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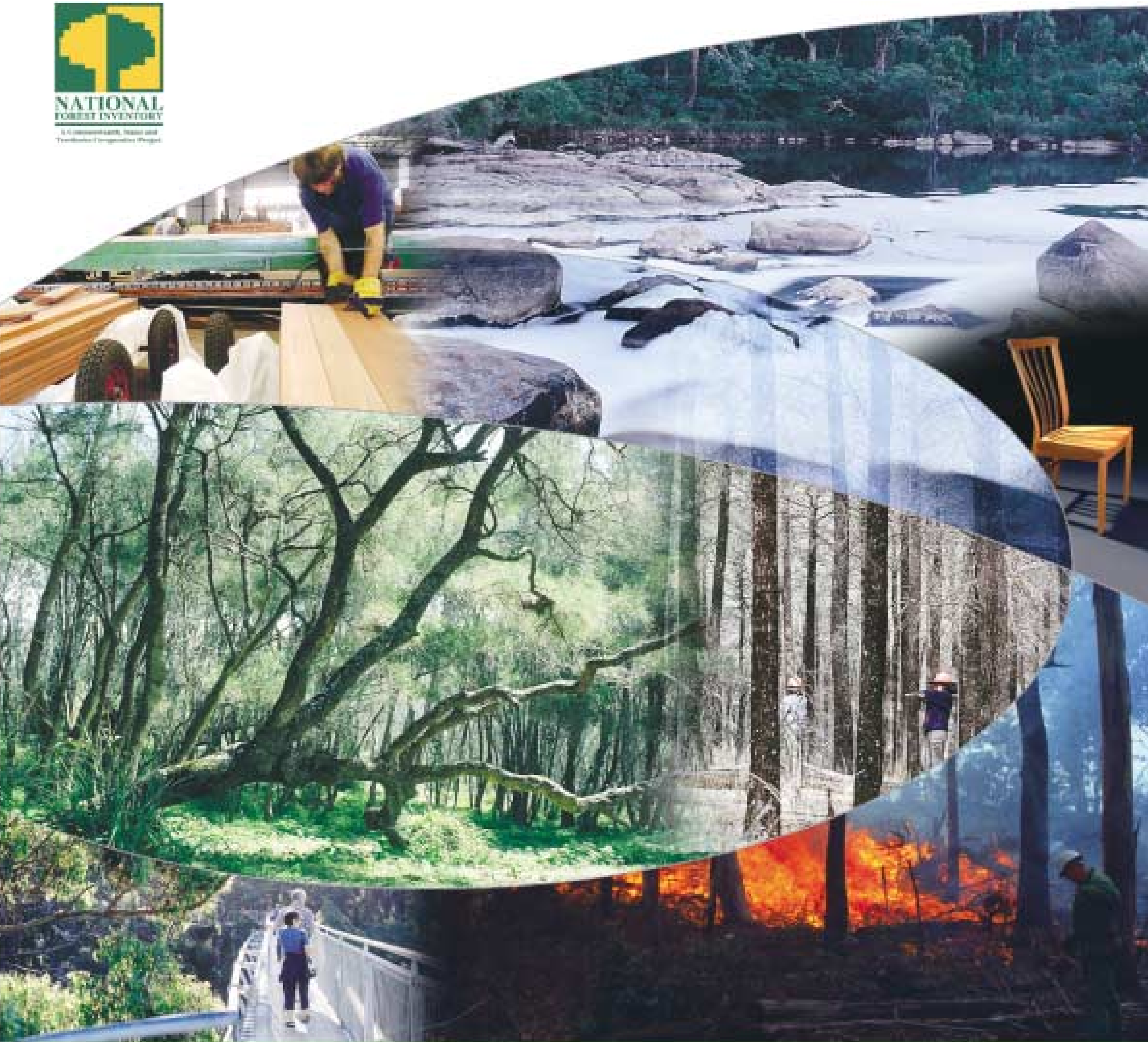
Department of Agriculture, Fisheries and Forestry

Bureau of Rural Sciences

2003 AUSTRALIA'S STATE OF THE FORESTS REPORT

NATIONAL FOREST INVENTORY



DEPARTMENT OF AGRICULTURE, FISHERIES AND FORESTRY

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2003

ISBN: 0 642 47569 5

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Internet: http://www.affa.gov.au/brs

Preferred way to cite this publication
National Forest Inventory (2003). *Australia's State of the Forests Report 2003*. Bureau of Rural Sciences, Canberra.

The data in this report are current to December 2002.

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Printed by Goanna Print, Canberra

Foreword

Forests hold many values for humans. They provide the resource base for Australia's second largest manufacturing industry. They are also important for biodiversity conservation and they inspire strong emotions and wonder for many who visit them. Management of Australia's forests is therefore a subject of major importance to the national and international community. Australians expect that our unique forest ecosystems will be protected for current and future generations to enjoy, while continuing to satisfy the needs for sustainably produced forest-products.

Over the past decade there has been an increased awareness of the need for sustainable natural resource management and human development. This was brought to international attention at the 1992 'Earth Summit' in Rio de Janeiro. Australian governments have been committed to sustainable forest management through the implementation of the 1992 *National Forest Policy Statement*, participation in the Montreal Process to develop criteria and indicators of sustainable forest management and other international processes, and through the development of Regional Forest Agreements between the Commonwealth and State governments.

This report, like the first *State of the Forests Report* in 1998, fulfils the obligation in the National Forest Policy Statement to provide a forest sustainability report to the Australian public every 5 years. This report also serves as Australia's contribution to the Montreal Process.

Australia's State of the Forests Report 2003 is structured on a nationally agreed framework based on the Montreal Process criteria and indicators. Seven broad criteria embrace the range of values the Australian community attaches to forests: biological diversity, productive capacity, ecosystem health, soil and water, carbon, socio-economic and management frameworks. This provides a logical organisation for reporting and a basis for measuring future progress towards sustainable forest management. In reporting fully against the Montreal Process criteria and indicators for the first time, shortcomings and overlap between some of the indicators are apparent. The report will therefore be a valuable contribution for a review and future use of the indicators.

Australia's State of the Forests Report 2003 represents a highly successful partnership between those agencies in States, Territories and the Federal Government with an interest in the management of Australia's forests. Representatives from many agencies provided substantial data and participated in drafting groups to prepare and review text. A wide range of scientific experts also provided specialist input for many indicators. The report received final review and clearance by the Forest and Forest Products Committee of the Primary Industries Standing Committee.

I thank the team of staff in BRS and the Department and their many collaborators for the dedication and commitment in bringing together such a comprehensive report. It provides a definitive picture of the state of Australia's forests.

Dr. Peter O'Brien
Executive Director
Bureau of Rural Sciences

September 2003

Executive summary

Purpose of report

This is Australia's second State of the Forests Report. It fulfils Australia's five yearly public reporting commitment identified in the 1992 National Forest Policy Statement, and also serves as Australia's report to the international Montreal Process on criteria and indicators of sustainable forest management.

Australia's framework of criteria and indicators, based on the Montreal Process, are used as a basis for reporting. Seven broad criteria and 74 indicators were developed during regional consultations with forest management and conservation agencies and other stakeholders around the country. Using consistent indicators also enables comparisons between countries in forest status and management.

An important nationwide change since the 1998 State of the Forests Report has been the development and implementation of Regional Forest Agreements (RFAs). This is the first national report since the RFA process and changes brought about by the process are detailed wherever data are available.

Data are presented without value-based interpretations. This allows readers to make up their own minds about whether a trend in a particular indicator is a good or bad thing.

The report provides a benchmark for future assessments. There are many areas where data are incomplete, of uncertain accuracy or entirely lacking. Awareness of these gaps in our knowledge will hopefully increase efforts to improve data collection.

Forest Extent

This assessment indicates that 164 million hectares, or 21 per cent of Australia's land area, is classified as forest (land with trees with an actual or potential height greater than 2 metres and 20 per cent crown cover). Of this total, 102.5 million hectares is woodland forest, 45.6 million hectares is open forest, 4.6 million hectares is closed forest (mainly rainforest) and 1.6 million hectares are plantation forests. Thirteen per cent of Australia's native forests are formally protected in nature conservation reserves, 70 per cent are privately managed, and 7 per cent are available for timber production in multiple-use forests.

The area is about 7 million hectares greater than that reported in 1998. This increase does not reflect a real increase in forest cover; improvements in forest mapping have yielded greater accuracy in the estimated area of forest. Other data indicates that net forest cover in Australia is decreasing, due largely to clearing of woodland forests for grazing and cropping. The annual rate of clearing is now much lower than in the 1970s and 80s. In the most recent estimates 240 000 hectares were cleared in 1998 compared with 546 000 hectares in 1988.

Commercial forest plantation establishment has averaged 87 000 hectares per year over the last five years. Nearly all of this occurred on land that was previously used for agriculture. In 2002 softwood plantations covered 988 000 hectares. The rate of expansion of new softwood plantations is low and the potential supply of softwood plantation timber will increase modestly over the next 20 years. There were 638 000 hectares of hardwood plantations in 2002. The majority of that area was established in recent years, much of it on former agricultural land.

An unknown area of new forest has also been established through revegetation activities including Landcare, Bushcare and other government sponsored programs.

Growth stage is known for only 14 million hectares, or 8 per cent, of Australia's forest, mainly on multiple-use tenure. At the national level there are 4 growth stages. Of the 14 million hectares, 6.6 per cent is in the regeneration stage, 11.8 per cent is regrowth, 57.4 per cent is mature and 24.2 per cent is classed as senescent.

Old growth forests are of particular interest to many in the community. They are defined as 'ecologically mature forest where the effects of disturbances are now negligible'. In forests assessed for the development of Regional Forest Agreements, more than 5 million hectares, or 22 per cent, are classified as old-growth. There has been little assessment in forests outside these regions.

Forest Tenure and Management

Forty-six percent of Australia's forest is under leasehold tenure. Seven per cent is on private tenure and 7 per cent is multiple-use (where timber harvesting is undertaken on public land). Since the last assessment, the area in nature conservation reserves (both formal and informal) has increased by 22.2 per cent to 21.5 million hectares, and the area of multiple-use forests has decreased by 14.6 per cent. Thirteen per cent of Australia's forest estate is now protected in nature conservation reserves, including almost 70 per cent of old growth forests in RFA regions. Fifteen per cent of Australia's native forests meet the international IUCN reserve classes. Fifteen of Australia's seventeen major native forest types exceed the international target of 10 per cent of the area of the forest type to be in IUCN categories I-VI.

Biodiversity

Sixteen thousand, five hundred and thirty-two higher plants and 3 817 animal species are considered forest-dependent species (defined as needing forest habitat for part of the life cycle.) This is an increase of 21.4 per cent and 211 per cent for plants and animals respectively since the last assessment, due to more comprehensive research, assessment and reporting by State and Territory agencies.

Eighty-eight animal and 771 higher plant taxa are considered critically endangered, endangered or vulnerable under the Australian Government *Environment Protection and Biodiversity Conservation Act 1999*.

Forest Products

Twenty-six per cent of native forest is legally restricted from timber harvesting. The remaining 74 per cent is available for timber harvesting, but this does not occur on a large proportion of this area because of environmental and economic restrictions. The report identifies that an annual average of 9.1 million cubic metres of timber were removed from public and private native forests for the 5 years to 2000–2001. The annual removal of wood from public native forests is estimated to be well within the sustainable level. Volumes of sawlogs and veneer logs harvested from native forests in all States except Tasmania have declined; pulpwood harvests have also declined in all jurisdictions except Tasmania and Victoria. National statistics reveal 12.2 million cubic metres of timber were removed from hardwood and softwood plantations during the same period.

No national data are kept on non-timber forest products that come solely from forested areas. It is known, however, that forests are important in the supply of honey, indigenous art products, seed, decorative foliage and some animals and animal products.

Forest Health

There is no comprehensive national database for forest fire occurrence, cost or impact. Between April 1998 and March 1999, remote sensing indicated that 14.3 million ha (9 per cent) of Australia's forests were burnt by fire. The following year, fire burnt 27.2 million hectares. These figures include fuel reduction burns as well as wild fires. Detailed statistics on area burnt, fire severity and recovery potential are not yet available for the extensive bush fires in Victoria, New South Wales and the Australian Capital Territory of December 2002 and January 2003.

Other threats to forest health—such as animal pests, weeds and pathogens—are monitored and, in some cases, controlled. However, there is little information available nationally on the extent and percentage of the national forest estate affected. Phytophthora fungi continue to be a major concern in many forested areas in temperate Australia, and management plans exist in most regions. Other fungi are a threat to some plantation species.

Several other factors can affect Australian forest health, such as grazing, mining or climatic extremes. There are few data on the amount of forest affected by soil hazards, or even the area assessed for hazards. Many forests are managed with the clear understanding that the existence of the forest protects other important biophysical attributes beyond that of the trees themselves. Benefits include flood mitigation, the prevention of landslides and soil erosion and the preservation of riparian zones. Forests protect watersheds, and it is well known that clearing deep-rooted native tree species is a cause of salinisation. However, forest protective functions are rarely mapped or quantified.

The strong inter-relationship between forest vegetation, soil, and water is increasingly understood. Soil type and availability of water determine, to a large extent, the type of forest that may occur. In turn the existence of the forest helps to protect the existing soil and water properties. Forests are vital in helping to provide good quality water for many highly populated parts of Australia. Comprehensive national data are still lacking, although some soil and water monitoring take place in several jurisdictions.

Forests are important carbon stores. Growing forests removes carbon from the atmosphere and harvesting or other disturbances results in release of carbon. Forests contain an estimated 23.4 million tonnes of biomass (10.5 million tonnes of carbon, excluding soil carbon). The vast majority of biomass is in native forests, with only about 0.8 per cent in plantations.

There is still considerable uncertainty about the uptake and release of carbon across the broader forest estate. 'Net greenhouse gas emissions (mainly carbon dioxide) from the 'land-use change and the forestry sector' were 7 per cent of national greenhouse gas emissions in 2001. Emissions from this sector have declined over the last ten years, in line with reductions in forest clearing.

Economic factors

In 2000–2001, the National Accounts valued the timber in plantations and native forests at $10.6 billion. Over the nine years to 2001–2002, the value of wood and wood products to the Australian economy increased from $5.9 billion to $6.6 billion (1 to 1.3 per cent of GDP).

Australia is a net importer of pulp and paper products. However, production and export of wood-based panels and woodchips has increased since the last report. Domestic supply of wood and wood products has also increased. Per capita consumption, however, has fallen due to population growth and some substitution away from timber products in the housing sector.

Non-wood forest products are also important, but data are scarce. The apiary industry is highly dependent on native forests. There are nearly 1 000 full-time apiarists in Australia, and many part-time ones, servicing domestic and overseas markets. Honey production in 2000 was estimated to be worth $36 million dollars nationally, with sales of bees and beeswax contributing a further three to four million dollars.

Investment and Employment

Since the early 1990s the forest sector, and in particular the plantation sector, has attracted new domestic and foreign investment to the value of more than $6.5 billion. New forest and wood-processing investments have occurred in each State and Territory.

Forest-related research and development expenditure in Australia has steadily increased over the last decade and in 2000–2001 totalled $216 million.

The forest sector remains a relatively small employer nationwide, but for many regional communities it is the major source of income. From 1993 to 2000, direct employment in the forest sector declined from 0.98 per cent to 0.81 per cent of the workforce, rising to 0.86 per cent in 2000–2001. However, the forest sector generates considerable employment in related fields of the economy, with the multiplier effect ranging from 1.57 in South Australia to 2.35 in Victoria.

Employment and spending on wages in the forestry sector increased in the three years to 2001. Unfortunately, much forestry work continues to be dangerous. The average injury rate for the forest, wood-milling and manufacturing sectors is somewhat higher than the national average, and the fatality rate is considerably higher.

Tourism, an increasingly important sector in the nation's economy, often makes use of forests. Most publicly owned forested lands are available for recreation or tourism. Available data are far from comprehensive but suggest that visitor numbers are increasing in most jurisdictions.

Over the past few decades, the Australian government has introduced tax changes to address what was an inequitable treatment of forestry operations. Taxation law does not discriminate against investment in forestry. Funding has been provided to assist restructuring of timber industries affected by government forest-use decisions.

Australia's export industries operate in a trade environment where they continue to face barriers to market entry. Australia supports a policy that will lead to the removal of tariffs in wood and wood products and is pursuing WTO-consistent Free Trade Agreements. For countries not party to multilateral or bilateral treaties, Australia's tariffs on imports of forest and forest products range from 0 to 5 per cent. However, Australia grants preferential tariff treatment for developing country products.

Indigenous Issues

More than 18 per cent of Australia's total land and about 13 per cent of forested land is under Indigenous ownership, mostly in the Northern Territory, South Australia and Western Australia. While there is no comprehensive national database of Indigenous land holdings, the Indigenous Land Corporation in Adelaide is compiling a national register. Native title applications to date have resulted in about 900 000 hectares of forested areas being available and accessible to Indigenous people.

There are 62 national heritage areas, totalling more than 10 million hectares, formally recognised as possessing both Indigenous values and forest values, that warrant protection.

In an important development since the last report, the *Regional Forest Agreement Act 2002* specifies that agreements between the States and the Australian Government about the management of forests must include the protection of Indigenous heritage values. Traditional management practices are increasingly recognised in forests with a strong link to the traditional owners.

Table of contents

List of Tables

List of Figures

Acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
AFS	Australian Forestry Standard
AGO	Australian Greenhouse Office
ALRA Act	Aboriginal Land Rights Act
ANCA	Australian Nature Conservation Agency
ANZECC	Australian and New Zealand Environment and Conservation Council
APEC	Asia–Pacific Economic Cooperation
ASEAN	Association of South East Asian Nations
AUSLIG	Australian Surveying and Land Information Group
AusRivAS	Australian River Assessment System
BRS	Bureau of Rural Sciences
CALM	Western Australian Department of Conservation and Land Management
CANRI	Community Access to Natural Resources Information
CAPAD	Collaborative Australian Protected Areas Database
CAR	Comprehensive, Adequate and Representative reserve system
CBD	Convention for Biological Diversity
CCNCO	Commonwealth Competitive Neutrality Complaints Office
CDEP	Community Development Employment Projects
CFMF	Continental Forest Monitoring Framework
CITES	Convention on International Trade in Endangered Species
CoC	Chain of Custody
CRA	Comprehensive Regional Assessment
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DLWC	New South Wales Department of Land and Water Conservation
DNRE	Victorian Department of Natural Resources & Environment
EMS	Environmental Management System
EPBC Act	Environmental Protection and Biodiversity Conservation Act
ESFM	Environmentally Sustainable Forest Management
ESOCLIM	Computer program that models climate
FGP	Forestry Growth Plan
FISAP	Forest Industry Structural Adjustment Program
FORESTCHECK	Integrated forest monitoring system for Western Australia
FRAMES	Forest Resource Assessment Management Evaluation System
FTA	Free Trade Agreement

FWPRDC	Forest and Wood Products Research and Development Corporation
IBRA	Interim Biogeographic Regionalisation of Australia
ILC	Indigenous Land Corporation
ILUA	Indigenous Land Use Agreements
IRR	Internal Rate of Return
ITTO	International Tropical Timber Organisation
IUCN	International Union for the Conservation of Nature and Natural Resources
IVA	Industry Value Added
JANIS	Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-committee
JAS – ANZ	Joint Accreditation System of Australia and New Zealand
LWA	Land and Water Australia
MCFFA	Ministerial Council on Forestry, Fisheries and Aquaculture
NAFI	National Association of Forest Industries
NAP	National Action Plan
NEFBS	North East Forests Biodiversity Study Report (New South Wales)
NEPMs	National Environment Protection Measures
NFI	National Forest Inventory
NFPS	National Forest Policy Statement
NGGI	National Greenhouse Gas Inventory
NHT	Natural Heritage Trust
NLWRA	National Land and Water Resources Audit
NOHSC	National Occupational Health and Safety Commission
NP	National Park
NPWS	National Park and Wildlife Service
NPI	National Pollutant Inventory
NRMMC	National Resource Management Ministerial Council
NSW	New South Wales
NWI	National Wilderness Inventory
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
RFA	Regional Forest Agreement
RIRDC	Rural Industries R&D Corporation
ROTAP	Rare or Threatened Australian Plants
SEIFA	Socio Economic Index for Areas
TAFE	Technical and Further Education
UNECE	United Nations Economic Commission for Europe
FAO	Food and Agriculture Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UV-B	Ultraviolet radiation B
W/m^2	Watts per square metre – Emissive Power (radiation)
WTO	World Trade Organisation

Glossary

Acid rain	Rain containing high concentrations of acid; a term arising from experience in North America and Europe where sulphur and nitrous dioxide pollution cause dieback and death of vegetation.
Acidity (acidification)	Chemical term 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 a five-year age class.
Anthropogenic	Caused by or arising from the actions of humans.
Biodiversity	Biological diversity is the variety of all life forms—the plants, animals and micro-organisms—their genes and the ecosystems they inhabit. 'Genetic diversity' is the diversity within each species. 'Species diversity' is the variety of species. 'Ecosystem diversity' is the diversity of different communities formed by living organisms and the relations between them.
Biogeography (biogeographic)	The study of the distribution of living things (referring to that distribution).
Biological diversity	*See* biodiversity
Biomass	Plant and other material of biological origin
Carbon accounting	Estimation of the amount of carbon in an ecosystem and changes in the amount stored. Carbon accounting in forests refers to estimating changes in carbon stored arising from activities such as reforestation.
Carbon sink	Components of the land and biomass where carbon is held in non-gaseous form for substantial periods of time.
Carbon sources	Sources of emissions of carbon dioxide to the atmosphere.
Clearfelling	A silvicultural system in which all trees in large areas are harvested in one operation. Trees needed to provide wildlife habitat, streamside reserves or other purposes are retained.
Closed forest	Forest in which the tree crown cover ranges from greater than 80 to100 per cent of the land area when viewed from above.
CO^2 equivalents	Measurement units used to express the effect in the atmosphere of different *greenhouse gases* as a unit of CO^2 (that is, carbon dioxide).
Code of forest practice	Set of principles, procedures, guidelines and standards that specify minimum acceptable practices in harvesting and associated forest management operations.
Community	*See* plant community
Crown cover	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.
Dieback	A symptom of disease in trees and other vegetation in which the foliage progressively dies from the extremities; commonly referred to with respect to native forests affected by cinnamon fungus (*Phytophthora cinnamomi*), or woodland forests affected by salinity.
Downstream processing	As used in manufacturing, refers to the processing of materials from primary products into manufactured products. For example, using sawlogs to produce sawn timber and using sawn timber to make furniture (also referred to as value adding).
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, whilst 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 diversity	*See* biodiversity
Edge effect	In relation to forests, effect of non-forest environmental influences on parts of the forest adjoining non-forested land.
Endangered species and communities	Species/communities at risk of extinction if factors causing population decline continue.
Endemic	Species of plant or animal that only occurs naturally in a region or country (*see also* exotic).
Exotic	Species of plant or animal found in a region where it does not occur naturally (*see also* endemic).
Farm forest (farm forestry)	Establishment and/or management of trees on farmland for commercial, aesthetic and/or environmental reasons.
Forest	A land area, incorporating all living and non-living components, 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 per cent. This definition includes native forests and plantations and areas of trees that are sometimes described as woodlands.
Freehold	*See* land tenure
Genetic diversity	*See* biodiversity
Geographic information system	A system, usually computer-based, for spatially relating geographic data for analysis, presentation and storage.
Global carbon cycles	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.

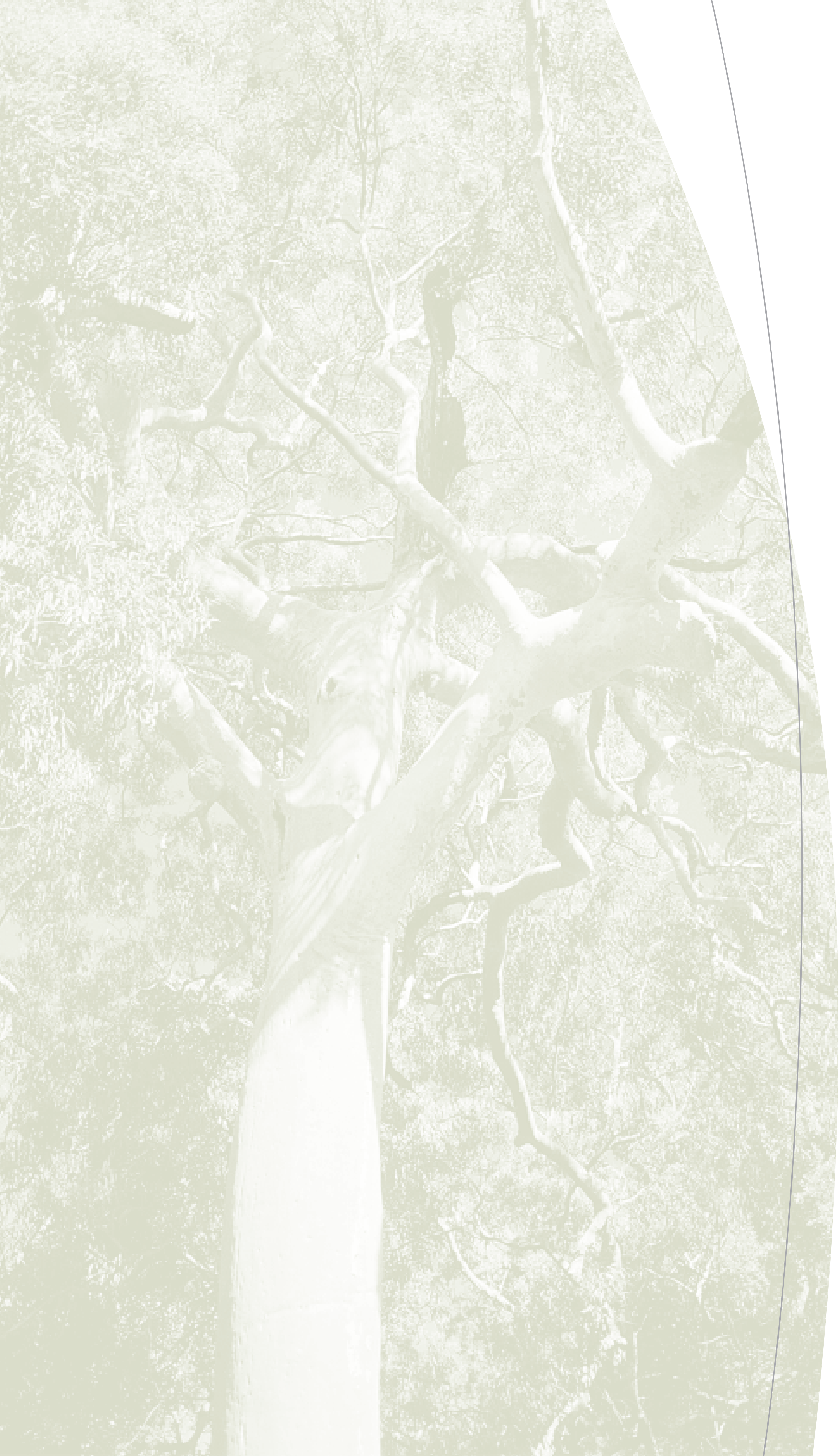
Group Selection	A silvicultural system in which groups (small patches) of trees are selected for harvesting, leading to a forest comprised of patches of different age trees.
Hardwood	Timber from flowering trees, such as eucalypts, irrespective of the physical hardness of the timber; also used to refer to the trees that have such timber.
Harvesting	As part of forest management, cutting (felling) of trees to produce timber products.
Indigenous	People of Aboriginal or Torres Strait Islander descent.
Intergenerational equity in natural capital	Ensuring that future generations will have access to natural resources of the same health, diversity and productivity as those available to current generations.
Land tenure	The land tenure (ownership or management) categories used for reporting Montreal Process criteria and indicators are: • Leasehold: Crown land leased for private use, such as for grazing or mining. • Multiple-use forest: State forests and timber production reserves and other areas of public forest where timber production is permitted. • Nature conservation reserves: Crown (that is, public) land formally reserved for environmental, conservation and recreation purposes; including national parks, state parks and crown lands reserved for water catchment purposes. • Other crown land: Crown land reserved for purposes other than those specified above, for example, utilities, research, education, stock travel routes and defence. • Private land: Land held under freehold title and private ownership; includes land held by designated Indigenous communities under freehold title with special conditions attached.
Lignotuber	Woody swelling at the base of the plant stem carrying buds by which the plant can regenerate; a notable feature of mallee eucalypts.
Montreal Process	The informal agreement by the Montreal Process Group of countries (currently 12) to work towards the implementation of a comprehensive set of criteria and indicators for the conservation and sustainable management of forests.
Mosaic/patchwork	When referring to vegetation, comprised 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 forest	*See* land tenure
Old-growth forest	Ecologically mature forest where the effects of disturbances are now negligible.
Open forest	Forest in which the tree crown cover ranges from greater than 50 to 80 per cent of the land area when viewed from above.

Particleboard	A panel product made by compressing wood particles (usually from softwood timber) and resin; commonly used in flooring and joinery.
Pheromone	Chemicals emitted by insects to attract sexual partners.
Photosynthesis	A process occurring in plants in which energy from sunlight and carbon dioxide from air are used to produce plant matter and oxygen is released.
Plant community	Recognisable association of a number of plant species.
Plantation	Intensively managed stands of trees of either native or exotic species created by the regular placement of seedlings or seeds.
Plywood	A panel product made by gluing veneers of wood together. Plywood is commonly used in construction and joinery.
Precautionary principle	The idea that where there is a threat of serious or irreversible damage, lack of certainty of that damage occurring should not be used as a reason for postponing measures to prevent it.
Provenance	The place of origin of a plant or animal.
Regeneration	New trees arising naturally or with human assistance after harvesting, fire or other causes have removed all or some of the overstorey. The site conditions that favour establishment of regeneration vary widely between plant species.
Regional Forest Agreement (RFA)	An agreement between the Commonwealth 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 upon the detection of energy—such as light and heat—emitted from or reflected by the object (the data obtained by such methods).
Respiration	Breathing—taking in oxygen and emitting carbon dioxide (*see also* photosynthesis).
Ringbarking	Killing a tree by cutting the sapwood in a ring around the trunk.
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 level of salt in water or soil. Salinisation is the process of increasing salinity levels, for example, as occurs in soils and streams when saline groundwater rises towards the surface following clearing of forests for farmland.
Sawnwood	Or sawn timber; timber produced by sawing logs into particular sizes for uses such as building.
Sclerophyll (sclerophyllous)	Refers to plants and vegetation, such as eucalypts and acacias, which have tough leaves adapted to arid climates.

Shrubland	Vegetation dominated by woody plants multi-stemmed at the base or, if single-stemmed, then less than 2 metres height at maturity.
Selective or Partial Logging	A silvicultural system in which trees above a certain specified size are removed singly or in groups whilst retaining regrowth, pole timber or habitat trees to maintain uneven-aged forest.
Siltation	Deposition of silt (that is, fine soil and mineral matter); refers to 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 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, where regeneration can occur in patches created by individual trees falling or being removed.
Snig tracks	The track along which a log is snigged (that is, towed) from where the tree was felled to where the log is loaded onto a truck.
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
Stomata	The pores in plant leaves through which air passes carrying oxygen, carbon dioxide and other gases.
Structure/forest structure	The characteristic of forests to have layers of canopies. The uppermost layer is formed by the tallest trees and there may be nil, 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 to the creation of habitat for a wide range of species.
Suite of forest values	A group of related values occurring in a forest.
Sustainable yield	Yield of forest products (eg timber, water) that ensures the functioning of the forest system as a whole is maintained and the flow of products is continuous in perpetuity.
Tall forest	Forest dominated by tree species capable of growing to a mature height greater than 30 metres.
Taxa	A classification of plant or animal, for example, a species or genus.
Tenure	Title to land as controlled by legislation. (*See also* land tenure)
Value Adding	Process of converting raw timber or forest products into one or more higher valued products.
Vulnerable species and communities	Species believed likely to move into the ‘endangered’ category in the near future if the factors causing population decline continue.

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 is capable of providing opportunities for solitude and self-reliant recreation.
Woodland	Sparse forest in which the tree crown cover ranges from greater than 20 to 50 per cent of the land area when viewed from above.

Introduction



INTRODUCTION

Forests are one of Australia's major natural assets. They have many uses and provide a range of valuable products and benefits. Accordingly, the Australian community expects to be kept informed about the nation's forest estate and its management. Australia has a National Forest Policy Statement, which was formulated following the United Nations Conference on Environment and Development (the Earth Summit) in Rio de Janeiro in 1992. The Statement includes a commitment to prepare a public report on the state of Australia's forests every five years. This report is the second such State of the Forests Report, prepared in fulfilment of these obligations.

The Montreal Process

Australia also participates internationally in forest-related programs. Since the Earth Summit, several national and international initiatives have been launched to assess forests and to improve our understanding of sustainable forest management. One of these, the 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, was formed in 1994. The Group's member countries are Argentina, Australia, Canada, Chile, China, Japan, South Korea, Mexico, New Zealand, Russian Federation, United States of America and Uruguay. The countries participating in this group span five continents and account for 90 per cent of the world's temperate and boreal forests (60 per cent of all forests on the globe) and 45 per cent of world trade in wood and wood products.

The member countries of the Montreal Process, including Australia, have agreed to present their own country reports at the 2003 World Forestry Congress. This State of the Forests Report will be tabled by Australia to fulfil this requirement. Hence, it will reach an international audience and present, to the world community, information describing Australia's forest estate and management.

In 1995, the Montreal Process Working Group countries issued a declaration containing 7 national criteria and 67 national indicators developed especially for the sustainable management of temperate and boreal forests. Australia has adapted some of these and added others, to reflect more accurately its own unique situation. After wide-ranging consultation, in 1998 Australia adopted a comprehensive set of 7 criteria and 74 regional (sub-national) indicators, some of which were identified as 'interim indicators'.

Assessing the state of Australia's forests

Monitoring, assessing and reporting on all the many forest types, tenures and uses within Australia is complex. The task is made easier by the use of a consistent framework, which defines forests to encompass plantations and many woodlands and provides a common understanding of what is meant by sustainable forest management. The next step is to evaluate progress towards the goals of achieving sustainable management nationwide. To achieve this, Australia has recently adopted the use of criteria and indicators that measure the progress being made and allow action to be directed where it is most needed.

The criteria and their indicators will improve the quality of information available to the Australian community as well as to decision-makers. The criteria describe the broad forest values that society aims to maintain. Examples are Biological Diversity (Chapter 1 in this report) and Socio-Economic Benefits (Chapter 6). Some criteria have more indicators than others and, to help in organising the report, they have been divided into sub-criteria.

Indicators are yardsticks to measure particular aspects of the criteria. For example, 'Fragmentation of Forest Types' (Indicator 1.1e), provides information on a feature that is important in the assessment of biological diversity. An important characteristic of indicators is that they are measurable or assessable. When observed over time, indicators may exhibit a trend. These trends yield useful feedback on the state of our forests, their management and their contribution to society.

The acceptance of these criteria and indicators as the basis for measuring and reporting varies across the country, depending on capacity, regional community demand and legislative requirements. Many public and private forest managers have adapted the criteria and indicators for their particular business and operational requirements. But wherever or however they are used, the approach embedded in the criteria and indicators is the sustainable management of forests as ecosystems. Of course, no single criterion or indicator by itself is a complete and true indication of sustainability. Rather, they must be looked at as a whole. This is an important point when reading this report. The text of many indicators contains references to others. Two indicators may be quite similar in what they are measuring and, to get a clearer picture, they may need to be read together or in conjunction with others.

Australia's State of the Forest Report 2003

Australia's second State of the Forests Report is the first occasion in which Australia's framework of 7 criteria (identified as chapters in this report) and 74 regional indicators has been reported. The report was prepared by the National Forest Inventory, a cooperative program of Australian Government, State and Territory governments, for the Montreal Process Implementation Group which is a Australian Government, State and Territory body established to develop and implement Australia's Montreal Process framework of criteria and indicators.

The report demonstrates an improvement in the process of reporting on Australia's forests. The organisation into criteria and indicators was not possible for the first report in 1998. Since then, much has been changed in forest management and in Australian Government–State relations to help gain a clearer picture of the national forest estate. For example, Regional Forest Agreements (RFAs) require criteria and indicators to be used in their regular periodic reviews.

Several national vegetation-related initiatives have also developed since the first report. In 1997 the National Land and Water Resources Audit established the National Vegetation Information System to compile a national vegetation dataset. The Australian Greenhouse Office's National Carbon Accounting System continued to produce updated vegetation related information. The most recent State of the Environment Report, which includes forest-related issues, was published in 2001. The National Forest Inventory is a participant in all of these national initiatives.

Interpreting this report

Some information from these initiatives are included in this report, however, due to the specific and comprehensive nature of the indicators, much of the information in this report is based primarily on a national call for data, which closed in December 2002, to all States and Territories, which collect, analyse and interpret most of the data on Australia's forests. These data remain the property of the custodian, usually respective State and Territory agencies or industry bodies, or national organisations for those indicators for which nationally collected data were used. Data were not available for some indicators because the necessary monitoring and management systems were not always in place—so data may have been incomplete, not collected, not centrally collated, or not available to this report. A dash (–) symbol has been consistently used in all tables to indicate where data are not available.

An assessment of the availability and completeness of the data for each of the 74 indicators in this report is provided in Indicator 7.4a. The assessment covers three categories: geographic coverage (ranging from nationally complete to case studies only), data currency (how up to date the data or information are), and frequency with which the data are collected. In the detailed discussion for each of the indicators throughout the report, three data assessment categories are presented in the following format according to the legend below.

●	coverage	(geographic coverage)
●	currrency	(data currency)
●	frequency	(frequency data are updated)

Legend for indicator coverage (from Indicator 7.4a, Table 122)

Key		Coverage	Currency[1]	Frequency[2]
Data complete at the national level	●	Whole country assessed	1998+	Annual to 5 yearly
Partial data	●	Incomplete data	1980 - 1997	Greater than 5 Years
Scientific studies or limited work available, or only required once	●	Case study	Incomplete	Once only
No data available	●	No data	No Data	No Data
Range of data coverage, currency and frequency[3]	○	Range	Range	Range

1 Currency of available coverage
2 Frequency the available coverage is updated
3 The predominant response appears in the relevant colour but is also a mix from other possible responses

While it is possible in parts of this report to compare data against those presented in the past, it is too early to assess the implications for sustainable forest management of any apparent trends. Indeed, comparisons against previously reported figures are not always advisable. Collection processes may have changed since the last report; different categories or classifications may be used, and legislation or management processes are likely to have changed. As a result, apparently similar data may not be truly comparable.

Another important issue to bear in mind when using this report is the fact that many indicators remain incomplete and may need further research. It is only to be expected that some indicators will be subject to refinement as more knowledge is acquired.

Further reading

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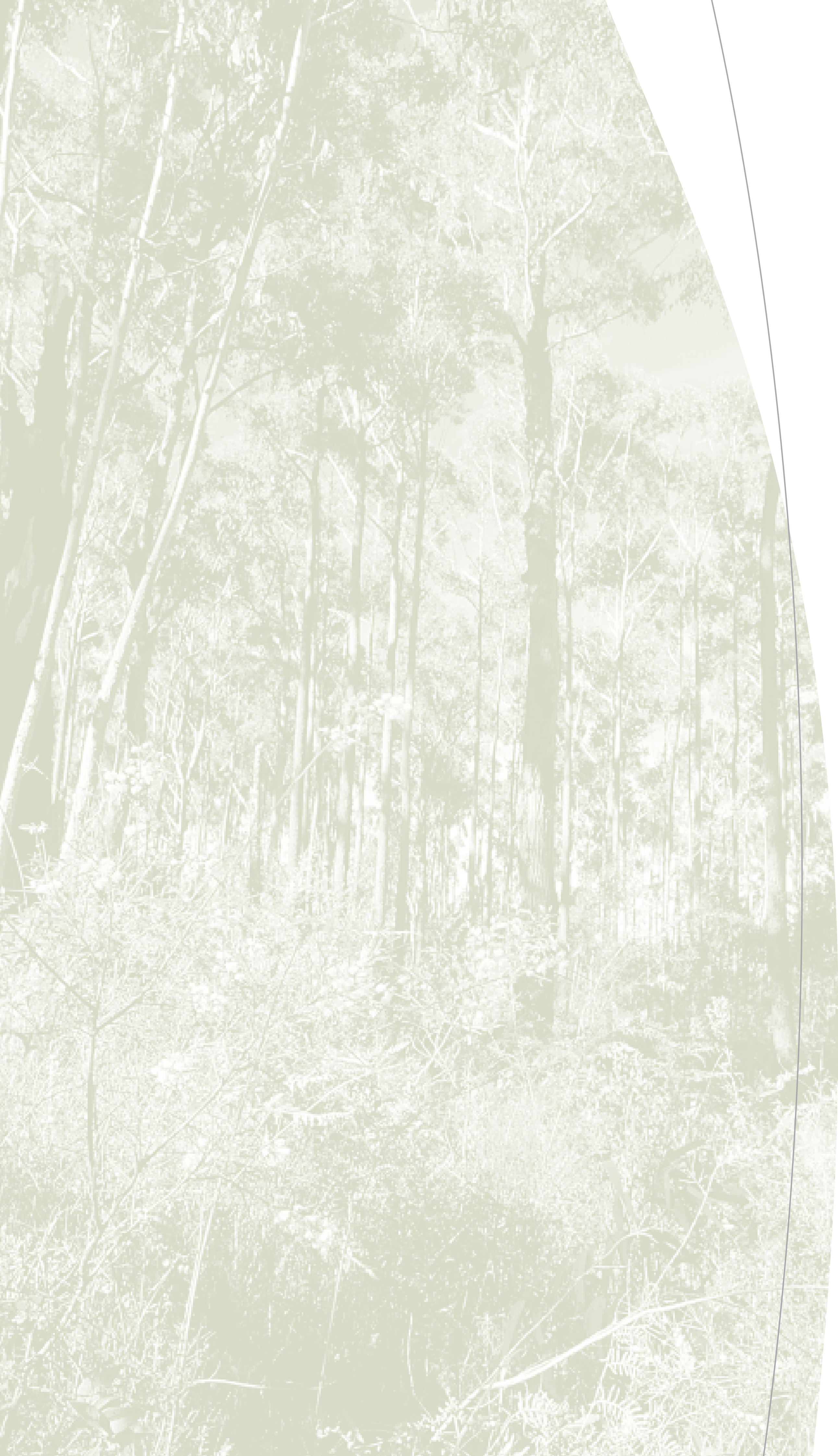
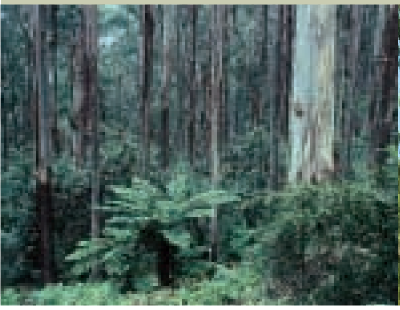
National Forest Inventory (1998). Australia's State of the Forests Report 1998. Bureau of Rural Sciences, Canberra

National Land and Water Resources Audit (2001). Australian Native Vegetation Assessment 2001, Canberra

Overview



Overview of Australia and its forests




The continent of Australia

Spanning about 4 000 kilometres from west to east and about 3 600 kilometres from north to south, Australia is the world's sixth largest country, with an area of about 768 million hectares. It experiences a wide range of climates: temperate, monsoonal tropical and wet tropical, Mediterranean, arid and semi-arid, and even a small alpine zone.

