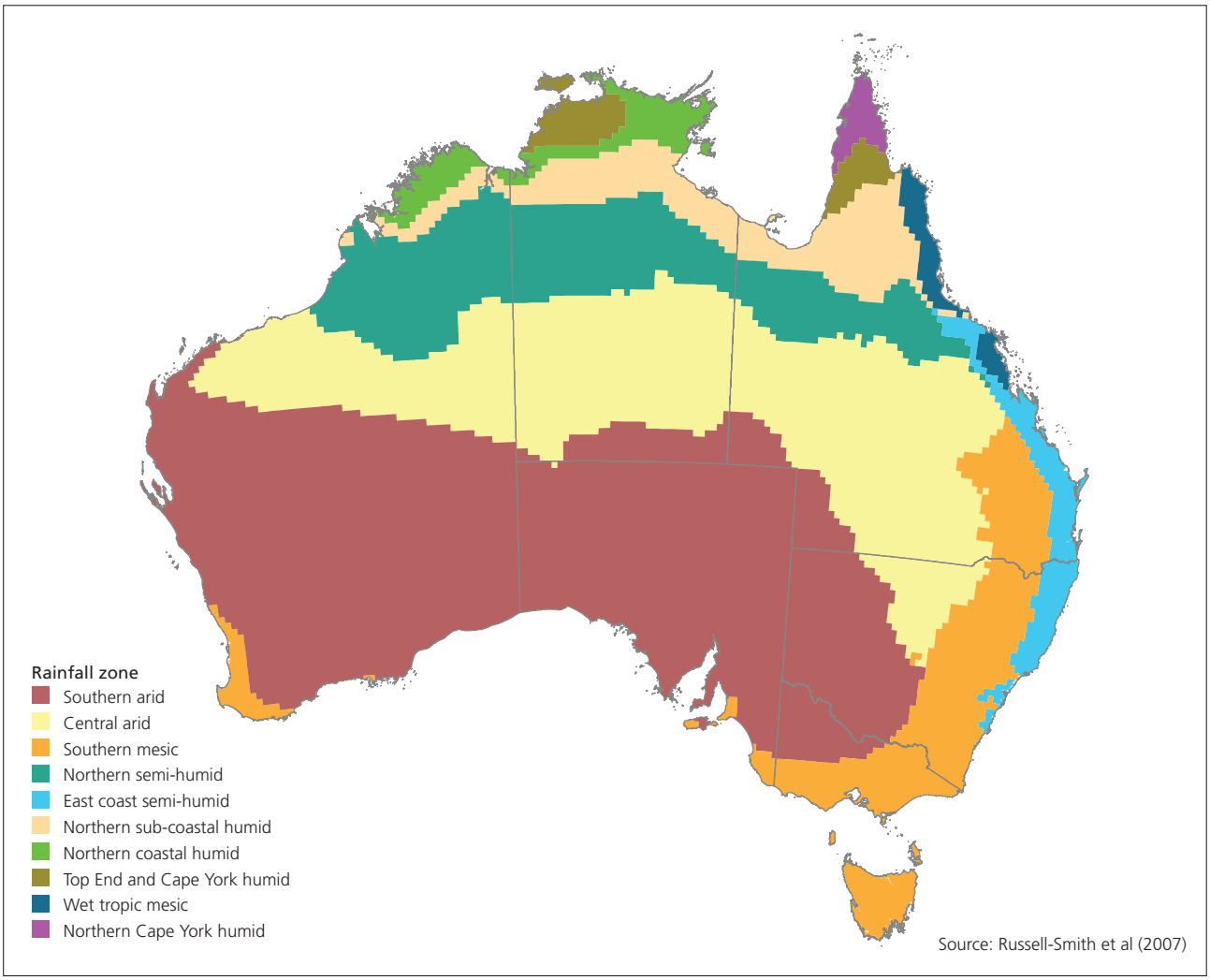
Table 44 shows the estimated total extent of planned and unplanned fire by jurisdiction, derived using the two methodologies. The reported data for the extent of fire in the southern forests (i.e. in New South Wales, South Australia, Tasmania, Victoria and southwestern Western Australia) were combined with estimates of fire-affected areas derived from MODIS for Australia's northern forests (i.e. the Northern Territory, Queensland and northern Western Australia) to generate the total area of Australian forests burnt between 2001–02 and 2005–06. Although the reporting of fire events in the popular media focuses mainly on southern Australia, where fires are particularly damaging to human life and infrastructure, most forest fires occur in northern Australia.

9 Hennessy et al (2005).

10 Russell-Smith et al (2007).

11 The relatively low resolution of 1 kilometre used in this analysis means that small, low-intensity fires are not easily detected, particularly when obscured by cloud cover or forest canopy. Such limitations may result in a significant underestimation of the extent of both planned and unplanned fires. The methodology and its advantages and disadvantages are described in Thackway et al (in press).

Figure 45: Rainfall classification showing 10 geographical regions that vary markedly in seasonal rainfall distribution over four nominal seasons



The differences between the two methodologies for 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.[12]

Planned and unplanned fires in southern forests

New South Wales, South Australia, Tasmania, Victoria and Western Australia provided data on the extent of planned and unplanned fire. Some reported fire on land that might include non-forested areas and some only on public land tenures (multiple-use public forest and/or public nature conservation reserves). According to these state-reported data, up to 5.2 million hectares of native and non-native forests was burnt by planned and unplanned fire in the southern mesic rainfall zone in New South Wales, South Australia, Tasmania, Victoria and southwestern Western Australia in the period from 2001–02 to 2005–06; more than 2.7 million hectares of this was burnt during the severe fire season of 2002–03 (Case study 26). Of the total, unplanned fires burnt about 3.6 million hectares and planned fires about 1.6 million hectares.

Planned and unplanned fires in northern forests

Data on the extent of forest in Australia and the occurrence of fire (as identified in MODIS satellite imagery) from 2000 to 2006 were used to classify fires into 10 rainfall zones (Figure 45) and four nominal seasons: January–March (summer), April–June (autumn), July–September (winter), and October–December (spring). For each rainfall zone, fires were classified as planned or unplanned according to season (Table 45). In northern Australia (zones 4, 6, 7, 8, 9 and 10), fires that occurred during autumn (i.e. the early dry season) were considered planned, while fires that occurred during spring (the late dry season) were considered unplanned (since it was unlikely that forest managers would deliberately light fires when they would be at their most

12 Walsh et al (2007).

Table 44: Total area burnt by planned and unplanned fire, 2001–02 to 2005–06, by jurisdiction (hectares)

	2001–02	2002–03	2003–04	2004–05	2005–06	Totals 2001–06
NSW[a]						
Planned	51,039	73,904	134,794	70,173	56,411	386,321
Unplanned	679,755	1,167,835	76,705	24,130	44,222	1,992,647
NT						
Planned	915,165	282,893	225,680	647,665	157,571	2,228,974
Unplanned	2,157,920	1,459,565	1,075,819	2,714,257	886,696	8,294,257
Qld						
Planned	168,800	186,346	97,419	160,002	94,213	706,780
Unplanned	2,189,488	1,319,413	948,369	1,240,991	1,144,032	6,842,293
SA[b]						
Planned	129	103	141	103	77	553
Unplanned	11	146	6	24	13	200
Tas.						
Planned[c]	17,900	16,700	15,300	16,000	13,000	78,900
Unplanned	378	32,468	60,203	11,472	787	105,308
Vic[d]						
Planned	52,669	30,178	101,193	97,509	51,898	333,447
Unplanned	38,448	1,141,828	12,167	19,157	103,975	1,315,575
WA[e]						
Planned	53,403	68,000	30,520	73,150	20,300	245,373
Unplanned	196,031	364,288	160,405	348,521	136,372	1,205,617
WA[f]						
Planned	87,330	130,780	171,930	186,380	182,400	758,820
Unplanned	17,640	131,680	22,190	50,630	22,560	244,700
Totals						
Planned	1,346,435	788,904	776,977	1,250,982	575,870	4,739,168
Unplanned	5,279,671	5,617,223	2,355,864	4,409,182	2,338,657	20,000,597
All reported fires	6,626,106	6,406,127	3,132,841	5,660,164	2,914,527	24,739,765

a Data supplied by Forests NSW and the Department of Environment and Climate Change (NSW) for multiple-use and nature conservation reserve tenures only and may include non-forest areas.

b Data for ForestrySA plantations in multiple-use public forests and public nature conservation reserves only.

c Planned fires on Forestry Tasmania land only.

d Data supplied by the Department of Sustainability and Environment (Vic.). Data are for public land tenures only.

e All regions except the southwest.

f Southwest forest region only.

Note: Unshaded cells show estimates supplied by state agencies for southern forests and shaded cells show estimates derived from MODIS imagery for northern forests. Totals may not tally due to rounding.

intense). According to the analysis, 3.2 million hectares of forest in northern Australia (the Northern Territory, Queensland and northern Western Australia) was subject to planned fires in the period from 2001 to 2006 and 16.3 million hectares to unplanned fires.

Native forest (*Hakea* sp.) in the foreground is adapted to fire with seedpods opening after being scorched.

Table 45: Proportion of forest area burnt in planned and unplanned fires in each rainfall zone, 2000 to 2006, based on MODIS data (%)

Rainfall zone	Proportion of forest burnt – unplanned	Proportion of forest burnt – planned	Unplanned fires as proportion of total area burnt	Planned fires as proportion of total area burnt
Southern arid (1)	2.9	0.1	97.9	2.1
Central arid (2)	8.0	2.3	77.4	22.6
Southern mesic (3)	10.1	1.6	86.0	14.0
Northern semi-humid (4)[a]	17.5	14.6	54.6	45.4
East coast semi-humid (5)	6.7	3.5	65.5	34.5
Northern subcoastal humid (6)[a]	31.8	4.1	88.5	11.5
Northern coastal humid (7)[a]	51.7	6.3	89.2	10.8
Top End and Cape York humid (8)[a]	44.8	11.5	79.5	20.5
Wet tropic mesic (9)[a]	17.5	0.7	96.3	3.7
Northern Cape York humid (10)[a]	48.0	0.8	98.3	1.7
Total (Australia)	17.8	3.8	82.3	17.7

a Denotes rainfall zones defined as wet–dry tropics. Other rainfall zones are considered to be temperate rainfall zones.

The proportion of forest area burnt was higher in the wet–dry tropical rainfall zones than in the temperate rainfall zones (Table 45). The northern semi-humid (4) and east coast semi-humid (5) rainfall zones had the highest proportions of planned fires as a proportion of total area burnt (45.4% and 34.5%, respectively). Table 45 also shows that most of the area burnt (82.3%) was burnt as a result of unplanned fire.

Mega-fires

Table 46 lists the main mega-fire events over the period from 1993–94 to 2006–07. The 2002–03 fire season in southern Australia was particularly bad, largely because it was in a period of severe drought. In New South Wales, 1.46 million hectares of both forest and non-forest landscapes was burnt over 151 consecutive days between September 2002 and February 2003; in Victoria, 1.1 million hectares of forest was burnt (Case study 26), including about 20,000 hectares of production alpine ash forest.[13] In the Australian Capital Territory, a severe fire in January 2003 burnt 157,000 hectares, including 11,000 hectares of pine plantation; 500 homes were destroyed and 4 people were killed.

Case study 27 describes the timber salvage operation undertaken after a large area of pine plantation was burnt near Tumut, New South Wales, in 2006.

Table 46: Mega-fires in southern Australia, 1993 to 2007

Fire season	Location	Area burnt (hectares)[a]
1993–94	Sydney/Blue Mountains/ North coast NSW	800,000+
1995	Southeast Qld	333,000
1997–98	Hunter/Blue Mountains/ Shoalhaven, NSW	500,000+
1997–98	Caledonia River, Gippsland, Vic.	32,000
2001–02	Greater Sydney, NSW	744,000
2002	Stanthorpe/Toowoomba, Qld	40,000
2002–03	Eastern Highlands, Vic.	1.1 million
2002–03	Brindabella Ranges/ Canberra, ACT/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

a Total area burnt, including vegetation types other than forests.
Source: Bartlett et al (2007)

References and further reading

ABS (2004b), Bartlett et al (2007), Dexter and Hodgson (2005), Ellis et al (2004), Hennessy et al (2005), Russell-Smith et al (2007), Thackway et al (in press), Walsh et al (2007), Wareing and Flinn (2003) (list at the back of the report).

Web resources

Case study 27: Tumut fire salvage operations

13 Dexter and Hodgson (2005).

Case study 26: The 2003 fires in Victoria

Eighty-seven fires were started by lightning in the northeast of Victoria on 8 January 2003. Eight could not be contained, and joined to form what became the largest fire in Victoria since the 1939 'Black Friday' bushfires. Burning for 59 days before being contained, the fires burnt 1.1 million hectares, including 507,000 hectares of multiple-use public forest, 470,000 hectares of national parks and 90,000 hectares of freehold land. Extreme fire activity on several days during the two months the fires were burning contributed significantly to the fire spread. The fires increased from 27,000 hectares on day 8 to 230,000 hectares on day 16 and to 880,000 hectares on day 23.

The fires destroyed 41 homes, 213 structures and thousands of kilometres of fencing and killed over 13,000 head of livestock. Tragically, one firefighter lost her life towards the end of the fires, drowning in a flash flood. The cost of fighting the Victorian bushfires has been estimated at $115 million, while an additional $86 million was spent on post-fire recovery operations. The fires saw unprecedented levels of cooperation between land management and related government agencies and rural fire services, private companies, local government and interstate and overseas-based fire personnel. The high priority accorded to the protection of assets undoubtedly reduced losses of private structures but may have concentrated resources near private property.

About 60% of the Alpine National Park and 81% of the Mount Buffalo National Park were burnt during the fires. Firefighting efforts were in hard-to-access, remote and rugged forest terrain, making the fires very difficult to control and extinguish. The consequences of the fires included reduced water quality and quantity, loss of vegetation (including habitats for flora and fauna), the destruction of commercial timber, and damage to recreation and tourism infrastructure assets, cultural sites and farms adjacent to public land.

According to at least one analysis,[14] the 2003 fires clearly demonstrated the widespread environmental, economic, cultural and social impacts that can result from a failure to control wildfires and showed that some environmental impacts, such as soil erosion, can be long lasting. The analysis concluded that similar bushfire conditions could occur in the following year due to the ongoing drought and that global warming is likely to increase the risk of more frequent and severe bushfires. It also considered that the trend towards the urbanisation of forest areas is occurring without adequate attention to fire risk and that the contraction of the native forest industry is affecting our ability to contain new fire outbreaks.

The rebuilding of local communities and the recovery of natural resources in bushfire-affected areas in the wake of the 2003 fires was a major task. The Victorian Government allocated $70.6 million for a bushfire recovery program for the environment and agriculture, focusing on four areas:

- asset repair or replacement in parks, forests and alpine resorts ($24.9 million)
- the protection and restoration of water catchments and water supply ($23.9 million)
- the restoration of ecological and cultural heritage values ($13.2 million)
- practical assistance to affected farm enterprises ($8.6 million).

This was the biggest bushfire recovery effort ever undertaken in Victoria and was characterised by a collaborative whole-of-government approach. The government agencies involved in coordinating and doing much of the recovery work were the Department of Sustainability and Environment, Parks Victoria and the Department of Primary Industries. Also involved were the North East and East Gippsland catchment management authorities, VicForests, and the managers of the three affected alpine resorts.

Sources: Bartlett et al (2007), Department of Sustainability and Environment (Vic.)

14 Wareing and Flinn (2003).

Log landing during salvage operations in a burnt alpine ash (*Eucalyptus delegatensis*) area following the 2003 fires.

Pulpwood stack, post-fire salvage operation.

Mountain ash (*Eucalyptus regnans*) and grey gum (*Eucalyptus punctata*) open forest, Kingslake, Victoria.

Criterion 4

Conservation and maintenance of soil and water resources

This criterion is concerned with the most fundamental resources of a forest environment: soil and water. Its five indicators assess the area of forest managed primarily for protective functions, and how the risk of soil erosion and the risks to soil physical properties and water quantity and quality are managed in forests.

Rainforest in a gully helps prevent erosion and protects water quality in the riparian zone.

Key findings

- Over 30 million hectares of public forests (20% of the total forest area) is managed primarily for protection, including of soil and water values. This is an increase of more than 8% over the reporting period.
- In catchments managed specifically for water supply, jurisdictions either do not allow disturbance activities to occur or limit and stringently control approved activities and/or public access.
- In most jurisdictions, activities that cause disturbances in forests are subject to codes of practice or other instruments that specify the measures to be taken to mitigate their contributions to soil erosion and their impacts on soil physical properties, and to maintain water quantity and quality. Compliance with such measures is generally high.
- Major wildfires during the period affected soil erosion and water quality across forest tenures, creating an increased challenge for forest managers. The resulting natural regrowth is expected to reduce water yields in affected catchments for decades.
- Water usage by tree plantations is the subject of increasing community attention and scientific research.

Indicator 4.1a

Area of forest land 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

- Over 30 million hectares of public forests (20% of the total forest area) is managed primarily for protection, including of soil and water values. The area of forest managed primarily for protective functions increased by more than 8% over the reporting period.
- This area includes all public nature conservation reserves and those parts of multiple-use public forests in which harvesting and roading are not permitted, such as on steep slopes or certain soil types or in riparian zones. It also includes catchments managed specifically for water supply.
- In catchments managed specifically for water supply, jurisdictions either do not allow disturbance activities to occur or limit and stringently control approved activities and/or public access.
- The re-establishment, restoration and maintenance of native vegetation, including forests, for protective functions is being encouraged by government and non-government programs.

State and territory governments protect soil and water values through legislation, codes of practice, management prescriptions and special measures and standards relating to watershed protection, areas vulnerable to erosion and slope instability, and riparian zones. Codes of forest practice set out activities to be undertaken in or near waterways, erosion-hazard areas and water catchments to minimise the impacts of wood harvesting and roading. Legislation exists in all states and territories to control and limit forest disturbances in designated water-supply catchments.

The main disturbances that can directly affect soil and water values in forested areas are road construction and maintenance, timber harvesting, fire, grazing and recreation. In some places, the activities of feral animals, such as pigs, can also affect soil and water values.[1]

The identification of forest managed primarily for protective functions is not always easy. In large areas of forest, including most multiple-use public forests, the protection of soil and water is one of several formal management objectives; such areas are generally not included in the data presented here. In most jurisdictions, forests in public nature conservation reserves may be defined as 'managed primarily for protective functions' and are therefore included. In addition, some areas of multiple-use public forests, such as those on steep slopes, on erosion-prone soils or close to streams, are counted because harvesting is not permitted for protective reasons. Forests managed specifically for water supply are also included in this indicator; in some cases, disturbances such as timber harvesting are permitted in those forests, but soil and water protection remains the primary objective.

Area of public forest managed for protective functions

Table 47 shows the area of forest from which harvesting activities that potentially affect soil and water values were excluded in 2006. In all jurisdictions combined, more than 60% of public forested land was managed for protective functions in 2006, an increase of 8% over 2000–01.

In Tasmania, the area of forest from which disturbance activities are excluded increased by 117,000 hectares, or 8%, to 1.67 million hectares in the five years to 2006.

1 Research into the impacts of feral pigs is under way in Warragamba catchment and the adjoining national parks west of Sydney.

This consisted of increased informal reserves in multiple-use public forest, additions to nature conservation reserves (including national parks), and a large increase in conservation covenants on private land under the private forest reserves program.

Table 48 shows the area of forest specifically managed to supply water for human or industrial use, a subset of the data shown in Table 47. In New South Wales, about 80% of the 250,000 hectares of forest managed specifically for water supply is in locked catchments not subject to disturbance; the remaining area is available for wood harvesting subject to scientifically based mitigation measures to protect soil and water values. In South Australia, approximately 1,000 hectares of pine plantation is managed for soil and water protection in the catchments immediately surrounding Adelaide reservoirs. In the Northern Territory, the protected area shown in Table 48 comprises the Manton Dam and Darwin River Dam catchments. In Victoria, the 2.91 million hectares of forest in 'declared' water catchments is on land of all tenures used in the supply of surface water for agricultural, domestic and industrial purposes. Significant areas of forest are in closed water-supply catchments, mostly used for the supply of domestic water in Melbourne; access is restricted to management vehicles. These areas include the Upper Yarra, O'Shannassy, Wallaby Creek and Maroondah catchments. Different levels of restrictions are placed on land use within declared catchments; for example, 77,150 hectares, or about 3% of the total, is locked and not subject to disturbance.

Many of the forested catchments in Tasmania supply water for domestic or industrial use, although most are not managed explicitly as water catchment areas. Approximately 5,000 hectares within Wellington State Park and Mount Field National Park is managed to provide about 40% of Hobart's water. The remaining 60% is obtained from the Derwent River catchment, which is a mixture of agricultural land and private and public forest. This water is generally of a high quality due to the large proportion of the upper catchment covered by state forests and national parks.[2]

In Western Australia, the area excluded from harvesting increased to 3.6 million hectares. The area excluded includes nature conservation reserves, informal reserves and fauna habitat zones in multiple-use public forest. However, there has been minimal overall change in the state in the total area managed specifically to supply water for human or industrial use; the existing commercial pine plantation on Perth's Gnangara Mound will be replaced over time to increase the recharge of that water resource (Case study 28). Public drinking-water source areas include both underground water pollution control areas and surface catchment areas, including water reserves. Catchments identified as sensitive to rises in saline groundwater are managed to reduce the risk of such rises occurring (Case study 29).

Natural resource management programs

On 3 November 2000, the Council of Australian Governments endorsed the National Action Plan for Salinity and Water Quality. The plan included a joint commitment by the Australian, state and territory governments to provide $1.4 billion over seven years for regional solutions to salinity and water-quality problems. In addition, the Australian Government committed $1.3 billion to the Natural Heritage Trust to repair and conserve the natural environment and further the sustainable use of the nation's natural resources. By 30 June 2005, governments had approved $858 million

Table 47: Area of forest from which timber harvesting was excluded, 2006 ('000 hectares)

	ACT[a]	NSW[b]	NT[a]	SA[a]	Tas.[c]	Vic.[d]	WA[a]	Qld[a]	Total
Area	112	7,001	4,536	4,155	1,673	4,518	3,597	4,861	30,453

a Area of forested public nature conservation reserves in IUCN categories I–VI.

b Estimate provided by NSW agencies for public nature conservation reserves and state forest in IUCN categories I–VI; may include non-forested land.

c Includes forests in all formal and informal nature conservation reserves (public and private) and other areas of multiple-use public forest generally unavailable for harvesting.

d Includes all nature conservation reserve forest and multiple-use public native forest not in the current Timber Resources Plan and therefore excluded from harvesting.

Sources: NFI, state and territory agencies

Table 48: Area of forest in catchments managed specifically to supply water for human or industrial use, 2006 ('000 hectares)

	ACT	NSW	NT	SA[a]	Tas.	Vic.[b]	WA[c]
Area	112	250	29	1	5	2,909	949

a Area of multiple-use public forest managed by ForestrySA (pine forests on SA Water land); does not include native vegetation and grassland areas in reservoir protection areas.

b Forested component across all tenures of 'declared' water catchments under various legislation. Included in this figure is 77,150 hectares of locked catchments.

c Includes only the southwest of Western Australia.

Note: Data for Queensland were not available. In 2006, the Australian Capital Territory released a draft plan for the conversion of extensive areas of pine plantation to native vegetation for the protection of the local water supply.

Source: State and territory agencies

2 Hobart Water (2006).

of regionally focused investment through these programs. Of this, about $80 million has been spent on activities with a prime focus on native vegetation, including the development of almost 1,420 conservation covenants and agreements and vegetation enhancement and revegetation covering more than 180,000 hectares (Table 49). In addition, there have been other major new initiatives in tree-planting and the implementation of increased controls on clearing in salinity-risk areas.

Table 49: Approved investments with a prime focus on native vegetation under natural resource management programs approved to June 2005 ($'000)

Jurisdiction	Investment
ACT	1,260
NSW	24,100
NT	1,460
Qld	10,900
SA	15,600
Tas.	1,600
Vic.	22,100
WA	3,720
Total	80,740

Source: Commonwealth of Australia (2005a)

Caring for our Country

Caring for our Country is the Australian Government's new natural resource management program that will commence on 1 July 2008. It will integrate delivery of the existing natural resource management programs, the Natural Heritage Trust, the National Action Plan for Salinity and Water Quality, the National Landcare Program, the Environmental Stewardship Program and the Working on Country Indigenous land and environmental program.

Rehabilitation and reforestation for protective functions

Numerous organisations and community groups across Australia plant trees to protect riparian zones, counter rising watertables and salinity, and arrest soil erosion. These plantings include a large range of projects supported by governments and the private sector. Table 50 shows measures for protecting, enhancing or establishing vegetation achieved nationally with funds from the Natural Heritage Trust in 2004–05. Note that not all the vegetation protected or established was forest.

Table 50: On-ground vegetation improvement under the Natural Heritage Trust reported in 2004–05 (hectares)

Activity	Outcome
Native vegetation protected by fencing	15,496
Native vegetation enhanced/rehabilitated	5,286
Native vegetation planted	2,622
Exotic vegetation planted	3,737

Source: Commonwealth of Australia (2005a)

Greening Australia is one such organisation working to build natural resource management capacity in regional communities. In 2006, for example, the organisation reported that it had planted over 2.6 million seedlings; direct-seeded 1,780 kilometres of treelines; collected 4,090 kg of native seed; conserved 58,600 hectares of native vegetation (not all of it forest); erected over 700 kilometres of fencing to protect and conserve native vegetation; partnered with 1,192 landholders in on-the-ground projects; worked with 419 schools nationwide; trained and educated over 15,200 people; united with over 11,200 volunteers; and organised 582 volunteer events.

At a more local level, landowners in Western Australia's Avon region working with Greening Australia had by 2005 planted 676 hectares of native vegetation, established more than 750,000 seedlings, collected 369 kg of seed and constructed 600 kilometres of fencing to protect native bushland.[3]

Since 2003, Forests NSW has established 195 hectares of plantation forest in the Hunter Valley for mine site rehabilitation (Case study 30), green corridors, carbon sequestration and biodiversity; since 2001, the agency has established 20 hectares of forests in central western NSW for salinity mitigation, catchment management and biodiversity. South Australia reported tree plantings of over 122 hectares by forestry companies for erosion-control purposes in the Cudlee Creek Forest and plantings to protect wetlands near Penola. In Tasmania, tree planting funded by the Natural Heritage Trust was carried out on 234 hectares, including the re-establishment of vegetation along 46 kilometres of stream lines and the restoration of degraded native vegetation. Victoria reported that 170 hectares of log landings was replanted with trees in 2005–06.

References and further reading

Bari et al (2004), Commonwealth of Australia (2005ab), Hobart Water (2006), Webb and Haywood (2005), Webb et al (2007) (list at the back of the report).

3 www.nrm.gov.au/projects/wa/avon/2006-03.html (accessed 1 July 2007).

Dryland salinity in the Western Australian wheatbelt.

Case study 28: The Gnangara Mound

The Gnangara Mound is a significant groundwater resource that lies under Perth's Swan Coastal Plain. The mound supplies up to 60% of Perth's drinking water, as well as water for irrigation and environmental amenity. Wetland and groundwater levels on the Gnangara Mound have declined in recent years due to a combination of a drying climate, usage for irrigation and public water supply and the presence of native forest and pine plantations that reduce recharge.

The Gnangara land-use and water management strategy addresses the need for the long-term protection of groundwater quality and quantity. The strategy was produced through a whole-of-government approach and aims to protect the important groundwater and environmental features of the mound while allowing compatible development for the benefit of the community.

A major feature of the strategy is the recognition and proposed reservation of a large area of the mound as the Gnangara Park. The park will replace 23,000 hectares of existing pine plantations as they are progressively harvested over the next 20 years. Gnangara Park will protect water quality on the mound while offering opportunities for nature-based recreation, as well as conservation and timber harvesting activities.

It is estimated that the proposed reduction of pine plantations on the Gnangara Mound could increase groundwater availability by up to 20 gigalitres per year, depending on a number of external factors. These yield benefits would be realised gradually from about 2020 onwards.

Source: Department of Water (WA)

Case study 29: Dryland salinity in the Western Australian wheatbelt

Dryland salinity is a major water and land management issue in large areas of Western Australia's agricultural zone. It is caused by the clearing of native vegetation for agriculture, followed by inappropriate agricultural practices; groundwater levels rise as a consequence, bringing salt deposits to or close to the soil surface.

One way to mitigate this problem is to re-establish deep-rooted, perennial vegetation over significant portions of the landscape. The Forest Products Commission undertakes a tree-farming program in collaboration with farmers, investors and natural resource management groups to grow commercial tree crops on Western Australian farmland. The commission has developed tree farming and industry development plans for lower rainfall regions in the southwest, one aim of which is to encourage tree planting at a scale that can support internationally competitive forest industries while also providing an opportunity to reduce the problem of rising groundwater.

Source: Forests Products Commission (WA)

Case study 30: Mine site revegetation in the Hunter Valley, NSW

In April 2007, Forests NSW negotiated a three-year agreement with Rio Tinto Coal Australia to establish 80 hectares of eucalypt plantation on land around the company's Howick Mine in the upper Hunter Valley. The land is classified as 'buffer land' and is favourable for plantation establishment. Forests NSW research trials on adjoining land owned by Macquarie Generation are performing very well. This may be the first step in achieving a profitable involvement in the rehabilitation of mine sites in the Hunter Valley.

Source: Forests NSW

Narama Mine rehabilitation, New South Wales.

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

- Measures to mitigate the effects of forest activities, particularly timber harvesting and associated roading, have been developed based on a sound understanding of soils and the potential impact of forest activities on them.
- In most jurisdictions, activities that cause disturbances in forests are subject to codes of practice or other instruments designed to mitigate their contributions to soil erosion.
- The assessment of the risks posed by forest disturbance to soil erosion is comprehensive in multiple-use public forests.
- Compliance with soil mitigation measures for timber harvesting and associated roading in multiple-use public forest is high in most jurisdictions.
- Major wildfires increase the potential for soil erosion in the period immediately following the fire, providing a challenge for all forest managers.

Protecting soil and water values in forested areas is critical to maintaining most other forest values and thus is an essential part of sustainable forest management. The actions taken to manage soil erosion can vary greatly and depend to a large extent on the nature of particular forest soils and the activities being undertaken in the forest. This indicator reports on the preventive intent directed at mitigating soil erosion, together with the area of forest assessed for the risk to soil values and the internal and external auditing of compliance or performance in the implementation of mitigation measures. The focus of reporting is on multiple-use public forest and public nature conservation reserves because, in most jurisdictions, little information is available for other tenures. The performance ratings reported here are the result of self-assessment by the jurisdictions.

Measures to mitigate soil erosion have been implemented in some jurisdictions for up to 30 years. These include actions related to forest road alignment, density and drainage; operations in or near streams or riparian areas; extraction or other temporary tracks; landing size, placement and management; wet-weather shutdowns; traffic restrictions on slopes; restrictions on clearing on steep slopes; and facility development.

These measures are now generally prescribed in codes of forest practice or other regulatory instruments, which are reviewed periodically and improved as a result of ongoing research. In most jurisdictions, measures to mitigate soil erosion were in place for the full reporting period but were not necessarily applied across all forested tenures. In Victoria and Tasmania, however, such measures usually apply to all forest harvesting operations regardless of tenure. Audits are used to ensure compliance with the codes.

Codes of forest practice generally require that features most susceptible to erosion, such as landings, log extraction tracks and access roads, be rehabilitated after harvesting. In New South Wales, Queensland, Victoria and Tasmania, for example, log landings are drained, bark heaps dispersed, soils ripped and topsoil replaced before regeneration or replanting begins.

Recreational activities can also cause erosion, particularly around roads, walking trails, picnic areas and campsites; these are managed in various ways, including by the provision of duckboards on walking trails in high-use areas.

Fire can have direct effects on soils, such as causing the loss of carbon and nutrients, and indirect effects, such as rendering the soil more susceptible to erosion. These effects are much greater for intense fires, but even low-

intensity prescribed burns can increase the risk of erosion on erodible soils, especially where terrain is steep and there are subsequent intense rain events. Therefore, it is important to consider the risks to soils posed by prescribed burning across all tenures; although the extent to which such consideration occurs varies considerably, it is most comprehensive for multiple-use public forest.

The inability to control bushfires, for whatever reason, can pose serious soil erosion risks (see Indicator 4.1e for a discussion of the effects of the 2003 fires in the Australian Capital Territory). Managing the impacts of bushfires on soils is extremely difficult, although certain recognised steps can be taken. In Victoria, for example, mitigation measures were developed to protect soil and water values during timber salvage harvesting after the 2003 wildfires. They have been re-applied, with some changes, to salvage harvesting following the 2006–07 wildfires.

Instruments in place that address the risk of soil erosion

Table 51 shows, by jurisdiction, the soil protection themes addressed by codes of forest practice, other regulatory instruments and forest management guidelines.

The extent to which legally and non-legally binding instruments such as codes of practice, guidelines and forest management plans that address soil values exist across state and territory jurisdictions can be rated using the category descriptions in Table 52. The ratings for various jurisdictions in Tables 53 and 54 show that legally binding instruments are in place in New South Wales, Victoria, Tasmania and Western Australia. In Table 54, South Australia's ratings refer to the plantation sector's industry-endorsed *Environmental Management Guidelines for Plantation Forestry*. It recognised that, apart from fire impacts, there is far less disturbance activity and generally a lower risk to soil values in nature conservation reserves.

Table 51: Soil protection themes addressed by codes of forest practice, other regulatory instruments and forest management guidelines for multiple-use public forests, 2006, by jurisdiction

Content theme	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA
Planning								
Care of soils	✓	✓	✓	✓	✓	✓	✓	✓
Water quality and flow	✓	✓	–	✓	✓	✓	✓	✓
Site productivity	✓	✓	✓	✓	✓	✓	✓	✓
Timber harvesting plans	✓	✓	–	✓	✓	✓	✓	✓
Access to the forest								
Planning and locating roads	✓	✓	–	✓	✓	✓	✓	✓
Road design and construction	✓	✓	–	✓	✓	✓	✓	✓
Upgrading existing roads and tracks	✓	✓	–	✓	✓	✓	✓	✓
Road quarries and gravel pits	✓	✓	–	–	✓	✓	✓	✓
Bridge, causeway and ford construction	✓	✓	–	✓	✓	✓	✓	✓
Road maintenance	✓	✓	–	✓	✓	✓	✓	✓
Harvesting								
Design, planning and equipment	✓	✓	✓	✓	✓	✓	✓	✓
Wet weather	✓	✓	✓	✓	✓	✓	✓	✓
Log extraction tracks and landings	✓	✓	✓	✓	✓	✓	✓	✓
Water quality and stream protection	✓	✓	✓	✓	✓	✓	✓	✓
Salvage operations	✓	✓	–	✓	✓	✓	✓	✓
Steep country	✓	✓	✓	✓	✓	✓	✓	✓
Forest establishment								
Reforestation/afforestation	✓	✓	✓	✓	✓	✓	✓	✓
Maintaining forests								
Fire management	✓	✓	–	✓	✓	✓	✓	✓
Thinning	✓	✓	–	✓	✓	✓	✓	✓
Non-wood uses								
Recreation	–	✓	–	–	✓	✓	✓	–

Sources: State and territory agencies

Table 52: Category descriptions for rating 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 and management practice resulting in soil disturbance. They are also applicable for 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 above.
5	The instruments do not mention the need to address risks of soil erosion.

Table 53: Extent to which legally binding instruments address the risk of soil erosion due to forestry operations, road and trail works, and recreation activities

	Category[a]					
	NSW	NT	SA	Tas.	Vic.	WA
Multiple-use public forests and plantations	1	3	4	1	1	4
Public nature conservation reserves	2[b]	3	4	1	1	4

a Values refer to category descriptions in Table 52.

b Nature conservation reserves are not as stringently prescribed as multiple-use public forests due to the significantly lower risk of erosion and water pollution.

Sources: State and territory agencies

Table 54: Extent to which non-legally binding instruments address the risk of soil erosion due to forestry operations, road and trail works, and recreation activities

	Category[a]						
	ACT	NSW	NT	SA	Tas.	Vic.	WA[b]
Multiple-use public forests and plantations	3[c]	1	5	1	1	3	3
Nature conservation reserves	–	1	5	4	1	2	4

a Values refer to category descriptions in Table 52.

b National park management plans describe the geomorphology, soils and landform of the area and indicate potential threats. Some plans list strategies to avoid or minimise threats.

c Conservation management plans describe the soils and landforms of the areas and potential threats.

Sources: State and territory agencies

The New South Wales code of practice for timber harvesting in plantations was upgraded in 2005. In Tasmania, the *Reserve Management Code of Practice*, designed to be applied in conservation reserves, was approved in 2003.

There are limited legally and non-legally binding instruments in Western Australia, and those that exist do not address all aspects of the category descriptions. However, the Forest Management Plan 2004–13, which covers all of the main timber production areas in the state's southwest, places strong emphasis on the protection of soil and water values. The Western Australian Department of Environment and Conservation is currently reviewing the soil erosion measures in place for disturbance activities in multiple-use public forests and timber reserves.

Table 55 shows examples of mitigating activities generally included in codes of forest practice and other instruments to protect soil values.

Assessment of erosion hazard

The assessment of erosion hazard generally uses a combination of available information, including erosion hazard maps, and field verification. Many forest managers use similar parameters to those appearing in category 1 of Table 56 as a series of overlays in a geographic information system. This enables them to make such assessments and then seek advice from regulatory agencies if necessary. Table 57 shows the area of multiple-use public forest for which disturbance activities were planned in 2005–06, the proportion of that area that was assessed for risk to soil values, and the category of assessment. In New South Wales, South Australia, Tasmania, Victoria and Western Australia, virtually all areas of multiple-use public forest subject to disturbance were assessed for risk to soil values.

Table 55: Examples of mitigation activities directed at minimising soil erosion

Mitigating activity	Designed to mitigate soil erosion
Protection of riparian zones by buffers or filters	✓
Road drainage (bridges, culverts, table drains)	✓
Log extraction track drainage by cross-drains and grips	✓
Log extraction track arrangement (maximise uphill extraction to avoid downhill funnelling of water flow)	✓
Minimisation of stream crossings	✓
Rehabilitation of log landings (ripping, replacement of topsoil, planting) and log extraction tracks	✓
Exclusion of identified vulnerable areas (erosion hazard, landslip potential, karsts, swamps) from harvest zone	✓
Wet-weather operational closures	✓

Table 56: Category descriptions for rating 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 practice resulting in 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 those 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.

Table 57: Area of multiple-use public forest where disturbance activities were planned, proportion assessed for risk of soil erosion and category of assessment, 2005–06

Disturbance activity		NSW	SA[a]	Tas.[bc]	Vic.[d]	WA
Native forest harvesting and silviculture	Area (ha)	101,000	Not applicable	16,000	7,500	–
	Proportion assessed for risk of soil erosion (%)	100		100	85	100
	Category[e]	1		1	2	3
Plantation operations	Area (ha)	13,200	–	4,600	–	–
	Proportion assessed for risk of soil erosion (%)	100	100	100	90	–
	Category[e]	1	1	1	2	–
Road construction and maintenance	Area (ha)	–	–	–	–	–
	Proportion assessed for risk of soil erosion (%)	100	100	100	90	100
	Category[e]	1	3	1	2	3
Fire management	Area (ha)	–	–	–	–	–
	Proportion assessed for risk of soil erosion (%)	100	100	100	90	–
	Category[e]	1	3	1	2	–

a South Australia does not harvest native forest.

b Includes area being converted to eucalypt plantation.

c In Tasmania, 14,400 hectares of private native-forest operations and 25,800 hectares of plantation operations were also assessed for the risk of soil erosion.

d 25,298 hectares of private plantations in Victoria was also assessed for the risk of soil erosion.

e Values refer to category descriptions in Table 56.

Sources: State and territory agencies

Table 58: Knowledge base on soil erosion and soil physical properties, by jurisdiction

State	Soil knowledge base
NSW	A comprehensive soil assessment procedure designed to minimise soil erosion and protect soil physical properties is in place for multiple-use public forest. Extensive training is provided to staff to implement the procedure. For other tenures, the impacts of activities on soil values are reasonably well understood, but risk factors remain that need to be better understood.
SA	Land is classified into eight land capability classes. Key factors that determine capability class include water erosion potential, drainage and soil depth, degree of rockiness, soil fertility, and wind erosion potential.
Tas.	Soil types have been mapped statewide and erosion risks identified, mainly for multiple-use public forest. Soil physical properties are understood. The Forest Practices Authority provides forest managers with regular training. Knowledge base is more limited for other forest tenures.
Vic.	The impacts of a range of forest activities on soil erosion and soil physical properties are reasonably well understood. Some identified risk factors need to be better understood.
WA	The impacts of a range of forest activities on soil erosion and soil physical properties are reasonably well understood for multiple-use public forest, but a lower level of knowledge exists for conservation reserves.

Sources: State and territory agencies

Table 59: Category descriptions for rating the performance of forest managers in complying with prescribed erosion mitigation measures

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

As part of the planning process for timber harvesting, Forests NSW undertakes comprehensive soil assessment, comprising inherent hazard category (assessment of soil erosion and water pollution potential), mass movement assessment, dispersibility assessment and seasonality of logging operations. The inherent hazard level category determines the level of protection that is implemented to protect soil and water values.

All Forests NSW field staff and industry operators are trained, assessed and accredited in compliance with regulatory requirements in forest soil and water protection. Industry must implement the requirements of an Environment Protection Licence issued by the New South Wales Department of Environment and Climate Change in native-forest and plantation operations. In Tasmania, all forest practices officers receive specialised training on soil and water values; the training is updated periodically as a result of ongoing research. Soil and water protection training has also been completed by VicForests staff to guide the planning and implementation of operations in public native forests in Victoria. In Western Australia, 100% of multiple-use public forest proposed for disturbance activities is assessed for soil erosion using the *Interim Manual of Procedures for the Management of Soils Associated with Timber Harvesting in Native Forests* and the *Manual of Management Guidelines for Timber Harvesting in Western Australia*.

Soil erosion knowledge base

The potential impacts on soils of disturbance by machinery are well known, and the assessment of soil erosion hazard in multiple-use public forest is carried out according to science-based procedures. The impact of fire and its contribution to the erosion of forest soils is less well understood, although planned fire is known to make a much lower contribution than bushfire because of its generally lower intensity (Indicator 4.1e). Further knowledge of the impacts of forest activities on soil erosion is required across other tenures, and there remain some risk factors on public land that need to be better understood.

A boardwalk installed to prevent foot traffic from damaging vegetation and soil at a sensitive site.

Table 60: Compliance outcomes achieved in multiple-use public forests, 2005–06

	Category[a]				
Activity	NSW	Vic.	SA	Tas.[b]	WA
Native-forest harvesting	2	2	Not applicable	2	3
Plantation operations	2	2	2	2	4
Roads and trails	2	2	2	2	4
Fire management	2	2	2	2	4

a Values refer to the category descriptions in Table 59.

b Similar compliance outcomes were also achieved for the same activities in private forests.

Sources: State and territory agencies

Site preparation (ripping and mounding) on the contour prior to planting blue gums (*Eucalyptus globulus*) to minimise the risk of soil erosion.

Knowledge of erosion hazards continues to improve. In Tasmania, for example, a recent study of more than 400 headwater streams found that determining the type and width of riparian buffer zones using erosion hazard concepts was superior to using riparian slope alone (as is commonly required in codes of practice).[4] This work led to the development and adoption in Tasmania of new guidelines for the protection of Class 4 streams,[5] including better protection for headwater streams based on five graded prescriptions according to erosion risk.

Compliance with soil erosion mitigation measures

Compliance with soil erosion mitigation measures is assessed in various ways across Australia by internal and external audits. Using the category descriptions in Table 59, Table 60 gives an indication of the performance of some jurisdictions.

The compliance levels in Table 60 are the average across all multiple-use public forests where activity occurred. New South Wales, South Australia, Tasmania and Victoria generally achieved satisfactory outcomes. Audits and investigations of complaints are carried out by the Forest Practices Authority in Tasmania and by the state environmental protection agencies in New South Wales and Victoria. While compliance in Western Australia has not been rated as highly as in other states, recent improvements have been directed towards reducing potential soil erosion on log extraction tracks and fire trails.

Planting holes for a second-rotation eucalypt plantation being prepared in harvesting slash. The slash prevents the machine's tracks disturbing the soil and protects the soil from erosion.

Myponga reservoir, South Australia. Pines have been planted to minimise erosion of soil from adjacent slopes.

References and further reading

Bunce et al (2001), Davies et al (2005), Laffan et al (2001), McIntosh (2004), McIntosh and Laffan (2005), McIntosh et al (2005), Pennington et al (2001) (list at the back of the report).

4 McIntosh and Laffan (2005).

5 Under Tasmania's stream classification system, streams with catchments smaller than 50 hectares.

Indicator 4.1c

Management of the risks 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, such as compaction and redistribution, affects soil integrity and as a consequence many associated values.

Key points

- Measures to mitigate the effects of forest activities, especially timber harvesting and associated roading, have been developed based on a sound understanding of soils and the potential impact of forest activities on them.
- In most jurisdictions, activities that cause disturbances in forests are subject to codes of practice or other instruments designed to mitigate impacts on soil physical properties.
- The assessment of the measures required to protect soil physical properties during forest disturbance activities is comprehensive, particularly in multiple-use public forests.
- Compliance with soil mitigation measures for timber harvesting and associated roads and tracks in multiple-use public forest is high in most jurisdictions.

Protecting soil physical properties is essential to the maintenance of forest productivity and contributes to the ongoing health of forest ecosystems. The actions taken to maintain soil physical properties vary greatly and depend to a large extent on the nature of particular forest soils and the activities being undertaken in the forest. This indicator reports on the measures directed at maintaining soil physical properties, together with the area of forest assessed for risk to soil physical properties and the auditing of compliance or performance in the implementation of mitigation measures. The performance ratings reported here are the result of self-assessment by the jurisdictions. The focus of reporting is on multiple-use public forest and public nature conservation reserves because, generally, little information is available for other tenures. The principal areas of concern for soil physical properties in forests, in particular soil compaction, are roads, trails, log extraction tracks and log landings.

Measures to protect soil physical properties have been implemented in multiple-use public forests in some jurisdictions for many years. They include actions related to log extraction operations in or near streams or riparian areas; cording and matting;[6] the construction and maintenance of extraction and other temporary tracks; the size, placement and management of landings; animal and recreational campsite compaction; wet-weather shutdowns; the selection of machines and tyres; traffic restrictions on slopes; restrictions on clearing on steep slopes; and facility development.

These measures are now generally prescribed in codes of forest practice or other regulatory instruments, which are reviewed periodically and improved as a result of ongoing research. In most jurisdictions, measures to protect soil physical properties were in place for the full reporting period but were not necessarily applied across all forested tenures; in Victoria and Tasmania, however, such measures applied to all forest harvesting operations regardless of tenure. Audits are used to ensure compliance with the codes.

Codes of forest practice generally require that the features most susceptible to compaction and mixing, such as landings, log extraction tracks and access roads, be rehabilitated after harvesting. For example, in New South Wales, Queensland, Tasmania and Victoria, log landings are drained, bark heaps dispersed, soils ripped and topsoil replaced before regeneration or replanting begins. Recreational activities can also affect soil physical

6 Cording is the practice of placing large (5–30 centimetre diameter) woody material on extraction tracks before harvesting to minimise erosion; matting is similar but involves smaller (<5 centimetre diameter) woody material.

properties, particularly around walking trails, picnic areas and campsites; these are managed in various ways, including by the provision of duckboards on high-use segments of walking trails.

Instruments in place to address risks to soil physical properties

The extent to which legally and non-legally binding instruments such as codes of practice, guidelines and forest management plans that address soil values exist across state and territory jurisdictions can be rated using the category descriptions in Table 61. The ratings for various jurisdictions in Tables 62 and 63 show that legally binding instruments are in place in New South Wales, Victoria, Tasmania and Western Australia. Apart from fire impacts, there is usually far less disturbance activity and generally a lower risk to soil values in public nature conservation reserves than in multiple-use public forests.

The New South Wales code of practice for timber harvesting in plantations was upgraded in 2005. In Tasmania, the *Reserve Management Code of Practice*, designed to be applied in public nature conservation reserves, was approved in 2003.

There are limited legally and non-legally binding instruments in Western Australia, and those that exist do not address all aspects of the category descriptions. However, the Forest Management Plan 2004–13, which covers all the main timber production areas in the state's southwest, places strong emphasis on the protection of soil and water values.

Table 64 shows examples of mitigating activities usually included in codes of forest practice and other instruments to protect soil values.

Table 61: Category descriptions for rating the extent to which the 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; the presence of litter, trash or slash; slope; and rainfall distribution and intensity • management factors such as the 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.

Table 62: Extent to which legally binding instruments address the risk to soil physical properties due to forestry operations, road and trail works, fire management and recreation activities

	Category[a]					
	NSW	NT	SA	Tas.	Vic.	WA
Multiple-use public forests	1	3	4	1	1	4
Public nature conservation reserves	2[b]	3	4	1	1	4

a Values refer to category descriptions in Table 61.

b Nature conservation reserves are not as stringently prescribed as multiple-use public forest due to the significantly lower risk of erosion and water pollution.

Note: Queensland has a *Code of Practice for Native Forest Timber Production* for public land and a *Private Native Forests Code of Practice*.

Sources: State and territory agencies

Table 63: Extent to which non-legally binding instruments address the risk to soil physical properties due to forestry operations, road and trail works, fire management and recreation activities

	Category[a]						
	ACT[b]	NSW	NT	SA	Tas.	Vic.	WA[c]
Multiple-use public forests	3	1	5	1[d]	1	3	3
Nature conservation reserves	3	1	5	4	1	3	4

a Values refer to category descriptions in Table 61.

b National park management plans describe the geomorphology, soils and landform of the area and indicate potential threats.

c Conservation management plans describe the soils and landforms of the areas and potential threats.

d Refers to the plantation sector's industry-endorsed *Environmental Management Guidelines for Plantation Forestry*. Some plans list strategies to avoid or minimise threats.

Sources: State and territory agencies

Table 64: Examples of mitigation activities directed at maintaining soil physical properties

Mitigation activity	Designed to maintain soil physical properties
Use of cording and matting or temporary culverts for log extraction tracks or minor logging roads in wet areas	✓
Minimisation of stream crossings	✓
Rehabilitation of log landings (ripping, replacement of topsoil, planting) and log extraction tracks	✓
Exclusion of identified vulnerable areas (erosion hazard, landslip potential, karsts, swamps) from harvest zone	✓
Wet-weather operational closures	✓

Assessment of soil physical properties

The assessment of the potential risk to soil physical properties is usually a combination of office-based assessment and field verification. Many forest managers use similar parameters to those appearing under category 1 in Table 65 as a series of overlays in a geographic information system to make such assessments and then seek advice from regulatory agencies if necessary. Table 66 shows the area of multiple-use public forest for which disturbance activities were planned in 2005–06, the proportion of that area that was assessed for risk to soil physical properties, and the category of assessment. In New South Wales, South Australia, Tasmania, Victoria and Western Australia, virtually all areas of multiple-use public forest subject to disturbance were assessed for risk to soil physical properties.

Assessments of the risk to soil physical properties are generally carried out by forest managers in conjunction with the assessment of soil erosion hazard using the various processes reported in Indicator 4.1b.

Table 65: Category descriptions for rating 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; the 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 include 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 soil physical properties 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 soil physical properties risk assessment system takes into account some of the factors listed in category 1 or only partly accounts for those factors.
4	The soil physical properties risk assessment system is ad hoc and/or does not take into account any of the factors listed in category 1.

Table 66: Area of multiple-use public forest where disturbance activities were planned, proportion assessed for risk to soil physical properties, and category of assessment, 2005–06

Disturbance activity		NSW	SA[a]	Tas.[b]	Vic.[c]	WA
Native forest harvesting and silviculture	Area (ha)	101,000	Not applicable	16,000	7,500	–
	% assessed for risk to soil properties	100		100	85	100
	Category[d]	1		1	2	3
Plantation operations	Area (ha)	13,200	–	4,600	–	–
	% assessed for risk to soil properties	100	100	100	90	–
	Category[d]	1	1	1	2	–
Road construction and maintenance	Area (ha)	–	–	–	–	–
	% assessed for risk to soil properties	100	100	100	90	100
	Category[d]	1	3	1	2	3
Fire management	Area (ha)	–	–	–	–	–
	% assessed for risk to soil properties	100	100	100	90	–
	Category[d]	1	3	1	2	–

a South Australia does not harvest native forest.

b In Tasmania, 14,400 hectares of private native-forest operations and 25,800 hectares of plantation operations were also assessed for the risk to soil physical properties.

c 25,298 hectares of private plantations in Victoria was also assessed for the risk to soil physical properties.

d Values refer to category descriptions in Table 65.

Sources: State and territory agencies

Soil physical properties knowledge base

The potential impacts on soils of disturbance by machinery are well known, and assessments of the risk to soil physical properties in multiple-use public forest are carried out according to science-based procedures. Further knowledge of the impacts of forest activities on soil physical properties is required across other tenures, and there remain some risk factors on public land that need to be better understood; Table 58 in Indicator 4.1b describes the knowledge base on soil erosion and soil physical properties.

Knowledge of the risks to soil physical properties continues to improve. In Western Australia, a recent study examined the impact of native forest harvesting on soil bulk density (compaction) at 18 sites with a known logging history of up to 50 years.[7] It showed increases in bulk density due to logging equipment, particularly on log extraction tracks and log landings, which when combined typically cover less than 15% of a logged area. Evidence of compaction persisted on some sites for up to 50 years after the harvesting event, whereas other sites on sandy soils showed little evidence of compaction. Continual improvements in forest management practices in recent decades probably mean that contemporary harvesting causes fewer compaction effects, although further research is required to verify this.

Compliance with measures to protect soil physical properties

Compliance with measures to protect soil physical properties is assessed in various ways across Australia by internal and external audits as part of the process of auditing the implementation of soil erosion mitigation measures, as reported in Indicator 4.1b.

References and further reading

Bunce et al (2001), Laffan et al (2001), McIntosh et al (2005), Pennington et al (2001), Whitford and Swinburn (2006) (list at the back of the report).

Depending on soil type and weather conditions, the choice of machinery, wheeled (above) or tracked (below) may determine the intensity of impact on soils during harvesting.

7 Whitford and Swinburn (2006).

Indicator 4.1d

Management of the risks 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

- Most jurisdictions have codes of practice and other regulatory instruments or management guidelines in place directed at managing water yields from forests.
- Practices such as the geographical dispersal of timber-harvesting operations, limits on the proportion of catchments subject to harvesting in a given year and thinning to increase water yield are employed to manage potential impacts on water quantity.
- The impacts of forest age and density on water yield are well understood, but the ability to predict results in specific circumstances is still developing.
- Water use by tree plantations is the subject of increasing community attention and scientific research.
- Major wildfires during the reporting period and the resulting natural regrowth are expected to reduce water yields in affected catchments for decades.

Copperlode Reservoir, far north Queensland.

With much of the country affected by drought during the reporting period, Australians have become increasingly concerned about maintaining water supply. Climate change may also result in rainfall deficits in southern Australia, reducing water yields (Indicator 3.1a). This concern has extended to the impact of forestry activities, particularly the impacts of plantation establishment and management, on water yields in drier parts of Australia. Recent research has focused on assessing the potential impacts of forestry activities on water yields and how those impacts can best be managed.

The age and structure of native forests and the establishment and growth of forest plantations can influence the level of stream flow in forested catchments. Recent large wildfires in southern Australia (Indicator 3.1b) and subsequent regrowth are expected to affect current and future water yields in burnt areas. Forest management activities can both increase and decrease water yields, as can deforestation (e.g. for agriculture) or major catastrophic events such as bushfires. The risks to water yield from fire may be as serious for nature conservation reserves as they are for multiple-use public forests; the effects can last for decades after the fire.

The practices likely to affect water yields from forests include the timing, scale and spacing of timber harvesting, thinning or clearing; fire management; woody weed control; modifications to rotation length; and land-use change.

Unlike fire, most activities carried out in nature conservation reserves have only minor effects on water quantity.

Table 67: Category descriptions for rating the extent to which the regulatory framework requires the maintenance of water quantity

Category	Category description
1	The instruments require the following components to be taken into account in addressing the risk to water quantity from disturbance activities: • local and regional requirements for 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 for addressing 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.

Instruments in place that address the risk to water quantity

Codes of practice and other regulatory instruments or management guidelines specify measures to be implemented to maintain stream flows and water quantity for particular locations and activities. Those instruments also provide the benchmark against which water quantity management measures can be assessed. Using the category descriptions in Table 67, Table 68 shows, by jurisdiction, the extent to which legally and non-legally binding instruments address the risk to water quantity due to forestry activities in multiple-use public forests.

Table 68: Extent to which legally and non-legally binding instruments address the risk to water quantity due to forestry activities in multiple-use public forest (including plantations), by jurisdiction

Instrument	NSW	SA	Tas.	Vic.	WA
Legally binding	2	2	1	1	4
Non-legally binding	Not applicable	5	1	1	5

Sources: State and territory agencies

In a number of states, the level of harvesting allowed annually in water-supply catchments is restricted to ensure that there are no major fluctuations in stream flow. These restrictions vary among and within jurisdictions and are influenced by the environmental conditions in particular catchments and by water supply and demand. In Tasmania, the code of forest practice restricts harvesting to no more than 5% of town water-supply catchments in any given year. In Victoria, a number of formal and informal limits apply to timber harvesting in catchments (including the Thomson, Tarago and Bunyip catchments) that supply water to Melbourne, restricting the area harvested annually to a very small proportion of those catchments. For example, the harvesting and regeneration of native forest in the Thomson catchment is limited to 0.3% of the catchment in any one year. The regulations and limits noted here are currently under review. These requirements are audited by the Environment Protection Authority Victoria.

In South Australia, commercial forestry in the lower southeast is prescribed as a water-affecting activity requiring a permit. The permit system is managed in concurrence with local-government development approvals.

In New South Wales, native-forest operations are required by law (as embodied in integrated forestry operations approvals, including environment protection licences) to be dispersed in space and time. Harvesting activities are generally restricted to about 1% of total catchment area in any one year.

In Western Australia, the forest management plan for the main timber production areas in the state's southwest includes a broad requirement to maintain water quantity.

In line with the management objectives for forested public nature conservation reserves, there is generally very little disturbance apart from fire in such reserves. Where planned disturbance occurs (such as during road construction, trail maintenance, fire management or facility development), legal instruments in all jurisdictions require the protection of water values.

Water quantity knowledge base

Knowledge of the effects of forest management on water quantity is well developed, particularly in New South Wales, South Australia, Victoria and Western Australia (Table 69). However, there is a limited capacity to model the effects of forest type, forest age, soil type and climatic variation on catchment water yields. Those issues are currently the topics of major research programs.

The ability to predict stream flow from forests has improved recently in Tasmania with the development of the TasLUCaS tool,[8] which helps predict changes to stream flow in regenerating native forest and after the conversion of grassland or native forest to plantations. The potential impact of proposed forest management actions on downstream water users can now be better taken into

8 Brown et al (2006a).

account and minimised during planning. The model has been independently tested in two subcatchments in northwest Tasmania.

Table 69: Water quantity knowledge base, by jurisdiction

	Water quantity knowledge base
NSW	Well-developed knowledge based on long-term (30 year) forest hydrology research on catchments in a number of locations. Research has been published. Regular training is provided to staff in order to retain accreditation.
SA	Reasonably good understanding of activity impacts on water quantity; includes local knowledge, training and codes of practice, published research and geographic information systems.
Tas.	Increasing knowledge of activity impacts on water quantity; includes local knowledge, modelling, research results, training and codes of practice.
Vic.	Good knowledge of activity impacts on water quantity; includes local knowledge, modelling, research, training and codes of practice.
WA	Well-developed knowledge, including published research, geographic information systems, decision-support tools, codes of practice, local knowledge, training and site-specific research models.

Source: State and territory agencies

In New South Wales, the results of research based on three long-term hydrological studies in three forest types have been published in recent years.[9] The studies all found an increase in water yield after harvesting disturbance. The increase persisted for at least three years, after which yield briefly returned to pre-harvest levels before progressively declining by up to 20% of pre-harvest yield at 16 years post-harvest. This relatively low decrease in water yield is expected to bottom out as the regenerating forest reaches about 20 years post-harvest and then to increase gradually as the forest matures and growth rates (and therefore water use) decline. This conclusion is supported by earlier work in *Eucalyptus regnans* forest in Victoria, which showed that sapwood area and hence growth rates and water use declined with age.[10]

In Western Australia, stream flows are reported every five years. Where shortfalls are identified, the reasons and trends are assessed and reported to the Conservation Commission and the Minister for the Environment.

There is a large body of research on the impacts of various forest management regimes on stream flow and groundwater in the southwestern forests of Western Australia. Two reviews summarised the studies undertaken in those forests based on the results of 27 experimental catchments.[11] The studies looked at the impacts of clearing for agriculture, timber harvesting and regeneration, thinning, tree dieback, reforestation, the interaction with rainfall zones and the effect of climate variability. Clearing for agriculture has resulted in a substantial increase in stream flow, groundwater levels and flood peaks. Timber harvest and regeneration results in a moderate transient increase in stream flow and groundwater levels. Thinning results in a more prolonged increase in stream flow, but the increase is dependent on the effectiveness of the control of regeneration. Increases are greatest in higher rainfall areas and with increased intensities of harvesting or thinning. A trial to assess the effects of various forest treatments on water yield is under way in the Wungong catchment (Case study 31).

Plantations

Forest plantations in Australia occupy only a small percentage of the catchments in which they occur.[12] 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).[13] Nevertheless, the issue of water use by plantation forests has arisen in the past decade as it has become clear that the impacts of prolonged drought have affected the availability of water in many catchments. This has created policy questions about water allocation and entitlement to rainfall. Plantation development was therefore included as one of the land-use changes to be considered by the Intergovernmental Agreement on a National Water Initiative, which provides a framework for considering the impacts of activities that may intercept water. The location and management of plantations is subject to land-use policies and planning controls; sustainability considerations are encompassed within codes of practice and management prescriptions.

A review of groundwater resource condition in southeastern South Australia identified seven areas where rates of groundwater level drawdown exceeded 0.1 metres per year or salinity increase exceeded 10 milligrams per litre per year.[14] Groundwater levels in one of the areas were affected by forest disturbance following the 1983 Ash Wednesday bushfires near Nangwarry, and forest plantations were also recognised as users of groundwater through interception and uptake. Another recent study calculated the total available recharge in the region.[15] Recharge interception due to forest plantations and direct water use (where the watertable is less than 7 metres below the ground surface) was estimated to be 2.6 megalitres per hectare per year for pine plantations and 2.3 megalitres per hectare per year for eucalypt plantations. In the future, groundwater management is likely to become more adaptive, employing allocation systems that are sensitive to changes in groundwater resource condition.

9 Lane and Mackay (2001), Cornish and Vertessy (2001) and Roberts (2001).

10 Roberts et al (2001).

11 Bari and Ruprecht (2003) and Ruprecht and Stoneman (1993).

12 Gerrand et al (2004).

13 Parsons et al (2007b).

14 Brown et al (2006b).

15 Latcham et al (2007).

Case study 31: The Wungong catchment

The Wungong catchment is a drinking-water catchment southeast of Perth. The Water Corporation's Wungong Catchment Environment and Water Management Project commenced in 2005 as a 12-year experimental trial to increase stream flows into the Wungong Reservoir by carrying out silvicultural treatments in selected parts of the catchment. The project is testing the managed thinning of the overstorey as well as the removal of woody weeds and their subsequent replacement with local species to improve water yield.

Under the project, it is expected that approximately 62% of the 12,845-hectare catchment area will be managed by thinning existing forest to a target basal area of 12–15 square metres per hectare. This is a reduction in forest stand density from nearly 1,000 stems per hectare to 300–350 stems per hectare. The Water Corporation expects an additional average of 4–6 gigalitres per year of stream flow during the trial, which is 25% of the average stream flow into the reservoir.

Source: Water Corporation, Western Australia

References and further reading

Bari and Ruprecht (2003), Benyon and Doody (2004), Benyon et al (2006), Bren et al (2006), Brown et al (2006a), Brown et al (2006b), Cornish and Vertessy (2001), Gerrand et al (2004), Lane and Mackay (2001), Latcham et al (2007), Parsons et al (2007b), Roberts (2001), Roberts et al (2001), Ruprecht and Stoneman (1993), Webb et al (2007) (list at the back of the report).

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 ecosystem health and water supply for human use.

Key points

- There is generally a good understanding of the potential impact of forest activities on water quality; this has enabled the development of sound mitigation measures and practices.
- In most jurisdictions, codes of forest practice or other instruments specify measures that must be carried out to help maintain water quality.
- Assessment of the risk posed by timber harvesting to water quality is reasonably comprehensive.
- Compliance with mitigation measures to protect water quality is generally high for timber harvesting operations.
- Major wildfires during the reporting period adversely affected water quality across forest tenures.

There is a public expectation that water leaving forests will be clean and good quality. For this reason, forest managers have commissioned research studies in experimental catchments and, in some forest areas, established monitoring programs to gain an understanding of the quality of water leaving forests. This indicator reports on the intent and implementation of mitigation measures that protect water quality. The focus of reporting is on multiple-use public forest and public nature conservation reserves because data are generally not readily available for other tenures in most jurisdictions.

Water quality is monitored at many sites across the states and territories to assess river condition and to determine whether water for different uses, including drinking water, meets the required standards. Not all these sites are located in forests; nor is it always possible to identify the causes of changes in water quality. Storm events can have significant impacts, even in pristine catchments. In southern Tasmania, for example, high turbidity levels, due mainly to organic matter, have been measured at the Warra Long-term Ecological Research Site during and after heavy rain in catchments that have never been roaded or logged.[16] Other research at the same site found considerable variation in turbidity among 15 monitored catchments, irrespective of forest treatment. Although turbidity levels at the site fall within the guidelines of the Australian and New Zealand Environment and Conservation Council (ANZECC) for upland rivers in Tasmania, they exceed drinking-water guidelines approximately 24% of the time.

It has been known for many years that roads, tracks and log landings are potential sources of suspended sediments that can increase turbidity in streams. The implementation of mitigation measures such as those listed in Table 55 in Indicator 4.1b to minimise soil erosion will also minimise the risk to water quality; such measures are included in the codes of forest practice and other instruments that help govern forest management in multiple-use public forests and some private forests.

Fires, both planned or unplanned, have the potential to affect water quality by increasing erosion risk (Indicator 4.1b). In recent years, the impacts of major fires on water quality have been demonstrated in Victoria and in the Australian Capital Territory, where fire burned more than 840 kilometres of riparian vegetation in 2003, about two-thirds at high or very high severity.[17] Vegetation cover was also lost in substantial parts of the east and northeast of the territory's water catchments. As a result, intense rainstorms in February 2003 washed massive amounts – an estimated

16 Ringrose et al (2001).

17 Carey et al (2003).

Table 70: Category descriptions and ratings applied in assessing the extent to which the regulatory framework requires the maintenance of water quality

Category	Category description
1	The 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; and 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 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 for addressing 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.

27 years worth – of sediment and burnt organic and mineral material from riparian zones, stream banks and hill slopes into most streams in the catchment and into the Bendora, Cotter and Corin reservoirs. For the first time, sheet erosion became the dominant source of sediment in Corin Dam; it was estimated to comprise well over 50% of total sedimentation, compared to 7% before the fires. Territory water-supply reservoirs were sufficiently polluted by this sediment to be closed by water authorities.

Instruments in place that address the risks to water quality

The extent to which legally and non-legally binding instruments such as codes of practice, guidelines and forest management plans that address water quality exist across state and territory jurisdictions is rated in Tables 71 and 72 using the category descriptions in Table 70. Key mitigation measures include providing adequate drainage for roads, trails and tracks and maintaining streamside protection with buffer or filter strips that minimise soil movement into streams.

Legally binding instruments are in place in New South Wales, Tasmania and Victoria (Table 71). South Australia 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. In New South Wales, forest managers have statutory obligations to address water-quality risks in nature conservation reserves and in multiple-use public native forests and plantations.

In Victoria, the *Code of Practice for Timber Production* (revised in 2007), which applies to all timber production on private and public land, outlines specific requirements and mandatory actions designed to prevent soil sediments, nutrients, chemicals, petroleum products and fertilisers from entering waterways. Actions 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 energy-dissipating structures or silt traps alongside roads, and road closures in wet weather. The *Code of Practice for Fire Management on Public Land* addresses the potential impacts of fire disturbance on water quality.

There are limited legally and non-legally binding instruments in Western Australia, but they do not address all the aspects listed in Table 70. However, the Forest Management Plan 2004–13, which covers all of the main timber production areas in the state's southwest, places strong emphasis on the protection of soil and water values. The soil erosion measures in place for disturbances in multiple-use public forest and timber reserves in Western Australia are currently being reviewed; any improvements that are implemented would be expected to have positive outcomes for water quality.

Table 71: Extent to which legally binding instruments address the risk to water quality due to forestry operations, road and trail works, fire management and recreation activities

	Category[a]				
	NSW	SA	Tas.	Vic.	WA
Multiple-use public forests	1	4	1	1	4
Public nature conservation reserves	1	4	1	1	4

a Values refer to category descriptions in Table 70.

Note: Queensland has the *Code of Practice for Native Forest Timber Production* for public land and the *Private Native Forests Code of Practice*.

Sources: State agencies

Table 72: Extent to which non-legally binding instruments address the risk to water quality due to forestry operations, road and trail works, fire management and recreation activities

	Category[a]				
	NSW	SA	Tas.	Vic.	WA
Multiple-use public forests	1	1	1	1	1 (native forest) 3 (plantations)
Public nature conservation reserves	1	Not applicable	1	1	4

a Values refer to category descriptions in Table 70.

Sources: State agencies

Table 73: Category descriptions and ratings applied in assessing the extent to which the risks to water quality are assessed in planning processes

Category	Category description
1	The water-quality risk assessment system comprehensively takes into account 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; and 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 properties for the particular disturbance activity and geographical setting.
3	The water-quality risk assessment system takes into account some of the factors listed in category 1 or only partly accounts for those 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.

Assessment of the risk to water quality

The assessment of the risk to water quality posed by disturbance activities is generally a combination of office-based analysis and field verification and is usually carried out in conjunction with an assessment of the risks of the proposed activity to soil values. Many forest managers use similar categories to those listed in Table 73 as a series of overlays in a geographic information system to make such assessments and then seek advice from the relevant regulatory agencies if necessary.

Table 74 shows that, in most states, comprehensive assessments of the potential risks to water quality are conducted before harvesting, silvicultural and roading operations in multiple-use public native forests and plantations. In 2005–06, in those states for which data were available, 100% of proposed activities were assessed before the commencement of most operations.

Water quality knowledge base

The knowledge base required to maintain water quality in multiple-use public forest is generally good (Table 75) and continues to improve (Case study 32); it is highly dependent on knowledge of soil erosion and the implementation of appropriate soil erosion mitigation measures. The major indirect impacts on water quality that can arise from unplanned fire are clearly seen in the aftermath of the 2003 fires in the Australian Capital Territory, as described earlier. Improved fire and fuel management should reduce the risk of bushfire in water catchments and, therefore, the potential risk to water quality. Further knowledge is required across other tenures, and some risk factors on public land need to be better understood.

Table 74: Multiple-use public forest where disturbance activities were planned in 2005–06, proportion assessed for risk to water quality, and category of assessment

Disturbance activity		NSW	SA[a]	Tas.	Vic.[b]	WA
Native-forest harvesting and silviculture	% assessed for risk to water quality	100	Not applicable	100	95	100
	Category[c]	1		1	1	2
Plantation operations	% assessed for risk to water quality	100	100	100	95	100
	Category[c]	1	1	1	1	3
Road construction and maintenance	% assessed for risk to water quality	100	100	100	95	100
	Category[c]	1	1	1	1	2
Fire management	% assessed for risk to water quality	100	100	100	95	–
	Category[c]	1	1	1	1	–

a South Australia does not harvest native forest.

b Plantations privately owned and managed in Victoria.

c Values refer to category descriptions in Table 73.

Sources: State agencies

Table 75: Water quality knowledge base, by jurisdiction

NSW	Comprehensive knowledge base to assess the risks to water quality, supported by published research, ongoing monitoring, codes of practice, statutory obligations, local knowledge and training, geographic information systems and the employment of specialists.
SA	Reasonable understanding of activity impacts on water quality. *Environmental Management Guidelines for Plantation Forestry* in place.
Tas.	Good knowledge for multiple-use public forest and some private forest. Code of practice has specific requirements for watercourse and water-quality protection. Forest Practices Authority provides regular training to forest managers.
Vic.	Reasonable knowledge of impacts of activities on water quality, including local knowledge, training, codes of practice, statutory obligations, mapping of slope limitations, specialist research and development projects.
WA	Well-developed knowledge, including published research, geographic information systems, decision-support tools, codes of practice, local knowledge, training and site-specific research models.

Sources: State agencies

Compliance with water quality measures

The assessment of compliance with requirements for the protection of soil values and water quality is part of the process of assessing compliance with soil-erosion prevention measures (Indicator 4.1b).

In New South Wales, water quality in multiple-use public forests is measured and monitored in 35 small catchments in native and plantation forests. Typically, multiple paired catchments of unharvested and disturbed sites are monitored immediately before and after disturbance – which may include a combination of harvesting, burning and roading activities – as well as in the long term.

Victoria has a large network of streamwater-quality monitoring sites that record parameters such as acidity, dissolved oxygen, electrical conductivity, sediments/total dissolved solids, temperature, phosphorus and nitrogen. A number of the sites are in or downstream from forested areas.

In 2004, Victoria undertook its second statewide assessment of river health using the Index of Stream Condition. The index measures the environmental condition of 1,040 river reaches, representing 26,000 kilometres of Victoria's major rivers and tributaries in forested and non-forested catchments. The index has five subindexes (hydrology, streamside zone, physical form, water quality and aquatic life), comprising 19 key indicators. The assessment found that 21% of Victoria's river length is in good-to-excellent condition; the overwhelming majority of that proportion is in the forested regions of eastern Victoria.

References and further reading

ANZECC (2000), Bari et al (2004), Carey et al (2003), Cornish (2001), DSE (2007), ForestrySA (1997), McIntosh (2004), McIntosh and Laffan (2005), Ringrose et al (2001), Webb and Haywood (2005), Webb et al (2007) (list at the back of the report).

Case study 32: Recent research on reducing impacts on water quality

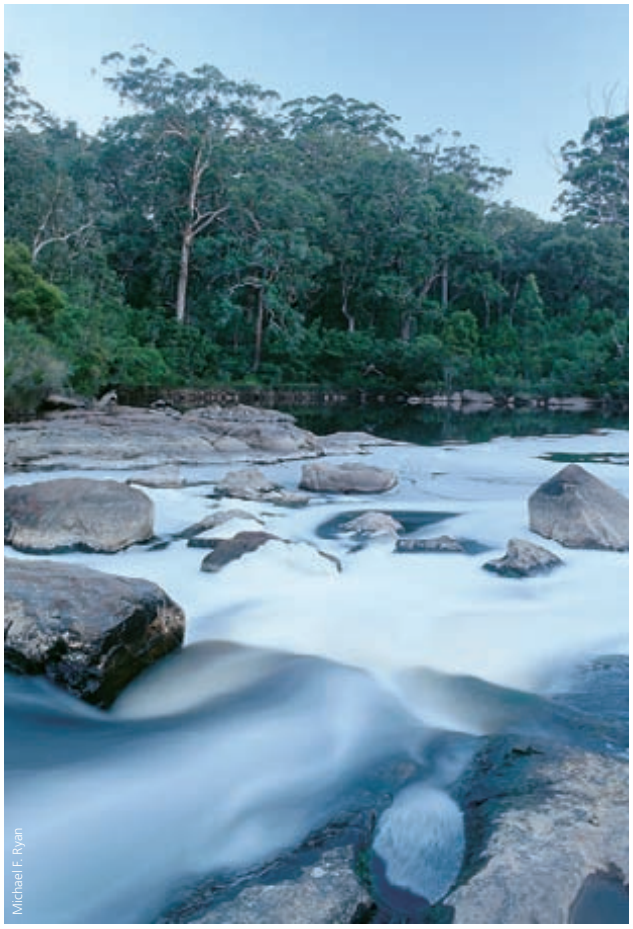
Data from a long-term catchment study at Karuah in northern New South Wales showed that road–stream connectivity was the most important factor in sediment delivery to streams in roaded catchments.[18] Harvesting in the absence of roads generally reduced turbidity levels, as did the implementation of prescriptions such as slope limits on logging and log extraction track construction, the retention of 20-metre wide undisturbed buffers on both sides of streams, and the rapid revegetation of catchments after logging. These findings led to the adoption of improved road drainage measures in the state's multiple-use public native forest, particularly aimed at intercepting road runoff near streams and diverting it to vegetation areas with good absorption characteristics. More recent small-catchment monitoring by Forests NSW has confirmed that the effects of forestry activities on water quality in both native forests and plantations are largely mitigated by the revised forest practices.[19]

In Tasmania, recent research led to the development of *New Guidelines for the Protection of Class 4 Streams*.[20] The guidelines include improved protection for headwater streams based on five graded prescriptions according to erosion risk.

In Western Australia, salinity levels in the Denmark River peaked at 1,520 milligrams per litre (total dissolved solids) at the Mount Lindesay gauging station in 1987, posing a threat to Denmark township's drinking water. Since 1991, stream salinity has decreased by an average of 8 milligrams per litre per year, due partly to a cessation of vegetation clearing and partly to the groundwater-lowering effects of tree plantations established after 1988.[21] By 2002, an area of 3,450 hectares of plantation had been established in the upper Denmark catchment. Further reductions in salinity are expected once all planned plantations are fully established, although the salinity target of 500 milligrams per litre at Mount Lindesay by 2020 might not be met. All salinity management works should be completed by 2010, but it will take a further 10 years before the full benefits of the work are known. Monitoring and evaluation of this work is ongoing, with the intention of producing five-yearly situation reports.

Forested catchments are critical to water quality in Australia.

18 Cornish (2001).
19 Webb and Haywood (2005), Webb et al (2007).
20 McIntosh and Laffan (2005).
21 Bari et al (2004).



Circular pool, Walpole, Western Australia.

Criterion 5

Maintenance of forest contribution to global carbon cycles

This criterion, which comprises only one indicator, quantifies and reports the effects of forest management and forest land-use change on greenhouse gas emissions and sequestration. Forests are an important component of the global carbon cycle, and the flux in forest carbon stocks is a key indicator of sustainable forest management.

Forests NSW

Cross-section of radiata pine (*Pinus radiata*). Annual growth sequesters carbon dioxide from the atmosphere; wider rings near the centre indicate faster growth and therefore more rapid uptake of carbon dioxide. During photosynthesis, about one tonne of carbon dioxide is captured from the atmosphere and combined with water taken up from the soil to produce about one cubic metre of wood. About 0.7 tonnes of oxygen is returned to the atmosphere.

Key findings

- Australia's forests sequester (absorb) more greenhouse gases from the atmosphere than they emit (release) and therefore help to offset Australia's contribution to global greenhouse gas emissions. Plantations offset about 3.5% and managed native forests about 5.5% of total Australian greenhouse gas emissions in 2005. Additional storage in wood products offset a further 1% of emissions.
- Deforestation, mainly for agriculture but also for urban development, was responsible for about 9% of total Australian greenhouse gas emissions in 2005. Carbon emissions from deforestation declined from about 70 million tonnes in 2002 to 53.3 million tonnes in 2005.
- A net amount of greenhouse gases equivalent to 43.5 million tonnes of carbon dioxide (11.9 million tonnes of carbon) was sequestered in managed native forests in 2005. About 3.8 million tonnes of carbon, or 0.06% of the total stock of biomass carbon in native forests, was removed yearly as roundwood (logs). Therefore, in 2005, about three times more carbon was sequestered than was removed or emitted in managed native forests subject to harvest and regrowth from prior harvest.
- Extensive wildfires in native forests during the reporting period released large amounts of greenhouse gases into the atmosphere. Over time, those emissions are expected to be offset by new forest growth since total native forest carbon stocks have changed little over the long term (i.e. 1989–2004).
- Fire in managed native forests caused greenhouse gas emissions equivalent to 1.3 million tonnes of carbon dioxide in 2005, a year of below-average fire impact (Indicator 1.3b). Those emissions were likely replaced in subsequent new forest growth.

Indicator 5.1a

Contribution of forest ecosystems and forest industries to the global greenhouse gas balance

Rationale

This indicator provides information on 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

- Australia's forests sequester (absorb) more greenhouse gases from the atmosphere than they emit (release) and therefore help to offset Australia's contribution to global greenhouse gas emissions.
- A net amount of greenhouse gases equivalent to 43.5 million tonnes of carbon dioxide was estimated to be sequestered in managed native forests in 2005.
- Plantations offset about 3.5% and managed native forests about 5.5% of total national greenhouse gas emissions in 2005. Additional storage in wood products offset a further 1% of emissions.
- The removal of carbon from native forests by timber harvesting was relatively constant over the period from 2001 to 2005: about 3.8 million tonnes of carbon or 0.06% of the total stock of biomass carbon in native forests was removed annually as roundwood.
- Extensive wildfires in native forests during the reporting period released large amounts of greenhouse gases to the atmosphere. Over time, those emissions are expected to be offset by new forest growth.
- Fire in managed native forests caused greenhouse gas emissions equivalent to 1.3 million tonnes of carbon dioxide in 2005. Those emissions will likely be replaced progressively in subsequent new forest growth.
- Deforestation, mainly for agriculture but also for urban development, was responsible for about 9% of total national greenhouse gas emissions in 2005.
- Carbon emissions from deforestation declined from about 70 million tonnes in 2002 to 53.3 million tonnes in 2005.

International concern about the effects of increased atmospheric concentrations of greenhouse gases, such as carbon dioxide (CO_2), on climate has focused attention on the global carbon cycle.[1] This indicator quantifies and reports on the effects of forest management and forest land-use change on net greenhouse gas balances at the national level.

Forests account for almost 60% of the carbon that exists in the vegetation and soils of the earth's land surface.[2] They absorb carbon dioxide from the atmosphere during photosynthesis and release it by respiration and the decay or burning of plant material. Forests can remove carbon dioxide from the atmosphere and store it in woody tissue in early-to-mid successional phases, but in mature forests the net exchange with the atmosphere is usually low, with the growth of young trees balanced by the death and decay of mature trees.

The amount of carbon stored in Australian forest landscapes can change over time because of:

- variation in climatic factors such as temperature and rainfall
- the natural developmental or successional dynamics of the forest
- disturbances such as harvesting, fire, storms and outbreaks of pests and diseases
- loss of forest area due to agricultural and urban expansion (clearing/deforestation[3])
- increases in forest area due to the establishment of commercial plantations and environmental plantings, the expansion and thickening of native forest, and the growth of exotic woody weeds.

1 Greenhouse gases other than carbon dioxide are accounted for here by converting them to carbon dioxide equivalents.

2 About half the dry weight of a tree is carbon. One tonne of carbon is equivalent to 3.67 tonnes of carbon dioxide.

3 Deforestation is used here to mean the conversion of forest land to cropland, grassland and urban infrastructure.

Forest management activities such as site preparation and planting, fertiliser application, spraying for pests and weeds, pruning and thinning can also influence the uptake and release of greenhouse gases. An aim of forest management is to minimise net greenhouse emissions within the constraints imposed by other management objectives. However, site-level greenhouse gas emissions should not be interpreted as a measure of sustainability. Rather, the greenhouse consequences of forest management are best interpreted at larger scales because it is the net effect across the landscape rather than local changes that influences the global atmosphere.

Once wood has left the forest, its role in the carbon cycle is determined by factors such as:

- change in the stock of wood and wood products in service
- the decay of redundant wood and paper products (mostly in landfill)
- the reduction of fossil-fuel emissions due to the substitution of wood for energy generation
- energy used and emissions produced during wood processing and transport.

Accounting for changes in carbon in the land sector is a significant challenge. The Australian Greenhouse Office (AGO) has developed the National Carbon Accounting System (NCAS) to calculate net greenhouse gas emissions and provide estimates for national reporting (see box).

According to the AGO, woody biomass (in plantations, commercial native forests and conservation forests) covers about 14% (108 million hectares) of Australia (Figure 46). This differs significantly from the estimates of forest cover given elsewhere in this report but is used in this indicator for the reasons outlined in Indicator 1.1a.

National Carbon Accounting System

The NCAS tracks emissions (sources) and removals (sinks) of greenhouse gases from Australian land-based systems. It underpins National Greenhouse Gas Inventory reporting and provides a basis for emissions projections. Significant land-based emissions and removals of greenhouse gases in Australia occur in the transition between forest and agricultural land uses; the integration of stock and change data on all forest and agricultural land is therefore essential.

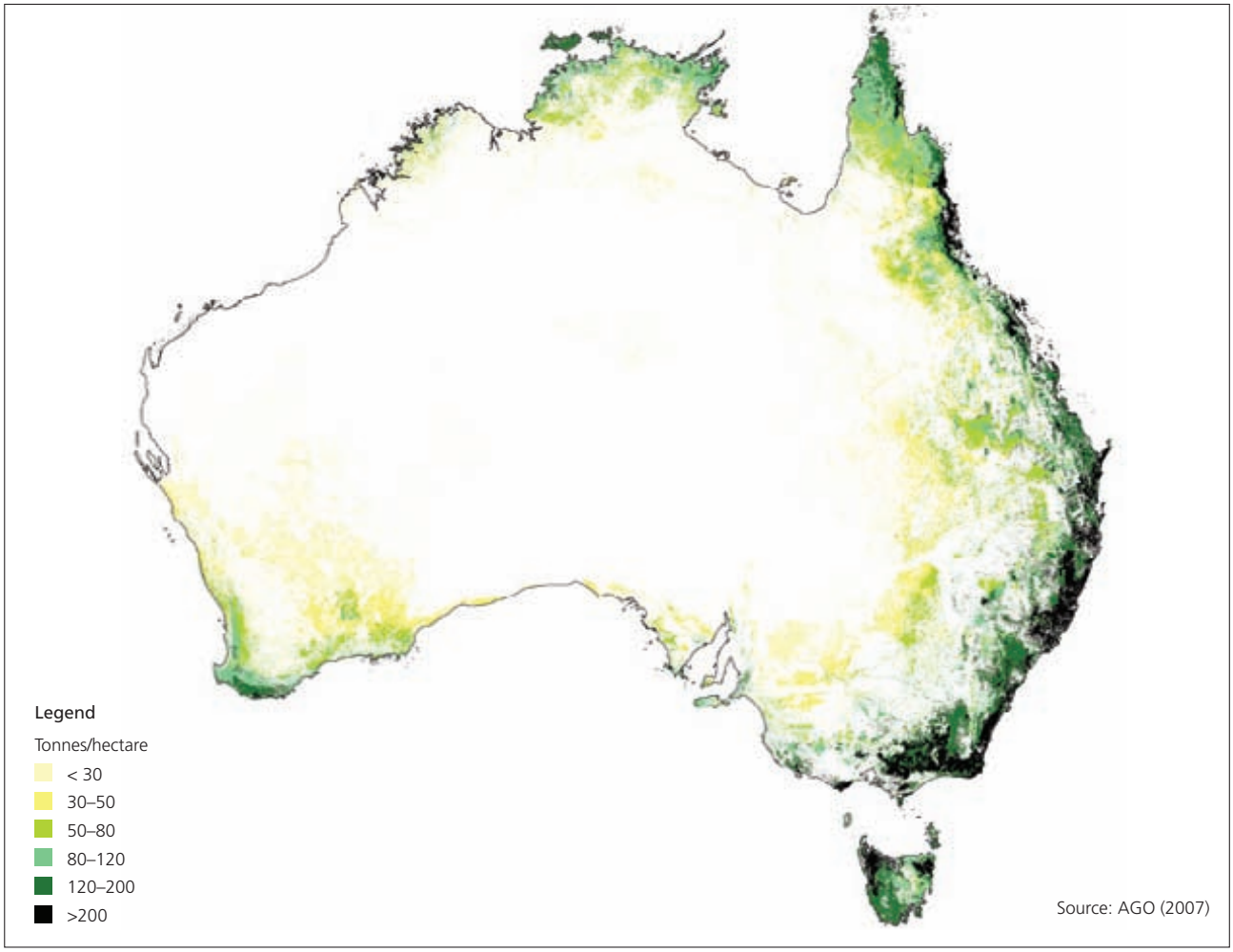
Early in the development of the NCAS, it was determined that sample-based measurement of carbon stock or stock change at the scales necessary for location-specific management or to monitor changes from pre-1990 levels was not feasible. Instead, an integrated approach using remote sensing, empirical and process modelling and intensive validation was adopted. Satellite images are used to determine changes in land cover, while a hybrid of verified empirical and process models is used to estimate the cycling of carbon and nitrogen in plant biomass, dead organic matter, soils and offsite products, and the emission and removal of greenhouse gases. This approach integrates a wide range of spatially referenced data and modelling to estimate carbon stock change and greenhouse gas emissions at fine temporal and spatial scales.

The implementation of the NCAS required the compilation of a critical mass of resource information based on relatively fine-scale, continent-wide satellite imagery for the 1972–2004 period. However, the total wooded area calculated by the AGO using those data differs from the area of forest estimated by the National Forest Inventory (NFI; Indicators 1.1a, 1.1b and 1.1c). The NFI estimates 149 million hectares of forest in Australia, while the AGO estimates a 'woody extent' of about 108 million hectares. Indicator 1.1a provides more information on the role of the NFI and the NCAS in meeting Australia's forest reporting needs.

Two different sets of rules are used in Australia for carbon accounting. One is under the United Nations Framework Convention on Climate Change (UNFCCC), the other under the Kyoto Protocol, which is an addition to that treaty. Carbon dioxide emissions from wildfire are not reported under either of these conventions. Kyoto Protocol rules do not count native forests and also exclude harvested wood products, with all the emissions assumed to occur at harvest. UNFCCC numbers include harvested wood products. Adopting an approach in carbon accounting that assumes that all emissions occur at harvest (as is the case under the Kyoto Protocol) gives a higher emission value than other approaches. In practice, a delay occurs in emissions following harvest because many wood products are stored in service for a significant time. The delay is increased when retention in landfill is also considered. Recent Australian research shows more than 95% of the carbon in wood remains in landfill after more than 30 years.

In this indicator, all carbon pools have been considered to the extent that available information allows. The exception is Table 82, which has been compiled using UNFCCC guidelines, with the separate addition of data on wood products in service.

Figure 46: Woody biomass distribution in Australia, 2004



Native forests

Australia's total tree biomass in native forests (i.e. above-ground woody biomass plus roots and including forests in conservation reserves but excluding soil carbon) held 6.56 billion tonnes of carbon in 2004 (Figure 47). This is equivalent to keeping 24 billion tonnes of carbon dioxide out of the atmosphere, or 46 years of Australia's current total emissions from all sources. It is also equivalent to about 3.3% of all the carbon emissions arising from human activities worldwide since 1800. Eucalypt open forests and open woodland together store 57% of the total carbon.

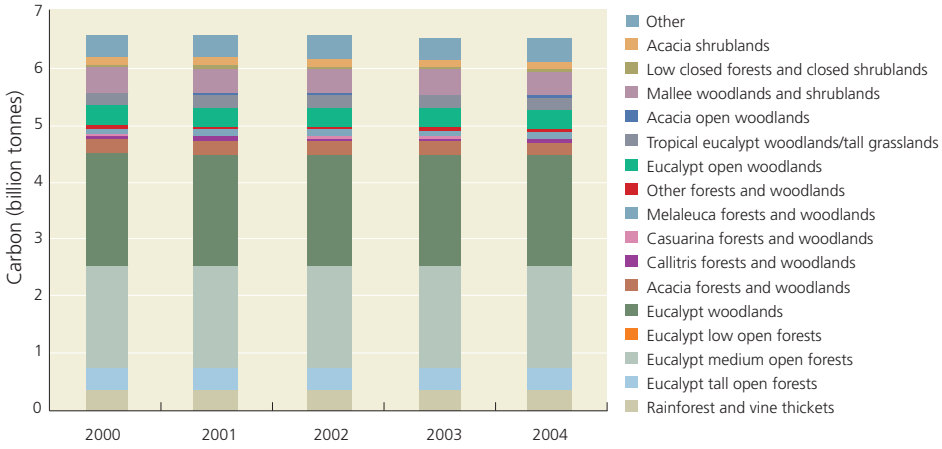
The amount of carbon in native forest total tree woody biomass reported here is about 20% lower than that reported in SOFR 2003. This is not a real decline; it is due partly to changes in the way forest extent is analysed and mainly to the fact that it is now possible to account for forest condition.

There was little real change in carbon in native forest total tree woody biomass in the period from 2000 to 2004, even though land clearing was still taking place, albeit at a lower level than previously reported (Figure 47). The amount of carbon held in native forest tree woody biomass is expected to increase as broadscale clearing of native forest (estimated by the AGO at about 260,000 hectares per year from 2000 to 2004) is reduced over time under legislative restrictions and as regrowth occurs in at least some previously cleared areas (Indicator 1.1d).

There was also almost no change (a decrease of 0.7%) between 1989 and 2004 in the amount of carbon held in native forest total tree woody biomass, although there was significant change in some forest groups (Table 76). Those groups that increased are generally known to have both thickened (i.e. the vegetation increased in density) and increased in extent, in some cases (such as the callitris forests and woodlands) probably due to reduced fire frequency. Those forest groups, such as eucalypt open woodlands, that decreased by more than 2% between 1989 and 2004 are known to have been affected the most by broadscale clearing, firewood collection and mortality due to a variety of causes, including different kinds of dieback and from bushfires. Other forest groups were probably in near-equilibrium, with growth about equal to decay.

Harvesting from managed native forests (that is, forests subject to harvest and regrowth from prior harvest) averaged around 11.8 million cubic metres of roundwood per year in the period from 2001 to 2005. About 3.8 million tonnes of carbon – equivalent to about 0.06% of the total carbon stored in native forests and 14.1 million tonnes of carbon

Figure 47: Total carbon in total tree biomass (above-ground plus roots) of native forests, 2000 to 2004, by forest vegetation group



Source: Derived from AGO data

dioxide – was removed.[4] This small removal was exceeded by new growth: about 43.5 million tonnes of carbon dioxide, equivalent to about 11.9 million tonnes of carbon, was estimated to have been sequestered in managed native forests in 2005 after taking into account the decay of slash produced during harvesting (Table 82). Therefore, yearly sequestration of carbon in 2005 was about three times yearly emissions and removals arising from managed native forests subject to harvest and regrowth from prior harvest.

Because the carbon stored in native forest biomass, including in nature conservation reserves, is 20 times more than that contained in forest plantations, wood in service and wood in landfill combined, it has a dominant effect on the overall amount of carbon stored by the forest sector. Harvesting (<1% of the native forest outside nature conservation reserves annually), planned and unplanned fires (see Indicator 3.1b) and other periodic and infrequent disturbances therefore had little impact on national average total native forest carbon stock over the longer term.

Plantations

Carbon stock in forest plantations rose during the reporting period (Figure 48), due almost entirely to the expansion and growth of hardwood plantations. In 2004, 84 million tonnes of carbon (equivalent to 308 million tonnes of carbon dioxide) was stored in the standing stock of plantation total tree biomass. This amount was equivalent to 53% of Australia's total annual emissions from all sources.

About 6 million tonnes of carbon – 6% of the total stock and equivalent to 22 million tonnes of carbon dioxide – was removed in the plantation log harvest in 2004. This was more than replaced by new growth, with total carbon stock rising by about 18% between 2000 and 2004, from 72 million to 85 million tonnes of carbon.

Table 76: Change in carbon storage in native forest total tree biomass (above-ground plus roots), 1989 to 2004

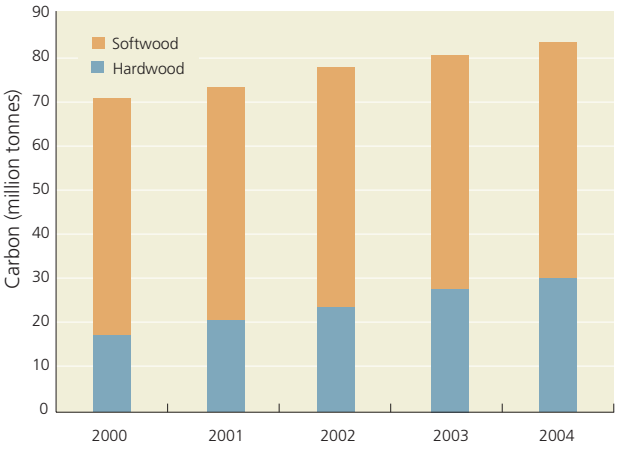
Forest vegetation groups with a net increase (+) of carbon over the period			Forest vegetation groups with a net decrease (–) of carbon over the period		
Forest type	Mt C	%	Forest type	Mt C	%
Acacia open woodlands	+2.6	+9.5	Melaleuca forests and woodlands	–5.8	–4.9
Acacia shrublands	+9.2	+7.9	Eucalypt open woodlands	–9.4	–2.8
Acacia forests and woodlands	+13.0	+5.5	Eucalypt tall open forests	–7.0	–1.9
Casuarina forests and woodlands	+0.9	+2.9	Low closed forest and closed shrublands	–1.0	–1.8
Tropical eucalypt woodlands/tall grasslands	+4.7	+2.4	Mallee woodlands and shrublands	–7.4	–1.7
Callitris forests and woodlands	+1.1	+2.1	Eucalypt low open forests	–0.4	–1.5
Other	+4.2	+1.1	Eucalypt medium open forests	–27.6	–1.5
			Other forests and woodlands	–0.9	–1.4
			Rainforest and vine thickets	–3.9	–1.0
			Eucalypt woodlands	–17.6	–0.9

Mt C = million tonnes of carbon

Source: Derived from AGO data

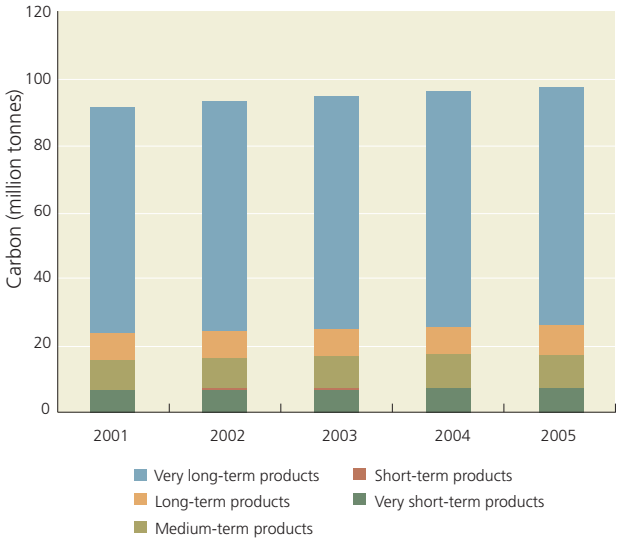
4 Roundwood removals include saw and veneer logs, sleepers, wood-based panels, paper and paperboard, fencing, mining timbers, poles and piles. The density of carbon in hardwood is assumed to be 0.325 t C/m^3.

Figure 48: Carbon storage in forest plantations, 2000 to 2004



Source: Derived from AGO data

Figure 49: Carbon stored in wood products in service, 2001 to 2005



Note: See Richards et al (2007) for an explanation of the components of each of the five product pools. In general terms, the range is: very short term, 1–3 years; short term, 3–10 years; medium term, 10–30 years; long term, 20–50 years; very long term, 30–90 years.

Source: Derived from AGO data

Carbon stored in wood products in service

The AGO has developed a model to estimate carbon flux in wood products. It accounts for logs harvested within Australia from native forests and plantations, processing, imports and exports, recycling, entry and decomposition in landfill, use for bioenergy and other losses to the atmosphere. The model was derived using production, consumption, export and import data reported since recording began in 1944.[5]

On average, carbon accumulated in wood products in service by 1.6% per year in the period from 2001 to 2005 (Figure 49), the bulk of it stored in very long term products such as timber used for construction. In 2004, 97 million tonnes of carbon was stored in wood products in service, equivalent to 356 million tonnes of atmospheric carbon dioxide and 61% of Australia's total annual emissions from all sources.

Carbon stored in wood products in landfill

Total net carbon stock in wood and wood products in landfill increased by about 2.3% per year in the period from 2001 to 2005 (Figure 50), due almost entirely to a rise in the volume of very short term products such as paper. Landfill volumes of very long term products such as waste timber remained constant. One reason for this is that much timber is now recycled, with demand for recycled solid wood close to exceeding supply. In 2004, 143 million tonnes of carbon (equivalent to 525 million tonnes of carbon dioxide) was stored in landfill. This was nearly 50% more than for wood products in service and 90% of Australia's total annual emissions from all sources.

The inclusion or exclusion of the landfill carbon store (and therefore emissions from landfill) is very significant for the forest sector. The annual increases in the landfill carbon store in effect provide a growing base for additional emissions. Future annual emissions from this store could potentially exceed inputs. At issue particularly, is uncertainty over greater methane (CH_4) emissions from landfill, although these are increasingly flamed off (a burning process that converts methane to the less greenhouse-powerful carbon dioxide) or captured and used for energy production (offsetting the need for fossil fuels). Further research is required to determine the proportions of carbon emitted as carbon dioxide and methane from landfill.

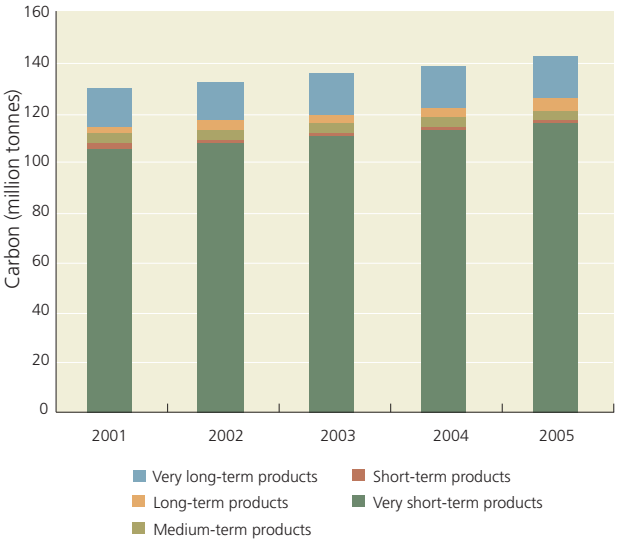
Forest soils

Uncertainty exists in the calculation of the flow of carbon into and out of forest soils. On-ground carbon (in litter) and below-ground carbon (in organic matter) are important in the carbon cycle, but soil carbon is difficult and expensive to measure. Soil type is an important factor, with higher clay content leading to greater carbon-carrying capacity. Climate is also a factor: carbon-carrying capacity tends to decline in drying soils and increase in moistening soils.

The AGO has estimated carbon both in biomass (above-ground and roots) and in soils for Australia's native forest types in 2004 (Table 77).

5 Richards et al (2007).

Figure 50: Carbon stock in products in landfill, 2001 to 2005



Note: See Richards et al (2007) for an explanation of the components of each of the five product pools. In general terms, the range is: very short term, 1–3 years; short term, 3–10 years; medium term, 10–30 years; long term, 20–50 years; very long term, 30–90 years.

Source: Derived from AGO data

On average, soil carbon constitutes about 46% of the carbon in the combined biomass and soil pools. Casuarina and callitris forests and woodlands contain the highest proportion of soil carbon, tropical eucalypt woodlands the lowest. Total soil carbon under native forest is 5.51 billion tonnes (20.2 billion tonnes carbon dioxide equivalent); this was equivalent to about 39 times Australia's total net greenhouse gas emissions from all sources in 2005.

In managed native forests (i.e. those forests subject to harvest and regrowth from prior harvest), change in soil carbon is believed to be insignificant because emissions caused by harvesting are balanced in a given inventory period by re-accumulation through regrowth. This reasoning is also used in the accounting rules set out by the UNFCCC.

Research by the Cooperative Research Centre for Greenhouse Accounting has shown that soils under forests and woodlands sometimes have more carbon in them than the agricultural systems they replace or are converted to, and sometimes less. For plantations, there is typically a long-term increase in soil carbon after some possible early losses. These effects are dependent on the pre-establishment condition and establishment technique (Polglase et al 2000). Notably, soil carbon stocks generally decline under pine plantations established on land that had previously carried pastures, but not on land formerly under broadleaved forests. In the case of pines, the loss of carbon is associated with a large loss of nitrogen from the soil.

Table 77: Carbon storage in soils in relation to biomass in native forest types, 2004

Vegetation type	Soil (Mt)	Biomass, including roots (Mt)	Biomass + soil (Mt)	Soil carbon as a proportion of total carbon (%)
Tropical eucalypt woodlands/tall grasslands	109.2	201.0	310.1	35.2
Other forests and woodlands	39.3	61.6	100.8	39.0
Acacia shrublands	82.9	126.4	209.3	39.6
Acacia open woodlands	20.9	30.2	51.1	40.9
Acacia forests and woodlands	180.4	247.0	427.4	42.2
Mallee woodlands and shrublands	328.9	432.3	761.2	43.2
Eucalypt woodlands	1,482.2	1,912.1	3,394.3	43.7
Low closed forests and closed shrublands	45.4	57.1	102.5	44.3
Rainforest and vine thickets	320.6	402.1	722.6	44.4
Eucalypt low open forests	19.5	24.0	43.5	44.8
Eucalypt tall open forests	303.3	356.4	659.7	46.0
Melaleuca forests and woodlands	98.6	111.4	210.0	46.9
Eucalypt medium open forests	1,674.4	1,795.8	3,470.2	48.2
Other	375.9	386.7	762.6	49.3
Eucalypt open woodlands	335.7	330.7	666.4	50.4
Callitris forests and woodlands	52.7	50.4	103.0	51.1
Casuarina forests and woodlands	37.1	30.9	68.0	54.5
Total native forest	5,506.7	6,556.1	12,062.8	45.7

Mt = million tonnes

Note: Soil carbon masses are for forest extant in 2004; estimates for later years and time-series data are not available. Soil carbon is relatively stable; the rate of change depends on initial soil carbon levels and past management practices. Masses have been determined from the available soil carbon inventory of native forest systems throughout Australia (Webbnet Land Resource Services 2002). Totals may not tally due to rounding.

Source: Derived from AGO data

Table 78: Summary of carbon storage in forests and wood products, Australia

	Stock (Mt)			
Storage pool and year	Carbon	Carbon dioxide	Annual change (%)	Storage as a percentage of Australia's net 2005 emissions (%)
Native forests, including conservation reserves (excluding soil carbon), 2004	6,560 (54%)	24,075	–0.3%	4,610[a]
Soil carbon under native forests in 2004	5,507 (46%)	20,210	Insufficient data	3,870[a]
Total carbon in native forests in 2004	12,065 (100%)	44,285	Insufficient data	8,480[a]
Plantations (excluding soil carbon), 2004	84	308	+4.6 (2001–04)	53
Wood and wood products in service, 2005	97	356	+1.5 (2001–05)	61
Wood and wood products in landfill, 2005	143	525	+2.3 (2001–05)	90

Mt = million tonnes

a Equivalent to 46, 39 and 85 years of Australia's 2005 net emissions from all sources (522.2 Mt CO_2 equivalents – see Table 82).

Source: Derived from AGO data

Research has improved models for determining soil carbon flux in major land-cover conversion from forest to non-forest where there are consistent large declines in carbon stocks. A model for soil carbon under plantations is expected to be available soon, but one for native forests will take longer because of the need to take into account a wide variety of ecosystems, forest types and maturation states.

Table 78 summarises carbon storage in forests and wood products in Australia.

Fire

Forest fires emit carbon dioxide, methane and other greenhouse gases. Severe forest fires have little impact on national forest carbon storage levels over the long term. For example, the 2002–03 Victorian and New South Wales alpine fires burned more than 1.3 million hectares (Indicator 3.1b) and were estimated to have released the equivalent of 40 million tonnes of carbon dioxide, or about 0.17% of the carbon stock in native forests. Biomass burning (planned and unplanned fire) in managed native forests used for timber production in 2005 caused an estimated 1.3 million tonnes of carbon dioxide equivalent emissions (Table 82), which was about 0.02% of the total native forest carbon stock. Those losses can be compared to the estimate that native forests managed for wood production (multiple-use public forests – 6% of Australia's forests) alone sequestered 43.5 million tonnes of carbon dioxide in new forest growth in one year (2005). Charcoal (black carbon) deposited during forest fires, although comprising only a few per cent of the original biomass, is a very long-term carbon storage sink.