Despite the spaciousness of the land, Australia's people are highly urbanised. Most of the population of about 20 million is concentrated in narrow bands of land along the east, south-east and south-west coasts. Australia's five major 'million-plus' cities account for 60 per cent of the population but occupy only 1 per cent of the land area. Only about 15 per cent of Australians live in rural or remote areas; the remainder live in cities and towns.

Australia straddles the Tropic of Capricorn, with more than one-third of the country lying within the tropics. It has the lowest rainfall of any inhabited continent. About one-third of the country receives an average rainfall of less than 250 millimetres per year and experiences high evaporation rates. The northern, eastern and south-western coastal zones receive the highest rainfall, exceeding 500 millimetres and in places in excess of 3 000 millimetres per year. Towards the interior rainfall diminishes greatly (Figure 1).

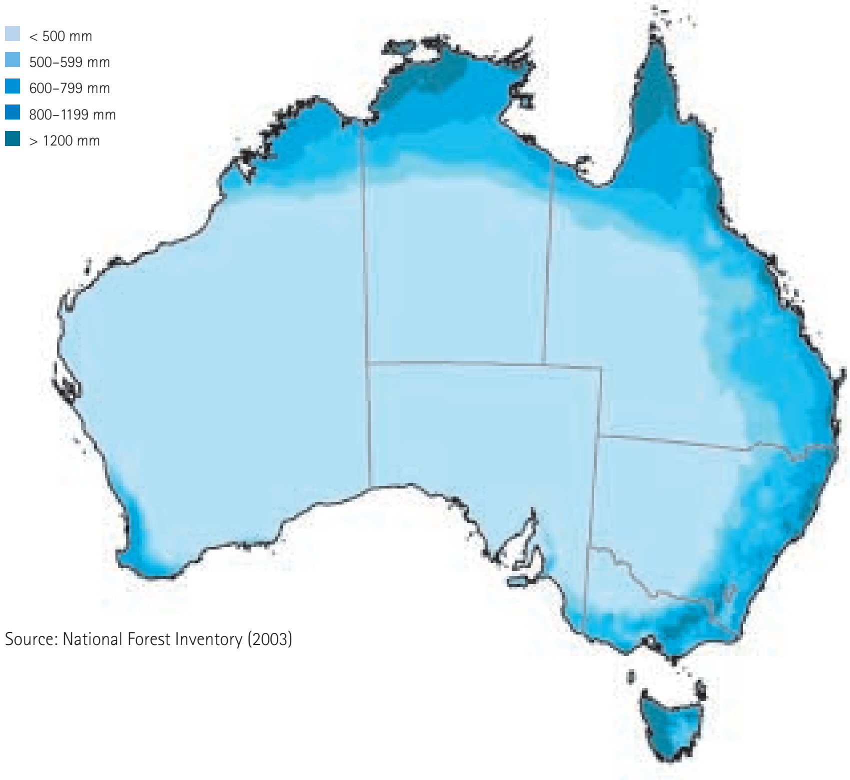
Australia is one of the seventeen most biologically diverse countries in the world. Parts of south-western Australia, the Queensland wet tropics, some Tasmanian forests and certain eucalypt forests are internationally recognised areas of high and significant biodiversity. The continent's long period of geographic isolation means that it contains large numbers of plant and animal species found nowhere else.

What is a forest?

Fundamental to reporting on the state of Australia's forests is a consistent definition of a forest. The definition used in this Report is that adopted by Australia's National Forest Inventory and used in the first State of the Forests Report (1998). Accordingly, a forest is:

> *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 per cent. This includes Australia's diverse native forests and plantations, regardless of age. It is also sufficiently broad to encompass areas of trees that are sometimes described as woodlands.*

Figure 1: Australian rainfall



Source: National Forest Inventory (2003)

It is based on the 1992 National Forest Policy Statement, signed by all State, Territories and the Australian Government, but modified to remove uncertainty relating to crown cover and height, and to meet operational implementation requirements. The minimum potential crown cover to qualify an area of trees as forest is now 20 per cent, which puts into effect the National Forest Policy Statement requirements that 'forest' is to include what has sometimes been called 'woodland'. The definition also refers to 'trees having usually a single stem' and sets the lower tree height limit at two metres. This allows inclusion of the forest-forming mallees. Shrublands are excluded, even if they are taller than two metres, because of the requirement to be of tree formation. This definition is biologically based, rather than focused on particular forest uses. It is similar to the single internationally agreed definition used by the United Nations Food and Agriculture Organisation, which is:

> *Land with tree crown cover (or equivalent stocking level) of more than 10 per cent and area of more than 0.5 hectares. The trees should be able to reach a minimum height of 5 metres at maturity* in situ. *May consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground; or of open forest formations with a continuous vegetation cover in which tree crown cover exceeds 10 per cent.*

This report uses the National Forest Policy Statement definition of a plantation, accepted by the National Plantation Inventory, that is:

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

Origin of Australian forests

At least 135 million years ago the land that was to become Australia started breaking away from the large super-continent of Gondwana. Gondwanan forests contained the trees that were the ancestors of most of our native trees today. That is why the Australian flora and much of the fauna resembles most closely that found in South America and southern Africa—both once parts of Gondwana—rather than the currently much closer areas of Asia.

About 38 million years ago, the Australian continental plate completed its final separation from Antarctica—the remnant of Gondwana. The continent started its gradual drift northwards into hotter and drier latitudes. Rainforests were gradually replaced by vegetation better adapted to drier conditions. This was the origin of the sclerophyllous vegetation—which usually has hard, spiky or shiny leaves to reduce moisture loss—over much of the country today. In particular, these forests adapted to the nutrient-deficient, weathered, shallow and fragile soils covering much of the continent. Eucalypts and acacias flourished, but species dependent on constant high levels of moisture were reduced in extent, becoming confined to relatively small areas of the continent. Fire frequency increased. Most of the original Gondwanan forests had disappeared by two million years ago, but some modified remnants managed to persist to the present and are of particular interest and rarity value.

Over the last two million years the climate has fluctuated between warm, wet periods and cool, dry ones. The forests have advanced and retreated along with these changes. But the isolated Australian land mass during this time also started coming into closer contact with Asia, and interchange of some species occurred. At a time of lower sea level, this proximity allowed humans to enter during the last 100 000 years.

Human occupation of Australia

The first humans are thought to have arrived in Australia from south-east Asia more than 60 000 years ago, and Indigenous occupation of the land has probably been continuous since then. Indigenous people applied fire as a land management and hunting tool, although its use varied considerably across the country. Over tens of thousands of years, regular burning by Indigenous people probably had a major effect on vegetation structure and composition, but the extent and implications of this are still debated.

The management practices used by Indigenous people were—and in some cases still are—set within a system of spiritual beliefs, including identity with the land. Traditional cultural and religious perspectives emphasise aspects of responsibility for and stewardship of the country.

Since the arrival of Europeans in 1788, impacts on forests have been more varied and far more profound. Europeans have cleared large areas of forest for agriculture and urban use. Much of Australia is now affected in some way by European use or by the removal of Indigenous people and the ensuing change in treatment of the land and vegetation.

It is not possible to determine precisely the changes that have occurred in the area and distribution of forests since 1788. There are no comprehensive observations of forest extent at that time, although estimates have been made based on climate and soils. These estimates, however, use a different definition of forest (Atlas of Australian Resources Vegetation, 1990) than that used in this report and in the National Forest Inventory, making direct comparisons difficult. Nevertheless, within these constraints, a reasonable estimate may be that about 33 per cent of the originally forested area has been cleared and another 40 per cent has been affected by harvesting at some stage. On the other side of the ledger, new plantations have been established, and changes in fire and grazing regimes may have encouraged regeneration in some areas.

Land ownership and tenure

The settlement of Australia by the British started with the arrival of only a few hundred people in 1788. All land became government property (referred to as 'Crown land'). It was then allocated to individuals—principally as leasehold but also as freehold—for use mainly in agriculture. Those areas not allocated over the past two centuries remain as multiple-use forests, timber reserves, nature conservation reserves or vacant Crown land. Much agricultural land is still operated as long-term Crown leases (by area rather than by parcels). Australia is rare among western countries in having such a high proportion of publicly owned land.

Changes in land tenure have occurred since the last State of the Forest Report in 1998. These have come from decisions by Courts recognising Aboriginal and Torres Strait Islander land claims, so that large areas of forest for example in northern Australia are now owned and managed by Indigenous people. In addition, as part of the recently completed Regional Forest Agreements, there have been transfers of multiple-use forests and unclassified Crown land to nature conservation reserves.

Political responsibilities

The Commonwealth of Australia is a federal democracy in the form of a constitutional monarchy. There are three main levels of government: Commonwealth, State/Territory and local. In some areas, the traditional law-making and land management processes of Aboriginal and Torres Strait Islander peoples continue.

Politically, Australia consists of six largely self-governing States and two mainland Territories. There are also several external or offshore territories controlled by the Australian Government. 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.

Management of land and natural resources, including forests, is largely the responsibility of the State and Territory Governments. Through its external powers, the Australian Government is responsible for meeting Australia's international obligations through the conventions and treaties to which it is party. In the past the Government has used its external powers in relation to domestic land use and environmental issues, for example in 1983 in the case of the proposed Franklin River dam in Tasmania, through the *World Heritage Conservation Act 1983*. Use of these powers is uncommon and it is more usual for the Australian Government to develop national policy and the means for implementation, in consultation and coordination with the States and Territories. The National Forest Policy Statement of 1992 and the Regional Forest Agreements (RFAs) developed over succeeding years to implement the policy is a good example of this collaboration. Nevertheless, the Australian Government reserves the right to legislate on matters of national importance, for example, through the *Environment and Biodiversity Conservation Act 1999*.

Grey gum (*Eucalyptus punctata*) forest

Forest clearance for agriculture

Europeans brought agriculture and species of plants and animals that had never lived in Australia. The removal of trees to create grazing land for pasture animals or for crops has been one of the most obvious effects of European settlement in the higher rainfall zones. Areas of good soil and rainfall were preferentially chosen for agriculture, and often these were the very places where tall and medium-height eucalypt forest or rainforest naturally occurred. Later, the colonists carried out extensive thinning and clearing of widely spread woodland forest in lower rainfall areas so that the land could be used for grazing. Thus, the removal of forests provided the colony with the three most important economic resources of its early history—wool, meat and grain.

Clearing in the twentieth century was encouraged by the soldier settlement scheme in operation after both World Wars. The scheme rewarded soldiers returning from the fighting with a grant of land to help them earn a living, with the proviso that the land was to be cleared for 'productive' use.

Now much of Australia's 'best' land—that is, land with adequate water and soil nutrients—is used for agriculture and urban settlement, and other areas are legally protected, so that forest clearance has dramatically declined. The annual rate of reported clearance has fallen from an average of 1.4 million hectares during the 1970s to about 240 thousand hectares in 1998. Forest remaining on private freehold land is not generally subject to the same kind of protective regimes that apply to forested public land. Most States have enacted legislation to prevent or restrict further native vegetation clearing on private land, while in others land clearing is the subject of negotiation between the State and the Australian Government.

While the States have constitutional responsibility for the management of natural resources, they are signatories with the Australian Government to national statements on native vegetation clearance, including the National Framework for the Management and Monitoring of Australia's Native Vegetation, the Intergovernmental Agreement on a National Action Plan for Salinity and Water Quality, and the Framework for the Extension of the Natural Heritage Trust.

All governments have agreed to reduce the national net rate of land clearance to zero, which means that the area of native vegetation communities cleared per year should be less than the area being re-vegetated to native vegetation communities over the same period. Governments have further agreed to prevent land-clearing that might lead to unacceptable land and water degradation, and to prevent the clearance of endangered or vulnerable vegetation communities or of habitat that is critical for threatened species.

Forest types and their extent

Climate and soil properties broadly determine the distribution of forests across Australia. Although other factors, such as fire history, are also important. As a result of its climate and the low nutrient status of many soils, Australia is the least forested continent apart from Antarctica. Moreover, the majority of the country's forests are open-crowned, with canopy covers of less than 70 per cent.

The latest estimate of Australia's forest area is close to 164 million hectares (Table 1), which is approximately 22 per cent of the continent. This area is shrinking as total land-clearing continues to exceed new forest establishment and regeneration.

Australia has few native conifers and 99 per cent of the native forest area is broadleaf. By contrast, about 60 per cent of plantations by area are exotic conifers. Nationwide, the main native forests are various types of eucalypt. Indicator 1.1a provides further information on Australia's forest types.

Table 1: Land area of major forest types

Forest type	Area ('000 ha)
Acacia	16 488
Callitris	2 330
Casuarina	2 039
Eucalypt	127 024
Mangrove	749
Melaleuca	7 056
Rainforest	4 214
Other	2 780
Total native forest	162 680
Hard wood plantation	638
Softwood plantation	988
Unknown plantation	2
Total plantation[1]	1 628
Total forest[2]	164 290

Source: National Forest Inventory (2003).

1 National Plantation Inventory (2003)

2 'Total forest' area for Tasmania is sourced from the Tasmanian RFA Review (2001) and does not include more recent NPI 2003 plantation figures. Therefore the total native forest area for Tasmania is a slight overestimate due to some clearing of native forest for plantation establishment after June 2001.

Note: All values have been rounded, hence, column and row totals may not tally exactly.

In general, and with the notable exception of mallee, forest distribution today is mainly confined to regions where average rainfall exceeds 500 millimetres per year. Most forests occur in the northern, eastern and south-western coastal zones, including Tasmania. However, woodland forests extend into some drier areas in several parts of the country. In some places, for example the Eastern Goldfields region of Western Australia, the stature and extent of the native forest is greater than would be expected from the low rainfall; trees there have developed survival mechanisms to withstand dry conditions, relying on groundwater stores or occasional floods.

The genus *Eucalyptus*—which occurs naturally mainly in Australia—accounts for the majority of the country's forests in terms of area. The second most important genus is *Acacia*. Despite the overwhelming dominance of these two genera, our forests are very diverse. There are more than 700 species of eucalypts, as well as many other genera of trees, in a rich array of ecosystems that vary in their floristic composition, structure and the fauna they support.

Forest uses

The many ways in which we directly or indirectly use forests are hard to classify. In general, however, there is a distinction between tangible products that are consumed, and the more general benefits, amenities or services that forests provide. Products include timber, woodchips, bark, honey, and native plant seeds, flowers and cuttings. Many services from forests are classified as ecosystem services. Forests provide habitats for tens of thousands of animal species and millions of microbial species. The existence of a forest may prevent soil erosion, yield unpolluted water for later human consumption, and influence local climate through shading and transpiration. Forests play an important role in the global carbon cycle. Forests are widely used as places for recreation and tourism. Finally, there are benefits that are impossible to quantify or value economically, and which may have no obvious utilitarian value. Forests may be appreciated for their beauty, their biological heritage and the mere fact of their existence.

The timber industry

The timber industry has been an important part of the Australian economy since British colonisation. Colonies required wood for houses, boats, bridges and local construction. The first timber exported was to Britain in 1791. The rate of timber harvesting was low until the mid-1800s when demand increased steeply and steam mechanisation facilitated transport and processing. The gold rushes—especially in the Victorian goldfields in the 1850s and around Kalgoorlie, Western Australia, in the 1890s—prompted urgent demands for timber for mining-related activities. The surrounding forests were rapidly depleted, although there was considerable natural regeneration later.

Gradually the number of sawmills increased, but inland transport remained a problem. Coastal forests were heavily used because their produce could be relatively easily loaded into boats. The extension of the railways from the 1870s increased opportunity for timber transport, and more distant forests were exploited. Riverboats and rail made available the use of the river red gums (*Eucalyptus camaldulensis*) along the Murray River. However, the industry did not enter remote and mountainous areas until the early twentieth century.

The jarrah (*E. marginata*) and karri (*E. diversicolor*) forests of Western Australia were opened up later than forests on the eastern side of the country. They were used extensively from the 1890s for railway sleepers and other heavy construction timbers, much of which was exported.

By the 1920s all States had established forest management agencies to control timber harvesting and manage forest resources. Pulp and paper-making began in the 1930s.

Single-tree selection and group selection harvesting were the norm across the country until the early to mid-1900s. Many patches of forest were left untouched because they were inaccessible or economically unviable, and many trees were left standing in harvested forests. The end of the Second World War marked a turning point. Clear-felling, particularly in moist forest types, increased during the 1950s with the introduction of chainsaws, heavy tractors and the development of the pulpwood industry. This practice generally resulted in good eucalypt regeneration. Selective harvesting has continued in drier forest types. In recent years, managers in moist eucalypt forest have tried alternative silvicultural techniques in conjunction with clear-felling.


Michael F. Ryan

Docking sawn timber

In the 1970s a woodchip export trade began with the construction of large woodchip mills in southern New South Wales (one), Tasmania (three) and Western Australia (one). Other operations were started later in Victoria. Originally proposed by sawmillers as a market for waste from their operations, the woodchip industry was supported by professional foresters because it provided an opportunity to rehabilitate and promote regrowth in forests that had been economically degraded by past harvesting.

Governments supported wood-chipping operations because they offered economic and regional development benefits from local processing in local pulp and paper mills. The bulk of the trade in the east was supplied from integrated (sawlog and residual roundwood) harvesting of tall and medium eucalypts in publicly managed forests that had previously been selectively harvested, while in the west it came from both clearfelling and selective cutting, depending on the silvicultural needs of each forest type. As the industry expanded, wood was obtained from several other types of operation, most importantly by thinning regrowth stands. It was also integrated into operations that were conducted on previously unharvested areas.

Recent and current practices of the timber industry are broadly aimed at the sustainable use of forests. The management goal is to retain as many of the different values of the forest as possible, whilst being able to harvest timber on a regular rotation in a mosaic or patchwork approach within the multiple-use forests available for timber production.

Other forest products

Timber is not the only product that forests yield. Honey is a valuable commodity, and apiarists frequently station hives in forests. Native Australian tree seeds are collected for research or for sale or supply to other countries. The native Australian wildflower industry relies partly on forested areas. Foliage, mushrooms and animals may all be harvested. Minerals are also extracted from some areas classified as forests.

Tourism and recreation

As an employer and generator of export earnings, tourism is now one of Australia's most significant industries. In an increasingly competitive tourist market, Australia's natural environment is a major attraction for domestic and overseas visitors, and forests are an important aspect of this. Many tourism-related and recreational activities take place in forests, and careful management of values important to tourism is now recognised as essential.

History of forest conservation

The increased clearing for timber in the mid-1800s led to some concern over the state of forests and of downstream water quality. As a result land started to be set aside for the sustainable harvesting of timber. At this time an increase in public awareness and interest in Australian species lead to the creation of small recreation areas, with no harvesting, for public use. In 1879 the first true National Park was declared when 73 000 hectares was set aside for the Royal National Park in the sandstone country south of Sydney. Later significant National Park additions included Mount Buffalo and Wilson's Promontory in Victoria in 1898, Cradle Mountain in Tasmania in 1922 and Kosciusko National Park in New South Wales in 1944. During the early 1900s conservation groups began to emerge, mostly forming from subgroups of existing natural and scientific organisations. These organisations were concerned with issues such as forest conservation, water catchment and soil conservation issues.

During the 1960s, a significant change occurred in the actions and thinking of the public regarding environmental protection. This change was perhaps galvanised by the proposal of the Tasmanian government to place hydro-electric dams in the south-west of the State, flooding Lake Pedder and later the Franklin River. In 1967 Tasmanian conservationists formed a committee to save the lake. Although the dam proceeded at Lake Pedder, the conservation groups realised the power of using the media to seek public support in furthering their cause.

In 1979 the first major forest blockade took place, at Terania Creek in New South Wales with considerable media coverage. Public campaigning to raise community awareness of conservation issues are now a major part of the forest debate.

Open eucalypt forest on plains and open melaleuca forest along rivers characterise areas of the Kimberley, Western Australia

The blockade of the Gordon River, below Franklin River dam, led to the introduction of the *World Heritage Conservation Act 1983* and the protection of the environmental values in the area.

During the 1970s the Australian Government, States and Territories introduced a range of legislation for environmental protection, and set up organisations for the management and protection of environmental values and conservation reserves. The Australian Government started to use its powers over trade, external affairs and investment to influence forest management decisions within the States.

In 1991 the Australian Government's Resource Assessment Commission instigated a large assessment of forest values, including public attitudes towards the management of forests. Public concerns over management of forests emerged from this assessment, with 75 per cent of Australians reporting that they regarded the preservation of forests as important. Governments continued to respond to these concerns and in 1992 signed a National Forest Policy Statement indicating guiding principles and objectives for forest management.

Using the principles of the National Forest Policy Statement, the Regional Forest Agreements (RFAs) process was introduced in 1995. The RFA process provided for considerable public consultation in the decision-making process. Conservation and industry groups lobbied government ministers and departments during the process and were often included on technical and steering committees, and contributed scientific analysis documents in the public consultation processes. Calls for submissions from the public on the draft options for the RFAs attracted tens of thousands of submissions for each region. The RFAs also increased the knowledge base (mapping and survey) of forest values and added a significant amount of forest to reserve, including areas of high value to conservation interests.

After the RFA process, several State agencies added further land to reserves, usually in response to outstanding issues that conservation groups or the public had raised. The tenure of about 2 million hectares of predominantly publicly owned forest was converted from multiple-use forest (which allows for timber harvesting) to nature conservation reserve (which emphasises protection of features of the forest environment). Examples include the protection of old growth in Western Australia, the additions to existing reserves in Victoria, and new additions in New South Wales in Whian Whian and Wollumbin.

Although an RFA was not finalised in South East Queensland, the Forest Agreement process between the State government, the timber industry and the conservation movement is sequentially converting multiple-use forests to the nature conservation estate by approximately one million hectares over the next 25 years.

Development of plantations

Plantations were established from the 1870s onwards to supplement Australia's limited natural endowment of softwoods, especially in areas where merchantable native forests were limited. South Australia took the lead and was eventually able to establish sawmills, pulp and paper mills, and panel board factories, based on softwood plantations. Aided by Australian Government loan funds, all States and Territories increased their rate of planting in the 1960s when the future decline in sawlog supplies from the native forests was forecast. Some of the pulp and paper companies also started plantations to provide softwood pulpwood. These, along with plantations established by the larger timber companies, gradually supplied increasing quantities of sawlogs as well as pulpwood. Despite the widespread use of eucalypts for plantations overseas, their use in Australia was minimal until recently. The establishment of eucalypt plantations has increased significantly since the late 1980s.

Total plantation establishment has increased from an average of about 30 000 hectares per year during the 1970s to an average of 87 000 hectares per year over the last five years.

Many of these plantations are on land that was previously used for agriculture. The National Forest Policy Statement encourages the conversion of cleared agricultural land to plantations, and all States and Territories except Tasmania have policies in place that limit the clearing of native forests for plantation establishment.

National Forest Policy Statement

In December 1992 the Australian, State and Territory governments agreed to the National Forest Policy Statement (NFPS), which sets out the vision, goals, objectives and policies for the future of Australia's public and private native forests and plantations. The Statement specifies national goals for sustainable forest management, conservation and the forest industry. It seeks to achieve a balanced return to the community from all forest uses within a regionally-based planning framework that integrates environmental, economic, social and heritage objectives.

Messmate (*Eucalyptus obliqua*) forest, Mason's Falls, Victoria

The NFPS provides a framework within which the Australian community derives optimal benefit from its forests and forest resources. It is a broad-ranging policy that includes most forest values and uses, and involves all relevant government jurisdictions.

In brief, the Statement proposes a framework for the use of native forests in order to achieve social and environmental goals. Two of the strategies for this are the establishment of a 'comprehensive, adequate and representative' (CAR) reserve system, and codes of practice to ensure that uses of public forests do not adversely affect the forests' ecological base and values. The NFPS proposes that each major forest region in which important commercial timber production occurs has an agreement between the Australian and relevant State governments that establishes the obligations and objectives of each party. These are called Regional Forest Agreements.

The Statement sets out the process for undertaking Comprehensive Regional Assessments (CRAs) of the natural, economic and social values of Australia's forests. These Assessments are the joint responsibility of the Australian and State governments. They provide the detailed information on which to base the negotiation of the Regional Forest Agreements.

Regional Forest Agreements

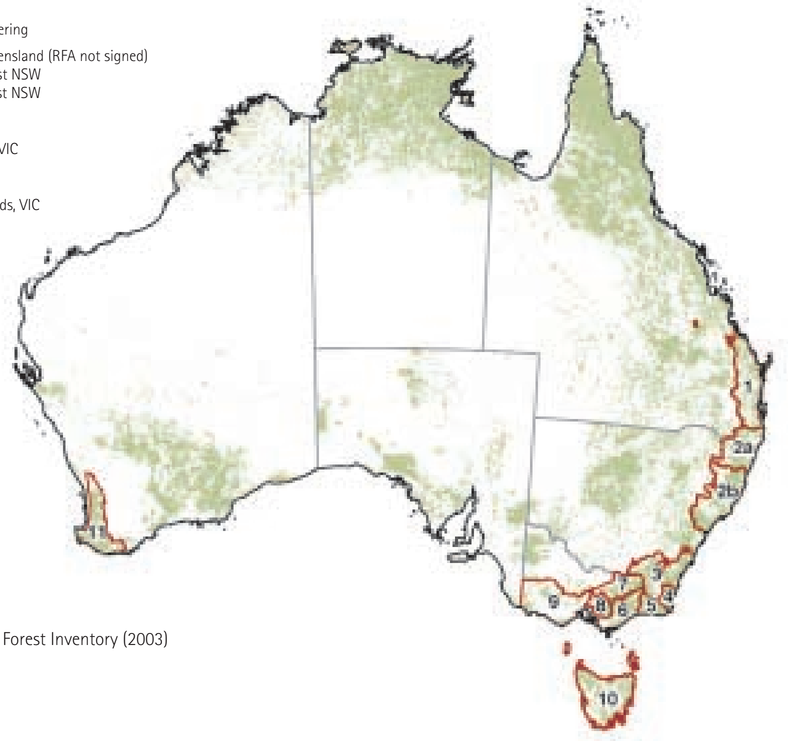
The implementation of Australia's Regional Forest Agreements (RFAs) is a major change since the last State of the Forest Report. RFAs are the way in which the commitments of the National Forest Policy Statement are implemented. They provide a long-term basis for dealing with the obligations of the Australian and State governments in meeting conservation, environmental, social and industry goals. They integrate the conservation and sustainable use of forest resources with the needs of local communities and industry. These agreements cover a large part of the native forest area that is commercially important for timber production. This is the first State of the Forest Report to include outcomes or results of the RFA process.

Ten RFAs have been negotiated between the Australian and relevant State governments (Figure 2). The first RFA was signed in February 1997 for the East Gippsland region. The last RFA to be agreed was the Southern Region of New South Wales in April 2001. While a

Figure 2: Regional Forest Agreement and Comprehensive Regional Assessment Regions

Key to region numbering

1 South east Queensland (RFA not signed)
2a Upper north east NSW
2b Lower north east NSW
3 Southern NSW
4 Eden NSW
5 East Gippsland VIC
6 Gippsland VIC
7 North east VIC
8 Central Highlands, VIC
9 West VIC
10 Tasmania
11 South west WA



Source: National Forest Inventory (2003)

comprehensive regional assessment (CRA) was completed in south-east Queensland, an RFA between the Australian and State governments was not finalised.

While the focus of the RFA process was on geographic regions in which commercial timber harvesting occurred, the regions actually encompassed a range of forest types, as shown in Table 2. Note the RFA process did not occur in the Australian Capital Territory, the Northern Territory or South Australia.

The RFA process involved a 'whole of forest' strategic land use and management planning exercise across all tenures. This took account of the ecological, heritage, economic and social values of forests relevant to achieving sustainable forest management. The twenty-year Agreements are regional strategic forest plans. Agreements define the forest areas that are to be protected as part of a comprehensive, adequate and representative reserve system, and those areas that are to be managed for wood production. Montreal Process Criteria and Indicators (see the Introduction to this report) are used in the monitoring and reporting cycle for the performance of RFAs. RFAs have sought to achieve a world-class conservation reserve system, secure access to forest resources for the forest-dependent industries, opportunities for the development of an internationally competitive timber industry, and a long term basis for ecologically sustainable management of Australia's forest resources and ecosystems. The States and Territories retain the primary responsibility for land management and forest policy continues to develop in response to new developments and community expectations.

The RFA process has not been without controversy as not everyone agrees with the RFA outcomes. This has led to some proposals to change the balance in certain regions. In addition, the States and Territories retain the primary responsibility for land management and forest policy continues to develop in response to new developments and community expectations

Table 2: Distribution of forest types ('000ha) within and outside Regional Forest Agreement and Comprehensive Regional Assessment regions by State/Territory

Forest type	ACT	NSW		NT	QLD[1]		SA	TAS		VIC		WA		Australia	
	Non-RFA	RFA	Non-RFA	Non-RFA	CRA	Non-CRA	Non-RFA	RFA	Non-RFA	RFA	Non-RFA	RFA	Non-RFA	RFA/CRA	Non-RFA/CRA
Acacia	0	10	1 240	1 613	3	6,982	1 939	74	0	34	30	0	4 563	118	16 369
Callitris	0	194	1 046	386	0	387	261	1	0	25	31	0	0	220	2 110
Casuarina	0	65	934	14	8	208	763	1	0	0	4	0	40	75	1 964
Eucalypt Mallee	0	21	2	0	1	121	6 044	0	0	0	1 171	0	4 969	22	12 307
Eucalypt Woodland	21	717	1 757	21 900	415	34 785	1 761	1 627	0	783	280	210	12 727	3 667	73 316
Eucalypt Open	95	7 272	12 450	5 960	1 893	1 493	44	847	0	4 853	475	1 911	329	16 770	20 853
Eucalypt Closed	0	0	0	51	0	0	0	0	0	0	0	0	39	0	90
Mangroves	0	3	0	355	9	186	19	0	0	1	1	0	173	13	736
Melaleuca	0	44	0	1 593	56	5 245	1	19	0	18	78	0	0	136	6 920
Rainforest	0	466	20	224	612	2 273	0	598	0	15	1	0	5	1 688	2 526
Other	0	199	216	738	233	826	34	0	0	15	120	0	397	448	2 332
Total Native Forest	117	8 992	17 666	32 836	3 230	52 504	10 866	3 169	0	5 744	2 191	2 121	23 244	23 157	139 523

Source: National Forest Inventory (2003).

1 A Comprehensive Regional Assessment (CRA) was undertaken in Queensland; however, a Regional Forest Agreement between the Australian and State governments was not made.

Australian Forestry Standard

The Forestry and Forest Products Committee—which comprises Australian Government, State and Territory forest management departments and agencies, under Australia's Primary Industries Ministerial Council—in partnership with the National Association of Forest Industries, Australian Forest Growers, and Plantation Timber Association of Australia, sponsored the development of the Australian Forestry Standard (AFS). Under procedures accredited by Standards Australia, AFS is intended for voluntary application in both native and plantation forests regardless of tenure or scale of ownership. The Standard provides a basis for third party independent auditing, either separately or in conjunction with the ISO 14001 Environmental Management System standard.

The AFS, published in February 2003, is a set of criteria and requirements for forest management in wood production forests. Independent, accredited auditors certify the Standard. Buyers of AFS-certified timber and wood products can thus be confident that they come from sustainably grown and managed Australian forests. Currently in preparation is a voluntary chain of custody standard, which can track a tree from its origin in a certified forest through to its final use by consumers. The steps of harvesting, transportation, processing, manufacturing, distribution and sales are all followed.

Further reading

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Sub-tropical rainforest canopy, Queensland

1

CONSERVATION OF BIOLOGICAL DIVERSITY

INTRODUCTION

Biological diversity, or biodiversity, refers to the variability among living organisms and the ecological complexes of which they are a part. The ultimate objective of the conservation of biological diversity is the survival of species and the genetic variability within those species. Biodiversity can be measured at the ecosystem, species and genetic levels.

Dynamic processes shape forest ecosystems. The species, populations, forest types and distribution of Australia's forest communities are important to fundamental ecological processes and are determined by cycles of disturbance and renewal. Maintaining biodiversity entails examining ecosystems at different time and spatial scales. It also involves making land-use and resource management decisions that incorporate biodiversity needs, such as limiting land clearing, creating protected areas, managing the harvest of wood and non-wood products, preventing invasion of exotic pests and diseases, and protecting wildlife habitat.

The indicators in this Chapter are divided into three Sub-Criteria: ecosystem diversity, species diversity and genetic diversity. Ecosystem diversity describes the range and extent of Australia's forest types and the tenure systems they are managed within. Species diversity is concerned with the number, variety and status of forest-dependent animal and plant species and with determining possible threats to their survival. Genetic diversity includes the range of genetic characteristics found within a species and among different species.

Australia, along with many other countries, signed and ratified the United Nations Convention on Biological Diversity. The Convention has three main objectives: the conservation of biological diversity; the sustainable use of its components; and fair and equitable sharing of the benefits that arise out of the use of genetic resources.

Australia is among the world's top 17 countries for richness of biodiversity. Many forest species here—particularly in the genus *Eucalyptus*—are found nowhere else. Given the size of the country and the numbers of species involved, it is not surprising that we still have much to learn about biodiversity in lower plants, invertebrates and soil microbes. Hence, many forest-dwelling species are still likely to be undescribed.

Echidna (*Tachyglossus aculeatus*)

1.1

ECOSYSTEM DIVERSITY

INTRODUCTION

Ecosystem diversity refers to the variety of habitats, communities and ecological processes within an ecosystem and between different ecosystems. There are three indicators in this section. They examine forests by biological type and also by tenure, and record the area of each type.

The first indicator, 1.1a, is fundamental as it measures the current level of forest cover by forest type and demonstrates whether the area is increasing or decreasing. It also reports on the International Union for the Conservation of Nature (IUCN) categories for conserving native vegetation and allows comparison of Australian performance to IUCN recommendations.

As forests grow and mature, the ecological processes and species associated with those processes change. Hence the age of the trees, their size and growth stage of the forest are important when considering patterns of species diversity and abundance. These are considered in Indicator 1.1.b.

The Australian regional Indicators 1.1a and 1.1b have integrated the content of the international Indicators 1.1c and 1.1d, so the latter are not considered separately. Hence the Indicators jump directly from 1.1b to 1.1.e.

Forest can be fragmented by natural barriers, such as rivers, swamps or patches of shrubland. Human activities, particularly clearing or road building, can add to this fragmentation. Since European settlement, many of Australia's forested landscapes have been converted to a patchwork of remnants. Fragmentation can have a major effect on biodiversity, and this is considered in Indicator 1.1e. Improved forest mapping is identifying greater levels of fragmentation, due mainly to improved accuracy in analysing different forest types. Further study is required to determine the degree to which the forest estate is being affected by fragmentation at a national scale and the effects of fragmentation on biodiversity.

Flooded gum (*Eucalyptus grandis*) forest adjacent to farmland, New South Wales

Extent of forest area by forest type and tenure

coverage

currrency

frequency

Indicator 1.1a

Extent of area by forest type and tenure

Rationale

This indicator is useful as it measures the current level of forest cover, by forest type, and demonstrates whether the area is increasing or decreasing. This is fundamental to our understanding and management of forests.

Australia's forest estate is 164 million hectares, including 1.6 million hectares of plantation. Approximately 13 per cent of Australia's native forest estate is formally protected in nature conservation reserves and 70 per cent of forest is privately managed. Seven per cent is available for timber production in multiple-use forests.

Australia covers an area of 768 million hectares with 21 per cent of the continent covered in forests (Figure 3). At the time of European settlement in 1788, it is estimated that Australia's forest covered approximately 33 per cent of the continent. The area of forests has significantly diminished in most localities while remaining constant or expanding in others.

The area of Australia's forest estate is 164 million hectares (Table 3). While this is an increase in the area reported since 1998, it largely represents more comprehensive forest mapping of the continent rather than an actual increase in the area of forest.

Current information on woody cover change indicates that forest cover in Australia is in fact decreasing. While regrowth on cleared agricultural land and establishment of new plantations, farm forestry and environmental planting are occurring, this does not exceed current conversion of forest for other uses such as agriculture and urban expansion.

Forest clearance records suggest that the rate of forest clearing has fallen from an average of 1.4 million hectares per year nationally in the 1970s. The most recent national figure published by the Australian Greenhouse Office reveals that 240 000 hectares of forest was cleared in 1998, of which over two-thirds occurred in Queensland. There are a number of national forest and vegetation mapping initiatives currently underway in Australia (for details see Indicator 7.4b).

Plantation establishment has increased from an average of 30 000 hectares per annum in the 1970s to an average of 87 000 hectares per annum over the last 5 years. In most States plantation establishment is occurring on previously cleared agricultural land in accordance with Australia's National Forest Policy Statement. In support of the National Forest Policy Statement, all States and Territories have developed policies that restrict the clearing of native vegetation for plantation establishment, however, Tasmania does not prevent clearing for plantation establishment .

In addition to plantation establishment, a significant area of tree planting occurs each year for nature conservation and protection of land or water resources.

Further information on Australia's forest types is provided in the Forest Profile section of this indicator.

Table 3: Forest area ('000 ha) according to forest type

Forest type	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia	Per cent of native forest
Acacia	0	1 251	1 613	6 984	1 939	74	63	4 563	16 488	*10*
Callitris	0	1 240	386	387	261	1	56	0	2 330	*1*
Casuarina	0	1 000	14	216	763	1	4	40	2 039	*1*
Eucalypt	116	22 218	27 911	38 706	7 849	2 476	7 562	20 184	127 024	*78*
Eucalypt mallee woodland	0	9	0	122	5 180	0	1 171	3 918	10 400	–
Eucalypt mallee open	0	13	0	0	864	0	0	1 051	1 929	–
Eucalypt low woodland	3	114	16 368	1 373	1 207	65	246	2 616	21 992	–
Eucalypt medium woodland	18	2 269	5 532	32 696	554	1 274	598	10 321	53 263	–
Eucalypt tall woodland	0	91	0	1 130	0	289	219	0	1 728	–
Eucalypt low open	4	72	257	0	1	0	273	22	629	–
Eucalypt medium open	63	15 921	5 703	3 326	42	7	2 809	2 048	29 920	–
Eucalypt tall open	28	3 729	0	59	1	841	2 246	170	7 073	–
Eucalypt low closed	0	0	18	0	0	0	0	8	27	–
Eucalypt medium closed	0	0	33	0	0	0	0	30	63	–
Eucalypt tall closed	0	0	0	0	0	0	0	0	0	–
Mangrove	0	3	355	196	19	0	2	173	749	*0*
Melaleuca	0	44	1 593	5 301	1	19	96	0	7 056	*4*
Rainforest	0	486	224	2 885	0	598	16	5	4 214	*3*
Other	0	415	738	1 059	34	0	135	398	2 780	*2*
Total native forest	117	26 658	32 836	55 734	10 866	3 169	7 935	25 365	162 680	*100*
Hardwood plantation	0[4]	51	3	26	32	135	143	248	638	
Softwood plantation	16	270	4	182	117	78	217	104	988	
Unknown plantation	0	1	0	0	0	0	0	0	2	
Total plantation[1]	16	323	7	208	149	213	360	352	1 628	
Total forest 2003	133	26 981	32 843	55 942	11 015	3 364[2]	8 295	25 716	164 290	
Total land area[3]	240	80 160	134 620	172 720	98 400	6 780	22 760	252 550	768 230	
Forest as per cent of land area	*55*	*34*	*24*	*32*	*11*	*50*	*36*	*10*	*21*	

Source: National Forest Inventory (2003)

1 National Plantation Inventory (2003)

2 'Total forest' area for Tasmania is sourced from the Tasmanian RFA Review (2001) and does not include more recent NPI 2003 plantation figures. Therefore the total native forest area for Tasmania is a slight overestimate due to some clearing of native forest for plantation establishment after June 2001.

3 Australian Yearbook (1997)

4 The Australian Capital Territory has 180 hectares of hardwood plantation (fuelwood) which was planted between 1988 and 1990.