Firewood

An estimated 4.5–5.5 million tonnes of firewood is burned for cooking and heating in Australia each year (see Indicator 2.1c), causing emissions equivalent to about 2.5–3.0 million tonnes of carbon (9–11 million tonnes of carbon dioxide). Nationally, firewood is consumed by about 23% of households, two-thirds of which are located in rural areas. Seventy two per cent of the locations where merchants source firewood are in low-rainfall, low-biomass forests.[6]

The use of firewood for domestic heating generally causes fewer greenhouse gas emissions than equivalent heating using other energy sources, such as gas and fossil-fuel-generated electricity,[7] although to some extent this is determined by the management regime operating in the forest and the efficiency of the burning process. Generally, little net carbon dioxide is produced per unit energy by efficiently (>60% efficiency) burning firewood collected from harvest residues and other materials obtained from sustainably managed native forests. Burning firewood collected from a coppiced plantation also produces very few greenhouse gas emissions, and may result in a net sequestration of carbon, because the use of coppicing avoids many of the emissions that occur in new plantations (e.g. those caused by nursery operations, weed control, cultivation and the planting of new seedlings). In plantations grown for sawlogs, the use of harvesting residues, thinnings and other material for firewood requires little energy over and above that used for producing the sawlogs.

Forest management and silviculture

The main greenhouse gas emissions from forest management and silviculture arise from the combustion of diesel fuel by machinery. In calculating those emissions, it is necessary to also take into account emissions caused by the original production of the diesel. The average value for production and consumption combined is 3.1 kg of carbon dioxide per litre (equivalent to 0.84 kg of carbon per litre).

Fuel usage rates for personal transport and chainsaw operation are negligible in a typical commercial forest harvesting operation. More significant is the fuel used in log extraction and transport. Estimates of diesel consumption

6 Driscoll et al (2000).

7 Paul et al (2003). Electricity generation in Australia from fossil fuels, mainly coal, usually produces about 1.0 kg CO_2/kWh.

Wood used in buildings is a long-term carbon sink.

rates in Tasmanian native forest operations range from 2.6 to 4.1 litres per tonne of green timber loaded onto a truck (assuming the operation of a skidder, an excavator at the landing and an excavator at the coupe workfront). If 4 litres is required, carbon dioxide emissions would be about 1.2% of that sequestered during tree growth.

Most new plantations are now established on former farmland. The establishment phase – site preparation, nursery maintenance and the planting of seedlings – is estimated to cause emissions of about 0.12 tonnes of carbon (0.44 tonnes of carbon dioxide) per hectare, which is about 1% of the average amount sequestered by plantations in one year (Table 79). Over the long term, carbon dioxide emissions caused by plantations are likely to be lower than those caused by agricultural production because, in contrast to annual crops, forest plantations need to be established only once in a 10–35-year period. It is estimated that, for a plantation rotation that includes up to three thinning events and the application of fertiliser and pesticides by helicopter, total carbon emissions are around 1.5% of the carbon sequestered in tree growth.

Transport

Given the size of Australia, emissions caused by the transport of products may be greater than those caused by production and processing. Lighter products such as wood require less energy to transport than materials such as steel and concrete. Moreover, it takes about 10 tonnes of raw material to make 1 tonne of cement and about 14 tonnes of iron ore to make 1 tonne of steel. While those raw materials are often found in very remote locations and need to be shipped long distances for processing, most plantations are close to urban centres and major transport routes. Many of the native forests used for timber production are also in or near the more populated regions of Australia.

Logs and sawn timber are mostly transported by road using diesel-fuelled trucks. Assuming diesel consumption of about 0.02 litres per tonne per kilometre and an average road-transport distance of 500 kilometres, carbon dioxide emissions caused by the transportation of the 22 million cubic metres (11 million tonnes) of timber and paper products consumed by Australians each year would be about 333,000 tonnes, or 0.4% of total annual emissions by Australia's transport sector (Table 80).

Table 79: Carbon sequestered in some Australian plantations

Plantation type and location	Carbon sequestered in biomass (CO_2 equivalent)	
	t/ha/year	t/ha/rotation
WA, high rainfall[a]	63.9	639
Vic.[b]	55.4	997
Qld/NSW[c]	43.5	566
Tas.[d]	38.0	570
WA, low rainfall[e]	32.3	323
SA/Vic.[f]	25.1	879
NSW[g]	20.2	707
Average	~40[h]	~670

a 10-year-old *Eucalyptus globulus* plantation in the high-rainfall zone (1,023–1,450 mm) of southwest Western Australia.

b 18-year-old *E. globulus* plantation in southeast Gippsland, Vic.

c 13-year-old *E. grandis* plantation in southeastern Qld and northeastern NSW.

d 15-year-old *E. nitens* plantation in Tas.

e 10-year-old *E. globulus* plantation in the low-rainfall zone (590–950 mm) of southwest WA.

f 35-year-old *P. radiata* plantation (with three thinnings) in the Green Triangle of SA and Vic.

g 35-year-old *P. radiata* plantation (with three thinnings) in the ACT and southeastern NSW.

h Equivalent to 10.8 t/ha/year of carbon

Source: www.ensisjv.com/Portals/0/PlantationsAsCarbonSinks_Commentary.pdf (accessed July 2007)

Building with wood

Wood products normally require less energy to make and therefore emit less carbon dioxide during manufacture than alternative materials such as steel, concrete and aluminium.

Work is under way in Australia to produce a life cycle inventory for forests (softwood plantations and regrowth eucalypts) and about 100 wood products during 2008.

A typical wood-framed house provides net storage of carbon (Table 80), while a steel-framed house is a net emitter of carbon to the atmosphere (Table 81). This is reflected in the 'storage in harvested wood products' part of Australia's national carbon accounting (Figure 49). In one study applying the TimberCAM carbon-accounting model and excluding potential storage in paper products, it was estimated that up to 70% of the carbon in commercial logs remained in long-term storage, either in products in use or in landfill, or through avoided fossil-fuel use.[8]

8 Gardner et al (2004).

Table 80: Emission and storage of carbon in the manufacture of building materials (kg/m³)

Building material	Carbon released in manufacture	Carbon stored in product	Net carbon released
Treated timber	22	250	–228[a]
Glue-laminated timber	82	250	–168[a]
Structural steel	8,132	15	8,117
Reinforced concrete	182	0[b]	182
Aluminium	6,325	0	6,325

a A negative value means carbon is stored for the life of the building.

b There is a tiny amount of carbon in the steel reinforcement. The long-term uptake of atmospheric carbon dioxide by concrete (carbonisation) is normally not considered: coatings and other means are usually applied to prevent carbonisation, as it can lead to the corrosion of the reinforcing steel.

Source: Buchanan and Honey (1994)

Table 81: Comparison of material use and effect on carbon storage for a typical 180m² house

	Wood-framed house	Steel-framed house
Frame only	13 m³ of wood	5 t of steel
Total house	21 m³ of wood	8 m³ of wood
Total carbon stored (t)	9.7	3.7
Total carbon released to the atmosphere (t)	2.2	6.6
Balance of carbon – tonnes stored (+) or released to the atmosphere (–)	+7.5	–2.9

Note for Tables 80 and 81: New information is expected during 2008 from a life cycle inventory project on wood and wood products.

Source: Turner (1990)

Increasing the use of wood in buildings is therefore a way of significantly reducing Australia's carbon emissions. In New Zealand, new government-funded building projects for structures up to four floors, including the ground floor, will soon be required to at least consider options for using wood or wood-based products as the main structural materials. New building technologies should soon make it possible to replace greenhouse-gas intensive concrete, steel and aluminium with wooden construction in buildings up to 10 storeys high.

Energy from biomass

The wood by-products of timber harvesting, processing and recycling are one of the largest sources of biomass in Australia; an estimated 12 million tonnes (dry weight) of waste wood is generated each year, comprising about 4.2 million tonnes of harvesting residues, 2.8 million tonnes of processing residues and 5.3 million tonnes of salvaged wood (from recycling and demolition projects). The net availability of this wood for bioenergy production is estimated to be about 3 million tonnes across a wide range of regional locations. This amount could potentially be used to meet some of Australia's mandatory renewable energy target while still leaving sufficient residues in the forest to maintain biodiversity and site quality.[9] Of the residues, coarse woody debris is proving to be very important for invertebrate biodiversity.

Twelve billion tonnes of carbon was stored in the biomass and soils of Australia's native forests in 2004.

Australia already generates 650 megawatts (MW) of electricity from biomass; this substitutes for electricity that would otherwise be generated from fossil fuels and therefore offsets carbon dioxide emissions. Projects using or proposing to use woody biomass for energy include Delta Electricity's 60 MW bagasse/wood plant in New South Wales; co-firing wood operations in Liddell, Muja and Wallerawang; Visy's 20 MW co-generation plant at Tumut; Verve Energy's oil mallee project (1 MW initially, 5 MW later); two 45 MW plants by Beacons International; and a 40 MW plant by Western Australia Biomass Pty Ltd. The last three of these ventures are in southwestern Western Australia.

Plantation Energy plans to build a wood-pellet manufacturing plant in Albany, Western Australia, to manufacture and export energy pellets, mainly to Europe. It would source the feedstock from harvesting residues derived from the 120,000-plus hectares of blue gum plantations growing on previously cleared farmland in the Great Southern region; initial production is likely to be 145,000 tonnes a year. The blue gum plantations in the region are grown on a 10-year rotation. An average of 12,000 hectares will be harvested annually, producing more than 2 million tonnes of woodchips for export and around 600,000 tonnes of harvesting residues for bioenergy or other uses.

The pulp and paper sector is a significant user of energy, particularly in mechanical pulping processes. It is also a major producer of renewable energy, using processing waste such as black liquor from chemical pulping. The energy can be used on site or supplied to the electricity supply grid. The pulp and paper sector used more than 50,000 terajoules of

9 In 2007, the Australian Government set a renewable energy target of 20% by 2020.

energy in 2004–05, of which more than 11,000 terajoules (22%) was produced on site from biomass.

Wood wastes also generate a considerable part of the energy used for the kiln drying of timber. The manufacture of wood products generally requires less net energy than manufacture from competing materials.

Australian forestry's yearly carbon account

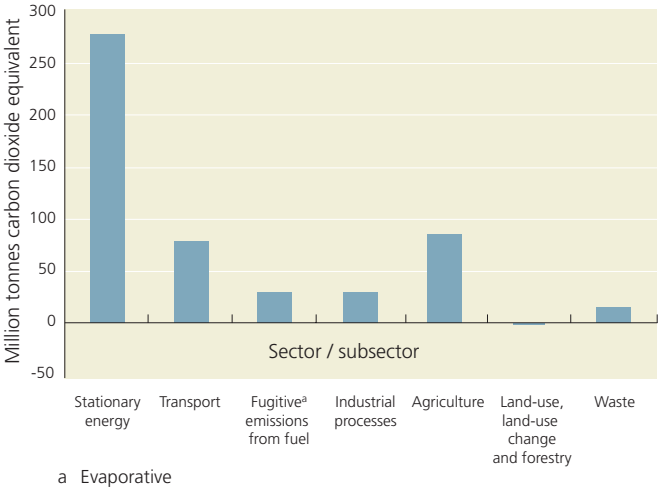
Table 82 summarises carbon sequestration and emissions in Australia's forests and agriculture in 2005.

Overall, native forests, plantations and wood products were net absorbers of greenhouse gases, sequestering a total of 56.5 million tonnes of carbon dioxide equivalent. However, deforestation – the conversion of forests mainly to agriculture – caused a total of 53.3 million tonnes of carbon dioxide equivalent (9% of total national emissions) to be emitted. The result is a net sequestration of 3.2 million tonnes of carbon dioxide equivalent.

Figure 51 shows that 'Land use, land-use change and forestry' was the only sector to show a net annual sequestration of carbon (more carbon stored than emitted), despite the emissions caused by clearing of forests. Forestry is one of the most greenhouse-friendly sectors of the Australian economy: it uses a renewable raw material and generates and uses renewable bioenergy through the burning of residues. Carbon dioxide emissions from forest management and industry are small compared to carbon dioxide sequestered in biomass in native forests and plantations and stored in wood and wood products, both in service and as waste in landfill. A continued reduction in forest clearing and increased use of wood in construction (long-term storage of carbon) will significantly assist Australia in offsetting its overall greenhouse gas emissions.

Commercial harvesting of firewood, Bairnsdale, Victoria.

Figure 51: Australia's net greenhouse emissions, by sector or subsector, 2005



a Evaporative

Source: AGO (2007)

Table 82: Sequestration and emissions in forests and agriculture, 2005

	Mt CO_2 equivalent greenhouse gases[a]	Proportion of total national emissions (%)[b]
Native forests		
Sequestration in managed native forests[c]	–43.5	
Biomass burning (prescribed fire and wildfire)	1.3	
Fuelwood used	10.4	
Net change in native forests	–31.9	~5.5
Plantations[d]		
Plantations established post-1990 on cleared land	–21.9	
Plantations established pre-1990	2.3	
Net change in plantations	–19.6	~3.5
Plantations plus managed native forests	–51.5	9
Wood products		
Storage in harvested wood products	–5.0	1
Agriculture	87.9	15
Deforestation (i.e. conversion to agriculture)	53.3	9
Total Australian emissions (before deducting sinks)	583.3	
Net Australian emissions (after deducting sinks)	522.2	

a A minus sign and green colour in this column means that greenhouse gases are removed from the atmosphere, while red indicates that greenhouse gases are emitted to the atmosphere.

b Green colour in this column means that greenhouse gases are removed from the atmosphere, while red indicates that greenhouse gases are emitted to the atmosphere.

c Forests subject to harvest and regrowth from prior harvest.

d Plantations established before 1990 are assumed to have been established by clearing native forests, even though a significant proportion was established on land that was already cleared. For plantations established after 1990, remote sensing data are used to distinguish the areas established on cleared sites from those established by clearing native forests.

Source: AGO (2007)

References and further reading

AGO (2005abcd, 2006, 2007), Australian Government (2007ab), Buchanan and Honey (1994), CRC for Greenhouse Accounting and FWPRDC (2006, reprinted 2007), Davidson et al (2008), Driscoll et al (2000), Gardner et al (2004), Markewitz (2006), Paul et al (2003), Perez-Garcia et al (2006), Polglase et al (2000), Raison et al (2003), Ranatunga et al (2008, in press), Richards and Brack (2004), Richards et al (2007), Roxburgh et al (2006), Turner (1990), Waterworth et al (2007), Webbnet Land Resource Services Pty Ltd (2002), Ximenes (2006) (list at the back of the report).

Web resources

Australian Greenhouse Office: www.greenhouse.gov.au

National Forest Inventory: www.daff.gov.au/brs/forest-veg/nfi

Integrated biomass fuel production plant, Narrogin, Western Australia.

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 forests contribute to national and regional economies, benefit personal and community wellbeing, and support cultural values. They are considered under the subthemes of production and consumption; recreation and tourism; investment (including in research and development); culture and spiritual benefit (including Indigenous values); employment and community needs; and community resilience.

Key findings

Production and consumption

- The gross value of logs harvested from native forests and plantations in the five years to 2006–07 increased by 11% in real terms. The volume of logs harvested from native forests declined by 14%, while the volume harvested from plantations increased by 28%.
- In 2005–06, the turnover of Australia's forest product industries was more than $19 billion, which was 5.3% of total manufacturing industry turnover and a real increase of about 10% since 2000–01. Value added in the forest products industries equalled 0.7% of Australia's gross domestic product, similar to the level in previous years.
- The total value of wood product imports increased from $3.7 billion in 2001–02 to $4.3 billion in 2006–07, while the total value of wood product exports increased from $2.0 billion to $2.4 billion. The trade deficit for the sector increased from $1.7 billion to $1.9 billion.
- Discarded forest products contribute approximately 6.5 million tonnes to the waste stream annually, mostly in the form of paper and timber products; the recycling rates for paper and timber products are estimated to be 53% and 30%, respectively. The volume of recovered paper exported increased by 250% in the reporting period to nearly 1.1 million tonnes in 2006–07, due mainly to increased demand from China.
- Annual production of non-wood forest products is worth hundreds of millions of dollars to the Australian economy. Many non-wood forest products are important for many remote Indigenous communities, which often rely on them for customary uses and cash income.
- Governments are implementing legislative and institutional reforms and establishing financial incentives to encourage the supply of forest-based environmental services. Initiatives to establish a national emissions trading scheme in Australia are likely to have a significant effect on Australian forestry.

Investment

- Governments spend hundreds of millions of dollars annually on the management of nature conservation reserves and multiple-use public native forests. Limited data are available on investment in privately owned native forests.
- Investment in public and private plantation expansion over the period from 2002 to 2006 amounted to an estimated $902 million. Investment in new or improved wood and wood product manufacturing facilities during the reporting period was worth several billion dollars.
- Reported annual expenditure on national forest-related research and development was $198.5 million in 2004–05, a decrease of $17.5 million from 2000–01. Of this total, annual investment in manufacturing-related research increased from $79 million in 2000–01 to $108 million in 2004–05. At the same time, nationally reported research on forest growing for wood production and forest-related environmental research declined.

Tourism and recreation

- Most publicly owned multiple-use and nature conservation reserve forests are available to the general public for recreation and tourism. Many facilities, such as visitor recreation centres and tree-top walks, were established or improved during the reporting period. For those forests for which data were available, the number of areas, tracks and sites available for recreation and tourism activities increased or remained the same over the period, varying with location and jurisdiction.
- Forest management agencies have strategies in place to actively manage forest areas of high recreation and tourism use.

Cultural and spiritual use

- More than 16% of Australia's land mass, or 122 million hectares, is under Indigenous ownership. Indigenous-managed land includes about 21 million hectares of forest, which is 14% of Australia's total forest area. Almost half the forest in the Northern Territory is under Indigenous management, with lower proportions in Western Australia (9%), Queensland (6%) and South Australia (3%). Very small areas of forest are under Indigenous ownership in New South Wales, Victoria and Tasmania. Legislative arrangements in all jurisdictions aim to ensure the identification and protection of Indigenous sites and places of significance.
- The number of Indigenous people employed in government agencies responsible for nature conservation and commercial timber production increased over the period. There was also a greater presence of Indigenous people in natural resource management committees and other forest stakeholder forums. Both planted and natural forests are increasingly valued by Indigenous people for their ability to contribute to economic independence.
- About 471,000 hectares of nationally listed, non-Indigenous, heritage places in forests is protected under the provisions of the national *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The states and territories are responsible for protecting thousands of additional sites in accordance with their heritage management and protection legislation.
- Many forest issues are of national importance and have played a role in recent national and state political debate, as the community seeks biodiversity conservation and the provision of environmental services from forests.
- The expansion of the plantation estate and the proposed development of new wood processing infrastructure have potentially significant employment benefits but are also accompanied by community concerns about their social and environmental impacts.

Employment and community needs

- Total direct employment in forestry and forest product manufacturing increased marginally between 2001–02 and 2006–07 from 82,800 to 83,400 full-time equivalents, although the proportion of the Australian workforce employed in the sector declined from 0.91% to 0.82%.
- Total national employment in businesses dependent on growing and using timber in 2006 was estimated to be about 120,000 people. Total annual wages and salaries in the wood and wood product industries increased from $2 billion to $3 billion between 2000–01 and 2004–05.
- There are limited national data on indirect employment, but it has been estimated that each direct job in the plantation forest industry in Western Australia's Great Southern region produces 0.7 indirect jobs.
- Limited data are available at the national level on the employment generated by the non-wood forest product and forest contact industries (such as tourism and park management). Nevertheless, case studies indicate that such industries generate considerable direct and indirect employment in some regional communities.
- The rate of injuries and fatalities per 1,000 employees in the wood and wood product manufacturing subsector declined from 48.9 to 37.2 between 2001–01 and 2002–03. Several organisations are working at the state level to improve occupational health and safety, with promising results.

Community resilience

- Dependence on the forestry and forest products industries as the primary means of employment has declined in some regions. Exceptions include areas of South Australia, East Gippsland in Victoria, and Tasmania. Populations in many forest-dependent regions are static or declining in line with a general trend in rural Australia, with the exceptions of Mount Gambier, Orbost, Oberon and Tumut, where populations have increased marginally. The number of working-age people is also declining in many regions. The growing investment in timber production and processing from plantations is becoming an increasingly important factor in forest-dependent communities.
- The recognition of native title through mechanisms such as Indigenous land-use agreements strengthens the potential value of forests for Indigenous people. Most state and territory land management agencies have targets for Indigenous employment, which help to build capacity in Indigenous communities and, therefore, community resilience.

Indicator 6.1a

Value and volume of wood and wood products

Rationale

This indicator measures the size of the wood products sector and its contribution to Australia's economy.[1] Analysis of trends in the value and volume of wood and wood products enables socioeconomic benefits derived from the forest industry to be assessed.

Key points

- The gross value of logs harvested from native forests and plantations in the five years to 2006–07 increased by 11% in real terms.
- The volume of logs harvested from native forests declined by 14%, while the volume harvested from plantations increased by 28%.
- In 2005–06, the turnover of Australia's forest product industries was $19 billion, which was 5.3% of total manufacturing industry turnover and a real increase of 10% since 2000–01.
- In the same year, value added in the forest product industries equalled 0.7% of Australia's gross domestic product. This is similar to the level in previous years.
- Timber product volumes generally increased over the reporting period.

Harvested logs

After allowing for inflation, the gross value of logs harvested in Australian forests increased by about 11% to about $1.7 billion in the five years to 2006–07 (Figure 52).[2] Volume increased by 11% overall but by 28% from plantations, mainly due to a greater than threefold increase from hardwood plantations. The volume harvested from native forests declined by 14% (Figure 53). Victoria, New South Wales and Tasmania were the major contributors to log production, followed by Western Australia, Queensland and South Australia (Figures 54 and 55).

The area of native forest available for harvesting has declined and so has the volume harvested.

1 Wood products comprise logs harvested from native and plantation forests and products made from logs, including sawn timber, wood-based panels, woodchips, paper, paperboard and pulp.

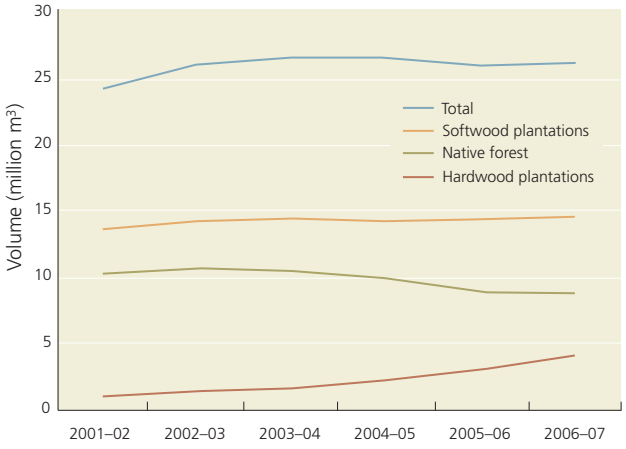
2 Value and volume figures quoted in this indicator incorporate data from all relevant tenures.

Figure 52: Value of logs harvested, 2001–02 to 2006–07

a Indexed by Consumer Price Index to 2001–02 values.

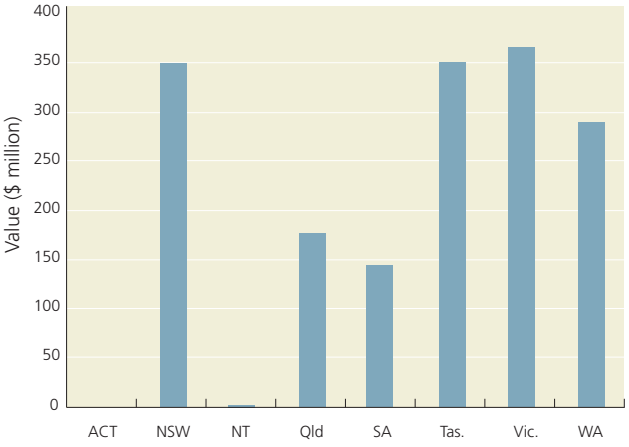
Source: ABARE (2007)

Figure 53: Volume of logs harvested, 2001–02 to 2006–07



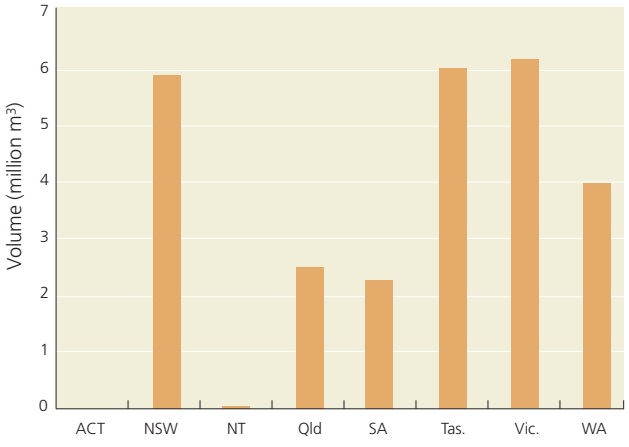
Source: ABARE (2007)

Figure 54: Value of log production, 2006–07, by jurisdiction



Source: ABARE (2007)

Figure 55: Volume of log production, 2006–07, by jurisdiction

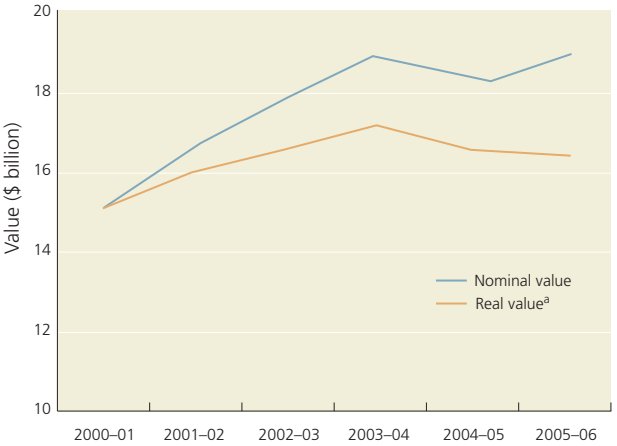


Source: ABARE (2007)

Wood products

The value of turnover in the wood and wood product industries, including paper and paper products, was $19 billion in 2005–06 (Figure 56); wood and paper product manufacturing comprised 6% of Australia's total industry value added in that year.[3] Value added in the forest product industries equalled 0.7% of Australia's gross domestic product in 2005–06. This is similar to the level in previous years. Both turnover and value added include the wholesale value of a wide range of wood and paper products (data on some of which are shown later), but not the value of finished products such as doors, windows and furniture.

Figure 56: Value of turnover in the wood and paper product industries, 2000–01 to 2005–06

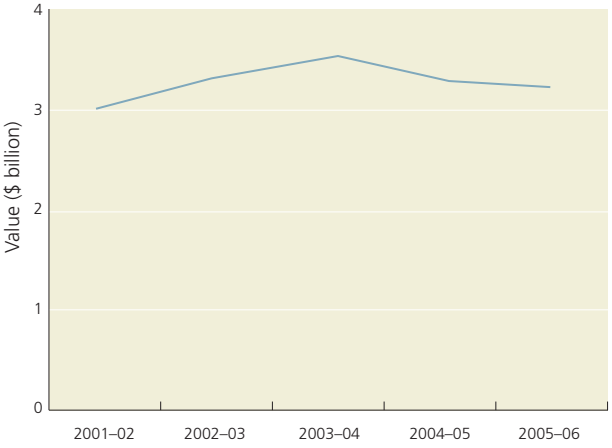


a Indexed by Consumer Price Index to 2000–01 values.

Source: ABS (2007c)

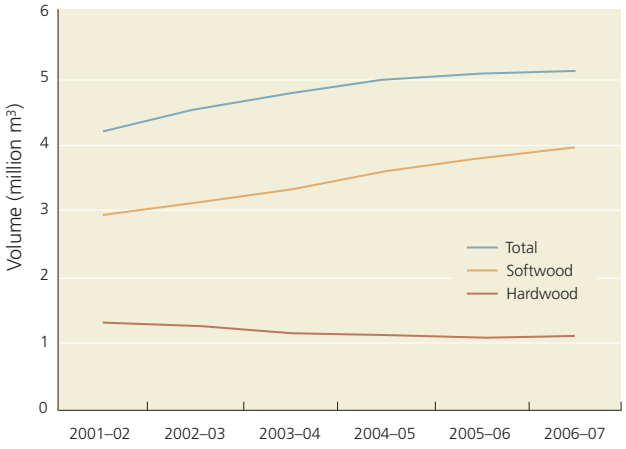
3 Industry value added is a measure of an industry's contribution to national gross domestic product.

Figure 57: Value of sawn timber production, 2001–02 to 2005–06



Source: ABS (2007c). Data for years before 2001–02 were derived by a different method and are not comparable.

Figure 58: Volume of sawn timber production, 2001–02 to 2006–07



Source: ABARE (2007)

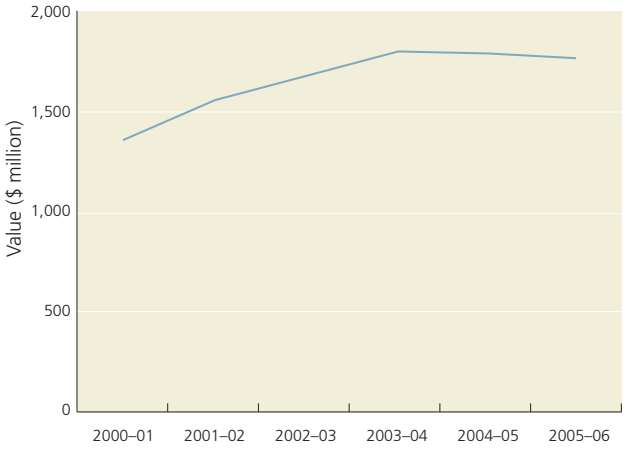
Sawn timber

The value of sawn timber production peaked at $3.56 billion in 2003–04, 18% more than in 2001–02, and then declined in 2004–05 to 7% more than in 2001–02 (Figure 57).[4] This pattern reproduces the level of activity in the housing and construction industry. The volume of sawn timber produced increased by 20% in the five years to 2006–07 due to increasing volumes of softwood sawn timber; the hardwood sawn timber volume produced declined by 16% (Figure 58).

Wood-based panels

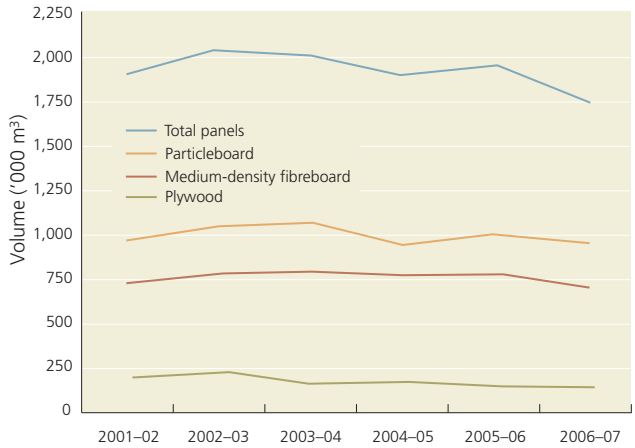
The value of wood-based panel production rose by almost 40% in the reporting period (Figure 59).[5] The increase was due to price increases, which were more than enough to offset an 8% decline in production caused by the closure of one of the seven medium-density fibreboard mills and a lower level of housing construction towards the end of the period (Figure 60). The decrease in volume contrasts with an increase of about 60% in the decade to 2002, which was primarily due to the construction of new medium-density fibreboard manufacturing mills.

Figure 59: Value of panel production, 2000–01 to 2005–06



Source: ABARE (2007)

Figure 60: Volume of panel production, 2001–02 to 2006–07

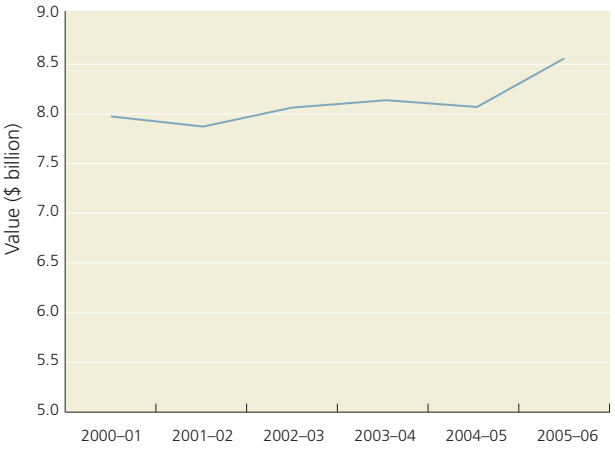


Source: ABARE (2007)

4 The value of sawn timber production was calculated from figures reported for the Australian and New Zealand Standard Industrial Classification classes 'log sawmilling' and 'timber re-sawing and dressing' in ABS (2007c).

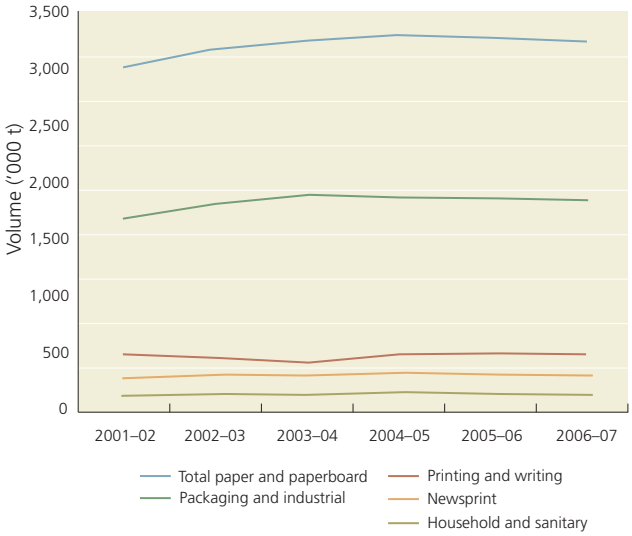
5 The value of wood-based panel production was calculated using data reported for the Australian and New Zealand Standard Industrial Classification classes 'plywood and veneer' and 'fabricated wood' in ABS (2007c).

Figure 61: Value of paper and paper products production, 2000–01 to 2005–06



Source: ABARE (2007)

Figure 62: Volume of paper and paper products production, 2001–02 to 2006–07



Source: ABARE (2007)

Paper and paper products

The annual value of paper and paper production fluctuated between $7.8 billion and $8.5 billion during the period (Figure 61). The volume produced increased by 10% (Figure 62).

Pulpwood for pulp and paper manufacture

The volume of pulpwood harvested from Australian native forests and plantations for pulp and paper manufacture increased by about 2.4 million cubic metres or 24% over the reporting period to 12.6 million cubic metres. This includes pulpwood used for pulp and paper manufacture in Australia and pulpwood exported as woodchips for manufacture in other countries. Pulpwood is also harvested and used with sawmilling residues to manufacture particleboard and medium-density fibreboard.

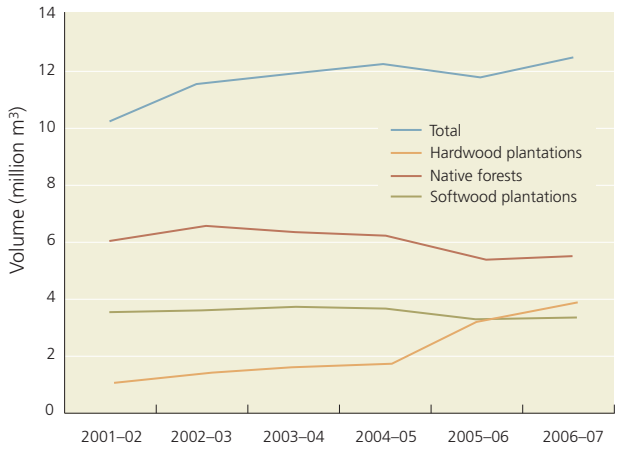
An 11% decrease in the volume of pulpwood harvested in native forests for pulp and paper manufacture was offset by a nearly fourfold increase in the volume harvested from hardwood plantations (Figure 63).

Data were not available for the total value of pulpwood harvested from Australian forests for pulp and paper manufacture. The real value of woodchip exports (Figure 64) increased by 17% in the reporting period.

References and further reading

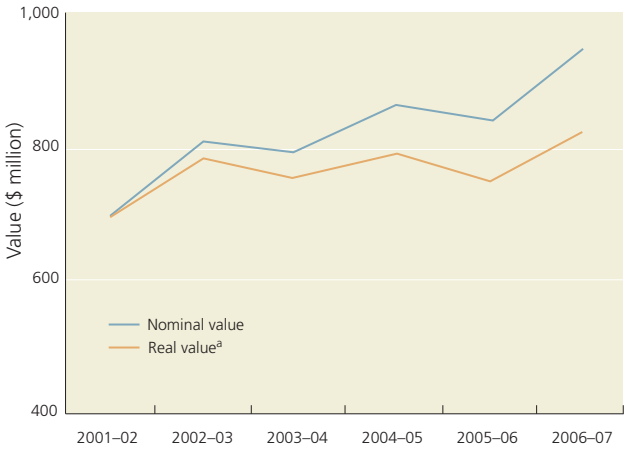
ABS (2006b, 2007c), ABARE (2006, 2007) (list at the back of the report).

Figure 63: Pulpwood for pulp and paper manufacture, 2001–02 to 2006–07



Source: ABARE (2007)

Figure 64: Value of woodchip exports, 2001–02 to 2006–07



a Indexed by Consumer Price Index to 2001–02 values.

Source: ABARE (2007)

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 socioeconomic benefits to be monitored by ascertaining trends in quantities, values and usage of those products.

Key points

- Non-wood forest product industries offer supplemental income and seasonal employment to rural communities.
- Case studies provide an insight into the nature, scale and socioeconomic value of the non-wood forest product sector. Annual production is worth hundreds of millions of dollars to the Australian economy.
- Non-wood forest products are a significant asset base for many remote Indigenous communities, which often rely on them for customary uses and cash income.

Bee hives in a private native forest.

Limited data are available for many non-wood forest product industries. Table 83 provides estimates of the annual value of some industries and lists the states and territories where they are of significant size. Some of the estimates include products derived from landscapes other than forests.

In the absence of comprehensive national data, case studies provide an insight into the nature, scale and socioeconomic value of the sector. In the Northern Territory, a number of non-wood forest products are harvested in large quantities and often have a high value, relative to the total incomes of harvesters and primary users. Two industries stand out: arts and crafts (Case study 33) and crocodile-egg collecting (Case study 34). Beekeeping, another valuable Australian industry, is the subject of Case study 35.

References and further reading

ABS (2001), Altman (2003), Altman and Taylor (1989), ANZECC (2001), Beal (1998), DIR (2005), Driscoll et al (2000), Gibbs and Muirhead (1998), Griffiths et al (2003), Koenig (2007), Koenig et al (2005, 2006), Miers (2004), PWSNT (2005), RIRDC (2007), Webb et al (1984), Webb et al (1994), Wood et al (1994), Wright and Morphy (1999) (list at the back of the report).

Table 83: Value of some of Australia's non-wood forest products

State	Kangaroo	Eucalyptus oil	Honey, beeswax, other apiary products	Hunting	Sandalwood oil	Whole plant harvests	Cut flowers (wild harvest)	Bark and wood for Indigenous art products	Grazing (including live export of cattle)	Crocodile eggs	Bushfood (e.g. *Acacia* seed, *Solanum centrale*)	Seed collection
ACT	✓	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✓
NSW	✓	✓	✓	✓	✗	✓	✓	✓	✓	✗	✗	✓
NT	✗	✗	✗	✓	✗	✓	✗	✓	✓	✓	✗	✓
Qld	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓
SA	✓	✓	✓	✓	✗	✓	✗	✓	✓	✗	✗	✓
Tas.	✓	✓	✓	✓	✗	✓	✓	✓	✓	✗	✓	✓
Vic.	✓	✓	✓	✓	✗	✓	✓	✓	✓	✗	✗	✓
WA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Total value of industry ($ million)	240[a]	<1.5[b]	49[ac]	36[a]	27[d]	12	7[ae]	~4[af]	446.9[ag]	1[ah]	0.33[i] (only for wild harvest of three bush products)	0.6[a]
Notes	Total value of industry	Decline in recent years due to exports from China. Estimate based on farm gate value in 1991; retail value was estimated to be $5 million.		Duck and quail shooting industry in Victoria; estimated value to the state economy	Predicted turnover of Mt Romance, 2005–06	Tree ferns exported from Tasmania to other states and overseas	15% of WA export production, which was ~55% of Australian exports (value $85 million)	NT arts and crafts industry valued at ~ $5–6 million	Value estimate derived from value of live export of cattle, mainly from northern Australia	Derived from permit returns of eggs collected with a retail price of $50 per hatchling		Cape York Peninsula 1992–97

a May include revenue derived from non-forested areas.

b Wood et al (1994).

c ABS (2001).

d DIR (2005).

e Beal (1998).

f Griffiths et al (2003).

g Sourced from www.livecorp.com.au.

h PWSNT (2005).

i Miers (2004) for *Acacia* and *Solanum*.

Case study 33: Arts and crafts in the Northern Territory

The Northern Territory Indigenous arts and crafts industry has grown substantially over the past few decades and now constitutes an important cultural and economic enterprise. Its overall value is not known; according to a 2002 estimate, however, community arts centres in the Northern Territory turn over $5–6 million annually. The industry is thought to employ 4,500 Indigenous artists in 39 remote communities. In a recent survey of 39 remote Indigenous communities in northern and central Australia, 18 communities listed wood sculpture as a market commodity.

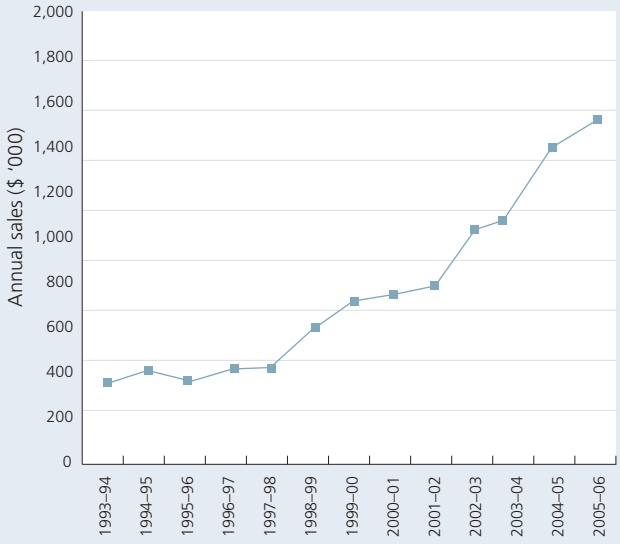
Arts and crafts are often the only commercial commodities produced by remote Indigenous communities, and income from the industry can amount to more than 40% of a community's cash income. The majority of the arts and crafts produced in remote communities use local woody plant material, including from forests. Those plant resources are therefore a significant asset to the communities and sustainability is an important issue.

The growth in the arts and crafts industry is reflected in trends in the value of art production at Maningrida Arts and Culture (MAC) in central Arnhem Land (Figure 65). The Maningrida region covers about 10,000 square kilometres; the township has a population of 1,350 residents, and another 500 people live on surrounding outstations. The products sold through MAC include carvings, bark paintings, fibre craft weavings, ochres and dyes. The number of wood carvings that pass through MAC has increased considerably since 1994 (Figure 66), as has the number of bark paintings. The number of artists producing sculptures increased steadily between 1985 and 2003; a total of 259 sculpture artists produced carvings for MAC during the period. Average returns to wood carvers for their work remained fairly constant between 1993 and 2003 at around $100–200 per item, generating an estimated $12–14 per hour. The two main types of carving wood used by Maningrida carvers are northern kurrajong *(Brachychiton diversifolius)* and cotton tree *(Bombax ceiba)*. Separate studies have found that the use of these woods for carving production is sustainable, even at sites that have had a long history of use.

The production of arts and crafts is an important economic activity for Australia's Indigenous people and is perhaps the only forest-dependent industry in which they play a decisive role. In addition to commercial arts-based products, a huge variety of non-wood items are used for customary ceremonial purposes. International and national sales through centres such as MAC contribute to the total national production of Indigenous visual art, which is estimated to be worth $100–300 million per year. While modest at the national level, this activity is critical in economically depressed remote regions of the Northern Territory.

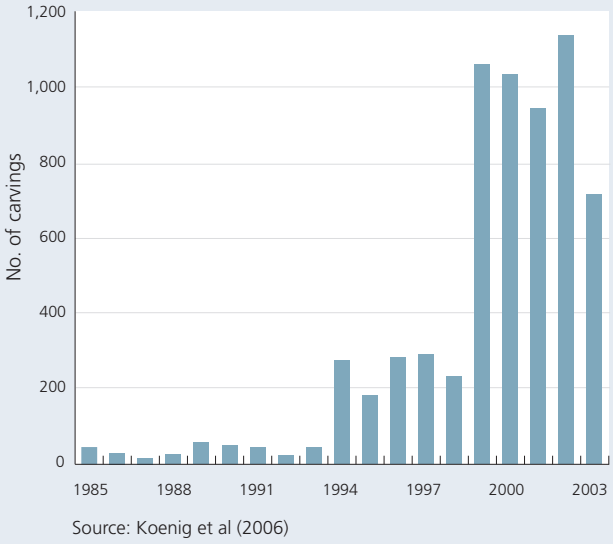
Sources: Altman and Taylor (1989), Griffiths et al (2003), Koenig et al (2005, 2006), Wright and Morphy (1999)

Figure 65: Annual sales of art based on the use of woody plants in the Maningrida region, 1993–94 to 2005–06



Source: Maningrida Arts and Culture

Figure 66: Wood carvings purchased by Maningrida Arts and Culture per year, 1985 to 2003



Source: Koenig et al (2006)

Case study 34: The crocodile egg industry

Saltwater crocodile (*Crocodylus porosus*) eggs can be considered non-wood forest products because they are often taken from forested (melaleuca) wetlands. The harvesting of saltwater crocodile eggs in the wild, largely by Indigenous Land and Sea Ranger groups on Indigenous land, has been taking place in the Northern Territory since 1984. The harvested eggs are hatched in farms; the crocodiles are grown to the desired market size and then used for skin and meat production.

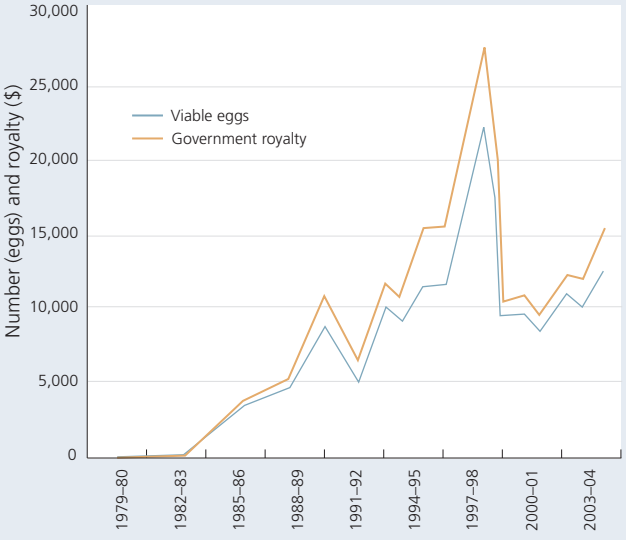
The commercial hunting of saltwater crocodiles started in the Northern Territory in 1945 and continued until 1971 when, in the face of a marked population decline, the species was protected. By that time, there were only an estimated 3,000 crocodile non-hatchlings (individuals >0.6 metres long) in the wild. On 1 July 1975, the species was listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which meant that no international trade of the species was permitted. In 1984, the number of non-hatchling crocodiles in the wild was estimated to be 30,000–40,000 and the species was deemed to have recovered sufficiently to be moved to Appendix II of CITES, thus allowing the controlled international trade of the species and of products derived from it.

The industry has worked to ensure that the offtake is sustainable and, since 1996, there has been only limited harvesting of adults and hatchlings. Under the Parks and Wildlife Service of the Northern Territory crocodile management plan, 25,000 eggs may be harvested from the wild each year, although collections have always been well below that number (Figure 67). The sustainability of the crocodile industry is evident from the continued increase in the population of non-hatchlings in the wild, which by 1994 had grown to 70,000–75,000 individuals despite more than a decade of egg harvesting.

The total number of viable eggs collected in the Northern Territory varied considerably between 1984 and 2004 and peaked at 21,872 in 1995–06 (Figure 67). Take permits must be submitted to the Parks and Wildlife Service regardless of the tenure of the land on which the eggs are collected. On all but Indigenous freehold land, a royalty payment of $1.25 per crocodile egg must be paid to the agency; this is used for administration costs or, in the case of jointly managed areas, goes back to the traditional owners. On Indigenous freehold land, traditional owners may collect eggs commercially without paying the royalty and can make independent royalty agreements with third parties wanting to collect from their land. Crocodile farms pay about $20 per egg and $50 per hatchling; this part of the crocodile industry is therefore worth hundreds of thousands of dollars to the Northern Territory economy annually (Figure 68).

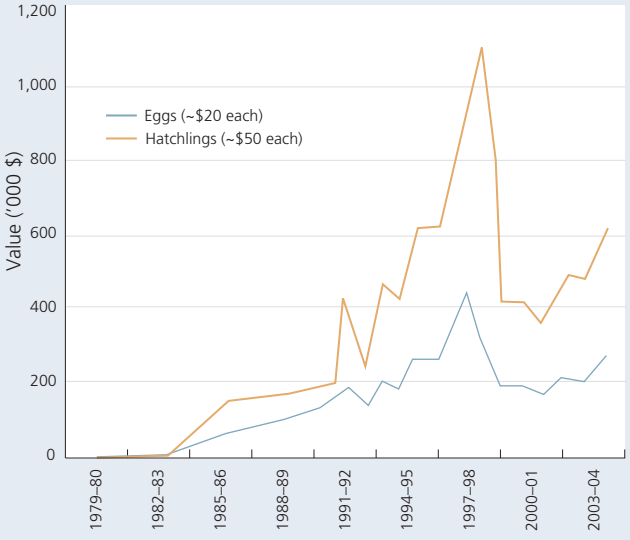
Sources: PWSNT (2005), Webb et al (1994)

Figure 67: Viable saltwater crocodile eggs harvested in the Northern Territory and estimated government royalty paid for their collection, 1979–80 to 2003–04



Source: PWSNT (2005)

Figure 68: Estimated value to Northern Territory crocodile farms of wild harvested eggs or hatchlings



Note: Based on what crocodile farmers would pay to buy the eggs. Since many farmers collect their own eggs (under agreement with landowners), these are probably overestimates.

Source: Estimated from PWSNT (2005)

Case study 34: The crocodile egg industry *continued*

Melaleuca forested wetlands, Northern Territory.

Saltwater crocodile (*Crocodylus porosus*).

Case study 35: Beekeeping

The European honey bee (*Apis mellifera*) was introduced to Australia in 1822 and quickly became widespread. Many of the continent's dominant native trees, including the eucalypts, produce large quantities of nectar that attract insects, birds, possums and fruit bats. This nectar is a major source of food for the introduced honey bees.

The apiary industry is well established in Australia, with a gross value of production of all products estimated at $60–65 million per year, of which $49 million is from honey production. Australia has just over 10,000 registered beekeepers, who manage 600,000 hives producing around 30,000 tonnes of honey every year; 24–30% of this annual production is exported. New South Wales, Queensland and Victoria dominate the industry, with 82% of the beekeepers and 80% of the hives, although South Australia, Western Australia and, to a lesser extent, Tasmania are also significant honey producers. In addition to honey, there are markets for beeswax, live bees (queens and packaged bees), pollination services in forest tree seed orchards and horticultural crops (such services may be provided free or in return for a fee to pay for transport and the setting up of hives), pollen, royal jelly and medicinal applications.

The apiary industry is economically and socially important in Australia, generating considerable income and employment. Because of its strong reliance on forests and the need to move hives around the landscape according to the seasonal availability of pollen and nectar, a number of forest-related issues have the potential to seriously affect the industry, including forest clearing, dieback among eucalypts, salinity and weed control. The industry depends largely on public lands (including conservation areas and national parks), so continued access to those areas is an important concern.

Honeybees (*Apis mellifera*).

Sources: Gibbs and Muirhead (1998), RIRDC (2007)

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

- Australia's forests are a major supplier of forest-based services to the community. Such services have traditionally been treated as public goods with little or no explicit financial value and, in the main, this is still the case.
- However, governments are implementing legislative and institutional reforms and establishing financial incentives to encourage the supply of forest-based services.
- Initiatives to establish a carbon trading regime in Australia are likely to have a significant effect on Australian forestry. In 2005, one state agency, Forests NSW, began trading carbon credits arising from its plantations in a registered greenhouse gas abatement scheme.

Forests produce a wide range of environmental services (also called 'ecological' or 'ecosystem' services). For example, forests help to regulate water flow and maintain water quality (Case studies 37 and 38) and play an important role in the long-term survival of species. Such services have traditionally been treated as public goods with little or no explicit financial value, but this is changing. Payments for forest-based services, such as carbon sequestration, salinity abatement and opportunities for ecotourism, wildlife photography and environmental education, can provide significant environmental, economic and social benefits and contribute to the financing of sustainable forest management. While markets for such services remain a small component of the national economy compared to markets for wood products, they are expected to grow.

Increasingly, forests are being established to deliver environmental benefits that have been lost due to the historical removal of native vegetation. This includes planting for salinity abatement, along riparian corridors to filter runoff, reduce erosion and enhance biodiversity, and to sequester carbon. Diverse market-based schemes are in place or being developed to promote such planting, including tradeable resource access rights, permit trading, environmental accreditation, eco-labelling and performance bonds. The continued development of such markets is critical for the conservation of private forests and the amelioration of land degradation because they provide landholders with additional incentives for forest restoration, regeneration and replanting.

Carbon markets

Carbon is set to become a significant tradeable commodity in Australia. The Greenhouse Gas Reduction Scheme, which commenced in New South Wales in 2003, is one of the world's first mandatory greenhouse gas emissions trading schemes. It establishes annual statewide greenhouse gas reduction targets and then requires individual electricity retailers and certain other parties who buy or sell electricity in New South Wales to meet mandatory greenhouse gas reduction benchmarks based on the size of their share of the electricity market; they are able to trade carbon to offset their emissions (Case study 36 describes the involvement of Forests NSW in the scheme). All states are investigating the establishment of frameworks to create carbon offset credits from forest projects based on an extension of the carbon sequestration framework now operating under the Greenhouse Gas Reduction Scheme. In the Northern Territory, a partnership between local Indigenous communities, government and a gas refinery is encouraging the re-introduction of traditional burning practices, partly for the carbon offsets this provides.

Re-introduction of early season traditional burning practices in northern Australia is being encouraged for the carbon offsets this provides.

The states are active in creating rights to the sale of carbon from forestry investments. Victoria, New South Wales, Queensland, South Australia and Western Australia have all enacted legislation establishing new property rights over carbon sequestered in forest plantations, allowing forest owners to enter into agreements to transfer the rights to carbon sequestered in their forests separately from the land and timber. Tasmania has not created new legislation for this purpose, but carbon rights can be defined and are recognised under the state's *Forestry Rights Registration Act 1990*.