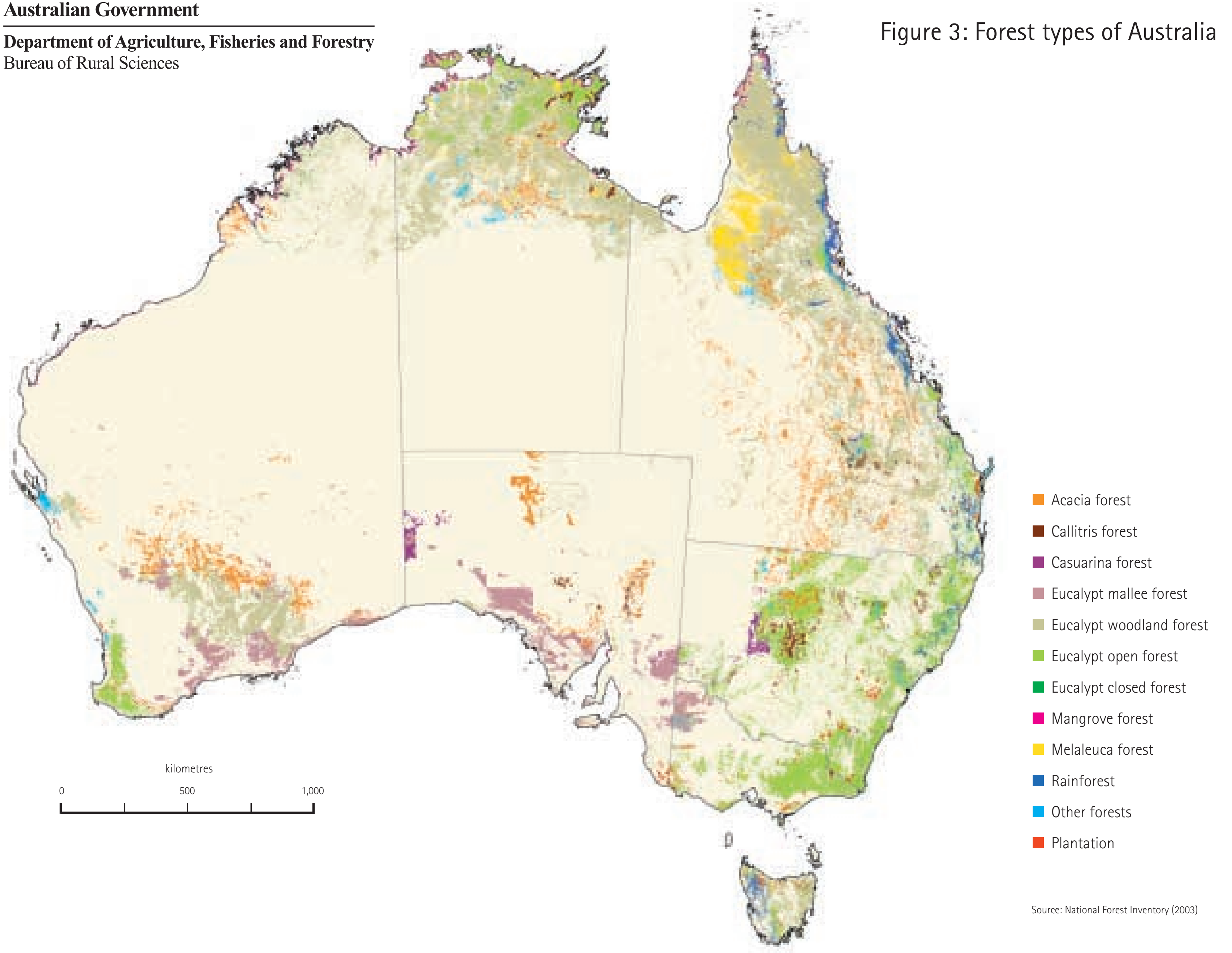
Note: All values have been rounded, hence, column and row totals may not tally exactly.

Australian Government

Department of Agriculture, Fisheries and Forestry

Bureau of Rural Sciences

Figure 3: Forest types of Australia



Source: National Forest Inventory (2003)

Figure 3: Forest types of Australia

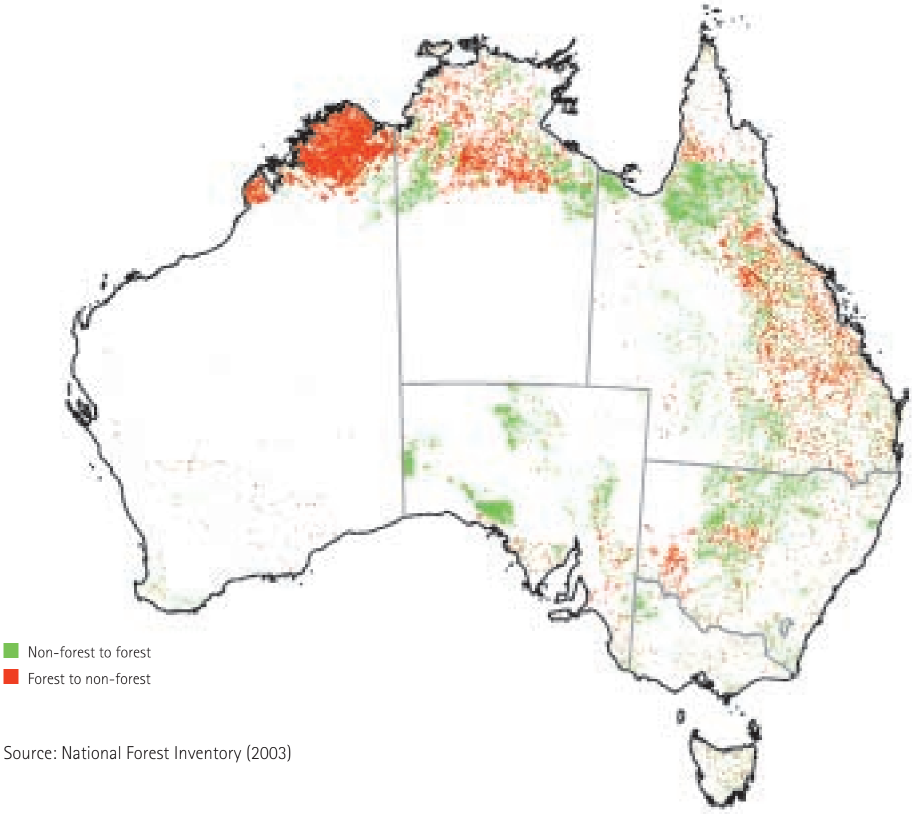
(fold out)

Changes in national forest mapping between 1998 and 2003

Although forest clearing has occurred in the last five years, the reported area of forest in Australia has increased by 7 million hectares. This change is primarily due to improvements and investment in forest mapping. Thus the increases in native forest area between 1998 and 2003 do not generally reflect significant changes in forest extent on the ground.

A direct comparison of two forest datasets (1998 and 2003) reveals that improved mapping has resulted in changes in the mapped extent of Australia's forests (Figure 4). There have been changes in the on ground extent of forest and changes from non-forest to forest, or from forest to non-forest and also changes in the categorisation of forest types. Most forest classes had over half of the 1998 area mapped as the same forest type again in 2003, and the national proportions among the forest type classes are comparable.

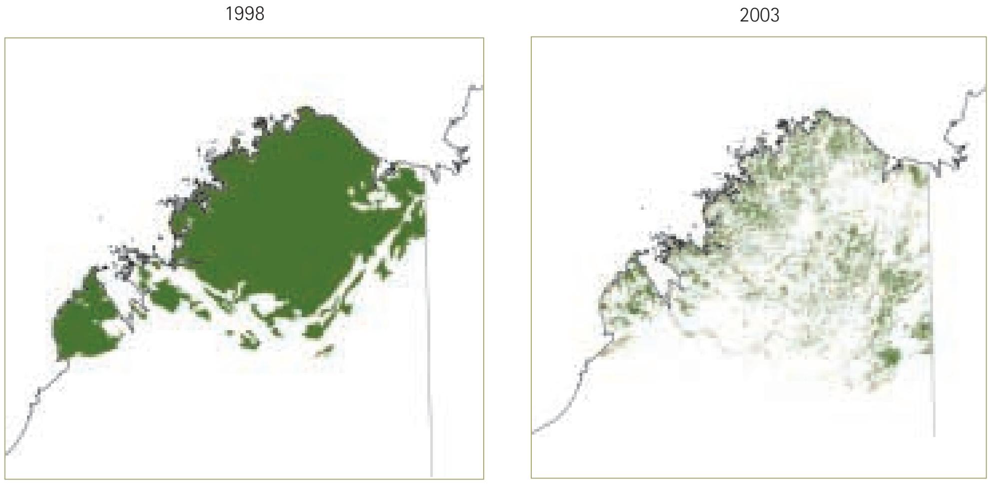
Figure 4: Changes in forest mapping between 1998 and 2003



Source: National Forest Inventory (2003)

The vast majority of these changed estimates can be explained by improved mapping of the forest estate over the five years between the datasets. Many areas, particularly in northern Australia, were classified as a single forest type of large extent in 1998. Since then they have been remapped to reveal that these areas consisted of many forest and grassland types of varying patch size. In the Kimberley region of northern Western Australia, forest cover in 1998 was represented by around 17 000 mapping units defining an area of approximately 13 million hectares. With improved mapping, the 2003 dataset identifies forest in this area is defined by 9 million mapping units representing a smaller but more accurate forest area of approximately 4.6 million hectares (Figure 5).

Figure 5: Changes in mapped forest extent, Kimberley region, Western Australia



Source: National Forest Inventory (2003)

In addition to new mapping, regular updates have occurred, primarily within Queensland, New South Wales, Victoria and Tasmania. Other changes include a comprehensive update in 2001of the extent of Australia's plantations.

Changes to the reported area have also occurred as a result of changes in forest type classification at the State and Territory level. The 2003 forest types now include a new national class—eucalypt closed forest. All areas that are now mapped as eucalypt closed forest were previously mapped as another forest type, largely rainforest.

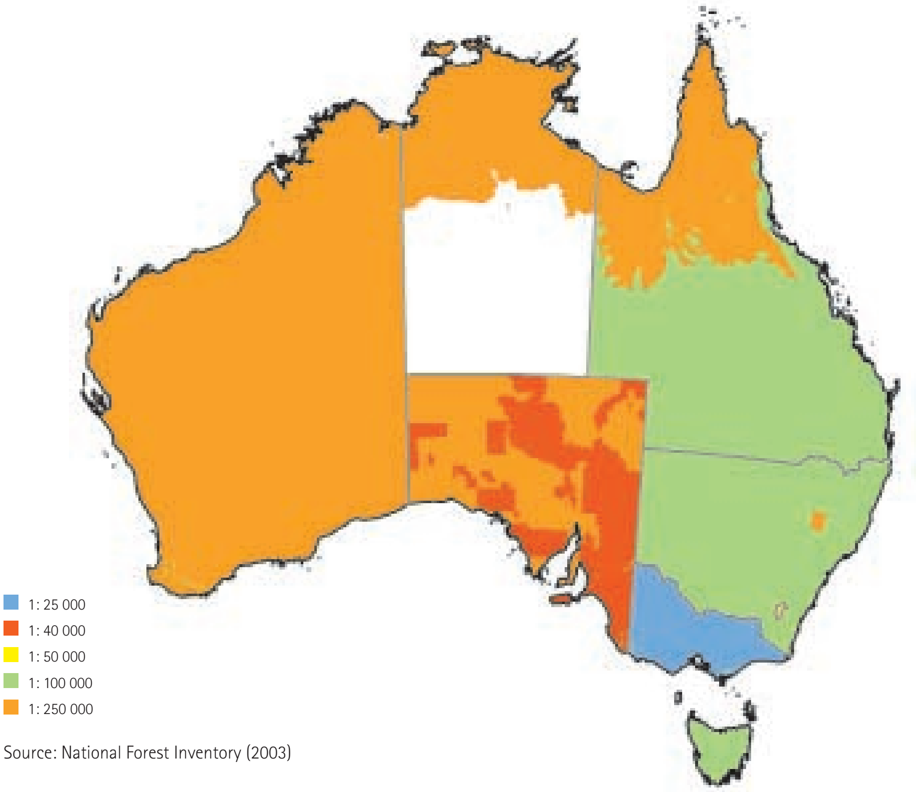
In response to continuing changes in improvement and investment in forest mapping, the National Forest Inventory is developing a national forest monitoring system. This Continental Forest Monitoring Framework will provide national consistency by using a multi-tiered system of remote sensing and a network of permanent sites from a systematic grid across all States/Territories, tenures and forest types. It will deliver a core set of scientifically reliable data on a range of forest values, including forest area and type.

A mosaic of cleared land, pine and eucalypt forests

Scale of data compilation

The forest type and tenure spatial datasets prepared by Australia's National Forest Inventory are compiled from national, State, Territory and regional sources. The data are collected using different methods and at different scales and as a result the scale of the output dataset is not nationally consistent (Figure 6).

Figure 6: Scale of forest datasets contributing to the National Forest Inventory



Source: National Forest Inventory (2003)

The currency date of the input data also varies. The compilation date of the National Forest Inventory's spatial data is 2003, however, the currency date of the input data ranges from 1992 to 2002, with the majority of the datasets dating from 1998 or later.

Crown cover and height

Australia's native forests are classified at the national level into three crown cover classes: woodland, open and closed. Woodland forest has a crown cover ranging from 20–50 per cent, open forest has a crown cover ranging from greater than 50 to 80 per cent, and closed forest ranges from greater than 80 to 100 per cent crown cover (Figure 7). Almost two-thirds of the native forest estate is woodland crown cover class and almost one-third is comprised of open forest types (Table 4).

The distribution of forest by crown cover is similar across most States and Territories, with the exception of New South Wales, Victoria and the Australian Capital Territory where the majority of the forests are classified as open forest types (Table 5; Figure 8).

Three height categories are used to classify Australia's native forests: low, medium and tall. Low forests are between two and ten metres in height, medium forests are greater than ten metres up to twenty metres, and tall forests exceed thirty metres at maturity (Figure 7).

Figure 7: Forest according to crown cover and height classes

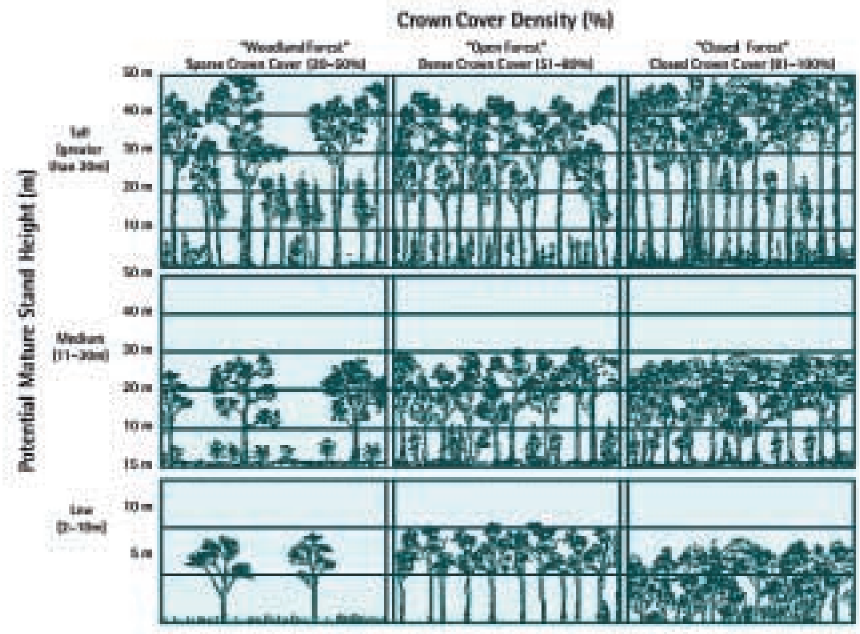


Table 4: Area ('000 ha) of forest type according to crown cover

Forest type	Woodland	Open	Closed	Unknown	Total
Acacia	11 364	2 998	0	2 126	16 488
Callitris	502	622	0	1 206	2 330
Casuarina	359	871	0	809	2 039
Eucalypt mallee	10 400	1 929	0	0	12 329
Eucalypt low	21 992	629	27	0	22 648
Eucalypt medium	53 263	29 920	63	0	83 246
Eucalypt tall	1 728	7 073	0	0	8 801
Mangrove	25	266	325	132	749
Melaleuca	1 056	763	15	5 222	7 056
Rainforest	0	0	4 214	0	4 214
Other	1 837	530	0	413	2 780
Total native forest	102 526	45 603	4 644	9 907	162 680

Source: National Forest Inventory (2003)

Note: All values have been rounded, hence, column and row totals may not tally exactly.

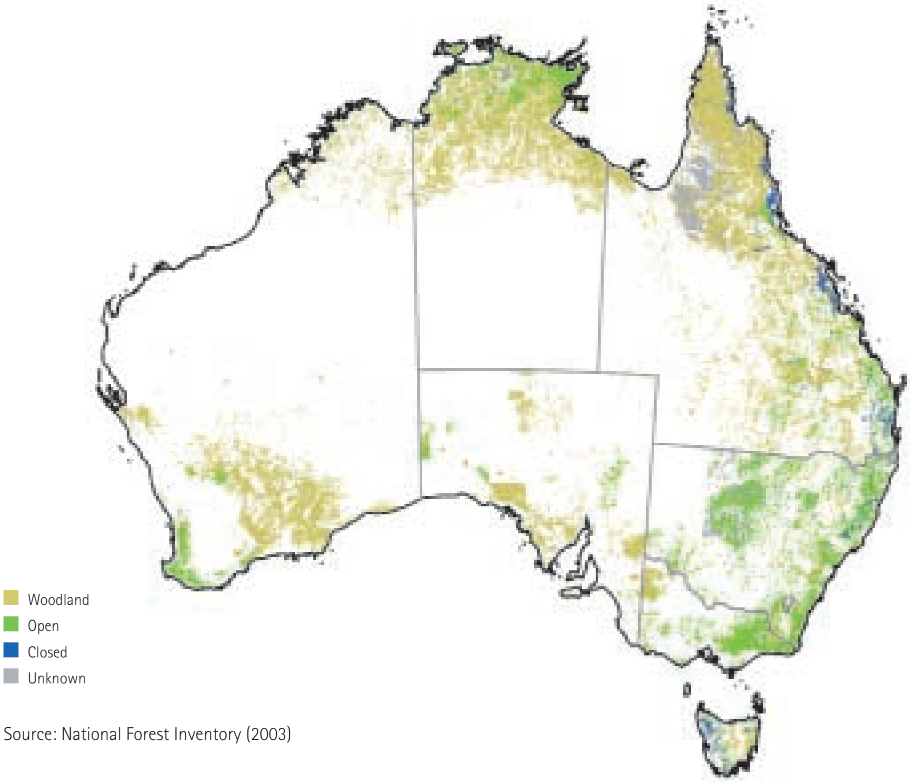
Table 5: Area ('000 ha) of native forest according to crown cover

Crown cover	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Woodland	22	2 755	25 290	39 739	8 739	1 682	2 431	21 869	102 526
Open	96	19 786	7 139	6 768	2 111	889	5 486	3 327	45 603
Closed	0	486	406	2 952	15	598	18	169	4 644
Unknown crown cover	0	3 632	0	6 275	0	0	0	0	9 907
Total native forest	117	26 658	32 836	55 734	10 866	3 169	7 935	25 365	162 680

Source: National Forest Inventory (2003)

Note: All values have been rounded, hence, column and row totals may not tally exactly.

Figure 8: Native forest according to crown cover



Source: National Forest Inventory (2003)

Tenure

The tenure classes used in this report for forests have been amalgamated from a wide range of classes used within each State or Territory (Table 6). The classes and types of tenure categories included within each are:

- *Multiple-use forest* – State forest, timber reserves and other forest areas on which a range of forest values are 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 on State forest and Crown lands reserved to protect water supply catchments. This does not include informal reserves and those pending gazettal.
- *Private land* – 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 land* – 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.
- *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.
- *Unresolved tenure* – Areas identified where tenure is unknown or for which there are no data. Most of these are methodological rather than tenure issues.

Table 6: Area ('000 ha) of forest according to tenure

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	11	9 470	16 313	35 581	5 255	0	46	8 920	75 596
Multiple-use forest	0	2 496	0	2 925	0	1 062	3 312	1 600	11 395
Nature conservation reserves	106	4 471	12	5 000	3 943	1 105	3 050	3 805	21 491
Other crown land	0	1 055	890	1 131	392	80	207	9 387	13 143
Private land	0	8 523	15 511	10 213	822	922	1 298	1 639	38 928
Unresolved tenure	0	643	110	883	454	0	23	14	2 127
Total native forest	117	26 658	32 836	55 734	10 866	3 169	7 935	25 365	162 680
Plantations; all tenures[1]	16	323	7	208	149	213	360	352	1 628
Total forest	133	26 981	32 843	55 942	11 015	3 364[2]	8 295	25 716	164 290

Sources: National Forest Inventory (2003); National Plantation Inventory (2003)

Note: All values have been rounded, hence, column and row totals may not tally exactly.

1 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.

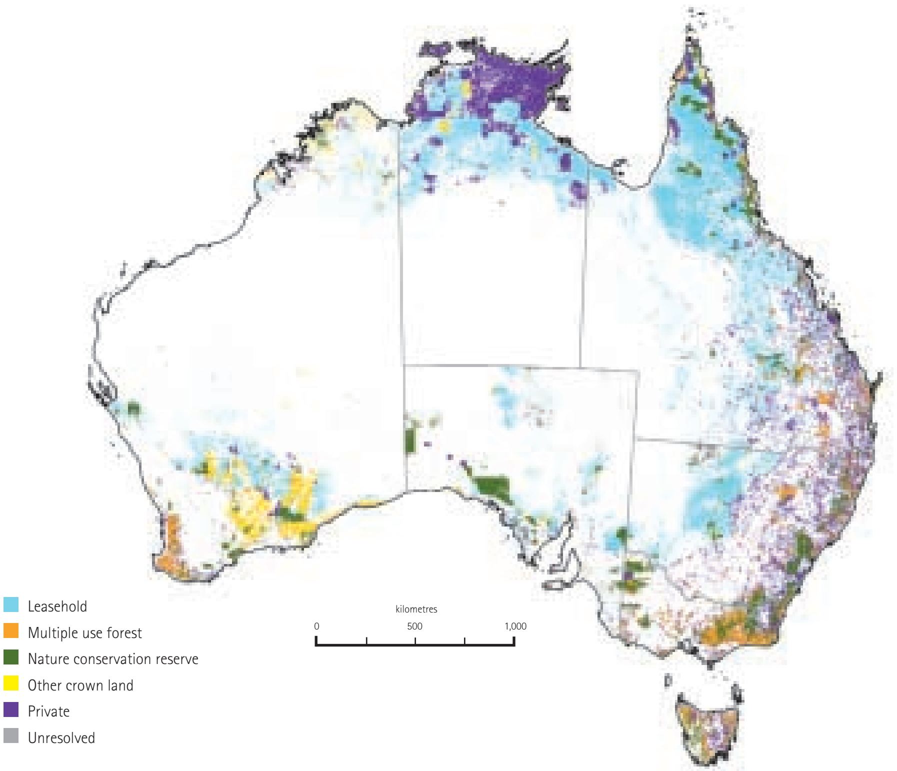
2 'Total forest' area for Tasmania is sourced from the Tasmanian RFA Review (2001) and does not include more recent NPI 2003 plantation figures. Therefore the total native forest area for Tasmania is a slight overestimate due to some clearing of native forest for plantation establishment after June 2001.

Seventy per cent of Australia's native forest estate is privately managed, under either private or leasehold tenure (Table 7; Figure 9). While this land is privately managed—24 per cent freehold and 46 per cent leasehold—it is still subject to State and Territory land use legislation. Over the last decade there has been a great deal of public investment and debate over the development of detailed forest conservation and management codes and policies, however, these have predominately been directed at the small portion (20 per cent) of forest that is public estate.

Seven per cent of Australia's native forest is multiple-use, in which timber harvesting can occur. Timber harvesting also occurs on other tenure categories such as leasehold lands, private land and other crown land. Thirteen per cent of forest is formally protected in nature conservation reserves.

A comparison between the forested area by tenure reported here and in the 1998 State of the Forests Report shows that although the estimates of the total area of forest has increased as discussed above, there has not been a substantial change in the proportion of forest across each tenure class.

Figure 9: Forest according to tenure



Source: National Forest Inventory (2003)

Table 7: Native forest types according to tenure ('000 ha)

Forest type	Leasehold land	Multiple -use forests	Nature conservation reserve	Other crown land	Private land	Unresolved tenure	Australia
Acacia	12 090	206	588	864	2 230	508	16 488
Callitris	1 178	240	124	70	706	12	2 330
Casuarina	1 043	7	800	28	145	15	2 039
Eucalypt mallee woodland	2 211	169	4 585	2 618	769	48	10 400
Eucalypt mallee open	378	6	760	394	371	19	1 929
Eucalypt low woodland	14 262	76	869	933	5 539	312	21 992
Eucalypt medium woodland	28 474	2 600	4 428	6 049	11 156	556	53 263
Eucalypt tall woodland	630	202	241	317	335	4	1 728
Eucalypt low open	103	169	157	28	171	2	629
Eucalypt medium open	7 840	4 061	4 047	1 192	12 414	366	29 920
Eucalypt tall open	221	2 836	2 016	100	1 897	4	7 073
Eucalypt low closed	8	0	1	6	12	0	27
Eucalypt medium closed	14	0	7	16	25	1	63
Eucalypt tall closed	0	0	0	0	0	0	0
Mangrove	85	1	69	166	329	99	749
Melaleuca	5 184	46	537	83	1 180	28	7 056
Rainforest	478	617	1 846	191	1 049	32	4 214
Other	1 398	160	415	88	599	120	2 780
Total native forest	75 596	11 395	21 491	13 143	38 928	2 127	162 680
Per cent of native forest	*46*	*7*	*13*	*8*	*24*	*1*	*100*

Source: National Forest Inventory (2003)

Note: All values have been rounded, hence, column and row totals may not tally exactly.

The area of forest by crown cover for each tenure class by State and Territory is shown in Table 6. Most of the woodland and open forest cover classes are on leasehold and private land whereas most of the closed forests are on nature conservation reserves and private land. Multiple-use forest lands are predominately covered by open forest, and other crown land is covered by woodland forest.

Table 8: Area ('000 ha) of forest according to crown cover and tenure

	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Woodland forest									
Leasehold land	5	427	15 406	27 598	4 552	0	8	8 700	56 695
Multiple-use forests	0	156	0	2 018	0	387	441	225	3 228
Nature conservation reserves	17	605	4	2 594	2 921	474	1 412	2 834	10 861
Other crown land	0	142	735	759	307	64	67	8 757	10 830
Private land	0	1 400	9 088	6 169	566	757	498	1 346	19 824
Unresolved tenure	0	24	57	602	393	0	7	6	1 088
Total	22	2 755	25 290	39 739	8 739	1 682	2 431	21 869	102 526
Open forest									
Leasehold land	7	6 900	859	2 232	701	0	38	193	10 930
Multiple-use forests	0	2 049	0	564	0	495	2 863	1 375	7 346
Nature conservation reserves	89	3 323	4	742	1 020	243	1 629	939	7 991
Other crown land	0	801	146	116	84	12	140	529	1 827
Private land	0	6 460	6 098	2 935	256	139	799	289	16 976
Unresolved tenure	0	252	32	180	51	0	16	2	533
Total	96	19 786	7 139	6 768	2 111	889	5 486	3 327	45 603
Closed forest									
Leasehold land	0	10	48	456	2	0	0	27	543
Multiple-use forests	0	101	0	327	0	180	8	0	617
Nature conservation reserves	0	289	3	1 176	2	387	8	32	1 897
Other crown land	0	2	9	190	1	5	0	101	309
Private land	0	83	325	751	1	26	1	4	1 190
Unresolved tenure	0	0	21	51	10	0	0	5	88
Total	0	486	406	2 952	15	598	18	169	4 644
Unknown crown cover									
Leasehold land	0	2 132	0	5 296	0	0	0	0	7 428
Multiple-use forests	0	189	0	16	0	0	0	0	204
Nature conservation reserves	0	254	0	488	0	0	0	0	742
Other crown land	0	111	0	67	0	0	0	0	178
Private land	0	579	0	359	0	0	0	0	938
Unresolved tenure	0	367	0	50	0	0	0	0	417
Total	0	3 632	0	6 275	0	0	0	0	9 907
Total native forest	117	26 658	32 836	55 734	10 866	3 169	7 935	25 365	162 680

Source: National Forest Inventory (2003)

Note: All values have been rounded, hence, column and row totals may not tally exactly.

Changes to tenure as a result of the Regional Forest Agreements

As a result of the Regional Forest Agreements (RFAs), some areas of forest were assigned formal reserve status for inclusion in the national reserve system. In these cases, the reserved area is assigned 'pending' status until the changes are passed through the relevant State parliament, at which time the reserves become legally protected as formal reserves. Other areas are designated informal reserves through zoning regimes in forest management planning process—such as Special Protection Zones—without being established through separate legislation. Table 9 identifies the changes in areas identified as being in either formal or informal reserves pre and post the Regional Forest Agreements (RFA). These areas include all ecosystems types that occur within RFA areas and as such are not limited to forests.

Table 9: Area ('000 ha) under Reserves (formal and informal) in Regional Forest Agreement areas - all ecosystems (native and non native) not just forests

Region	Pre RFA	Post RFA	Percentage Increase
New South Wales	2 154	3 739	*74*
Tasmania	2 305	2 747	*19*
Victoria	2 114	2 876	*36*
Western Australia	933	1 047	*12*
Total	7 506	10 409	*39*

Source: Figures derived by the Australian Government departments of the Environment and Heritage, Agriculture, Fisheries and Forestry, and the Prime Minister and Cabinet.

In an attempt to quantify the changes in tenure as a result of the RFA process in forest areas the 1997 tenure data and the 2003 tenure data were analysed against the 2003 forest areas data. Table 10 reflects changes in tenure approved by the end of 2002. The data available indicate that the area of forest in nature conservation reserves in RFA regions has increased by 1.7 million hectares. Correspondingly, the area of multiple-use forest and private forest fell by 1.2 million hectares and 0.65 million hectares respectively. It should be noted that changes in forest tenure resulting directly from the RFA process occurred soon after those processes were completed.

Table 10: Area ('000 ha) of native forest by tenure in Regional Forest Agreement regions

Tenure	Pre-RFA tenure[1]	Post-RFA tenure[2]
Leasehold land	0	484
Multiple-use forests	7 977	6 777
Nature conservation reserve	4 879	6 615
Other crown land	800	430
Private land	6 251	5 598
No tenure data	21	23
Total native forest in RFA[3]	19 927	19 927

Source: National Forest Inventory (2003)

1 Areas calculated using NFI 1997 tenure and NFI 2003 forest area

2 Reports post RFA changes that have been passed through parliament as at December 2002 and does not include pending reserves

3 Figures may differ to those reported in regional RFA reports due to different forest type mapping

Subsequent tenure changes are the result of decisions taken by the relevant States and Territories. In addition to RFAs, changes in protected status have occurred in some States which have resulted in further changes to forest tenure, for example in Western Australia, New South Wales and Queensland.

Protected areas

Australia's National Reserve System (NRS) represents the collective efforts of the States, Territories, Australian Government and non-government organisations to achieve an Australian system of protected areas as a major contribution to the conservation of our native biodiversity. Protected areas are those systems of nature conservation reserves and other types of conservation areas dedicated to the protection and maintenance of biological diversity, and are formally managed and protected for this purpose. Management objectives for all types of reserves are required to meet the International Union for Conservation of Nature and Natural Resources (IUCN) definition of a protected area to be considered part of the NRS, and all protected area categories across each jurisdiction have notionally been assigned to one of the IUCN protected area categories (see next section in this indicator for further IUCN discussion). There are over 40 types of public reserves in Australia, from strict nature conservation reserves and wilderness parks to forest and even game reserves. In addition a number of protected areas have been established on indigenous-owned lands, and a number of private protected reserves have been established under a range of covenanting programs. Spatial data on Australia's protected area estate is held in the Collaborative Australian Protected Area Database (CAPAD).

Australia's forests are protected in both formal and informal, and in some instances in pending reserves.

Formal reserves usually include nature conservation reserves and reserves meeting IUCN categories as defined by the IUCN Commission for National Parks and Protected Areas (1994). The status of formal reserves is secure and underpinned by legislation, requiring action by a State or Territory parliament for dedication or revocation. Formal reserves identified during all RFA processes meant reserves equivalent to IUCN Protected Area Management Categories I, II, III and IV, as defined the by the IUCN Commission for National Parks and Protected Areas (1994). In addition, the Tasmanian RFA included IUCN category VI.

Informal reserve refers to an area reserved on non-nature conservation reserve tenure through both legislated and non-legislated means. The status of informal reserves is not secure, relying on the State or Territory management agency responsible for the interpretation and application of the guidelines applicable to the area within an informal reserve. Within RFA regions, an informal reserve is one that contains and is managed for conservation values which unequivocally contribute to the comprehensive, adequate and representative reserve system, and meets the principles for informal reserves as described in the Australian Government's JANIS Report (see further reading).

Pending reserve is used to describe an area identified for reservation through an RFA process but awaiting legislation to formalise its reserve status.

While formal reserves include all forest, both within and outside RFA regions, data on informal and pending reserves are only available for areas covered by the Regional Forest Agreements. Note that data on pending reserves are only available for Queensland and are therefore an underestimate of the total area of forest in this category. There are also large areas of pending reserves, post-RFA, in Western Australia, however, these data are unavailable.

The total area of protected forest (formal, informal and pending reserves) exceeds 22 million hectares, or 14 per cent of the total native forest estate (Table 11).

Table 11: Area ('000 ha) of native forest in formal, informal and pending reserves

State/Territory	Formal[1]	Informal[2]	Pending[3]	Total
Australian Capital Territory	106	-	0	106
New South Wales	4 471	450	0	4 921
Northern Territory	12	-	0	12
Queensland	5 000	9[4]	37[4]	5 009
South Australia	3 943	n/a	0	3 943
Tasmania[5]	1 097	174	0	1 271
Victoria	3 050	503	0	3 553
Western Australia	3 805	n/a	0	3 805
Total	21 484	1 137	37	22 620

Source: National Forest Inventory (2003)

1 All nature conservation reserve tenure, except Tasmania

2 Available for RFA regions only

3 Data available for Queensland only

4 On tenures other than nature conservation reserve only

5 Tasmanian RFA Review (2001). Figure shown is less than Tasmania's NCR figure as Crown Lands Act reserves, which may be included in Tasmania's NCR category, are not necessarily classified as formal reserves

International Union for Conservation of Nature and Natural Resources categories

The World Conservation Union provides a consistant reporting framework with an internationally defined set of management categories, known as International Union for Conservation of Nature and Natural Resources (IUCN) categories. The definition of Protected Area as defined by the IUCN is:

> *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.*

There are six IUCN protected area categories used under Australia's National Reserve System Program, although, as with most of the RFA processes, only the first four are generally used under Australia's National Reserve System program. These are:

Category Ia – Strict Nature Reserve: Protected area managed mainly for science

Category Ib – Wilderness Area: Protected area managed mainly for wilderness protection

Category II – National Park: Protected area managed mainly for ecosystem conservation and recreation

Category III – Natural Monument: Protected area managed for conservation of specific natural features

Category IV – Habitat/Species Management Area: Protected area managed mainly for conservation through management intervention

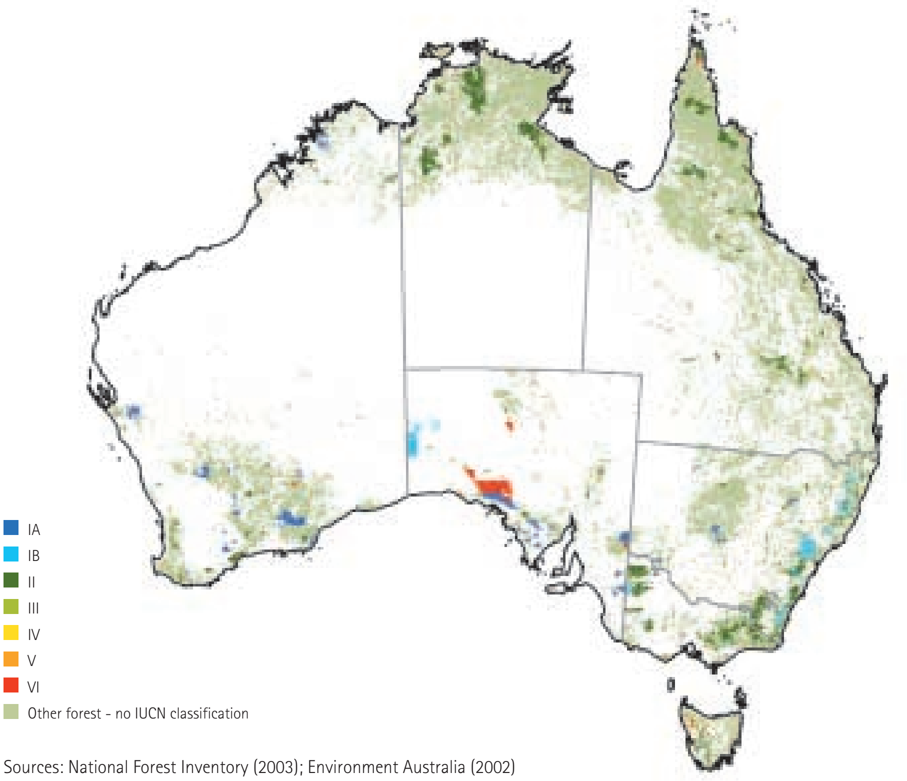
Category V – Protected Landscape/Seascape: Protected area managed mainly for landscape/seascape conservation and recreation

Category VI – Managed Resource Protected Areas: Protected area managed mainly for the sustainable use of natural ecosystems

The area of Australia's forest type in each IUCN classification is shown in Table 12, and the area by State in Table 13. The forest areas with an IUCN classification are shown in Figure 10.

The IUCN recommends a target of 10 per cent of each vegetation or forest type to be in reserve categories I –VI. All of Australia's major forest types meet this target except Acacia, Callitris and Eucalypt medium woodland (Table 12). Eucalypt mallee woodland has the greatest proportion of area reserved (44.8 per cent), followed closely by Casuarina (39.3 per cent) and Eucalypt mallee open (39 per cent). There are also large variations in total native forest classified according to jurisdiction and IUCN reserve classes (Table 13), ranging from almost 91 per cent in the Australian Capital Territory, to almost 7 per cent in Queensland. Nationally, 15 per cent of Australia's native forests are in IUCN reserve categories, which exceeds the IUCN target of 10 per cent.

Figure 10: Areas of forest according to IUCN classification



Sources: National Forest Inventory (2003); Environment Australia (2002)

Table 12: Proportion of native forest by forest type in IUCN conservation reserve categories

IUCN conservation reserve classes		Ia		Ib		II		III		IV		V		VI		Total conserved	
		Percentage of															
Forest Type	Total forest ('000 ha)	forest type	category	forest type	category	forest type	category	forest type	category	forest type	category	forest type	category	forest type	category	forest type	categories I–VI
Acacia	16 488	0.7	2.6	0.0	0.1	2.6	3.0	0.1	6.6	0.1	9.2	0.1	9.2	0.8	6.3	4.6	3.1
Callitris	2 330	1.7	0.9	0.2	0.2	3.1	0.5	0.0	0.3	0.1	0.6	0.1	0.8	0.0	0.0	5.4	0.5
Casuarina	2 039	2.9	1.3	31.3	25.1	4.1	0.6	0.0	0.2	0.0	0.1	0.2	1.6	0.8	0.7	39.3	3.3
Eucalypt Mallee Woodland	10 400	20.6	47.6	3.0	12.4	9.6	6.9	0.4	18.3	0.1	2.7	0.0	0.0	11.2	54.7	44.8	19.1
Eucalypt Mallee Open	1 929	8.8	3.8	0.1	0.1	19.5	2.6	1.2	11.7	0.0	0.0	0.3	2.5	8.9	8.1	39.0	3.1
Eucalypt Low Woodland	21 992	1.3	6.3	0.0	0.4	13.5	20.7	0.0	3.8	0.0	0.5	0.1	5.6	0.3	2.8	15.2	13.8
Eucalypt Medium Woodland	53 263	1.8	20.8	0.3	7.0	5.6	20.7	0.1	29.8	0.2	42.6	0.2	31.3	0.5	13.3	8.7	19.1
Eucalypt Tall Woodland	1 728	0.3	0.1	0.1	0.1	10.7	1.3	0.2	1.3	0.5	3.0	0.2	1.0	1.5	1.2	13.4	1.0
Eucalypt Low Open	629	0.5	0.1	0.4	0.1	28.8	1.3	0.2	0.5	0.1	0.2	0.1	0.2	0.1	0.0	30.7	0.8
Eucalypt Medium Open	29 920	1.8	11.9	2.3	27.4	9.3	19.5	0.1	15.6	0.1	11.0	0.3	32.2	0.1	2.0	14.2	17.4
Eucalypt Tall Open	7 073	1.1	1.8	6.4	17.7	18.0	8.9	0.2	7.2	0.5	14.9	0.1	3.5	0.8	2.8	27.5	8.0
Eucalypt Low Closed	27	0.0	0.0	0.0	0.0	11.9	0.0	0.0	0.0	0.0	0.0	0.5	0.1	0.0	0.0	12.4	0.0
Eucalypt Medium Closed	63	7.4	0.1	0.0	0.0	7.3	0.0	0.0	0.0	0.0	0.0	2.5	0.6	0.2	0.0	17.5	0.0
Mangroves	749	4.0	0.7	0.1	0.0	7.7	0.4	0.3	1.1	0.0	0.1	0.9	2.4	0.4	0.1	13.5	0.4
Melaleuca	7 056	0.1	0.2	0.2	0.5	9.6	4.7	0.0	0.3	0.0	0.4	0.1	1.7	0.2	0.8	10.3	3.0
Other	2 780	2.2	1.4	3.2	3.5	9.3	1.8	0.1	1.8	0.0	0.2	0.0	0.0	0.2	0.2	15.0	1.7
Rainforest	4 214	0.5	0.5	3.3	5.4	24.1	7.1	0.1	1.5	0.9	14.4	0.5	7.3	3.5	7.0	33.0	5.7
Total native forest	162 680	2.8	100.0	1.6	100.0	8.8	100.0	0.1	100.0	0.2	100.0	0.2	100.0	1.3	100.0	15.0	100.0

Source: National Forest Inventory (2003); Department of the Environment and Heritage (2002)

Table 13: Proportion of native forest by State/Territory in IUCN conservation reserve categories

		Ia		Ib		II		III		IV		V		VI		Total conserved	
		Percentage of															
State/Territory	Total nativeforest ('000 ha)	state	category	state	category	state	category	state	category	state	category	state	category	state	category	state	categories I–VI
ACT	117	*0.0*	*0.0*	*0.0*	*0.0*	*90.7*	*0.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*90.7*	*0.4*
NSW	26 658	*2.3*	*13.9*	*5.6*	*58.8*	*8.2*	*15.3*	*0.0*	*0.1*	*0.1*	*7.3*	*0.0*	*1.7*	*0.1*	*1.1*	*16.4*	*18.0*
NT	32 836	*0.0*	*0.2*	*0.0*	*0.0*	*12.3*	*28.0*	*0.0*	*0.6*	*0.0*	*0.0*	*0.4*	*47.2*	*0.1*	*1.0*	*12.7*	*17.2*
QLD	55 734	*0.0*	*0.4*	*0.0*	*0.0*	*6.1*	*23.8*	*0.0*	*10.4*	*0.1*	*18.6*	*0.0*	*0.4*	*0.3*	*7.9*	*6.6*	*15.2*
SA	10 866	*12.7*	*30.6*	*7.9*	*33.6*	*3.1*	*2.4*	*1.0*	*54.2*	*0.1*	*5.2*	*0.8*	*33.1*	*13.8*	*70.5*	*39.4*	*17.6*
TAS[1]	3 169	*0.3*	*0.2*	*0.0*	*0.0*	*19.2*	*4.2*	*0.5*	*7.0*	*4.7*	*57.4*	*1.5*	*17.6*	*8.8*	*13.1*	*34.9*	*4.6*
VIC	7 935	*2.3*	*4.0*	*2.5*	*7.7*	*30.6*	*16.9*	*0.7*	*26.3*	*0.4*	*11.3*	*0.0*	*0.0*	*0.6*	*2.3*	*37.0*	*12.1*
WA	25 365	*9.0*	*50.6*	*0.0*	*0.0*	*4.9*	*8.6*	*0.0*	*1.2*	*0.0*	*0.2*	*0.0*	*0.2*	*0.3*	*4.0*	*14.2*	*14.9*
Total native forest	162 680	*2.8*	*100.0*	*1.6*	*100.0*	*8.8*	*100.0*	*0.1*	*100.0*	*0.2*	*100.0*	*0.2*	*100.0*	*1.3*	*100.0*	*14.9*	*100.0*

Source: National Forest Inventory (2003); Department of the Environment and Heritage (2002)

1 Does not include informal reserves and does not recognise informal reserves and private forest reserves accredited under the Tasmanian RFA, which includes an additional 5.2 per cent of forest area

National Estate and World Heritage Areas

The Register of the National Estate (the Register) is Australia's national register of places of natural, historical and indigenous significance. The Australian Heritage Commission, the Australian Government's advisor on the National Estate, compiles and maintains the register. A place may be added to the Register if it contains aspects of, or contributes to a greater understanding of, Australia's natural or cultural history, if it is aesthetically valued by the community, or if it is highly valued for social, cultural or spiritual reasons. Inclusion of a place on the Register has direct legal consequences only for action proposed by the Australian Government. It does not affect the management of private or State property, and imposes no additional legal constraints on access to the place. Twenty-two million hectares of forested land are identified on the Register (Table 14).

As a signatory to the World Heritage Convention, Australia has an international obligation to identify, protect, conserve and present its world heritage. The Convention establishes a list of places that have natural and/or cultural values of outstanding universal significance. Inclusion of a place on the World Heritage List does not affect ownership rights and State and local laws still apply.

A place may be included on both the Register of the National Estate and the World Heritage List. There are different criteria for National Estate and World Heritage listing and, as a consequence, the boundaries of the two listings may not necessarily coincide.

Nearly 4.5 million hectares of Australia's native forests are within World Heritage listed areas (Table 16; Figure 11). Examples of forested World Heritage Areas include Kakadu National Park (Northern Territory), the Wet Tropics of Queensland (Queensland), Shark Bay (Western Australia), Fraser Island (Queensland), and the Tasmanian Wilderness (Tasmania).

From July 2000, Australia's World Heritage is protected as matter of national environmental significance under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act provides automatic protection for World Heritage Areas by ensuring that an environmental impact assessment process is undertaken for proposed actions that will, or are likely to, have a significant impact on the World Heritage values of a declared World Heritage Area.

The distribution of forest within Australia's National Estate listed places, and in World Heritage Areas, according to tenure categories, is shown in Table 16.

Table 14: Areas ('000 ha) of native forest on Australia's Register of the National Estate, according to forest type

Forest type	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	Australia	Per cent of total forest type
Acacia	0	26	2	141	119	7	30	173	499	*3*
Callitris	0	52	76	2	18	0	37	0	186	*8*
Casuarina	0	71	0	69	651	0	2	15	809	*40*
Eucalypt Mallee	0	12	0	2	1 502	0	927	1 178	3 622	*29*
Eucalypt Woodland	15	413	2 102	2 509	178	371	424	1 029	7 042	*9*
Eucalypt Open	75	2 463	1 052	702	14	269	1 111	447	6 133	*16*
Eucalypt Closed	0	0	15	0	0	0	0	7	22	*24*
Mangroves	0	1	42	97	2	0	1	32	175	*23*
Melaleuca	0	12	341	518	0	10	81	0	963	*14*
Other	0	50	1	251	4	0	126	174	607	*22*
Rainforest	0	116	126	1,423	0	416	7	2	2 090	*50*
Total native forest	91	3 216	3 758	5 715	2 488	1 074	2 746	3 059	22 147	*14*

Source: National Forest Inventory (2003); Department of the Environment and Heritage (2003)

Table 15: Areas ('000 ha) of native forest in World Heritage Areas, by forest type

Forest type	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	Australia	Per cent of total forest type
Acacia	0	0	0	37	0	2	0	0	39	*0*
Callitris	0	4	0	0	0	0	0	0	4	*0*
Casuarina	0	20	0	2	0	0	0	0	22	*1*
Eucalypt Mallee Woodland	0	7	0	0	0	0	0	0	7	*0*
Eucalypt Mallee Open	0	2	0	0	0	0	0	0	2	*0*
Eucalypt Low Woodland	0	0	726	0	0	34	0	0	760	*3*
Eucalypt Medium Woodland	0	269	155	129	0	100	0	0	653	*1*
Eucalypt Tall Woodland	0	1	0	5	0	31	0	0	37	*2*
Eucalypt Low Open	0	2	23	0	0	0	0	0	25	*4*
Eucalypt Medium Open	0	653	337	128	0	0	0	0	1 118	*4*
Eucalypt Tall Open	0	127	0	34	0	115	0	0	277	*4*
Eucalypt Low Closed	0	0	1	0	0	0	0	0	1	*4*
Eucalypt Medium Closed	0	0	1	0	0	0	0	0	1	*2*
Mangroves	0	0	7	5	0	0	0	3	15	*2*
Melaleuca	0	0	104	15	0	7	0	0	127	*2*
Other	0	46	0	54	0	0	0	156	256	*9*
Rainforest	0	130	45	738	0	201	0	0	1 114	*26*
Total native forest	0	1 261	1 400	1 149	<1	491	0	159	4 459	*3*

Source: National Forest Inventory (2003); Department of the Environment and Heritage (2003)
Note: All values have been rounded, hence, column and row totals may not tally exactly.

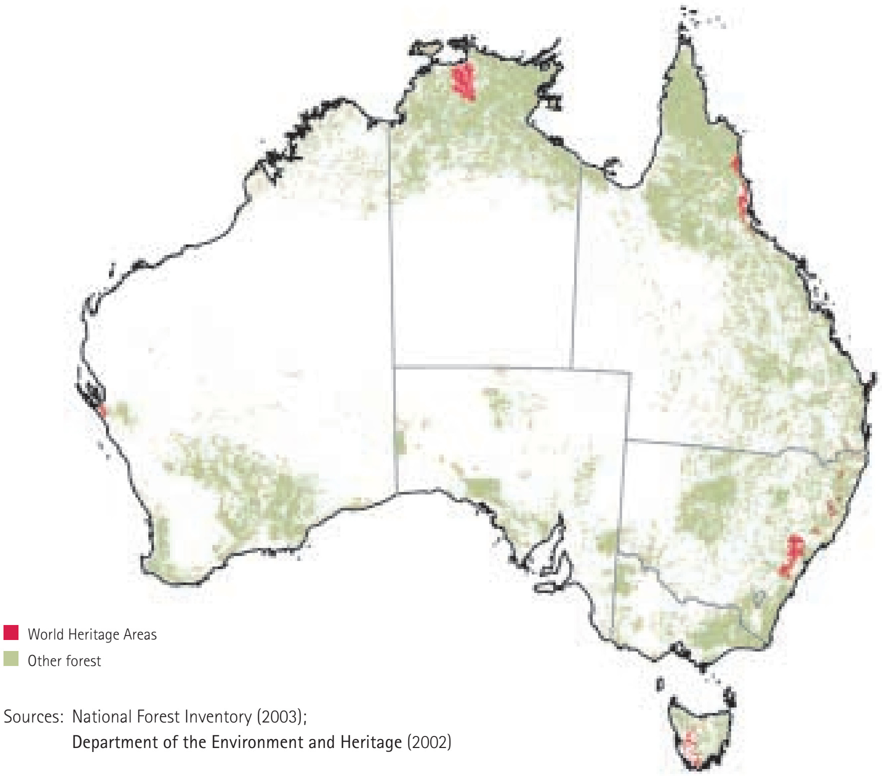
Table 16: Area ('000 ha) of native forest, by tenure, in World Heritage Areas and National Estate listed places

Tenure	World Heritage Area	Per cent of Total Tenure	National Estate Area	Per cent of total Tenure
Leasehold land	172	0.2	2 515	*3*
Multiple-use forest	102	1	1 101	*10*
Nature conservation reserve	2 675	12	13 088	*61*
Other crown land	341	3	1 025	*8*
Private land	1 157	3	4 305	*11*
Unresolved tenure	12	1	113	*5*
Total native forest	4 459	3	22 147	*14*

Source: National Forest Inventory (2003); Department of the Environment and Heritage (2003)

Note: All values have been rounded, hence, column and row totals may not tally exactly.

Figure 11: Australia's Forests within World Heritage Areas



Sources: National Forest Inventory (2003);
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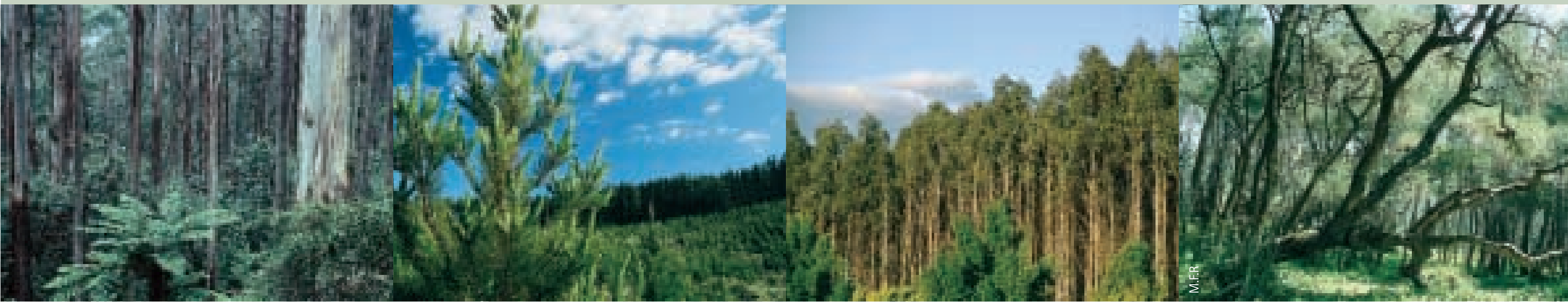
Australia's forest types



Acacia forest

Forests dominated by acacia form either open or woodland forest communities. These forests are generally found where rainfall averages less than 750 mm per year. The canopies of acacia forests are more open and the trees decrease in height in areas with lower rainfall and poorer soils. In wetter locations acacia can form open forest usually dominated by a single species. For example, blackwood (*Acacia melanoxylon*) dominates extensive stands of 'swamp forest' at poorly drained sites in Tasmania. Acacia forests may form mosaics with areas of grassland and semi-arid eucalypt woodlands, such as in north-eastern Australia. In contrast, the open forests of brigalow (*A. harpophylla*) in central Queensland are extensive, almost reaching the coast. Acacias are also widespread in forests as an understorey or sub-dominant canopy species.

Together with eucalypts, acacias are an important element of Australia's forested landscapes. They are the second most extensive forest type, contributing more than 16 million hectares of forest or 10 per cent of the total native forest area (Table 17).

Table 17: Area ('000 ha) of acacia forest by crown cover

	Woodland	Open	Closed	Unknown crown cover	Total native forest
Acacia	11 364	2 998	0	2 126	16 488
Total native forest	102 526	45 603	4 644	9 907	162 680

Source: National Forest Inventory (2003)

Due to their wide distribution, acacia forests are important for maintenance of ecosystem processes and landscape integrity. The brigalow belt, for example, covers more than 36 million hectares from the New South Wales-Queensland border in the south, to Townsville in the north. The brigalow biogeographical region supports 148 species of reptiles, 13 of which are either rare or endangered, and 328 species of birds, 24 of which are threatened. Mature brigalow provides the sole food source of the Northern imperial hairstreak butterfly (*Jalmenus evagoras*), which only occurs in about 30 locations from northern New South Wales to north Queensland.

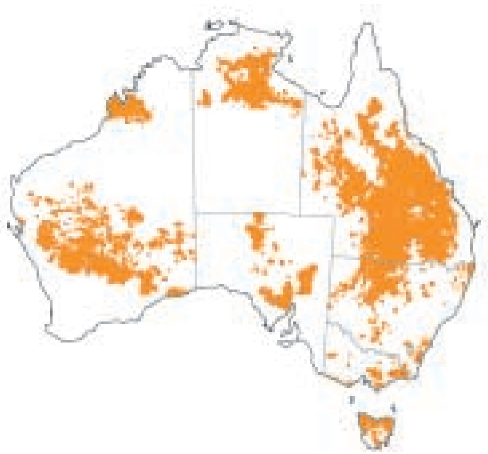
Acacia was one of the first plants ever collected by Europeans from this continent and *A. pycnantha* (golden wattle) is the National Floral Emblem.

Acacia phyllodes and leaves

Acacia species produce leaves of great variety. However, in most cases these are not really leaves at all, but phyllodes—flattened leaf stalks—which have adapted to appear and function as leaves. Size is extremely variable and some of the phyllodes are large—up to 30 centimetres long; others are so small they are hard to see. Some stems have distinctive wide wings with tiny phyllodes present, as in *A. glaucoptera*. Several acacias have bipinnate (fern-like) leaves, made up of a large number of small leaflets (pinnules) along a central stalk.

Distribution

Figure 12: Acacia distribution



Source: National Forest Inventory (2003)
Note: The distribution represented on this map has been enhanced for clarity

The genus *Acacia* contains more than 1 500 species. It is represented naturally on all continents except Europe and Antarctica, although there is a current proposal for the genus to be divided and restricted to species in Australia–Pacific, south-east Asia, Madagascar, Reunion and Mauritius. Regardless, the centre of greatest acacia numbers and diversity is the southern hemisphere. Australia boasts 955 species, making *Acacia* the largest genus of vascular plants (excludes plants such as fungi and liverworts) in the country. Acacia species display an amazing range of variation in appearance, leaf-type (see box), habitat and genetic diversity. They dominate vast areas of the country and are found in all habitats. They are especially common and conspicuous in arid, semi-arid and dry subtropical areas.

Acacia forests occur in all Australian States and the Northern Territory (Table 18), with the greatest area occurring in Queensland and Western Australia (Figure 12). They are the dominant species in low woodland forests of the arid zone where the average annual rainfall is as low as 250 mm, but some species also extend into moister regions, including rainforests.

There are 54 species of acacia that can be dominant or subdominant forest species. Mulga (*A. aneura*) is the dominant species over vast areas in the arid and semi-arid zone and also occurs as an understorey species in some eucalypt forests in the east. Brigalow is widespread in Queensland and as outliers in New South Wales on clay soils of flat or undulating country, and sometimes forms dense forests. Patches of lancewood (*A. shirleyi*) occur as forest on rocky outcrops and steep slopes in the tropics and subtropics, whereas myall (*A. pendula*) dominates forests adjacent to streams or saltbush shrublands. Gidgee (*A. cambagei*) is widespread in areas where average rainfall is less than 500 mm per year and is even found along drainage lines in the Simpson Desert.

Tenure

Less than 4 per cent of acacia forests are in nature conservation reserves. Most occur on leasehold or private land (Table 18).

Table 18: Tenure of acacia forest, by State and Territory ('000 ha)

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	0	833	1 274	4 867	1 709	0	3	3 403	12 090
Multiple-use forests	0	8	0	134	0	37	15	12	206
Nature conservation reserves	0	40	1	302	49	13	35	148	588
Other crown land	0	30	9	17	90	1	1	714	864
Private land	0	43	326	1 541	6	22	9	283	2 230
Unresolved tenure	0	296	3	122	84	0	0	2	508
Total acacia forest	0	1 251	1 613	6 984	1 939	74	63	4 563	16 488

Source: National Forest Inventory (2003)

Values and uses

The biological diversity of the Australian acacias represents a significant economic, social and environmental resource. Some of the main uses of the acacia forests are for cut flowers and oils, wood products (including sawlogs, fence posts, fuel wood and wood pulp for paper manufacture), tannins, edible seeds, fodder and land rehabilitation. Most Australian species are easy to propagate and often show good survival and rapid growth. They are often grown in community and land rehabilitation plantings. Indigenous people have long used acacias for fuel, food, medicine, musical instruments, tools and weapons, and in ritual practices.

A substantial industry has been built on the attractive timbers derived from some species, particularly blackwood for furniture. Other species, such as black wattle (*A. mearnsii*) were used as sources of tannin. Many other species are useful in horticulture, land management and reafforestation. Mulga is an important fodder tree, sustaining stock across semi-arid northern Australia through times of drought.

Australian acacias, including mangium or hickory (*A. mangium*), are planted in over 70 countries and cover about 2 million hectares. Mangium occurs naturally in Queensland and Papua New Guinea and is a major timber plantation species in tropical countries as well as in the Northern Territory. The Queensland populations are valuable sources of genetic material for use in breeding better forms of this species.

Despite the large number of acacia species, relatively few are intensively cultivated, suggesting that the potential of many species remains unexplored. Traditional Indigenous knowledge of acacia species has been an invaluable guide to potential wider use.

Gidgee (*Acacia cambagei*) woodland, Central Queensland

Callitris forest

Callitris forests typically occur as small populations in drier inland regions. In some places they form vast tracts, however, and coastal cypress pine (*Callitris columellaris*) reaches the coast in north-east New South Wales. Pure stands of callitris forest are most often restricted to undulating to flat land with sandy soils or in upland rocky areas that are protected from frequent and/or high intensity fires. More commonly, callitris species co-dominate a forest canopy with species of eucalypt, casuarina or acacia over an herbaceous, sparse, shrubby understorey.

Species of callitris are tolerant of a wide variety of climates, with temperatures from below 0°C to over 40°C, and rainfall usually greater than 300 millimetres per year. Some callitris forests survive on annual rainfalls as low as 200 millimetres, including small areas in the Great Victoria Desert of Western Australia, or as high as 2000 millimetres, on Queensland's Atherton Tablelands. Most callitris species occur in woodland and open forest types (Table 19).

Table 19: Area ('000 ha) of callitris forest by crown cover ('000 ha)

	Woodland	Open	Closed	Unknown crown cover[1]	Total native forest
Callitris	502	622	0	1 206	2 330
Total native forest	102 526	45 603	4 644	9 907	162 680

Source: National Forest Inventory (2003)

1 The unknown crown cover category is mainly *Callitris* forest in New South Wales and Queensland, most of which is likely to be evenly distributed between the woodland and open crown cover categories

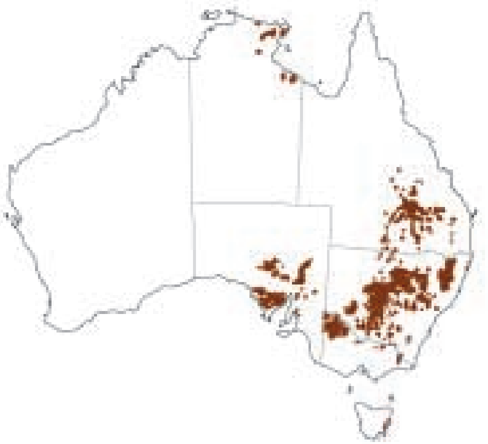
While callitris occurs with fire tolerant species, it does not survive intense fire; but when burnt it regenerates from seed. If fires occur too frequently or if grazing is excessive, callitris is eliminated from the site. It survives in Australia's fire prone environment in areas protected from fire by the local topography and where the slow rate of fuel accumulation prevents frequent intense fires.

Callitris trees are commonly called 'cypress pines' because of their resemblance to northern hemisphere cypresses and pines.

Callitris forest occupies a diverse range of habitats and supports a wide range of animals. Fauna diversity is high in mixed eucalypt/callitris forest but extremely low in pure callitris stands. A survey in mixed eucalypt/callitris forest in the Barakula State Forest (south Queensland) located 127 native animal species, including 84 birds, 6 bats, 19 reptiles and two rare or threatened species (the yellow-bellied glider *Petaurus australis* and the yellow-tufted honeyeater *Lichenostomus melanops*).

Distribution

Figure 13: Callitris distribution



Source: National Forest Inventory (2003)

Note: The distribution represented on this map has been enhanced for clarity

Callitris is a genus that occurs only in Australia (14 species) and New Caledonia (2 species). This distribution reflects the presence of callitris on the ancient super-continent of Gondwana over 80 million years ago, when Australia and New Caledonia were part of one landmass along with South America and Africa.

The 2.3 million hectares (Table 20) of callitris that occur in Australia are components of many Australian ecosystems from the arid tropics to the Australian Alps (Figure 13).

The most common species of callitris is white cypress pine (*C. glaucophylla*). Changes in fire frequency and land management have enabled white cypress pine forests to expand since European settlement. Woodland and open forests of white cypress pine and other callitris species occur in Queensland, New South Wales and South Australia. Tall open forests of Port Jackson pine (*C. rhomboidea*) occur in Tasmania and there are open forests of Rottnest Island pine (*C. preissii*) in coastal Western Australia and South Australia. Localised areas of woodlands dominated by black cypress pine (*C. endlicheri*) and family pine (*C. preissii* subsp. *verrucosa*) occur in localised areas in Queensland, New South Wales and the Australian Capital Territory, while slender cypress pine (*C. gracilis*) woodland forests occur in Victoria. Pygmy cypress pine (*C. oblonga*) is the only member of the genus adapted to riverine habitats, but it can also occur on very dry sites.

Tenure

While callitris forests are a small proportion of native forest, they are regionally significant. Most are found on leasehold and private land (Table 20). About 10 per cent of callitris is managed as multiple-use forest.

Table 20: Tenure of callitris forest, by State and Territory ('000 ha)

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	0	637	111	203	226	0	0	0	1 178
Multiple-use forests	0	108	0	128	0	0	5	0	240
Nature conservation reserves	0	54	0	6	24	0	40	0	124
Other crown land	0	62	5	0	2	0	2	0	70
Private land	0	379	270	41	6	0	9	0	706
Unresolved tenure	0	0	0	9	2	0	0	0	12
Total callitris forest	0	1 240	386	387	261	1	56	0	2 330

Source: National Forest Inventory (2003)

Values and uses

Callitris is the second most important genus in the native forest industry after Eucalyptus, and is the only significant native softwood timber harvested commercially. The major commercial callitris species is the white cypress pine. In Queensland, more timber is produced from this species than from any other native tree outside plantations, and in New South Wales, more than from any other native species except blackbutt (*Eucalyptus pilularis*).

The strength and durability of the timber are important assets. It can resist decay and termites for up to 50 years, and so has been widely used for in-ground applications, such as house stumps, fence posts and telephone poles, as well as for flooring and furniture. Resin from the white cypress pine has also been used as a substitute for sandarac resin, a raw material for specialist varnishes and incense.

A total of about 250 000 cubic metres of callitris sawlogs are harvested each year from forests in New South Wales and Queensland. In 1999, in Queensland, the Australian cypress industry generated $30 million and employed more than 2 000 people directly and indirectly. Areas of callitris forests are also used for grazing and bee-keeping.

Callitris forests have been an important part of the culture of Australia's Indigenous people and contain significant sites of cultural value. Indigenous people use northern cypress pine (*C. intratropica*) wood for firewood and torches, as well as for spears, spear throwers, ceremonial objects, paddles and music sticks. Resin is used to make glue while the cones, bark, leaves and ash are used in various medicines. Callitris bark is used to make rope and to repel mosquitoes and, in Arnhem Land, Northern Territory, to make waist belts. The Walbiri people of central Australia make implements from the wood of the white cypress pine.

Queensland Herbarium

White cypress pine (*Callitris glaucophylla*) forest, Queensland

Casuarina forest

Commonly called she-oaks or oaks, casuarina species are a distinctive part of the Australian landscape. This forest type also includes the genus *Allocasuarina*.

Only some casuarina species form forest communities. Casuarina forests occur in all States and Territories of Australia, with a total area of over 2 million hectares (Table 21). Because their roots can produce nitrogen through microbial associations, casuarinas can colonise nutrient-poor soils and other marginal environments such as granite outcrops and lateritic or sandy soils. As a result, most casuarina forests tend to be low in stature—sometimes with a dense shrubby understorey. The tallest casuarina forests occur in riverine habitats, where they may be over 20 metres tall.

Table 21: Area ('000 ha) of casuarina forest by crown cover

	Woodland	Open	Closed	Unknown crown cover	Total native forest
Casuarina	359	871	0	809	2 039
Total native forest	102 526	45 603	4 644	9 907	162 680

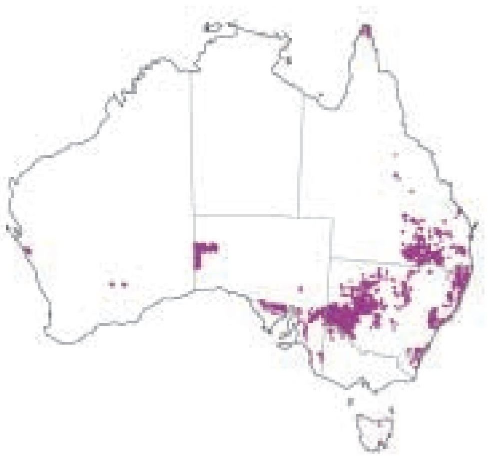
Source: National Forest Inventory (2003)

The name casuarina is derived from the Malay kasuari, which means cassowary, and refers to the similarity of the drooping foliage to the feathers of that bird. Casuarina species' unusual branchlets, which bear a superficial resemblance to the conifer (*Pinus* spp.), are their most obvious characteristic. The needle-like foliage is not, in fact, composed of true leaves, but rather of green, jointed branchlets that have taken on the function of a leaf. The true leaves are tiny, tooth-like structures protruding from the top of each joint.

Casuarinas are important for biodiversity and remnants of casuarina forests support a wide range of vertebrate and invertebrate fauna. Casuarinas provide food for native wildlife, such as the glossy black-cockatoo (*Calyptorhynchus lathami*), which is dependent on the seeds of forest oak (*Allocasuarina torulosa*) and black oak (*A. littoralis*) as its primary food source.

Distribution

Figure 14: Casuarina distribution



Source: National Forest Inventory (2003)

Note: The distribution represented on this map has been enhanced for clarity

Casuarina is a genus of about 60 Australian species, with related species in New Guinea, Indonesia, Malaysia and the Pacific Islands.

The largest extent of casuarina forest in Australia is in western New South Wales, extending as a band into semi-arid zones in South Australia and Queensland. There are also extensive areas in coastal New South Wales. They occur primarily on rocky sites across Australia and near water bodies and streams. Belah (*Casuarina cristata*) forests have the widest distribution, occurring in habitats varying from stony slopes to calcrete to heavy clay soils.

Typical species of inland areas include belah and river she-oak (*C. cunninghamiana*), which often occur in association with acacias and eucalypts. Pure stands of casuarina are restricted in area to specific sites, such as coast she-oak (*C. equisetifolia*) on coastal fore-dunes of eastern Australia and rock she-oak (*A. huegeliana*) on granitic soils and outcrops in Western Australia. Coast she-oak also occurs in association with coastal banksias along the south-eastern and eastern seaboards in less exposed sites. Drooping she-oak (*A. verticillata*) forms pure stands on the driest sites in Tasmania, as it is more drought resistant than local eucalypts.

Tenure

Nearly half the casuarina forests occur in New South Wales, with 37 per cent in South Australia and 11 per cent in Queensland (Table 22). Nationally, the majority of these forests occur on leasehold land and nature conservation reserves. The total extent on private land nationally is 7 per cent, while less than 2 per cent are located in multiple-use forests or other crown land.

Table 22: Tenure of casuarina forest, by State and Territory ('000 ha)

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	0	877	0	47	95	0	0	23	1 043
Multiple-use forests	0	5	0	2	0	0	0	0	7
Nature conservation reserves	0	61	0	69	650	1	3	16	800
Other crown land	0	12	0	1	14	0	0	1	28
Private land	0	36	14	90	4	1	1	0	145
Unresolved tenure	0	8	0	6	1	0	0	0	15
Total casuarina forest	0	1 000	14	216	763	1	4	40	2 039

Source: National Forest Inventory (2003)

Values and uses

The wood of some casuarina species is used in flooring, cabinet making and other ornamental woodworking, such as Western Australian she-oak (*A. fraseriana*) for furniture in Western Australia and forest oak (*A. torulosa*) for shingles and shakes in eastern Australia. The quantities used are very small because the resource is small, but the product is keenly sought after and very expensive. The wood of most casuarinas is very hard and provides excellent fuel. Coast she-oak is used for timber, poles, pulpwood, mulch, windbreaks, and in soil reclamation and erosion control. It has reputedly the best fuel wood in the world as it is relatively smokeless when it burns. It also produces high quality charcoal. The foliage of species, such as river she-oak, is used as fodder for stock during drought. Belah is often used for fence posts, firewood, and as windbreaks on agricultural land.

River she-oak (*Casuarina cunninghamiana*) coastal forest, New South Wales

Eucalypt forest overview

Eucalyptus is an iconic Australian tree genus. There are over 700 species, some of which are still to be named. Almost all eucalypt species occur naturally only in Australia. Many secrete a resinous gum—hence the common name 'gum tree'.

Eucalypts form the overstorey and dominant components of closed forest, open forest and woodland forests. Eucalypts also occur as emergent trees from shrublands and grasslands in most regions, from high rainfall to semi-arid and from sea-level to sub-alpine environments. Unless their canopy cover exceeds 20 per cent they are not covered by the category 'eucalypt forest' in this report.

Eucalypts evolved from rainforest ancestors and adapted to an environment where nutrient-poor soils were common and aridity was generally increasing. They now thrive mainly in temperate and arid environments. Fire frequency has also been an important factor in their evolution.

Argyle apple (*Eucalyptus cinerea*) blossom

Because of their extent, eucalypt forests are extremely important to the conservation of biodiversity and the maintenance of ecosystem processes over large areas of the continent. Eucalypt forests support most of the continent's native plant and animal species. It is possible that Australian termites and eucalypts evolved together, with the trees providing food and the termites helping to return nutrients to low fertility soils. Hollows in eucalypt trees created by fire, fungi, insects, drought or wind damage, provide habitat for a wide range of wildlife, such as small mammals, lizards, insects, spiders and birds.

There are more dominant eucalypt species in the forests of south-eastern Australia than in the forests of south-western Australia or the woodlands of northern Australia. In the south-east, the more variable topography results in major changes in species groupings. However, in south-western and northern Australia, where the topography is more regular, a few species of eucalypts dominate wide expanses of forest (e.g., woollybutt *Eucalyptus miniata*, stringybark *E. tetrodonta* and jarrah *E. marginata*) although many other species occur in localised areas.

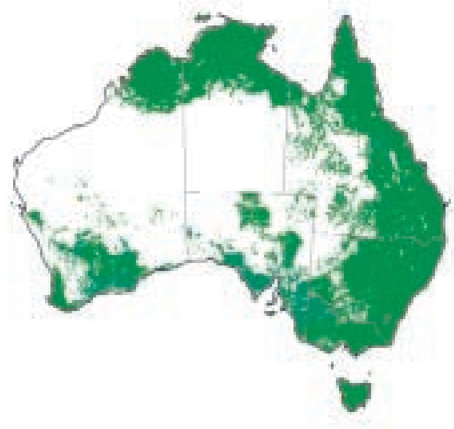
The name *Eucalyptus* is derived from the Greek words '*eu*', meaning 'well' and '*kalyptos*', meaning 'covered'. 'Well covered' refers to the bud cap that covers the stamens—male floral parts—and falls off when the tree flowers.

The majority of eucalypts produce large numbers of small flowers grouped into large flower clusters. The flowers of most eucalypt species attract insects, but some species develop fewer, larger, coloured flowers that attract birds and sometimes mammals.

Eucalypts belong to the Myrtaceae family, along with bottlebrushes, tea-trees and paperbarks. For the purposes of this report, the eucalypts are taken as defined by State and Territory herbaria. Their preferred usage is that the eucalypts consist of three major genera: *Eucalyptus*, *Corymbia* and *Angophora*. 'Eucalypt forests' in this report refer to those forests dominated by *Eucalyptus* or *Corymbia*. Forests dominated by *Angophora* are covered under 'Other forests'.

Distribution

Figure 15: Eucalypt distribution



Source: National Forest Inventory (2003)
Note: The distribution represented on this map has been enhanced for clarity

Almost all eucalypt species occur naturally only in Australia. Four tropical species are restricted to Timor, New Guinea, Sulawesi and Mindanao.

Eucalypts dominate over 127 million hectares of forest in Australia. Over half the area of eucalypt forest is woodland and there is a substantial area of open forest (Figure 15). The dominance of Australian native forests by eucalypts is apparent in Table 23.

Table 23: Area ('000 ha) of eucalypt forest by crown cover

	Woodland	Open	Closed	Unknown crown cover	Total native forest
Eucalypt mallee	10 400	1 929	0	0	12 329
Eucalypt woodland	76 983	0	0	0	76 983
Eucalypt open	0	37 623	0	0	37 622
Eucalypt closed	0	0	90	0	90
Total eucalypt forest	87 383	39 551	90	0	127 024
Total native forest	102 526	45 603	4 644	9 907	162 680

Source: National Forest Inventory (2003)

Values and uses

The most important native timber trees in Australia are eucalypts. The timber is used for many purposes, predominantly sawlogs veneer logs, poles, piles and girders and pulpwood. Eucalypts of the arid regions grow slowly and have wood that is among the densest timbers in the world.

Large areas of eucalypt forest provide water catchment protection, as well as providing venues and resorts for recreation, tourism and aesthetic pursuits. Many eucalypt forests provide nectar and pollen for honey production and beeswax.

Indigenous people use a great range of materials from eucalypt forests. The seeds of many species are ground and made into cakes, while the forests also provide fruit and nut trees, berries, tubers of rushes and yams, grass seeds, honey from native bees, wallabies, possums, snakes and lizards. The root bark of mallees—shrubby, multi-stemmed eucalypts—is roasted, pounded and chewed, and flowers of some eucalypts are soaked in water for sweet drinks. Eucalypt bark is used for paintings and to construct shields, canoes, coolamons (bowls), drinking vessels, cladding for huts and blankets, and torches. The wood is used for fuel and fashioned into spears, digging sticks, clap-sticks, clubs and boomerangs. Resins are used for making adhesives.

Eucalypt mallee forest

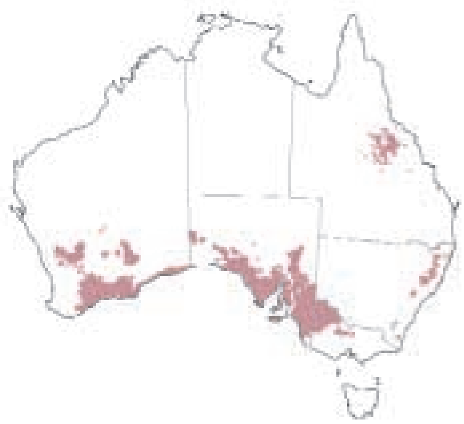
'Mallee' is used to describe plant communities dominated by mallee eucalypts and to describe the individual mallee eucalypt plants. Mallee eucalypts have multiple stems arising at ground level from a large woody structure known as a lignotuber or 'mallee root'. Eucalyptus mallee forest includes vegetation where the tallest stratum is dominated by mallee trees greater than 2 metres tall. It does not include vegetation where mallee eucalypts are clearly shrubby in form.

The main mallee communities in south-eastern Australia are the ridge-fruited mallee (*Eucalyptus incrassata*) and *E. leptophylla* types, which have a relatively species-rich, heath understorey, and types dominated by red mallees (*E. oleosa* and *E. socialis*), yorrell (*E. gracilis*) or white mallee (*E. dumosa*), with semi-succulent saltbush or hummock grass understoreys. The dominant species depends on the type of soil, especially soil depth and clay content. Mallee forests dominated by eucalypts such as *E. redunca* and *E. eremophila* are widespread in Western Australia.

Although a complete inventory of mallee species complexes has not been compiled, it is likely that there are at least 200–250 eucalypt species of mallee form. The highest species richness occurs in south-western Australia where as many as three-quarters of the eucalypts are mallees. In this region, many mallees may have evolved this form as the climate became more arid.

Distribution

Figure 16: Eucalypt mallee distribution



Source: National Forest Inventory (2003)

Note: The distribution represented on this map has been enhanced for clarity

Most mallee communities are located in areas where the average annual rainfall is 250–400 millimetres and rainfall is predominantly in winter (Figure 16). Such climates are referred to as Mediterranean. Significant falls of summer rain can occur in association with decaying tropical cyclones, although such events are uncommon; and drought is common. Where rainfall is higher, mallees are replaced by woodlands of single stemmed eucalypts, sometimes of the same species. Where rainfall is lower, mallee forests are usually replaced by acacia forests or shrublands.

In South Australia, prominent and widespread mallee species include white mallee (*Eucalyptus anceps*), gilja (*E. brachycalyx*), square-fruited mallee (*E. calycogona*), desert mallee (*E. concinna*), coastal white mallee (*E. diversifolia*), slender-leaved mallee (*E. foecunda*), yorrell, ridge-fruited mallee (*E. incrassata*), peppermint box (*E. odorata*), the red mallees and Kingscote mallee (*E. rugosa*). These are accompanied variously by a few tree species of other genera including mallee cypress pine (*Callitris canescens*), southern cypress pine (*C. preissii*), belah (*Casuarina cristata*) and dryland tea tree (*Melaleuca lanceolata*).

Tenure

The majority of mallee forests occur in South Australia (49 per cent) and Western Australia (40 per cent), while the remainder occur in north-western Victoria (9.5 per cent), Queensland (1 per cent) and New South Wales (0.2 per cent) (Table 24). A substantial proportion of mallee vegetation is within nature conservation reserves (43 per cent), the majority in South Australia, while 24 per cent occurs on other crown land, 21 per cent on leasehold land, 9 per cent on private land and 1 per cent in multiple-use forests.

Table 24: Tenure of eucalypt mallee forest, by State and Territory (000' ha)

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	0	1	0	114	2 168	0	0	305	2 588
Multiple-use forests	0	1	0	0	0	0	161	13	175
Nature conservation reserves	0	14	0	2	3 004	0	812	1 512	5 345
Other crown land	0	0	0	0	165	0	17	2 830	3 013
Private land	0	6	0	3	640	0	182	309	1 140
Unresolved tenure	0	0	0	1	66	0	0	0	67
Total eucalypt mallee	0	23	0	122	6 044	0	1 171	4 969	12 329

Source: National Forest Inventory (2003)

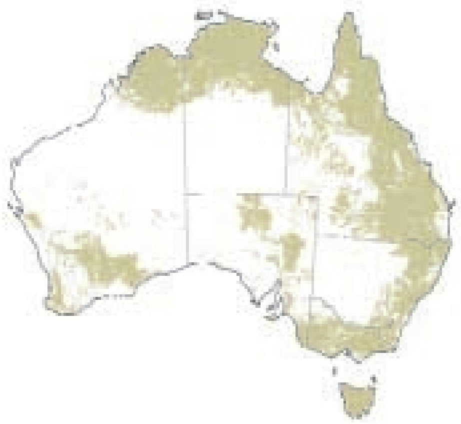
White mallee (*Eucalyptus dumosa*) Lake Mungo National Park, New South Wales

Eucalypt woodland forest

Woodland forests have very open canopies. Their crown cover is from 20 per cent to 50 per cent. The classification includes open woodlands, which are called savanna in some parts of the country. Nearly half of all Australia's forests are classified as eucalypt woodland forest.

Distribution

Figure 17: Eucalypt woodland forest distribution



Source: National Forest Inventory (2003)

Note: The distribution represented on this map has been enhanced for clarity

Woodland forests occur in four main areas of Australia: a broad band across tropical northern Australia; subtropical and warm temperate eastern Australia; the warm temperate south-west; and the cool temperate south eastern Australia, including Tasmania (Figure 17). Almost half of Australia's woodland forests occur in Queensland, with large amounts also in the Northern Territory (28 per cent) and Western Australia (17 per cent).

The tropical woodland forests grade from very tall to very low and are often widespread. For example, low woodland forest dominated by northern white gum (*Eucalyptus brevifolia*) occurs on sandstone or quartzite ridges from the Ord River in north-western Australia, through to the Leichhardt River in the Gulf of Carpentaria (Queensland), whereas silver box (*E. pruinosa*) woodland tends to occur on heavier soils over the same range. A number of locally endemic eucalypts also occur in those landscapes. This is particularly so in three separate areas of high-rainfall across northern Australia, where *Corymbia abergiana* and *C. stockeri* are endemic to the north-east, *C. arenaria* and *C. collina* to the north-west and *C. oocarpa* and *C. arnhemensis* to the north. The understorey of eucalypt woodlands in northern Australia may include palms, cycads and grasses.

The majority of eucalypts are evergreen trees, but there are a few that lose their leaves seasonally. These eucalypts occur in woodland forests throughout the seasonally-inundated cracking clays of northern Australia. Eucalypts such as the white gum (*E. alba*), *E. foelscheana*, *E. confertiflora* and *E. bleeseri* are important in these environments. Moisture and soil conditions determine which species are dominant. The trees in these forests lose all or part of their leaf canopy under conditions of water stress, but flower and have a growth flush before monsoonal rains usually start. This characteristic is called 'drought deciduousness' because of its relationship to the annual dry season.