Other market-based instruments

Nationally, programs such as the Natural Heritage Trust have invested in research on market-based incentives, focusing primarily on the feasibility of alternative market instruments. There is agreement across jurisdictions to pursue an expansion of market-based instruments, stewardship arrangements and environmental management systems as part of national natural resource management programs.

The states and territories are also investing in other mechanisms that promote markets for forest-based services. For example, under its 2006 *Environmental Sustainability Action Statement*, the Victorian Government is investing $14 million over four years to design and develop efficient markets for ecosystem services on private land, using innovative economic approaches such as competitive tenders, tradeable permits and offset markets for improved environmental outcomes. This includes projects such as BushTender, CarbonTender and EcoTender, which typically involve incentives for improved native vegetation management and the revegetation of degraded areas. BushBroker is a native vegetation credit registration and trading system under which landholders can obtain a native vegetation credit for permanent gains in the quality or extent of native vegetation (including forests) on their properties.

Forests NSW provides plantation forest management services for timber and carbon to third-party private investors. Major investments have been made by TEPCO, ST Microelectronics (one of the world's largest semi-conductor companies), and NM Rothschild & Sons (a leading independent investment bank). Since 2000, Forests NSW has established around 11,000 hectares of plantation under contracts that so far have delivered over $40 million in capital investment and provided jobs in regional New South Wales for Forests NSW staff and private contractors, and income for private landowners.

Ecotourism

The aesthetic quality of forests can also be viewed as a service that benefits the ecotourism sector, which in turn provides considerable benefits to the community (Indicator 6.3b). Some jurisdictions earn significant revenues from forest visitors, concessions operating in national parks, and fees and charges levied on certain activities. Commercial tourism operators generate revenue from forest environmental services if forests comprise part or all of their tours. Other local businesses benefit too, because forests attract visitors who, in turn, buy local goods and services. Some businesses provide park management services, such as supplying picnic tables and constructing and maintaining camping grounds and walking tracks.

Further reading

Australian Government (2007a), IPART (2007), Van Bueren et al (2002) (list at the back of the report).

Web resources

Case study 38: Water for Sydney

One-year-old sugar gum (*Eucalyptus cladocalyx*) planted in saline-affected soils, Katanning, Western Australia. Markets for salinity abatement are expected to grow.

Case study 36: A world first in carbon trading

In early 2005, the NSW Greenhouse Gas Reduction Scheme accredited Forests NSW to become the first body in the world to trade carbon credits arising from forests in a registered greenhouse gas abatement scheme. Forests NSW registered 166,005 certificates, each equivalent to one tonne of carbon dioxide, representing the carbon sequestered during 2004 by 10,000 hectares of planted hardwood forests. The first batch of Forests NSW carbon certificates, worth more than $1 million, was purchased by EnergyAustralia to help offset the greenhouse gases released into the atmosphere as a result of electricity use in New South Wales. Forests NSW has since registered over a million more certificates.

The initial success of the scheme confirms that there is a market for tradeable carbon certificates. The ability to trade carbon credits in New South Wales provides an incentive to companies and other landowners to establish new plantations and to manage them over longer rotations, either for high-quality sawlogs or purely for environmental reasons, with income from credits offsetting establishment and management costs.

In addition to developing a carbon accounting system that is robust enough to gain accreditation under the NSW Greenhouse Reduction Scheme, Forests NSW has been heavily involved in developing state, national and international standards and guidelines to enable carbon accounting and trading.

Source: Forests NSW

Case study 37: Water for Melbourne

Melbourne Water is responsible for the harvesting, distribution and supply of safe, high-quality drinking water that consistently meets stringent requirements. Not only is Melbourne's water safe, but it was judged Australia's best-tasting drinking water at the National Water Olympics in 2003. Approximately 90% of Melbourne's water supply comes from closed catchments, making it one of only about five cities in the world that draw water from protected forest catchments.

Melbourne now has more than 157,000 hectares of native forest in the Yarra Ranges and Kinglake area reserved for the purpose of harvesting water. A significant area of these forests has been closed to the public for more than 100 years. This means that the water requires minimal treatment to assure its quality. High-quality water is harvested from the catchments and stored in 10 major water-storage reservoirs, often for years at a time, to help purification.

If Melbourne did not have the closed forested catchments, it is estimated that it would have to build an additional water treatment plant at a cost of up to $1 billion and spend hundreds of millions of dollars a year in operating costs. In 2005–06, $3 million was spent to protect catchments from bushfire due to the prolonged fire season.

Source: Melbourne Water

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 domestic production and importation, to meet Australian society's demand for forest products, and of the industry's contribution to the economy.

Key points

- The total value of timber product imports increased from $3.7 billion in 2001–02 to $4.3 billion in 2006–07, while the total value of product exports increased from $2.0 billion to $2.4 billion. The trade deficit in those products therefore increased from $1.7 billion to $1.9 billion.
- The larger categories of wood product exports are packaging and industrial papers, woodchips, medium-density fibreboard and softwood sawn timber. The larger categories of wood product imports are printing and writing papers, newsprint and softwood sawn timber.
- Many native plants and animals are highly sought after by national and international markets. Controls have been put in place with the aim of ensuring that the production, consumption and export of native plants and animals do not put species at risk of extinction.
- The harvesting of non-native plants and animals can provide a source of income and livelihood opportunities.

This indicator reports on the production, consumption and trade of wood, wood products and non-wood products by product category. Wood and wood product categories include sawn timber, wood-based panels, paper and paperboard. Categories of non-wood products typically include native flora and fauna, honey, water, mined commodities, grazing products, and Indigenous people's products. Domestic (or 'apparent') consumption is assessed and reported by assuming that it equals domestic production plus imports minus exports.

Wood and wood products

Production and consumption

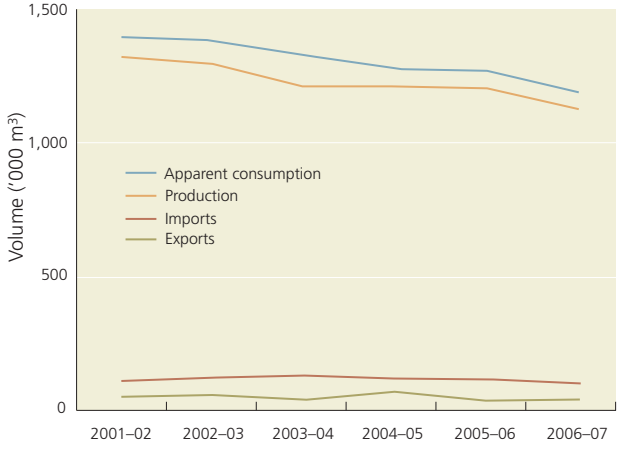
Australia's production and consumption of wood products increased by about 10% between 2001–02 and 2006–07. The production of sawn timber and wood-based panels increased from 6.4 million to 6.8 million cubic metres, and the production of paper and paperboard increased from 2.9 million to 3.2 million tonnes. The volumes of logs used to make those products are reported in Indicator 6.1a.

Australia produces substantial volumes of all major categories of wood products. Information on some of the major categories is provided below. Information on woodchip exports is reported in Indicator 6.1a.

Trade performance

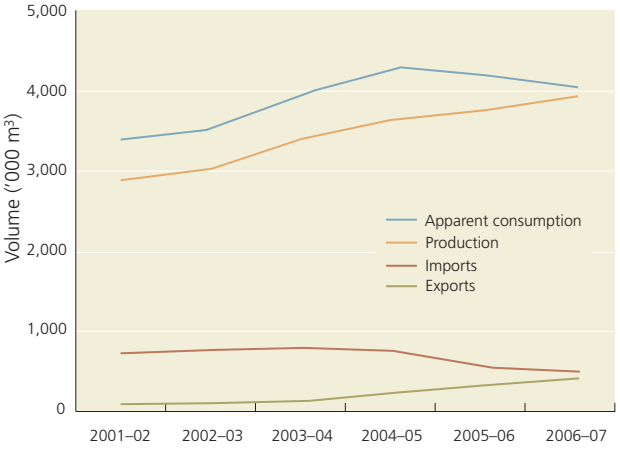
Domestic production of most products is less than consumption, so substantial volumes are imported to meet demand. The total value of wood product imports increased by 14% in the five years to 2006–07, from $3.7 billion to $4.3 billion, while the total value of exports increased by 17%, from $2.0 billion to $2.4 billion. The trade deficit in the sector therefore increased from $1.7 billion to $1.9 billion.

Figure 69: Hardwood sawn timber production, 2001–02 to 2006–07



Source: ABARE (2006, 2007)

Figure 70: Softwood sawn timber production, 2001–02 to 2006–07



Source: ABARE (2006, 2007)

The overall growth in exports was due to substantial growth in specific sectors of the wood product industry, particularly sawn timber (where the value of exports has more than doubled since 2001–02) and wastepaper (in which exports have increased by 250% since 2001–02). Exports of woodchips, paper and paperboard, and paper manufactures also increased, while the value of wood-based panel exports declined by 27%. The main export destinations include Japan (38% of total value of exports), New Zealand (17%) and China (16%).

Some sectors experienced significant import growth. For example, the value of wood-based panel imports increased by 64% and paper and paperboard by 35% over the period. The main sources of imports include New Zealand (19% of total value of imports), China (10%) and Indonesia (8%).

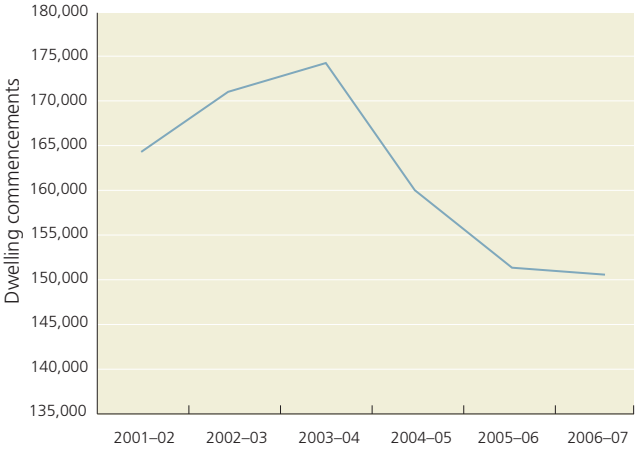
Sawn timber

Most hardwood sawn timber is used in flooring, decking, joinery, furniture and similar applications where particular appearances or colours are required, or for engineering and architectural applications that demand particular strength, hardness, durability or other technical characteristics. The production and consumption of hardwood sawn timber declined by about 15% in the reporting period (Figure 69), reflecting lower sawlog supply from native forests (Indicators 2.1a and 2.1c). Imports increased by 23% but are still a small proportion of consumption (7% of consumption in 2001–02 and 11% of consumption in 2006–07).

Softwood sawn timber is used mainly as a structural component of house walls and roofs. Softwood sawn timber production increased by 24% in the reporting period (Figure 70) due to increasing sawlog supply from pine plantations established in the 1960s and 1970s by state governments, supported by loans from the Australian Government. Consumption also rose, but to a lesser extent because the level of house construction waned during the reporting period (Figure 71). The volume of imports declined from 18% to 12% of consumption, probably because domestic production became more plentiful and competitive. Exports increased from about 43,000 cubic metres in 2001–02 to 367,000 cubic metres in 2006–07.

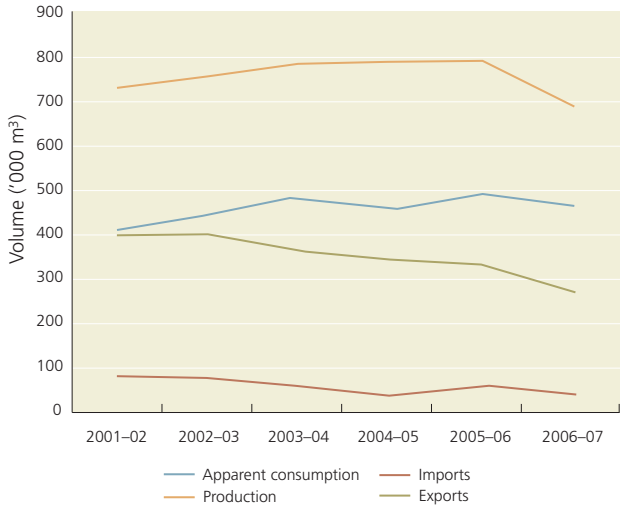
The value of exports of sawn timber from Australia in 2006–07 was $145 million, twice the level at the start of the reporting period. At the same time, the value of sawn timber imports declined by about 5% to $418 million.

Figure 71: Dwelling commencements, 2001–02 to 2006–07



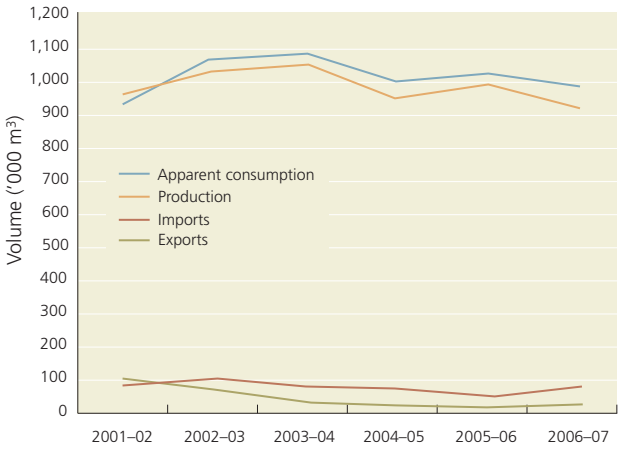
Source: ABARE (2007)

Figure 72: Medium-density fibreboard production, 2001–02 to 2006–07



Source: ABARE (2006, 2007)

Figure 73: Particleboard production, 2001–02 to 2006–07



Source: ABARE (2006, 2007)

Panel products

Medium-density fibreboard and particleboard are used mainly for flooring and joinery (e.g. kitchen benches and cupboards) and together comprise about 90% of all timber-based panels. Therefore, as for sawn timber, trends in the consumption of these products follow trends in the building industry, in particular the rate of house construction.

Australia's medium-density fibreboard production stabilised during the reporting period (Figure 72) after increasing substantially in the previous few years due to the development of new mills. About half of the medium-density fibreboard produced in Australia is exported. That proportion waned during the reporting period.

Particleboard is a relatively heavy and low-value product, and little of it is exported or imported. Domestic production, which nearly equals consumption, fluctuated with the level of building activity in the reporting period (Figure 73).

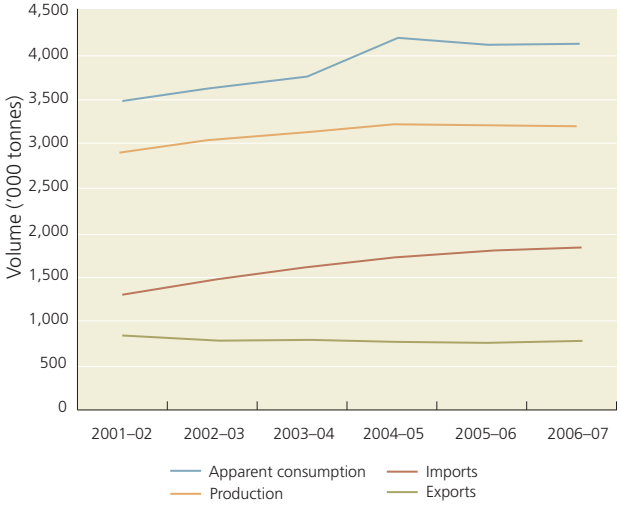
Paper and paperboard

The major categories of paper and paperboard are newsprint, printing and writing papers, household and sanitary papers, and packaging and industrial papers and paperboard. Packaging and industrial papers and paperboard is by far the largest category, representing about 60% of domestic production of paper and paper products, followed by printing and writing papers (21%), newsprint (13%) and household and sanitary papers (6%).

Australia's consumption of paper and paperboard increased by about 20% in the reporting period (Figure 74), to nearly 4.2 million tonnes per year. Consumption far exceeds domestic production. The shortfall is made up by imports of about 1.8 million tonnes per year, 65% of which is printing and writing papers and 15% is newsprint. Those imports are partly offset by exports of 0.8 million tonnes, about 80% of which comprises packaging and industrial papers.

The value of exports of paper and paperboard increased from $613 million to $650 million over the reporting period, while the value of imports increased from $2 billion to nearly $2.3 billion.

Figure 74: Paper and paper product production, trade and consumption, 2001–02 to 2006–07



Source: ABARE (2006, 2007)

Non-wood products

Many products other than wood are harvested from Australia's forests and plantations. They include water, minerals, tree bark, honey, plant oils, flowers, foliage, seeds, animal meat and skins, and 'bush foods'. Some of these products (such as minerals), occur in but are not produced by the forest. Forests are also used for grazing and recreation.

Several native plant species are used to create non-wood forest products that are in demand internationally. Sandalwood (various *Santalum* species), a tree native to Australia, is considered a non-wood forest product because it is not used in the conventional timber sector; its uses and markets are canvassed in Case study 39. The market for billy-goat plum, a fruit harvested from the tree species *Terminalia ferdinandiana*, is also growing (Case study 40).

The live export of native vertebrates other than fish is prohibited under the EPBC Act, but non-native species can be harvested and exported. Case study 41 describes the live export trade of Asian water buffalo in the Northern Territory.

References and further reading

ABARE (2006, 2007), ABS (2006c, 2007c), Altman (1987), Brand et al (1982), CALM (2001), DPIFM 2007, Henschke (2000), Johnson (2000), PWSNT (2007), Ridpath and Waithman (1988), Stratham (1987), Tonts and Selwood (2002) (list at the back of the report).

Web resources

Case study 40: Billy-goat plum (including Figure 75)

Case study 41: Asian water buffalo (including Figure 76)

Mark Parsons

Planted young sandalwood (*Santalum spicatum*), beneath its host plant jam wattle (*Acacia acuminata*), Katanning, Western Australia.

Case study 39: Sandalwood

Sandalwood usually occurs as a slow-growing tree that requires a host plant for survival. Of the 16 species in the *Santalum* genus, only two – *S. album* and *S. spicatum* – are commercially important. The wood from those species is highly valued in Southeast Asia and is used as incense in Buddhist and Hindu religious ceremonies, as well as for carving; Indigenous Australians in northern Australia also value the wood for its aroma. Santalol oil, which is distilled from the heartwood of the tree and used as a fixative in soaps and perfumes, is particularly valuable. Despite being widely distributed across Southeast Asia, *S. album* is so threatened that both India and Indonesia have placed a moratorium on its export.

S. spicatum is slower growing, less fragrant and has a lower oil content than *S. album*. Australia has the world's largest reserve of *S. spicatum*; the species is distributed over an area of about 42 million hectares and has an estimated total standing wood volume of 200,000 tonnes. Under the *Sandalwood Control Act 1929* (WA), the Governor of Western Australia may limit and restrict the amount of sandalwood that can be harvested from natural stands in that state.

Exports of sandalwood have been restricted to about 2,000 tonnes per year for the past two decades, while world demand for the product is increasing at around 5% per year. The best quality unprocessed sandalwood harvested in Western Australia now fetches $10,000 per tonne. In 1995, a newly formed company, Westcorp Sandalwood Inc, won a tender from the Western Australian Government for the sandalwood harvest. In addition to exporting raw logs, the company set up a sister company, New Mountain Company, which started value-adding by producing joss sticks; revenue from this value-added product increased by 400% between 2001 and 2002.

A sandalwood oil distillation company, Mt Romance Australia Pty Ltd, was set up in Albany, Western Australia, in 1999. The company has a 10-year agreement with the Forest Products Commission to process up to 1,000 tonnes of sandalwood per year – a contract estimated to be worth $40 million. One tonne of sandalwood produces about 50 litres of sandalwood oil, which is worth about $500 per litre. Mt Romance is looking to add further value by capitalising on sandalwood-based products in the cosmetics industry.

Sources: CALM (2001), Henschke (2000), Stratham (1987), Tonts and Selwood (2003)

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 increases, there is a growing need to meet societal demands for the recycling of forest products.

Key points

- Discarded forest products contribute approximately 6.5 million tonnes to the waste stream annually, usually in the form of paper and timber products.
- The recycling rates for paper and timber products are estimated to be 53% and 30%, respectively.
- The volume of recovered paper exported increased by 250% in the reporting period, to nearly 1.1 million tonnes in 2006–07, due mainly to increased demand from China.

As global demand for forest products increases, there is a growing awareness of the opportunity and need to extend the life of forest products and improve the efficiency of their use. This indicator identifies the extent to which the recycling and reuse of forest (wood) products occur and can be linked to the conservation of forest resources and reductions in solid waste.

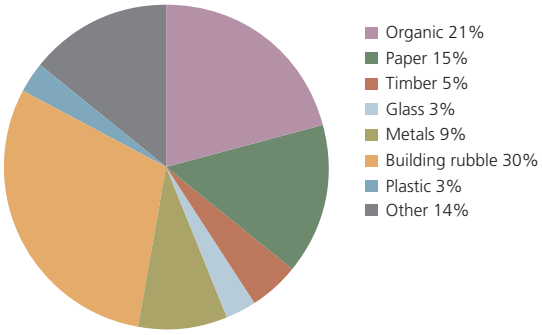
In general, forest products are highly recyclable. Recycling – the collection, separation and processing of materials for manufacture into raw materials or new products – reduces both the need to harvest the forest resource and the volume of solid waste going to landfill. High rates of recycling can also help reduce pressure on forest resources and the country's reliance on forest product imports. Waste wood products can also be used in the generation of heat and electricity for domestic and industrial use.

The processing of wood wastes is regulated by the states and territories. Some jurisdictions have initiated schemes that encourage producers to reduce and recycle wood wastes.

In 2002–03 (the most recent period for which data were available), Australians generated approximately 32.4 million tonnes of solid waste, of which an estimated 6.5 million tonnes (20%) was discarded forest products, mostly paper and timber (Figure 77).

An estimated 46% of all waste in Australia is recycled. Paper (53%) has one of the highest product recycling rates, while the estimated rate for timber (30%) is also substantial.[6] These are at the high end of rates achieved internationally, although direct comparison with other countries is difficult because some countries report the amount of material collected for recycling and others report the amount that is actually reprocessed. The rate of recycling is influenced by many factors, some of which are discussed below.

Figure 77: Composition of solid waste, Australia, 2002–03



Source: Productivity Commission (2006)

6 Australian Plantation Products and Paper Industry Council data, 2004–05, www.a3p.asn.au (accessed September 2007).

Printing paper containing 10% recycled fibre.

Paper products

Australians consumed over 4 million tonnes of paper products in 2006–07. The municipal, commercial and industrial sectors were the largest contributors to this total, with paper comprising 22–23% of waste in these streams. The vast majority of paper and cardboard produced is recyclable; however, because the fibres in paper products become shorter and weaker the more they are processed, most can only be recycled from four to six times. Virgin fibre is usually added to provide strength, the amount depending on the type of paper product being produced; for example, high-quality writing paper requires more virgin fibre than does tissue. Most paper recovered from waste is reprocessed in Australia, but significant volumes of recovered paper are also exported. The volume of recovered paper exported increased by 250% in the reporting period, from 0.3 million tonnes in 2001–02 to nearly 1.1 million tonnes in 2006–07. The increase is mainly due to increased demand from China.

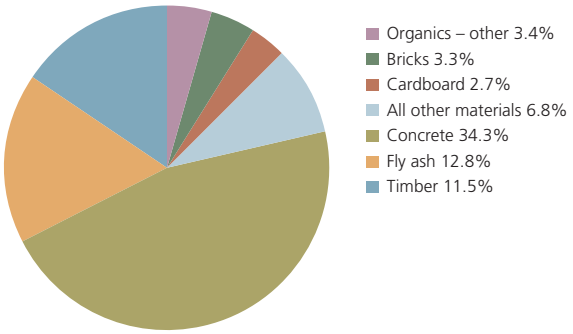
Timber products

An estimated 1.7 million tonnes of wood products contributes to the Australian waste stream each year, mainly from the commercial and industrial sectors.[7] Waste timber products are made up of untreated timber; composite wood products, such as particleboard, plywood and laminated veneer; and treated timber products. Untreated, uncontaminated timber is the most valuable of these and the easiest to recycle, while treated timber products are difficult to recycle. Limited data suggest that around 30% of waste timber products is recycled to make mulch and compost, biofuel and particleboard. There is also a small industry for the recovery of high-quality timbers from demolition sites.

According to a recent study conducted as part of a joint project by the Timber Development Association and the Australian Plantation Products and Paper Industry Council, an estimated 1.4 million cubic metres of treated timber is consumed in Australia each year. The biggest markets are for agricultural uses; urban fencing and landscaping; outdoor building and construction applications (decks, pergolas, etc); and termite-resistant house framing. Another study conducted under the same project, on demolition timber, found a high degree of reuse of good-quality hardwoods and Douglas fir recovered from demolitions. According to the study, key impediments to increased recycling of demolition timber are a lack of end products and markets for low-value timbers. A third study, on packaging timber, found that 636,000 cubic metres of timber was used to make timber packaging in Australia in 2005–06. In addition, 120,000 tonnes of timber pallets was used to import goods into Australia. While a high proportion of that packaging comprises reusable pallets, 290,000 tonnes of timber packaging are disposed of in landfills in Australia each year. All three studies are being considered as part of the development of a national strategy for waste timber by the National Timber Stewardship Group.

An estimated 500,000 tonnes of timber is added to landfill in Victoria each year. In an effort to reduce this, the Victorian Government's EcoRecycle program is supporting timber recycling businesses that recycle timber into high-value, high-quality particleboard and convert clean and untreated timber into a range of garden mulches and fuel bricks. The South Australian Government is also working to reduce waste (Case study 42), including waste timber. In 2004–05, timber was the major organic material recovered (Figure 78), with 300,980 tonnes recycled, of which 62% was bark from the forestry industry.

Figure 78: Composition of recovered materials in South Australia, by weight, 2004–05



Source: O'Farrell (2006)

References and further reading

ABS (2006c), A3P (2004–05), O'Farrell (2006), Productivity Commission (2006), Taylor et al (2005), Zero Waste SA (2005) (list at the back of the report).

7 Taylor et al (2005).

Case study 42: South Australia's Waste Strategy, 2005–10

State and local government agencies, the waste management industry, business and the community have been involved in helping Zero Waste SA to develop a waste strategy that will guide the way waste is managed in South Australia. The five-year strategy establishes waste reduction goals and targets for the state and sets out a range of strategies and steps to achieve them. It is focused on five key objectives:

- **Foster sustainable behaviour.** Simply providing information will not influence people to recycle or reuse material or resources in a sustainable way.
- **Less waste**. Substantially reducing the waste going to landfill in South Australia means that materials must be redirected towards more beneficial uses.
- **Effective systems**. South Australia needs to establish, maintain and increase the capacity of recycling systems and reprocessing infrastructure in metropolitan and regional areas.
- **Effective policy instruments**. Economic, regulatory and other policy measures must be introduced to give the necessary traction in the marketplace to encourage the avoidance, reduction, reuse and recycling of waste.
- **Successful cooperation**. Targets of this and future strategies will only be reached with the successful cooperation of a range of stakeholders.

The strategy sets key material and recycling targets for each waste stream as follows:

Waste stream	By 2006	By 2008	By 2010	By 2014
Municipal solid waste	At least 25% of all material presented at the kerbside is recycled	50% of all material presented at the kerbside is recycled	75% of all material presented at the kerbside is recycled (if food waste is included)	Reduce waste to landfill by 25% (as required by South Australia's Strategic Plan)
Commercial and industry	5% increase in recovery and use of materials	15% increase in recovery and use of materials	30% increase in recovery and use of materials	–
Construction and demolition	20% increase in recovery and use of materials	35% increase in recovery and use of materials	50% increase in recovery and use of materials	–

Source: Zero Waste SA (2005)

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. This indicates the long-term and short-term commitment to forest management, further processing and other forest uses.

Key points

- Governments spend hundreds of millions of dollars annually on the management of nature conservation reserves and multiple-use public native forests. Few data are available on investment in privately owned native forests.
- Investment in public and private plantation expansion increased over the period from 2002 to 2006, totalling an estimated $902 million.
- Investment in new or improved manufacturing facilities during the reporting period was several billion dollars.

The purpose of this indicator is to assess the level of forest-related investments aimed not only at providing commercial products but also environmental services such as catchment protection and nature conservation. Forests managed for all purposes on all land tenures would ideally be included in such an assessment, but that has not been possible for this report. Information is available on investments in the management of public nature conservation reserves and multiple-use public forests in some states, in plantation development and, to some extent, in timber processing. However, few data are available on investment in privately owned native forests.

Nature conservation reserves may be managed by the Australian Government or by state or territory governments, and some private land is also managed for nature conservation. Nature conservation reserves often contain other ecosystems besides forests, and it is difficult to identify the portion of expenditure dedicated to forest ecosystems within the reserve system. Therefore, the estimates of public expenditure given in Tables 84 and 85 apply to all land in nature conservation reserves, not just forests.

The New South Wales Department of Environment and Climate Change manages more than 750 individual reserves, including 174 national parks, covering 8% of the state's land area. Table 85 shows total expenditure on protection and conservation, visitor facilities, fire protection and other activities.

Tasmania's Parks and Wildlife Service manages 1.11 million hectares of forests in national parks and other reserves; its annual operating budget in 2005–06 was about $20 million. The total investment in infrastructure to facilitate recreation and tourism, including roads, bridges, walking tracks, camping areas, viewing platforms and other facilities is conservatively estimated to be $230 million. There is also considerable private investment in servicing tourism in forested reserves.

The southwest forests of Western Australia are managed according to a management plan developed by the Conservation Commission of Western Australia.

Table 84: Expenditure on the seven Australian Government-managed nature conservation reserves (forest and non-forest), 2002 to 2006 ($ million)

	2002	2003	2004	2005	2006
Expenditure	52.8	54.6	57.5	58.7	57.0

Note: The reserves are the Kakadu, Uluru–Kata Tjuta, Booderee, Pulu Keeling, Christmas Island and Norfolk Island national parks and the Australian National Botanic Gardens. They cover a total of 2.13 million hectares.

Source: Standing Committee on Environment, Communications, Information Technology and the Arts (2007)

Table 85: Expenditure on New South Wales public nature conservation reserves (forest and non-forest), 2002 to 2006

	2002	2003	2004	2005	2006
Number of reserves	–	–	660	671	753
Area managed (million hectares)	–	–	5.95	6.07	6.49
Expenditure ($ million)	284	338[a]	247	305	326

a Includes costs associated with organisational restructuring.

Note: Total operational expenditure on protection and conservation, visitor facilities, fire protection and other activities.

Source: Department of Environment and Climate Change (NSW) annual reports

The plan applies to about 2.5 million hectares of forest, 52% of which is in national parks and other nature conservation reserves and 48% of which is designated as multiple-use public forest (which includes commercial timber plantations). Western Australia's Department of Environment and Conservation is the land manager and the Forest Products Commission manages timber production. Expenditure by those agencies is shown in Tables 86 and 87. Because the commission sells forest products, the revenue earned and the value of the assets held are also shown for that agency.

Table 86: Expenditure by Western Australian Department of Environment and Conservation on management of native forests in multiple-use public forests, southwest Western Australia, 2004 to 2006

	2004	2005	2006
Area managed (million hectares)	1.25	1.30	1.30
Expenditure ($ million)	$34.4	$40.9	$38.4

Source: Department of Environment and Conservation (WA) annual reports

Table 87: Expenditure, revenue and assets of Forest Products Commission, multiple-use public forests, southwest Western Australia, 2002 to 2006 ($ million)

	2002	2003	2004	2005	2006
Gross revenue	114	66	67	67	71
Natural resource asset	190	185	194	233	240
Expenditure	100	56	60	65	49

Note: Comprises multiple-use public (state) forest, including commercial timber plantations.

Source: S Eccleston, Forest Products Commission, pers comm, February 2008

Plantation development

The total annual investment in plantations in Australia is not known, but the area of new plantation establishment provides a guide as to whether investment is increasing or declining. Table 88 reports the area of new plantations established annually in Australia from 2002 to 2006; it shows that the rate of establishment increased significantly in 2005 and 2006.

The expenditure required to develop a plantation varies widely depending on planning and land costs, the need to develop roads and other infrastructure, the tree species planted, the site preparation techniques used, the scale and management structure of the project and other factors. Assuming that the average cost of planning, preparation and establishment is $3,000 per hectare, expenditure on plantation expansion in Australia from 2002 to 2006 was approximately $902 million.

Table 88: New plantation establishment in Australia, 2002 to 2006 ('000 hectares)

	2002	2003	2004	2005	2006
Area of new plantations	54.4	42.3	53.6	72.0	78.3

Source: Parsons et al (2007a)

Timber processing

A massive investment was required to develop the infrastructure and manufacturing facilities that processed the 27 million cubic metres of logs harvested from Australia's native forests and plantations in 2005–06. Several billion dollars was invested in new or improved manufacturing facilities during the reporting period. As well as servicing the capital cost of that investment, Australia's forest product industries continue to invest in new or improved manufacturing facilities, including at least $700 million in developing and adopting new processing techniques in the Tasmanian forest sector over the past decade, and the Forest Industries Structural Adjustment Program funded by the Australian and state governments. The Australian and Tasmanian governments also committed $250 million under the 2005 Tasmanian Community Forest Agreement to support programs that 'enhance forest conservation and the development of forest industries'. Those programs aim to help re-equip mills so they can adapt to changing markets and wood supply. Indicator 7.1c provides more information.

References and further reading

Parsons et al (2006, 2007a); Standing Committee on Environment, Communications, Information Technology and the Arts (2007) (list at the back of the report).

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 forest-based industries. It also quantifies the level of research and development. Significant investment in research, development and new technologies results in continual improvements to forest management practices.

Key points

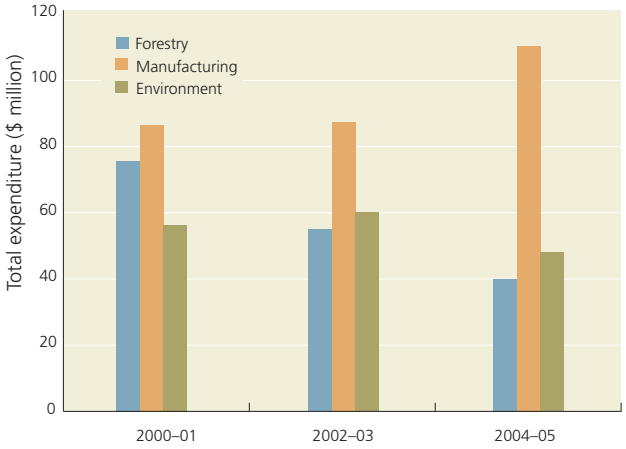
- Reported expenditure on national forest-related research and development was $198.9 million in 2004–05, a decrease of $17.2 million from 2000–01.
- Of that total, investment in manufacturing-related research was reported to have increased from $79 million in 2000–01 to $108 million in 2004–05.
- At the same time, nationally reported research in forest growing for wood production declined.
- Forest-related environmental research declined from $56 million in 2000–01 to $47 million in 2004–05.
- The benefits of research are maximised via ongoing partnerships with the private sector and new delivery arrangements through collaborative research programs, such as cooperative research centres.

Aerial application of fertiliser to a blue gum plantation.

This indicator provides a national view of investment in research and development in forestry, wood and paper product manufacturing and environmental management in forests using information collected nationally by the Australian Bureau of Statistics (ABS). It is valuable in establishing broad trends, although limitations exist in the capture of investment in activities dispersed across and within jurisdictions, particularly environment-related research, which is broad-based and not easily partitioned into forest and non-forest research.

Over the period from 2000–01 to 2004–05, the proportion of funds allocated to forest sector research declined for forestry (i.e. primary wood production) and environment, and increased for manufacturing (Figure 79). Total reported annual forest-related research expenditure declined by 8%, from $216 million in 2000–01 to $199 million in 2004–05 (Table 89). This decline, which follows a sustained period of growth in expenditure in the previous decade, coincides with reduced native forest production and maturity in plantation (particularly softwood) research. The most significant contributor to expenditure was private sector research in wood, wood product and paper manufacturing, which totalled $112 million in 2004–05, while forestry research amounted to $40 million (Table 90). These data may not fully reflect the true situation because they do not include new research conducted by organisations other than traditional forest research providers.

Figure 79: Government and private research and development expenditure in the forest sector, 2000–01 to 2004–05



Forestry = primary wood production; Manufacturing = manufacturing in the wood, wood products and paper sectors; Environment includes research and development related to 'forests and wooded lands', an ABS category similar in scope to the definition of forests used in this report.

Source: Derived from ABS data

Table 89: Government and private research and development expenditure in forest sector, by objective, 2001–02 to 2004–05 ($ million)

Socioeconomic objective	2000–01	2002–03	2004–05
Forestry (primary wood production)	74.9	54.4	40.2
Manufacturing (wood, wood product and paper)	85.0	85.9	111.9
Environmental management (forest and wooded lands[a])	56.2	60.5	46.8
Total	216.1	200.8	198.9

a 'Forest and wooded lands' is an ABS category similar in scope to the definition of forests used in this report.

Source: Derived from ABS data

Table 90: Research and development expenditure, by objective, 2004–05 ($ million)

	Sector		
Socioeconomic objective	Public	Private	Total
Forestry (primary production)	38.5	1.7	40.2
Manufacturing (wood, wood product and paper)	3.9	108.0	111.9
Environmental management (forest and wooded lands[a])	44.1	2.7	46.8
Total[b]	86.5	112.4	198.9

a 'Forest and wooded lands' is an ABS category similar in scope to the definition of forests used in this report.

Source: Derived from ABS data (expenditure by higher education institutions not included)

Table 91: National, state and territory government research and development in forest-related areas, 2002–03 and 2004–05

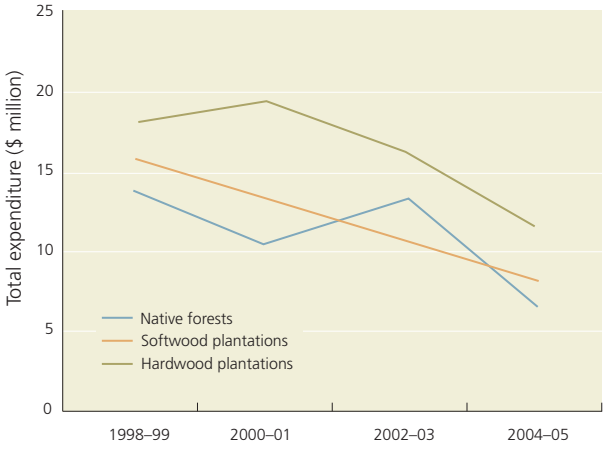
Socioeconomic objective	2002–03 ($ million)	2004–05 ($ million)
Forestry (primary wood production)	33.2	38.5
Manufacturing (wood, wood product and paper)	4.1	3.8
Environmental management (forest and wooded lands)	59.6	44.1
Total	96.9	86.4

Source: Derived from ABS data

The major focus of public sector forest-related research and development expenditure is on forestry (also referred to as 'primary wood production') and environmental management. Total annual government expenditure in those two areas in 2004–05 was $86 million, down from $97 million in 2002–03 (Table 91). The investment by state and territory governments was around the same as that reported for the Australian Government. The other major public investment occurred in higher education institutions, which reported expenditure of $12.6 million in 2004–05, a similar amount to that reported in 2002–03.

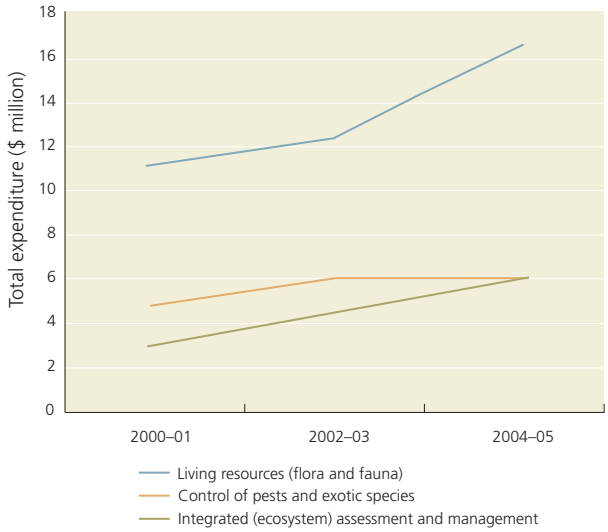
The decline in government research in forestry production illustrated in Figure 80 coincides with declining native forest production and the maturation of plantation (particularly softwood) research. On the other hand, government funds available for research into fauna and flora increased significantly between 2000–01 and 2004–05, while investment in research into forest-related pests and invasive species and integrated ecosystem assessment and management both grew marginally (Figure 81). Although investments in research and development relating to land and water management apparently declined between 2001–02 and 2004–05, that is likely to be a growth area in the future. Increasing attention is likely to be paid to water quality and quantity and the impact of

Figure 80: Government research and development expenditure on forest-related primary wood production, 1998–99 to 2004–05



Source: Derived from ABS data

Figure 81: Government research and development expenditure on forests, 2000–01 to 2004–05



Note: Respondents to the ABS survey self-report using the given categories but adopt their own definitions.

Source: Derived from ABS data

climate change, along with the role of trees and forests in delivering environmental outcomes such as reduced salinity in agricultural landscapes. For example, a 12-year, $20 million trial on the role of forests and vegetation in delivering better water quantity and quality outcomes is now under way in the Wungong catchment near Perth. There is increasing interest and activity in long-term research sites (Case study 43).

Substantial new programs are under development to intensify research and development into efficient, cost-effective industry practices and improved environmental outcomes. For example, governments, industry and educational institutions have established an active partnership under the umbrella of the Cooperative Research Centre (CRC) for Forestry, an Australia-wide research venture designed to operate between July 2005 and June 2012. The CRC, which is headquartered in Hobart, focuses on new technologies, innovation, value-adding, efficiency and competitive advantage as well as landscape issues and community engagement. Over its seven years of operation, it will receive $26.6 million from the Australian Government and $57 million in cash and in-kind contributions from partners.

Forest and Wood Products Australia brings together key industry stakeholders to provide a competitive program of research and development to address national priorities. It supports a range of activities that reflect national research priorities, including the development of:

- sustainable forest management assessment systems, certification and chain-of-custody arrangements for plantations and multiple-use forests
- control or management strategies for biotic and abiotic risk factors (pests, fire, drought)
- economically efficient and low environmental impact harvesting and transport operations
- precision forestry systems/technologies for more profitable plantation forest management
- new forests for commercial products and environmental services in lower rainfall environments (through the Joint Venture Agroforestry Program).

Case study 43: The Warra Long-term Ecological Research Site

Forestry Tasmania's Division of Forest Research and Development and the state's Parks and Wildlife Service manage the Warra Long-term Ecological Research Site in southern Tasmania. The site provides a focal area for collaborative research in wet eucalypt forests by nine site partner agencies. Over 100 research projects have been conducted at Warra, many of them ongoing; they are progressively documenting the climate, geomorphology, hydrology and aquatic and terrestrial biodiversity of the site, as well as testing the development of sustainable forest management indicators.

The long-term flagship projects at Warra are a silvicultural systems trial, a log decay study, baseline altitudinal monitoring plots, a hydrological program and a set of wildfire time-sequence plots. The findings of these and other, shorter term, projects are directed into forest management. For example, the silvicultural systems trial provided data on variable-retention silviculture that enabled the Tasmanian Government to commit to phasing out clearfelling in old-growth forests (Case study 67). Projects on coarse woody debris and its associated biodiversity, along with the wildfire time-sequence plots, inform the management of key structural attributes in production forests at a range of spatial and temporal scales.

The hydrological program at Warra has included measures of the quantity and quality of run-off.

Source: J Davidson, BRS, pers comm, 2007

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. This provides an indication of the emphasis placed by society on the management of forest for those purposes.

Key points

- Most publicly owned multiple-use and nature conservation forests are available to the general public for recreation and tourism.
- Some forests that are generally available for public recreation and tourism may be closed temporarily, mainly for safety reasons related to harvesting operations and fire and to minimise the spread of disease. Public access to private land for recreation and tourism is generally limited.
- Access to forests for some recreation and tourism activities may be restricted where such activities are likely to compromise the primary objective of management, such as the protection of sensitive environmental and cultural values.

Facilities like this skywalk are available in many forest areas to assist ecotourism, recreation and nature education.

Most publicly owned forested lands designated for multiple uses or nature conservation are available for general recreation and tourism; Table 92 illustrates this for New South Wales, Queensland, South Australia, Victoria and Western Australia. For specific forests, forest management plans may specify the types of visitor activities that are permissible and the conditions of use. In forests not subject to management plans, the broad policies of the responsible agency usually indicate the types of recreation and tourism permitted. Public access to private land for recreation and tourism is generally limited, although few data are available on this.

Some publicly owned forest areas may be closed to the public, including designated scientific reference and conservation areas, some water catchment areas, significant Indigenous cultural sites, and defence training areas. In Western Australia, some forest areas under the threat of spread of the fungal pathogen *Phytophthora cinnamomi*, known as 'disease risk areas', are closed to the public. Such areas account for a significant part of the 40% of multiple-use forests not open to recreation and tourism in Western Australia. In Queensland, recreation and tourism are permanently excluded from designated scientific areas making up less than 1% of multiple-use forests. In New South Wales, South Australia, Victoria and Western Australia, nearly all multiple-use forests and nature conservation reserves are available for recreation and tourism (Table 92). In Tasmania, 2.32 million hectares of forest, or 70% of the total forest area in that state, is available for general recreation.

Table 92: Area of forest available for general recreation and tourism in New South Wales, Queensland, South Australia, Victoria and Western Australia, by tenure and percentage

	Multiple-use public forests		Public nature conservation reserves	
	Area ('000 ha)	%	Area ('000 ha)	%
NSW	2,400[a]	99[a]	5,750[b]	88[b]
Qld	2,500	99	–	–
SA[c]	106	100	22.8	100
Vic.[d]	3,080	99	3,330	97
WA[e]	1,070	60	847	89

a Forests NSW.

b Parks and Wildlife Group of the Department of Environment and Climate Change (NSW); based on the whole-of-parks system and not specific to forests.

c Primary Industries and Resources SA Forestry; based on all ForestrySA-managed forest reserves.

d Department of Sustainability and Environment (Vic.).

e Department of Environment and Conservation (WA); for the southwest forest area only; does not take into account restrictions on access to reservoir protection zones; data for other areas not included.

Swimming.

In some cases, forests that are generally available for public recreation and tourism may be closed temporarily due to harvesting, extreme fire danger, fuel reduction burning, the control of feral animals or weeds, special events or bad weather. Road access, a lack of facilities or other practical considerations may also restrict or prevent public use of multiple-use and nature conservation forests.

Orienteering.

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 recreation and tourism facilities help to optimise visitor satisfaction and minimise environmental impacts.

Key points

- A wide range of forest-based recreation and tourism services are available to meet demand by the general public.
- For those forests for which data were available, the number of areas, tracks and sites available for recreation and tourism activities increased or remained the same over the reporting period.
- Forest management agencies have strategies in place to actively manage forest areas of high recreation and tourism use within their jurisdictions.

Visitor accommodation in a rainforest, southeast Queensland.

In all jurisdictions, forest management aims to provide a balanced range of opportunities for recreational pursuits such as walking, running, cycling, climbing, fishing, camping, horse riding, snow activities and water sport, and facilities that are appropriate for each forest setting and consistent with demand and resources (Case study 44). Two measures are used in this indicator: the numbers of areas, tracks and sites, used to measure the range and number of recreation and tourism facilities provided by forest managers; and the numbers of people, vehicles and licences, which indicate the level of use of those facilities.

Some jurisdictions conduct comprehensive visitor surveys and have a good understanding of visitor needs and expectations (Case study 45); others provide sites and facilities in response to local demand and patterns of current use. Table 93 indicates the numbers of areas, tracks and sites available for forest-based tourism and recreation activities in multiple-use public forests in New South Wales, South Australia and Victoria, the three states for which data were available. These figures do not include sites and facilities managed by local governments or the commercial and private sectors. The figures show that the number of facilities available to visitors generally increased in South Australia and Victoria from 2001–02 to 2005–06 but, in some instances, decreased in New South Wales due to the transfer of significant additional areas of multiple-use public native forest to national parks as a result of the Brigalow Belt Bioregion and Western regional assessments.

Table 93: Numbers of areas, tracks and sites provided for recreation and tourism in multiple-use public forests in New South Wales, Victoria and ForestrySA-managed forests in South Australia, 2001–02 and 2005–06

		NSW[a]		Vic.[b]		SA[c]	
Activity	Unit	2001–02	2005–06	2001–02	2005–06	2001–02	2005–06
Riding or walking animals	km of tracks	n.d.	n.d.	160	170	65	84
Cycling	no. of permits (NSW) km of tracks (SA, Vic.)	n.d.	107	11	170	200	232
Driving	no. of permits (NSW) km of roads (SA, Vic.)	19	24	248	733	140	130
Walking or running	no. of permits (NSW) km of tracks (SA, Vic.)	48	37	550	715	190	304
Climbing	no. of documented sites	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cultural (non-Indigenous) heritage appreciation	no. of managed sites	n.d.	n.d.	25	34	1	1
Events or festivals	no. of events	230	193	344	142	2	2
Fishing	no. of managed sites	n.d.	n.d.	20	25	1	1
Nature study	no. of sites	n.d.	n.d.	5	7	11	11
Camping	no. of sites	177	94	200	227	21	21
Picnicking and playing	no. of sites	94	77	200	226	25	27
Snow activities	no. of managed sites	4[d]	4[d]	10	10	n.d.	n.d.
Swimming and diving	no. of managed sites	n.d.	n.d.	5	5	n.d.	n.d.
Watercraft (motorised)	no. of sites	n.d.	n.d.	2	2	n.d.	n.d.
Watercraft (non-motorised)	no. of sites	n.d.	n.d.	5	5	1	1
Total length of roads and trails	km of roads	33,751	32,846	n.d.	n.d.	n.d.	n.d.

n.d. = no data available

a Forests NSW; comprises multiple-use public forests.

b Department of Sustainability and Environment (Vic.).

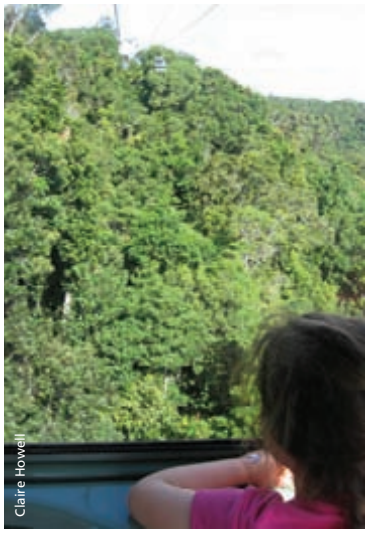
c Primary Industries and Resources SA Forestry; based on all ForestrySA-managed forest reserves, comprising public multiple-use and nature conservation reserve forests.

d These four ski resort centres (Perisher, Charlotte Pass, Selwyn and Thredbo) – are in the New South Wales national park system.

Visitor numbers in forests are monitored by a mixture of counts and estimates by agency staff. Counted data are based on entry fees, traffic counters, camping permits and surveys and are relatively accurate, while estimates are likely to be less accurate. Visitor numbers are difficult to estimate 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 greatly increases during holiday periods. Sites that are well signposted and promoted in various media receive many more visits than lesser known sites, where usage depends more on word of mouth.

In Tasmania, while data are not available for all sites used for recreation, more than 1.1 million person-visits to forests were recorded during 2005–06. Sites recording more than 100,000 person-visits were Freycinet National Park, Cradle Mountain – Lake St Clair National Park, Mount Field National Park and the Tahune airwalk in state forest. In September 2004, Forestry Tasmania opened a new ecotourism development at Dismal Swamp near Smithton in northwest Tasmania; the agency is now further developing environmentally sensitive tourism infrastructure.

Tables 94 and 95 show data on forest-related tourism and recreation use in South Australia, Victoria and Western Australia. Forests NSW does not measure the number of visitors using forests but notes an increase in the number of permits issued to stakeholders for access to multiple-use public forests for recreation; it is redeveloping its information database to improve its future capacity to report on built facilities and activities within its forest areas. This will build on a 2005 estimate of 22 million visits annually to New South Wales national parks, including forested landscapes.



A cable skyway facility is a major tourist attraction in northern Queensland.

Table 94: Forest recreation and tourism in South Australia, Victoria and Western Australia, 2001–02 and 2005–06

		SA[a]		Vic.[b]		WA[c]
Activity	Unit	2001–02	2005–06	2001–02	2005–06	2005–06
Riding or walking animals	People/year	960	1,100	266,000	266,000	
Cycling	People/year	2,900	5,000	304,000	304,000	36
Driving	Vehicles/year	51,000	42,000	304,000	304,000	
Walking or running	People/year	10,100	9,800	510,000	510,000	435
Climbing	People/year	–	–	–	–	16
Cultural heritage appreciation	People/year			160,000	160,000	364
Events or festivals	People/year	13,900	26,700	27,520	11,360	
Fishing	Licences/year	–	–			80
Hunting	Licences/year	–	–	29,823[d]	32,832[d]	
	No. of deer-hunting days			120,511[d]	123,908[d]	
Nature study	People/year			304,000	304,000	205
Camping	Overnight visitors/year	9,100	12,800	400,000	400,000	245
Picnicking and playing	People/year	7,900	8,900	490,000	490,000	236
Snow activities	People/year	–	–	100,000	100,000	
Swimming and diving	People/year	–	–	152,000	152,000	169
Watercraft (motorised)	People/year	–	–	114,000	114,000	
Watercraft (non-motorised)	People/year	50	50	152,000	152,000	46
Caving	People/year	2,150	2,400			
Fossicking	People/year	570	410			
Trail-bike and 4-wheel-drive activities	People/year			432,000	432,000	

a Data from the Department of Primary Industries and Resources SA; based on all ForestrySA-managed forest reserves, comprising multiple-use public and nature conservation reserve forests.

b All Victorian multiple-use forests (Parks Victoria facilities are shown in Table 95). Activities such as camping and horse riding are permitted in most multiple-use public forests (in line with codes of forest practice). For example, the public can camp almost anywhere if adhering to certain rules. The figures supplied are for sites and tracks that are actively promoted and maintained for specific activities.

c Data from visitor feedback survey in forest areas on lands managed by the Department of Environment and Conservation (WA). Data based on the responses of 649 people at 20 survey sites, including national parks and state forests; therefore, these data are not estimates of absolute usage, but a sample.

d Game licences in Victoria are not tenure specific. Estimates derived from the Department of Sustainability and Environment (Vic.) Hunter Mail Survey 2000–06.

Table 95: Facilities available for recreation and tourism activities in nature conservation reserves managed by Parks Victoria

	Protected areas	Other Crown land
Driving (km of roads)	13,300	2,633
Walking or running (km of tracks)	See note a	See note a
Climbing (no. of documented sites)	52	–
Cultural heritage appreciation (no. of managed sites)	193	36
Fishing (no. of managed sites)	633	6
Hunting (no. of managed sites)	20	1
Camping (no. of sites)	668	10
Picnicking and playing (no. of sites)	599	214
Snow activities (no. of managed sites)	62	–
Swimming and diving (no. of managed sites)	630	5
Watercraft – motorised (no. of sites)	30	–
Watercraft – non-motorised (no. of sites)	348	3

a There are 3,700 kilometres of walking tracks in areas managed by Parks Victoria, the majority in forest, including some on other Crown land.

Note: The total number of visitor assets is 12,500. About 80% of the following assets managed by Parks Victoria occur on forested land: 54 visitor centres, nearly 1,000 toilet blocks, over 400 lookouts, 900 vehicle bridges and 1,200 car parks.

Source: Parks Victoria

Case study 44: Visitors to South Australian forest reserves

South Australia's forest reserves are a significant open space and tourism resource that contain an interesting diversity of landscape types, including native forest, plantations, open spaces and heritage areas. Survey data indicate that more than 200,000 day visits are made each year to the Mount Lofty Ranges forest reserves near the Adelaide metropolitan area. A wide range of recreational activities are undertaken, including walking, nature study, picnicking, camping, cycling, horse riding, fossicking and motor sports. The plantation areas provide locations for many of the more active pursuits that may be unavailable in other public open spaces, such as conservation and national parks.

ForestrySA manages facilities to support these activities, including 30 picnic and camping areas that provide shelters and hut accommodation. More than 300 kilometres of multiple-use trails are maintained, including the long-distance Heysen, Mawson and Kidman trails. Each year, more than 50,000 visitors enjoy a range of community events, including the Bundaleer Weekend Arts Festival and the Rally of SA – a round of the Australian Rally Championship.

Source: ForestrySA

Picnic shelters at Bundaleer Forest Reserve, South Australia.

Case study 45: Visitor Satisfaction Index in Western Australia

The Western Australian Department of Environment and Conservation has developed a Visitor Satisfaction Index as a key performance indicator for the Parks and Visitor Services Division. The index was developed from an annual visitor feedback survey using satisfaction ratings given by respondents visiting parks and other areas managed by the department. Two questions relate to satisfaction: 'How did you feel about your visit today?' and 'How would you rate your visit overall?' Respondents are asked to rate their responses on a scale of 1 to 7, where 1 is the lowest and 7 the highest level of satisfaction.

The overall mean (average of the means of these two questions) constitutes the Visitor Satisfaction Index for all parks, which was calculated to be 6.22 in 2005–06 based on a sample of 2,580 respondents. This is above the state benchmark rating of 6.1, which was derived from a consultant's study on the parameters that contribute to visitor satisfaction in natural areas in Western Australia.

Source: DEC, WA

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 people's values in forests. An acceptable level of accountability for the protection of Indigenous people's cultural, religious, social and spiritual values is an essential part of forest management.

Key points

- Indigenous-owned land includes around 21 million hectares of forest, which is 14% of Australia's total forest area. Most of it is eucalypt woodland or open forest in the tropical northern areas.
- Almost half the forest in the Northern Territory has Indigenous ownership, but the proportion is lower in Western Australia (9%), Queensland (6%) and South Australia (3%). Only very small proportions of the forest estate are under Indigenous ownership in New South Wales, Victoria and Tasmania.
- Legislative arrangements in all jurisdictions aim to ensure the identification and protection of Indigenous sites and places of significance.

Interpretation board describing aboriginal use of Australia's tropical rainforests.

This indicator uses information from the Indigenous Land Corporation (ILC) to report the area of land on which Indigenous people have use and rights that protect their special values and which are recognised through formal and informal management regimes. It also reports on the number of Indigenous heritage places recognised and protected under legislation. Indicator 6.4c reports on the range of measures that promote Indigenous engagement and involvement in forest management.

There are no lands in Australia on which Indigenous people fully determine land management objectives and practice, because all lands are subject to environmental or resource allocation laws made by the national and state and territory governments. Nonetheless, Indigenous people have obtained full legal title to various areas of land and re-established large measures of customary control. The extent to which Indigenous people have gained ownership or other rights to land varies by geographical location and formal land valuation. In general, Indigenous ownership and other rights apply to fewer areas in longer settled landscapes in southern Australia and the more fertile mesic (often forested) lands of the eastern coast, where land has been alienated from Indigenous control.

Aboriginal and Torres Strait Islander peoples represent 2% of Australia's population of 21 million. The ILC reports that more than 16% of Australia's land mass, or 122 million hectares, is under Indigenous ownership (44.8% in the Northern Territory, 15% in Western Australia). Much of that land is in Australia's arid zones, where there are few forests. Based on ILC information and National Forest Inventory mapping, 14% of the country's forests, or more than 20.8 million hectares, is estimated to be under Indigenous ownership. That area has not changed significantly from that reported in SOFR 2003, and any slight changes are more likely due to forest mapping than tenure changes. The vast majority (98%) of these forests are in the Northern Territory, Queensland and Western Australia, where 38% of the Indigenous population resides (Figure 82, Table 96).

Figure 82: Forests on Indigenous Land Corporation registered lands, 2006

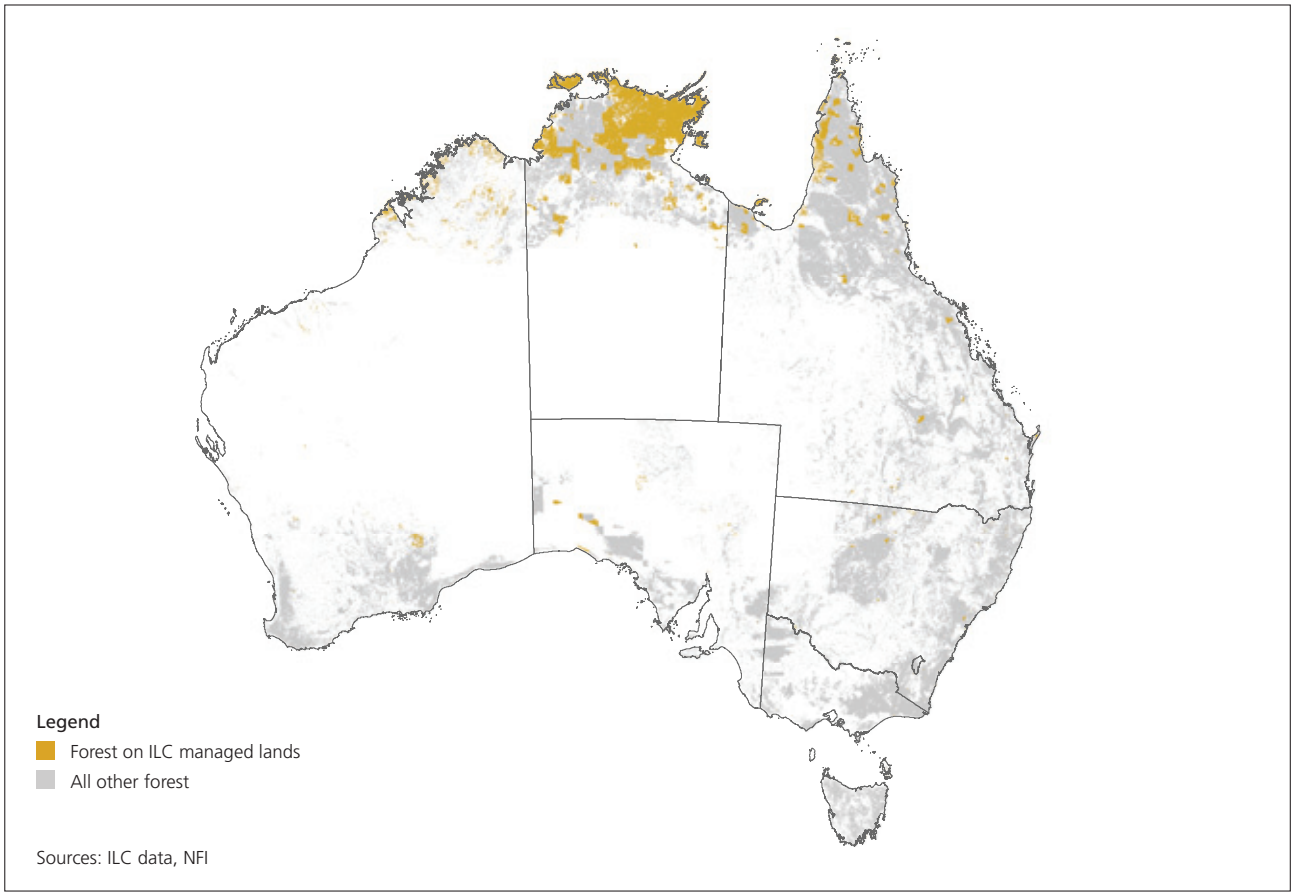


Figure 83: Register of the National Estate: forests on Indigenous sites

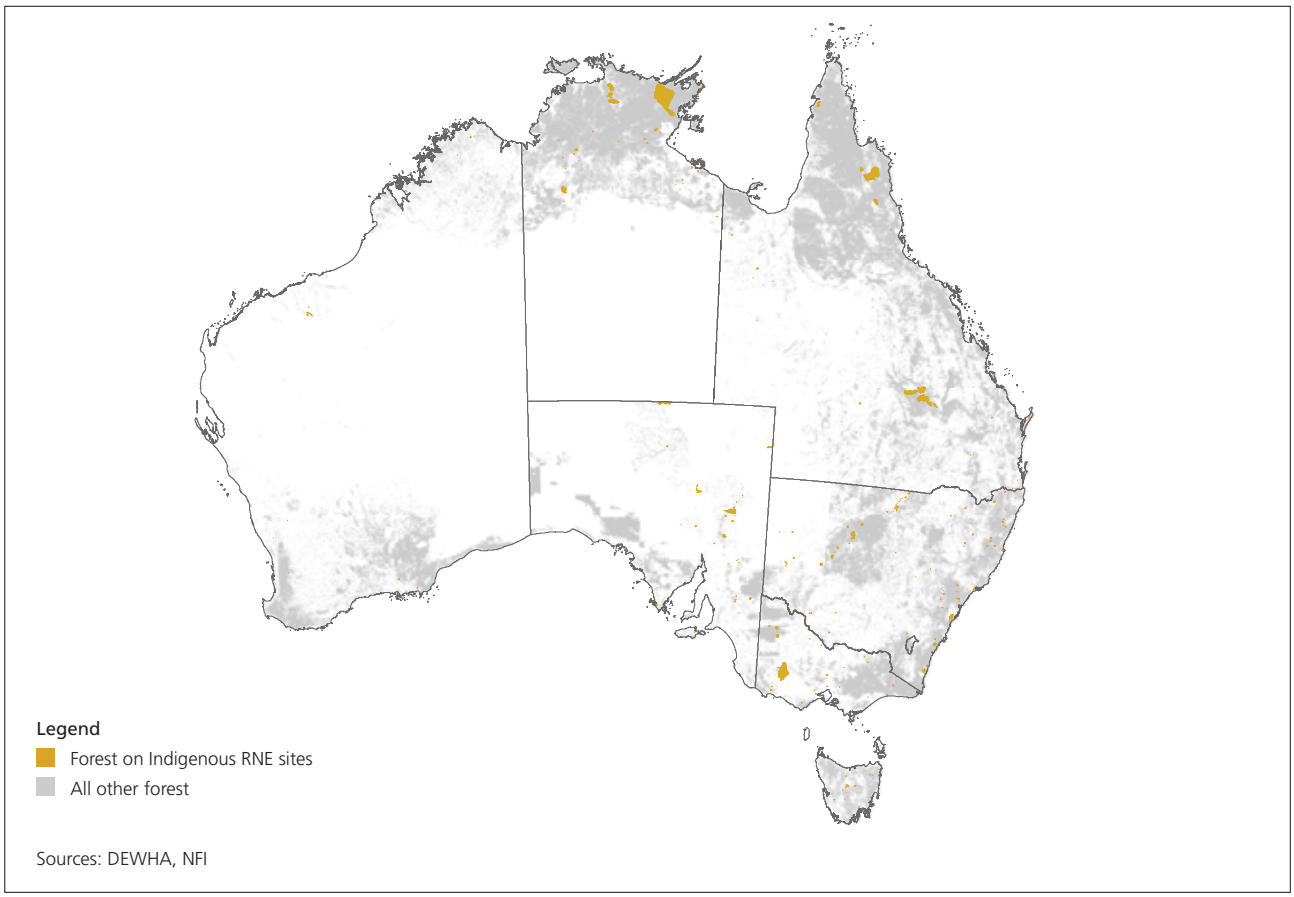


Table 96: Area of forest and non-forest land under Indigenous ownership ('000 hectares)

Forest type	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Total
Acacia	–	30	195	211	–	–	–	227	663
Callitris	–	2	315	3	3	–	–	–	323
Casuarina	–	1	73	1	–	–	–	2	77
Eucalypt	–	159	13,492	2,638	279	4	4	1,331	17,908
Eucalypt low closed	–	–	9	–	–	–	–	3	11
Eucalypt low open	–	–	462	80	–	–	–	6	548
Eucalypt low woodland	–	–	2,362	86	43	–	–	505	2,996
Eucalypt mallee open	–	–	–	–	31	–	–	–	31
Eucalypt mallee woodland	–	–	–	–	192	–	–	6	199
Eucalypt medium closed	–	–	55	1	–	–	–	11	67
Eucalypt medium open	–	132	4,395	137	–	–	3	90	4,757
Eucalypt medium woodland	–	13	6,209	2,335	12	4	1	711	9,287
Eucalypt tall closed	–	–	–	–	–	–	–	–	–
Eucalypt tall open	–	12	–	–	–	–	–	–	12
Eucalypt tall woodland	–	–	–	–	–	–	–	–	–
Mangrove	–	–	237	82	–	–	–	22	342
Melaleuca	–	1	724	257	–	–	–	–	982
Rainforest	–	1	254	132	–	–	–	2	389
Other	–	4	51	49	1	–	–	60	165
Subtotal native forest	–	*197*	*15,342*	*3,374*	*283*	*4*	*4*	*1,645*	*20,848*
Plantation hardwood	–	–	14	2	–	–	–	–	17
Plantation softwood	–	–	1	–	–	–	–	1	2
Plantation mixed or unknown species	–	–	–	–	–	–	–	–	–
No data	–	3	31,573	5	10	–	–	56	31,647
Non-forest land	–	243	13,598	1,470	20,044	58	6	34,591	70,010
Total Indigenous land	–	443	60,528	4,851	20,337	63	11	36,292	122,524

Note: Totals may not tally due to rounding.

Source: NFI

The ILC and the Indigenous Land Fund were established in recognition of the likelihood that many Indigenous people will not be able to prove native title to land under the *Native Title Act 1993* (Cwlth). The ILC came into existence on 1 June 1995 with the commencement of the *Land Fund and Indigenous Land Corporation (ATSIC Amendment) Act 1995* (Cwlth). The aim of the corporation's land acquisition and land management program is to deliver environmental, cultural, economic and social benefits to Indigenous people.

All jurisdictions have in place legislative protection for significant Indigenous heritage and additional protection under codes of practice and other procedures that support the discovery and management of Indigenous heritage sites in forests. Where land acquisition and management are not possible, other legislative and administrative arrangements must provide the means for Indigenous interests to identify the attributes they wish to protect and to strongly influence land use and management practice. Among the most significant of those arrangements are the various heritage protection mechanisms employed by governments.

Indigenous places on the Australian Government's Register of the National Estate, the National Heritage List and the Commonwealth Heritage List are subject to the provisions of the Environment Protection and Biodiversity Conservation Act (although the status of the Register of the National Estate is changing – Indicator 1.1c). The Minister for the Environment, Heritage and the Arts is required to consider these lists when making certain decisions under the Act. Proposals for actions that could affect such values are assessed by relevant government agencies.

Australia-wide, 2.6 million hectares of land is listed on the Register of the National Estate for its Indigenous values; of that area, 1.6 million hectares is forested (Table 97). Such areas are mostly outside the major timber production forests (Figure 83).

State and territory legislation, codes of practice and management prescriptions govern the management of Indigenous places in forests, and cover many places not included on the Register of the National Estate. Case studies 46 and 47 (also Case study 48 on the SOFR website) illustrate the commitment of state governments to the protection of Indigenous cultural values and the involvement of Indigenous people in forest management.

Web resources

Case study 48: Tasmania

Table 97: Area of land and forest on the Register of the National Estate for Indigenous values ('000 hectares)

Forest type	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Total
Acacia	–	8	–	25	–	–	1	–	34
Callitris	–	2	73	5	3	–	20	–	101
Casuarina	–	6	8	–	2	–	1	–	18
Eucalypt	–	74	557	383	47	2	133	4	1,199
Eucalypt low closed	–	–	1	–	–	–	–	–	1
Eucalypt low open	–	–	19	43	–	–	–	–	62
Eucalypt low woodland	–	1	16	12	24	–	–	3	56
Eucalypt mallee open	–	–	–	–	1	–	–	–	1
Eucalypt mallee woodland	–	–	–	–	14	–	1	1	16
Eucalypt medium closed	–	–	1	–	–	–	–	–	1
Eucalypt medium open	–	43	261	34	–	–	50	–	389
Eucalypt medium woodland	–	25	259	286	7	1	80	–	658
Eucalypt tall closed	–	–	–	–	–	–	–	–	–
Eucalypt tall open	–	4	–	9	–	–	–	–	14
Eucalypt tall woodland	–	–	–	–	–	–	–	–	–
Mangrove	–	–	2	5	–	–	–	–	8
Melaleuca	–	–	123	15	–	–	3	–	142
Rainforest	–	1	27	10	–	–	–	–	38
Other	–	5	–	14	–	–	15	–	35
Subtotal native forest	–	*96*	*790*	*458*	*51*	*2*	*173*	*4*	*1,574*
Plantation hardwood	–	–	–	–	–	–	–	–	–
Plantation softwood	–	–	–	–	–	–	–	–	–
Plantation mixed or unknown species	–	–	–	–	–	–	–	–	–
No data	–	3	179	–	9	–	–	–	191
Non-forest	–	74	80	173	293	14	28	171	834
Total	–	173	1,048	631	353	16	202	175	2,599

Note: Totals may not tally due to rounding.

Source: NFI

Case study 46: New South Wales

In New South Wales, about 400,000 hectares of land managed by the Department of Environment and Climate Change is set aside as Indigenous-owned reserves or places managed under memorandums of understanding or other forms of agreement between government and Indigenous community groups, including co-management or other arrangements to maintain or enhance Indigenous cultural connection to land, objects and places (Table 98).

In multiple-use public forests, the Anaiwan Traditional Owner Group (New England area), the Bahtoo Aboriginal Corporation (Taree area), the Eden Local Aboriginal Land Council (south coast) and the Darkinjung Local Aboriginal Land Council (central coast) all have formal arrangements with Forests NSW.

Entry into such agreements is usually initiated by an Indigenous community with the aim of increasing the involvement of the community in cultural management or to engage in cultural practice, thereby fulfilling cultural obligations and needs. Forests NSW also works with Indigenous groups to develop memorandums of understanding, under which approaches to further joint interests are identified and undertaken.

To protect Indigenous places in multiple-use public forests, Forests NSW consults Indigenous representatives at both the regional level and operational levels. Pre-operational field inspection identifies sites and places of importance or interest to Indigenous people, who assist in the identification of prescriptions that are appropriate for protecting those values. The operational *Guidelines for Aboriginal Cultural Heritage Management* identify processes for consultation and the management of Indigenous cultural heritage. An Indigenous cultural awareness program has given Forests NSW staff increased awareness and appreciation of Indigenous values and helped to improve communication between the agency and local Indigenous communities.

Source: Forests NSW

Table 98: Area of DECC-managed lands formally managed to protect Indigenous values

Tenure category	Hectares	Proportion of DECC-managed lands (%)
Sites gazetted for their Indigenous values	563	0.1
Indigenous-owned reserves	96,626	21.0
Indigenous areas	12,349	2.7
Indigenous land-use agreements	186	0.0
Memorandums of understanding	286,405	62.0
Declared Aboriginal Places (based on total gazetted area)[a]	5,306	1.2
Total	401,435	87.0

DECC = Department of Environment and Climate Change (NSW)

a Some of these areas may overlap with non-parks and Wildlife Division-managed lands.

Note: Totals may not tally due to rounding.

Source: DECC

Case study 47: Western Australia

The *Aboriginal Heritage Act 1972* (WA) provides protection for Indigenous objects and places of significance across all land tenures in the state. The Act provides for the protection of Aboriginal cultural material from damage resulting from forest management activities.

The Department of Environment and Conservation (DEC) recognises the importance of Indigenous participation in nature conservation and land management. It continues to develop an approach to achieve an adequate recognition of the importance of land to Indigenous cultural heritage and to consider matters of cultural importance in land and wildlife management. DEC also works towards joint management arrangements between Indigenous and non-Indigenous Australians to achieve sustainable conservation outcomes throughout Western Australia, both on and off the DEC-managed estate. DEC consults with Indigenous stakeholder groups for various levels of land management planning, including high-level area management planning (such as for conservation reserves) and local management planning (such as special proposals for disturbance activities).

Consultation with key Indigenous stakeholders is undertaken for all area management plans, including forest management plans. The Forest Management Plan 2004–13, which covers all the main timber production areas in the state's southwest, commits the department to a number of actions to involve Indigenous people in the identification, interpretation, protection and management of significant cultural heritage sites within the forest management plan area. These actions include the establishment of a formal Nyoongar consultative working group to advise on issues relating to Indigenous heritage, identifying Nyoongar women and men with authority and knowledge relating to Indigenous cultural heritage in the area and providing for their involvement in the management of the forest, and facilitating cross-cultural awareness and interpretive activities to inform and educate the wider community about Indigenous culture.

At the local scale, DEC engages local Indigenous representatives when forest management activities occurring on land managed by the department are likely to cause significant disturbance to Indigenous cultural heritage. In circumstances that necessitate the disturbance of a registered Indigenous site, appropriate ministerial consent is required; the proponent must apply to the state Aboriginal Cultural Heritage Materials Committee for approval to undertake the activity in the vicinity of the registered site.

Source: DEC (WA)

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 people's values associated with forests.

Key points

- About 485,000 hectares of nationally listed, non-Indigenous historic or cultural heritage places in forests are protected under the provisions of the Environment Protection and Biodiversity Conservation (EPBC) Act.
- The states and territories are responsible for protecting thousands of additional sites within their jurisdictions in accordance with their respective heritage management and protection legislation.
- State and territory governments maintain legislative provisions that provide for the notification of new sites on public land.

Australia's forests include many sites that provide evidence of the complex interactions between people and forest landscapes and the activities that have taken place on the continent since European settlement. A wide variety of sites, features, structures and landscapes may have cultural value at a local, regional, state or national level, including places associated with people and settlers; pastoral–agricultural settlement; exploration and survey; telecommunications; forestry and timber production; mining; and social activities. Significant features can also include graves and cemeteries; railways and tramways; travel routes; recreation sites; and natural places of aesthetic value.

Places of outstanding national heritage significance, including historic places, on the Australian Government's Register of the National Estate, National Heritage List and Commonwealth Heritage List are subject to the provisions of the EPBC Act (although the status of the Register of the National Estate is changing – Indicator 1.1c). The Minister for the Environment, Heritage and the Arts is required to consider these lists when making certain decisions under the Act. Proposals for actions that could affect such values are assessed by relevant government agencies.

National Estate places listed for their historic values cover more than 862,000 hectares, of which 485,000 hectares is forest land; most is in the drier woodlands and open forests (Table 99). Figure 17 in Indicator 1.1c shows forest areas listed on the Register of the National Estate.

States and territories have legislation and operational procedures (including codes of practice) for the protection of non-Indigenous heritage places; they usually require the notification of newly discovered sites in multiple-use and conservation forests and maintain site registers. A large number of sites are protected on public land. Examples include the following:

- Around 4,000 listings of places are managed formally for non-Indigenous cultural heritage in Victoria's public forests (Case study 49).
- 3,804 places of non-Indigenous cultural heritage in nature conservation reserves are formally managed to protect cultural values in New South Wales.[8] There are an additional 689 sites in multiple-use public forest.
- Around 883 places of non-Indigenous cultural heritage have been identified in Western Australia's southwest forest region.
- 1,400 sites in multiple-use forests are specifically managed to protect non-Indigenous cultural heritage in Tasmania in 'special management zones'. The area of special management zones and areas of Indigenous cultural heritage, combined, exceeds 49,000 hectares (Case study 50 on the SOFR website).

8 This figure is derived from a count of sites that have been assigned one or more specific non-Indigenous cultural heritage themes. Many recognised sites have not been assigned themes and are therefore not included.

Table 99: Register of National Estate non-Indigenous places in forests

Forest type	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Total
Acacia	–	–	–	–	–	–	–	–	1
Callitris	–	–	–	–	–	–	–	–	–
Casuarina	–	–	–	–	–	–	–	–	–
Eucalypt	2	360	57	2	5	34	19	1	480
Eucalypt low closed	–	–	–	–	–	–	–	–	–
Eucalypt low open	–	1	–	1	–	–	–	–	2
Eucalypt low woodland	–	95	41	–	–	–	–	–	136
Eucalypt mallee open	–	–	–	–	–	–	–	–	–
Eucalypt mallee woodland	–	–	–	–	4	–	–	–	4
Eucalypt medium closed	–	–	–	–	–	–	–	–	–
Eucalypt medium open	–	191	–	–	–	–	14	–	206
Eucalypt medium woodland	1	8	16	1	–	19	3	1	49
Eucalypt tall closed	–	–	–	–	–	–	–	–	–
Eucalypt tall open	–	66	–	–	–	15	2	–	82
Eucalypt tall woodland	–	–	–	–	–	–	–	–	1
Mangrove	–	–	–	–	–	–	–	–	–
Melaleuca	–	–	2	–	–	–	–	–	3
Rainforest	–	–	–	–	–	–	–	–	1
Other	–	–	–	–	–	–	–	–	–
Subtotal native forest	*2*	*361*	*59*	*3*	*5*	*35*	*20*	*1*	*485*
Plantation hardwood	–	–	–	–	–	1	–	–	1
Plantation softwood	–	–	–	–	–	1	–	–	1
Plantation mixed or unknown species	–	–	–	–	–	–	–	–	–
No data	5	7	6	–	7	1	1	–	27
Non-forest	–	123	31	4	84	90	9	8	349
Total	7	491	96	7	96	127	30	9	862

Note: Totals may not tally due to rounding.

Sources: Australian Government Department of the Environment, Water, Heritage and the Arts; NFI for forest areas

Sites on leasehold and other state lands, and on freehold tenure, might not be formally protected unless listed on the relevant state/territory heritage register.

Legislative protections are particularly important in those states with significant harvesting for wood production in public forests. Victoria, New South Wales, Queensland, Tasmania and Western Australia all conduct inspections or surveys of heritage places in multiple-use public forest before allowing timber harvesting operations to proceed, and carry out targeted and/or comprehensive cultural heritage place surveys and heritage studies. The purpose, definitions, criteria and methods used to identify and record heritage places vary by jurisdiction according to statutory responsibilities and management practices. All jurisdictions endeavour to manage the effects of threatening processes such as fire, development, timber harvesting and road building in heritage places. However, as shown by the 2003 wildfires, which destroyed several historic huts in the Australian Alps, there are limits to the protection that can be provided against fire under extreme conditions.

Web resources

Case study 50: Tasmania's approach to cultural heritage in forests

Early 20th century timber cutters' hut near Launceston, Tasmania.

Case study 49: Victoria's approach to cultural heritage in forests

Under the Victorian *Heritage Act 1995*, it is an offence to damage or disturb archaeological sites or relics unless consent has been obtained from Heritage Victoria. All known archaeological sites are listed on the Victorian Heritage Inventory, and places deemed to be of statewide significance are listed on the Victorian Heritage Register.

Places listed on the Victorian Heritage Inventory cannot be removed, demolished, despoiled, developed, altered or excavated without a permit from the Victorian Heritage Council, while Victorian Heritage Register listing provides the highest level of protection. There are almost 200 reserves in Victoria for which the primary land use is the protection of historic and cultural features.

Historic places, including those in forests, are managed in accordance with the principles of the Burra Charter. The charter is used by Australia ICOMOS (International Council on Monuments and Sites) to set a standard of practice for those who provide advice on, make decisions about, or undertake works in places of cultural significance, including owners, managers and custodians. In multiple-use public (state) forest, known historic places are listed in forest management plans or regional inventories. In many forest management areas, specific management actions are prescribed for each site to protect it from potentially damaging forest operations. Significant sites are protected by forest management prescriptions or heritage management plans.

As a consequence of survey programs, the state's historic places database has over 8,000 records, covering all Victorian public land under the control of the Department of Sustainability and Environment; almost half the records relate to historic places in forests (Table 100). New sites are added to the database mainly as a result of opportunistic field surveys.

Table 100: Places of non-Indigenous cultural heritage in forests formally managed to protect cultural values, Victoria

Culturally significant themes	Number of places recognised at state level	Number of places recognised at local level	Number of places to be assessed or not significant
Developing local, regional and national economies[a]	139	877	538
Settlements, towns and cities[a]	7	84	63
Educating[a]	1	10	7
Governing[a]	1	6	1
Australia's cultural life[a]	3	16	21
Marking the phases of life[a]	3	46	9
Historic places[b]	236	2,400	

a Applies to all public forested land except that managed by Parks Victoria.

b Clumped for all public land and assets managed by Parks Victoria. Asset types known not to occur on forested land (e.g. piers, shipwrecks) are excluded.

Source: Department of Sustainability and Environment (Vic.)

Historic place, the first Conservator's hut, Bundaleer, South Australia.

Remains of tram tracks used for transporting logs in the early 20th century, Tasmania.

Indicator 6.4c

The extent to which Indigenous values are protected, maintained and enhanced through Indigenous participation in forest management

Rationale

This indicator focuses on the extent to which Indigenous people participate in forest management. Active participation in management reflects the relationship between people and the land, and the integration of Indigenous people's values with forest management practice, policy and decision making.

Key points

- Mechanisms now exist to facilitate Indigenous participation in the forest sector and to provide economic benefit to Indigenous communities.
- Greater numbers of Indigenous people are now employed in the government agencies responsible for nature conservation and commercial timber production, and there is also a greater presence of Indigenous people in natural resource management committees and other forest stakeholder forums.
- Both planted and natural forests are increasingly valued by Indigenous people for their ability to contribute to economic independence.

Indigenous consultation in forest management, Northern Territory.

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 the forests.

In the past, the forest sector has tended to deal with Indigenous issues mostly in terms of archaeological 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 movements for social justice and land rights. Moreover, greater numbers of Indigenous people are now employed in the government agencies responsible for nature conservation and commercial timber production, and there is also a greater presence of Indigenous people in natural resource management committees and other forest-stakeholder forums.

Indigenous values

Indigenous values can be divided into three broad but not mutually exclusive categories: heritage, contemporary and aspirational.

Heritage values are associated with Indigenous history and are important for connecting people with the landscape and the past. Examples of features with heritage value include the following:

- **Archaeological sites**. These provide tangible evidence of prior Indigenous presence. Most states protect archaeological sites by statute and maintain databases on them.
- **Natural landscape features associated with dreaming/ creation stories**. Information on these is 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 discretionary basis according to customary laws.

Indigenous people also value forests for contemporary reasons, including the following:

- **A landscape of reconciliation and empowerment**. For example, logging on the sacred mountains of Mumbulla and Gulaga on the south coast of New South Wales was halted as a result of Indigenous protests in 1979 and 1990.
- **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.
- **Natural areas where Indigenous cultural values can be protected**.

Both planted and natural forests are also increasingly valued by Indigenous people for their ability to contribute to economic independence.

Forests may also have aspirational value for Indigenous people. Most native forests are in public ownership, under which native title rights and interests may prevail; they can therefore potentially contribute to inter-generational equity. Forests are valued as areas in which Indigenous people can gain greater autonomy and economic returns through a range of mechanisms, including ownership.

Indigenous participation

Accurate data on Indigenous involvement in forest management are not readily available at a national level. However, a review of annual reports, equal employment opportunity data, forest codes of practice and forest management agency corporate plans in New South Wales, Queensland, Victoria and Western Australia suggests that Indigenous people participate more in native forest management, forest conservation and the use of non-wood forest products than in direct employment in industrial wood production and processing.

Effective consultation and participation are essential for the protection, maintenance and enhancement of Indigenous forest values. Various studies in the past 20 years have shown that Indigenous people want to participate more in the forest sector for two main reasons: to ensure that Indigenous values are protected, and for economic benefit.[9] Participation can occur through a variety of mechanisms, including:

- direct employment in the forest sector
- community employment schemes, such as Community Development Employment Projects program and projects funded by the Natural Heritage Trust
- forest management agencies' consultative processes, which can be ongoing or one-off and can vary in their effectiveness (e.g. face-to-face meetings in culturally appropriate places with adequate time for inter-community consultation are likely to be more effective than letters requesting responses with short turnaround times)
- cooperative research programs, such as forest surveys for endangered species (these are usually short term but can help build the land management capacity of Indigenous people and maintain good relationships between land management agencies and Indigenous organisations)
- partnerships, formal examples of which include the joint management of national parks; Indigenous land-use agreements (ILUAs), such as the Githabul ILUA; Indigenous protected areas; the 'Caring for Country' programs in the Northern Territory; Land and Sea Councils; local memorandums of understanding for hunting-and-gathering access, such as that between the Eden Local Aboriginal Land Council and Forests NSW, and cultural camps.

Indigenous people are also increasingly participating in forest management as:

- forest owners, such as the Arnhem Land and Tiwi Island communities
- owners of land on which plantations can be established (these are increasing in number)
- business operators, including for ecotourism, firewood collection, bush food and arts and crafts manufacture
- forest stewards (managing land on behalf of the Australian population).

Different kinds of participation have differing effects on the maintenance, protection and enhancement of Indigenous forest values. A process of consultation with elders about a forest management plan will provide information on those spiritual and cultural values about which the elders are able to speak publicly. On the other hand, Indigenous participation through direct employment in a sawmill or commercial plantation is less likely to be relevant to the protection of Indigenous forest values, especially if the employee is not from the local area. However, income generated from this type of participation may still contribute to protecting Indigenous forest values by increasing the ability of a family or community to engage in such protection.

Examples of participation that helps protect cultural values and allows for economic development include plantation-related work near Esperance and heritage surveys in multiple-use forests in New South Wales (Case study 51).

9 For example, BDO Consulting (SA) Pty Ltd (2004), Black et al (2003), Brooks et al (2001), Buchy and Hoverman (1999), Cane (1990).

References and further reading

BDO Consulting (SA) Pty Ltd (2004), Black et al (2003), Brooks et al (2001), Buchy and Hoverman (1999), Cane (1990), English (2004), Feary (1988) (list at the back of the report).

Case study 51: Indigenous employment and business

A plantation company in Western Australia contracts the Esperance Aboriginal Corporation to perform land management tasks, such as weeding, fencing and erecting signs, in research plots of planted blue gums. The corporation has limited machinery and equipment and so cannot carry out some of the more mechanised or technical components of plantation management. This is an example of participation for economic purposes, but it also has indirect non-economic benefits because it builds the capacity of the Indigenous people involved and the status of the Indigenous community as a whole in the regional economy. The Esperance Aboriginal Corporation administers the contract, and the wages contribute to the social and economic wellbeing of workers and their extended families.

The Eden Local Aboriginal Land Council in southern New South Wales runs a business that conducts heritage surveys of crown timber production forests before logging. Forests NSW uses this service on a fairly regular basis, and other government agencies and some private companies also require similar forest-based surveys from time to time. The business builds on good local relations between Forests NSW and the land council. Its ongoing viability depends on a number of factors, including the long-term future of timber harvesting in the region.

Source: S Feary, PhD candidate, Australian National University, pers comm, May 2007

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

- Many forest issues are of national importance and have played a role in recent national and state political debate, as the community seeks biodiversity conservation and the provision of environmental services from forests.
- Regional forest agreements are an attempt to find the balance between social, economic and environmental forest values in some forests.
- The expansion of the plantation estate and the proposed development of new wood processing infrastructure have potentially significant employment benefits but are also accompanied by community concerns about their social and environmental impacts.

Surveys have been used to identify community attitudes to timber-harvesting methods and non-industrial forest uses, such as tourism and conservation.[10] However, there is a general lack of data about such attitudes, and the research methods used have not been uniform. Many forest issues are of national importance and have played a role in recent political debate.

The regional forest agreements (RFAs) struck in the period from 1997 to 2001 between the Australian Government and several state governments were an attempt to find a balance between social, economic and environmental forest values. Since then, most jurisdictions have continued to assess the role of multiple-use public forests and forests in nature conservation reserves; overall, the area of forest within the latter has increased at the expense of the former (changes in forest tenure are discussed in Indicator 1.1a).

A recently completed study sought to identify attitudes to forest management practices, such as clearfelling in Tasmania's eucalypt forests.[11] Researchers used visual aids and psychological theory to link the values held by respondents with their knowledge of the kinds of management practices used in harvesting. The study found that the public acceptability of forest harvesting tended to increase as the proportion of forest excluded from harvesting increased.

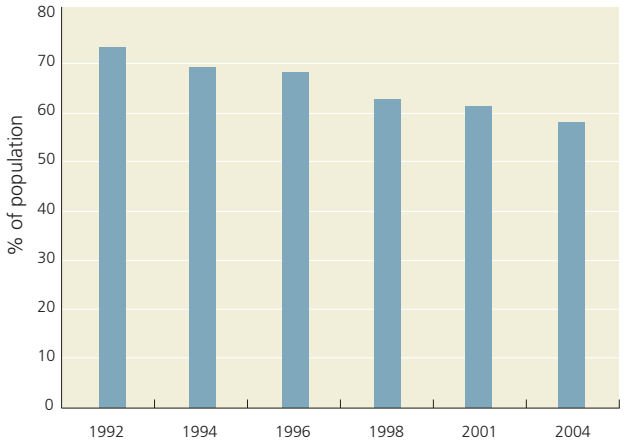
Many forest issues are of national importance and have played a role in recent national and state political debate, as the community seeks biodiversity conservation and the provision of environmental services from forests.

Since the 1990s, there has been a rapid increase in the commercial timber plantation estate, with a subsequent change in the aesthetic values of the landscape, the incidence of heavy traffic on rural roads, and the delivery of economic and environmental benefits. Moreover, water use by plantations and wood processing facilities has become the focus of attention in some communities.

10 The importance of forests to people can be measured in a number of ways, including with visual prompts to observe public reaction to a range of forest management practices. Another method uses survey techniques to identify the importance that people place on forest use, which might be:
- **non-consumptive**: the value of forest areas gained from their existence (e.g. viewing nature films or enjoyment of the recreational and aesthetic value of an area and contact with nature)
- **consumptive**: the value of forest areas gained from the use of the resource for human benefit (e.g. timber harvesting).

11 Ford et al (2004).

Figure 84: Level of public concern about environmental issues, 1992 to 2004



Source: ABS (2004a)

Substantial research was undertaken during the reporting period into the socioeconomic impacts of forest plantations in rural Australia.[12] It identified three overlapping phases of plantation development:

- In the *establishment* phase, when new plantations are being planned and established, some previous landowners may leave the region, and jobs are created in nursery, planting and field management enterprises. Beneficiaries during this phase include machinery suppliers and contractors, suppliers of materials such as chemicals and fertilisers, and providers of services that apply these inputs in the field.
- In the *transition* phase, further employment opportunities are generated by the commencement of harvesting and processing and, often, the continued expansion of the plantation estate and the development of processing facilities. Total employment per unit area of plantation usually increases rapidly.
- During the *mature* phase, the processing of plantation wood provides most of the employment generated by the sector. The extent of local and regional employment therefore depends on the location of the processing facilities, although there is also ongoing employment in plantation management, harvesting and haulage and in the re-establishment of trees on harvested areas. Periodic upgrading and expansion of facilities provide additional jobs. Once the plantation estate reaches the mature phase, the employment it generates per unit area is higher than for cropping, sheep or beef-cattle enterprises.

Despite the significant employment benefits provided by forest industries, communities may be divided over social issues and environmental effects associated with the establishment of large processing infrastructure, such as pulp mills. In recent years, particular concern has been expressed over possible air and water pollution produced by pulp mills proposed in northern Tasmania and southeastern South Australia, as well as over impacts on local transport, tourism and water consumption.

People's general concern for the environment might be another way of gauging the importance of forests to them. According to the ABS, there was a gradual decline in public concern about environmental issues in all jurisdictions between 1992 and 2004 (Figure 84). However, the decline may have reversed recently because of concerns about water supply, drought, climate change and wildfire. For example, results from a recent survey of community attitudes in New South Wales suggest that such issues are significant in that state.[13]

References and further reading

ABS (2004a), DEC NSW (2007), Ford et al (2004), Schirmer et al (2005ab), Williams (2002), Williams et al (2001b), Williams et al (2005), Winter (2005) (list at the back of the report).

Public field day, discussion of the management of Leadbeater's possum.

12 Schirmer et al (2005ab).

13 DEC NSW (2007).

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

- The forest-growing and wood product sectors employ many people in regional areas.
- Total national employment in businesses dependent on growing and using timber in 2006 was estimated to be about 120,000 people.
- Total direct employment in forest sector employment increased marginally between 2001–02 and 2006–07, from 82,800 to 83,400 full-time equivalents, although the proportion of the Australian workforce employed in the sector declined from 0.91% to 0.82%.
- While there are limited national data on indirect employment, it has been estimated that each direct job in the plantation forest industry in Western Australia's Great Southern region produces 0.7 indirect jobs.
- The non-wood forest product and forest contact industries generate considerable direct and indirect employment in some regional communities.

The 'forest sector' category encompasses several subsectors reliant on forests – primarily forest growing and wood product industries, non-wood forest product industries (e.g. beekeeping, grazing) and forest contact industries (e.g. tourism, park management). Direct employment data for the forest growing and wood product industries are collected as part of the national statistical collection system. National data are less readily available for employment directly attributed to the non-wood forest product or forest contact industries; instead, state and territory data are used here to analyse trends. The national-level data discussed in this indicator differ from those used in Indicators 6.5c and 6.5d, which are collated at a regional scale.

Employment in the forest growing and wood product industries

Data on employment in the forest growing and wood product industries are available from the ABS and the National Skills Company for the Forestry and Forest Products, Furnishing and Pulp & Paper Industries Ltd (ForestWorks). The Australian Bureau of Statistics' (ABS) labour force survey data include several categories within the forest-growing and wood product industries. The labour force survey is updated annually and a long-term trend is available. Forestworks initiated a survey for the Forest and Wood Products Research and Development Corporation in 2003. That survey covers a wider range of businesses dependent on growing and using timber than does the ABS data and is updated periodically.

The ABS labour force categories relevant to the forest-growing and wood product industries are 'forestry and logging' and 'wood manufacturing', the latter including the three subsectors of 'log sawmilling and timber dressing', 'paper and paper products', and 'other wood products'. Total direct employment in the four groupings combined increased marginally from 2001–02 to 2006–07, from 82,800 to 83,400 full-time equivalents (Figure 85). Total Australian employment increased by 11% in the period, so the proportion employed in the four groupings declined from 0.91% to 0.82%.

Table 101 shows estimates of the numbers of people employed in each major industry sector derived from the ForestWorks survey. The numbers employed in each state and territory are shown in Table 102.

Figure 85: Direct employment in ABS forest-growing and wood product industry sectors, 2001–02 to 2006–07

Note: Annual employment data is the average of monthly survey data.
Source: ABARE (2007)

Non-wood forest product and forest contact industries

Direct employment in the non-wood forest product and forest contact industries comprises jobs in beekeeping, grazing, forest reserve management, ecotourism, fishing and hunting, recreation, extractives (e.g. gravel and stone), mineral exploration, mining and water production. Several of these, such as forest-based tourism and recreation, are known to provide significant levels of employment in some regions, but few data are available at the national level. Table 103 shows direct employment related to the non-wood forest product and forest contact industries in Forests NSW and the South Australian Department for Environment and Heritage and ForestrySA for 2001–02 and 2005–06.

Indirect employment

Indirect employment is employment in other sectors that is generated from direct employment in the sectors of interest. Indirect employment might be in wholesale and retail trade; legal, 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, and technical and computer support; government administration; and media services. SOFR 2003 provided indications of the multiplier effects of forest production; no additional information was available for this report, beyond some regional reviews (e.g. Case study 52).

Since indirect employment covers such a broad range of occupations, data are not collected routinely on a national basis and vary with industry development drivers; for example, the impacts of indirect employment in plantations are likely to be more pronounced at the maturation and harvesting stage. Case studies 52 and 53 illustrate the regional impact of indirect forest employment.

Table 101: Estimated employment in forest-growing and wood product industry sector, 2006

Sector	No. of employees
Forest growing and management	7,348
Timber harvesting and haulage	8,973
Sawmilling and timber processing	19,081
Timber product manufacturing	37,800
Wood panel and board production	5,635
Pulp and paper manufacturing	11,024
Timber merchandising	22,134
Support service internal to industry	5,445
Support service external to industry	2,745
Total	120,184

Source: ForestWorks (2006)

Table 102: Estimated numbers of enterprises and employees in forest-growing and wood product industry sectors, 2006, by jurisdiction

	No. of businesses	No. of employees
ACT	105	1,563
NSW	2,511	38,328
NT	42	339
Qld	1,250	19,732
SA	634	12,999
Tas.	522	7,930
Vic.	1,875	32,154
WA	501	7,139
Total	7,440	120,184

Source: ForestWorks (2006)

Table 103: Direct employment related to the non-wood forest product and forest contact industries in some government agencies in New South Wales and South Australia, 2001–02 and 2005–06

	NSW		SA[a]	
	2001–02	2005–06	2001–02	2005–06
Forest management	1,146[b]	1,109[b]	302[c]	729
Recreation/tourism	36	36		
Apiary	397	294		
Firewood/fencing	169	110		
Grazing	119	420		
Miscellaneous plant products	15	12		
Volunteers (unpaid)			4,356	5,850
Various employment schemes	1	105		

a Department for Environment and Heritage (SA) and ForestrySA employees only, for employment related to the management of state-owned land covered by the *National Parks and Wildlife Act* and ForestrySA land.

b Forests NSW employees in publicly owned multiple-use forests only.

c Department for Environment and Heritage (SA) Conservation Management staff carry out land management activities such as firefighting, policy, regulatory, education, ancillary. Total includes forest policy, forest management/growing, regulatory, conservation research, conservation management, others (ForestrySA Corporate Services and Support).

Sources: State agencies

References and further reading

ABARE (2007), ABS (2006ab, 2007ab), ANZSIC (2006), FWPRDC (2003), Forestworks (2006), GTRPC (2006), Schirmer et al (2005ab) (list at the back of the report).

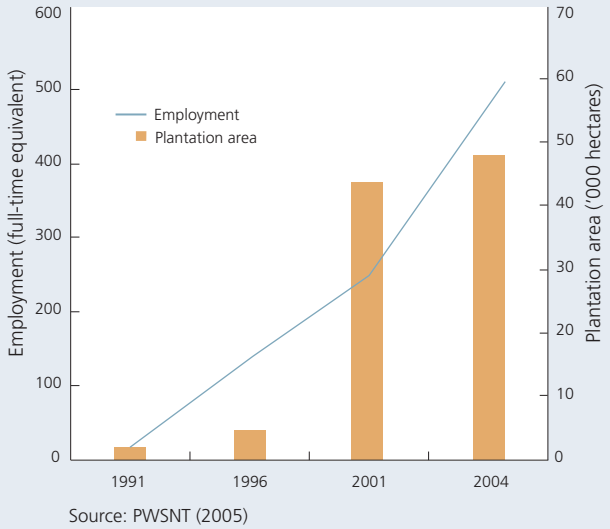
Case study 52: Employment in Western Australia's Great Southern region

The Great Southern region stretches from east of Bremer Bay on the south coast of Western Australia, north past Nyabing and Katanning, west beyond Kojonup and south to Denmark. The region's forest plantations increased from 6,150 hectares in 1991 to 127,500 hectares in 2001. Employment in the sector has grown rapidly since harvesting began in 2001, almost doubling from 263 employees in 2001 to 500 in 2004. Plantation harvesting and processing have also supported the expansion of local contracting businesses in the region.

Based on recent studies, it is estimated that 17 jobs are created for every $1 million spent in the forest industry. In addition, each direct job produces 0.7 indirect jobs in the region, as well as employment outside the region when goods and services are imported from elsewhere. The region generally experienced either rural population growth or reduced rates of rural population decline between 1991 and 2004 due to the expansion of the plantation estate (Figure 86). The supply of local independent employment in the forest sector and the integration of plantations with multiple forms of land use have contributed to a diverse economic base that has helped stabilise the population and improved prospects for long-term economic growth in the region.

Source: Schirmer et al (2005b)

Figure 86: Forest-sector employment and plantation area in the Great Southern region, 1991 to 2004



Source: PWSNT (2005)

Case study 53: Employment in the Green Triangle

The Green Triangle straddles the border between southeastern South Australia and southwestern Victoria (Figure 87). It is a major plantation region, containing around 20% of the nation's plantation estate – almost 300,000 hectares of radiata pine (*Pinus radiata*) and 150,000 hectares of blue gum (*Eucalyptus globulus*). The forestry and wood processing sector directly and indirectly employs around 8,760 people, about 12% of total employment in the region. In 2003–04, the forestry and wood processing industries contributed more than $778 million to the region.

The forestry sector actively promotes opportunities for skills and training development through a vocational education and training program for secondary school students and a four-year forestry degree at the Mount Gambier campus of Southern Cross University. Employment generated by the forest sector in the Green Triangle has increased the skills base of regional forest-dependent communities, which will help to sustain the forestry sector in the longer term.

Source: GTRPC (2006)

Figure 87: The Green Triangle in southeastern South Australia and southwestern Victoria

Indicator 6.5b

Wage rates and injury rates within the forest sector

Rationale

This indicator measures wage and injury rates in the forest sector. A sustainable industry will ensure high levels of workforce health and welfare and wage rates comparable with national averages for other occupations.

Key points

- Total wages and salaries in the wood and wood product industries increased from $2 billion to $3 billion between 2000–01 and 2004–05.
- The rate of injuries and fatalities per 1,000 employees in the wood and wood product manufacturing subsector declined from 48.9 to 37.2 between 2001–01 and 2002–03. No trend in this measure was evident in the forestry and logging subsector, although the number of compensated fatalities within this subsector dropped from seven in 2000–01 to two in 2002–03.
- Several organisations are working at state level to improve occupational health and safety standards in the wood and wood product sector, with promising results.

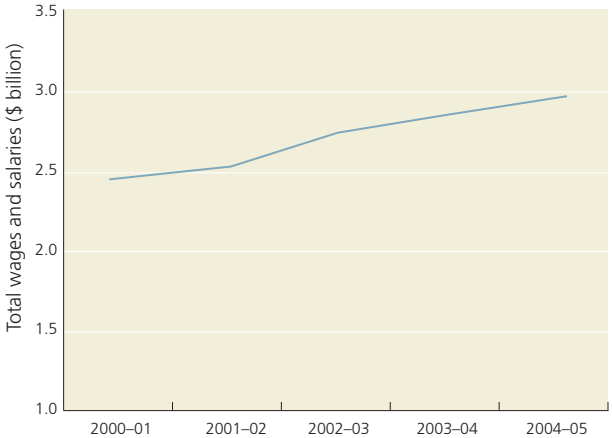
Loading pine logs.

This indicator focuses primarily on the wood and wood product sector, for which data are collected both nationally and by states.

Wage rates

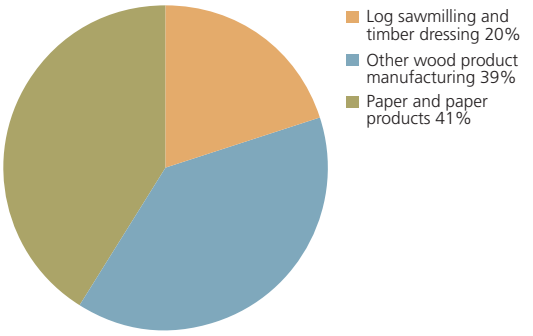
Total wages and salaries in the sector increased from about $2.5 billion to $3 billion over the period (Figure 88) due to general wage inflation, an increased emphasis within the sector on positions requiring greater levels of skill (and therefore attracting high wages), and a possible reduction of less skilled positions. Figure 89 shows that the 'paper and paper products' and 'other wood products' subsectors provided the bulk of total wages and salaries in 2004–05.

Figure 88: Wages and salaries in wood and wood product industries, 2000–01 to 2004–05



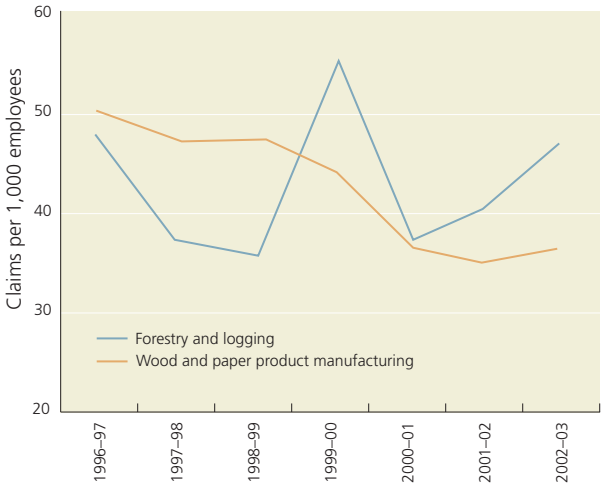
Sources: ABARE (2006), ABS (2006b)

Figure 89: Wages and salaries in different classes of wood and wood product industries, 2004–05



Sources: ABARE (2006), ABS (2006b)

Figure 90: Notified fatal and non-fatal compensated claims per 1,000 workers, 1996–97 to 2002–03



Source: Australian Safety and Compensation Council (2006)

Injury rates

Injury and fatality rates reflect occupational health and safety standards as well as the level of danger inherent in the industry. The number of compensated fatalities in the forestry and logging subsector fell from seven in 2000–01 to two in 2002–03 (Table 104); there were five fatalities in the forestry and logging sector and the wood manufacturing sector combined in 2002–03, compared to eight in 2000–01 and twelve in 1996–97. However, given the overall very low numbers of compensated fatalities in the sector it is difficult to discern a trend.