In the temperate regions, the natural distribution of woodland forests coincides with the core of Australia's agricultural regions; as a consequence, most woodlands are remnant patches in an agricultural landscape. In southern Queensland, central New South Wales and northern Victoria, such woodlands occur in areas of between 400 mm and 600 mm rainfall per annum. They are often referred to as box and ironbark woodlands and contain species such as bloodwood (*Corymbia polycarpa*), poplar box (*Eucalyptus populnea*), narrow-leaf ironbark (*E. crebra*), silver-leaf ironbark (*E. melanophloia*), grey box (*E. microcarpa*) and in Western Australia, tuart (*E. gomphocephala*).

Broad-leaved carbeen woodland (*Corymbia confertifolia*) north-west Kimberley, Western Australia

Red river gum (*E. camaldulensis*) is the most widely distributed eucalypt, occurring in all Australian mainland states, but is primarily found along the Murray River and its tributaries in New South Wales and Victoria, where it relies upon periodic flooding and underground water.

In the wheatbelt of Western Australia, wandoo (*E. wandoo*) and salmon gum (*E. salmonophloia*) woodlands are dominant. The latter species may grow up to 30 metres in height in areas that receive only 200–300 millimetres of annual rainfall whereas *E. wandoo*, *E. capillosa* and *E. salubris* woodlands may be 12–18 metres tall. The box and wheatbelt woodlands tend to have an understorey of sclerophyllous shrubs, such as banksias, acacias and casuarinas, or succulent shrubs, such as bluebush and saltbush.

The pattern of distribution of woodlands in southern Australia is affected by soil and temperature conditions. For example, stands of white box (*E. albens*) and yellow box (*E. melliodora*) woodland forests with grassy understoreys occur on the fertile western slopes of southern Queensland, New South Wales and Victoria. Narrow-leaved red ironbark is dominant on sites with slightly sandy or deep, weathered soil and broad-leaved ironbark (*E. fibrosa*) is dominant on sandier sites. Tasmanian snow gum (*E. coccifera*), and snow gum (*E. pauciflora*), dominate woodland forests in subalpine environments in Tasmania and south-east Australia. In south-western Australia, woodland forests dominated by red mallee (*E. oleosa –E. flocktoniae* Merrit) occur on soils containing calcium carbonate in low rainfall zones (below about 300 millimetres), while wandoo (*E. wandoo*), gimlet (*E. salubris*) and salmon gum occur on loamy soils in higher rainfall (300–800 millimetre) zones.

Tenure

Most of the woodland forests occur on leasehold or private lands, but 7 per cent are in nature conservation reserves and 4 per cent in multiple-use forest areas (Table 25). In Western Australia, 43 per cent of woodland forests occur on other crown land.

Table 25: Tenure of eucalypt woodland forest, by State and Territory ('000 ha)

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	5	178	12 980	24 294	1 043	0	5	4 862	43 367
Multiple-use forests	0	156	0	1 908	0	361	249	205	2 878
Nature conservation reserves	17	580	2	2 276	194	465	466	1 538	5 538
Other crown land	0	138	695	742	107	63	44	5 509	7 298
Private land	0	1 400	8 172	5 477	130	739	294	818	17 030
Unresolved tenure	0	22	51	503	287	0	6	4	873
Total eucalypt woodland	21	2 475	21 900	35 199	1 761	1 627	1 063	12 937	76 983

Source: National Forest Inventory (2003)

Eucalypt open forest

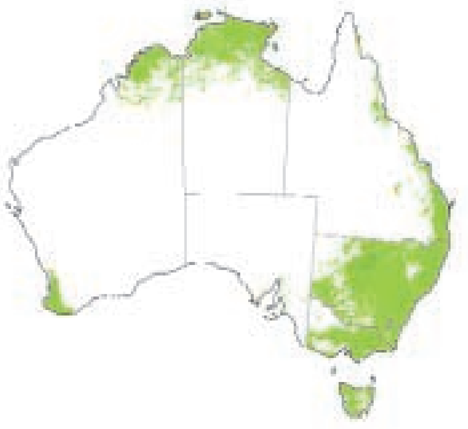
Tall open forests—also known as wet sclerophyll forests—are open forests dominated by trees at least 30 metres tall. This forest type contains some of the greatest quantity of plant biomass per unit area found in terrestrial ecosystems, and also includes trees that are among the tallest in the world. Mountain ash (*Eucalyptus regnans*) is the world's tallest flowering plant and reaches over 100 metres in height. Eucalypts are by far the most common dominant tree species in tall open forest; about 11 species of *Eucalyptus* are confined to this forest type and another 27 to 30 species may occur locally. Many of the species are highly genetically variable—for example, Tasmanian blue gum *E. globulus*, blackbutt *E. pilularis*, messmate *E. obliqua*—and occur also in open and woodland forest.

Open forests are dominated by trees with an open canopy—that is, they have a crown cover between 50 per cent and 80 per cent. Eucalypts dominate the overstorey of nearly all the open forests of southern Australia. Three major zones of occurrence are recognised: coastal and sub-coastal south-eastern Australia; Tasmania; and south-western Australia.

There may be up to 10 eucalypt species per hectare in the open forests of south-eastern Australia. In contrast, in the forests of south-western Australia where jarrah (*E. marginata*) and marri (*Corymbia calophylla*) are dominant, there are large areas where there is only one main tree species—for example, the northern jarrah forest. Extensive stands of one eucalypt species, such as snow gum (*E. pauciflora*), mountain ash and alpine ash (*E. delegatensis*) are also found in south-eastern Australia.

Distribution

Figure 18: Eucalypt open forest distribution



Source: National Forest Inventory (2003)

Note: The distribution represented on this map has been enhanced for clarity

Eucalypt open forest occurs in all States and Territories of Australia. The largest expanses are in New South Wales, the Northern Territory and Victoria (Figure 18).

In general, open forests occur in areas of moderate temperature and rainfall—where average annual rainfall exceeds 600 millimetres—where the phosphorus status of the soil is also relatively moderate by Australian standards. In each major zone, the range in rainfall from high to low is typically marked by a change from tall open forest to woodland forest on the more fertile soils.

Tall open forests are distributed in a discontinuous arc of high rainfall country from north-east Queensland to southern Tasmania. In eastern Australia, a gradual replacement of dominant species occurs down the coastline. Tall open forest is also found in south-western Australia, but not in the low rainfall gap of 2 100 kilometres between western Victoria and south-western Australia.

Tenure

The largest proportion of eucalypt open forests occur on private land (38 per cent) although the distribution by State and Territory on private land varies considerably, from 0 per cent in the Australian Capital Territory to 88 per cent in the Northern Territory (Table 26). Nationally, about 20 per cent of eucalypt open forest occurs on leasehold land, multiple use forest or nature conservation reserve tenures, while 4 per cent is on other crown land. The States with the largest areas of eucalypt open forest in nature conservation reserves are New South Wales (17 per cent) and Victoria (28 per cent). The Australian Capital Territory and South Australia, which have much smaller total areas of forest, have the highest proportions in nature conservation reserves (93 per cent and 39 per cent, respectively).

Table 26: Tenure of eucalypt open forest, by State and Territory ('000 ha)

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	7	6 862	607	586	4	0	38	61	8 163
Multiple-use forests	0	2 048	0	337	0	481	2 830	1 370	7 066
Nature conservation reserves	89	3 315	3	562	17	228	1 518	489	6 220
Other crown land	0	800	120	85	10	11	135	160	1 320
Private land	0	6 455	5 215	1 720	12	128	793	159	14 481
Unresolved tenure	0	242	15	96	1	0	15	1	371
Total eucalypt open forest	95	19 722	5 960	3 385	44	847	5 328	2 240	37 623

Source: National Forest Inventory (2003)

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

Eucalypt closed forest

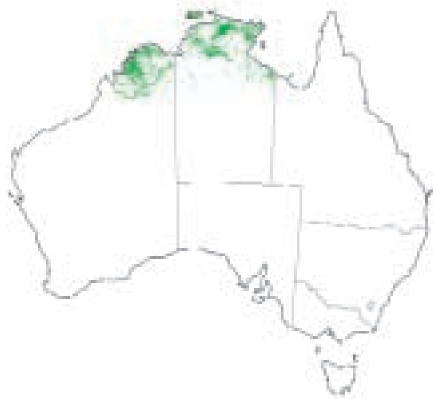
In northern Australia, eucalypts can form a forest with over 80 per cent crown cover in wet or sheltered areas at the margins of, or within, open eucalypt forests. These forests are referred to in this report as 'closed eucalypt' forest (Figure 19).

Although forming a distinct forest type, closed eucalypt forests are generally comprised of species typical to northern Australian open forests, such as stringybark (*E. tetrodonta*) and woollybutt (*E. miniata*).

More than 70 per cent of these forests are classified by height as medium closed eucalypt forest (10–30 metre canopy height), with the remainder being low closed eucalypt forest (2–10 metre canopy height).

Distribution

Figure 19: Eucalypt closed forest distribution



Source: National Forest Inventory (2003)

Note: The distribution represented on this map has been enhanced for clarity

Closed forest of stringybark (*Eucalyptus tetradonta*) Gunn Point, Northern Territory

Tenure

Most of the closed eucalypt forests occur on private or leasehold land in the Northern Territory and on other crown land, nature conservation reserves and leasehold land in Western Australia (Table 27).

Table 27: Tenure of eucalypt closed forest, by State and Territory ('000 ha)

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	0	0	12	0	0	0	0	10	22
Multiple-use forests	0	0	0	0	0	0	0	0	0
Nature conservation reserves	0	0	0	0	0	0	0	7	7
Other crown land	0	0	3	0	0	0	0	19	22
Private land	0	0	36	0	0	0	0	1	37
Unresolved tenure	0	0	0	0	0	0	0	1	1
Total eucalypt closed forest	0	0	51	0	0	0	0	39	90

Source: National Forest Inventory (2003)

Mangrove forest

Mangrove forests form some of Australia's most important and widespread coastal ecosystems, growing in the intertidal zone of tropical, subtropical, and protected temperate coastal rivers, estuaries and bays. Mangrove forests cover 750 000 hectares (Table 28) in a discontinuous pattern around the Australian coastline (Figure 20).

Table 28: Area ('000 ha) of mangrove forest by crown cover

	Woodland	Open	Closed	Unknown crown cover	Total native forest
Mangrove	25	266	325	132	749
Total native forest	102 526	45 603	4 644	9 907	162 680

Source: National Forest Inventory (2003)

Mangrove forests generally range from 2–10 metres in height, but their structure and height vary with the environment. In high rainfall areas of far north Queensland, they may reach 30 metres in height. Whereas in some temperate and highly salty areas on the inland side of tropical mangroves, trees may only reach 1 metre high, and therefore be too short to be classified as forest. Mangroves can form dense, almost impenetrable stands, often dominated by only one or two species.

Tropical mangrove forests are the most diverse and widespread, with the greatest concentration of species along the north-east coast of Queensland. The number of species decreases further south due to lower winter temperatures, and from east to west across the tropics as rainfall decreases. Some scientists consider mangroves to be a special form of tropical rainforest as they have many families of plants in common, but in Australia mangroves have traditionally been considered a separate vegetation type.

The total Australian mangrove flora consists of 40 species from 19 families. White mangrove (*Avicennia marina*) is the most widespread and common. Several other salt tolerant species may occur in mangrove forests. For example, the mangrove palm (*Nypa fruticans*) occurs in tropical mangrove forests, while the mangrove fern (*Acrostichum speciosum*) inhabits the mangrove forest floor. Other ferns and orchids grow on the trunks and branches of mangroves in tropical areas. Species composition of mangrove varies with tidal inundation and latitude.

Mangroves play important roles in the ecology of wetlands and estuaries. By reducing the speed of currents and hence trapping sediments, mangroves help to reduce siltation in adjacent marine habitats. In addition, river-borne nutrients and chemicals are trapped and recycled within mangroves. They provide habitat and breeding sites for birds, fish and other wildlife. They are also highly valued for their unique biodiversity.

Mangrove forest, Lockhart River, north-east Cape York, Queensland

Mangrove species are adapted to tidal inundation and high salinity in coastal estuaries, inlets and bays. They deal with salinity in two broad ways; either by keeping out the dissolved salt as their roots absorb water or absorbing the salt and then extruding it through special glands in their leaves.

Mangroves have adapted to low oxygen levels in the deep muddy soil by evolving aerial or breathing roots (see box) that grow up through the water into the air.

Distribution

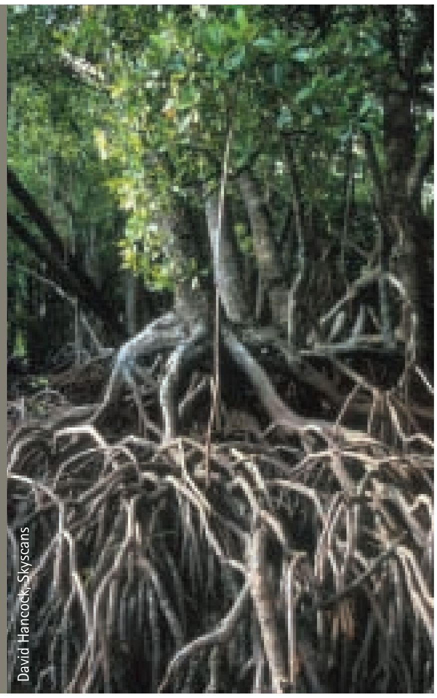
Figure 20: Mangrove distribution

Source: National Forest Inventory (2003)
Note: The distribution represented on this map has been enhanced for clarity

Mangrove forests are widespread in tropical, sub-tropical and some temperate regions of the world. In Australia, most mangrove forests are located in the tropical north-west, north and north-east, but there are isolated occurrences in Victoria, South Australia and in temperate Western Australia (Figure 20). The southern most occurrence of mangroves in Australia is at Wilson's Promontory, Victoria.

Mangrove roots

All plant roots need oxygen from the surrounding soil in order to survive. But the soft sediment in which many mangroves grow is frequently very low in oxygen. To cope with this, most mangroves have developed aerial roots (or pneumatophores) that rise above the surface of the mud. These are designed to allow air to reach the deeper roots that absorb water and nutrients. The shapes of the aerial roots vary enormously, but the three most conspicuous types are pencil roots (found in *Avicennia* species, for example), knee roots (as found in *Bruguiera* species) and stilt roots (as found in *Rhizophora* species). The true root systems of mangrove trees are very shallow, extending less than two metres below the surface. However, they spread horizontally in a dense mass over large distances. Many mangrove species are unusual in that there is a greater proportion of plant material below the surface than above, another feature that helps them to remain anchored in soft mud.



Mangrove forest, Northern Territory

Tenure

Reflecting their predominantly tropical distribution, the greatest area of mangrove forest is in the Northern Territory, while Queensland and Western Australia have most of the remainder. More than 40 per cent are on private land, which includes Indigenous land (Table 29).

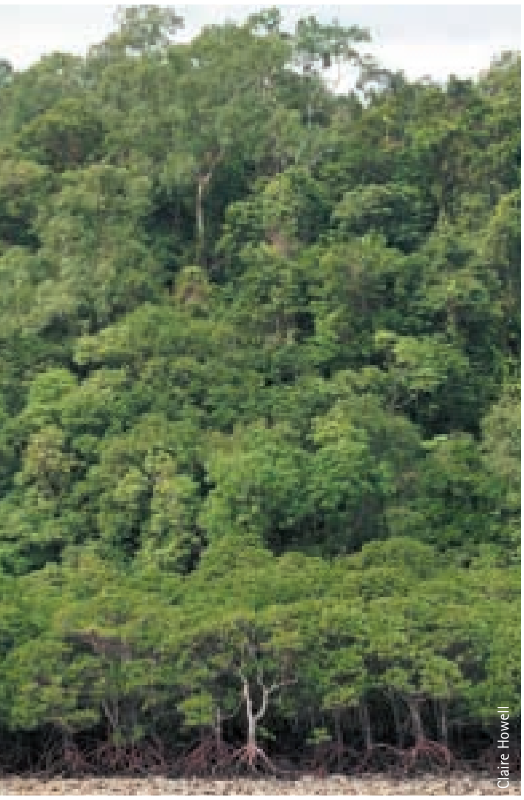
Table 29: Tenure of mangrove forest, by State and Territory ('000 ha)

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	0	0	44	18	2	0	0	20	85
Multiple-use forests	0	0	0	0	0	0	0	0	1
Nature conservation reserves	0	1	4	22	3	0	1	37	69
Other crown land	0	0	11	46	3	0	0	106	166
Private land	0	1	261	61	1	0	1	4	329
Unresolved tenure	0	0	36	48	11	0	0	5	99
Total mangrove forest	0	3	355	196	19	0	2	173	749

Source: National Forest Inventory (2003)

Values and uses

One of the most important economic beneficiaries of mangroves is the fishing industry. A high proportion of the commercial and recreational fish catch around Australia are species, such as barramundi (*Lates calcarifer*) and banana prawn (*Penaeus merguinensis*), that require estuarine habitat for at least part of their lifecycle. Many mangrove forests provide nursery areas for the young of these valuable fish.



The transition from mangrove forest to rainforest

Historically, many mangrove species provided useful products, such as tannin, wood for poles, firewood, charcoal and, occasionally, milled timber.

Mangroves are also an important resource for Indigenous people in the Northern Territory. The plants are a source of honey and fruit, as well as medicines. Mangrove worms, found within decaying mangrove wood, are used as food. The timber can be used for implements, firewood and construction. Many edible fish and shellfish are harvested from mangrove swamps. Mangrove leaves are also palatable for livestock.

Melaleuca forest

Melaleuca forests generally occur in damp or wet habitats that dry out seasonally. They occur as large tracts of low woodland forests across estuarine plains and seasonal swamps, in the coastal and near-coastal areas of monsoonal northern Australia. Melaleuca forests also occur as narrow strips of dense, pure stands, beside streams and in and around swamps. These ecologically important forests are often too small to be mapped.

Some melaleuca species are called paperbarks because of the peeling, papery texture of their bark, which consists of thin layers of cork. Another commonly used name for melaleuca is tea tree. More than seven million hectares of melaleuca forests have been identified in Australia, the majority as woodland and open forest (Table 30).

Table 30: Area ('000 ha) of melaleuca forest by crown cover

	Woodland	Open	Closed	Unknown crown cover	Total native forest
Melaleuca	1 056	763	15	5 222	7 056
Total native forest	102 526	45 603	4 644	9 907	162 680

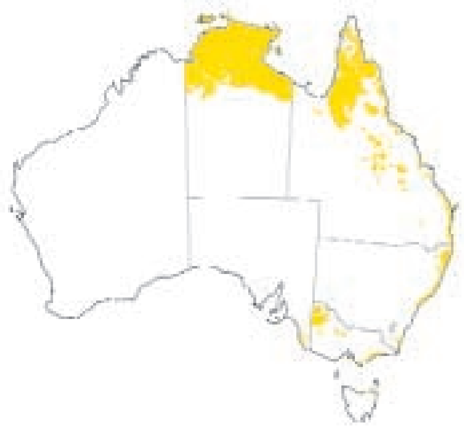
Source: National Forest Inventory (2003)

Many melaleuca wetlands have been altered by drainage and flood mitigation during the 1970s and 1980s. Melaleuca forests along creek lines and watercourses in agricultural areas have been affected by increased waterlogging and salinity, especially in areas of irrigation. Peat and other materials have been extracted from swamp areas for use in horticulture. Areas have been cleared for grazing and cropping, for example, for sugar cane on the Herbert River floodplain in Queensland.

Even remnant melaleuca forests can provided significant habitat for other species. For example, the Swamp paperbark (*Melaleuca ericifolia*) riparian swamp in the Damper Creek Reserve in Monash, Victoria, contains a diversity of habitats, and is considered to be a site of Regional Zoological Significance. Melaleuca forests provide habitat for the nationally significant southern bell frog (*Litoria raniformis*), and an assortment of State and regionally significant fauna.

Distribution

Figure 21: Melaleuca distribution



Source: National Forest Inventory (2003)

Note: The distribution represented on this map has been enhanced for clarity

Melaleuca is a genus of trees and shrubs that occurs predominantly in Australia, but also in India, Indonesia, Malaysia, New Caledonia, New Guinea and the Pacific Islands. There are about 143 species, and 140 of these are endemic to Australia.

About 75 per cent of Australia's melaleuca forests occur in Queensland, concentrated in the far north region adjacent to the Gulf of Carpentaria and on Cape York Peninsula (Figure 21) with a further 23 per cent in the Northern Territory. Small pockets occur along the subtropical and temperate coasts of

Weeping paperbark (*Melaleuca leucadendra*) Pilbara, Western Australia

Queensland, New South Wales and Victoria, and on the fringes of rivers and coastal wetlands, including brackish and saline areas. Extensive stands of swamp dominated by melaleucas, blackwood (*Acacia melanoxylon*) and *Leptospermum* species occur on poorly drained sites in north-western Tasmania.

Melaleuca forests occur on a wide range of sites throughout non-arid Australia, and display marked variability in the dominant species. Northern Australian melaleuca forests are dominated by broad-leaved paperbark (*M. viridiflora*), weeping paperbark or long-leaved paperbark (*M. leucadendra*), silver paperbark (*M. argentea*), blue paperbark (*M. dealbata*) and yellow-barked paperbark (*M. nervosa*). In southern and eastern Australia, melaleuca forests tend to be confined to more permanently wet watercourses and swamps. The most common coastal species is paperbarked tea-tree (*M. quinquenervia*). In Western Australia, melaleuca forests are restricted to small pockets in specific sites, such as Preiss's paperbark (*M. preissiana*) in near-coastal swampy areas, and freshwater or swamp paperbark (*M. rhaphiophylla*) on creek lines and watercourses.

Tenure

Nationally, 74 per cent of melaleuca forests and woodlands occur on leasehold land and an additional 17 per cent on private land. In both cases the main land use is cattle production (Table 31). Only 7.5 per cent of melaleuca forests occur in nature conservation reserves. Less than 2 per cent are located in multiple-use forests or other crown land.

Table 31: Tenure of melaleuca forest, by State and Territory ('000 ha)

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	0	1	736	4 447	0	0	0	0	5 184
Multiple-use forests	0	2	0	23	0	4	18	0	46
Nature conservation reserves	0	16	1	443	0	10	66	0	537
Other crown land	0	1	33	42	0	0	6	0	83
Private land	0	25	821	322	1	5	6	0	1 180
Unresolved tenure	0	0	2	25	0	0	1	0	28
Total melaleuca forest	0	44	1 593	5 301	1	19	96	0	7 056

Source: National Forest Inventory (2003)

Values and uses

The leaves of some melaleucas, particularly tea tree (*M. alternifolia*) and paperbarked tea tree supply the raw material for the tea tree oil industry. The oil is a very effective antiseptic, and is used in creams, shampoos, soaps, mouthwashes and toothpastes. Indigenous Australians living traditionally in parts of the Northern Territory use the bark of long-leaved paperbark for making sheaths for stone knives and spearheads, as tinder for starting fires, a cover for baking food, a component of fish traps, and a material for making blankets or capes. As the only large diameter trees in the north, melaleuca trees were also used to make canoes.

Rainforest

In Australia, ‘rainforest’ is used as an all-embracing term that includes both the evergreen types along the moist eastern coast of the Australian mainland and Tasmania, and the deciduous types in the more seasonally wet-dry northern areas.

Since European settlement, rainforests were recognised as different from the typical eucalypt-dominated forests, and have been treated almost completely separately from other vegetation types. Rainforest has been defined and classified locally in all States and Territories where it occurs. The general definition of rainforest has often been debated, however, all rainforest has a crown cover of 80 per cent or more and so is classified as closed forest. Rainforest comprises a significant proportion of Australia’s closed forest, but only 2.6 per cent of the total area of native forests (Table 32).

Table 32: Area ('000 ha) of rainforest by crown cover

	Woodland	Open	Closed	Unknown crown cover	Total native forest
Rainforest	0	0	4 214	0	4 214
Total native forest	102 526	45 603	4 644	9 907	162 680

Source: National Forest Inventory (2003)

There are many types of rainforest, varying mainly with rainfall and latitude. Tropical and sub-tropical rainforests occur in northern and eastern Australia in the wetter, coastal areas as far south as New South Wales. Dry rainforests are a variation of tropical/sub-tropical rainforest that occur in pockets protected from frequent fire in sub-coastal and inland areas across northern and eastern Australia. Monsoon rainforests occur in northern and north-western Australia in the seasonally dry coastal and sub-coastal regions. Temperate rainforests occur in eastern and south-eastern Australia; warm temperate rainforests in New South Wales and Victoria, and cool temperate rainforests in Victoria and Tasmania, with a few outliers in the high altitudes of New South Wales and Queensland.

Rainforest ground-covers are often sparse due to the low levels of light under the dense canopies. Understoreys are varied depending on the kind of rainforest. Some are characterised by vines or ferns. Mosses and other epiphytes are often a feature of rainforests. Vine forests are a kind of rainforest characterised by the presence of significant vines growing on the trees. They are largely confined to the tropics and sub-tropics. Rainforest with a significant cover of ferns and mosses are concentrated in the temperate zones and at high altitudes in the tropics.

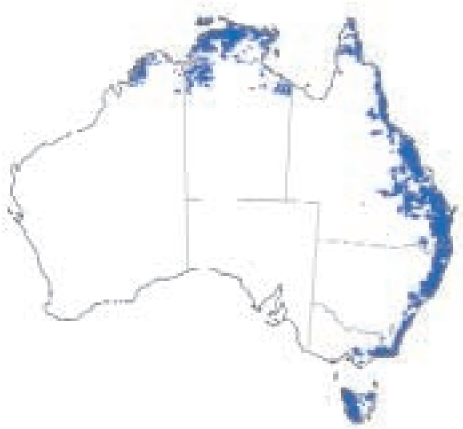
Part of the appeal of rainforests is their strong contrast with the arid and semi-arid communities that dominate the Australian continent. The lush image has been promoted photographically in conservation campaigns and tourism advertising. The high biological diversity, structural complexity and aesthetic appeal of tropical rainforests in particular, together with the presence of unique animals such as the cassowary (*Casuarius casuarius*), have also contributed to rainforest being given a high priority in the consideration of maintenance of biodiversity and conservation planning.

Studies have shown that rainforests are remnants of the oldest types of vegetation in Australia. Many species had ancestors dating back to the Cretaceous or early Tertiary Period, over 65 million years ago. For this reason, rainforests have major historical and scientific significance. Australian tropical rainforests contain eight of the 14 primitive flowering plant families, while the cool temperate rainforests of Tasmania contain several primitive conifers and flowering plants.

Australian rainforests are more important for the maintenance of biodiversity than their small area would suggest. They contain 60 per cent of the plant families occurring in Australia, including many that do not exist outside Australia. About 17 per cent of all Australian bird species occur in rainforests. The wet tropics rainforests of Queensland cover only 0.18 per cent of the area of the continent, but contain about 30 per cent of Australia's marsupial and frog species and 62 per cent of its butterfly species. Five of the 13 centres of plant diversity identified in Australia are dominated by rainforest, while a further three have rainforest components.

Distribution

Figure 22: Rainforest distribution



Source: National Forest Inventory (2003)
Note: The distribution represented on this map has been enhanced for clarity

Rainforest extends across the top of northern Australia from the Kimberley region to Cape York, and down the east coast to the cool temperate zone in southern Tasmania (Figure 24). It is patchily distributed, but occurs in all States except South Australia. In all but the areas of highest rainfall, it occurs in discontinuous patches in locally sheltered, moist areas and where it is protected from frequent fire. Associated with this wide geographical and environmental range, there is significant variability in the structure and types of plants, and a broad range of species that can be found.

High annual rainfall is an important factor controlling rainforest distribution. Rainfalls vary from over 3 600 millimetres per annum in the wet tropics of Queensland and 3 500 millimetres in western Tasmania down to 1 000 millimetres per annum in other regions. Average annual rainfalls lower than 1 000 millimetres are generally not suitable for rainforest.

In some regions (Queensland and northern New South Wales) the area of rainforest has increased, replacing tall open eucalypt forest. This is probably due to changes in fire frequency following European settlement.

Tenure

Most Australian rainforests occur in Queensland with significant areas in the Northern Territory, New South Wales and Tasmania. About 44 per cent is in nature conservation reserves, 25 per cent on private land, and 19 per cent in multiple-use forests and other crown land (Table 33).

Table 33: Tenure of rainforest by State and Territory ('000 ha)

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	0	10	17	450	0	0	0	0	478
Multiple-use forests	0	101	0	327	0	180	8	0	617
Nature conservation reserves	0	289	0	1 161	0	387	7	2	1 846
Other crown land	0	2	5	175	0	5	0	3	191
Private land	0	83	200	740	0	26	0	0	1 049
Unresolved tenure	0	0	1	31	0	0	0	0	32
Total rainforest	0	486	224	2 885	0	598	16	5	4 214

Source: National Forest Inventory (2003)

Values and uses

Rainforest timbers are prized for their fine qualities and aesthetic value. Although harvested or cleared in the past, rainforest is now largely protected, except in some States, where it occurs on private land. Harvesting of rainforest still occurs in Tasmania in areas designated to provide a small ongoing supply of Tasmania's special species for high value end uses such as joinery timbers and craftwood. Tourism is the main economic use of rainforests, particularly in the wet tropics of far north Queensland and in Tasmania. Bioprospecting surveys are ongoing for species that may be useful for medical and dietary purposes. Production of honey from leatherwood (*Eucryphia lucida*) is another important usage in Tasmania.

Myrtle beech (*Nothofagus cunninghamii*) rainforest, Otways, Victoria

Other forest

This report lists 11 major forest types plus a category called 'other forest'. There is a long list of minor forest types that are locally important (and occasionally widespread), though none cover significantly large areas at the national scale. Together with forest for which information is limited for a variety of reasons, such types have been categorised together to form 'other forest'. For this report, about 2.8 million hectares (less than 2 per cent) of Australia's native forests are classified as 'other forest'.

Two-thirds of Australia's 'other forest' is woodland forest, as shown in Table 34, with lesser areas of open forest and a small amount uncategorised as to crown cover. Other forest can be mapped using a variety of techniques, including satellite information. Often it consists of small patches of forest in grassland and agricultural regions with limited survey data, particularly of the dominant species. Therefore, although mappable in terms of area, it cannot be attributed to a forest type, due to the lack of floristic details.

Table 34: Area ('000 ha) of other forest by crown cover

	Woodland	Open	Closed	Unknown crown cover	Total native forest
Other forest	1 837	530	0	413	2 780
Total native forest	102 526	45 603	4 644	9 907	162 680

Source: National Forest Inventory (2003)

Peppermint forest (*Agonis flexuosa*) Donnelly River, Western Australia

There are many species of canopy dominating trees in the category 'other forest'. This is because there are many unrelated environmental and climatic conditions that characterise the diversity of forest types covered by this category. Examples of dominant genera are *Angophora*, *Archidendropis*, *Atalaya*, *Flindersia*, *Hakea*, *Heterodendrum*, *Lamarchea*, *Leptospermum*, *Lophostemon* and *Lysiphyllum*.

Examples of 'other forests'

Following are examples of forest types and their areas that are classified as 'other forest' for this report.

Queensland (1 059 000 hectares):

- low woodland forest, with a grassy understorey, dominated by *Lysiphyllum*, *Grevillea*, *Atalaya* and *Corymbia* species;
- deciduous low woodland forest dominated by *Cochlospermum*, *Erythrophleum* and *Terminalia*.

Northern Territory (740 000 hectares):

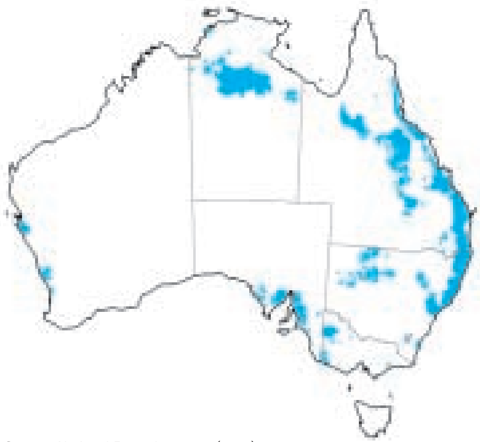
- forests dominated by bauhinia (*Lysiphyllum cunninghamii*) or nutwood (*Terminalia arostrata*), which are medium-sized trees associated with woodlands and savanna grasslands, often near creeks and seasonal watercourses;
- monsoon vine forest communities dominated by northern black wattle (*Acacia auriculiformis*), *Allosyncarpia ternata* and *Ficus* species that occur in seepage sites, streams, springs and seasonally dry sites.

New South Wales (415 000 hectares):

- open and woodland forest dominated by species of *Angophora*, *Syncarpia*, *Lophostemon* and the exotic *Cinnamomum*, with minor components of *Eucalyptus*, *Banksia* and *Allocasuarina*.

Distribution

Figure 23: Distribution of other forest



Source: National Forest Inventory (2003)

Note: The distribution represented on this map has been enhanced for clarity

This category of forest is found in many parts of Australia. The largest areas of it are in Queensland, Northern Territory, New South Wales and Western Australia, but some is found in all other States and Territories as well (Figure 23).

Tenure

The majority of 'other forest' are located on leasehold or private land, while only 21 per cent occurs in nature conservation reserves or multiple-use forests, where species data is likely to be more comprehensive (Table 35).

Table 35: Tenure of other forests by State and Territory ('000 ha)

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	0	71	531	554	7	0	0	235	1 398
Multiple-use forests	0	67	0	65	0	0	27	0	160
Nature conservation reserves	0	99	0	157	2	0	103	54	415
Other crown land	0	8	10	22	2	0	2	43	88
Private land	0	97	196	218	22	0	2	65	599
Unresolved tenure	0	73	2	42	2	0	1	0	120
Total other forest	0	415	738	1 059	34	0	135	398	2 780

Source: National Forest Inventory (2003)

Values and uses

'Other forests' tend not to be of commercial timber value, although they provide benefits in terms of biodiversity conservation, the maintenance of ecological processes and landscape integrity. There are exceptions with species such as brush box (*Lophostemon confertus*), which is valued for its timber. Some of the dominant species are also valued for their horticultural qualities.

Plantation forest

This report uses the National Forest Policy Statement's definition of a timber plantation:

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

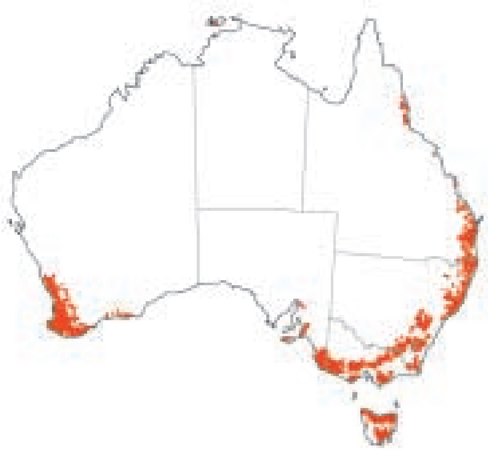
Australia has over 1.6 million hectares of timber plantations. That area is approximately 1 per cent of the country's total forested area. The area of plantations in Australia has increased by 50 per cent since 1990, primarily due to private investment supported by government policy initiatives such as the 1997 *Plantations for Australia: The 2020 Vision*, which has the goal of trebling the plantation area existing at that time by the year 2020. New plantations in Australia have been established at an average rate of over 87 000 hectares per year for the last five years.

Plantations currently supply over half the raw material required for Australia's forest products requirements. They can also provide a range of environmental services, such as salinity and erosion control, and social services, such as employment.

In terms of conservation values, the population densities of forest dwelling native animals can be much lower in plantations than in native forests. However, plantations provide habitat for some flora and fauna species that can be absent on cleared agricultural land. Animals found frequently in surveys of softwood plantations include echidnas (*Tachyglossus aculeatus*), kangaroos (*Macropus* spp.), wombats (*Vombatus ursinus*), possums, birds such as the yellow-tailed black-cockatoo (*Calyptorhynchus funereus*), as well as abundant other bird and insect fauna.

Distribution

Figure 24: Plantation distribution



Source: National Forest Inventory (2003)

Note: The distribution represented on this map has been enhanced for clarity

Victoria, Western Australia and New South Wales each have about 20 per cent of the nation's total area of plantations, while Queensland and Tasmania account for about 13 per cent each and South Australia 9 per cent (Table 36). All South Australian commercial forests are plantation forests. The Australian Capital Territory's plantation area is only a small part of the Australian total, but the Territory is unusual in that plantations account for about 11 per cent of all its forests.

Table 36: Total area of plantation by State and Territory ('000 ha, December 2002)

Plantations	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Hardwood	0	51	3	256	32	135	143	248	638
Softwood	16	270	4	182	117	78	217	104	988
Unknown	0	1	0	0	0	0	0	0	2
Total	16	323	7	208	149	213	360	352	1 628

Source: National Plantation Inventory (2003)
Note: The impact of the 2002/2003 fire season is not included in this table

Tenure

Australia's plantation resource is split almost evenly across public and private land tenures, with 51 per cent (822 681 hectares) on private land and 49 per cent on public land (803 492 hectares). However, there has been an increasing trend in recent years to establish new plantings on private land. In 2002, 50 000 (or 92 per cent) of new plantations were established on private land.

Plantation of exotic radiata pine (*Pinus radiata*)

Softwood plantations

There are almost one million hectares of softwood plantations in Australia, representing 62 per cent of the plantation estate. The main softwood species planted in temperate regions are radiata pine (*Pinus radiata*); caribbean pine (*P. caribaea*) and slash pine (*P. elliottii*). A hybrid of the latter two species is also grown in tropical and sub-tropical regions. Hoop pine (*Araucaria cunninghamii*) is the most important planted native conifer for wood production in Australia, and has been predominantly planted in Queensland. Western Australia has a significant maritime pine (*Pinus pinaster*) plantation resource.

Radiata pine (*Pinus radiata*) plantation, South Australia

Exotic softwood tree species are valued for plantation forestry because they are productive on a wide range of sites. The choice of species grown generally reflects climatic and site conditions.

Although softwoods make up the majority of the total plantation resource, their proportion of the plantation estate has declined from 85 per cent in 1998 to 60 per cent in 2002 due to the increasingly large area of hardwood plantation established.

Aside from Tasmania most recently established plantations are on agricultural land largely cleared of trees many years ago. Clearing of native forests for plantations is restricted by State and Territory government policies and planning regulations in all States and Territories except Tasmania and Queensland.

Values and uses

Softwood plantation forests produce sawlogs in a relatively short time (25–35 years), and can be managed to produce products of relatively consistent size and quality. Softwood timber is relatively easy to dry and highly permeable to wood preservatives. Softwood plantations also produce wood that is suitable for newsprint and cardboard. About 70 per cent of softwood plantation timber is used domestically. However, 39 per cent of timber consumed locally is imported because of a shortage of domestic supply.

Australian native softwood plantations

Plantations of hoop pine (*Araucaria cunninghamii*) were first established in Queensland in 1916. This is the only native conifer used as a plantation species. It is best developed on deep loams originally carrying rainforest. It occurs naturally as a component of rainforest. Between 1940 and 1999, an average area of 3 560 hectares of hoop pine were planted every five years in south-east Queensland. The total resource in 2000 was 46 588 hectares of which 94 per cent is in south-east Queensland and about 3 per cent in each of northern New South Wales and north Queensland. Hoop pine timber is ideal for plywood, furniture, joinery, flooring and many other purposes.

Hardwood plantations

Australia has about 638 000 hectares of hardwood plantations. About 85 per cent of that area is comprised of eucalypts and the remainder includes tropical rainforest, *Acacia* and *Corymbia* species. Most of the hardwood plantations were established in the last 10 years and are managed for pulpwood production. The planned production period is 10 to 15 years but there is growing interest in growing hardwoods for longer periods to produce sawlogs and other high value products.

Only a few eucalypt species are used widely in plantations. The main species are Tasmanian or southern blue-gum (*Eucalyptus globulus*), shining gum (*E. nitens*), blackbutt (*E. pilularis*) and flooded or rose gum (*E. grandis*), mountain ash (*E. regnans*), gympie messmate (*E. cloeziana*), spotted gum (*Corymbia citriodora* subsp *variegata*) and Dunn's white gum (*E. dunnii*). Of the total hardwood species, the Tasmanian or southern blue gum comprises over 62 per cent while other eucalypts comprise at least another 19 per cent.

In several regions hardwood plantations have been integrated into the agricultural sector, linking farm forestry plantations to whole farm planning for sustainable development.

Shining gum (*Eucalyptus nitens*) plantation, New South Wales

Values and uses

Most eucalypts in commercial plantations are suitable for a wide range of products depending on their management, although some species have properties that limit their value. For example some of the older, darker timbers are less suitable for paper production because it is expensive to remove their accumulated extractives and the pulp quality may be damaged in the process. The rotation length for eucalypt plantations varies from 10–40 years or more, depending on the kind of product being grown. For example, a plantation can produce firewood and woodchips on a rotation of 10–20 years. At 20–30 years, farm, sawn and appearance timbers can be produced. Depending on the species grown, it may take 40 years or more to produce large diameter, top quality logs for high value timber products.

Oil mallee plantations in Western Australia

Since 1994, a significant eucalyptus oil enterprise has begun to be established in the low rainfall areas of Western Australia. The industry uses various mallee species, targeted at different soil types and climates.

The total area of plantations in 2000 was almost 6 000 hectares. Eucalyptus oil is used in pharmaceuticals, cleaning products and perfumery. Currently, Australia produces 200 tonnes of oil for specialty markets (e.g., fragrances). World production is about 3 000 tonnes per year, mainly from China, Portugal and India (and all using Tasmanian blue gums).

The oil mallee plantations provide a variety of other benefits, such as salinity control, carbon sinks to offset carbon dioxide emissions, decreased waterlogging and erosion, increased yields of surrounding agricultural crops, activated carbon (charcoal) to absorb chemicals, ions and odours (e.g., in water treatment, gold recovery, the food and beverage industry) and fuel to produce electricity.