The number of notified fatal and nonfatal compensated claims can be expressed as a rate per 1,000 workers in a given employment class (incidence rate, Table 104), thereby allowing comparisons between datasets. The incidence rate in the wood manufacturing sector declined from 48.9 to 37.2 claims per 1,000 employees between 1996–97 and 2002–03. Figure 90, which was derived from data in Table 104, shows that no clear trend was apparent in the forestry and logging sector over the same period.

Workforce health and welfare have significant secondary effects on expenditure in the forest sector. Employee health can affect individual income and can also affect national income through loss of workdays and the costs of insurance and staff replacements. The human and social assets held by the industry can be reduced by the loss of trained workers through workplace injuries or fatalities.

In 2002–03, the incidence rate for forestry and logging (47.4 claims per 1,000 employees) was higher than that for the combined grouping of agriculture, fishing and forestry (30.3 claims). The incidence rate for wood and paper product manufacturing (37.2 claims) was higher than that for all manufacturing industries (29.3 claims) in the same period.

Several groups are working within the wood and wood product sector to improve and update workplace safety measures. Education and training are primary mechanisms (Case studies 54 and 55). For example, attitudinal changes can be initiated by identifying barriers to the adoption of safety measures and proposing new methods to change the underlying attitudes of forest-industry participants.

Figure 91 shows that the injury frequency rate in Tasmania for the 'log sawmilling and timber dressing' and 'other wood product manufacturing' subsectors declined significantly

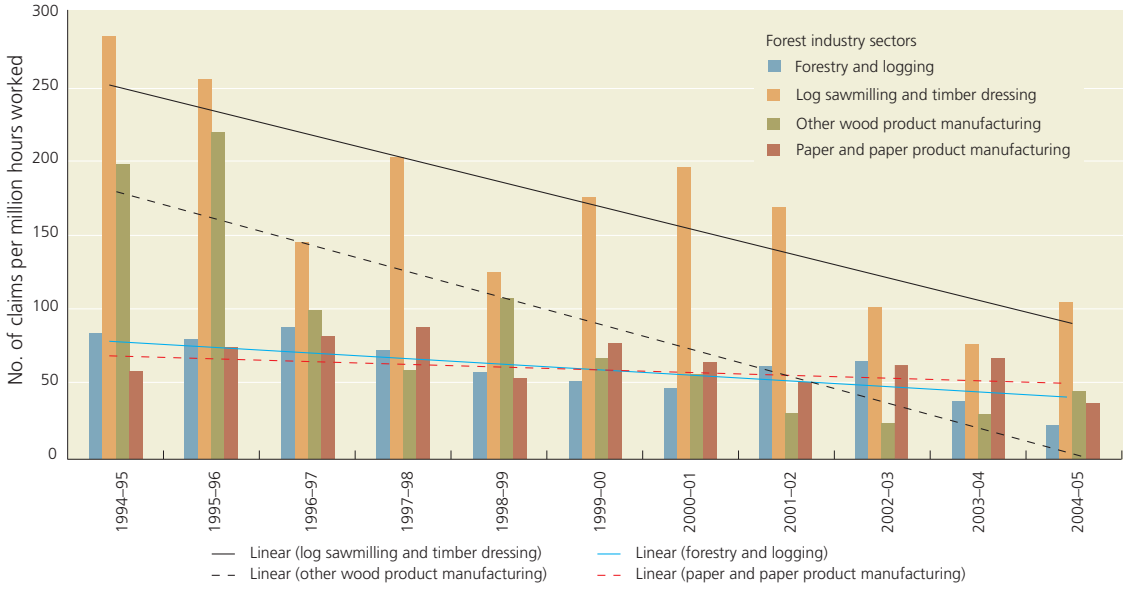
Table 104: Number of fatalities and number of notified fatal and non-fatal compensated claims per 1,000 workers (incidence rate), 1996–97 to 2002–03

Financial year	1996–97[a]	1997–98[a]	1998–99[a]	1999–2000	2000–01	2001–02	2002–03
Number of fatalities							
Forestry and logging	6	6	6	7	7	4	2
Wood manufacturing	6	5	3	5	1	6	3
Incidence rates for all fatal and non-fatal compensated claims (claims per 1,000 employees)							
Forestry and logging	46.9	34.7	33.4	56.2	37.3	40.2	47.4
Wood manufacturing	48.9	44.6	44.9	42.6	36.5	35.6	37.2

a Excludes ACT private sector.

Source: Australian Safety and Compensation Council (2006)

Figure 91: Injury frequency rates in Tasmania, 1994–95 to 2004–05



Source: WorkCover Tasmania

over the 11 years from 1994–95 to 2004–05; smaller declines also occurred in the 'forestry and logging' and 'paper and paper product manufacturing' subsectors.

The improvements in injury frequency rates in Tasmania may be due to a number of factors, including the emphasis placed on safety management by forestry companies; post-accident investigations leading to improved practices; awareness, promotional and enforcement activities relating to safety management by Workplace Standards Tasmania; and the increasing mechanisation of forest operations.

References and further reading

ABARE (2006), ABS (2006b), Australian Safety and Compensation Council (2005, 2006), Forests NSW (2006), GPF (2005), NLWRA and BRS (2005), Spencer (2005), WorkSafe Victoria (2007) (list at the back of the report).

Web resources

Case study 55: The 'Think safe, act safe, stay safe' campaign in New South Wales (including Figure 93)

Firefighting carries a higher degree of risk than most other forestry activities.

Safety helmets and high visibility vests are specified for all in-forest activities, including tree-marking.

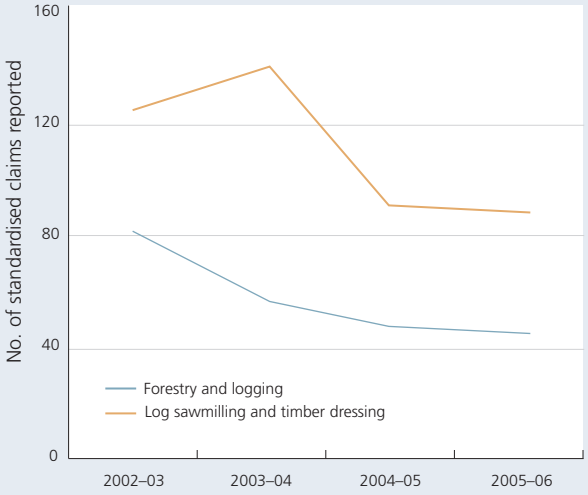
Case study 54: Forest Industry Occupational Health and Safety Stakeholder Forum – WorkSafe Victoria

WorkSafe Victoria established the Forest Industry Occupational Health and Safety Stakeholder Forum in October 2002 with the aim of identifying and prioritising occupational health and safety issues to achieve practical outcomes for Victoria's forest industry workers. Among other things, the forum produces guidelines to help improve occupational health and safety. These include *Fatigue Management in the Forest Industry*, *Manual Handling Solutions for the Sawmill Industry* and the *Safety in Forestry Operations (Harvesting and Haulage) Industry Standard*. The last of these, which was released in July 2007, uses a combination of illustrations, images and a traffic-light model to establish a benchmark and raise occupational health and safety standards for high-risk forestry operations.

Two new short courses specific to the Victorian forest industry have been developed in response to a review of the national training competency package. This initiative delivers presentations to the National Forest Industry Trainers Association and international forest industry conferences and also conducts compliance inspectorate visits to promote the uptake of occupational health and safety risk-control systems.

The forum is co-funded and co-owned by the industry. Together with the support of industry land managers, principal contractors and government agencies, it can effectively develop risk-control tools and increase the adoption of a systematic approach to occupational health and safety in the Victorian forest industry. The downward trend in injury rates in forestry and logging and log sawmilling and timber dressing in Victoria since the forum's inception (Figure 92) is therefore expected to continue.

Figure 92: Standardised claims reported, Victoria, 2002–03 to 2005–06, by industry sector



Source: WorkSafe Victoria (2007)

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 that they remain viable into the future.

Key points

- Dependence on the forestry industry as the primary source of employment has declined in some regions. Exceptions include areas of South Australia, East Gippsland in Victoria, and Tasmania.
- Populations in many forest-dependent regions are static or declining in line with a general trend in rural Australia, with the exceptions of Mount Gambier, Orbost, Oberon and Tumut, where populations have increased marginally. The number of working-age people is also declining in many regions.
- Areas near larger population centres, such as Mount Gambier, appear to have greater resilience than others because of their larger economic base, greater economic diversity and alternative employment opportunities.
- The growing investment in timber production and processing from plantations is becoming an increasingly important factor in forest-dependent communities.

Assessing the extent to which communities with high economic and social dependence on forests and forest-related industries can adapt to and manage change is a way of gauging forest management sustainability.

The focus of this indicator is on native and plantation wood production forests, which cover approximately 20% of Australia's total forest area. Data are sourced from the ABS censuses of population and housing for 1996 and 2001.[14] Because it uses relatively old census data, the analysis presented here does not capture significant recent changes that are known to have occurred in some regions, such as Tumut (New South Wales) and the Huon Valley and Smithton (Tasmania).

Regions with significant dependence on the Australian wood production and processing sector have been identified by statistical local area (SLA – a unit of aggregation used by the ABS; see Figure 94).[15] Table 105 presents data useful in assessing the dependence, vulnerability and resilience of those regions and the change in those factors between 1996 and 2001. The dependence of forest users outside the wood sector, such as harvesters of non-wood forest products, graziers, apiarists and tourism operators, and the indirect or flow-on employment generated by the demand for goods and services from the plantation industry, are less easily quantified and are not assessed here.

14 The results of the 2006 census were not available at the time of report preparation. Updated assessments of the social and economic conditions of forest-dependent communities based on the 2006 census are currently being prepared by BRS.

15 Using the ABS categories 'forestry and logging', 'forestry support services', and 'wood and paper product manufacturing'.

Australian forest industry communities

The sustainability of forest industry communities is a function of their dependence on the industry, their vulnerability and their resilience.

Dependence

Direct employment in the wood production and processing sector gives a good indication of a community's economic dependence on the forest industry. ABS data suggest the following:

- Dependence on the forestry industry as the primary means of employment has declined in some regions. Exceptions include areas of South Australia, East Gippsland in Victoria, and Tasmania.
- Declining employment can be attributed to broader rural population decline as well as to changes in the forestry sector, which include reduced native forest harvesting and labour requirements and the increased efficiency of plantation processing.

Vulnerability

The vulnerability of forest-dependent communities to change (e.g. in forest allocation and use) can be indicated by population size, age distribution and mobility:

- **Static or declining population**. This has occurred in most highly dependent SLAs, with the exception of Mount Gambier, Orbost, Oberon and Tumut, where populations increased marginally.
- **Declining working-age (15–64 years) population**. This has also occurred in most highly dependent SLAs, although some, such as Oberon (+4.1%), saw an increase.
- **High population mobility**. This can affect the fabric of communities positively (an area may be attracting new people to live and work) and negatively (people may be leaving the area in search of education or employment opportunities). Mobility can be measured by the number of respondents with a different address in consecutive censuses. Oberon, Wattle Range East and Grant showed particularly high mobility between the 1996 and 2001 censuses.

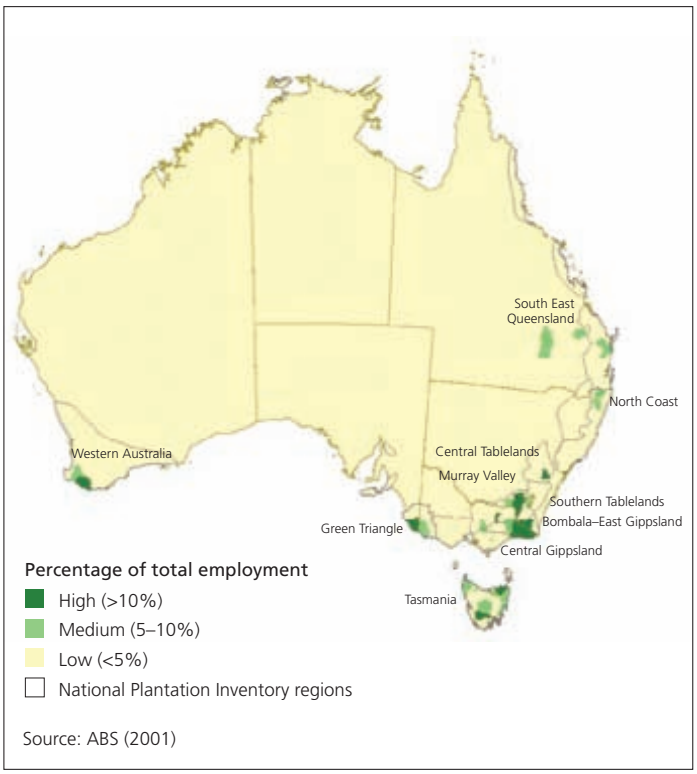
Resilience

The resilience of forest-dependent communities – their ability to absorb and bounce back from the effects of change – may be shaped by a number of factors, including the following:

- **Population change**. Forest-dependent areas follow the general trend in rural Australia of declining populations. Areas with larger population centres, such as Mount Gambier, appear to have greater resilience than others because of their larger economic base, greater economic diversity and alternative employment opportunities.
- **Population mobility**. Higher mobility could mean a greater ability to adapt or, alternatively, a general lack of commitment to an area. For example, relatively high mobility in Gympie and Copmanhurst is possibly more a reflection of the increasing attraction of coastal living, particularly along the more densely populated east coast of Australia.
- **Post-school qualifications**. A higher proportion of people with post-school qualifications indicates a greater capacity for learning and therefore an increased ability to adapt to new situations and changing employment opportunities. The number of higher qualifications is particularly high in areas closer to universities (such as La Trobe University in central Victoria).
- **Dependent population**. The working-age population in areas with relatively low numbers of dependents (children and the elderly) has a lower economic burden to bear.
- **Unemployment**. This is strongly influenced by other economic processes. Higher unemployment generally means lower resilience to further shocks, such as decreasing employment in the forest sector.
- **Historical response to change**. Communities with a proven ability to deal with the effects of change have greater self-belief and, therefore, a stronger capacity to adapt to further change.

Social resilience can also be affected by other, less readily measured factors, such as relationships within a community and the attitudes and values that shape how changes are perceived. Typically, such information must be collected through surveys, focus groups and other methods on a case-study basis.

Figure 94: Employment dependence in the wood and wood processing sectors in selected statistical local areas, 2001



Source: ABS (2001)

Table 105: ABS 2001 census data for statistical local areas with high (>5%) regional employment dependence on the forestry industry

SLA	% Forest industry employment, 2001[a]	% Change forestry industry employment 1996–2001	% Population change, 1996–2001[b]	% Age dependency, 2001[c]	% Change in working age, 1996–2001[d]	% Different address, 1996–2001[e]	% Higher qualification, 2001[f]	% Unemployment, 2001[g]
Australian Capital Territory								
Gungahlin–Hall	8.6	–	3.7	24.4	31.3	–	–	–
Remainder of ACT	5.6	–41.7	1.9	62.8	6.6	38.8	31.9	2.7
New South Wales								
Oberon	18.7	–34.4	1.0	53.3	4.1	21.4	5.8	7.0
Tumut	15.7	–28.7	0.4	59.0	2.5	15.5	6.6	6.8
Bombala	15.7	–43.8	–3.4	58.6	–17.1	13.8	6.3	6.3
Tumbarumba	13.4	–45.1	–0.3	56.4	–1.4	15.3	6.6	5.2
Copmanhurst	8.1	14.7	0.8	56.3	4.6	28.3	6.5	13.2
Kyogle	7.2	–22.0	–1.1	65.0	–4.8	17.7	6.7	13.4
Holbrook	7.2	62.2	–1.6	66.0	–5.1	16.7	7.1	3.8
Queensland								
Eidsvold	9.6	16.3	–0.9	51.9	0.5	26.1	5.3	5.3
Cooloola (excluding Gympie)	6.8	–20.7	1.5	55.4	8.4	29.4	5.6	11.6
Cooloola – Gympie only	6.6	–4.2	–0.1	63.2	0.9	26.7	6.3	10.4
Bungil	5.7	–3.0	0.1	54.3	1.8	27.9	6.1	1.5
Tiaro	5.5	–9.9	1.0	50.9	5.2	33.1	4.0	20.1
Woocoo	5.3	15.6	0.6	52.1	3.1	27.9	5.8	8.8
South Australia								
Wattle Range–West	19.4	–15.4	–0.8	56.3	–2.7	12.1	4.3	6.8
Mount Gambier	15.4	6.7	0.6	54.5	2.7	18.8	6.4	6.9
Wattle Range–East	13.2	–20.9	–0.7	51.5	–0.3	18.2	7.5	3.3
Grant	13.1	10.1	–0.1	46.1	1.4	23.3	5.6	5.4
Tasmania								
Dorset	17.0	–9.6	–0.3	61.7	–0.5	13.3	5.7	7.0
Derwent Valley – Pt B	13.5	–1.4	–1.5	42.7	–3.5	25.2	5.5	13.8
Derwent Valley – Pt A	11.9	–38.6	–1.0	58.3	–6.4	17.6	3.3	14.0
Burnie – Pt B	9.8	–43.9	–1.1	47.2	–3.0	21.9	5.4	10.4
Launceston – Pt C	8.7	–2.0	–0.7	46.7	–2.0	19.3	7.8	9.9
Glamorgan/Spring Bay	8.5	–31.5	0.1	58.1	–1.7	21.5	6.7	10.9
Circular Head	7.9	0.4	–1.0	54.3	–4.4	9.9	4.1	7.9

Table 105: ABS 2001 census data for statistical local areas with high (>5%) regional employment dependence on the forestry industry *continued*

SLA	% Forest industry employment, 2001[a]	% Change forestry industry employment 1996–2001	% Population change, 1996–2001[b]	% Age dependency, 2001[c]	% Change in working age, 1996–2001[d]	% Different address, 1996–2001[e]	% Higher qualification, 2001[f]	% Unemployment, 2001[g]
Break O'Day	7.3	–26.7	–0.3	58.5	–0.5	22.6	6.0	16.3
Waratah/Wynyard – Pt A	5.7	–13.3	–0.4	61.5	–2.1	18.6	6.0	12.1
West Tamar – Pt B	5.4	39.0	–0.4	44.5	0.9	23.4	8.3	8.8
Central Highlands	5.4	–66.7	–1.5	50.4	–7.4	20.7	5.9	11.8
Victoria								
Alpine–West	15.6	–13.3	–1.0	60.9	–5.7	15.4	6.9	6.7
East Gippsland–Orbost	11.6	7.5	0.2	60.4	1.3	19.9	7.5	8.6
Latrobe–Traralgon	7.6	1.6	0.7	52.5	4.5	17.6	9.5	9.1
Glenelg–North	6.6	–5.4	–1.7	71.9	–9.0	14.6	5.2	4.7
Yarra Ranges – Pt B	5.9	45.5	–6.8	60.1	–23.7	31.8	8.0	7.8
East Gippsland Bal	5.6	10.2	–2.5	55.7	–10.3	22.1	8.3	7.4
Delatite–Benalla	5.5	22.1	0.1	69.7	1.1	21.4	6.7	8.8
Colac–Otway–Colac	5.4	–11.9	0.2	69.4	1.0	18.2	5.3	6.3
Murrindindi–East	5.2	12.7	0.5	59.8	4.7	23.7	10.6	6.2
Western Australia								
Manjimup	14.3	–13.0	–0.3	58.0	–2.2	18.1	7.8	4.5
Bridgetown–Greenbushes	8.8	–42.5	0.1	53.4	2.8	26.9	9.3	6.8
Nannup	7.1	–62.2	0.9	44.8	10.8	28.2	8.8	7.9
Donnybrook–Balingup	5.4	–21.9	1.4	52.3	9.8	27.1	8.2	5.4

a Proportion of total people employed in the forestry industry (forestry and logging, forestry support services, wood and paper product manufacturing), 2001.

b Average annual population change, 1996 to 2001.

c Total dependency ratio, 2001 (ratio of children aged 0–14 years and elderly aged 65+ years to the working-age population aged 15–64 years).

d Change in the proportion of working-age (15–64 years) people, 2001.

e Proportion of the population who live in an SLA different from the one they lived in five years previously.

f Proportion of the population with a bachelor degree or higher qualification, 2001.

g Proportion of the labour force not employed, actively looking for work, 2001.

Note: Results of the 2006 census were not available at the time of report preparation.

Source: ABS (2001)

The changing nature of the Australian forest industry

The Australian forest industry has changed significantly in recent years. For example, there has been a shift in timber production from native forests to production from plantations, which affects both the character and location of the wood processing sector; usually it means that wood production is more intensive and products are more uniform. In addition, some public plantation forests have been privatised, and there has been greater international investment in plantation forests and processing.

These changes have affected communities in different ways. On the southwest slopes of New South Wales, for example, the populations of towns with large-scale plantation-processing facilities have tended to grow or remain stable, while those without such facilities have often diminished. Other towns that once relied on timber production from native forests have needed to adapt to a reduction in the scale of harvesting.

Increasingly, employees in the forest sector are able to travel long distances to their places of work. In effect, this means that even if a forest industry is based in a small town its employees might live elsewhere, perhaps in a larger regional centre. Alternatively, processing facilities may be located some distance from the resource, nearer to regional centres that provide pools of human resources as well as markets for products.

References

ABS (2001), Davidson et al (2008) (list at the back of the report).

Case study 56: High forestry industry dependence in South Australia's part of the Green Triangle

Comprising the large regional centre of Mount Gambier and many smaller localities, South Australia's part of the Green Triangle is one of the most forest-dependent regions in Australia, with the forest industry providing 13% or more of total direct employment.

Between 1996 and 2001, forest industry employment grew by more than 10% in Mount Gambier and the neighbouring municipality of Grant; population mobility and the number of working-age people also increased. In contrast, forest industry employment declined by more than 15% in the Wattle Range East and Wattle Range West SLAs, where the proportion of non-working-age people increased and population mobility decreased. Considering the predominance of low-income households (18%), a relatively high unemployment rate (7%), smaller population base, dependence on the working-age population (56.3%) and fewer employment opportunities outside the sector, Wattle Range may be less resilient than Mount Gambier and Grant to continued change in the industry.

Source: Bureau of Rural Sciences

Harvesting pines in the Green Triangle, South Australia.

Indicator 6.5d

Resilience of forest dependent Indigenous communities 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 their sustainability into the future.

Key points

- The recognition of native title through mechanisms such as Indigenous land-use agreements strengthens the potential value of forests for Indigenous people.
- Most state and territory land management agencies have targets for Indigenous employment, helping to build capacity in Indigenous communities and therefore resilience.

Current employment levels and extensive oral history research indicate that fewer Indigenous people are employed today in forestry or forest-based industries in southeastern Australia than were employed in the mid-20th century. This is due to a combination of factors, including improved technology and increased mechanisation (which mean less employment per unit of production across the sector), stricter requirements for skills and education, and the availability of alternative sources of income, including welfare.

Conversely, there has been a significant increase in the number of Indigenous people employed in forest-related conservation and natural resource management. Most state and territory land management agencies have targets for Indigenous employment; for example, about 15% of staff in the New South Wales Department of Environment and Climate Change are Indigenous. Special mentoring and training programs assist in reaching these targets. The majority of natural resource management committees have Indigenous representatives; participation in the committees and employment in land management agencies build capacity and therefore resilience.

Forest dependence

Measuring forest dependency in relation to Indigenous people is difficult because of the influence of welfare payments and Community Development Employment Program (CDEP) income.[16] Forest dependence has differing levels of intensity and economic, social and cultural dimensions.

Table 106 summarises data compiled from the 1996 census as part of the social assessment phase of two regional forest agreement processes in New South Wales, for the Lower North East and Upper North East regions. Industry employee profiles suggest that Indigenous employment in hardwood processing in the two regions was above what would be expected, given the proportion of Indigenous people in the wider community. This may reflect the presence of a local CDEP project targeting forest employment and is not necessarily representative of other forest regions. Nevertheless, it shows that the timber industry is a substantial employer of Indigenous people.

Conventional descriptions of the dependence of Indigenous people on forests have often focused on cottage industries, such as arts and crafts. In practice, however, Indigenous involvement is much broader, including timber processing (Case study 57), plantation management, agroforestry, heritage surveys of crown timber production forests, and ecotourism (Case study 58). Other economic enterprises include the collection and sale of fuelwood, contract road building, the manufacture of fine furniture, charcoal-burning and nursery management.

16 The CDEP program makes up part of the Australian Government's 'work for the dole' program, which, according to one survey (Morphy and Sanders 2001), accounts for 38% of income in Indigenous communities.

Table 106: Indigenous employment in the timber industry in Upper and Lower North East RFA areas, New South Wales (%)

Regional forest agreement catchment	Indigenous people in total population	Indigenous people in hardwood mills	Indigenous people in hardwood processing	Indigenous people as contract employees (bush crew)
Lower North East	1.9	4.5 (Survey sample 1)	2.4	–
		12 (Survey sample 2)		
Upper North East	2.8	3.5	–	3

Source: Brooks et al (2001)

Most Indigenous people, even those living significant distances away, are likely to have some cultural dependence on forests, particularly where the forest is part of the traditional country for which a particular group has customary responsibility. Native forests are places where new generations of Indigenous people can learn about cultural practices and laws. Access to the forests is critical for the continuation and maintenance of cultural values; conversely, loss of access to or use of forests and their products may lead to a diminution of culture and therefore of resilience.

Native title rights and interests over Crown native forests are increasingly being recognised. Such recognition is difficult to quantify but generally occurs through partnerships and negotiated outcomes for the ongoing use of the land, often through Indigenous land-use agreements (ILUAs) negotiated under the national *Native Title Act 1993*. For example, the Githabul ILUA is an agreement between native-title holders and the New South Wales Government for access to and use of multiple-use public forests and national parks in the northern part of the state. It includes access to over 112,000 hectares in 10 national parks and 13 state forests, the freehold transfer of 102 hectares of public land, and job creation within the Department of Environment and Climate Change. The recognition of native title through mechanisms such as ILUAs strengthens the role of forests in assisting Indigenous people to pursue forest-based economic independence.

Resilience

Indigenous systems of kinship confer resilience at individual, family and community levels. Resilience is not related just to economic status; it is influenced by personal, family and community health and wellbeing and the ability of a community to access its country and to engage in and teach cultural practices. Poor health reduces resilience, as do low levels of education, training and job readiness. Addressing health and education and maintaining and increasing access to traditional lands are therefore fundamental to the future prosperity of Indigenous communities.

Generally, the most resilient Indigenous communities are those in which economic development occurs in the context of customary values and laws. However, applying those values and laws can be difficult in the face of pressures to meet demand and apply modern technology. Adaptability requires the proper use of customary knowledge in the modern economy. Sometimes, greater resilience may be achieved by separating the economic business from social activities.

References

Annandale and Taylor (2007), Brooks et al (2001), Egloff et al (2005), Koenig et al (2005), Morphy and Sanders (2001) (list at the back of the report).

Case study 57: Nanum Tawap sawmill, Weipa, Cape York Peninsula

Nanum Tawap, a company operating a sawmill near Weipa on the Cape York Peninsula, is owned and managed by the five major Indigenous clan groups of the wider Napranum–Weipa area. The venture, which has been made possible by collaboration between mining company Comalco, the Queensland Government and Nanum Tawap, uses timber salvaged from Comalco's bauxite mining lease and employs about five local Indigenous men.[17]

Comalco has been extracting bauxite on Cape York Peninsula since 1955. Before the establishment of Nanum Tawap, the forests on the mining lease were cleared and burned.

With potential domestic and overseas markets, Nanum Tawap has access to enough timber to keep the sawmill operating for the foreseeable future. There are also proposals to expand the existing mill and to establish sawmills in nearby communities, as well as to construct a plant for further processing at a nearby regional centre.

17 Annandale and Taylor (2007).

Case study 58: Forest-based ecotourism

Umburra Cultural Tours, based on the south coast of New South Wales, is run by the Yuin people of Wallaga Lake. The operation offers a range of cultural activities, including guided tours of two culturally significant mountains, known as Biamanga and Gulaga.

The Biamanga and Gulaga national parks were proclaimed in 1994 and 2001, respectively, after Indigenous people fought to halt logging in the area, believing that it was destroying the cultural values of the mountains. In 2006, the ownership of the area was returned to the Yuin people, who lease the national parks back to the National Parks and Wildlife Service and jointly manage them through two boards of management.

The ecotourism experience provided by Umburra Cultural Tours is centred on the forest-covered mountains and involves guided tours by Indigenous owners. The cultural significance of the landscape is revealed using traditional storylines and customary knowledge. Forests also provide the physical setting for the Umburra Cultural Centre, where a wide range of customary activities are demonstrated for tourists.

Sources: Egloff et al (2005), www.umbarra.com.au/culture.htm

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, as well as the capacity to monitor change and to conduct and apply research and development.

Key findings

Legal, institutional and economic framework

- A comprehensive legal, institutional and economic framework designed to achieve the conservation and sustainable management of forests is in place at the state, territory and national levels. Over the reporting period, jurisdictions strengthened this framework through the continued implementation of regional forest agreements (RFAs) and new measures governing vegetation clearing and the allocation of water to land uses such as forestry. Several jurisdictions also passed legislation to provide property rights for carbon sequestered by forests and other vegetation.
- There has been rapid growth in forest certification as a means of verifying the quality of forest management and maintaining access to markets, with more than 9 million hectares of native forest and plantations certified under the Australian Forest Certification Scheme and the Forest Stewardship Council at September 2007. In addition, most multiple-use public forests and some private forests are now managed in accordance with codes of forest practice and externally accredited environmental management systems, which provide a structured approach to the planning and implementation of measures to protect the environment.
- Tariffs on imported forest products are in the range from zero to 5%; goods imported from all least-developed countries have been tariff and quota-free since July 2003.
- Several billion dollars of private investment in wood processing infrastructure was announced by investors between 2001–02 and 2005–06, including proposals for two new pulp mills. National taxation arrangements for plantation-based managed investment schemes contributed to significant increases in Australia's plantation base.
- Governments are developing market-based mechanisms and incentives to promote reforestation and improved forest management as a way of protecting catchment values, particularly in agricultural landscapes.
- Six environmental assets have been added to national and sector balance sheets, including native standing timber available for harvest and plantation timber. The value of those two assets grew at average annual rates of 5.6% and 3.8%, respectively, over the period from 1997 to 2005.

Capacity to measure and monitor changes

- The capacity to report trends, while still variable, is generally much improved since 2003. Data are comprehensive in coverage, currency and frequency for 15 indicators and more limited for 25 indicators. Case studies and other narrative material provide a large part of the information for four indicators. Jurisdictions have improved the coordination of forest reporting, including through the Montreal Process Implementation Group for Australia.

- The ability to report on forest change varies considerably by tenure. The best information is available for multiple-use public forests, for which governments require forest-management reporting. The biggest data gaps remain for leasehold and private forests.

Capacity to conduct and implement research and development

- Australian, state and territory forest agencies have developed the following national critical research priorities: the impact of climate change on forest management; the role of forests in managing Australia's water resources; managing Australia's forests for multiple objectives; forest health and biosecurity; and forest products.
- Forest and Wood Products Australia provides a nationally coordinated investment approach to forestry industry research and development and has been given a stronger role in marketing and promotional services. It works with national, state and territory research providers. Governments are also investing in research and development through a variety of specific-purpose packages.

Pine plantation, ForestrySA's Kuitpo Forest Reserve, certified under the Australian Forest Certification Scheme.

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 supports continuous improvements in sustainable forest management.

Key points

- A comprehensive legal framework designed to achieve the conservation and sustainable management of forests is in place at the national, state and territory levels.
- Over the reporting period, jurisdictions strengthened this legal framework through the continued implementation of regional forest agreements (RFAs) and new measures governing vegetation clearing and the allocation of water to land uses such as forestry.
- Several jurisdictions also passed legislation to provide property rights for carbon sequestered by forests and other vegetation.

Land and resource management activities in Australia operate within a framework of environmental laws and regulations, usually implemented at the state or territory level, where the primary responsibility for forest management lies. All states and territories have legislation designed to ensure the conservation and sustainable management of forests, some of which are administered by, and require coordination between, state and local governments, statutory authorities and regional management authorities. Table 107 shows that in New South Wales, South Australia, Tasmania, Victoria and Western Australia, comprehensive legislative provisions govern forest management planning and review, public participation, Indigenous participation, and the regulation of forest clearing in multiple-use public forests, public nature conservation reserves and private forests.

Table 108 shows examples of forest conservation and management-related legislation enacted in the same states in the period from 2002 to 2006. For example, Victoria's *Sustainable Forests (Timber) Act 2004* provides a framework for sustainable forest management and sustainable timber harvesting in that state's multiple-use public forests.

National and state forest agreements

National policy development plays a key role in promoting the conservation and sustainable management of forests. A key element of the approach adopted in the 1992 National Forest Policy Statement (Indicator 7.1b) involved the negotiation of RFAs between the Australian Government and some state governments. RFAs are 20-year plans for the conservation and sustainable management of Australia's native forests; they are designed to provide certainty for forest-based industries, forest-dependent communities and conservation. They use a science-based methodology to determine forest allocation for different uses and forest management strategies, and are the result of substantial scientific study, consultation and negotiation covering a diverse range of interests.

A total of 10 RFAs have been negotiated bilaterally between the Australian Government and four of the six state governments (New South Wales, Victoria, Western Australia and Tasmania; Figure 1 in the Introduction). The Australian and Tasmanian governments are also party to the Tasmanian Community Forest Agreement, which complements the Tasmanian RFA. The protection provided by RFAs is given legal status through the national *Regional Forest Agreements Act 2002*. The Australian and Queensland governments completed a comprehensive regional assessment for southeast Queensland but did not sign an RFA. Queensland has initiated its own process, known as the Southeast Queensland Forest Agreement.

The RFAs include provisions to establish comprehensive, adequate and representative ('CAR') reserve systems. Overall, the aim was to place in nature conservation reserves

15% of the pre-1750 distribution of each forest type, 60% of the existing distribution of each forest type if vulnerable, 60% of existing old-growth forest, 90% or more of high-quality wilderness forests, and all remaining occurrences of rare and endangered forest ecosystems (including rare old-growth forests).

Some jurisdictions have passed legislation providing further protection for additional areas of forests. For example, New South Wales enacted the *Brigalow and Nandewar Community Conservation Area Act 2005*.

Environment Protection and Biodiversity Conservation Act

Australia's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) 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, and Commonwealth marine areas.

The Act came into force in July 2000 and was amended in December 2006. The comprehensive assessments undertaken as part of the RFA process mean that RFAs are regarded as providing an equivalent level of protection to that provided by the EPBC Act. Therefore forestry operations undertaken in RFA areas do not require approval under the Act.

Codes of forest practice

Jurisdictions continue to improve codes of forest practice for use by forest managers, contractors and operators in multiple-use public forest and, in some jurisdictions, private forest. Most of the more recently developed or revised state-wide codes include a public consultation stage, and some (such as those in Tasmania and Victoria) incorporate processes to ensure independent scientific and technical review at 5–7-year intervals. 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 products.

Table 107: Examples of new legislation, 2002 to 2006, by jurisdiction

Jurisdiction	New legislation	Purpose
NSW	National Parks and Wildlife Regulations 2002	Conserves nature, including threatened species; conserves objects, places and features of cultural value; and fosters public appreciation, understanding and enjoyment of nature and cultural heritage and their conservation.
	National Park Estate (Reservations) Acts 2002, 2003, 2005, 2006	An Act to transfer state forest land to the national park estate, and for other purposes.
	Brigalow and Nandewar Community Conservation Area Act 2005	An Act to establish and provide for the management of the Brigalow and Nandewar Community Conservation Area.
	Native Vegetation Management Act 2003	Addresses the management and protection of native vegetation.
Qld	*Vegetation Management and Other Legislation Amendment Act 2004*	Protects all threatened and 'of concern' remnant native vegetation from clearing and phases out the broadscale clearing of less-threatened remnant vegetation.
SA	*Fire and Emergency Services Act 2005* (replaces the *Country Fires Act 1989*)	Provides for a country fire service to provide for the control and suppression of fires.
	Natural Resource Management Act 2004	Promotes the sustainable and integrated management of the state's natural resources and makes provision for their protection.
Tas.	*Nature Conservation Act 2002*	Provides for the declaration of certain types of reserves and sets out the values and purposes of each reserve class.
	National Parks and Reserves Management Act 2002	Reserves are managed under the Act according to management objectives for each reserve class.
Vic.	*Sustainable Forests (Timber) Act 2004*	Provides a framework for sustainable forest management and sustainable timber harvesting in multiple-use public forest.
	Victorian Plantations Corporation Act 2003	Establishes the Victorian Plantations Corporation to manage state plantations and to require that timber harvesting complies with a code of practice.
WA	*Carbon Rights Act 2003*	Provides for the creation of certain interests in land in relation to the effects of carbon sequestration from, and carbon release to, the atmosphere, and for related matters.
	Tree Plantation Agreements Act 2003	Enables the ownership of planted trees as an interest in land, separate from ownership of the land itself.

Sources: State agencies

Codes of forest practice vary in their legal status and coverage. Codes in New South Wales, Tasmania and Victoria are prescribed in legislation and cover public and private native and plantation forests. In the Australian Capital Territory, Queensland and Western Australia, the codes are prescribed at the agency level.

Table 108 shows the planning frameworks and codes of practice in place for plantations in various jurisdictions. For example, in South Australia the forest industry adopted industry-endorsed guidelines for best practice forest management (*Environmental Management Guidelines for Plantation Forestry in South Australia*) in 1997. Two major projects are under way to develop new statewide codes of forest practice: one to cover all plantations in New South Wales and another to cover all plantations in Queensland.

In the Northern Territory, private forest harvesting is governed by licences, which prescribe certain management requirements in a manner similar to a code of forest practice. In 2007, New South Wales published four regional private native forest codes of practice: for southern New South Wales, northern New South Wales, river red gum forests, and cypress and western hardwood forests. In some states, specific codes of practice also exist for fire management and some other activities. Several public forest-related agencies and private companies have adopted environmental management systems (described in more detail in Indicator 7.1b) that, in many cases, perform some of the functions of or are complementary to codes of forest practice.

Land clearing

All jurisdictions have committed to the national goal of increasing the extent and condition of native forests and have enacted legislation to curtail and/or strengthen controls on the broadscale clearing of native vegetation. Over the reporting period, New South Wales and Queensland enacted legislation to limit the clearing of forests and other native vegetation. In New South Wales, the *Native Vegetation Act 2003* and Native Vegetation Regulation 2005 require landholders to negotiate property vegetation plans with one of 13 regional catchment management authorities set up under the *Catchment Authorities Act 2003*.

The *Native Vegetation Act 2003* is designed to:

- provide for, encourage and promote the management of native vegetation on a regional basis in the social, economic and environmental interests of the state
- prevent broadscale clearing unless it improves or maintains environmental outcomes
- protect native vegetation of high conservation value
- improve the condition of existing native vegetation
- encourage revegetation and rehabilitation with appropriate native vegetation.

In Queensland, the clearing of native vegetation is regulated by the *Vegetation Management Act 1999*. The purpose of the Act is to conserve remnant 'endangered', 'of concern' and 'not of concern' regional ecosystems and declared areas, to ensure

Table 108: Plantation-related planning framework and codes of practice

Jurisdiction	Status of planning frameworks and codes of forest practice relevant to plantations
NSW	The *Plantations and Reafforestation Act 1999* and the Plantations and Reafforestation (Code) Regulation 2001 replaced the *Timber Plantations Harvest Guarantee Act 1995*. The Act and code streamline the approval process and are aimed at increasing investment security for growers while maintaining environmental standards. In 2005, a review found that the objects of the legislation were still relevant and that the terms of the Act were delivering the desired results. A report on the review was tabled in Parliament in December 2005.
NT	Planning approvals for plantations are centrally controlled under the *Planning Act 2005*. The Northern Territory Department of Business, Industry and Resource Development has developed an approved *Code of Practice for Plantation Forestry*.
Qld	The *Integrated Planning Act 1997* provides the planning framework for plantation establishment in Queensland. Queensland is drafting a code of forest practice that guides or regulates plantation development on private land.
SA	Local government councils require a development application to be submitted for approval before plantation development. *Guidelines for Establishing and Managing Commercial Forest Plantations in South Australia* (1998) and *Environmental Management Guidelines for Plantation Forestry in South Australia* (1997) have been developed in consultation with industry, local governments and a range of planning and land management authorities.
Tas.	The *Forest Practices Act 1985* is administered by the Forest Practices Authority. The *Forest Practices Code* operates under the Act.
Vic.	The *Planning and Environment Act 1987* provides the legislative mechanism for plantations on private land and offers a streamlined approach to the plantation development approval process in Victoria. The Act establishes a *Code of Forest Practice for Timber Production*, which has recently been reviewed. On private land, the code is regulated by local government.
WA	The *Planning and Development Act 2005* enables local government to prepare planning schemes that define land-use zones. Permits are required from local government to establish tree plantations in most areas. The *Tree Plantation Agreements Act 2003* enables the ownership of planted trees as an interest in land, separate from ownership of the land itself. The *Code of Practice for Timber Plantations in Western Australia* provides a set of voluntary guidelines for plantation developers relating to plantation development and management. The code was released in September 2006.

Source: Commonwealth of Australia (2002)

that clearing does not cause land degradation, to prevent the loss of biodiversity, to maintain ecological processes, to manage the environmental effects of clearing, and to reduce greenhouse gas emissions. The Act regulates the clearing of remnant vegetation on freehold land and the clearing of remnant and some non-remnant vegetation on state tenures. Broadscale clearing of remnant native vegetation ceased on 31 December 2006; however, clearing for defined relevant purposes may be allowed subject to permit.

Carbon

The issue of property rights for sequestered carbon is receiving considerable attention at the state level. New South Wales, South Australia, Tasmania, Western Australia and Victoria all now have specific legislation recognising the right to own carbon sequestered by vegetation on freehold land, although the name given to this right varies between states. In South Australia, for example, the *Forest Property (Carbon Rights) Amendment Act 2006* provides for the separation of ownership of land, forest vegetation and carbon rights for improved investment security and transferability; the amendments came into effect in July 2007. Developments in carbon trading are discussed in Indicator 6.1c.

Water

In June 2004, the Australian Government and all state and territory governments, except Tasmania and Western Australia, signed the National Water Initiative, a strategy to improve water management nationwide (Tasmania signed in June 2005 and Western Australia in April 2006). The initiative builds on the previous Council of Australian Governments framework for water reform signed by the Australian Government and all state and territory governments in 1994. It encompasses a wide range of water management issues and encourages best-practice approaches to the management of water in Australia. The National Water Initiative includes measures such as:

- regional assessments of the level of water intercepted by land-use change activities and a requirement that new activities likely to intercept significant volumes of water hold a water access entitlement if the catchment is at, or close to, its sustainable level of water allocation
- investment in water recovery for six significant ecological assets, such as the Barmah–Millewa Forest along the Murray River.

Public participation

Australia has well-established practices for public participation. The environmental impact and planning laws of the Australian, state and territory governments contain various requirements for public consultation, and the National Forest Policy Statement calls for public consultation in forest planning. In some jurisdictions, there are also avenues for public involvement in the management of forests on privately owned or leasehold land through planning laws administered by local governments.

In all states and territories, public consultation and participation processes for publicly managed forests extend to the level of management planning. They include the provision of information on resources, impacts, uses and values; discussion papers on alternative plans; invitations to provide comment or written submissions; and discussion forums and public meetings.

Table 109 shows the coverage of ecologically sustainable forest management in the legislative frameworks of New South Wales, South Australia, Tasmania, Victoria and Western Australia, including provisions for public participation.

Table 109: Coverage of ecologically sustainable forest management provisions in legislative frameworks, by jurisdiction and tenure

	NSW			SA			Tas.			Vic.			WA		
Tenure	MUF	NCR	PRIV	MUF	NCR	PRIV	MUF	NCR	PRIV	MUF	NCR	PRIV	MUF	NCR	PRIV
Forest management planning and review[a]	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	n.d.
Public participation	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	P	Y	Y	n.d.
Indigenous participation	Y	Y	n.d.	Y	Y	Y	Y	Y	N	Y	Y	N	N	N	n.d.
Regulation of forest clearing	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	n.d.	Y

MUF = multiple-use public forest; N = limited or no legislation exists; n.d. = insufficient data; NCR = public nature conservation reserve; P = legislation or mechanisms exist but do not cover all aspects or are limited in their application; PRIV = private forest; Y = legislation is comprehensive for most aspects

a Components include accountable management body, dispute resolution process, forest management planning, management review, planning for environmental values, planning review, policy review, property rights and periodic assessment of forest-related resources.

Note: No data available for the Australian Capital Territory, the Northern Territory or Queensland.

Sources: State agencies

Indigenous people's property rights

The Australian Government enacted the *Native Title Act 1993* and established the Indigenous Land Corporation in 1995 to purchase land for Indigenous groups displaced from their lands. States and territories subsequently passed complementary native title legislation. The *Regional Forest Agreements Act 2002* specifies that agreements between the state and Australian governments about the management of forests must include the protection of Indigenous heritage values.

There is a growing trend in some parts of Australia to settle native title claims over national parks by agreement, which may give rise to a consent determination in the Federal Court that includes the recognition of such rights. The agreement may also address how those rights may be exercised, including whether or not firearms may be used in the determination area. The agreement may also put in place 'joint management' arrangements.

References and further reading

Commonwealth of Australia (1992, 2002, 2005b), Forestry Tasmania (2007) (list at the back of the report).


BRS

The red gum forests of the Barmah region are a significant ecological asset on the Murray River. Their good health relies on an adequate allocation of water to environmental flows in a highly regulated river system.


PIRSA Forestry

Field days are opportunities for growers to observe the application of new technologies and practices.

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 the engagement of the wider community in the process of continuous improvement and sustainable management of forests.

Key points

- Australia has a well-established institutional framework to support the conservation and sustainable management of forests.
- There has been rapid growth in forest certification as a means of verifying the quality of forest management. More than 9 million hectares of native forest and plantations were certified under the Australian Forest Certification Scheme and the Forest Stewardship Council by September 2007.
- Most multiple-use public forests and some private forests are now managed in accordance with codes of forest practice and externally accredited environmental management systems, which provide a structured approach to the planning and implementation of environmental protection measures.
- Governments have responded to a skills shortage by supporting programs to further develop human resources in the sector.

Policy framework

The management of Australia's forests is guided by the National Forest Policy Statement,[1] 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. Through the policy statement and other mechanisms, the Australian, state and territory governments are committed to the sustainable management of all Australian forests, whether the forest is on public or private land or within conservation reserves or production forests.

A number of other policies and programs have been established nationally by governments through ministerial council decisions, established by bilateral arrangements between the Australian Government and a state or territory government, endorsed by the Australian Government, or introduced by an individual state or territory government. Examples for each of these categories include the following:

- **Ministerial Council decisions**. Plantations for Australia: the 2020 Vision is a partnership involving the Australian Government and state and territory governments and the plantation timber growing and processing industry. It aims to treble Australia's plantation area from 1 million hectares in 1997 to 3 million hectares by 2020.
- **Bilateral arrangements**. Through the Tasmanian Community Forest Agreement, which was signed in May 2005, the Australian and Tasmanian governments committed to a comprehensive program of conservation, silvicultural improvement, tourism, industry development and other measures designed to enhance the sustainability and competitiveness of Tasmanian forests and forest industries.
- **Australian Government initiatives**. The National Indigenous Forestry Strategy, endorsed by the Australian Government, is being implemented in conjunction

1 Commonwealth of Australia (1992).

with corresponding state and territory strategies and programs. It aims to contribute to the overall sustainable development of Indigenous land and communities, and addresses areas such as natural resource management, business development, cultural heritage, education, employment and training.

- **State and territory government initiatives**. The Victorian Government's Our Forests, Our Future policy, announced in February 2002, aims to ensure the sustainable future of Victoria's native forests and the timber industry communities they support.

Table 110 shows some state-level policy provisions for aspects of forest management, by tenure, for New South Wales, South Australia, Tasmania, Victoria and Western Australia.

Regional assessment and policy review

The level of regional assessment and policy review varies according to the type and tenure of forest.

For public forest land, all jurisdictions in Australia undertake planning, assessment and policy reviews. The Primary Industries Ministerial Council, the Natural Resource Management Ministerial Council, the Forestry and Forest Products Committee and the Natural Resource Policies and Programs Committee coordinate policy and planning across jurisdictions. The Forestry and Forest Products Committee provides the major forum for agencies to consider national forest policy issues.

Ten regional forest agreements (RFAs) (Indicator 7.1a) covering almost all Australia's major native timber production forests were signed by the Australian and relevant state governments between 1997 and 2001. By signing the RFAs, the states agreed to join the Australian Government in periodic reviews of the implementation and progress of the agreements. Tasmania conducted a 5-year review in 2002 and began a 10-year review in mid-2006 that was due for completion in November 2007. In mid 2007, Western Australia agreed to undertake its five-year review. Discussions have begun between the Australian Government and the governments of Victoria and New South Wales to begin reviews in those states. All jurisdictions except the Northern Territory have formal requirements for the periodic review of planning in public forested lands. Park management policies are also reviewed regularly for conservation lands. For example, in New South Wales, park management policy is reviewed every five years. Fire management plans are prepared jointly by forest agencies, conservation agencies and rural fire services in most jurisdictions.

Landowners make plans for their forested land consistent with management objectives, often as part of overall farm plans, and local communities or regional organisations are required to develop regional vegetation management plans. Community approaches to planning are fostered in the Landcare movement and in some cases through private forestry development committees or similar bodies. Private corporations make detailed plans for their own plantations.

Community awareness

Australian governments are committed to public participation in forest management, extension activities and the provision of information. All states and territories have forest extension and education programs (Case studies 59, 60 and 61) and all public forest management agencies publish forest-related information such as annual reports and technical papers on research and other matters of interest. The Australian Government coordinates both the national *State of the Forests Report* and the national *State of the Environment Report*. Some states publish their own state-specific versions of those reports.

Human resource skills

A range of training and education facilities exist for the teaching of all aspects of forest management, offering graduate and postgraduate degrees, diploma and certificate courses, and operational competency certificates. In 2006, the Australian Government funded the *Wood and Paper Products Industry Skills Shortage Audit*, a report by the National Association of Forest Industries in conjunction with the Australian Plantation Products and Paper Industry Council. The report made a number of recommendations directed at industry, government, universities and research organisations; progress is being made towards implementing some of the report's recommendations.

One key area of concern relates to a shortage of professional foresters (Case study 62 on the SOFR website). As the jurisdiction with responsibility for university education, the Australian Government pledged $1.6 million in 2007 to help deliver the National Forestry Masters Program offered jointly by the Australian National University, Southern Cross University, the University of Melbourne, University of Queensland and the University of Tasmania. The curriculum for the new program, which will be developed and implemented jointly, is designed to make it easier for students and staff to move between institutions. The collaborating universities are also the principal research training partners in the Cooperative Research Centre for Forestry, ensuring strong links to research on nationally identified priorities. The Australian Government has also committed $4 million towards improving training and skills development in Tasmania as part of the Tasmanian Community Forest Agreement, and provided significant funding for skills and training development as part of the National Indigenous Forestry Strategy.

Enforcement

States and territories use a range of measures to monitor compliance with legislation and to investigate breaches (Case study 63 on the SOFR website for the Tasmanian approach). In general, enforcement officers, regionally based specialist staff and legally constituted bodies such as tribunals are charged with ensuring compliance with forest and forestry legislation.

Generally, compliance is high with the law, regulations and guidelines relating to timber harvesting in multiple-use public forests. For example, Forests NSW has introduced a four-tier audit system to monitor compliance both with regulatory and with non-regulatory conditions in forest operations. In the first tier, the supervising foreman audits compliance with harvesting plan conditions and uses harvesting inspection reports to document compliance and breach reports. In 2005–06, just over 120,000 compliance checks in the state's multiple-use public forests resulted in 1,142 non-compliance incidents and, ultimately, four fines issued to Forests NSW by regulatory agencies.

In all jurisdictions, the monitoring of recreational use on public lands and harvesting on private lands is generally less extensive.

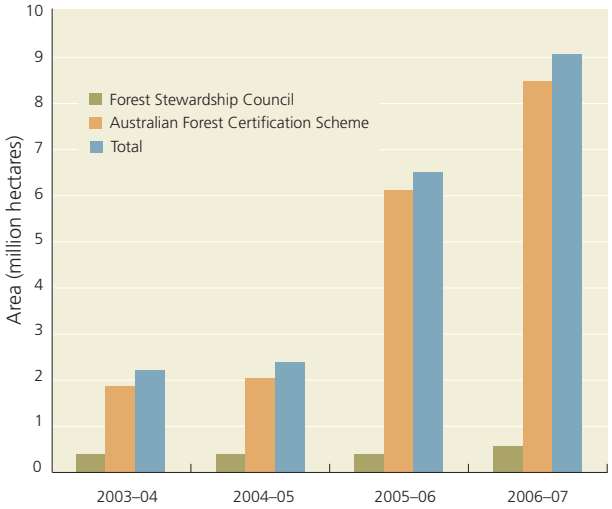
Certification

Consumers, governments and enterprises around the world are increasingly seeking assurance that the forest and wood products they buy are sourced from legally harvested and sustainably managed forests. This requirement is being met progressively through forest certification, which is the voluntary, independent assessment of forest management activities and operations undertaken in a particular area of forest. Certification schemes typically require forest management practices that are more stringent than provided for by law alone, and encourage forest managers to display their sustainability credentials when marketing their products. The certification of a forest area is carried out by an accredited organisation against standards set out by one of several existing certification schemes.

Two major forest certification schemes operate in Australia – the Australian Forest Certification Scheme (AFCS) and the scheme operated by the Forest Stewardship Council (FSC). Both have a forest management standard and a chain-of-custody standard (which certifies that a product came from a particular forest area). The AFCS uses the Australian Forestry Standard,[2] which was developed through an extensive process involving representatives of the Australian community, industry and government and based on international frameworks such as the International Organization for Standardization's ISO 14000 environmental management standards and the Montreal Process criteria and indicators. While the AFCS is currently the only scheme certifying native forest in Australia, the FSC has committed to developing a national standard that will encompass all forest types, including native forest.

Figure 95 shows that forest certification has grown rapidly since 2003. By September 2007, 8.55 million hectares of native and plantation forests had been certified under the AFCS and 550,000 hectares of plantations had been certified under the FSC.

Figure 95: Forest certified in Australia, 2003–04 to 2006–07



Source: Department of Agriculture, Fisheries and Forestry

In addition to forest certification, most multiple-use public forests and some private forests are managed in accordance with codes of forest practice (Indicator 7.1a) as well as environmental management systems (EMSs) externally certified to an ISO standard. An EMS 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. Forest management agencies with a certified EMS in place include Forests NSW; ForestrySA; Queensland's Department of Natural Resources and Water (Forest Products) and Forestry Plantations Queensland; Western Australia's Forest Products Commission; Victoria's Department of Sustainability and Environment; and Forestry Tasmania. Several major private forestry companies also have EMSs in place.