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Forest growth stage by tenure

coverage
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frequency

Indicator 1.1b

Area of forest type by growth stage distribution and tenure

Rationale

Ecological processes and the species associated with those processes, within any forest ecosystem or forest type, are associated with vegetative structures (age of the vegetation and its dimensions) and successional stages (varies between species). The strategy for nature conservation should include a system of reserves that are comprehensive, adequate and representative.

Growth stage is known for only 14 million hectares or 8 per cent of Australia's forest area. Growth stage has been determined for 41 per cent of multiple-use forest tenure and 24 per cent of the forests in nature conservation reserves.

As forests grow and mature, the ecological processes and species associated with those processes change. Hence the age of the trees, their size and growth stage are important when considering patterns of species diversity and abundance. For native forests managed primarily for timber production, the age class can be determined in most States and Territories. With respect to the total area of native forests, the amount of information on age class and/or growth stage varies.

At a national level, the following four growth stages are used: regeneration (less than 20 years); regrowth (20–80 years); mature (80 or more years); and senescent (irregular crown form due to age) (Figure 25). A further two categories can occur: two (mixed) growth stages; and three or more (mixed) growth stages. Different methods have been developed for describing growth stages or age classes of stands in the States and Territories.

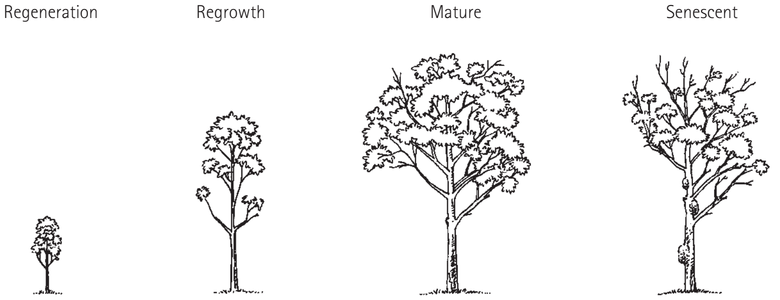
The total area for which growth stage is known is almost 14 million hectares, or 8 per cent, of Australia's native forest estate. This is an increase of 7 million hectares subsequent to the 1998 State of the Forests Report. The largest gaps in the data are on private, leasehold and other crown land tenures.

Growth stage information is available for:

- 100 per cent of forests in Tasmania;
- 67 per cent of forests in Victoria;
- 20 per cent of forests in New South Wales;
- 1 per cent of forests in Queensland; and
- 8 per cent of forests in Australia.

In Western Australia, growth-stage information has been produced in the south-west Regional Forest Agreement (RFA) area but has not been supplied for national level reporting. In South Australia, the Australian Capital Territory and the Northern Territory, forest mapping is not undertaken to this level of detail. This is because no harvesting or large scale clearance of native forest occurs. A mix of growth stages could be present as a result of previous clearance and natural disturbances such as fire.

Figure 25: National classification of growth stage for native forest



Regeneration:	Includes juvenile and sapling stages where tree is very small and crown exhibits apical dominance.
Regrowth:	Tree has well developed stem with crown of small branches, but below maximum height for stand, apical dominance apparent in vigorous trees.
Mature:	Tree reached maximum height and crown reached full lateral development. Branch thickening can occur.
Senescent:	Crown form contracting, decrease in crown diameter and crown leaf area.

Mountain ash (*Eucalyptus regnans*) forest showing various stages of regrowth

Other methods have been adopted for forests that are generally characterised as mixed-age and mixed species. In Queensland, Ecological Maturity Classes (EMC) are used to describe successional classes where all growth stages may be present. Areas classified as EMC 1 (most mature) contain areas with a dominant or sub-dominant proportion of over-mature trees, but have only a trace of regenerating trees, whereas areas classified as EMC 4 contain low proportions of over-mature trees but are dominated by regenerating trees. For the purpose of this report these successional stages have been aligned with the national growth stage classifications.

The RFA process provided an opportunity to collect growth stage data for those regions of New South Wales, Western Australia, Queensland, Tasmania and Victoria. The area of forest type by growth stage is shown in Table 37. Most growth stage information is known about eucalypt forests, which represent 77 per cent of Australia's forests. The majority of the eucalypt forests for which growth stage is known are considered to be mature forests (Table 38).

Table 37: Area ('000 ha) of forest by growth stage by tenure

Growth stage	Leasehold land	Multiple-use forest	Nature conservation reserve	Other crown land	Private land	Unresolved tenure	Total
Regeneration	53	486	161	4	174	26	905
Regrowth	17	620	461	21	466	21	1 608
Mature	98	3 228	2 761	194	1 524	41	7 848
Senescent	237	386	1 786	73	794	27	3 302
Total	405	4 721	5 169	293	2 958	114	13 662

Source: National Forest Inventory (2003)
Note: Growth stage class definitions vary between States
All values have been rounded, hence, column and row totals may not tally exactly.

Table 38: Area ('000 ha) of forest type by growth stage where known

Forest type	Regeneration	Regrowth	Mature	Senescent	Total
Acacia	1	2	2	0	6
Callitris	0	0	19	22	42
Casuarina	1	1	2	4	8
Eucalypt mallee	1	1	1	7	9
Eucalypt woodland	148	320	1 907	217	2 591
Eucalypt open	669	1 217	5 859	2 953	10 698
Eucalypt closed	0	0	0	0	0
Mangrove	0	0	0	0	0
Melaleuca	1	1	1	3	6
Rainforest	69	55	33	59	216
Other	16	11	22	34	83
Total	905	1 608	7 848	3 302	13 662

Source: National Forest Inventory (2003)

The 1998 State of the Forests Report identified that about half of Australia's multiple-use forests and 6 per cent of forests in nature conservation reserves had been assessed for growth stage. The area of forests in nature conservation reserves that have been assessed for growth stage has increased to 24 per cent, largely reflecting changes in forest tenure from multiple-use forests to nature conservation reserves in the last 5 years.

Old-growth forest

Old-growth forest is not a growth stage. It is determined by combining growth stage and forest disturbance information. The agreed national operational interpretation, identified through the RFA process and based on that defined in the National Forest Policy Statement, is:

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

The area of old-growth forest is known for Regional Forest Agreement (RFA) and Comprehensive Regional Assessment (CRA) areas. Over 5 million hectares, or 23 per cent of the RFA forest estate, is known to be old-growth forest as at 1996–1997. Few forests outside RFA regions have been assessed for old-growth values.

The identification and mapping of old-growth forest in each State depends on the definition agreed to in the various RFA processes. Further, the methods applied used different principles of 'ecological maturity' and disturbance for different types and site conditions.

Old-growth forests are important as some plants and animals are restricted to or dependent on them for their habitat requirements. Some wildlife species, such as the powerful owl (*Ninox strenua*), require more than one growth stage for their survival: one for nesting and another for feeding. Accordingly, it is important that Australia's forests have a mosaic of growth stages to ensure the maintenance of species and that management regimes reflect this requirement. Furthermore, it is recognised that old-growth, as part of an ecological succession, is not static and cannot be maintained indefinitely merely through the reservation of existing examples of that age-class. The inclusion of old-growth in the reserve system should be seen in the context of the selection and reservation of an appropriate mosaic of age-classes, which, with ecological processes intact, will have the potential to generate the old-growth of the future.

In addition to these ecological values, old-growth forests provide a range of aesthetic and cultural values. A framework to protect old-growth was identified in the National Forest Policy Statement and has largely been implemented in those areas covered by RFAs, based on criteria established for this purpose.

Over 5 million hectares of old-growth forest has been identified in Australia's RFA/CRA regions. Of this area, 66 per cent is managed in formal or informal reserves. The majority of identified old-growth forest occurs on public land (Table 39). Almost half of Australia's total identified old-growth forests are in New South Wales. Tasmania has the highest proportion of old-growth forest—almost 40 per cent of the State's total forest estate. Only for Tasmania are data on growth stage available for all tenures (Figure 26).

Table 39: Old-growth forest in RFA/CRA regions ('000 ha)

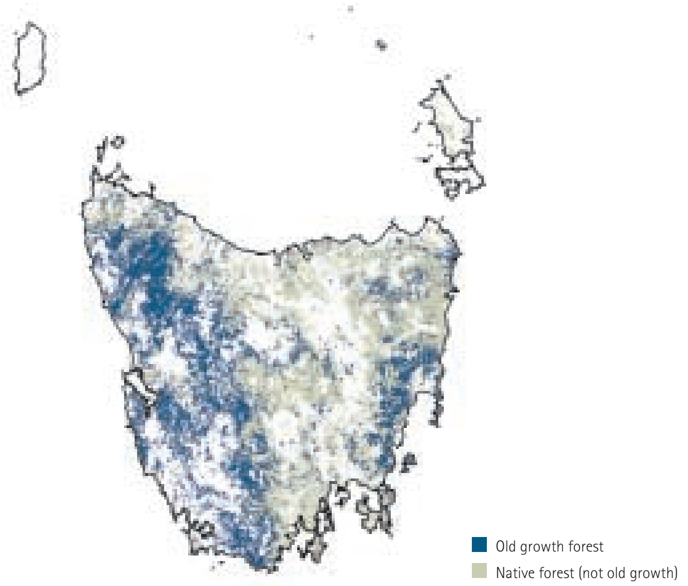
State	Total forest	Total old-growth forest	Old-growth in formal and informal reserves[1]	Distribuition of old-growth by tenure		
				Private	Public	Unreserved
New South Wales	8 992	2 536	1 742	644	1 892	0
Queensland	3 230	270	166	71	196	3
Tasmania	3 169	1 239	851	115	1 124	0
Victoria	5 744	841	455	–	838	2
Western Australia[2]	2 121	347	233	0	346	1
Native forest total	23 256	5 233	3 447	830	4 396	6

Source: National Forest Inventory (2003)

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

2 Based on mapping for the Western Australia RFA. Mapping has subsequently been refined. All old-growth forest in Western Australia is protected by government policy.

Figure 26: Area of old-growth forest in Tasmania



Old growth mountain ash (*Eucalyptus regnans*) forest, Victoria

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Fragmentation of forests

Indicator 1.1e

Fragmentation of forest types

Rationale

This indicator aims to provide information on the loss of forest cover and the spatial configuration of that loss within a region. This is important because fragmentation can cause small populations to become vulnerable and can reduce gene pools.

Improved forest mapping since the 1998 State of the Forest Report has identified greater levels of fragmentation, due mainly to both improved mapping accuracy combined with actual on-ground change in forest fragmentation

Forest fragmentation is the study of the distribution of forests in the landscape in terms of size, shape, density and connectivity. The forests may be naturally fragmented where they occur in a matrix of non forest communities, or fragmentation can be caused by conversion of forests to other uses.

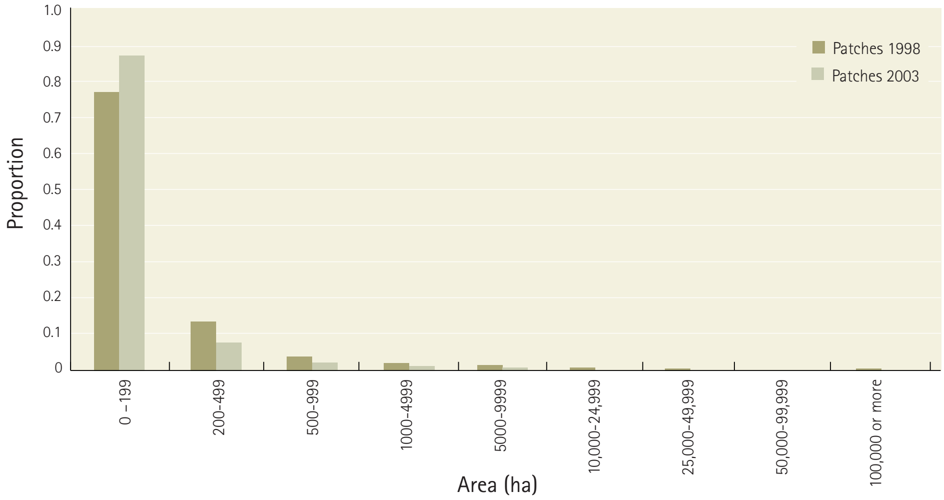
Detailed research into fragmentation has identified a correlation between the size of forest habitats and their ability to support viable populations of certain species. Some forest fragments are too small to maintain viable breeding populations of some species. Species dependent on the interior regions of forests require an area of adequate size that is not close to a forest edge. Significant distances between forest patches can interfere with pollination, seed dispersal, wildlife migration and breeding. Other changes resulting from fragmentation include a potential increase in invasion by exotic species, environmental changes and predation problems.

An analysis of fragmentation at any level requires data to be of consistent scale, quality and content. While an Australian dataset does not yet exist at a consistent scale and quality, the current data are in a state of continual improvement, with cooperation occurring between all agencies involved in the collection and analysis of forest data. A national forest dataset of consistent scale and quality will significantly aid studies into fragmentation, enabling quantitative assessments for measurement of changes in forest cover.

To date the only published national scale analyses of forest cover fragmentation are from Australia's 1998 State of the Forests Report. The analysis reported used Advanced Very High Resolution Radiometer satellite imagery to infer the presence of vegetation, not necessarily forest cover. For the current report, two mapped forest datasets (1998 and 2003) were analysed to give an indication of fragmentation occurring over the intervening five years. The datasets were chosen because both have been accepted as the best datasets of national forest extent for their time. Analyses were carried out to classify patch size and patch area within each of the regions defined by the Interim Biogeographical Regionalisation of Australia (IBRA)(Figures 27 and 28). The regions vary in size from around 415 000 hectares to just under 42 million hectares (equivalent to half the area of New South Wales). Within the IBRA regions the study demonstrated an increase in forest patches smaller than 200 hectares and a decrease in the number of large patches (exceeding 100 000 hectares) over the 1998–2003 period. However, fragmentation change during this period resulting from actual on-ground change in forest patch size cannot be separated from change resulting from improved forest mapping (as described in Indicator 1.1a).

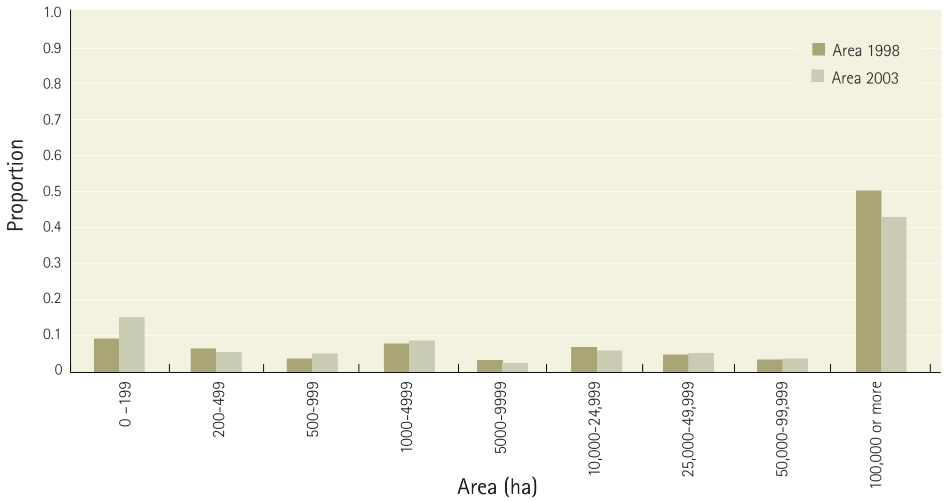
Within the IBRA regions the study demonstrated an increase in forest patches smaller than 200 hectares and a decrease in the number of large patches (exceeding 100 000 hectares) over the five year period 1998–2003.

Figure 27: A comparison of statistics on the number of forest patches in Australia, 1998 and 2003: patch size class per number of patches in IBRA region



Source: National Forest Inventory (1998, 2003)

Figure 28: A comparison of statistics on the area of forest patches in Australia, 1998 and 2003: area in patch size class per area of forest in IBRA region



Source: National Forest Inventory (1998, 2003)

Fragmented forest in agricultural landscape

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1.2

SPECIES DIVERSITY

INTRODUCTION

An important indicator of biodiversity is the number of different plants and animals that depend on a forest habitat for all or part of their life cycle. An increase or decrease in the number of species, and knowledge as to which species are present in a forest, can provide an indication of the extent and condition of habitat and ecosystem health.

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires that a list of all taxa defined as critically endangered, endangered, vulnerable or presumed extinct is maintained at the national level. Endangered taxa and ecological communities are those in danger of extinction and whose survival is unlikely if the causal factors continue operating. Vulnerable taxa and ecological communities are those likely to move into the endangered category if causal factors continue operating.

In general, we know that biodiversity at the species level is tending to decline in Australia. Between 1993 and 2001 the number of listed endangered taxa in all Australian habitats more than doubled.

Species assessments were carried out as part of the Regional Forest Agreement (RFA) process. These assessments considered not just the distribution of endangered or vulnerable species, but also the processes that could threaten them, and the requirements necessary to conserve them. Population levels of a number species from diverse habitats are monitored across their range.

Red tingle (*Eucalyptus jacksonii*) and yellow tingle (*Eucalyptus guilfoylei*) forest, south west Western Australia

Forest-dwelling species

coverage
currrency
frequency

Indicator 1.2a

A list of forest-dwelling species

Rationale

This indicator documents the presence or absence of forest-dwelling species over time.

The number of forest-dwelling species identified has increased by 2 910 higher plants and 2 590 animals over the last five years.

Australia's biota is estimated to consist of at least two million species of animals and plants, along with a vast and unknown number of microorganisms. Australia's species are considered to represent nearly one-fifth of the world's biodiversity, and yet they must be documented, managed and conserved by less than 0.4 per cent of the world's population. Approximately 80 per cent of Australia's terrestrial and aquatic flora and fauna occur nowhere else in the world.

Attempts to extrapolate generic biological data for application to particular types of environment, such as forests, are not generally well developed. Such lists could never be comprehensive but they can provide an indication of forest species diversity and presence at a given time and may enable some monitoring, albeit crude, of change over time. Following the lead of the first State of the Forests Report 1998, Table 40 represents a second attempt at enumerating a raw list of forest-dwelling and forest-dependent species in Australia's forests.

Forest dependency for a species has been defined as the requirement for a forest habitat for part of the life cycle. In many cases ecological understanding of species is not sufficient to determine whether it is wholly, partly or cyclically forest-dependent or even whether the species occurs within the forest.

Between the 1998 State of the Forests Report and the most recent collation (2001) there has been a significant overall increase in the number of forest-dwelling and dependent flora and fauna species reported by the States and Territories. The magnitude of this change represents a major increase in knowledge of which species are forest-dwelling, rather than an increase in the actual numbers of such species.

This indicator has two major values. For now, at the national level, and for much of the medium term future, it will track the level of knowledge about which species dwell in Australia's forests. As regions and taxonomic groups become better known, the indicator will be able to track changes in their conservation status. Assessments of these trends need to take account of taxonomic changes and scientific discoveries.

DW Stock Picture Library

Southern hairy-nosed wombat (*Lasiorhinus latifrons*)

Table 40: Forest-dwelling species by State/Territory (2001)

	ACT[1]	NSW[2]	NT	Qld	SA	Tas	Vic	WA[3]	Australia
Fauna: invertebrates[4]									
Arthropods: insects	–	3	–	–	–	–	–	1 723	1 726
Arthropods: others	1	–	–	–	–	–	–	230	231
Non-arthropods	–	4	–	–	–	–	–	39	43
Total 2001	1	7	–	–	–	–	–	1 992	2 000
Fauna: vertebrates									
Fish	3	70	–	163	–	11	–	–	203
Amphibians	1	76	37	117	23	8	28	49	183
Reptiles	–	197	231	369	187	13	97	345	706
Birds	2	333	84	403	167	67	207	137	473
Mammals	2	104	87	162	85	32	83	115	252
Total 2001	8	780	439	1 214	462	131	415	646	1 817
Fauna (including invertebrates)									
Total animals 2001	9	787	439	1 214	462	131	415	2 638	3 817
Total animals 1998	–	504	449	582	–	125	485	239	1 227
Flora (higher plants)									
Total plants 2001	4	7 448	4 042	8 443	2 346	908	2 872	3 178	16 532
Total plants 1998	–	–	1 691	7 830	–	1 043	2 959	2 639	13 622

Source: National Forest Inventory (2003)

1 The Australia Capital Territory only includes rare and endangered species, rather than a comprehensive list of forest-dwelling species

2 The New South Wales data on invertebrates only includes those species listed as endangered or vulnerable under the New South Wales *Threatened Species Act 1995*

3 Western Australia includes only species documented in the Regional Forest Agreement region (south-west Western Australia) rather than the entire State

Green tree frog (*Litoria caerulea*)

Systematic surveys of species are usually undertaken for specific purposes, such as surveys for rare, threatened or endangered species. As more surveys are undertaken, more species might be found in areas where they previously were not known and, in rare cases, entirely new species might be discovered. As a result it can sometimes appear that species are colonising a region, when in fact it may simply be that surveys and documentation have improved knowledge.

Species numbers in a given forest might increase or decrease as a response to particular events. These changes might be: incremental, such as species invasion or gradual domination by non-indigenous species; random catastrophic events, such as fire, flood or drought; or direct human-caused changes, such as timber harvesting. For instance, when a forest is changed to an early successional stage by fire, different species, in different numbers, could colonise the regrowth area. As a general rule, assessment of the data, whether it shows increase, decrease or no change in numbers of species, requires a sound knowledge of the biophysical areas concerned in relation to survey activity and disturbance factors.

Status of forest-dwelling species

coverage
currrency
frequency

Indicator 1.2b

The status (threatened, rare, vulnerable, endangered, or extinct) of forest-dwelling species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment.

Rationale

There is a need to manage threatened species so as to improve their conservation status and formal designation.

A review of the species listed in the Environment Protection and Biodiversity Conservation Act 1999 *as dependent on forests for at least part of their life cycle identified 88 fauna and 771 flora taxa as critically endangered, endangered or vulnerable. Between 1993 and 2001 the number of listed endangered taxa in all Australian habitats doubled.*

This indicator is a way of measuring biodiversity, and also provides information on the status of species that are already known to be threatened.

A review of the species listed under the EPBC Act (described in the introduction to this sub-criterion) and considered to be dependent on forests for at least part of their life cycle, identified 771 taxa of higher plants and 88 taxa of fauna as critically endangered, endangered or vulnerable (Table 41).

The two additional categories under the EPBC Act, 'extinct in the wild' and 'conservation dependent', do not contain any forest-dwelling species.

Table 41: Status of forest-dwelling species in Australia under the *Environment Protection and Biodiversity Conservation Act 1999*: number of taxa in each category

Species	Extinct	Critically endangered	Endangered	Vulnerable
Fauna				
Invertebrates	–	–	7	1
Fish	–	–	8	6
Amphibians	–	–	13	11
Reptiles	–	–	3	2
Birds	–	–	8	9
Mammals	–	–	15	5
Flora (higher plants)	34[1]	20	261	490

Source: Environment Australia (2003)

1 Extinct species are not included in the total species counts for States and Australia in Indicator 1.2a

Under the EPBC Act a series of criteria are used to determine whether a species is listed, and whether or not its status is extinct in the wild, critically endangered, endangered, vulnerable or conservation dependent. These criteria include the extent of the reduction of numbers; evidence that numbers will continue to decline; how restricted the distribution is; the estimated number of mature individuals; and the probability of the species becoming extinct in the wild.

Between 1993 and 2001, the number of species listed in Australia (not only in forest areas) has been refined as a result of further study. This has changed the status of some species (see Table 42). The composition of the list reflects current research initiatives and the fact that the majority of this work is occurring in flora. This has resulted in the number of plants assumed to be extinct being revised downwards, while the number of plants identified as endangered has more than doubled.

A 2001 report identified that land clearing for agricultural development was the single greatest threat to species abundance, but there were other factors that also contributed.

Table 42: Total numbers of taxa and communities in Australia (forest and non-forest) that were identified as endangered, vulnerable and presumed extinct species in 1993 and 2001

Taxon	Presumed extinct		Endangered		Vulnerable	
	1993	2001	1993	2001	1993	2001
Ecological communities	–	–	–	27	–	–
Invertebrates	–	–	–	–	–	4
Fish	–	–	7	13	6	17
Amphibians	–	4	7	15	2	12
Reptiles	–	–	6	11	15	38
Birds	20	23	26	33	25	61
Mammals	21	27	28	29	18	45
Fungi	–	–	–	–	–	–
Non-vascular plants	–	–	–	1	–	1
Vascular plants	74	63	226	517	661	654
Total species	115	117	300	646	727	832

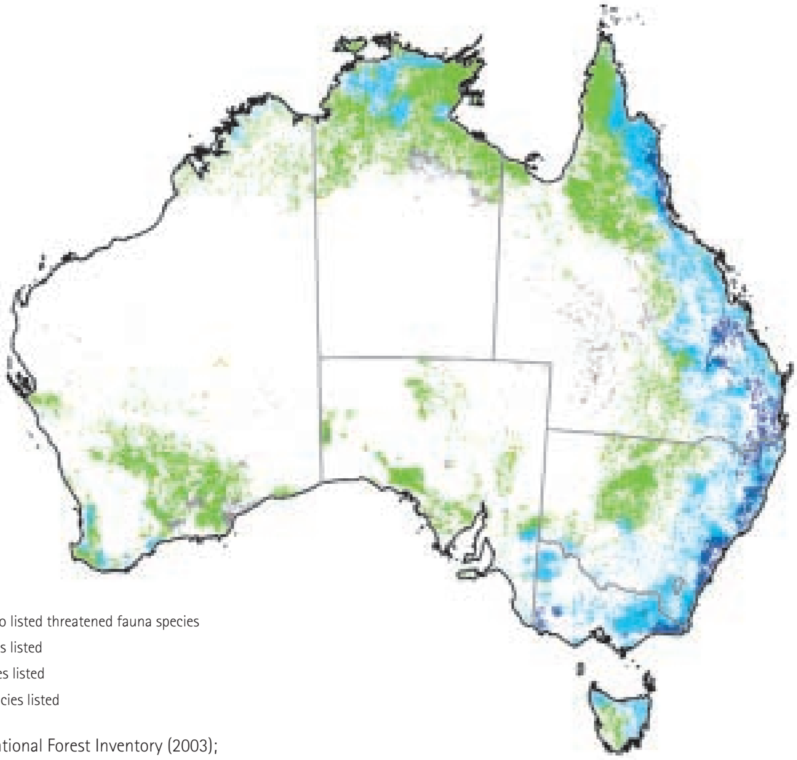
Source: Williams *et al.* 2001

Rare and threatened forest-dwelling species

Figures 29 and 30 show the distribution of listed threatened fauna and flora, respectively. They include threatened Species of National Environmental Significance as listed in the EPBC Act. The maps show those species that occur in forest areas, and do not include migratory or marine species including whales, dolphins and porpoises.

There are listed threatened fauna species in almost all of Australia's forests, with high numbers of threatened species occurring in the eastern part of the country. The areas with the highest number of listed threatened species occur in Tasmania, Victoria and the eastern part of New South Wales. Listed threatened flora species occur in much of Australia's forests, however, low numbers of species are reported for most of the country. Only small areas report high numbers of threatened flora species, and these occur in the north east of Cape York Peninsula (Queensland), and small patches within New South Wales and Victoria.

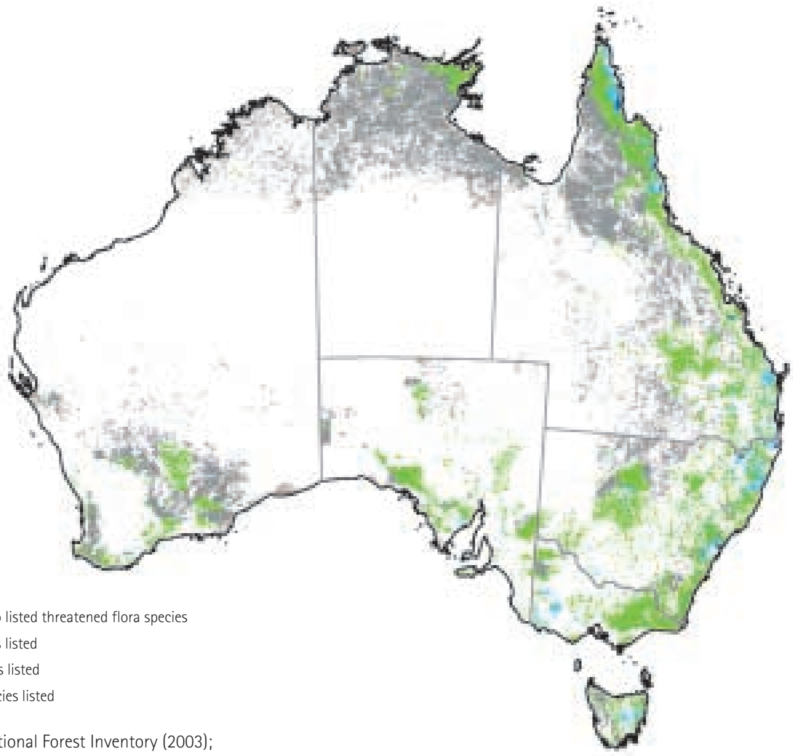
Figure 29: Distribution of rare and threatened fauna



Forest – no listed threatened fauna species
< 5 species listed
5–9 species listed
10–29 species listed

Sources: National Forest Inventory (2003);
Department of the Environment and Heritage (2003)

Figure 30: Distribution of rare and threatened flora



Forest – no listed threatened flora species
< 5 species listed
5–9 species listed
10–29 species listed

Sources: National Forest Inventory (2003);
Department of the Environment and Heritage (2003)

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White Beauty Spider-orchid (*Caladenia argocalla*), a threatened native orchid of the Mount Lofty Ranges

Species monitoring

coverage
currrency
frequency

Indicator 1.2c

Population levels of representative species from diverse habitats monitored across their range

Rationale

This indicator is a broad measure of the conservation status of a range of representative species across habitats. The intention is to provide early warning of changes in conditions that may impact negatively on biodiversity. This measure reflects elements of ecosystem and genetic diversity.

Currently, population monitoring is focused on threatened species in Australia. There are limited forest-dependent plant or animal species monitored for population levels across their entire range. The species for which detailed population information is collected are generally those sensitive to commercial forestry activities, or endangered and vulnerable species.

This indicator is an effective surrogate for genetic diversity when the genetic pool of the species populations varies across its range. Population levels can be used to suggest potential genetic diversity in the different communities. Changes in representative species populations should provide an early warning of changes in conditions that may reduce biodiversity.

Species population survey data are collected by government (Australian, State, Territory and local government departments), research institutions (for example universities and CSIRO) and in some cases by non-government organisations, individuals or private consultants.

Under the *Environment Protection and Biodiversity and Conservation Act 1999*, the Australian Government requires survey information on critically endangered, endangered and vulnerable species across their entire range. Accordingly, the Australian Government has collated species survey points and species environmental requirements from other jurisdictions and institutions, and modeled the likely distribution of these species across their ranges. This does not, however, provide information on populations of the species across their range, nor is it proof of presence across the entire modelled range.

Where a species' range exists entirely within one jurisdiction (for example within a State) there is potential for this species to have had systematic population surveys, with information collected across its range. Where a species crosses jurisdictions it is more likely that there will be information gaps, or differences in methods that prevent complete mapping across its range. An example of a forest-dwelling species with surveys across their restricted range is the Baw Baw frog (*Philoria frosti*), which is restricted to the Baw Baw Mountain in Victoria. Another example of a limited range species, which is adequately surveyed, is the southern corroboree frog (*Pseudophryne corroboree*), whose distribution is limited to the Snowy Mountains within Kosciusko National Park in New South Wales. There are also cases where jurisdictions co-operate in survey and recovery plan work for endangered species, such as the long-footed potoroo (*Potorous tridactylus*) in Victoria and New South Wales.

There are few good national level datasets on species population levels that cover temporal monitoring. One notable exception, however, is the Atlas of Australian Birds, which has collated information on bird species distributions across Australia, using information from thousands of volunteer bird surveyors.

The first Bird Atlas was conducted between 1977 and 1981 and the second twenty years later, from 1998 to 2001. There was a decline in populations of ground foragers, ground and hollow nesters, and an increase in populations of foliage gleaners, fruit eaters, highly mobile species that respond quickly to flowering and seeding and understorey species that respond to increased plant growth after suitable rainfall conditions. These changes were due in part to wetter conditions during the second atlas survey period.

Information collected through the Comprehensive Regional Assessments provided base data on the distribution of forest dependent species. This information is useful as it provides a baseline for forest species, but has limitations in that it may not cover the full range of the species, and does not currently include population or temporal information.

The State of the Environment reports for States, Territories and the Australian Government include information on species status, numbers and population trends. The reports include information on trends in selected species within jurisdictions (e.g. koalas (*Phascolarctos cinereus*) and brush-tailed rock-wallabies (*Petrogale penicillata*) in the NSW State of the Environment Report). The Australian Government report includes aggregated trend information on the condition and extent of species groups and of vegetative ecosystem types. The reports are limited in terms of detailed survey information, but do cover a good temporal trend component, which will continue to add value as later reports are produced.

Government departments, research organisations and universities are undertaking detailed population survey and trend analysis. Although in most cases the surveys do not cover the full range of the species, these studies increase our knowledge, which in turn can help in extrapolation of population information. Prominent studies include:

- Yellow-bellied glider (*Petaurus australis australis*) survey in Queensland;
- Study of the effect of woodland thickening on the Golden-shouldered parrot (*Psephotus chrysopterygius*) in Cape York Peninsula, Queensland;
- Leadbeater's possum (*Gymnobelideus leadbeateri*) survey in New South Wales and Victoria;
- South Australia is undertaking temporal population surveys on a range of species including the southern brown bandicoot (*Isoodon obesulus obesulus*), koala (*Phascolarctos cinereus*), the Kangaroo Island subspecies of glossy black-cockatoo (*Calyptorhynchus lathami halmaturinus*), and the south-east Australian subspecies of the red-tailed black-cockatoo (*Calyptorhynchus banksii graptogyne*);
- Other South Australian species monitoring programs include a Frog Watch program, and a Threatened Native Orchids of the Mount Lofty Ranges program;
- Forty-spotted pardalote (*Pardalotus quadragintus*), wedge-tailed eagle (*Aquila audax fleayi*), grey goshawk (*Accipiter novaehollandiae*) and the swift parrot (*Lathamus discolor*) are being monitored by colony or territory and for breeding success in Tasmania.

To report fully on this indicator it is important to identify and monitor key indicator species, aggregate all existing distribution, population, condition and trend information, and target surveys to fill gaps in information. On the whole there is still academic debate on what are appropriate species and functional groups that indicate where environmental change is having a significant impact on biodiversity.

Glossy black cockatoo (*Calyptorhynchus lathami*) is one of the forest dwelling species identified as being endangered

Functional groups are groups of species with similar behaviour—for example, owls, frogs and, in drier communities, ants and termites—are generally agreed to be good indicators for their respective environments. It may be necessary to choose several species or functional groups for every major temporal or spatial climatic change within Australia to get an effective picture of what is happening to biodiversity, and how well the genetic resources of species are adapting to any change.

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1.3

GENETIC DIVERSITY

INTRODUCTION

Genetic diversity refers to the variety of genetic information in all the individual organisms in an area. This is quite distinct from species diversity, because it operates at the level of genes. Two populations of the same species can vary in their genetic diversity. One population, for example on an island, may be descended from relatively few individuals. Thus the gene pool of that population may be narrow. The other population may be descended from a large number of individuals. Thus the gene pool of that population would have greater variety.

Genetic diversity helps ensure the survival of species because it is what gives rise to the variation between individuals. This variation may allow a species to change over time and thereby survive changing environmental conditions. In other words, greater genetic diversity can offer greater resilience. In order to maintain the capacity of our forests to adapt to future changes, therefore, genetic diversity must be preserved as much as possible through suitable management practices.

Direct measurements of genetic diversity in forest flora and fauna are being carried out but the task is not easy. Specific research is being conducted on representative species to determine population condition and trend information.

This section also considers the extent of native forest and plantations of indigenous species for which genetic resource conservation plans have been prepared and implemented. The forest management plans and guidelines established in most States and Territories have recognised the significance of conserving the genetic diversity of our forests. As new and more cost-effective methods of monitoring genetic variation in forests are developed, forest management plans will incorporate this information and management practices are expected to change in accordance with the results.

The international Montreal Process Indicator 1.3b, which examined the population levels of representative species from diverse habitats monitored across their range, has been integrated into the Australian regional indicator 1.2c.

Smooth barked apple (*Angophora costata*)

Genetic variation in forest-dwelling species

coverage
currrency
frequency

Indicator 1.3a

Amount of genetic variation within and between populations of representative forest-dwelling species

Rationale

Direct measures of genetic variation are possible and are sensitive to the loss of variation that will prevent long term survival and adaptation.

Direct measurements of genetic diversity in forest flora and fauna are being carried out but nationally conclusive results are not available.

Genetic diversity can be measured directly by sampling tissue from individuals within a population and by testing for genetic markers to detect the degree of difference between those individuals. These tests have not been carried out extensively because of high costs.

There are limitations, however, on the availability of information on the former ranges of species. Using historical records, expert opinion and incidental observations, some of this information can be mapped or modelled. Existing models currently exist primarily for vascular plants and ecological communities. The Regional Forest Agreements, in particular, provide pre-1750 and current models of forest ecosystems within the production forest estate.

Studies have shown that species whose range has been reduced or fragmented have a consequent loss of genetic variability. Hence, knowing the number of forest-dependent species whose ranges have shrunk gives an idea of how much genetic diversity may have been lost.

Various research institutions, including State, Territory and Australian Government organisations, are undertaking direct measurements of genetic diversity using DNA techniques and genetic markers. The results may help to develop guidelines to minimise decreases in genetic diversity without the need for sampling. Research on direct genetic variability is occurring on both flora and fauna.

Flora

A study on the genetic composition of two eucalypt species across a coupe following harvesting and regeneration identified the impacts of different management practices on their genetic composition. The practices involved were clear-felling with aerial sowing, seed tree system with burning, and seed tree system with mechanical disturbance. These were compared with unharvested controls. The results of this study have been supported by studies in East Gippsland, Victoria, where sampling has shown that the genetic diversity of dominant *Eucalyptus* species is less affected by harvesting and management techniques than that of minor species. Specific methods to ensure maintenance of the genetic diversity of minor species are yet to be developed.

A study of the three remaining isolated populations of the rare tree species *E. benthamii* (Camden white gum) has shown a high level of genetic differentiation between populations. The conservation of the entire *E. benthamii* gene pool relies on the future availability of genetic material from all three populations. The two smallest populations are in danger of

Tasmanian quoll (*Dasyurus maculatus maculatus*)

extinction. Should this happen, the total genetic diversity of this species would be permanently reduced.

Genetic studies have also been undertaken on the mangrove species *Avicennia marina*. Within some populations there was considerable genetic variation, but in the populations towards the extremes of this species' range, there was relatively little variation.

Fauna

There is a reasonable amount of information available on population and distribution of animal species. This can be used for the broader genetic diversity indicator, which is based on the number of forest-dependent species that occupy only a small portion of their former ranges. The information required for this surrogate on current populations coincides with the information available in Indicator 1.3c.

For example a genetic study of quolls (*Dasyurus species*) suggested that the Tasmanian tiger quoll (*Dasyurus maculatus maculatus*) was sufficiently genetically different from mainland animals that it should be reclassified as a separate subspecies and conserved accordingly.

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Genetic resource conservation

coverage
currrency
frequency

Indicator 1.3c

Extent of native forest and plantations of indigenous species which have genetic resource conservation plans prepared and implemented

Rationale

Genetic resource management plans aim to maintain the range of genetic diversity of commercially utilised indigenous species, and to avoid the introgression of genetic resources from native forest plantations.

The importance of maintaining genetic diversity in native forests and plantations is acknowledged by various forest management organisations in management plans and guidelines.

Genetic variation within native plantation and native forest species makes individuals in each species physically different from one another and gives each species the chance to adapt to environmental change over time. Genetic diversity is therefore important for long-term survival. Genetic resource conservation plans enable us to maintain genetic diversity within and between species in our native plantations and native forests.

The forest management plans and guidelines established in most States and Territories recognise the significance of conserving the genetic diversity of our forests. As new and more cost-effective methods of monitoring genetic variation in forests are developed, forest management plans should incorporate this information and management practices will change in accordance with the results.

In most States and Territories, forest management plans stipulate that regeneration and rehabilitation strategies are to be conducted using species and provenances native to the area or the general locality. This is undertaken with the aim of maintaining the local gene pools and the approximate composition and spatial distribution of species that were present before harvesting. These plans include guidelines for seed collection and the selection of seed trees of good form and health.

The Australian Tree Seed Centre maintains a national collection of seeds of more than 30 000 genetically distinct seed acquisitions from 1 300 species, providing a high quality, representative sample of genetic diversity. Other seed collections are maintained by various communities, forest and research agencies. For example, in Western Australia the Department of Conservation and Land Management and The Botanic Gardens and Parks Authority are partners in the Millennium Seed Bank Project designed to conserve and maintain Western Australia's biodiversity at the levels of ecosystem, species and gene. By 2010, the seeds of 2 340 taxa listed as rare, threatened or poorly known for Western Australia will be collected and held within germplasm facilities both in Western Australia and in the United Kingdom (although not all these plants are forest species.) This seed will be used to implement the species recovery plans for the restoration of threatened species and ecological communities.

Also important is monitoring and controlling genetic flow from native plantations into native populations, where such flows could result in a diminution of the full range of variation within the population. This could occur when pollen from the native plantation fertilises the adjacent native forest. Limiting such flow would help preserve the diversity and integrity of the genetic resources in the native forest. On the other hand, genetic resource management plans aim to maintain the range of genetic diversity of commercially utilised indigenous species, and to avoid genetic flow that is identified as potentially damaging to the whole genetic resource.

Conservation of genetic diversity can be achieved through the preservation of native populations and habitats or through storing genetic resources in special plantations, seed collections and breeding programs.

Tree-breeding programs are an integral aspect of maintaining genetic diversity in plantation species. A diverse genetic resource base decreases the risk of pest or disease epidemics. It provides sufficient genetic variation for continued genetic gains over multiple generations and a source for new traits to be incorporated into future breeding programs. Tree breeding programs exist for many native and exotic hardwood and softwood species (Table 43).