Illegal logging

Illegal logging is widely regarded as a serious threat to the sustainable management of the world's forests, imposing substantial environmental, economic and social costs on countries where it occurs. The Australian Government strongly opposes illegal logging and the importation of illegally sourced forest products. However, verifying the legality of forest product imports is extremely difficult, partly because of a lack of information on forest law enforcement in many countries and partly because of the complexity of the supply chains that link producers and consumers.

The Australian Government released a discussion paper on illegal logging for public comment in November 2006 to illuminate the issues associated with illegal logging and to explore options for reducing the volume of illegally sourced forest products imported into Australia. An Australian Government policy on illegal logging was released in 2007.

2 The AFS was recognised by Standards Australia as an Australian Standard® on 5 August 2007 and has been designated as AS 4708 2007 The Australian Forestry Standard.

Table 110: Coverage of aspects of forest management in non-legislative policy frameworks, by jurisdiction and tenure

	NSW			SA			Tas.			Vic.			WA		
Tenure	MUF	NCR	PRIV	MUF	NCR	PRIV	MUF	NCR	PRIV	MUF	NCR	PRIV	MUF	NCR	PRIV
Forest management planning and review	Y	Y	n.d.	Y	Y	N	Y	Y	P	Y	Y	Y	Y	Y	n.d.
Public participation	Y	Y	n.d.	Y	Y	N	Y	Y	P	Y	Y	n.d.	Y	Y	n.d.
Indigenous participation	Y	Y	n.d.	Y	Y	Y	P	P	N	Y	Y	n.d.	Y	Y	n.d.
Regulation of forest clearing	Y	Y	n.d.	Y	Y	Y	Y	Y	P	Y	Y	Y	Y	Y	Y

MUF = multiple-use public forest; N = limited or no policies exist; n.d. = insufficient data; NCR = nature conservation reserve; P = policies exist but do not cover all aspects or are limited in their application; PRIV = private forest; Y = policies are comprehensive for most aspects

Note: No data available for the Australian Capital Territory, the Northern Territory or Queensland.

Sources: State agencies

References and further reading

Commonwealth of Australia (1992, 2002, 2005c, 2006, 2007), Crawford (2006), Department of Natural Resources and Environment (2002), Forestry Tasmania (2007), National Association of Forest Industries and the Australian Plantation Products and Paper Industry Council (2006) (list at the back of the report).

Web resources

Case study 60: Forest education and awareness in Western Australia

Case study 61: Forest education and awareness in New South Wales

Case study 62: Forestry skills in the Green Triangle

Case study 63: Tasmania's Forest Practices Authority

Information on the Tasmanian Community Forest Agreement is available at www.daff.gov.au/forestry/national/cfa

Information on the Australian Government's policy on illegal logging is available at www.daff.gov.au/forestry/international/illegal-logging

Mini-rangers participating in a school holiday trekking program.

Case study 59: Forest education and awareness in South Australia

The South Australian Government supports programs to develop and deliver forestry education and awareness, principally through the Department of Primary Industries and Resources SA (PIRSA) Forestry and ForestrySA.

About 8,000 schoolchildren visit South Australian public forest reserves each year for outdoor and forestry education purposes, mostly by arrangement with forestry staff. Rangers are available to host tours and to work with teachers in giving talks and assisting with other forest education activities. A dedicated forest education centre has been developed to support some visits.

PIRSA Forestry produces *Forestry Matters!*, a periodically updated, forest education resource about the plantation-based timber industries in South Australia. *Forestry Matters!* is used by teachers preparing for forestry education activities, students researching forestry topics, and others wanting to know more about forestry. Originally developed in 2000 in consultation with teachers, educational consultants and industry and updated in 2007, *Forestry Matters!* has been circulated to all schools in the state and is also available on the PIRSA website.[3]

Visitors to forest reserves can obtain pamphlets from forest information centres or read interpretive signs while in the forest. Forest education and awareness programs are linked to other environmental education programs and are used by government agencies, the forest industry, educational institutions and especially by ForestrySA's Friends of the Forest volunteer program.

3 www.pir.sa.gov.au/forestry/programs/education/current_forestry_matters_resource

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 growing and timber processing.

Key points

- Australia continued to pursue economic and trade reforms over the reporting period, with a general aim of further increasing efficiency in the allocation of resources.
- Tariffs on imported forest products are in the range from zero to 5%; goods from all least-developed countries have been tariff and quota-free since July 2003.
- Several billion dollars of private investment in wood processing infrastructure was announced by investors between 2001–02 and 2005–06, including proposals for two new pulp mills.
- National taxation arrangements for plantation-based managed investment schemes have contributed to significant increases in Australia's plantation base.
- Governments are developing market-based mechanisms and incentives to promote reforestation and improved forest management as a way of protecting catchment values, particularly in agricultural landscapes.
- Environmental assets have been added to national and sector balance sheets, including native standing timber available for harvesting and plantation timber. The values of those two assets grew at average annual rates of 5.6% and 3.8%, respectively, over the period from 1997 to 2005.

Plantation expansion

Over the past decade there has been a significant increase in plantation establishment, particularly of short-rotation hardwoods (Indicators 2.1b and 6.2a). The main economic driver of this growth has been managed investment schemes (see below). The development of the plantation estate is underpinned by *Plantations for Australia: the 2020 Vision*, a strategic partnership between the Australian, state and territory governments and the plantation timber-growing and processing industry. The overarching principle of the vision is to enhance regional wealth creation and international competitiveness through a sustainable increase in Australia's plantation resources, based on a notional target of trebling the 1997 area of commercial tree crops by 2020 (Indicator 7.1b).[4]

Private investment

During the period from 2001–02 to 2005–06, several billion dollars of private investment in infrastructure was announced in the wood processing industry. Announcements included the development of a $1.7 billion pulp mill at Bell Bay in Tasmania, a $1.5 billion pulp mill in Penola in South Australia, and a $450 million upgrade of Visy's pulp and paper mill at Tumut in New South Wales.

Managed investment schemes

New taxation arrangements for investments in forestry managed investment schemes came into effect in July 2007. The arrangements, which are intended to encourage the further expansion of the plantation estate through private sector investment, require that 70% of investor funds be used to meet direct forestry costs, such as land rental and plantation establishment, tending and harvesting. Other key changes include extending the time for planting from 12 to

4 www.plantations2020.com.au/vision/index.html

18 months, and allowing secondary trades in investments after a holding period of four years. The latter change will increase the liquidity of investments and contribute to the development of market pricing information, and may also encourage the development of longer-rotation plantations for structural grade timber.

Industry restructuring

Australian governments allocated $48 million over the reporting period to support structural adjustment programs in the native forest hardwood timber industry in the main native timber producing states (New South Wales, Queensland, Tasmania, Victoria and Western Australia). The purpose is to encourage investment in capital equipment to improve the performance of the harvesting and haulage sectors, and to increase the ability of the industry to process and add value to Australian native forest timber and to market and promote its products.

In Tasmania, industry restructuring is being assisted by funds provided through the Tasmanian Forest Community Agreement, which was announced jointly by the Australian and Tasmanian governments in May 2005. Under the agreement, the two governments committed over $250 million to preserve old-growth forests (through a Forest Conservation Fund) and revitalise the timber industry. For the latter purpose, investments of over $200 million are to be made in the Tasmanian forest industry, including $115 million to fund plantation establishment and productivity improvements, $42 million to support the hardwood industry, $4 million to build skills in the forest industry, $10 million in assistance to the softwood industry, and $11.4 million in assistance to non-wood forest product industries, such as beekeeping.

Environmental services

The sale of environmental goods and services in forests emerged during the reporting period as a future driver of growth in the forest sector. For example, South Australia introduced a framework for carbon rights and informed the investment community of opportunities to invest in the wood processing industries and plantation resources of the Green Triangle. In Western Australia, the Forest Products Commission is producing a series of tree farming and industry development plans, which aim to deliver environmental services in target areas through the development of viable plantation industries. In New South Wales, Forests NSW has initiated various joint-venture arrangements for plantations; for example, the Pilot NSW Environmental Services Scheme has mechanisms for rewarding land managers for investing in commercial activities that also have environmental benefits.

Table 111: Value of Australia's environmental assets (current prices)

	June 1997 ($ billion)	June 2005 ($ billion)	Average annual increase (%)
Rural land	93	209	10.6
Other land	633	1,710	13.3
Oil and gas	69	148	10.0
Other subsoil	47	195	19.3
Native standing timber	2	3	5.6
Plantation standing timber	6	8	3.8
Total	851	2,273	13.1

Note: Totals may not tally due to rounding.
Source: ABS (2006e)

A significant amount of work took place over the period to develop a basis for trading carbon sequestered by plantations. For example, legislation was enacted in most states for the recognition of carbon sequestered by plantations as a separate property right (Indicators 6.1c and 7.1a).

Assessing environmental and social values

The Australian Bureau of Statistics now includes six environmental assets in national and sector balance sheets: rural land, other land, oil and gas, other subsoil assets, native standing timber available for harvesting, and plantation timber. The Australian national balance sheet recorded $5.6 trillion in assets on 30 June 2005, of which $2.3 trillion (41%) was classed as environmental assets (Table 111). Over the 1997–2005 period, the value of environmental assets grew at an average annual rate of 13.1%. This strong growth can be attributed mainly to price effects, with an average annual real change of 1.6%.

National Competition Policy

The National Competition Policy aims to promote efficient competition between public and private enterprises to ensure that government businesses have no competitive advantages or disadvantages compared with their private competitors. To comply with the policy's competitive neutrality requirements, state forest agencies must charge prices (royalties) for sawlogs and pulplogs which, over the long term, generate revenues that at least cover the costs of managing their forests for wood supply and provide a commercial return on assets, including land and timber. Moreover, the focus on cost recovery and the trend to the greater transparency and accountability of public agencies in their management of public resources have encouraged forest agencies to evaluate the efficiency and financial performance of their forest management practices.

Trade policy

Australia imposes tariffs ranging from zero to 5% on imported forest products; the government introduced tariff and quota-free entry for all goods from all least-developed countries on 1 July 2003. The low level of protection offered to the Australian forestry industry, and the market-oriented approach to exports, have led to an increase in resource allocation efficiency and the development of a competitive and sustainable forest and forest product sector that is responsive to global markets.

The Australian Government works actively for the removal of policies in other countries that may distort international markets and lead to over-harvesting. It promotes the removal of trade barriers such as tariffs and tariff quotas on forest products to create improved opportunities in key export markets.

Australia pursues opportunities to negotiate better trade and investment conditions by:

- negotiating globally through the World Trade Organization (WTO)
- cooperating with countries in our region, such as through the Asia Pacific Economic Cooperation (APEC) forum
- negotiating free trade agreements (FTAs).[5]

Australia pursues bilateral and regional trade agreements where they complement Australia's wider trade-reform objectives and deliver benefits either faster or beyond those that can be achieved through the World Trade Organization. Australia is negotiating free trade agreements (FTAs) with China, Japan and Malaysia and a regional FTA with the Association of Southeast Asian Nations and New Zealand. Australia has agreed in principle to begin bilateral negotiations with Chile. In addition, the private sector is conducting a joint study on the feasibility of an FTA with the Republic of Korea.

FTAs are increasingly important to the forest-based industries. For example, China is expected to import 125 million cubic metres of wood per year by 2010. By then, Australia will be harvesting 36 million cubic metres per year with the potential to export up to 10 million cubic metres to help meet Chinese demand.

The new and potential FTA negotiations will build on FTAs already completed with the United States of America, Singapore, Thailand and New Zealand, and are expected to provide greater export opportunities for Australia's forest products.[6]

Investment, including foreign investment

Stringent controls over land-use changes and industrial development exist in Australia to protect environmental, cultural and amenity values. Provided such values are protected, private investment in the forest and forest product industries is generally free of industry-specific legal and regulatory constraints. Foreign investment is regulated by the *Foreign Acquisitions and Takeovers Act 1975* (Cwlth). Certain types of proposals by foreign interests to invest in Australia require prior approval and need to be declared to the Australian Government.

Private forest management

The sustainability of forest operations in Australia's private native forests is under increased scrutiny, which has led to an increase in legislative, regulatory and voluntary measures governing the management of private forests (Indicator 7.1a). Recent research indicates that economic incentives are required in order to improve the management of private native forests and that those incentives should recognise the public benefits of good forest stewardship.[7] Several recent initiatives aim to encourage the conservation and management of private native forests through incentives-based mechanisms.

Partnerships involving the states and the Australian Government support 19 private forestry development committees in plantation regions throughout Australia. The role of the committees is to assist the development of sustainable private forestry, including through regional strategies to encourage industry investment and development. Some (such as the Northern Territory Private Forestry Development Committee) have developed codes of practice for private plantations to improve management practices.

A number of state-based incentive programs were launched during the reporting period to discourage land clearing. In South Australia, they included a statewide project to provide incentives for farmers to manage their native forests, and amendments to the *Native Vegetation Act 1991* that have made it more difficult to get clearance approval for land clearing, in particular for dead standing vegetation.

References and further reading

ABS (2006e), Mallawaarachchi and Szakiel (2007), Thompson and Connell (in review) (list at the back of the report).

5 www.dfat.gov.au/trade/ftas.html

6 www.dfat.gov.au/trade/ftas.html

7 Thompson and Connell (in review).

Case study 64: Community conservation areas in western NSW

Forests NSW has worked extensively with the timber industry and other agencies to implement the state government's decision on the Brigalow Belt South (and Nandewar) Regional Assessment, which was announced in May 2005. The decision permanently conserves 352,000 hectares of forest stretching from Dubbo to the Queensland border, including 328,000 hectares in a 'Community Conservation Area' (CCA).

The CCA is a new land tenure created as part of the assessment process. It is divided into different zones that allow for differing land uses and intensities of human management, including conservation, Indigenous cultural heritage, mineral exploration and extraction, and forestry. A Brigalow and Nandewar CCA Agreement currently being developed will provide a framework for coordinated management across government for the entire area.

The Community Conservation Council, which was established under the *Brigalow and Nandewar Community Area Act 2005*, oversees the CCA and is advised by three new community-based community conservation advisory committees. The committees have strong community representation through local industries such as forestry, mining, the apiary industry and farming, along with local recreation users, environmental groups and Indigenous communities.

The Community Conservation Council supported Forests NSW's proposal for cypress thinning, inventory and access to private-property timber to improve biodiversity and timber values. As a result, $12 million will be provided over five years to create up to 45 additional jobs in the region, including jobs for affected timber and forest workers, as well as opportunities for employment in rural towns and Indigenous communities.

Up to 57,000 cubic metres of cypress sawlogs has been allocated per year in 20-year wood-supply agreements signed with Gunnedah Timbers, Baradine Sawmilling, Grants Sawmilling at Narrandera and Condobolin, Gulargambone Sawmilling and Austin's Sawmill at Quirindi to ensure the maintenance of the timber industry in the region.

An integrated forestry operations approval will be finalised in 2008. This provides a framework for forestry operations, including regulatory regimes for environmental planning and assessment, for the protection of the environment and the conservation of threatened species.

Source: Forests NSW

Eucalypt–cypress pine forest in the Brigalow Belt South region.

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 program provides the basis for forest planning to support sustainable management.

Key points

- The capacity to report trends in indicators, while still variable, is generally much improved since SOFR 2003.
- Data are comprehensive in coverage, currency and frequency for 15 indicators and more limited for 25 indicators. Case studies and other narrative material provide a large part of the information for four indicators.
- The ability to report on forest change varies considerably by tenure. The best information is available on multiple-use public forests and some public nature conservation reserves, for which governments require reporting against indicators. The biggest data gaps remain for leasehold and private forests.
- Jurisdictions continue to improve the coordination of reporting on forest indicators.

The extent to which relevant and up-to-date information about forests is available 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.

Reporting on sustainable forest management and management of forest values

State forest management agencies are committed to reporting regularly on forest management in multiple-use public forests using a 'triple bottom line' approach that incorporates economic, environmental and social values. Their reporting processes provide the level of specificity required for their jurisdictions, while the national reporting process provides a whole-of-nation overview and the basis for meeting international obligations.

For example, Victoria produced its first SOFR in 2005 as a benchmark for future five-yearly reports on forest management in the state's forests. The report is structured in line with the international Montreal Process, is consistent in style with the national SOFR, and complements the Victorian *State of the Parks Report* and *State of the Environment Report*. Tasmania's most recent SOFR was prepared in 2007 (Case study 66 on the SOFR website). In New South Wales, the State of the Parks assessment is conducted every three years (Case study 65 describes the reporting process for multiple-use public forests in New South Wales).

Capturing data and information

If a reporting system is to measure change in Australia's forests successfully, it must be underpinned by adequate and ongoing data collection. Few national reporting indicators are measured easily, and the availability, coverage and currency of data vary considerably. In the preparation of this report, data on all indicators were received from New South Wales, South Australia, Tasmania, Victoria and Western Australia; data on some indicators were received from the Australian Capital Territory, the Northern Territory and

Queensland. For some indicators, national-level data formed the major part of the analysis.

The focus on and priority given to data collection vary widely according to tenure. In publicly managed forests, especially those managed for multiple uses, including timber production, data are available for reporting on a range of indicators. By contrast, private landowners are rarely required and often have little incentive to collect data on their forests or to make such data available. As a result, the biggest gaps in information on Australia's forests are for privately managed forests or concern non-timber values. The SOFR reporting framework provides a mechanism for presenting disparate data in a consistent and repeatable format and should, over time, help to address problems associated with varying data collection processes, classification systems and standards.

Overall, the capacity to report trends has increased since SOFR 2003. For SOFR 2008, there was generally very good information on indicators relating to the contributions of forests to carbon cycles (Criterion 5), the legal, institutional and economic frameworks for forest conservation and sustainable use (Criterion 7), and several indicators in Criteria 2 and 6. For those indicators (around a third of all the indicators), it is possible to report change across various forest tenures. The remaining indicators were generally less amenable to reporting trends.

The best information is available for multiple-use public forests and some public nature conservation reserves, for which governments require reporting. Table 112 provides an assessment of the capacity to report on trends and an assessment of data availability, currency and coverage, by indicator.

Key data gaps in forest mapping

Data quality for forest type and extent varies by jurisdiction. In general, jurisdictions with large commercial forest areas and public forest management agencies were usually able to provide a significantly higher quantity and quality of data. Quality is highest for forest types in wetter regions along the country's east coast and in the southeast and southwest, with coarser-resolution mapping and little plot data available for drier inland forest types. In most jurisdictions, the best data are available for public forest land managed for wood production, while the biggest gaps are for forests on leasehold land. Data for forests on private land are slightly better than for those on leasehold land, although mapping is often old and inconsistent. Data on forests in nature conservation reserves are of variable quality, although some forests are well mapped for conservation management purposes.

Data systems

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 varies across the jurisdictions and by tenure. Inventories and assessments are undertaken regularly in all public forests managed for timber production, both for management purposes and to monitor and report performance. At the national level, the National Forest Inventory has primary responsibility for national forest assessment and reporting; it compiles and integrates data supplied by states and territories into national classification schemes and national databases. Inventories of plantation forests are conducted annually at the state and territory level and every five years at the national level.

Varying data collection techniques are needed to monitor and assess Australia's widely dispersed and varied forest types, including coarse-scale, remotely sensed data, air photo interpretation, and finer-scale, highly accurate data collected manually in the field. In addition to traditional forest inventories, broader forest assessments require a variety of social and economic data that must be obtained from a wide range of sources. These include the Australian Bureau of Statistics and the Australian Bureau of Agricultural and Resource Economics for data on employment and production, the National Land and Water Resources Audit for data on salinity, the Department of Climate Change for carbon-related data, and research agencies for a wide range of other data.

Recently, information availability has been improved by substantial investment in public forest inventory and by new information generated through government-mandated measures to protect non-wood forest values. However, private forest owners do not always have sufficient resources to undertake forest mapping, inventory or other data-gathering surveys.

References and further reading

DEC NSW (2004), DSE (2005), EPA SA (2003), EPA Qld (2003), EPA WA (2007), Forests NSW (2006), Forestry Tasmania (2007), Parks Victoria (2007) (list at the back of the report).

Web resources

Case study 66: TASVEG – Tasmania's reporting system

Table 112: Capacity to report trends in indicators and availability, coverage and currency of data to address indicators

Indicator		Data status			
		Report trend	Data coverage	Data currency	Data frequency
Criterion 1: Conservation of biological diversity					
1.1	**Ecosystem diversity**				
1.1a	Area of forest by type and tenure	●	●	●	●
1.1b	Area of forest by growth stage	●	●	●	●
1.1c	Area of forest in protected area category	●	●	●	●
1.1d	Fragmentation by forest cover	●	●	●	●
1.2	**Species diversity**				
1.2a	Forest-dwelling species with ecological information	●	●	●	●
1.2b	The status of forest-dwelling species at risk	●	●	●	●
1.2c	Representative species monitored	●	●	●	●
1.3	**Genetic diversity**				
1.3a	Species at risk of loss of genetic variation	●	●	●	●
1.3b	Genetic resource conservation mechanisms in place	●	●	●	●
Criterion 2: Maintenance of productive capacity of forest ecosystems					
2.1a	Native forest available for timber production	●	●	●	●
2.1b	Age class and growing stock of plantations	●	●	●	●
2.1c	Annual removal of wood products and volume sustainable	●	●	●	●
2.1d	Annual removal of non-wood products and volume sustainable	●	●	●	●
2.1e	Effective forest regeneration and plantation establishment	●	●	●	●
Criterion 3: Maintenance of ecosystem health and vitality					
3.1a	Scale and impacts on forest health and vitality	●	●	●	●
3.1b	Planned and unplanned fire NEW	●	●	●	●
Criterion 4: Conservation and maintenance of soil and water resources					
4.1a	Managing for protective function NEW	●	●	●	●
4.1b	Managing soil erosion NEW	●	●	●	●
4.1c	Managing soil physical properties NEW	●	●	●	●
4.1d	Managing water quantity NEW	●	●	●	●
4.1e	Managing water quality NEW	●	●	●	●
Criterion 5: Maintenance of forest contribution to global carbon cycles					
5.1a	Contribution to greenhouse gas balance	●	●	●	●
Criterion 6: Maintenance and enhancement of long term multiple socio-economic benefits to meet the needs of societies					
6.1	**Production and consumption**				
6.1a	Value and volume of wood products	●	●	●	●
6.1b	Value, volume and use of non-wood products	●	●	●	●
6.1c	Value of forest-based services NEW	●	●	●	●
6.1d	Wood production and consumption	●	●	●	●
6.1e	Recycling	●	●	●	●
6.2	**Investment in the forest sector**				
6.2a	Investment and expenditure in forests	●	●	●	●
6.2b	Investment in R&D and new technologies	●	●	●	●
6.3	**Recreation and tourism**				
6.3a	Forest area available for recreation/tourism	●	●	●	●
6.3b	Forest recreation facilities and use	●	●	●	●
6.4	**Cultural, social and spiritual**				
6.4a	Area to which Indigenous people have use and rights	●	●	●	●
6.4b	Registered places of non-Indigenous cultural value	●	●	●	●

Table 112: Capacity to report trends in indicators and availability, coverage and currency of data to address indicators *continued*

Indicator		Data status			
		Report trend	Data coverage	Data currency	Data frequency
6.4c	Protection of Indigenous values	●	●	●	●
6.4d	Importance of forests to people NEW	●	●	●	●
6.5	**Employment and community needs**				
6.5a	Employment	●	●	●	●
6.5b	Wage and injury rates	●	●	●	●
6.5c	Resilience of forest communities	●	●	●	●
6.5d	Resilience of Indigenous communities	●	●	●	●
Criterion 7: Legal, institutional and economic framework for forest conservation and sustainable management					
7.1a	Legal framework NEW	●	●	●	●
7.1b	Institutional framework NEW	●	●	●	●
7.1c	Economic framework NEW	●	●	●	●
7.1d	Capacity to measure and monitor NEW	●	●	●	●
7.1e	Capacity to conduct and apply R&D NEW	●	●	●	●

Key

Colour rating	Report trend	Data coverage	Data currency[a]	Data frequency[b]
●	Able to report trends across all or most tenures	Whole country assessed	1998+	Annual–5-yearly
●	Partial capacity to report trends	Incomplete data	1980–2001	>5 years
●	Limited capacity to report trends	Case study	Incomplete	Once only
●	No capacity to report trends	No data	No data	No data
○	Not applicable	Range in data coverage, currency and frequency	Range in data coverage, currency and frequency	Range in data coverage, currency and frequency

a Currency of available coverage.

b Frequency at which the colour code is updated.

Note: The predominant response appears in the relevant background colour but is also a possible mix of other possible responses. New indicators are red in the 'Report trend' column since there are no earlier matching data to enable trend analysis.

Case study 65: Transparent reporting for continual improvement in New South Wales

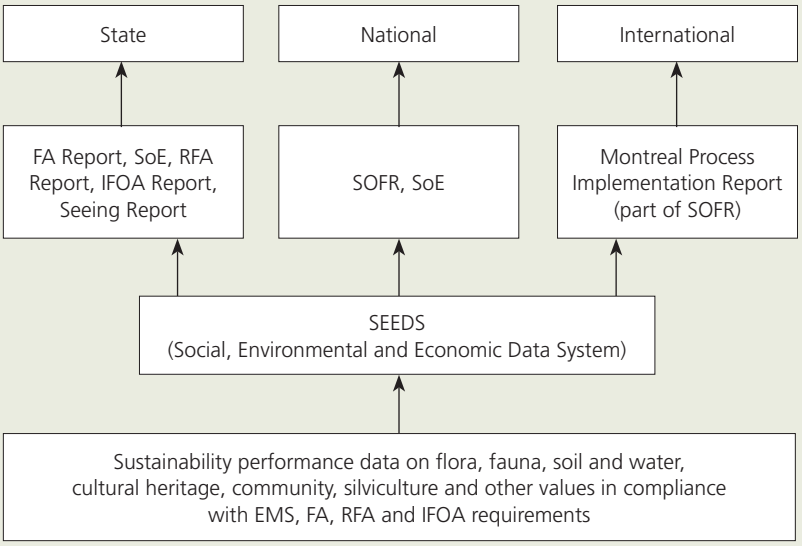
Since 1997, Forests NSW has produced an annual sustainability report, the *Social, Environmental and Economic (Seeing) Report*, with the aim of communicating the outcomes of management in multiple-use public forests for a range of forest values. The database used for the report, known as SEEDS (Social, Environmental and Economic Data System), also forms the basis of other statutory and non-statutory reports, including those associated with state forest agreements, integrated forestry operations approvals, ecologically sustainable forest management plans, performance against the Australian Forestry Standard, the New South Wales *State of the Environment Report*, the national SOFR, and the Commonwealth–state RFAs.

The Forests NSW reporting process is based on criteria and indicators formulated through the international Montreal Process. The agency's new environmental management system (EMS), which is certified to the International Organization for Standardization's ISO 14001:2004 EMS standard, sets the framework for achieving and continually improving environmental performance by introducing a systematic approach to measuring and monitoring. Central to the EMS is the Forests NSW environment policy, which is supported by ecologically sustainable forest management plans and which outlines the agency's broad strategies, performance indicators and defined outcomes.

Figure 96 shows the reporting processes served by the SEEDS database at the state, national and international levels.

Source: Forests NSW (2006)

Figure 96: Reporting processes served by the SEEDS database of Forests NSW



EMS = environmental management system; FA = (state) forestry agreement; IFOA = integrated forestry operations approval; RFA = regional forest agreement; SoE = state of the environment; SOFR = State of the Forests Report

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 the 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

- To improve overall collaboration and coordination of forest research, Australian, state and territory forest agencies have developed the following set of nationally critical research priorities: the impact of climate change on forest management; the role of forests in managing Australia's water resources; managing Australia's forests for multiple objectives; forest health and biosecurity; and forest products.
- Forest and Wood Products Australia provides a nationally coordinated investment approach to forestry industry research and development and has been given a stronger role in marketing and promotional services. It works with Australian, state and territory research providers.
- Governments are also investing in research and development through a variety of specific-purpose initiatives in partnership with the private sector, which drives investment in forest processing and manufacturing.

A scientific understanding of the characteristics and functions of Australian forest ecosystems is needed to underpin their management. Research and development provide the basis for biological and timber inventory, forest management, the silviculture of harvested forests and the development of methods for assessing sustainable forest management. This indicator examines the institutional capacity for research and development. Indicator 6.2b quantifies investments in research and development and shows changes in investment priorities over the reporting period.

Research and development

Among the key national research priorities announced by the Australian Government in 2002 are improvements in processing efficiencies and sustainable natural resource management. Research by Australia's forest-related research organisations is contributing to both those priorities.

Forest and Wood Products Australia (FWPA) is Australia's major national research body in the forest and wood product sector.[8] It invests in research and development projects relevant to the Australian forest and wood products sector and supports promotional and marketing activities. FWPA is jointly funded by the forest and wood product industry and the Australian Government. Other organisations also undertake forest-related research and development at a national level, including cooperative research centres (CRCs), universities, and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

The Australian Government and state and territory governments encourage research bodies such as universities, CSIRO and other government research agencies to cooperate with industry, government and clients as a way of ensuring that collaborative research focuses on key priorities. Such cooperation is often achieved through CRCs. CRCs that undertook forest-related research in

8 FWPA is an industry-owned research and development and marketing company created in 2007 to replace the Forests and Wood Products Research and Development Corporation.

the reporting period include the CRCs for greenhouse gas accounting; tropical rainforest ecology and management; tropical savanna management; and wood innovations. The CRC for Forestry continues the work of two previous forestry-based CRCs – the CRC for Temperate Hardwood Forestry (1991–97) and the CRC for Sustainable Production Forestry (1997–2005). A notable recent addition to the list of forest-related CRCs is the Bushfire CRC, which was established in July 2003.

A considerable amount of forest-related research is undertaken independently in government agencies (such as the Bureau of Rural Sciences and the Australian Bureau of Agricultural and Resource Economics at the national level) and universities. Most state governments reported that investments and employment (full-time equivalents) in forest-related research and development in 2005–06 were similar to those in 2001–02.

Recent research has led to the development of new silvicultural regimes designed to replace clearfelling and improve the conservation of all forest values. Case study 67 in this indicator examines research into alternatives to clearfelling in Australia's native forests; Case study 43 in Indicator 6.2b describes a long-term research endeavour in Tasmania.

To improve overall collaboration and coordination of forest research, the Australian, state and territory governments are supported by the Research Priorities and Co-ordination Committee (RPCC), which is a subcommittee of the Forestry and Forest Products Committee. The RPCC comprises representatives of national, state and territory agencies involved in forest and forest management research. It aims to:

- optimise the national and regional benefit from investment in forest research
- maintain an overview of forest research in Australia, with particular reference to the integration of public and private research and development arrangements and the implementation of research findings
- address research-related policy issues.

The RPCC oversees eight research working groups covering genetic resources; forest measurement and information; forests and water; native forest management; plantation management; fire management; forest health; and forest products.

In 2007, the RPCC developed a paper titled *Directions for Research and Development in the Forestry Sector – 2007–2010* based on the outcomes of a stakeholder driven workshop on forest research priorities and directions held in September 2006. The paper identifies five broad forest research themes of national importance: the impact of climate change on forest management; the role of forests in managing Australia's water resources; managing Australia's forests for multiple objectives; forest health and biosecurity; and forest products.

As discussed in indicator 6.2b, there has been a significant increase in research relating to the manufacture of forest products.

New technologies

Technology development can improve the contribution of the forest sector to national wealth through improved production efficiency and increased employment.

New technologies were adopted across all sectors of the forest and forest product industries during the reporting period. This has resulted in significant changes to employment and the location of wood harvesting and processing industries and influenced the shift of production from native forests to plantations. Case studies 68 and 69 illustrate those changes.

References and further reading

Forestry Tasmania (2007), FWPRDC (2006) (list at the back of the report).

Web resources

Australian Government Department of Education, Employment and Workplace Relations. National Research Priorities: www.dest.gov.au/sectors/research_sector/policies_issues_reviews/key_issues/national_research_priorities

Council of Rural Research & Development Corporations' Chairs website: www.innovateaustralia.com

Forest and Wood Products Australia website: www.fwprdc.org.au

Warra Long-term Ecological Research Site website: www.warra.com

Tall eucalypt forest, Victoria.

Case study 67: Research on alternatives to clearfelling in Australia's native forests

Recent research has led to the development of new silvicultural regimes designed to replace most clearfelling and improve the conservation of all forest values.

The 2005 Tasmanian Community Forest Agreement (Indicators 7.1a and 7.1c) requires Forestry Tasmania to implement non-clearfelling silviculture in a minimum of 80% of the annual harvest area of couped old-growth forest in multiple-use public native forest by 2010.

The clearfell, burn and sow (CBS) system has raised concerns, particularly because of reductions in late secondary species and structures, a decline in the special species timber resource (slow-growing non-eucalypt species prized by craft workers) when rotations of about 90 years are used, and the aesthetic effect of the system immediately after felling and burning. These concerns indicated a need to explore alternatives to clearfelling that are more socially acceptable, that increase the ability, or shorten the period, for the regenerated forest to return to pre-harvest condition, and that are still safe to implement and commercially viable.

Researchers took advantage of the Silvicultural Systems Trial, one of the projects under way at the Warra Long-term Ecological Research Site. The 200-hectare trial was conducted from 1998 to 2004 in multi-aged, 50-metre tall lowland wet eucalypt forest dominated by messmate stringybark (*Eucalyptus obliqua*), with the aim of comparing CBS with five alternative treatments:

- CBS with dispersed understorey islands that occupy <5% of the coupe area
- 80-metre width stripfells
- 10–15% (basal area) dispersed retention
- 30% (canopy area) aggregated retention
- single tree/small group selection (openings < mature tree height wide).

The development of these treatments was informed by the relatively few silvicultural systems that had previously been established in wet eucalypt forests in southeastern Australia, the most significant of which was the silvicultural systems project in Victoria. Subsequent terminology and modification and interpretation of the treatments have been informed by a developing awareness of international efforts to develop silvicultural alternatives in forest types traditionally managed for wood production by clearfelling.

The outcome of these trials has been the adoption of a form of variable retention silviculture called 'aggregated retention', which has been advocated for tall old-growth forest designated for wood production on public land. Under aggregated retention, representative patches of the original forest are kept among harvested sections of a coupe, so that forest influence is maintained over most of the area. As currently practised in Tasmania, 0.5–1.0-hectare aggregates of uncut forest are retained across a coupe, separated by 'fairways' approximately two tree heights in width. The slash on the fairways is burned to prepare a receptive seed bed for eucalypt regeneration.

Ten pilot variable-retention coupes have been harvested, with eight burned in the autumn 2007 burning season. Experience with these coupes indicates that planning for future aggregated retention coupes will need to consider a broader landscape approach, in preference to planning at the individual coupe level.

Source: Forestry Tasmania

As a result of research undertaken at Warra in the Silvicultural Systems Trial, variable retention silviculture has been applied operationally in other locations in Tasmania, here contrasted with clear-felled coupes in the background.

Case study 68: Value-adding technology

In Western Australia, Lignor Pty Ltd has developed and patented manufacturing technology to turn woodchips from the increasing supply of plantation hardwoods into engineered strand lumber and engineered strandboard – highly durable timber products that rival the strength of steel. The products' manufacture involves permanently setting the timber using a special resin under heat and pressure that prevents a loss of bonding when the products are immersed in water. Both are resistant to swelling, shrinking and warping and can be machined in any direction. Further treatments can be applied to make the products rot, termite and fire-resistant or to give them a smooth or anti-slip surface.

Other examples of new technologies in the forest industry include the use of soundwaves to measure timber stiffness in stress-grading machines and new, environmentally friendly, timber preservatives.

A plantation hardwood log is reduced to strands which are mixed with resin and compressed under heat and pressure to produce lumber.

Case study 69: Innovative planning for wood flows

The conceptual design, development and application of a high-tech plantation management system won Forests NSW a gold award in the 2005 New South Wales Premier's Public Sector Awards. Using the latest technology, the system forecasts the flow of softwood plantation timber from forest to customer. It predicts where wood is going to grow and where it will be transported, improving long-term forest management by ensuring that the best trees are harvested at the right time. While mainly used by Forests NSW in softwood plantations on the southwestern slopes, the system is also being deployed in even-aged regrowth native forests on the far south coast.

Streamlined planning and forecasting mean more efficient management of staff time, road networks and heavy machinery. About two-thirds of Forests NSW business is now on a 'delivered sales' basis, with the organisation responsible for growing, harvesting and hauling wood to the mill door. The new system allows planning across a 50–200-year period, which creates advantages in both environmental and commercial performance.

Source: Forests NSW

Appendix A

Comparison of international Montreal Process indicators with those used in SOFR 2003 and SOFR 2008

In reporting on the state of its forests, Australia uses the criteria developed by the international-level Montreal Process Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests. It has adapted the indicators to better suit reporting on the country's unique forests. In SOFR 2003, 74 indicators were devised and used as the basis of reporting (SOFR 1998 did not use the criteria-and-indicators approach). However, some of the indicators proved difficult to measure and some were repetitive.

The national-level Montreal Process Implementation Group for Australia, which comprises representatives of the Australian Government and state and territory governments, reviewed the list of indicators in 2005 with the aim of eliminating duplication, ambiguity and gaps; as a result of that review, the list of indicators was reduced to 44. The final list of indicators underpins Australia's 2008 State of the Forests Report. The three sets of indicators are presented in Table A1.

Table A1: Comparison of indicators: Montreal Process, SOFR 2003, SOFR 2008

No. in 1996 and/or 2003	International-level Montreal Process set of indicators (published 1996)	Indicators used in Australia's SOFR 2003	No. in 2008	Indicators used in Australia's SOFR 2008
Criterion 1 – Conservation of biological diversity				
1.1	Ecosystem diversity	Ecosystem diversity	1.1	Ecosystem diversity
1.1a	Extent of area by forest type relative to total forest area	Extent of area by forest type and tenure	1.1a	Area of forest by forest type and tenure
1.1b	Extent of area by forest type and by age class or successional stage	Area of forest type by growth stage distribution by tenure	1.1b	Area of forest by growth stage
1.1c	Extent of area by forest type in protected area categories as defined by IUCN or other classification systems	Combined with 1.1a	1.1c	Area of forest in protected area categories
1.1d	Extent of areas by forest type in protected areas defined by age class or successional stage	Combined with 1.1b		Combined with 1.1b
1.1e	Fragmentation of forest types	Fragmentation of forest types	1.1d	Fragmentation of forest cover
1.2	Species diversity	Species diversity	1.2	Species diversity
1.2a	The number of forest-dependent species	A list of forest-dwelling species	1.2a	Forest dwelling species for which ecological information is available
1.2b	The status (threatened, rare, vulnerable, endangered or extinct) of forest-dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment	Same as international	1.2b	The status of forest dwelling species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment
1.2c		Population levels of representative species from diverse habitats monitored across their range (moved from 1.3b)	1.2c NEW	Representative species from a range of habitats monitored at scales relevant to regional forest management

Table A1: Comparison of indicators: Montreal Process, SOFR 2003, SOFR 2008 *continued*

No. in 1996 and/or 2003	International-level Montreal Process set of indicators (published 1996)	Indicators used in Australia's SOFR 2003	No. in 2008	Indicators used in Australia's SOFR 2008
1.3	Genetic diversity	Genetic diversity	1.3	Genetic diversity
1.3a	Number of forest-dependent species that occupy a small portion of their former range	Amount of genetic variation within and between populations of representative forest-dwelling species	1.3a NEW	Forest associated species at risk from isolation and the loss of genetic variation, and conservation efforts for those species
1.3b	Population levels of representative species from diverse habitats monitored across their range	Included in 1.2c		
1.3c		Extent of native forest and plantations of indigenous species which have genetic resource conservation plans prepared and implemented	1.3b NEW	Native forest and plantations of indigenous timber species which have genetic resource conservation mechanisms in place
Criterion 2 – Maintenance of productive capacity of forest ecosystems				
2.1a	Area of forest land and net area of forest land available for timber production	Same as international	2.1a	Native forest available for wood production, area harvested, and growing stock of merchantable and non-merchantable tree species
2.1b	Total growing stock of both merchantable and non-merchantable tree species on forest land available for timber production	Same as international		Combined in 2.1a
2.1c	The area and growing stock of plantations of native and exotic species	The area, age class and future yields of plantations of native and exotic species	2.1b	Age class and growing stock of plantations
2.1d	Annual removal of wood products compared to the volume determined to be sustainable	Same as international	2.1c	Annual removal of wood products compared to the volume determined to be sustainable for native forests, and future yields for plantations
2.1e	Annual removal of non-timber forest products (e.g. fur bearers, berries, mushrooms, game), compared to the level determined to be sustainable	Annual removal of non-timber forest products (e.g. berries, mushrooms, game, honey, wildflowers, tree ferns, possums), compared to the sustainable level	2.1d	Annual removal of non-wood forest products compared to the level determined to be sustainable
2.1f		Area and per cent of plantation established meeting effective stocking one year after planting	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
2.1g		Area and per cent of harvested area of native forest effectively regenerated		Combined in Indicator 2.1e
2.1h		Extent of exotic plantations managed according to documented procedures or management plans to maintain genetic resources		Not included in new indicator set
Criterion 3 – Maintenance of ecosystem health and vitality				
3.1a	Area and per cent of forest affected by processes or agents beyond the range of historic variation	Area and per cent of forest affected by processes or agents that may change ecosystem health and vitality	3.1a	Scale and impact of agents and processes affecting forest health and vitality

Table A1: Comparison of indicators: Montreal Process, SOFR 2003, SOFR 2008 *continued*

No. in 1996 and/or 2003	International-level Montreal Process set of indicators (published 1996)	Indicators used in Australia's SOFR 2003	No. in 2008	Indicators used in Australia's SOFR 2008
3.1b	Area and per cent of forest land subjected to levels of specific air pollutants (e.g. sulfates, nitrate, ozone) or ultraviolet B that may cause negative impacts on the forest ecosystem	Area and per cent of forest land subjected to levels of specific air pollutants (e.g. sulfates, nitrate, ozone) or ultraviolet B that may cause negative impacts on forest ecosystem health and vitality		Not included in new indicator set
3.1c	Area and percentage of forest land with diminished biological components indicative of changes in fundamental ecological processes (e.g. soil nutrient cycling, seed dispersion, pollination) and/or ecological continuity (monitoring of functionally important species such as fungi, arboreal epiphytes, nematodes, beetles, wasps, etc)	Area and percentage of forest land with diminished or improved biological, physical and chemical components indicative of changes in fundamental ecological processes		Not included in new indicator set
			3.1b NEW	Area of forest burnt by planned and unplanned fire
Criterion 4 – Conservation and maintenance of soil and water resources				
4.1a	Area and per cent of forest land (including plantation) with significant soil erosion	*(Interim indicator) Area and per cent of forest land systematically assessed for soil erosion hazard, and for which site-varying scientifically based measures to protect soil and water values are implemented*		Not included in new indicator set
			4.1a NEW	Area of forest land managed primarily for protective functions
4.1b	Area and per cent of forest land (including plantations) managed primarily for protective functions (e.g. watersheds, flood protection, avalanche protection, riparian zones)	Same as international		Not included in new indicator set
			4.1b NEW	Management of the risk of soil erosion in forests
4.1c	Per cent of stream kilometres in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation	Same as international		Not included in new indicator set
			4.1c NEW	Management of the risks to soil physical properties in forests
4.1d	Area and per cent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties	*(Interim indicator) The total quantity of organic carbon in the forest floor (< 25 mm diameter components) and the surface 30 cm of soil*		Not included in new indicator set
			4.1d NEW	Management of the risks to water quantity from forests
4.1e	Area and per cent of forest land with significant compaction or change in soil physical properties resulting from human activities	*(Interim indicator) Proportion of harvested forest area with significant change in bulk density of any horizon of the surface (0–30 cm) soil*		Not included in new indicator set
			4.1e NEW	Management of the risks to water quality in forests

Table A1: Comparison of indicators: Montreal Process, SOFR 2003, SOFR 2008 *continued*

No. in 1996 and/or 2003	International-level Montreal Process set of indicators (published 1996)	Indicators used in Australia's SOFR 2003	No. in 2008	Indicators used in Australia's SOFR 2008
4.1f	Per cent of water bodies in forest areas (e.g. stream kilometres, lake hectares) with significant variance of biological diversity from the historic range of variability	Same as international		Not included in new indicator set
4.1g	Per cent of water bodies in forest areas (e.g. stream kilometres, lake hectares) with significant variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation or temperature change	Same as international		Not included in new indicator set
4.1h	Area and per cent of forest land experiencing an accumulation of persistent toxic substances	Same as international		Not included in new indicator set
Criterion 5 – Maintenance of forest contribution to global carbon cycles				
5.1a	Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age class, and successional stages	Same as international	5.1a NEW	Contribution of forest ecosystems and forest industries to the global greenhouse gas balance
5.1b	Contribution of forest ecosystems to the total global carbon budget, including absorption and release of carbon (standing biomass, coarse woody debris, peat and soil carbon)	Same as international		Considered in new Indicator 5.1a
5.1c	Contribution of forest products to the global carbon budget	Same as international		Considered in new Indicator 5.1a
Criterion 6 – Maintenance and enhancement of long term multiple socioeconomic benefits to meet the needs of societies				
6.1	Production and consumption	Production and consumption	6.1	Production and consumption
6.1a	Value and volume of wood and wood products production, including value added through downstream processing	Same as international	6.1a	Value and volume of wood and wood products
6.1b	Value and quantities of production of non-wood forest products	Same as international	6.1b	Values, quantities and use of non-wood forest products
6.1c	Supply and consumption of wood and wood products, including consumption per capita	Same as international	6.1c NEW	Value of forest-based services
6.1d	Value of wood and non-wood products production as percentage of GDP	Value of wood and non-wood products production as percentage of regional value of production	6.1d NEW	Production, consumption and trade of wood, wood products and non-wood products
6.1e	Degree of recycling of forest products	Same as international	6.1e	Same as 2003
6.1f	Supply and consumption/use of non-wood products	Same as international		Combined in Indicator 6.1d
6.2	Recreation and tourism	Recreation and tourism	6.3	Recreation and tourism
6.2a	Area and per cent of forest land managed for general recreation and tourism, in relation to the total area of forest land	Area and per cent of forest land available for general recreation and tourism	6.3a	Area of forest available for public recreation/tourism
6.2b	Number and type of facilities available for general recreation and tourism, in relation to population and forest area	Number, range and use of recreation/tourism activities available in a given region	6.3b	Range and use of recreation/ tourism activities available
6.2c	Number of visitor days attributed to recreation and tourism, in relation to population and forest area	Number of visits per annum		Combined in new Indicator 6.3b

Table A1: Comparison of indicators: Montreal Process, SOFR 2003, SOFR 2008 *continued*

No. in 1996 and/or 2003	International-level Montreal Process set of indicators (published 1996)	Indicators used in Australia's SOFR 2003	No. in 2008	Indicators used in Australia's SOFR 2008
6.2d		Proportion of forest sites available for recreation and tourism which are impacted unacceptably by visitors		Not included in new indicator set
6.3	Investment in the forest sector	Investment in the forest sector	6.2	Investment in the forest sector
6.3a	Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation and tourism	Same as international	6.2.a	Investment and expenditure in forest management
6.3b	Level of expenditure on research and development, and education	Same as international	6.2b NEW	Investment in research, development, extension and the use of new and improved technologies
6.3c	Extension and use of new and improved technologies	Same as international		Combined in new Indicator 6.2b
6.3d	Rates of return on investment	Same as international		Not included in new indicator set
6.4	Cultural, social and spiritual needs and values	Cultural, social and spiritual needs and values	6.4	Cultural, social and spiritual needs and values
6.4a	Area and per cent of forest land managed in relation to the total area of forest land to protect the range of cultural, social and spiritual needs and values	(i) Area and per cent of forest land in defined tenures, management regimes and zonings which are formally managed in a manner which protects Indigenous peoples' cultural, social, religious and spiritual values, including non-consumptive appreciation of country	6.4a	Area of forest to which Indigenous people have use and rights that protect their special values and which are recognised through formal and informal management regimes
		(ii) Proportion of places of non-Indigenous cultural value in forests formally managed to protect those values	6.4b	Registered places of non-Indigenous cultural value in forests that are formally managed to protect those values
		(iii) Extent to which the management framework maintains and enhances Indigenous values including customary, traditional and native title use by Indigenous peoples and for Indigenous participation in forest management (not reported)	6.4c NEW	The extent to which Indigenous values are protected, maintained and enhanced through Indigenous participation in forest management
6.4b	Non-consumptive use forest values	Same as international	6.4d	The importance of forests to people
6.5	Employment and community needs	Employment and community needs	6.5	Employment and community needs
6.5a	Direct and indirect employment in the forest sector and forest sector employment as a proportion of total employment	Same as international	6.5a	Direct and indirect employment in the forest sector
6.5b	Average wage rates and injury rates in major employment categories within the forest sector	Same as international	6.5b	Wage rates and injury rates within the forest sector
6.5c	Viability and adaptability to changing social and economic conditions, of forest-dependent communities, including Indigenous communities	(i) Viability and adaptability to changing social and economic conditions, of forest-dependent communities	6.5c	Resilience of forest-dependent communities to changing social and economic conditions

Table A1: Comparison of indicators: Montreal Process, SOFR 2003, SOFR 2008 *continued*

No. in 1996 and/or 2003	International-level Montreal Process set of indicators (published 1996)	Indicators used in Australia's SOFR 2003	No. in 2008	Indicators used in Australia's SOFR 2008
		(ii) Viability and adaptability of forest-dependent Indigenous communities	6.5d	Resilience of forest-dependent Indigenous communities to changing social and economic conditions
6.5d	Area and per cent of forest land used for subsistence purposes	Area of land available and accessible for Indigenous people to exercise their inherent rights to meet subsistence or individual and family cultural and spiritual needs		Combined into new Indicator 6.4c
Criterion 7 – Legal, institutional and economic framework for forest conservation and sustainable management				
7.1	Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it:			
			7.1a NEW	Extent to which the legal framework supports the conservation and sustainable management of forests
7.1a	Clarifies property rights, provides for appropriate land tenure arrangements, recognises customary and traditional rights of Indigenous people and provides means of resolving property disputes by due process	Provides mechanisms to clarify property rights and establish appropriate land tenure arrangements that recognise traditional management practices and self-management as well as the existence of native title and the customary and traditional rights of Indigenous peoples		Combined in new Indicator 7.1a
7.1b	Provides for periodic forest-related planning, assessment, and policy review that recognises the range of forest values, including coordination with relevant sectors	Same as international		As above
7.1c	Provides opportunities for public participation in public policy and decision making related to forests and public access to information	Same as international		As above
7.1d	Encourages best practice codes for forest management	Encourages the development and application of best practice codes for forest management		As above
7.1e	Provides for the management of forests to conserve special environmental, cultural, social and/or scientific values	Provides for the management of environmental, cultural, social and/or scientific values in forests and ensures the participation of Indigenous peoples in all aspects of forest planning and management processes		As above
7.2	Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to:			
			7.1b NEW	Extent to which the institutional framework supports the conservation and sustainable management of forests

Table A1: Comparison of indicators: Montreal Process, SOFR 2003, SOFR 2008 *continued*

No. in 1996 and/or 2003	International-level Montreal Process set of indicators (published 1996)	Indicators used in Australia's SOFR 2003	No. in 2008	Indicators used in Australia's SOFR 2008
7.2a	Provide for public involvement activities and public education, awareness and extension programmes and make available forest-related information	Same as international		Combined in new Indicator 7.1b
7.2b	Undertake and implement periodic forest-related planning, assessment, and policy review including cross-sectoral planning and coordination	Same as international		As above
7.2c	Develop and maintain human resource skills across relevant disciplines	Same as international		As above
7.2d	Develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and support forest management	Same as international		As above
7.2e	Enforce laws, regulation and guidelines	Same as international		As above
7.3	Extent to which the economic framework (economic policies and measures) supports the conservation and sustainable management of forests through:			
			7.1c NEW	Extent to which the economic framework supports the conservation and sustainable management of forests
7.3a	Investment and taxation policies and a regulatory environment which recognise the long-term nature of investments and permit the flow of capital in and out of the forest sector in response to market signals, non-market economic valuations, and public policy decisions in order to meet long-term demands for forest products and services	Same as international		Combined in new Indicator 7.1c
7.3b	Nondiscriminatory trade policies for forest products	Same as international		As above
7.4	Capacity to measure and monitor changes in the conservation and sustainable management of forests, including:			
			7.1d NEW	Capacity to measure and monitor changes in the conservation and sustainable management of forests
7.4a	Availability and extent of up-to-date data, statistics and other information important to measuring or describing indicators associated with Criteria 1–7	Same as international		Combined in new Indicator 7.1d
7.4b	Scope, frequency and statistical reliability of forest inventories, assessments, monitoring and other relevant information	Same as international		As above
7.4c	Compatibility with other countries in measuring, monitoring and reporting on indicators	Same as international		As above
7.5	Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services			

Table A1: Comparison of indicators: Montreal Process, SOFR 2003, SOFR 2008 *continued*

No. in 1996 and/or 2003	International-level Montreal Process set of indicators (published 1996)	Indicators used in Australia's SOFR 2003	No. in 2008	Indicators used in Australia's SOFR 2008
			7.1e NEW	Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services
7.5a	Development of scientific understanding of forest ecosystem characteristics and functions	Same as international		Combined in new Indicator 7.1e
7.5b	Development of methodologies to measure and integrate environmental and social costs and benefits into markets and public policies, and to reflect forest-related resource depletion or replenishment in national accounting systems	Same as international		As above
7.5c	New technologies and the capacity to assess the socio-economic consequences associated with the introduction of new technologies	Same as international		As above
7.5d	Enhancement of ability to predict impacts of human intervention on forests	Same as international		As above
7.5e	Ability to predict impacts on forests of possible climate change	Same as international		As above
7.5.f		Per cent of native forests and plantations that are formally supported by silvicultural and utilisation research support		Not included in new indicator set

Appendix B

Indicator 1.1d – Fragmentation metrics

Table B1: Fragmentation metrics for Tasmanian bioregions, all forest types combined, by tenure, 1972 to 2002

Bioregion	Number of patches[a]	Mean patch size	Mean nearest neighbour	Patch density	Edge density	Fragmentation: overall synthesis by bioregion
Forests in nature conservation reserves[b]						
Tasmanian Central Highlands	Decreased 3% 1972–92, then increased 2% to 2002	Increased 4% 1972–92, then decreased 4% to 2002	Increased 4% to 1992, then decreased 4% to 2002	Decreased 4% 1972–92, then increased 4% to 2002	Fluctuated within a 2% range	Decreasing fragmentation 1972–92, then increasing to 2002
King	Decreased 10% 1972–92, then increased 6% to 2002	Increased 20% 1972–92, then about the same to 2002	Increased 21% to 1992, then decreased 11% to 2002	Decreased 17% 1992–2002	Fluctuated within a 4% range	Large decrease in fragmentation 1972–92, then increasing to 2002
Tasmanian Northern Slopes	Decreased 2% 1972–92, then increased 2% to 2002	Increased 4% 1972–98, then decreased 2% to 2002	Fluctuated within a 5% range 1972–2002	Decreased 4% 1972–98, then increased 2% to 2002	Fluctuated within a 1% range 1972–2002	Decreasing fragmentation 1972 to 1992–98, then increasing to 2002
Tasmanian South East	Decreased 10% 1972–98, then increased 1% to 2002	Increased 14% 1972–98, then decreased 2% to 2002	Increased 60% to 1998, then decreased 1% to 2002	Decreased 11% 1972–2002	Decreased 6% 1972–92, then increased 1% to 2002	Large decrease in fragmentation 1972 to 1992–98, then increasing to 2002
Tasmanian Southern Ranges	Decreased 6% 1972–92, then increased 1% to 2002	Increased 15% 1972–92, then decreased 2% to 2002	Increased 25% to 1998, then decreased 1% to 2002	Decreased 7% 1972–92, then increased 2% to 2002	Decreased 5% 1972–92, then increased 1% to 2002	Large decrease in fragmentation 1972 to1992–98, then increasing to 2002
Tasmanian West	Decreased 3% 1972–92, then increased 6% to 2002	Increased 4% 1972–92, then decreased 6% to 2002	Increased 3% to 1992, then decreased 7% to 2002	Decreased 4% 1972–92, then increased 7% to 2002	Decreased 1% 1972–92, then increased 4% to 2002	Decreasing fragmentation 1972–92, then increasing to 2002
Multiple-use public forests						
Ben Lomond	Decreased 2%	Increased 5%	Fluctuated within a 1% range	Decreased 5%	Fluctuated within a 3% range	Decreasing fragmentation
Tasmanian Central Highlands	Decreased 4%	Increased 8%	Fluctuated within a 3% range	Decreased 8%	Fluctuated within a 3% range	Decreasing fragmentation 1992–2002
Flinders	Decreased 5%	Increased 7%	Increased 6%	Decreased 7%	Decreased 7%	Decreasing fragmentation
King	Decreased 16%	Increased 32%	Increased 3%	Fluctuating within a 7% range	Decreased 16%	Decreasing fragmentation
Tasmanian Northern Slopes	Decreased 5%	Increased 11%	Increased 3%	Decreased 10%	Decreased 7%	Decreasing fragmentation
Tasmanian Northern Midlands	Increased 3%	Decreased 1%	Increased 4%	Increased 1%	Fluctuating within a 2% range	Increasing fragmentation

Table B1: Fragmentation metrics for Tasmanian bioregions, all forest types combined, by tenure, 1972 to 2002 *continued*

Bioregion	Number of patches[a]	Mean patch size	Mean nearest neighbour	Patch density	Edge density	Fragmentation: overall synthesis by bioregion
Tasmanian South East	Decreased 10%	Increased 10%	Increased 10%	Decreased 13%	Decreased 9%	Greatly decreasing fragmentation
Tasmanian Southern Ranges	Increased 1% 1972–92, then decreased 5% to 2002	Decreased 3% 1972–92, then increased 8% to 2002	Decreased 7% 1972–1998, then increased 3% to 2002	Increased 3% 1972–92, then decreased 8% to 2002	Fluctuated within a 2% range	Increasing fragmentation 1972 to 1992–98, then decreasing to 2002
Tasmanian West	Increased 1% 1972–80, then decreased 8% to 2002	Decreased 2% 1972–80, then increased 13% to 2002	Increased 5%	Increased 2% 1972–1980, then decreased 13% to 2002	Increased 2% 1972–80, then decreased 7% to 2002	Increasing fragmentation 1972–1980, then decreasing greatly to 2002
Private forests						
Ben Lomond	Fluctuated within a 2% range	Decreased 9%	Fluctuated within a 1% range	Decreased 8%	Decreased 6%	Fragmentation fluctuating
Tasmanian Central Highlands	Fluctuated within a 1% range	Fluctuating within a 1% range	Fluctuated within a 2% range	Fluctuated within a 1% range	Fluctuated within a 3% range	Fragmentation fluctuating
Flinders	No change 1972–80, then increased 6% to 2002	Fluctuating within a 2% range	Increased 1% 1972–92, then decreased 5% to 2002	Fluctuated within a 2% range	Fluctuated within a <1% range	Fragmentation fluctuating
King	Decreased 1% 1972–80, then increased 8% to 2002	Decreased 6% 1972–92, then increased 5% to 2002	Decreased 7%	Fluctuated within a 3% range	Fluctuated within a 1% range	Fragmentation fluctuating
Tasmanian Northern Slopes	Decreased 4% 1972–80, then increased 9% to 2002	Decreased 5% 1972–92, then increased 13% to 2002	Increased 3% 1972–80, then decreased 8% to 2002	Fluctuated within a 7% range	Fluctuated within a 4% range	Fragmentation fluctuating
Tasmanian Northern Midlands	Fluctuated within a 5% range	Fluctuated within a 1% range	Fluctuated within a 7% range	Fluctuated within a 2% range	Decreased 4%	Fragmentation fluctuating
Tasmanian South East	Decreased 5% 1972–92, then increased 2% to 2002	Increased 10% 1972–92, then decreased 1% to 2002	Fluctuated within a 2% range	Fluctuated within a 6% range	Decreased 6% 1972–92, then increased 1% to 2002	Fragmentation fluctuating
Tasmanian Southern Ranges	Fluctuated within a 2% range	Decreased 5% 1972–92, then increased 3% to 2002	Fluctuated within a 2% range	Fluctuated within a 4% range	Fluctuated within a 3% range	Fragmentation fluctuating
Tasmanian West	Increased 4% 1972–92, then decreased 7% to 2002.	Decreased 3% 1972–92, then increased 9% to 2002	Decreased 13% 1972–92, then increased 7% to 2002	Fluctuated within a 6% range	Fluctuated within a 1% range	Fragmentation fluctuating

a See Table 17 in Indicator 1.1d for meanings of column headings.

b There was insufficient area of nature conservation reserves in Ben Lomond, Flinders and Tasmanian Northern Midlands bioregions for meaningful analysis.