Table 43: Conservation plans for some widely planted forest species in Australia

Organisation	Species
CSIRO – Australian Tree Seed Centre	*Acacia* species, *Casuarina* species, *Eucalyptus* species
Southern Tree Breeding Association	Blue gum (*Eucalyptus globulus*)
Cooperative Research Centre for Sustainable Production Forestry	Blue gum (*E. globulus*), shining gum (*E. nitens*)
Queensland Forestry Research Institute	Blackbutt (*E. pilularis*), broad leaved red mahogany (*E. pellita*), flooded gum (*E. grandis*), Gympie messmate (*E. cloeziana*), Dunn's white gum (*E. dunnii*), Chinchilla white gum (*E. argophloia*), mangium (*Acacia mangium*), red cedar (*Toona ciliata*), silky oak (*Grevillea robusta*), spotted gum (*Corymbia variegata*, *C. henryi*, hoop pine (*Araucaria cunninghamii*), Wollemi pine (*Wollemia nobilis*)
Australian Low Rainfall Tree Improvement Group	Blue-leaved mallee (*E. polybractea*), mulga (*E. sideroxylon*), red ironbark (*E. tricarpa*), river red gum (*E. camaldulensis*), spotted gum (*Corymbia maculata*, *C. variegata*), sugargum (*E. cladocalyx*), swamp yate (*E. occidentalis*), Western Australian oil mallees (*E. kochii* and *E. horistes*)

Source: National Forest Inventory (2003)

Minimising genetic pollution

The national Joint Venture Agroforestry Program is conducting research and providing strategic recommendations to limit the flow of genetic pollution from Farm Forestry initiatives into native forest. Its recommendations include:

- selection of species/provenance;
- genetic manipulation of flowering times and abundance; and
- silvicultural practices such as isolation distances, buffer zones and reduced spacing.

There has also been a shift from the planting of any provenance in Landcare ventures to the use of more local provenances.

Rare species

Rare and threatened plant species are the targets of specific genetic resource conservation plans in most states and Territories. A good example is the Wollemi Pine Recovery Plan in New South Wales.

Jaime Plaza

Nets catch seeds of the Wollemi pine (*Wollemia nobilis*) as part of the Wollemi Pine Recovery Program

Case Study: Wollemi Pine Recovery Plan

The Wollemi pine was discovered in 1994 in the Wollemi National Park, 150 km from Sydney. This endangered species has only 43 known adult trees in the wild and is from an evolutionary line once thought to be extinct. A thorough management strategy has been implemented to protect the existing wild specimens. This includes protection of the species under the New South Wales *Threatened Species Conservation Act 1995* and Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*. A Memorandum of Understanding exists between New South Wales National Parks and Wildlife Service and the Royal Botanic Gardens Sydney for the management of the wild populations and development of a cultivation and propagation program.

The site of the wild stand is carefully protected. The exact location of the known stands is not revealed, other than to scientific research teams; the sites are monitored, minimising the number and duration of visits; and permitted visitors must adhere to strict procedures to avoid trampling seedbeds and seedlings, compacting the soil or introducing disease.

Research and development programs designed to protect the species include ecological studies, botanical research and horticultural development. As part of the protection strategy, commercial propagation is being developed and licensed to make the plant widely available.

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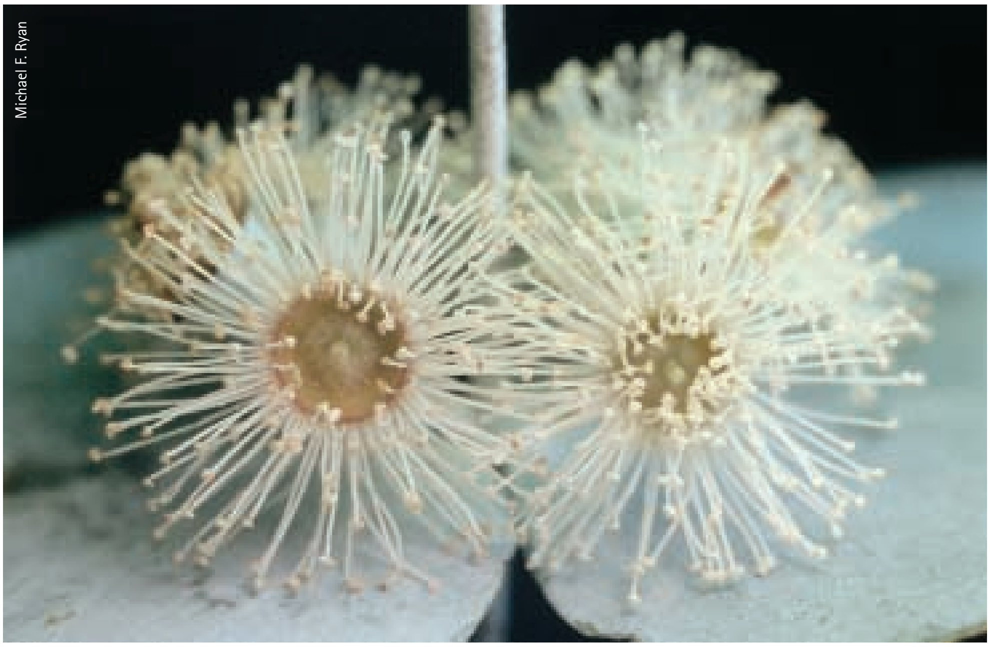

Argyle apple (*Eucalyptus cinerea*) blossom

2

MAINTENANCE OF PRODUCTIVE CAPACITY OF FOREST ECOSYSTEMS

INTRODUCTION

Forests provide many benefits to society. These include wood and non-wood products, recreation opportunities and other non-market goods and services. They also include environmental functions, such as catchment protection and habitat for plant and animal species. This criterion concerns forests used to produce market products. It comprises indicators that aim to show whether production of those products is at a level that can be sustained without affecting the productive capacity of the forest.

Data on the areas of forests—native forests and plantations—used to produce wood products provide a starting point for estimation of the potential supply of wood and non-wood products. These data also enable the areas used for wood production to be compared with the areas of forest and other land used for nature conservation, agriculture and other purposes. Changes in the area of forest used for wood production will affect national capacity to supply wood products.

This criterion includes indicators that aim to assess the volumes of wood products that are currently present in plantations and native forests managed for wood production. Comparing those volumes with the volumes harvested each year enables an assessment of whether the level of production is sustainable. Products other than wood are also considered.

Three indicators under this criterion deal with factors that affect productivity of plantations and native forests used for timber production. The effectiveness of plantation establishment is assessed as an indicator of whether the plantations will be productive. Regeneration of native forests after harvest of wood products is assessed because future production will be less if harvested areas are not effectively regenerated. Lastly, as for agricultural crop species, productivity of plantations is affected by the genetics of the trees used. Maintenance of genetic resources of species used in exotic plantations is therefore considered.

Spotted gum (*Corymbia maculata*) forest southern New South Wales

coverage
currrency
frequency

Forest available for timber production

Indicator 2.1a

Area of forest land and net area of forest land available for timber production

Rationale

This indicator is a fundamental element of the capacity of forests to meet society's demand for wood products.

Timber is produced from both native forests and plantations. Seven per cent of Australia's forests are publicly managed for wood supply with a further area of forest under leasehold and private tenure also potentially available, depending on land holder intent, markets and environmental constraints. In total a gross area of 74 per cent is not legally restricted.

The area of forests available for timber harvesting indicates the capacity of our forests to meet domestic and export demand for wood and wood products. International reporting standards define the area available for timber production as land where harvesting is 'not legally restricted'.

Timber is produced from native forests, which are managed for a range of uses as well as timber production. Timber is also produced from plantations, which are developed and managed intensively for timber production in a similar way to agricultural crop production. There were 1.6 million hectares (net productive area) of plantation forests established in Australia up to December 2002. This compares with approximately 473 million hectares used for agriculture. Further details on plantations are provided in Indicator 2.1c.

In Australia, timber harvesting is not permitted in nature conservation reserves. Timber harvesting is not legally restricted from leasehold land, multiple-use forests and private land. The areas of forest in those tenures are shown in Table 44. Timber may also be harvested from some categories of other crown land.

Table 44: Area of native forest by tenure not legally restricted from timber harvesting ('000 ha)

Tenure	ACT	NSW[1]	NT	Qld	SA	Tas	Vic	WA	Australia
Leasehold land	–	9 470	16 313	35 581	0	–	46	8 920	70 330
Multiple-use forests[2]	0	2 496	0	2 925	0	1 062	3 312	1 600	11 395
Private land	n/a	8 523	15 511	10 213	0	922	1 298	1 639	38 106
Total	0	20 489	31 824	48 720	0	1 984	4 656	12 159	119 832

Source: National Forest Inventory (2003)

1 Since these data were prepared the area of multiple-use forest in New South Wales has decreased due to additions to nature conservation reserves arising from Regional Forest Agreements.

2 Includes areas of multiple-use forest reserved from timber harvesting to protect particular plant or animal species, catchment or other values.

The national area of forest not legally restricted from timber harvesting is 119.8 million hectares, or 74 per cent of Australia's forests. However, the area potentially available is significantly less because extensive areas are leasehold land predominantly used for grazing. As well, much of the area does not contain marketable species or is too far from markets to support viable timber production.

The area available for timber harvesting is further reduced by a range of regulatory constraints concerned with environmental and economic factors that are addressed by codes of practice and licences. The net area of forest where timber may be harvested after allowing for those constraints is approximately 64 per cent of the national total area of multiple-use forests (Table 45). The net area has not been assessed for leasehold land and private forests.

Harvesting of mixed species forest

Table 45: Net harvestable area as a proportion of total multiple-use forest (per cent)

Net harvestable area	ACT	NSW	NT	Qld	SA	Tas[1]	Vic	WA[2]	Australia
Per cent	*0*	*63*	*0*	*64*	*0*	*60*	*62*	*70*	*64*

Source: National Forest Inventory (2003)
1 Tasmanian data as at June 2001
2 Data from Australia's State of the Forests Report (1998)

Victoria has been able to identify the percentage of each of the native forest areas by land tenure where timber harvesting is permitted (Table 46). This demonstrates that, with the exception of nature conservation reserves, there are native forests technically available for timber harvesting in all tenures.

Table 46: Native forest areas in Victoria in which timber harvesting is permitted

Tenure	Proportion of tenure (%)
Multiple-use forest	*62*
Nature conservation reserves	*0*
Other crown land	*37*
Leasehold land	*30*
Private land	*27*

Source: Department of Sustainability and Environment, Victoria.

Since the 1998 State of the Forests Report, Regional Forest Agreements and other land use decisions have changed the tenure of around 2 million hectares of predominantly publicly owned forest, largely from multiple-use forest (which allows for timber harvesting) to nature conservation reserve (which emphasises protection of features of the forest environment).

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coverage
currrency
frequency

Growing stock in native forests available for timber production

Indicator 2.1b

Total growing stock of merchantable and non-merchantable tree species on native forest land available for timber production

Rationale

A fundamental element of the productive capacity of the area of native forest.

Growing stock for native forests is not normally reported as part of forest management in Australia. Merchantable growing stock is used in the calculation of sustainable yields for multiple-use forests.

The 'growing stock' is the volume of timber—merchantable and non-merchantable—in the forest at a particular time. The trend in growing stock may indicate whether the harvesting of timber products being undertaken is sustainable.

In practice, forest managers measure growing stock of merchantable tree species to forecast sustainable yield for multiple-use forests. The term 'merchantable' refers to timber that is of saleable quality. Non-merchantable timber is not of saleable quality. Whether timber is saleable depends to some extent on its intrinsic properties but to a greater extent on market supply and demand factors. The distinction between merchantable and non-merchantable is therefore arbitrary because market factors change.

Sustainable yield is the volume of timber products that can be harvested from the forest under a given management regime without reducing the long-term timber production capacity. The key elements of management that affect sustainable yield are the silvicultural system applied and the rotation, that is, the tree age when harvesting is planned.

With the exception of Tasmania, there are little or no data available on growing stock, potential sustainable yield or the owner's management intentions for private native forests. Sustainable yield is considered in Indicator 2.1d.

Non-merchantable coastal tea-tree (*Leptospermum laevigatum*) and eucalypt forest

Plantation resources

coverage
currrency
frequency

Indicator 2.1c

The area, age and future yield from plantations of native and exotic species

Rationale

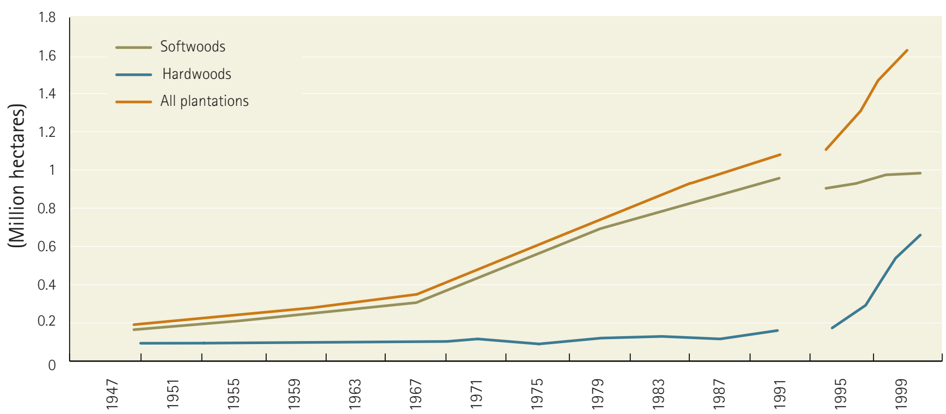
This is a direct measure of plantation production.

The area of softwood plantations was 988 000 hectares in 2002. The rate of expansion of new softwood plantations is low and the potential supply of softwood plantation timber will increase modestly over the next 20 years. There were 638 000 hectares of hardwood plantations in 2002. The majority of that area was established in recent years, much of it on former agricultural land. Hardwood plantation timber supply will potentially increase five-fold over the next 40 years.

Development of plantation forests in Australia started in the late 19th century when governments realised that additional sources of timber, especially softwood timber, were needed for building. The rate of development varied widely from year to year depending on government reforestation and economic development programs and interest from the private sector.

The total plantation estate reached about 200 000 hectares by 1960 (Figure 31). The area of softwood plantations increased rapidly from the 1960s to the 1980s, largely due to loan agreements between the Australian and State governments. The area of hardwood plantations reached 50 000 hectares by 1980 and did not increase further until the late 1980s when substantial private sector investment in hardwood plantations commenced.

Figure 31: Cumulative area of plantations over time



Source: Gerrand *et al.* (2002)

Note: The discontinuity between 1991 and 1994 is due to data inconsistencies prior to the start of the National Plantation Inventory.

The area of softwood plantations reached about 988 000 hectares in 2002 (see Table 47 and Figure 31). The annual average area of new softwood plantations established was more than 10 000 hectares for most of the 1990s but declined to 5 200 hectares in 2002. In contrast, the area of new hardwood plantations—almost entirely eucalypt species—doubled between 1991 and 1994 and increased four-fold between 1994 and 2002, albeit from a small base.

Table 47: Area of plantations ('000 ha)

Plantation type	1991	1994	2002
Hardwoods	84	159	638
Softwoods	893	884	988
Total	977	1 043	1 628

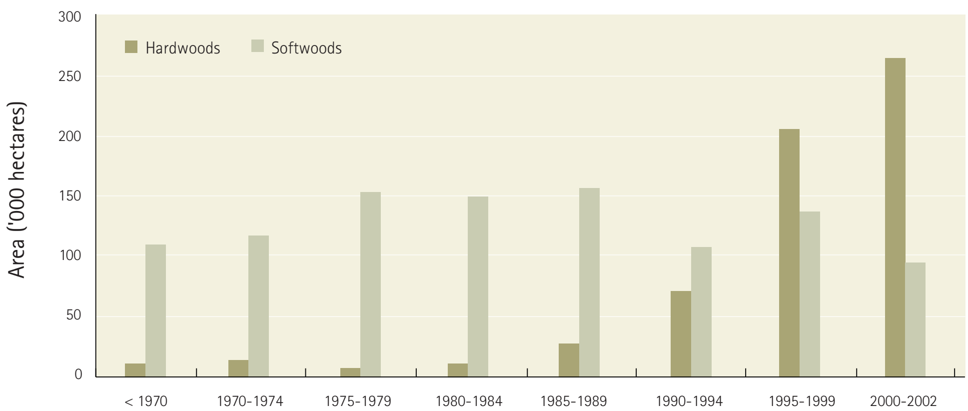
Sources: Resource Assessment Commission (1992); National Plantation Inventory of Australia (1997, 2003)

Note: The apparent decline in the area of softwood plantations between 1991 and 1994 is due to data inconsistencies prior to the start of the National Plantation Inventory

The area of plantation according to year of planting (Figure 32) shows how the rate of establishment of new softwood plantations has reduced since the 1980s. Most of the area of softwoods now planted each year is replanting existing areas after harvesting, rather than establishing new areas.

In contrast, most of the hardwoods are the first crop on the site. Only small areas of hardwoods have reached harvest age, and the rate of establishment of new hardwood plantations greatly exceeds the area harvested annually.

Figure 32: Area of plantations according to year of planting



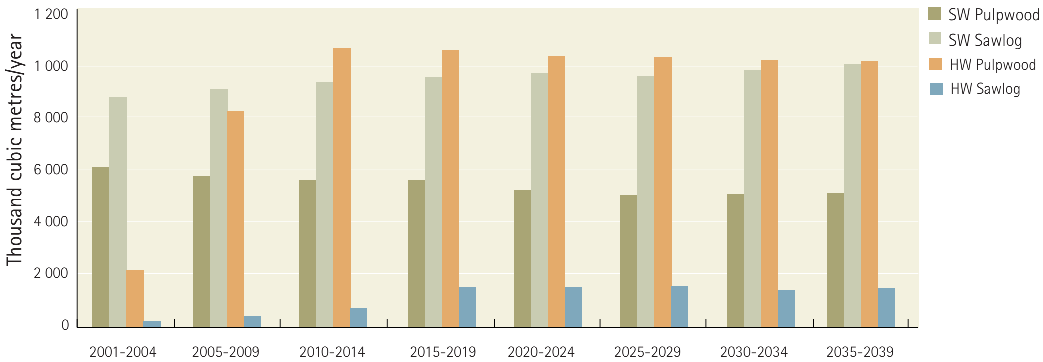
Source: National Plantation Inventory (2001, 2003)

The National Forest Inventory has developed estimates of potential future timber production from the existing plantations (Figure 33; the estimates assume no additional plantations). These estimates are based on records and assumptions about yields of timber products per unit land area and assume that all plantation sites harvested are replanted so that the current size of the plantation estate is maintained.

For softwood plantations there is a considerable amount of data available from over 100 years of experience to underpin the assumptions. By contrast, there is relatively little operational experience for hardwood plantations and the forecasts are therefore less reliable. The proportion of the total volume produced that is suitable for sawlogs is particularly difficult to estimate accurately.

The production from softwood plantations is nearing its maximum potential and is expected to reach a plateau by the end of the current decade (Figure 33). Most of the hardwood plantations are still immature. Potential production of hardwood will increase substantially in the next few years from about 2 million cubic metres per year in the period to 2004 to a maximum level of around 10 million cubic metres per year after 2010.

Figure 33: Estimated potential national production from plantations 2001–2039



Source: Ferguson *et al.* (2002); National Forest Inventory (2003)

Notes: Pulpwood includes roundwood used for poles, posts and reconstituted wood panels. Veneer log volumes are included with sawlog volumes. HW = hardwood; SW = softwood

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Plantation of native blue gum (*Eucalyptus globulus*)

coverage
currrency
frequency

Removal of wood products

Indicator 2.1d

Annual removal of wood products compared to the sustainable volume

Rationale

A measure of the actual harvest, to meet society's demand for wood products, against the sustainable level of production.

Multiple-use forests are the major source of native forest wood products. The volumes harvested from public native forests are less than the sustainable level. Private native forests are substantial sources of wood products in Queensland, New South Wales and Tasmania.

It is important to compare the volume of wood harvested annually with the forecast sustainable yield to ensure that the environmental values and productive capacity of forests are not compromised. Plantations are developed and managed primarily for timber production and market forces, rather than ecological sustainability. This indicator therefore focuses on native forests.

Sustainable yields from forests can be calculated in various ways, but should take into account environmental, social and economic factors. The concept of a sustainable level of production is that the forest can provide for society's needs and maintain its productive capacity.

Timber products can be divided into major and minor wood products. Major wood products include veneer logs, sawlogs and pulpwood. Pulpwood includes logs used for paper and wood-based panel products. There are formal processes, backed by legislation or codes of forest practice, to calculate sustainable sawlog yields for publicly managed native forests, primarily multiple-use forests. The volume of timber available for harvest is based on the net area of forest available for timber 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 from high quality sawlog production. Sustainable volume calculations are not determined for those products.

Minor wood products include posts and poles, bush sawn/hewn timber, firewood, speciality timber, and sleepers. Licences or permits are usually required to harvest minor wood products. The supply of these products is often opportunistic and may not be factored into sustainable yield calculations.

Sustainable sawlog volumes are determined using timber resource information, including forest type and age-class, volume data, terrain, accessibility information, growth and yield forecasts, and other values such as recreation, water and conservation. Once calculated, the sustainable volumes are used to produce an optimum schedule of harvesting, and a view of the future spatial and temporal characteristics of the forest.

Sustainable volumes vary over time according to management strategies, improved resource data and utilisation standards, and areas of land available for harvesting. The estimates are therefore reviewed periodically, usually every five years. For a range of reasons, some States and Territories allow annual harvest levels to fluctuate around the sustainable volume, but periodic reconciliation with sustainable yield is necessary to ensure future supply.

For Queensland, the supply of wood products from private native forests has often exceeded the supply from public native forests. For New South Wales and Tasmania, the supply from private native forests is significant but less than the supply from public native forests. Private native forests are a minor source of wood products in the other States.

The vast majority of private native forest managers in Australia have not adopted formal sustainable forest management procedures. Most have tended to be opportunistic in supplying timber, depending on immediate needs and the availability of markets. The Queensland Timber Board and Queensland Government are working with the Australian Government to assess private native forests in south-east Queensland for timber and some non-timber values. The results will be used to recommend assessment methods in other regions and is being undertaken in conjunction with a survey of landowner management intent.

Major wood products

Harvesting of wood products occurs primarily in New South Wales, Queensland, Tasmania, Victoria and Western Australia (Table 48). Harvest of wood products in native forests is not permitted in the Australian Capital Territory and South Australia. Sustainable yields have not been determined for the Northern Territory.

Over the past decade, the annual harvest of wood products has, on average, been less than the sustainable volume (Table 48). The data show a downward trend in volumes of sawlogs and veneer logs harvested from native forests in all States but Tasmania. The volume of pulpwood harvested has declined in all States except Tasmania and Victoria.

In 1996–1997, Victoria recalculated the sustainable volume to include all grades of sawlogs, based on the proportion of medium quality logs to low quality logs harvested in 1995–1996, which were subsequently reviewed in 2002 for all forest management areas. An outcome of the Tasmanian Regional Forest Agreement was to increase the available sawlog volume by 100 000 cubic metres in 1998–1999 to support the Forestry Growth Plan.

In 1999 the Queensland government agreed to a 25-year transition from public native forest harvesting in south-east Queensland to a plantation-based industry. Some harvesting will occur in these forests before they are transferred to nature conservation reserve. Hardwood plantations are being established to provide an alternative resource.

Michael F. Ryan

Young blue gum (*Eucalyptus globulus*) and mature radiata pine (*Pinus radiata*) plantation forest

Table 48: Sawlog, veneer log and pulpwood production from native forests ('000 cubic metres)

	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001
Sawlogs and veneer logs from multiple-use forests									
NSW sustainable volume[1]	–	–	–	–	–	–	595	629	518
NSW harvested volume[1]	1151	1262	1224	1075	942	806	572	497	554
Qld sustainable volume	–	–	–	–	–	–	–	–	–
Qld harvested volume[2]	344	345	367	308	339	317	324	296	289
Tas sustainable volume[3]	300	300	300	300	300	300	400	400	400
Tas harvested volume[3]	292	209	309	276	262	273	266	281	294
Vic sustainable volume[4]	743	743	743	743	921	921	921	921	921
Vic harvested volume[4]	632	660	664	589	729	804	821	820	667
WA sustainable volume[5]	758	758	758	–	704	704	704	510	–
WA harvested volume[5]	636	615	694	544	568	581	541	471	–
Sawlogs and veneer logs harvested from private native forests									
New South Wales	393	346	254	248	441	111	–	–	–
Queensland	339	425	416	340	260	210	230	270	230
Tasmania[3]	–	–	–	–	216	162	203	162	126
Pulpwood harvested from multiple-use forests									
New South Wales	710	700	699	768	605	615	472	503	533
Queensland[2]	1.3	0	0	2.7	3.5	0.5	0	0	1.0
Tasmania3	–	–	–	–	1550	1890	1624	2368	2762
Victoria4	–	–	–	1011	1033	1120	1165	1403	1580
Western Australia5	639	570	673	654	610	601	515	446	–
Pulpwood harvested from private native forests									
New South Wales	53	45	60	22	87	–	–	–	–
Tasmania[3]	–	–	–	–	1188	1714	1553	2367	1912
Western Australia[5]	99	74	59	89	58	–	–	–	–
Other States	–	–	–	–	–	–	–	–	–

Source: National Forest Inventory (2003)

Notes: Sawlogs and veneer logs from native forest hardwood and softwood species. Pulpwood includes logs used for pulp and paper products, woodchips and panel products.

1 For New South Wales, sustainable yields are determined and the volumes shown are for high quality sawlogs and veneer logs. The Regional Forest Agreements permit the volume harvested to vary by 25% in any year and by 5% over a five-year period. Low quality sawlogs and pulpwood are also produced where high quality sawlogs are harvested.

2 For Queensland, the volumes for multiple-use forests include timber harvested from multiple-use forest and other crown land.

3 Source: Tasmanian RFA Background Report (2001).

4 For Victoria, sustainable yields are expressed as net volume (i.e., gross volume less allowances for defect). Pulpwood volume includes logs that are sawn but do not meet sawlog grade standards. For Victoria, until 1995–96 the sustainable yield figures did not include D grade (i.e., low quality) sawlogs. This changed in 1996–97 to include D grade sawlogs.

5 Source: Annual Reports of the Department of Conservation and Land Management; includes sawlogs and veneer logs from multiple-use forest and other crown land. Figures to 1998–99 are those set by Ministerial determination and include jarrah saw logs grade 1 and 2, and karri saw logs grade 1. Figures for 1999–2000 are those set by the Regional Forest Agreement and include jarrah sawlogs grades 1 and 2, and karri sawlogs grades 1 and 2.

Minor wood products

Sustainable volume figures for minor wood products are not usually determined but strategies are being developed for some products. Posts, poles and rails are often removed as part of thinning and sawlog harvesting in native multiple-use forests. Permits are usually required for removal of minor products, including South Australia where specific approvals are granted for firewood removal under the *Native Vegetation Act 1991*. Timber harvested for didgeridoos, bark painting and sculpture in the Northern Territory is covered in Indicator 6.1b.

A national approach for firewood collection and use in Australia was developed in 2001. It aims to ensure all firewood collection, including commercial cutting, is ecologically sustainable and not a major cause of loss or degradation of remnant forests or the habitats of threatened species. This national approach forms the basis for each State and Territory to develop its own firewood collection action plan or strategy.

Victoria released a draft firewood strategy discussion paper in 2002 in conjunction with forest management plans for publicly owned forests. Data on firewood removal from private forests is not available. Table 49 shows estimates for firewood consumed in 2000.

Table 49: Estimated firewood use in 2000

State/Territory	Millions of tonnes
Australian Capital Territory	0.03–0.06
New South Wales	1.18–1.68
Northern Territory	–
Queensland	0.23–0.45
South Australia	0.32–0.53
Tasmania	0.61–0.85
Victoria	0.96–1.48
Western Australia	0.45–0.69
Total	4.52–5.74

Source: Driscoll (2000)

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coverage
currrency
frequency

Non-timber forest products

Indicator 2.1e

Annual removal of non-timber forest products (e.g. berries, mushrooms, game, honey, wildflowers, tree ferns, possums), compared to the sustainable level

Rationale

This indicator provides an indication of the level of use of non-timber forest products compared with forecast sustained yield, including some products that are significant for Indigenous communities.

No national data are kept on the non-timber forest products that are sourced solely from forested areas. Some State and Territory governments estimate sustainable harvest volumes for selected plant and animal species.

In recent times the quantities of non-timber products from Australia's forests being used for commercial purposes have increased. Management of non-timber products is becoming increasingly formalised through management plans and programs. There is a need to quantify volumes taken and sustainable yields, but there are few available data.

Animals and animal products

Removing native animals from Australian forests is prohibited or subject to regulations enforced by government agencies. There are few examples of hunting adversely affecting the viability of a forest-dependent animal species. The thylacine (*Thylacinus cynocephalus*), also known as the Tasmanian tiger, may be an exception. Hunting in the 19th to early 20th centuries is suspected to have been a significant cause of its extinction.

Some native and exotic animals are used for commercial purposes. These include introduced deer, native brush-tail possum (*Trichosurus vulpecula*) and certain species of wallabies. Information on the use of licensing for hunting of these species indicates harvesting pressure. For example, bag limits and hunting seasons are applied for hunting deer in Victoria, based on the provisions of the Victorian *Wildlife Act 1975*. The number of deer taken fluctuated from 8 600 to13 500 per year in the period between 1996–1997 and 2000–2001 while the number of licenses increased from 8 000 to just over 10 800. Although 2 715 valid deer licenses were issued in Tasmania in 1999–2000, only 760 deer were actually taken. This example demonstrates that the licence numbers may not accurately reflect the actual harvesting level.

Red and grey kangaroos (*Macropus rufus* and *M. fuliginous*) are also taken from the wild for a variety of products, including meat and skins. Red kangaroos live mainly in arid grassland, whereas grey kangaroos are also found in forested areas.

New South Wales has established a Kangaroo Management Program that specifies the number of kangaroos that may be taken each year for commercial use. The estimated population level, the allowed annual quota and the proportion of the quota actually taken are shown in Table 50.

Table 50: Commercial harvest of red and grey kangaroos in New South Wales ('000)

Year	Population	Quota	Take as % population	Take as % quota
1991	9 734	1 520	*9*	*56*
1992	7 982	2 074	*8*	*38*
1993	7 112	1 664	*10*	*47*
1994	5 963	1 409	*14*	*69*
1995	6 202	1 147	*16*	*85*
1996	5 170	1 206	*19*	*95*
1997	6 550	976	*17*	*92*
1998	8 363	1 175	*14*	*80*
1999	7 654	1 533	*11*	*61*
2000	7 689	1 390	*12*	*64*

Source: Kangaroo Management Program 2002–2006, NPWS (2002)

The data show that quotas have fluctuated with estimates of the populations and are set at a small proportion of the total population. The recorded harvest is low compared to total population size.

Non-wood plant products

A variety of plant products is taken from Australia's forests, generally under permit. The conditions applying to permits to remove plants vary from State to State. Legislation prohibits removal of plants and plant products from nature conservation reserves. The collection and commercial use of wildflowers is restricted by legislation and licences to protect threatened species.

There are records of the volumes of some plant products taken from forests in Queensland and New South Wales (Tables 51 and 52). Sustainable levels are not known for these products.

Table 51: Non-wood plant products, Queensland 2001–2002

Product	Amount
Bunya cones and banksia pods (pieces)	3 140
Pine cones (from plantations) (m^3)	2 150
Foliage (decorative; koala feed) (kg)	171 630
Fern fronds (pieces)	10 720
Leaf litter, mulch, bark, charcoal (m^3)	210
Christmas trees (from plantations)	1 740

Source: National Forest Inventory (2003)

Table 52: Non-wood plant products, New South Wales 2000–2001

Product	Amount
Native plants (number of permits)	9 870
Leaf for oil production (kg)	910
Bark (tonnes)	10
Broombrush (tonnes)	2 520
Charcoal (tonnes)	1 180

Source: National Forest Inventory (2003)

Seed

Harvesting of wild seed occurs for native forest regeneration and the maintenance of genetic diversity. Prior to the development of seed orchards or propagation programs, wild seed may be used to grow plantation stock. The amount of material collected is believed to be small compared to the total volume of seed for all but rare species, for which special permits are required (Table 53).

Table 53: Native tree seed harvested in New South Wales, Victoria and Tasmania (kg)

State/Territory	1997–1998	1998–1999	1999–2000	2000–2001
New South Wales	969	214	688	2 460
Victoria	7 100	4 700	6 000	4 800
Tasmania	1 370	564	1 278	1 712

Source: National Forest Inventory (2003)

Indigenous products

Indigenous people use a significant volume of forest products for commercial and subsistence art and crafts. For example, the Maningrida people (Arnhem Land, Northern Territory) reported that 1 476 and 937 bark paintings were produced in 1999–2000 and 2000–2001 respectively. Bark for these paintings is usually derived from the tree *Eucalyptus tetrodonta* (stringybark). Material for wood sculptures is also commonly derived from forests, and it was reported that 1 183 and 1 111 sculptures were produced in 1999–2000 and 2000–2001, respectively.

Extracting honeycombs from bee hives

Apiary

Forests in a number of Australian States and Territories are used to produce honey in commercial quantities. Tasmania is particularly well known for honey production, which contributed $2.1 million to the local economy in 1999–2000. Indigenous people use wild honey produced from a variety of native bee species occurring in forests, particularly in northern Australia. The value of the production of honey is reported in Indicator 6.1b.

First harvest of cork (*Quercus suber*) in experimental cork oak plantations

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coverage
currrency
frequency

Effectiveness of plantation establishment

Indicator 2.1f

Area and per cent of plantations established meeting effective stocking one year after planting

Rationale

This indicator determines success of the planting effort.

Monitoring is undertaken routinely following plantation establishment but plantation managers do not report the data at the national level.

The goal of plantation establishment is to achieve an adequate stocking of vigorous trees. Plantation establishment techniques and seasonal conditions, most importantly rainfall, have a major impact on planting success. Considerable research and development is being undertaken to develop and refine techniques (see Indicator 7.5f).

Acceptable stocking in a young plantation depends on tree species, the site and preferred plantation products. The planting rate can vary from a few hundred trees per hectare to a few thousand. Whatever the rate, costs are involved in preparing the site and obtaining and planting the trees. Additional costs may be incurred if remedial treatment is required due to inadequate stocking.

Plantation owners and managers usually set minimum acceptable stocking targets to be achieved within a set time after planting. Operational staff check stocking on a sample of the site to determine whether replanting is required. State Forests of New South Wales makes this information available to the public (Table 54).

Table 54: Percentage of newly planted forest effectively stocked

	Effective stocking (per cent)		
Plantation type	1998	1999	2000–2001
Hardwood	*94*	*100*	*95*
Softwood	*97*	*98*	*96*

Source: State Forests of New South Wales

Young radiata pine (*Pinus radiata*) plantation

Further reading

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Regeneration in harvested areas

coverage

currrency

frequency

Indicator 2.1g

Area and per cent of harvested native forest effectively regenerated

Rationale

To determine success of the regeneration effort.

There are regulations that require regeneration of multiple-use forests where native forest harvesting occurs, and for private forests in some States. The definition of, and standard for, effective regeneration varies between States and Territories.

Effective regeneration of native forest after timber harvesting is necessary to manage a forest sustainably. Regeneration is not always necessary after thinning. To this end, an understanding of the forest management objectives and the dynamics of the forest type are necessary.

Public forest managers are required by codes of practice and other regulations to measure the effective regeneration of areas harvested for timber production and to report it publicly. Codes of practice also apply to private native forests in some States.

Measures of effective regeneration include stocking, density and species composition. State forest agencies establish standards for effective regeneration of multiple-use forests. Regeneration is assessed usually between one and three years after harvest. Further regeneration treatment is required if regeneration standards are not met. Browsing impacts on the effectiveness of regeneration. Each State has its own method of assessing the success or effectiveness of regeneration. The variation in methods is due to regional differences in forest types, climatic and biophysical conditions, and management objectives. While assessment techniques in even-aged stands are well developed, methods to measure regeneration success in multi-aged stands are still being developed.

Figures on effective regeneration are not available for all States and Territories for all tenures. However, case studies are provided for Victoria (Table 55) and Tasmania (Tables 56 and 57).

Table 55: Regeneration success in multiple-use forests, Victoria

Regeneration year	Total area treated (hectares)	Total area effectively regenerated (hectares)	Percentage effectively regenerated
1993–1994	9 328	6 987	*75*
1994–1995	6 742	5 902	*87*
1995–1996	8 961	8 046	*90*
1996–1997	3 789	2 706	*71*

Source: Department of Sustainability and Environment (2003)

Notes: Regeneration is assessed from 1.5 years to 3 years after harvesting. The regenerated areas shown are after the first regeneration treatment. Remedial treatment is undertaken where regeneration is inadequate. For 1996–1997 data are incomplete.

Table 56: Regeneration success in clearfelled eucalypt coupes, Tasmania

Regeneration year	Total area regenerated (hectares)	Area effectively regenerated (hectares)	Percentage effectively regenerated
1994–1995*	844	805	*95*
1995–1996	2 364	2 183	*92*
1996–1997	2 146	1 951	*91*
1997–1998	1 805	1 741	*96*

Source: National Forest Inventory (2003).

Notes: For multiple-use forests regenerated to native forest. The 1994–95 regeneration program was smaller than average because a very wet autumn restricted regeneration burns.

Table 57: Regeneration success in partially harvested eucalypt coupes, Tasmania

Regeneration year	Total area regenerated (hectares)	Total area effectively regenerated (hectares)	Percentage effectively regenerated
1994–1995	1 974	1 861	*94*
1995–1996	1 586	1 586	*100*
1996–1997	3 058	3 010	*98*
1997–1998	2 320	2 250	*97*

Source: National Forest Inventory (2003).

Note: For multiple-use forests regenerated to native forest.

Two management regimes are presented for Tasmania over a four-year period to 1998. The effective regeneration achieved ranged between 91 per cent and 100 per cent across the two regimes. Coupes where the stocking standard was not achieved were generally environmentally difficult sites (e.g., steep or rocky). The recent introduction in Tasmania of compliance reporting under the *Forest Practices Act 1995* will, in future, provide data on the achievement of prescribed stocking standards across all tenures in the State.

The small sample of areas assessed for regeneration in areas harvested for ironwood (*Erythrophleum chlorostachys*) in the Northern Territory revealed that the primary factor influencing regeneration was fire regime, and inadequate management of fire was adversely impacting on young trees. This points to a need for management plans to cover this factor if adequate regeneration is to be assured.

Mountain ash (*Eucalyptus regnans*) seedling after regeneration of harvested forest

Further reading

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Genetic conservation of plantation species

coverage
currrency
frequency

Indicator 2.1h

Extent of exotic plantations managed according to documented procedures or management plans to maintain genetic resources

Rationale

Genetic resource management plans aim to maintain the full range of genetic resources available for commercial plantation species.

Research and development of genetic resources of a substantial number of species used in exotic plantations is progressing. The risk of narrowing the genetic variability of the trees used in plantations is being managed.

This indicator addresses the conservation of genetic resources of the exotic species used in plantations in order to enable the productivity of those plantations to be maintained. Conservation of genetic resources in native forests and in plantations of indigenous species is addressed in Indicator 1.3c.

Exotic species are those that are growing outside the region where they naturally occur. Species that are indigenous to Australia but are grown outside their natural range are treated as exotic and are reported under this indicator.

Many different species are used for timber plantations and farm forests in Australia. Some of the main species, their region of origin, and the regions in which they are used in plantations, are shown in Table 58.

Table 58: Some species used in plantations in Australia

Species	Region of origin	Region/s used in plantations
Pinus radiata	California	Southern Australia
Eucalyptus globulus subsp. *globulus*	Tasmania and south Gippsland, Victoria	Southern Australia, including Tasmania
Eucalyptus grandis	North coast New South Wales and Queensland	North coast New South Wales and southern Queensland
Eucalyptus pellita	Coastal New South Wales and Queensland	Coastal north Queensland
Eucalyptus nitens	New South Wales and Victoria	Southern Australia, including Tasmania
Acacia mangium	North Queensland, Papua New Guinea	Northern Territory

Source: National Forest Inventory (2003)

Controlled pollination bags on genetically improved radiata pine (*Pinus radiata*)

Whereas radiata pine (*Pinus radiata*) is clearly an exotic plantation species, Tasmanian or southern blue gum (*Eucalyptus globulus* subsp. *globulus*) is considered an indigenous species in plantations in Tasmania and an exotic species in plantations in Western Australia. Flooded gum (*E. grandis*) and red mahogany (*E. pellita*) are indigenous plantation species. Mangium (*Acacia mangium*) is being used in plantations well outside its natural range and is therefore an exotic species in these plantations.

Flooded gum and mangium are major timber plantation species worldwide. Conservation of the genetic material of these species where they occur naturally in Australia therefore has implications for plantations in other countries.

Tree species are selected for establishment in timber plantations on the basis of their suitability for timber or other products and their suitability for the climate and land at the plantation site. As in agriculture, the focus of genetic management for plantations is to improve productivity in terms of volume and value of products. This is possible because there are genetic differences between individuals in each species. Breeding from individuals with preferred characteristics enables genetic variation to be used to improve productivity.

Selecting individuals that grow more vigorously in the area available for plantation development can improve tree productivity. Better vigour may be related to better suitability to climate or soil and/or to better resistance to pests and diseases. Selecting individuals with better timber-producing properties can also improve productivity. For example, wood density and tree branching habit have substantial impacts on wood volume and value.

Genetic improvement of radiata pine (*Pinus radiata*) has been a focus of forestry research and development in Australia since soon after plantation forestry began here in the late 19th century. All radiata pine trees now planted in Australian plantations are the result of this genetic improvement. Less progress has been made for the other common plantation timber species because their use in plantations commenced more recently. Other timber plantation species for which genetic improvement research and development is underway include *Eucalyptus globulus*, *P. pinaster*, *P. brutia*, *E. cloeziana*, *E. grandis* and *E. camaldulensis*.

As in agricultural crop species, breeding plantation timber species for improved productivity carries the risk of narrowing the genetic variability within the plantations to the point that the selected genotypes are susceptible to unforeseen hazards. The key hazards of concern are usually pests and diseases. Tree breeding programs allow for this risk by trying to ensure that adequate genetic variability is maintained. The other key risk management strategy is to ensure the conservation of the exotic plantation species within its natural range.