Table B2: Fragmentation metrics for Queensland bioregions, all forest types combined, by tenure, 1972 to 2002

Bioregion	Number of patches[a]	Mean patch size	Mean nearest neighbour	Patch density	Edge density	Fragmentation: overall synthesis by bioregion
Forests in nature conservation reserves						
Banana–Auburn Ranges	Decreased 29%	Increased 47%	Increased 53% to 1998, then constant to 2002	Fluctuated within a 30% range	Fluctuated within a 4% range	Large decrease in fragmentation
Barakula	Decreased 6% 1972–92, then constant to 2002	Increased 8% 1972–92, then constant to 2002	Increased 13% to 1992, then constant to 2002	Fluctuated within a 13% range	Fluctuated within a 6% range	Decrease in fragmentation
Burnett–Curtis Coastal Lowlands	Decreased 45%	Increased 105%	Increased 96%	Decreased 53%	Decreased 37%	Decrease in fragmentation
Burnett–Curtis Hills and Ranges	Decreased 35%	Increased 76%	Increased 94% to	Decreased 43%	Decreased 35%	Large decrease in fragmentation
Carnarvon Ranges	Fluctuated within a 6% range	Fluctuated within a 7% range	Fluctuated within a 37% range	Fluctuated within a 7% range	Fluctuated within a 12% range	Fragmentation fluctuating
Inglewood Sandstones	Decreased 56%	Increased 132%	Extremely large increase	Decreased 56% 1972–99, then constant to 2002	Fluctuated within a 7% range	Large decrease fragmentation 1972–92, then increasing to 2002
Southeast Hills and Ranges	Increased 6%	Decreased 10% 1972–92, then constant to 2002	Decreased 27% 1972–98, then constant to 2002	Fluctuated within a 6% range	Fluctuated within a 4% range	Decrease in fragmentation
Woorabinda	Decreased 19%	Increased 29% 1972–98, then decreased 1% to 2002	Increased 25% 1972–98, then decreased 2%to 2002	No data	Fluctuated within a 6% range	Large decrease in fragmentation
Multiple-use public forests						
Banana–Auburn Ranges	Fluctuated within a 6% range	Fluctuated within a 8% range	Increased 22% 1972–80, then decreased 19% to 2002	Fluctuated within a 7% range	Fluctuated within a 5% range	Fragmentation fluctuating
Barakula	Increased 3% 1972–80, then decreased 8% to 1998, then constant to 2002	Decreased 2% 1972–80, then increased 8% to 2002	Decreased 1% 1972–80, then increased 10% to 2002	Fluctuated within a 13% range	Decreased 10%	Decreasing fragmentation
Burnett–Curtis Coastal Lowlands	Decreased 22% 1972–98, then increased 1% to 2002	Increased 48% 1972–98, then decreased 1% to 2002	Increased 18% 1972–98, then decreased 1% to 2002	Decreased 32%	Decreased 24%	Decreasing fragmentation
Burnett–Curtis Hills and Ranges	Fluctuated within a 5% range	Increased 15% 1972–98, then decreased 1% to 2002	Increased 15% 1972–98, then decreased 1% to 2002	Fluctuated within a 12% range	Decreased 14%	Fluctuating fragmentation
Carnarvon Ranges	Decreased 30%	Increased 48%	Decreased 14% 1972–92, then increased 40% to 2002	Decreased 33%	Fluctuated within a 9% range	Large decrease in fragmentation
Inglewood Sandstones	Increased 26% 1972–98, then increased 2% to 2002	Increased 38% 1972–98, then decreased 2% to 2002	Increased 32% 1972–98, then decreased 10% to 2002	Decreased 29% 1972–98, then constant to 2002	Decreased 11%	Increase in fragmentation
Southeast Hills and Ranges	Fluctuated within a 5% range	Fluctuated within a 4% range	Decreased 7% 1972–92, then increased 1% to 2002	Fluctuated within a 5% range	Decreased 6%	Fluctuating fragmentation
Woorabinda	Fluctuated within a 12% range	Increased 28% 1972–92, then decreased to 2002	Fluctuated within a 7% range	No data	Decreased 28% 1972–80, then fluctuated within a 3% range 1980–2002	Fluctuated fragmentation

Table B2: Fragmentation metrics for Queensland bioregions, all forest types combined, by tenure, 1972 to 2002 *continued*

Bioregion	Number of patches[a]	Mean patch size	Mean nearest neighbour	Patch density	Edge density	Fragmentation: overall synthesis by bioregion
Private forests						
Banana–Auburn Ranges	Fluctuated within a 9% range	Fluctuated within a 12% range	Fluctuated within a 5% range	Fluctuated within a 10% range	Fluctuated within a range of 7%	Fragmentation fluctuating
Barakula	Fluctuated within a 5% range	Fluctuated within a 8% range	Fluctuated within a 6% range	Fluctuated within a 7% range	Fluctuated within a 8% range	Fragmentation fluctuating
Burnett–Curtis Coastal Lowlands	Fluctuated within a 5% range	Fluctuated within a 10% range	Increased 4% 1972–92, then decreased 5% to 2002	Fluctuated within a 4% range	Decreased 8%	Fragmentation fluctuating
Burnett–Curtis Hills and Ranges	Decreased 18%	Increased 41%	Increased 11%	Decreased 29%	Decreased 21%	Fragmentation decreasing
Inglewood Sandstones	Fluctuated within a 14% range	Fluctuated within a 20% range	Fluctuated within a 8% range	Decreased 23% 1972–80, then fluctuated within a 4% range to 2002	Decreased 4%	Fragmentation fluctuating
Southeast Hills and Ranges	Fluctuated within a 5% range	Fluctuated within a 7% range	Fluctuated within a 4% range	Fluctuated within a 7% range	Decreased 11% 1972–80, then fluctuated within a 1% range to 2002	Fragmentation fluctuating
Woorabinda	Decreased 21% 1972–92, then increased 5% to 2002	Increased 49% 1972–92, then decreased 5% to 2002	Fluctuated within a 12% range	No data	Decreased 30% 1972–80, then fluctuated within a 2% range to 2002	Fragmentation increasing

a See Table 17 in Indicator 1.1d for meanings of column headings.

Appendix C

Indicator 1.3a – Forest associated species at risk from isolation and the loss of genetic variation, and conservation efforts for those species

Table C1: Examples of forest-associated tree species for which genetic data are available

Species	Common name	Genetic marker	Publications
Eucalyptus kochii	Oil mallee	RFLPs (nuclear)	Byrne M (1999). High genetic identities between three oil mallee taxa, *Eucalyptus kochii*, subsp. *plenissima* and *E. horistes*, based on nuclear RFLP analysis. *Heredity* 82:205–211.
E. loxophleba	York gum	RFLPs (chloroplast DNA)	Hines B and Byrne M (2001). Genetic differentiation between mallee and tree forms in the *Eucalyptus loxophleba* complex. *Heredity* 87:566–572.
			Byrne M and Hines B (2004). Phylogeographical analysis of cpDNA variation in *Eucalyptus loxophleba* (Myrtaceae). *Australian Journal of Botany* 52:459–470.
E. marginata	Jarrah	RFLPs, isozymes	Millar M, Byrne M, Coates D, Stukely M and McComb J (2000). Mating system studies in jarrah, *Eucalyptus marginata* (Myrtaceae). *Australian Journal of Botany* 48:475–479. Wheeler MA, Byrne M and McComb JA (2003). Little genetic differentiation within the dominant forest tree, *Eucalyptus marginata* (Myrtaceae) of South-Western Australia. *Silvae Genetica* 52:5–6.
		Chloroplast DNA	Wheeler M and Byrne M (2006). Congruence between phylogeographic patterns in cpDNA variation in *Eucalyptus marginata* (Myrtaceae) and geomorphology of the Darling Plateau, south-west of Western Australia. *Australian Journal of Botany* 54:17–26.
E. occidentalis	Yate	RFLPs (nuclear)	Elliott C and Byrne M (2003). Genetic diversity within and between natural populations of Eucalyptus occidentalis (Myrtaceae). *Silvae Genetica* 52:3–4.
E. angustissma subsp. *angustissma*	Narrow-leaved mallee	RFLPs (nuclear and chloroplast DNA)	Elliot CP and Byrne M (2004). Phylogenetics and the conservation of rare taxa in the *Eucalyptus angustissima* complex in Western Australia. *Conservation Genetics* 5:39–47.
E. diversicolor	Karri	Isozymes	Coates D and Sokolowski R (1989). Geographic patterns of genetic diversity in karri (*Eucalyptus diversicolor* F. Muell.). *Australian Journal of Botany* 37:145–156.
E. gompho-cephala	Tuart	Isozymes	Coates D, Keighery G and Broadhurst L (2002). Genetic and morphological variation, and the mating system in tuart. In: *Tuart* (Eucalyptus gomphocephala) *and Tuart Communities*. Wildflower Society of Western Australia, Perth Branch, Nedlands, 89–107.
Acacia saligna	Orange wattle	RFLPs (nuclear)	George N, Byrne M, Maslin B and Yan G (2006). Genetic differentiation among morphological variants of *Acacia saligna* (Mimosaceae). *Tree Genetics and Genomes* 2:109–119.
E. grandis	Flooded gum	Chloroplast DNA	Jones M, Shepherd M, Henry R and Delves A (2006). Chloroplast DNA variation and population structure in the widespread forest tree, *Eucalyptus grandis*. *Conservation Genetics* 7(5):691–703.

Table C2: Examples of forest-associated fauna species for which genetic data are available

Species	Common name	Genetic marker	Publications
Setonix brachyurus	Quokka	Allozymes, mtDNA	Sinclair E (2001). Phylogeograhpic variation in the quokka, *Setonix brachyurus* (Marsupialia: Macropodidae): implications for conservation. *Animal Conservation* 4:325–333.
Phascogale tapoatafa	Brush-tailed phascogale	mtDNA	Spencer P, Rhind S and Eldridge M (2001). Phylogeographic structure within *Phascogale* (Marsupialia: Dasyuridae) based on partial cytochrome b sequence. *Australian Journal of Zoology* 49:369–377.

Appendix D

Impacts of animals, plant pests and pathogens on ecosystem health

Table D1: Impact of various vertebrates on ecosystem health and vitality in forest areas, by jurisdiction and tenure

	ACT		NSW		NT		Qld		SA		Tas.		Vic.		WA	
	MUF	NCR	MUF	NCR[a]	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR
Mammals																
Native																
Dingo (*Canis familiaris dingo*)	Y3		Y4	N-	Y1	Y1	Y3	Y3	N0	N0	N0	N0	Y1	N-	N-	N-
Kangaroo (*Macropus* spp.)	Y4		Y3	N-	Y3	Y3	Y3	N3	Y4		N1	Y4	Y3	N-	Y3	Y3
Native rat	N-		N-	N-	Y3	Y3	Y3	Y3	Y1	Y1	N3	N3	Y3	N-	N	N
Pademelon (*Thylogale* spp.)			Y1	N-		N-	Y3	Y3	N0	N0	Y5	Y4	Y0	N-		
Possum	N-		Y4	N-	Y1	Y3	Y3	Y3	Y1	Y1	Y5	Y4	Y3	N-	N	N
Wallaby (several species)	N-		Y3	N-	Y3	Y3	Y3	Y3	Y1	Y1	Y5	Y4	Y3	N-	N	N
Exotic																
European red fox (*Canis vulpes*)	Y5		Y4	Y-	Y1	Y1	Y5	Y5	Y3	Y5	Y2	Y2	Y4	Y5	Y5	Y5
Feral cat (*Felis cattus*)	Y4		Y4	Y-	Y4	Y4	Y5	Y5	Y1	Y3	Y3	Y3	Y3	Y4	Y4	Y4
Feral deer (several species)	Y0		Y2	Y-	Y1	Y0	Y2	Y2	Y4	Y4	Y2	Y1	Y4	Y1	N	N
Feral dog (*Canis familiaris*)	Y3		Y4	Y-	Y3	Y3	Y3	Y3	N1	N1	N1	N1	Y3	Y2	Y1	Y1
Feral donkey (*Equus asinus*)			Y1	N-	Y4	Y4	Y1	Y0	N0	N0	N0	N0	Y0	N-	N	N
Feral goat (*Capra hircus*)	Y5		Y3	Y-	Y1	Y1	Y5	Y4	N1	Y2	Y1	Y2	Y1	Y2	N	N
Feral horse (*Equus caballus*)	Y2		Y3	Y-	Y4	Y4	Y1	Y4	N1	N1	N0	N0	Y1	Y2	N	N
Hare (*Lepus capensis*)	Y3		Y1			N-	Y3	Y1	Y5		N1	N1	Y1	N-	N	N
House mouse (*Mus musculus*)	Y3		Y3		Y3	Y1	Y3	Y3	Y1	Y3	N1	Y3	Y1	N-	N	N
Pig (*Sus scrofa*)	Y5		Y5	Y-	Y5	Y5	Y4	Y4	N1	N1	N0	N2	Y1	Y2	Y4	Y4
Rabbit (*Oryctolagus cuniculus*)	Y5		Y5	Y-	Y3	Y2	Y3	Y3	Y1	Y4	Y4	Y2	Y3	Y5	Y3	Y3
Rat, exotic (some *Rattus* spp.)	Y3		Y2		Y3	Y3	Y1	Y1	N1	Y1	N1	Y3	Y1	N-	N	N
Amphibians																
Exotic																
Cane toad (*Bufo marinus*)			Y2	Y-	Y5	Y4	Y5	Y4	N0	N0	N0	N0	Y0			
Birds																
Native																
Cockatoo (*Cacatua* spp.)			Y2	N-		Y0			N0	N0	N3	N3	Y3		Y4[b]	N
Parrot			N-	N-		Y0			N0	N0	N3	N3	Y3		Y5[c]	N
Exotic																
Blackbird (*Turdus* merula)	Y5		N-	N-		N-		N0	N0	N0	N1	Y1	Y1		N-	N-
Common myna (*Acridotheres tristis*)	Y4		N-	N-		N-	Y1	N0	N0	N0	N0	N0	N0		N-	N-
Starlings/sparrows (*Sturnus vulgaris*/*Passer domesticus*)	Y4		N-	N-		N-	Y4	N0	N0	N0	N3	Y2	Y0		N-	N-

MUF = multiple-use public forest; N = not considered to be a problem; N- = not rated; NCR = public nature conservation reserve; Y = considered to be a problem

Impact scores: 0 = reported present but not problematic; 1 = occurs but restricted distribution, has little impact; 2 = restricted distribution and adverse impact; 3 = widespread distribution but having minimal impacts; 4 = widespread distribution and having adverse impacts locally; 5 = very widespread and having widespread adverse impact; - = not scored; blank = no data

a NSW only rated top-five threats in NCRs.

b Plantation only.

c Plantation only; Y2 for native MUF.

Source: State and territory agencies

Table D2: Impact of various invertebrates on ecosystem health and vitality in forest areas, by jurisdiction and tenure

	ACT		NSW		NT		Qld		SA		Tas.		Vic.		WA	
	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	PTN/ MUF[a]	NCR
Australian plague locust (*Chortoices termanifera*)			Y5								N0	N0				
Autumn gum moth (*Mnesampela privata*)	Y1		Y0				N1		Y4		Y3	N3	Y4	Y3	N1/N1	N0
Bees (several species)	Y4		Y0		Y3		N0		Y0		N3	Y3	Y0	Y1	N0/N1	Y1
Beetle, African black (*Heteronychus arator*)			Y0				N0		Y1		N0	N0	Y1	Y1	Y4/N1	N1
Beetle, Christmas (*Anoplognathus* spp.)	Y3		Y4		Y3		Y2		Y0		N1	N1	Y3	Y3	Y0/Y0	Y0
Beetle, five-spined bark (*Ips grandicollis*)	Y1		Y3				Y4		Y4		N0	N0	Y3	Y0	Y4/Y4	N0
Beetle, leaf/flea (chrysomelids)			Y4		Y3		Y4		Y4		Y4	N3	Y4	Y4	Y2/Y0	N1
Beetle, longicorn (cerambycids)			Y4				Y3		Y3		Y4	N3	Y2	Y3	Y2/Y2	N1
Beetle, spring (*Heteronyx* spp.)									Y3		Y4	N1				
Borers (*Lepidoptera*)			Y4				Y4		Y1		Y4	N3	Y4	Y3	Y2/Y1	N1
Cup moth (*Doratifera* spp.)			Y0				N3		Y2		N0	N0	Y4	Y2	N1/N1	N1
Grasshopper (acridids)	Y1				Y3		Y4		Y3				Y4	Y1	N1/N1	Y1
Gum tree scale (*Eriococcus* spp.)			Y0								Y3	N1	Y4			
Gumleaf skeletoniser (*Uraba lugens*)			Y0				N1		Y1		Y3	N2	Y1	Y2	Y0/Y5	Y5
Leaf miner (*Perthida glyphopa*)	Y1		Y0		Y3		N0		Y1		N3	N3	Y3	Y3	Y0/Y4	Y4
Lerps (psyllids)	Y4		Y4		Y3		Y3		Y1		Y4	N3	Y4	Y4	N0/N0	Y5
Monterey pine aphid (*Essigella californica*)			Y5				Y3				Y1	N0	Y5	Y0		
Saw fly (*Perga dorsalia, Pergagrapta bella*)			Y0				Y4		Y4		Y3	N1	Y4	Y1	N1/N1	N1
Termites (*Cryptotermes, Coptotermes* spp.)			Y0				N3		Y0		Y4	N3	Y1	Y1	N1/N1	N1
Wasp, European (*Vespula germanica*)	Y3		Y0		Y3		N0		Y0		Y4	Y4	Y1	Y1	N1/N0	N0
Wasp, sirex (*Sirex noctilio*)	Y3		Y4				N0		Y3		Y4	N0	Y4	Y0	N0/N0	N0
Weevils (curculionids)	Y1		Y0		Y3		N3		Y3		Y4	N3	Y3	Y1	Y3/Y1	N1
Wingless grasshopper (*Phaulacridium vittatum*)	Y1		Y1				Y4		Y4		Y1	N1	Y1		Y4/Y1	N1

MUF = multiple-use public forest; N = not considered to be a problem; NCR = public nature conservation reserve; Y = considered to be a problem

Impact scores: 0 = reported present but not problematic; 1 = occurs but restricted distribution, has little impact; 2 = restricted distribution and adverse impact; 3 = widespread distribution but having minimal impacts; 4 = widespread distribution and having adverse impacts locally; 5 = very widespread and having widespread adverse impact; - = not scored; blank = no data

a Plantations/MUF.

Source: State and territory agencies

Table D3: Impact of various plant pests (weeds) on ecosystem health and vitality in forest areas, by jurisdiction and tenure

	ACT		NSW[a]		NT		Qld		SA		Tas.		Vic.		WA	
	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR
Blackberry (*Rubus fruticosus* agg. *Rubus vulgaris*)	Y4		Y4	Y-			Y4	Y4	Y2	Y2	N1	Y2	Y4	Y4	[b]	[b]
Bracken fern (*Pteridium esculentum*)	Y1	Y1	N-	N-			Y3	Y3	Y4	N-	Y4	N3	Y4	Y1	N-	N-
Broadleaved weeds			Y3	Y-			Y4	Y-	Y4	Y1	Y4	Y4			Y4	Y4
Cobbler's peg, Canadian fleabane (*Erigeron canadensis*)			N0	N-			Y4	Y4	Y5	Y1	N0	N0	N1	N0		
Crofton weed/mist flower (*Ageratina* spp., *Eupatorium* spp.)			Y4	Y-			Y4	Y4	N0	N-	N0	N0		N0	N0	N0
Eucalypts (*Eucalyptus, Corymbia* spp.)			N-	N-			N3	N3	Y1	N-	Y4	N3	N3	N0	Y2	Y2
Grass, gamba (*Andropon gayanus*)			N0	N-			Y4	Y4	N0	N-	N0	N0				
Grasses, exotic (not separately identified)	Y4		N-	Y-	Y4		Y5	Y5	N1	Y1	Y1	Y4			Y4	Y4
Great brome (*Bromus diandrus*), soft brome (*B. molliformis*)			Y2	N-			Y5	Y2	Y4	Y2	N0	Y1		N	Y3	Y3
Horehound (*Marrubium vulgare*)			Y1	Y-			Y4	Y4	N1	Y1	N0	Y1	N1	Y2	N0	N0
Lantana (*Lantana camara*)			Y5	Y-	Y1		Y5	Y5	N0	N-	N0	N0	N0	N-	N0	N0
Paterson's curse/salvation Jane (*Echium plantagineum*)			Y4	Y-			Y4	Y2	N1	Y1	N0	N0	N1	Y2	Y3	Y3
Prickly pear (*Opuntia* spp.)			Y4	Y-			Y3	Y3	N0	N-	N0	N0	N1	Y2	Y3	Y3
St John's wort (*Hypericum perforatum*)	Y2		Y4	Y-			Y1		N1	Y1	N0	N0	Y3	Y2	Y2	Y2
Thistle (several species)			Y3	Y-			Y4	Y-	Y4	Y1	Y2	Y4	N3		Y1	Y1
Vines, creepers – bridal (*Asparagus asparagoides*); rubber (*Thunbergia grandiflora*); others			Y0	Y-			Y5	Y5	Y2	Y2	N0	Y2	N1	Y3	Y4/Y5	Y4/Y5
Water hyacinth (*Eichhornia crassipes*)			N0	Y-			Y4	Y4	N0	N-	N0	N0	N0	N-	N	N
Wattles (*Acacia* spp.)							N3	N3	Y4	Y2	Y4	Y2	N3	Y3	Y5	Y5

MUF = multiple-use public forest; N = not considered to be a problem; NCR = public nature conservation reserve; Y = considered to be a problem

Impact scores: 0 = reported present but not problematic; 1 = occurs but restricted distribution, has little impact; 2 = restricted distribution and adverse impact; 3 = widespread distribution but having minimal impacts; 4 = widespread distribution and having adverse impacts locally; 5 = very widespread and having widespread adverse impact; - = not scored; blank = no data

a NSW only rated top-five threats in NCRs.

b *Rubus fruticosus* is not relevant to Western Australia. The species relevant to Western Australia are *R. anglocandicans* (Y4); *R. ulmifolius* (Y2); *R. laudatus* (Y2).

Source: State and territory agencies

Table D4: Impact of various pathogens on ecosystem health and vitality in forest areas, by jurisdiction and tenure

	ACT		NSW		NT		Qld		SA		Tas.		Vic.		WA	
Pathogens	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	MUF	NCR	PTN/ MUF[a]	NCR
Armillaria spp.			Y1				Y1			Y1	Y3	N3	Y4		Y1/Y4	Y4
Aulographina eucalypti			Y0				Y4									
Cyclaneusma minus			Y3				N-		Y3/ Y4		Y4	N0			N1/N0	N0
Dothistroma septospora			Y4				N-				Y2	N0			N1/N0	N0
Kirramyces eucalypti			Y4				Y4									
Mycosphaerella spp.			Y3				Y3		Y4		Y4	N3	Y3		Y2/Y1	Y1
Phelinus noxius							Y4				N0	N0			N-	N-
Phytophthora cinnamomi			N1	Y-			Y1		N-	Y2	Y2	Y2	Y4		Y1/Y5	Y5
Pilidiella (formerly known as *Coniella*) spp.			Y0				Y4									
Quambalaria corycup											N0	N0			Y0/Y4	Y4
Quambalaria pitereka			Y5				Y5									
Rigidoporus vinctus							Y4								N-	N-
Sphaeropsis sapinea (formerly known as *Diplodia pinea*)			Y4				Y3		Y3/ Y4		Y3	N0			Y1/Y0	N0

MUF = multiple-use public forest; N = is not considered to be a problem; NCR = public nature conservation reserve; Y = is considered to be a problem

Impact scores: 0 = Reported present but not problematic; 1 = occurs but restricted distribution, has little impact; 2 = restricted distribution and adverse impact; 3 = widespread distribution but having minimal impacts; 4 = widespread distribution and having adverse impacts locally; 5 = very widespread and having widespread adverse impact; - = not scored; blank = no data

a Plantations/MUF.

Source: State and territory agencies

Appendix E

State and territory legislation related to the harvesting of non-wood forest products

New South Wales

The New South Wales *National Parks and Wildlife Act 1974* protects all native fauna (mammals, birds, reptiles and amphibians) and flora. The protection of fauna is extended by the Act to the protection of threatened interstate fauna. It is an offence to harm any protected fauna or flora without a licence or, in the case of fauna, without consent of the owners of private or Indigenous land. Under the *Forestry Act 1916*, Forests NSW (formerly the Forestry Commission of New South Wales) can legally issue licences to take protected fauna, with the exception of endangered fauna. Forests NSW may not license the removal of protected native plants unless it is satisfied that they would otherwise be destroyed by lawful forestry activities under the Forestry Act. An exception to this is in certain protected areas such as wildlife refuges, in which Forests NSW can authorise harvests. Animals not native to Australia fall under the control of the *Non-Indigenous Animals Act 1987* but also need a permit to be imported, kept, moved, transported or liberated without a permit (Bates 2002).

The *Threatened Species Conservation Act 1995* provides for the conservation of threatened species, populations and ecological communities of animals and plants. The Act sets out a number of specific objects relating to the conservation of biological diversity and the promotion of ecologically sustainable development, including the amendment of other Acts to provide for the facilitation of the appropriate assessment, management and regulation of actions that may damage critical or other habitat or otherwise significantly affect threatened species, populations and ecological communities. This includes the insertion of offences into the *National Parks and Wildlife Act 1974* relating to harming (of listed threatened species, populations and ecological communities (animals)) and picking (of listed threatened species, populations and ecological communities (plants)), buying, selling or possessing threatened species or populations (animals or plants) and damaging of critical and other habitat. Part 2A of the *Threatened Species Conservation Act 1995* establishes the Biodiversity Banking and Offsets Scheme. The scheme enables the establishment of biodiversity banking sites, the creation of biodiversity credits, the trading of biodiversity credits, and the use of credits to offset development otherwise impacting on biodiversity values.

The *Environmental Planning and Assessment Act 1979* also has provisions relevant to the harvesting of non-wood forest products. The clearing of remnant native vegetation or protected regrowth for tourism (and other purposes) requires approval under the *Native Vegetation Act 2003* unless the clearing is a permitted activity.

Queensland

Queensland's *Nature Conservation Act 1992* provides for the ecologically sustainable use of protected animals, and adopts an ecosystem approach. It envisages a protective framework that specifically allows the ecologically sustainable use, including commercial use, of protected wildlife. Commercial activities within areas managed by Queensland Parks and Wildlife Service operate through a licensing system that controls the taking, keeping and use of protected wildlife in protected areas under section 63 of the Nature Conservation (Protected Areas Management) Regulation 1996, in state forest under section 27 of the Forestry Regulation 1988, and in recreation areas under section 26 of the *Recreational Areas Management Act 1988* (commercial tour operators and commercial filming and photography) (EPA Qld 2007). A conservation plan subject to public consultation is needed for any proposed take of wildlife species that have a higher conservation status than 'common'.

Northern Territory

Regulations under the *Territory Parks and Wildlife Conservation Act 2001* manage the use of native flora and fauna through a permit system. A permit to 'take or interfere with wildlife' is issued to people wishing to take native flora or fauna from the wild. The Department of Natural Resources, Environment and the Arts regulates this permit system; if the integrity of a species is starting to be compromised by commercial use, the department develops a management plan for that species. Such management plans are in place for cycads, crocodiles, magpie geese and the red-tailed black cockatoo.

In 1994, the Northern Territory Government adopted a set of guiding principles for advancing nature conservation and environmental protection in its *Conservation Strategy for the Northern Territory*. The strategy recognised that Territorians use and value wild plants, animals and ecosystems in a variety of ways. However, the goals set out in the strategy did not provide clear guidelines and direction about the sustainable use of wildlife; instead, guidelines and objectives were established in *A Strategy for Conservation through Sustainable Use of Wildlife in the Northern Territory of Australia*. That strategy encourages the sustainable use of wildlife for commercial purposes where landholders are the beneficiaries, and encourages the development of management plans.

Western Australia

Under Western Australia's *Conservation and Land Management Act 1984*, the Department of Environment and Conservation (formerly known as the Department of Conservation and Land Management, or CALM) is responsible for administering the *Wildlife Conservation Act 1950*, which provides for the conservation and protection of all native flora and fauna in Western Australia. The department employs a system of licensing, area and species-specific management, and monitoring. A management plan for the commercial harvesting of protected flora in Western Australia for 2003–08 was developed by CALM to satisfy the requirements of the national *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In 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'. This plan does not cover species listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora, Appendix I or listed as threatened under the EPBC Act. A commercial purposes licence is required for the commercial use of protected species on Crown or private land. In the case of Crown land, the proponent of a commercial purposes licence must demonstrate that it has an area in which to harvest the species as well as written permission from the government agency that is managing that land (Nature Base 2007).

South Australia

The South Australian *National Parks and Wildlife Act 1972* provides the state's legislative framework for the conservation of wildlife in its natural environment. This framework allows the Department for Environment and Heritage to monitor, prevent and control the illegal exploitation of protected wildlife and regulate legal activities such as hunting. Protected animals include only indigenous and migratory birds, mammals and reptiles. The department administers a permit system, under which a permit is needed to take any protected species, except where the Minister for Environment and Heritage declares otherwise, based on a threat to crops or property. The Minister may also declare an open hunting season for protected animals of specified species, except those listed as endangered. Flora is also protected under the National Parks and Wildlife Act; a permit is needed to take native plants on any reserved land, including forest reserves or other Crown land, as well as certain native plants on private land (Bates 2002).

Tasmania

Wildlife in Tasmania is protected by the Wildlife Regulations 1999. 'Wildlife' is defined as all living creatures except stock, dogs, cats, farmed animals and fish. Open season may be declared by the responsible minister for particular species of wildlife, such as wallabies, possums, deer, wild duck and mutton-birds (Bates 2002). The *Tree Fern Management Plan* was formulated and additions 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*. Protected species can become locally unprotected if they are causing damage to property or crops. The responsible minister can issue a closure notice that prohibits or regulates the taking, destroying or hunting of any species of wildlife in any area (Bates 2002). A licence or authorisation is needed to take, destroy or disturb wildlife in a state wildlife reserve, with game reserves and wildlife sanctuaries being exceptions. Flora is protected under the Flora and Fauna Guarantee Act; it may include indigenous and non-indigenous species. A permit is needed to take, trade in, keep, move or possess protected fauna.

References

Bates G (2002), Nature Base (2007), Queensland EPA (2007) (list at the back of the report).

Tables

Criterion 1

Criterion 2

Criterion 3

Criterion 4

Criterion 5

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Acronyms and abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
AFCS	Australian Forest Certification Scheme
AGO	Australian Greenhouse Office
ANZECC	Australian and New Zealand Environment and Conservation Council
BRS	Bureau of Rural Sciences
CALM	Department of Conservation and Land Management (WA – now DEC)
CAR	comprehensive, adequate and representative
CBS	clearfell, burn and sow silviculture system
CCA	community conservation area (NSW)
CDEP	Community Development Employment Program
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CRC	cooperative research centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry (Australia)
DEC	Department of Environment and Conservation (WA – formerly CALM)
DECC	Department of Environment and Climate Change (NSW – formerly Department of Environment and Conservation)
DEW	Department of the Environment and Water Resources (now DEWHA)
DEWHA	Department of the Environment, Water, Heritage and the Arts (formerly DEW)
DFTD	(Tasmanian) devil facial tumour disease
DSE	Department of Sustainability and Environment (Vic.)
EMS	environmental management system
EPA	Environment Protection Authority (SA), Environmental Protection Authority (WA), Environmental Protection Agency (Qld)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
FAFPESC	Forest and Forest Products Employment Skills Company
ForestWorks	National Skills Company for the Forestry and Forest Products, Furnishing and Pulp & Paper Industries Ltd (formerly FAFPESC)
FPA	Forest Practices Authority (Tas.)
FTA	free trade agreement
FWPA	Forest and Wood Products Australia
IBRA	Interim Biogeographic Regionalisation of Australia
ILC	Indigenous Land Corporation
ILUA	Indigenous land use agreement
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JANIS	Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-committee
MAC	Maningrida Arts and Culture
MIG	Montreal Process Implementation Group for Australia
MODIS	Moderate-resolution Imaging Spectroradiometer
NCAS	National Carbon Accounting System
NFI	National Forest Inventory
NLWRA	National Land & Water Resources Audit
NSW	New South Wales
NT	Northern Territory
PIRSA	Department of Primary Industries and Resources South Australia
Qld	Queensland
RFA	regional forest agreement
RPCC	Research Priorities and Co-ordination Committee
SA	South Australia
SEEDS	Social, Environmental and Economic Data System (NSW)
SLA	statistical local area
SoE	State of the Environment
SOFR	*State of the Forests Report*
Tas.	Tasmania
UNFCCC	United Nations Framework Convention on Climate Change
Vic.	Victoria
WA	Western Australia

Glossary

Acidity, acidification Chemical terms relating to corrosiveness. Acidification refers to increasing levels of acidity, for example in soil. Soil acidification can damage soil and vegetation.

Age classes Groupings of a similar age; for example, plantations established between 1990 and 1994 are in a five-year age class.

Aggregate retention Trees retained in clumps or clusters in forests harvested for timber.

Biodiversity The variety of all life forms – plants, animals and microorganisms, their genes and the ecosystems they inhabit. 'Genetic diversity' is the diversity within each species, 'species diversity' is the variety among species, and 'ecosystem diversity' is the diversity of different communities formed by living organisms and the relations among them.

Biogeographic Relating to the study of the distribution of living things (referring to that distribution).

Biological diversity See *Biodiversity*.

Biomass Plant and other material of biological origin.

Biome A large, regional ecological unit, usually defined by some dominant vegetative pattern.

Bush sawn/ hewn timber Timber cut from logs in the forest using portable equipment.

Carbon accounting Estimation of the amount of carbon in an ecosystem and changes in the amount stored. Carbon accounting in forests includes estimating changes, arising from activities such as reforestation, in the amount of carbon stored.

Carbon sequestration The removal and storage of carbon from the atmosphere in vegetation and soils.

Carbon sink Components of the land and biomass where carbon is held in non-gaseous form in the long term.

CAR reserve system A reserve system based on three principles: including 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).

Certification See *Forest certification*.

Clearfelling A silvicultural system in which all trees in large areas are harvested in one operation. Trees needed to provide wildlife habitat or streamside reserves or for other purposes may be retained.

Clonal propagation Production of identical copies of a plant, allowing maximum benefit to be gained from proven superior individuals occurring in nature or developed by breeding.

Closed forest Forest in which the tree crown cover, viewed from above, ranges between 80% and 100% of the land area.

CO_2 equivalent Measurement unit used to express the effect in the atmosphere of various greenhouse gases as units of CO_2 (carbon dioxide).

Code of forest practice A set of principles, procedures, guidelines and standards that specify minimum acceptable practices in harvesting and associated forest management operations.

Community See *Plant community*.

Coppicing A traditional silvicultural method in which young tree stems are cut down to near ground level. In subsequent growth years, many new shoots emerge; after a number of years, the coppiced tree is ready to be harvested again.

Cording The practice of placing large (5–30 centimetre diameter) woody material on extraction tracks before harvesting in order to minimise erosion (see also *Matting*).

Crown cover The area of ground covered by tree canopies, ignoring overlaps and gaps within individual canopies.

Crown cover density Measure of crown cover.

Crown land Land owned by the government.

Data Statistics, usually in a quantitative form.

Deforestation A type of land clearing involving the permanent removal of tree cover.

Dicotyledon A plant with two embryonic leaves (the first leaves of the seedling).

Dieback A symptom of disease in trees and other vegetation in which the foliage dies progressively from the extremities; commonly used in reference to native forests affected by cinnamon fungus (*Phytophthora cinnamomi*) or woodland forests affected by salinity.

Dispersed retention Retention of individual trees scattered throughout an area in forests harvested for timber.

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.

Ecosystem The biotic and abiotic components of an environment that interact to produce a flow of energy and cycling of nutrients. Ecosystems are extremely difficult to define practically because of high variation, temporal changes and lack of discreteness.

Ecosystem diversity See *Biodiversity*.

Ecosystem health The state of ecosystem processes (energy, nutrient, hydrological and biological processes) that maintain the vitality of the ecosystem.

Edge effect In relation to forests, the effect of non-forest environmental influences on parts of the forest adjoining non-forested land.

Endangered species and communities Species/communities at high risk of imminent extinction if factors causing population decline continue.

Endemic Species of plants or animals that occur naturally in a region or country (see also *Exotic*).

Even-aged forest Forest in which trees are all about the same age or of the same age class, even though they may vary in size because of their different rates of growth.

Exotic Species of plants or animals found in a region where they do not occur naturally (see also *Endemic*).

Farm forestry Establishment and/or management of trees on farmland for commercial, aesthetic and/or environmental reasons.

Fibreboard A category of engineered wood panel products made from pulpwood and/or wood-processing residues such as woodchips, sawmill shavings and sawdust and a resin or binder, pressed into panels. Types of fibreboard (in order of increasing density) include particleboard, medium-density fibreboard, high-density fibreboard and hardboard.

Foliar Of or relating to a leaf or leaves.

Forest A land area, incorporating all living and non-living components, dominated by trees usually having 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 definition includes native forests and plantations and areas of trees that are sometimes described as woodlands.

Forest certification A process whereby the sustainable forest management credentials of a forest are investigated and certified by a third party.

Forest-dependent species A species that requires a forest habitat for at least part of its lifecycle. In many cases, our ecological understanding of the species is not sufficient to determine whether it is wholly, partly or cyclically forest-dependent.

Forest-dwelling species A species that uses a forest habitat for all or part of its lifecycle.

Forest structure The three-dimensional layout of a forest. The uppermost vertical layer is formed by the canopies of the tallest trees, and there may be no, one or more understorey layers. Ground surface characteristics (amount of litter, presence of dead fallen wood, stoniness) and the presence of vines also contribute to forest structure. Structure is usually important in the creation of habitat for a wide range of species.

Formally managed Includes management required by legislation or other agreements for which legislation allows (e.g. memorandums of understanding, partnerships, management agreements, access agreements, informal understandings) for the protection of places through management zones, prescriptions and/or codes of practice, where these management techniques lead to all relevant sites being actively managed or protected on the ground.

Fragmentation (of habitat) The emergence of discontinuities (fragmentation) in an organism's preferred environment (habitat). Habitat fragmentation can be caused by geological processes that slowly alter the layout of the physical environment or by human activity, such as land conversion, that can alter the environment on a much shorter timescale.

Freehold See *Private forest*.

Fuel load The total amount of combustible material in a defined space.

Gall A proliferation and modification of plant tissue caused by various parasites, from fungi and bacteria to insects and mites.

Genetic diversity See *Biodiversity*.

Geographic information system A system for capturing, storing, analysing and managing data and associated attributes that are spatially referenced to the earth.

Global carbon cycle The movement of carbon between different parts of the earth, including the storage of carbon in those parts.

Greenhouse gases Gases that affect the temperature of the earth's surface and climate. They include water vapour, ozone, chlorofluorocarbons, carbon dioxide, methane and nitrous oxide. The 'enhanced greenhouse effect' refers to changes in the earth's climate as a result of increasing levels of greenhouse gases in the atmosphere due to human activity.

Group selection A silvicultural system in which groups (small patches) of trees are selected for harvesting, leading to a forest comprising patches of differently aged trees.

Growing stock The total volume of wood in all living trees in a forest at a particular time.

Gymnosperm A plant, such as a cycad or conifer, the seeds of which are not enclosed within an ovary.

Habitat The total of environmental conditions and resources surrounding and available to an organism.

Hand pollination The mechanical transfer of pollen grains (male reproductive cells) to the plant carpel, the structure that contains the ovule (female reproductive cell); used when natural, or open, pollination is inadequate or undesirable.

Hardwood Timber from flowering trees, such as eucalypts, irrespective of the physical hardness of the timber; also used to refer to the trees that have such timber.

Harvesting As part of forest management, cutting (felling) of trees to produce timber products.

Hybridisation The process of crossing breeds or cultivars of a single plant species, or crossing plants of different taxa (subspecies, species or genera).

Indigenous (of people) Of Aboriginal or Torres Strait Islander descent.

Informal forest reserve See *CAR reserve system*.

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.

Introgression The movement of a gene from one species into the gene pool of another.

Land clearing Permanent removal of vegetation.

Land tenure See *Crown land, Leasehold forest, Multiple-use public forests, Nature conservation reserve, Other Crown land, Private forest* and *Unresolved tenure.*

Leasehold forest Forest on Crown land held under leasehold title and generally regarded as privately managed; includes land held under leasehold title with special conditions attached for designated Indigenous communities.

Log landing Any place where logs are laid after being yarded and before transport to the worksite.

Matting The practice of placing small (<5 centimetre diameter) woody material on extraction tracks before harvesting to minimise erosion (see also *Cording*).

Monocotyledon A plant with a single embryonic leaf (first leaf of the seedling).

Montreal Process The informal agreement by the Montreal Process Working Group of (currently 12) countries to work towards the implementation of a comprehensive set of criteria and indicators for the conservation and sustainable management of temporal and boreal forests.

Mosaic/patchwork (of vegetation) Vegetation composed of patches of different types, perhaps arising from periodic disturbance (such as fire or timber harvesting) or related to differences in soil or landform.

Multiple-use public forest Publicly owned state forest, timber reserves and other forest areas on which a range of forest values is managed, including timber harvesting, water supply, conservation of biodiversity, recreation and environmental protection. Such forests are managed by state and territory agencies in accordance with relevant Acts and regulations.

Native Located within the organism's natural range (see also *Non-native*).

(Public) Nature conservation reserve Crown land that is formally reserved for environmental, conservation and recreational purposes. Nature conservation reserves include national parks, nature reserves, state and territory recreation and conservation areas, and formal reserves in state forests and on Crown lands reserved to protect water-supply catchments. They do not include informal reserves and those pending gazettal. The harvesting of wood and non-wood forest products is generally not permitted.

Non-native Located outside the organism's natural range (see also *Native*).

Non-wood forest product A product of biological origin, other than wood, derived from forests. Examples are game animals, seeds, berries, mushrooms, oils, foliage, medicinal plants and forage.

Old-growth forest Ecologically mature forest in which the effects of disturbances are now negligible.

Open forest Forest in which the tree crown cover, viewed from above, ranges between 50% and 80% of the land area.

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 use by Indigenous communities.

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) in the process.

Particleboard A panel product made by compressing wood particles (usually from softwood timber) and resin; commonly used in flooring and joinery.

Photosynthesis A process in plants in which energy from sunlight and carbon dioxide from air are used to produce plant matter, and in which oxygen is released.

Phyllode A widened and flattened stalk attaching a leaf to the stem. The leaf is reduced, and the phyllode performs photosynthesis.

Plantation Stands of trees of native or exotic species, created by the regular placement of seedlings or seeds.

Plant community A recognisable association of a number of plant species.

Plywood A panel product made by gluing veneers of wood together; commonly used in construction and joinery.

Private forest Forest on land held under freehold title and under private ownership; includes land held under freehold title with special conditions attached for designated Indigenous communities.

Provenance The place of origin of a plant or animal.

Pteridophyte A vascular plant (a plant with xylem and phloem) that neither flowers nor produces seeds, but reproduces and disperses only via spores.

Pulpwood Timber used to manufacture pulp or paper products.

Recycling The collection, separation and processing of materials for manufacture into raw materials or new products.

Regeneration New trees arising naturally or with human assistance after harvesting, fire or other causes have removed all or some of the overstorey. Plant species vary widely in the site conditions that they need in order to regenerate.

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.

Remote sensing (remotely sensed data) Obtaining data with a sensor some distance from the object. Sensors rely on the detection of energy, such as light and heat, emitted from or reflected by the object. Remotely sensed data are data obtained by such methods.

Re-sawing Cutting timber along the grain to reduce larger sections into smaller sections or veneers.

Resolution (image) A 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; 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.

Ringbarking Killing a tree by cutting the sapwood in a ring around the trunk.

Riparian zone The interface between land and a flowing water body. Plant communities along river margins are called 'riparian vegetation'.

River regulation The control or modification of the natural flow of a river or stream, most commonly by the use of dams.

Rotation In forestry, the planned number of years between regeneration and final harvesting of a stand of trees. Rotation length is used in forest management planning to determine sustainable yield. Due to variability in growth, market demand and other factors, the actual age at final harvesting is likely to be more or less than the planned rotation.

Roundwood Sawlogs, pulpwood, poles, etc, in round form.

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 commercial or non-commercial harvest of trees that are dead or dying due to insect attack, disease, drought, fire, etc.

Sawlogs Logs used to manufacture sawn timber.

Sawn timber Timber produced by sawing logs into particular sizes; also called 'sawnwood'.

Sclerophyll Plants and vegetation, such as eucalypts and acacias, that have tough leaves adapted to arid climates.

Selective or partial logging A silvicultural practice in which trees above a certain specified size are removed singly or in groups while regrowth, pole timber or habitat trees are retained to maintain uneven-aged forest.

Shrubland Vegetation dominated by woody plants that are multi-stemmed at the base or by single-stemmed plants that are less than 2 metres tall at maturity.

Siltation The deposition of silt (fine soil and mineral matter); refers to the degradation of watercourses due to soil erosion.

Silvicultural practices The methods used in managing forest establishment, composition and growth.

Silviculture The science and technology of managing forest establishment, composition and growth.

Single tree/small group selection The harvesting of single trees or small groups of trees of various ages; a method suitable for promoting regeneration of shade-tolerant species.

Single tree selection A silvicultural system in which individual trees are selected for harvesting. This system may be used in types of forest, such as tropical rainforests, in which regeneration can occur in patches created by individual trees falling or being removed.

Softwood Timber from cone-bearing trees, such as conifers, irrespective of the physical softness of the timber; also used to refer to the trees that have such timber.

Soil erosion hazard The susceptibility of soil to erosion.

Species diversity See *Biodiversity*.

Stochastic events Random or chance events that influence ecosystems, such as fires or floods.

Stocking A description of stand density, which can be measured in a number of ways: number of trees, basal area or volume per unit area, or percentage of crown closure.

Strandboard	An engineered wood product formed by layering strands (flakes) of wood in specific orientations. The product may have a rough and variegated surface, with the individual strips lying unevenly across each other.
Stripfelling	The practice of felling alternate strips of the forest, leaving uncut strips in between to provide seed and shelter.
Structure	See *Forest structure*.
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	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.
Sustainable yield	Yield of forest products (e.g. timber, water) that ensures that the functioning of the forest ecosystem as a whole is maintained and the flow of products continues indefinitely.
Taxon	A classification of plants or animals (e.g. a species or genus).
Tenure	Title to land as controlled by legislation (see also *Land tenure*).
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 seeds, cuttings or propagated seedlings.
Uneven-aged forest	Forest with more than one age class closely intermingled on the same site.
Unresolved tenure	Areas where tenure is unknown or for which there are no data.

Unit abbreviations

CH_4	methane
CO_2	carbon dioxide
ha	hectare
kg	kilogram
km	kilometre
m	metre
m^2	square metre
m^3	cubic metre
mm	millimetre
Mt	megatonne (10^6 tonnes)
MW	megawatt (10^6 watts)
t	tonne
TJ	terajoule (10^{12} joules)

Value adding	The process of converting raw timber or forest products into one or more higher valued products.
Veneer	Thin slices of wood, usually thinner than 3 millimetres, glued and pressed onto core panels (typically wood, particleboard or medium-density fibreboard) to produce flat panels.
Veneer logs	Logs used to manufacture veneers or plywood.
Virgin fibre	In pulp and paper manufacture, fibre used for the first time, as opposed to fibre recovered from paper and reused.
Vulnerable species and communities	Species and ecological communities under threat of extinction that are believed likely to move into the 'endangered' category in the near future if the factors causing population decline continue.
Watershed	The dividing line between two drainage basins, shedding water in either direction.
Watertable	The underground level at which the ground is saturated with water, where the water pressure is equal to atmospheric pressure.
Water yield	The amount of water that flows out of a catchment.
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.
Woodchips	Wood that is converted from logs into small chips before being used in fibre products.
Woodland	Sparse forest in which the tree crown cover, viewed from above, ranges between 20% and 50% of the land area.

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