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3

MAINTENANCE OF ECOSYSTEM HEALTH AND VITALITY

INTRODUCTION

This criterion is concerned with the state of forest ecosystems and the factors that can damage ecosystem health. The two pillars of forest existence—soil and water—are covered separately in Chapter 4. Here the chief considerations are a range of natural and human-induced changes that can damage forests. The main examples are fire, animal and plant pests, pathogens, salinisation and soil acidification, as well as broader issues such as air pollution and increasing ultraviolet irradiation. Forest damage may be extensive, obvious and immediately apparent such as the impact of an intense fire, or far more subtle, slow-acting and hard to detect such as the effects of increasing ultraviolet irradiation. Therefore, assessing some of these factors is much harder than for others.

As well, insufficient data remains a problem. Nevertheless, enough information is available on the main issues and it is clear that many agents affecting forest ecosystems are common to most jurisdictions and affect a large proportion of our forests. However, impacts vary considerably with location. Climate, vegetation type, soil type and history, patterns of land use and burning, and historical facts—such as introduction of exotic or pest species—can all play a part in determining why some areas suffer from certain problems while others do not. It should also be noted that damage to ecosystem health is not always irreversible. Fire, for example, has been a natural occurrence in many Australian ecosystems for hundreds of thousands of years and it is well-known that much Australian vegetation is fire-adapted.

Markers exist that allow us to presume that changes in fundamental ecological processes are occurring. An example being developed is the Eucalypt Crown Condition Indicator. This examines physiological and structural changes in eucalypt canopies measured using a high-resolution spectrometer on an aircraft. It is possible to relate the reflectance of tree crowns to canopy health. Indicator 3.1c provides further details.

A fuel reduction burn in native forest

coverage
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frequency

Factors affecting forest health

Indicator 3.1a

Area and per cent of forest affected by processes or agents that may change ecosystem health and vitality

Rationale

Many agents can affect basic ecological processes in forests. Where these processes are altered beyond some critical threshold they may produce significant changes to the condition of the forest—hence the importance of monitoring this indicator.

Some factors that affect ecological processes in forests are biological (such as introduced species or tree diseases), while others are physical (such as fire, soil salinity or extreme weather events). Overall, there is considerable general information on both classes of factors but relatively little precise data on areas and percentages of forest affected.

As this indicator covers such a large subject area, it has been divided into sections. The following table (Table 59) gives an overview of the various issues covered, and whether they are perceived, by public land managers, as being problems in each State or Territory.

Table 59: Occurrences of processes or agents impacting on forest ecosystem health and vitality by State or Territory

Processes or agents impacting on forested areas	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
Animal pests	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Insect pests	Yes	Yes	–	Yes	Yes	Yes	Yes	Yes
Weeds	Yes	Yes	–	Yes	Yes	Yes	Yes	Yes
Pathogens	Yes	Yes	–	Yes	Yes	Yes	Yes	Yes
Introduction of exotic biota[1]	–	Yes	–	Yes	Yes	Yes	Yes	–
Clearing	–	Yes	–	Yes	–	Yes	Yes	–
Grazing	–	Yes	–	Yes	–	–	Yes	–
River regulation	–	Yes	–	Yes	Yes	–	Yes	–
Salinisation and soil acidification	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Mining	–	–	Yes	Yes	–	Yes	Yes	Yes
Fire	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Climatic events	–	Yes	Yes	Yes	Yes	Yes	Yes	–

Source: National Forest Inventory, 2003.

[1] Exotic biota is defined as any species not endemic to a locality

Fire in Australian forests

The degree of fire impacts varies significantly with location in Australia. The effects of fire are determined by the interaction of vegetation type, fire intensity, seasonality and fire history.

Fire is an inevitable, periodic event in most Australian forests that can have both positive and negative impacts on forest health and vitality. The impact of fire on the biota varies according to ecosystem sensitivity to fire, intensity and frequency, which in turn depends upon many factors including fuel availability, prevailing weather and the season. Whether started by humans or lightning, forest fires occur somewhere in Australia every year. However, although fire is an ecological disturbance, most forests are able to naturally regenerate, given appropriate climatic conditions, proximity to seed and sufficient recovery time between disturbances.

Although individual agencies within the States and Territories keep a range of statistics, there is no comprehensive national database on fire occurrence, cost and impact, and no standard protocol or custodian. Between April 1998 and March 1999, 14.3 million hectares (9 per cent) of Australia's forests were identified through remote sensing as having been burnt by fires. The following year 27.2 million hectares (17 per cent) were burnt by fire. These figures include both wild fires and fuel reduction burns. Furthermore, the definition of wildfire varies: in southern regions, concerted efforts are made to control wildfires; in remote locations in the north of Australia there is little or no control or management of fires.

Charcoal deposits in carbon dated sediments indicate that periodic bushfires have occurred in Australian forests for hundreds of thousands of years. Recurrent fires have been an evolutionary pressure on vegetation, favouring selection for protective mechanisms, and for the ability to regenerate after fires. Some species, especially acacia, require fire for their continued existence and regeneration.

Humans have provided sources of ignition for forest fires for at least 60 000 years. Indigenous people and more recently Europeans deliberately and accidentally caused fires. Indigenous people carried out frequent, regular and wide-scale burning, especially in the drier forest types. The net effect was a mosaic of burnt and unburnt patches. Fires in northern Australia are frequently associated with pastoralism and in these areas there has been little change in the fire regime and, consequently, virtually no change to bushfire hazard or occurrence over the last hundred years. In northern Australia the reduction in mosaic burning practices over the last two hundred years has been associated with fires that are more intense and cover a larger area than previously occurred. The intensity of these fires is still low compared to fires in southern Australia.

The frequency of intense fires in forests increased following European settlement. The increased frequency of intense fires was associated with a reduced occurrence of low intensity fires. For example, based on studies in jarrah (*E. marginata*) forests there was a decline from about three fires per decade under Indigenous management to about one fire per decade under post-European management. During the same time, the average frequency of fires sufficiently intense to cause scarring on trees increased from one in 82 years to one in 13 years.

Most Australian forests contain flammable vegetation and are naturally fire-prone. In addition, many parts of Australia experience periodic drought, which increases the flammability of forests and the likelihood of extensive fires. There is, however, a wide range in the type, frequency and intensity of fire occurrence across the country. Fire and its associated impacts generally decrease in intensity to the north as fire season changes from summer to spring and winter and fuel loads and intensity decrease. Fire is rare in the tropical rainforests of northern Australia and in the temperate and mixed rainforests and wet sclerophyll forests in parts of Tasmania and Victoria; however, even these areas can dry out during prolonged periods of drought and will then burn if ignited.

Fire is also rare in the more arid inland forests, where fuels do not accumulate readily because of low rainfall, relatively low biomass or steep rocky slopes. The quantities of fine fuels are also small in the rangelands used by the pastoral industry, because of grazing by native and exotic species. However, even in these areas large bushfires do occur. This is especially likely in the wake of a heavy wet season that promotes a dense grass and shrub layer which later dries out becoming available fuel when dry conditions return. Nevertheless, these inland forests and woodlands also possess a powerful regenerative capacity.

In the absence of fire, Australian forests—especially eucalypt—accumulate fine fuels reaching fluctuating equilibrium levels of up to 25 tonnes per hectare in 5 to 15 years depending on the forest type. Fuel arrangement also continues to change over time with the potential to increase fire intensity. Fuel comprises fallen leaves, twigs, logs and branches, the bark and foliage on tree trunks and crowns, and the flammable shrub layer. Although this can provide ecological benefits, under severe weather conditions, fires from such heavy fuel loads are extremely intense.

Fire impacts

Fire is a naturally occurring element of many Australian forests and from a human perspective has positive and negative impacts depending on the values and intensity of effects generated. Fires in forests impact on; (i) human lives, assets and values; and (ii) ecological processes and ecosystem structure, species composition, age and function. Fire management practices reflect a range of potentially conflicting objectives in an attempt to reduce the undesirable impacts on these values.

Burning native forest after harvest to promote regeneration

Impacts on people

While bushfires affect the health of forests in both positive and negative ways, their impact on human communities is usually characterised as negative because of the damage they can do to buildings, fences, bridges, power lines, water supplies and streams and commercial timber assets.

Impacts on ecological values

The degree of impact of fire on a forest ecosystem is variable. The rate of recovery after fire varies with the type of vegetation, and the intensity, season and history of previous fires. A range of other factors interact, including the reproductive capacity of the site (e.g., the seed bank), the proceeding climatic conditions, post fire grazing and predation and the prevalence of other disturbances. For example, the impact of a mild, patchy fire in dry sclerophyll forest may not be apparent one or two years later, while an intense fire in wet sclerophyll forest may trigger complete stand replacement, and affect flora, fauna, habitat and landscape for a century or more. Some plants and animals are fire adapted to the extent that they are dependent on periodic fire for habitat maintenance.

The structure and composition of northern savannah forests—as in the Northern Territory, north-western Queensland and the Kimberley region of Western Australia—appear to be a result of burning every year or so, especially where the understorey is dominated by cane grass. A fire in these areas can be very extensive, but the ecological impact is believed to be low, with complete ecosystem recovery apparently occurring within a few months. Variations in the fire frequency and season—between one and four year intervals and between lower intensity winter fires and hotter fires later in the year—are associated with shifts in structure and composition of the forest understorey.

The impact of a single fire is of lesser ecological interest than the cumulative impact of a fire regime. Fire regimes are expressed in terms of frequency (i.e., the interval between fires), intensity, distribution or patchiness of burnt areas, and the season of burning. Frequent low intensity fires can have a large impact compared with one-off, intense fires. Different combinations of these factors can benefit or disadvantage different elements of the ecosystem. Some plant and animal species, especially the 'pioneer species', benefit from frequent fires. Other species are favoured by long fire intervals; in fire-prone landscapes, these are provided for by protected situations such as deep sheltered gullies.

The most dramatic environmental impact is caused by large, high intensity fires. These result in localised and usually temporary loss of plants, animals and habitat, but also stimulate the regeneration of many plant species. The result of such fire can therefore be even-aged regeneration over wide areas, loss of species which prefer frequently or mildly burnt forest, and potential degradation of soils and waterways.

Understanding of forest fire ecology suffers from limited data, the time-frames over which recovery occurs and the complexity of interactions between fire regimes and forest types. Most is known about the ecological impacts of fairly frequent (<10 years interval), high intensity fires, especially in shrublands, woodlands and eucalypt forests around Sydney, New South Wales. There is some knowledge of the impacts of low intensity prescribed fires in eucalypt forests in southern Australia, as well as prescribed fires in tropical woodlands in northern Australia. Least is known about the long-term impacts of infrequent very high intensity fires. The very large and very intense forest fires which occurred in several parts of Australia in the 2002–2003 fire season provide an opportunity for further study.

Fire management

Early forest managers attempted to deal with the potential fire threat through a policy of fire exclusion. This policy remains in force today in some agricultural districts in southern Australia where the main assets are crops, pasture and domestic stock. The policy required that bushfires were rapidly located and suppressed by fire-fighting forces. In some forest areas this policy was also accompanied by strategic burning to remove accumulated forest fuels in narrow strips adjacent to railway lines, roads, farms and settlements.

Fire exclusion generally has not proved to be a successful means of dealing with fires in Australian forests. This is because ignition is inevitable—by lightning or humans. Fires can be very difficult to control, even under relatively mild weather conditions and with a large and expert fire-fighting force. Prescribed burning is not a fire management system in itself, but is only effective when it is an integral part of an holistic approach that also incorporates fire prevention, suppression, education and training, research and law enforcement.

Research findings have led to modifications in burning practices so as to take into account biodiversity values or to protect particular species or forest types, and to ensure smoke from prescribed burning does not cause smoke haze in urban areas. While prescribed burning has become increasingly sophisticated, it has also become more costly and difficult to conduct when these additional community values are applicable. This is especially true in Western Australia, Victoria and New South Wales.

Recent transfers of substantial areas of forest from multiple-use forests to nature conservation reserves have created debate in Australia about which fire regimes are most appropriate to balance protection of life and property with biodiversity and or timber production values.

Across all tenures, the primary aim of fire management is to protect life and property. After this requirement is met, managers of multiple-use forests have a responsibility to ensure that timber and environmental values are not destroyed by fire. Managers of nature conservation reserves have a responsibility to conserve biodiversity that may require a different mix of intensity and frequency to that needed to protect timber assets.

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Michael F. Ryan

Erosion as a result of high intensity fire in native forest

Animal pests and weeds

There is little information on the extent and percentage of forest affected by animal pests and weeds. Programs to monitor and control damaging agents are in place in most States and Territories in plantations and, to a lesser degree, in native forests.

Australia's agricultural crops and exotic plantations have remained free of many of the major pests and diseases prevalent elsewhere. Native animals and plants have evolved with several pests and pathogens, most of which are listed below. There are strict quarantine procedures at both national and regional levels to minimise the risk of entry of pests and diseases.

In 2000 the National Forest Health Committee released a Generic Forest Incursion Management Plan to prepare for responses to potential new entries of exotic pathogens or invertebrate pests into Australia. A field guide to exotic pests and diseases of forests and timber has also been produced for forest health and quarantine officers. At a regional level, the spread of plant and insect pests and pathogens is controlled by local hygiene and quarantine restrictions.

Surveillance for pests and diseases in native and plantation forests is standard procedure. In some localities, there are control programs in place for feral cats, dogs, foxes, goats, horses, pigs, rabbits, cane toads and other animals, weeds and pathogens, particularly where the impacts are more severe. While the States and Territories collaborate on strategies to combat nationally significant pests, there are significant problems in reporting consistently on animal and plant pests on a national level. Compilations of assessments often combine quantitative data and expert opinion, which may vary within and between States and Territories. They are presented without reference to tenure, forest use or disturbance levels and therefore embody a wide range of perspectives on potential threats to forest health and vitality. For example, the same pest would be managed differently in the context of a nature conservation reserve, a plantation, a nursery and multiple-use forests.

Animal vertebrate pests

Animal (vertebrate) pests are responsible for a suite of destructive impacts including browsing and ring-barking of mature and juvenile vegetation, erosion, competition for food and habitat, and predation on native fauna.

Exotic Species

- Foxes occur across mainland Australia and have had significant impacts on populations of medium-sized ground-dwelling and semi-arboreal mammals. Extensive and expensive baiting control programs have reduced fox populations at some key sites but eradication is not foreseen. Foxes appear to have been recently introduced to Tasmania and The Fox Free Tasmania Taskforce has been established to manage control measures.
- Wild dogs and dingoes are widespread in Australian forests. Their impacts are likely to be greatest on medium to large macropods, however, control is driven largely by their impacts on livestock. Wild dogs and dingoes are usually controlled by baiting.
- Cats are widely distributed across Australia and their impacts are most apparent on small mammals, reptiles and invertebrates in the arid zone and ground-nesting birds particularly on off-shore islands. The impacts of cats on forest fauna is unclear. Given the difficulty in controlling cats using toxic baiting, broad area cat control has rarely been successful.
- Rabbits are a major agricultural and environmental pest across most of Australia. They are a major cause of soil erosion through the prevention of regeneration of native vegetation, foraging on foliage and ring-barking trees. Rabbits probably impact on a wide range of fauna via competition for food and habitat degradation. A concentrated and integrated management program exists for rabbits and includes biological (myxomatosis, calicivirus), chemical (baiting and fumigation) and mechanical control methods (shooting, fencing, warren destruction).

- Pigs have a severe and widespread impact on agricultural and native ecosystems across Australia, particularly in the ACT and Queensland. Rooting of soil causes physical damage and erosion, soil fauna is affected and some pathogens may be transmitted (for example, the fungal pathogen *Phytophthora cinnamomi*). Ground cover is destroyed, the composition of plant communities may change and invasion by weeds often ensues. However, the long-term impacts on plant communities in most ecosystems are unclear.

Native Species

- Adverse impacts on forestry are felt in most States and Territories from some abundant and widespread species of macropods (kangaroos and wallabies). Whilst a number of macropod species have been disadvantaged by European settlement (11 per cent of macropod taxa extinct, 25 per cent of taxa threatened) many species have remained stable or increased in numbers over this period. The presence of widespread and abundant macropods supports a significant industry in rural Australia, based on the sustainable harvesting of a renewable native resource, however such populations also compete with forestry interests, primarily through browsing damage to plantation seedlings and native forest regrowth.
  - For example, wallabies accounted for approximately 80 per cent of browsing damage on regenerated juvenile trees following forest harvesting in Victoria (1994–1996). In Tasmania, wallabies, pademelons and brushtail possums cause significant stocking losses and adversely impact on tree growth by the browsing of foliage in native forest regeneration less than two years old, and eucalypt and *Pinus radiata* plantation less than one year old. In a survey of a 40 hectare eucalypt plantation without browsing control, 77 per cent of seedlings lost more than 50 per cent of their foliage within 18 days of planting. Bark-stripping of young trees by wallabies is prevalent in 10-20 per cent of 3-5 year-old *Pinus radiata* plantations but mortality resulting from ring-barking (girdling) is rare. The use of 1080 poison and shooting are the most common browsing control methods used in Tasmania.
- Parrots are a serious problem in blue gum plantations in south-west Western Australia. The parrots ring-bark stems and cut off the tips of trees, which seriously reduces their commercial value. Parrots are also sometimes a problem in blue gum plantations in western Victoria and south-east South Australia.

A collated assessment by State and teritory jurisdications of the impact of the major animal pests of forest ecosystems is summarised in Table 60.

Table 60: The impact of animal vertebrate pests on ecosystem health and vitality in forest areas according to State or Territory

Animal vertebrate pests	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
Mammals								
Native								
Dingo (*Canis familiaris dingo*)	3	4	1	3	0	–	1	1
Kangaroos (*Macropus* spp.)	5	3	3	3	3	1	3	1
Pademelons (*Thylogale* spp.)	–	1	–	3	0	4	0	–
Possums	3	1	1	3	1	5	1	1
Rats, native	1	1	3	3/4	0	4	3	3
Wallabies	1	3	3	3/4	3	5	5	3
Exotic								
European red fox (*Canis vulpes*)	5	4	1	5	3	2	3	5
Feral cat (*Felis cattus*)	4	4	4	5	–	1	–	3/4
Feral deer	–	3	1	1	1	2	3	–

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Table 60: The impact of animal vertebrate pests on ecosystem health and vitality in forest areas according to State or Territory

Animal vertebrate pests	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
continued from previous page								
Feral dog (*Canis familiaris*)	3	4	3	3	0	–	1	–
Feral donkey (*Equus asinus*)	–	1	4	1	0	–	0	–
Feral goat (*Capra hircus*)	5	3	1	3	1	2	1	1
Feral horse (*Equus caballus*)	2	3	4	1	0	–	1	–
Hare (*Lepus capensis*)	3	1	–	3	5	–	1	–
House mouse (*Mus musculus*)	3	3	3	3	3	–	1	3
Pigs (*Sus scrofa*)	5	3	5	4	1	–	1	3
Rabbits (*Oryctolagus cuniculus*)	5	2/4	3	3	2/5	4	3	3
Rats, exotic (some *Rattus* spp.)	3	1	3	1	1	0	0	1
Amphibians								
Exotic								
Cane toad (*Bufo marinus*)	–	2	5	5	–	0	0	–
Fish								
Exotic								
Carp (*Cyprinus carpio*)	–	1	–	–	–	2	–	–
Birds								
Native								
Bell miner (*Manorina melanophrys*)	–	4	–	–	–	–	0	–
Brush turkey (*Alectura lathami*)	–	–	–	3	–	–	0	–
Cockatoos (*Cacatua* spp.)	–	–	–	–	–	–	3	–
Parrots	–	–	–	–	–	–	0	5
Exotic								
Blackbird (*Turdus merula*)	5	1	–	–	–	–	1	–
Common Myna (*Acridotheres tristis*)	3	–	–	1	–	–	0	–
Starlings/sparrows (*Sturnus vulgaris*/*Passer domesticus*)	1	1	–	4	–	–	1	–

Source: National Forest Inventory, 2003.
Note: Some pests are perceived to have different impacts in production forests than in conservations forests.
When differing impacts are reported the production forest impact is reported first followed by the conservation forests impact.
0 = Reported present but not problematic
1 = Occurs but is not widespread, has little impact, and requires little or no control
2 = Extent and impact are limited but control measures are intensive
3 = Widespread or having adverse impacts
4 = Widespread and having adverse impacts
5 = Very widespread and having severe adverse impact

Damage caused by wallaby grazing on young blue gum (*Eucalyptus globulus*) seedling

Animal invertebrate pests

Eucalypt forests and plantations are regularly browsed by a wide range of native insects including leaf-chewing chrysomelid beetles, scarab beetles, sawflies, leaf skeletoniser moth larvae, and sap-sucking psyllids (Table 61). Infestations are sometimes severe and repeated. Control programs have been conducted in plantations where attacks may result in reduced growth and damaged form. Except for chronic attacks, eucalypts are generally resilient and able to replace their foliage after infestation subsides.

Where control of severe insect infestations in young plantations is required, insecticides are sometimes used. One of the problems with this approach is that the insecticide can also harm beneficial insects, that is, those insects that reduce the population of the pest through predation or parasitism.

The gumleaf skeletoniser (*Uraba lugens*) causes widespread and locally severe defoliation of natural eucalypt stands in all States across a range of climatic and vegetation types, but generally few trees are killed. In plantations, impacts are not usually severe and control is not necessary. For example, in Western Australia this pest has initially been selected as a target species in the newly implemented FORESTCHECK monitoring program, together with jarrah leaf miner (*Perthida glyphopa*) and bullseye borer (*Phoracantha acanthocera*).

Autumn gum moth (*Mnesampela privata*) catepillar

Stick insect outbreaks, for example, the species *Didymuria violescens*, occur cyclically in mature eucalypt forests in high elevation regions in New South Wales and Victoria where entire patches or hillsides of mature eucalypts—for example, manna gum (*Eucalyptus viminalis*), alpine ash (*E. delegatensis*), and mountain ash (*E. regnans*)—are sometimes totally defoliated. Population monitoring and outbreak predictions are made from monitoring egg numbers in soil and litter.

Christmas beetle infestations occur at the forest/cleared land interface, particularly in river red gum (*E. camaldulensis*) communities in Victoria, but also in blue gum (*E. globulus*) and flooded gum (*E. grandis*) plantations in eastern Australia. These pests are difficult to control and breeding strategies are being developed to produce resistant strains of eucalypt. Prolonged chronic outbreaks of sap-sucking psyllids—for example, in river red gum forests in Victoria—which often involve *Cardiaspina* spp., can result in tree dieback and death.

Wingless grasshoppers cause total defoliation in young eucalypt plantations, particularly during droughts, and have been significant in several States including Western Australia and South Australia. Pest management programs are sometimes necessary.

Pests of exotic pine plantations that can reduce the commercial productivity of these forests include the Monterey pine aphid (*Essigella californica*), and the five-spined bark beetle (*Ips grandicollis*).

The sirex wasp (*Sirex noctilio*) generally attacks stressed pine trees (*Pinus* spp). Wasp numbers sufficiently high to cause significant attack do not generally develop in vigorous healthy stands although this has been know to occur. In South Australia and Victoria between 1987 and 1989, the sirex wasp killed more than five million pine trees with a value of $10–12 million (1989 dollars). The National Sirex Control Strategy program facilitates an integrated pest management approach based on ensuring low wasp populations. This is achieved by the maintenance and release of virulent strains of the introduced nematode *Beddingia siricidicola*, as well as a range of parasitising wasps, as biological controls, and by encouraging optimum plantation thinning practices and site selection to minimise the occurrence of stressed trees in areas at risk. Regular trapping and surveillance programs monitor sirex wasp levels, and controls are implemented to avoid major outbreaks.

The Monterey pine aphid, first observed in Australia in 1998 and able to infest a range of pine species, has since been detected in most pine-growing areas in Australia. Thus far, mild to severe defoliations have been recognised in pine plantations in Victoria, New South Wales and South Australia, but the effects on growth yield are still to be assessed. Aphid levels are regularly monitored in most States using standard foliage beating methods during surveys.

The five-spined bark beetle is a serious pine bark beetle pest accidentally introduced from the northern hemisphere that is able to infest all plantation pine species grown in Australia. The beetle has been present in Australia for at least sixty years. Pheromone traps are used to monitor beetle presence and beetle numbers in some States. Population levels build up primarily on fresh harvesting debris or in damaged or severely stressed standing trees. The beetle is also able to spread harmful blue stain fungi such as *Ophiostoma ips*. A range of parasites has been introduced into Australia to limit beetle numbers.

In 2001, red fire ants (*Solenopsis invicta*) native to South America were found in south-east Queensland. This insect pest has the potential to inhabit large areas of forest in coastal Australia and to cause serious impacts on environment values, agricultural production and, because of their painful sting, human lifestyle. A national surveillance and eradication program, funded by all States and the Australian Government, has been set up to eliminate red imported fire ants from Australia.

Table 61: The impact of invertebrate pests on ecosystem health and vitality in forest areas according to State or Territory

Invertebrate pests	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
Army worms (*noctuids*)	–	1	3	1	0	1	0	1
Autumn gum moth (*Mnesampela privata*)	1	3	–	1	3	3	3	-
Bees	4	0	3	3	0	3	3	3
Beetle, African black	–	1	–	1	0	–	0	?
Beetle, Christmas (*Anoplognathus* spp)	3	3/4	3	3	0	1	3	–
Beetle, five-spined bark (*Ips grandicollis*)	1	1	–	4	4	–	-	3
Beetle, leaf/flea (*chrysomelids*)	–	3	3	4	3	1	3	1
Beetle, longicorn (*cerambycids*)	–	0	–	3	1	1	-	3
Beetle, white fringe	–	1	–	3	0	1	0	–
Beetle, monolepta (*Monolepta australis*)	–	1	–	–	–	–	–	3
Borers	–	3	–	–	1	1	4	3
Budworm	–	0	3	1	0	1	0	1
Cup moths (*limacodids*)	–	3	–	3	1	–	0	–
Cut worm	–	0	–	1	0	–	0	–
Grasshoppers (*acridids*)	1	1	3	5	3	3	1	5
Gumleaf skeletoniser (*Uraba lugens*)	–	3	–	3	1	3	4	1
Gum tree scale (*Eriococcus* spp.)	–	3	–	–	–	1	4	–
Leaf miner	1	0	3	–	1	3	3	5
Lerps (psyllids)	4	2/4	3	3	1	3	5	1

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Table 61: The impact of invertebrate pests on ecosystem health and vitality in forest areas according to State or Territory

Invertebrate pests	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
continued from previous page								
Millipedes	1	0	3	0	0	3	3	–
Monterey pine aphid (*Essigella californica*)	–	1	–	3	–	–	1	–
Mosquitoes (*culicids*)	1	1	3	1/3	0	3	3	3
Saw fly (*Perga dorsalis*, *Pergagrapta bella*)	–	3	–	3	3	1	3	1
Stick insects (*phasmatids*)	1	1	3	3	0	1	3	1
Termites (*Cryptotermes*, *Coptotermes* spp.)	–	0	–	–	0	–	5	3
Tramp ant (*Anoplolepis gracilipes*, *Pheidole megacephela*)	–	0	3	–	–	–	–	–
Wasp, European (*Vespula germanica*)	3	0	3	–	–	4	1	–
Wasp, sirex (*Sirex noctilio*)	3	3	–	1	5	3	2	–
Weevils (*curculionids*)	1	0	3	3	1	3	3	1
Wingless grasshopper (*Phaulacridium vittatum*)	1	1	–	1	3	3	1	1
Spring beetle (*Heteronyx* spp.)	–	–	–	–	3	3	–	–

Source: National Forest Inventory, 2003.
Note: Some pests are perceived to have differing impacts between production forests and conservations forests.
When differing impacts are reported the production forest figure is reported first followed by the conservation forests figure
0 = Reported present but not problematic
1 = Occurs but is not widespread, has little impact, and requires little or no control
2 = Extent and impact are limited but control measures are intensive
3 = Widespread or having adverse impacts
4 = Widespread and having adverse impacts
5 = Very widespread and having severe adverse impact

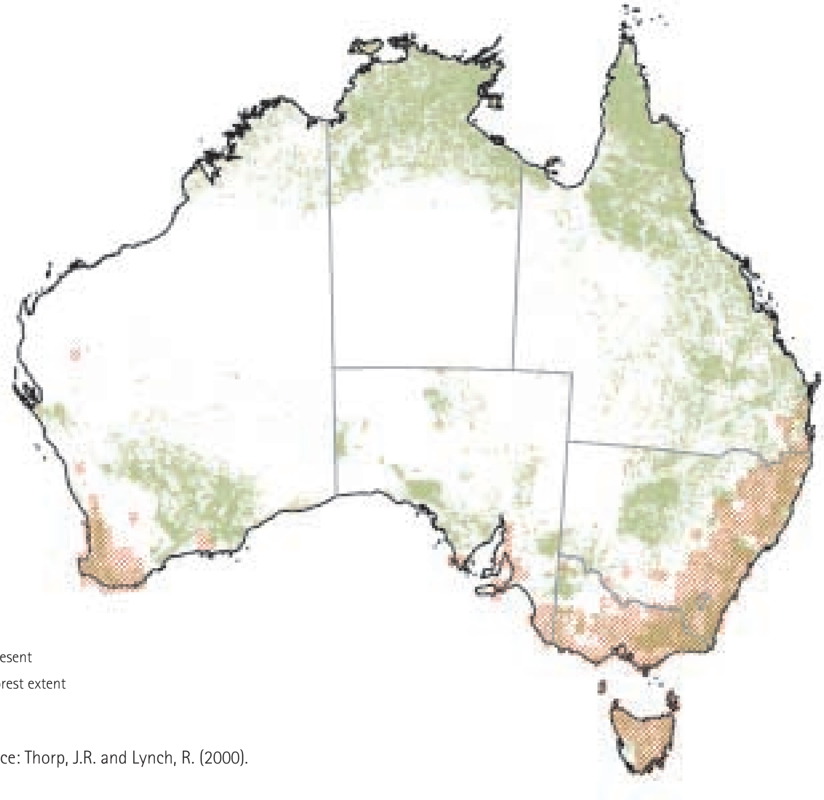
Weeds

Blackberries (*Rubus vulgaris*), gorse (*Ulex europaeus*), lantana (*Lantana camara*) and pampas grass (*Cortaderia* spp.) are examples of exotic plants that have become pests in Australia (Table 62). These species compete with native flora in forests and can reduce biodiversity and other values. These four species are included in the Weeds of National Significance program under the National Weeds Strategy. Pest plants also interfere with crop trees in commercial forest plantations, with concomitant negative effects on human access, tree establishment and growth, and product yield.

Blackberries occur in all jurisdictions, except the Northern Territory (Figure 34). They are the single most widespread pest plant in southern Australia, mainly in regions with annual rainfall of more than 750 millimetres. Current costs and changes in area affected are difficult to calculate, but an estimate of the area affected is 9 million hectares, including non-forested landscapes. Control of blackberry in forests is primarily by spraying with herbicides. Strains of a blackberry rust fungus (*Phragmidium violaceum*), have been introduced into Australia during the past 20 years, but have had limited success as control agents. Victoria has recently implemented an enhanced major long-term strategy for blackberry management and eradication on a statewide basis.

Gorse is more problematic as a weed in Tasmania and southern Victoria than elsewhere in Australia. In Tasmania alone the estimated annual cost of production loss is $1 million and the cost of control and rehabilitation was $700–$1 500 per hectare in 2001.

Figure 34: Distribution of blackberry in Australia



Source: Thorp, J.R. and Lynch, R. (2000).

Lantana infests approximately 4 million hectares, predominantly in the coastal forests and woodlands extending from far north Queensland to southern New South Wales but also occurs to a small extent in parts of the Northern Territory, Western Australia and Victoria. Whole ecosystems and many species are affected and others threatened by this shade-tolerant, invasive pest plant which develops dense shrubby thickets that out-compete native species. Environmental impacts also include major reductions in invertebrate and avian biodiversity. This in turn may increase the severity of crown defoliation dieback in forest overstorey. Lantana is gradually extending further inland. Control measures include introduced sap-sucking insects and fungi that damage leaves. Cutting back the plant, however, results in stimulated shoot proliferation.

Pampas grasses occur as weeds in Victoria, Tasmania, New South Wales, South Australia and Western Australia. National and/or regional weed strategies are in place. In Tasmania a statewide eradication program implemented in 1998 resulted in the removal of tens of thousands of pampas plants.

Other significant exotic pest plants affecting some forest communities include broom and bromes (*Bromus* spp, *Cytisus* and *Teline* spp.), bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*) and boneseed (*Chrysanthemoides monilifera*), and willows (*Salix* spp.). States most affected by exotic broom species are Victoria, Tasmania, New South Wales and South Australia and forest environments are


Michael F. Ryan

Blackberries (*Rubus vulgaris*) in pine forest amongst those invaded. Scotch broom (*Cytisus scoparius*) is particularly invasive across an area of about 50 000 hectares in nature conservation reserve in the Barrington Tops area of New South Wales, and a major protective weed eradication and integrated management program has been implemented.

Bitou bush is listed as a key threatening species in New South Wales. It mainly invades dune vegetation systems, but also encroaches into coastal forest and woodland communities. Biological controls such as bitou tip moth have been used with some success in New South Wales and are part of the management strategy there. Boneseed is more widespread across different environments and is found in southern New South Wales, Victoria, south-eastern South Australia and Tasmania. It is an invader of a range of forest types and is spread by seed. Biological controls have not been successful so far and eradication is by conventional means including fire.

Willows have been recognised as serious invaders of streams within many forested parts of southern Australia; Tasmania, Victoria, New South Wales and the Australian Capital Territory are the most affected. Guidelines for identification and eradication of particular willow species from inappropriate environments have been prepared and implemented in a range of jurisdictions, particularly in the last 5 years. For example, an interstate cooperative program has been conducted for willow removal in the Genoa River catchment in the eastern border region of New South Wales and Victoria. The Tasmanian government has implemented restrictions on the import, sale and planting of particular problematic willow species.

Tall African grasses such as gamba grass (*Andropogon gayanus*) and mission grass (*Pennisetum polystachion*) have particularly severe impacts on forests in northern Australia through their interactions with fire. These species are taller and produce more fuel that cures later than native grasses—hence, they carry higher, hotter flames into the tree canopy, frequently causing tree death.

Strategies to map and collect data on the extent of major environmental weeds in nature conservation reserves in several States are being implemented. As well as being local strategic management tools, such records of weed distribution can facilitate future comparisons and monitoring on a national scale.

Determining the effects of pest plants on productivity and biodiversity on a regional, State or national scale is problematic.

In most forest jurisdictions and land tenures throughout Australia the environmental costs of pest plants have not been quantified and few data are available. Direct total economic costs for the public forestry sector are retrievable, based on annual expenditure on eradication or control measures. Estimates of lost economic productivity are also feasible for clearly defined examples but resolution on a broader scale presents considerable difficulties.

Table 62: Plant pests affecting ecosystem health and vitality in forest areas by State or Territory

Plant pests	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
Bathurst burr (*Xanthium spinosum*)	0	1	1	1	0	2	1	1
Blackberry (*Rubus vulgaris*)	3/4	5	–	3	1	–	5	3
Blackberry (*Rubus fruticosus* agg.)	–	1	–	–	1	5	1	–
Blue morning glory (*Ipomoea indica*)	–	0	–	–	–	–	0	–
Blue-bell creeper (*Sollya heterophylla*)	–	0	–	–	1	0	0	–
Bone seed (*Chrysanthemoides monilifera*)	–	0	–	–	1	4	1	–
Boxthorn, African (*Lycium ferocissimum*)	–	1	–	–	3	2	0	–
Bracken fern (*Pteridium esculentum*)	1	–	–	3	5	4	3	–
Broadleaved weeds	–	0	–	–	–	2	0	–
Calliopsis/coreopsis (*Coreopsis lanceolata*)	–	0	–	–	–	–	0	–
Cape broom (*Teline monspessulana*)	–	0	–	–	1	2	–	–
Cape ivy (*Delairea odorata*)	–	–	–	–	–	–	1	–
Chess or cheat (*Bromus secalinus*)	–	0	–	–	–	–	–	–
Canadian fleabane (*Conza canadensis*)	–	1	–	–	0	–	0	–
Cotoneaster (*Cotoneaster* spp)	–	0	–	–	0	–	0	–
Crofton weed/mist-flower (*Ageratina* spp.)	–	1	–	–	0	–	0	–
Dodder laurel (*Cassytga melantha*)/ Australian dodder (*Cuscuta australis*)	–	1	–	–	0	–	1	–
Eucalypt (*Eucalyptus* spp.)	–	0	–	–	1	0	0	–
Galvanised burr (*Sclerolaena birchii*)	–	1	–	–	–	–	–	–
Gorse (*Ulex europaeus*)	–	1	–	–	1	3	1	–
Grasses, exotic (*Poaceae* spp.)	4	2	4	5	4	2	1	4
Great brome (*Bromus diandrus*), soft brome (*B. molliformis*)	–	0	–	–	–	–	–	–
Groundsel bush (*Baccharis halimofolia*)	–	1	–	–	0	–	0	–
Horehound (*Marrubium vulgare*)	–	1	–	–	0	1	1	–
Lantana (*Lantana camara*)	–	3	1	5	0	–	1	–
Madrid (*Bromus madritensis*), red brome (*B. rubens*)	–	0	–	–	–	–	–	–
Paperbark (*Melaleuca* spp.)	–	0	–	–	0	1	0	–
Mimosa (*Mimosa* spp.)	–	0	3	–	0	–	0	–
Mistletoe	–	0	–	–	0	–	1	–
Noogoora burr (*Xanthium occidentale*)	–	1	1	–	0	–	1	–
One-leaved cape tulip (*Homeria flaccida*)	–	0	–	–		–	0	–
Ox-eye daisy (*Leucanthemum vulgare*)	–	0	–	–	0	–	0	–
Paterson's curse/salvation Jane (*Echium plantagineum*)	–	1	–	–	1	2	1	–
Pines (*Pinus* spp.)	–	1	–	–	1	2	1	–
Prickly pear (*Opuntia* spp.)	–	1	–	–	–	–	0	–
Ragwort (*Senecio jacabaea*)	–	0	–	–	0	2	1	–
She-oak (*Allocasuarina* spp.)	–	0	–	–	0	–	0	–
St John's wort (*Hypericum perforatum*)	–	1	–	–	0	1	1	–

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Table 62: Plant pests affecting ecosystem health and vitality in forest areas by State or Territory

Plant pests	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
continued from previous page								
Stinging nettle/dwarf nettle (*Urtica urens* or *U. dioica*)	–	0	–	–	0	1	0	–
Sweet briar (*Rosa rubiginosa*)	–	1	–	–	0	1	1	–
Sweet pittosporum (*Pittosporum undulatum*)	–	–	–	–	–	–	1	–
Tea tree (*Leptospermum* spp.)	–	0	–	–	0	1	0	–
Thistle	–	1	–	–	1	2	1	–
Tree of heaven (*Ailanthus altissima*)	–	1	–	–	0	–	0	–
Vines, creepers – bridal (*Asparagus asparagoides*)	–	1	–	–	1	–	1	–
Water hyacinth (*Eichhornia crassipes*)	–	0	–	–	–	–	0	–
Wattles (*Acacia* spp.)	–	0	–	–	1	3	1	–
Willows (*Salix* spp.)	–	1	–	–	0	2	1	–
Pasture legumes	–	–	4	–	–	–	–	–
Calopo (*Calopogonium mucunoides*)	–	–	3	–	–	–	–	–
Neem (*Azadirachta indica*)	–	–	3	–	–	–	–	–
Morning glory vines – various	–	–	3	–	–	–	–	–
Castor oil (*Ricinus communis*)	–	–	4	–	–	–	–	–
Candle bush (*Senna alata*)	–	–	3	–	–	–	–	–
Sicklepod (*Senna obtusifolia*)	–	–	3	–	–	–	–	–
Sida (*Sida* spp)	–	–	3	–	–	–	–	–
Snakeweeds (*Stachytarpheta* spp.)	–	–	3	–	–	–	–	–
Gambia pea (*Crotalaria goreensis*)	–	–	3	–	–	–	–	–
Mintweed (*Hyptis suaveolens*)	–	–	3	–	–	–	–	–

Source: National Forest Inventory, 2003.
Note: Some pests are perceived to have differing impacts between production forests and conservations forests.
When differing impacts are reported the production forest figure is reported first followed by the conservation forests figure
0 = Reported present but not problematic
1 = Occurs but is not widespread, has little impact, and requires little or no control
2 = Extent and impact are limited but control measures are intensive
3 = Widespread or having adverse impacts
4 = Widespread and having adverse impacts
5 = Very widespread and having severe adverse impact

Further reading

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Sawfly larvae on eucalypt sampling

Pathogens

Phytophthora species of fungi are a major concern in many forested areas and management plans are in place in most regions. Other fungi are a threat to some plantation species. There are no national figures on areas affected, although mapping has been carried out in Western Australia, Victoria and Tasmania.

Native forests and plantations are affected mainly by indigenous plant pathogens. In plantations of non-native species, however, pests and pathogens are primarily of overseas origin.

Table 63: Distribution of *Phytophthora* spp. in forest areas by State or Territory

	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
Fungi (*Phytophthora* spp.)	4	3	3	5	–	5	5	5

Source: National Forest Inventory, 2003.

0 = Reported present but not problematic

1 = Occurs but is not widespread, has little impact, and requires little or no control

2 = Extent and impact are limited but control measures are intensive

3 = Widespread or having adverse impacts

4 = Widespread and having adverse impacts

5 = Very widespread and having severe adverse impact

The root-rotting fungus *Phytophthora cinnamomi* (and a number of other *Phytophthora* species) kill a wide range of plants in susceptible areas—predominantly regions with more than 600 mm annual rainfall. It has been associated with the death of commercially important eucalypt species, such as jarrah (*E. marginata*) in Western Australia, silvertop ash (*E. sieberi*) in south-eastern mainland Australia, and young plantation Gympie messmate (*E. cloeziana*) in Queensland. However, the most significant impacts are on biodiversity. Quantitative nationwide data are limited in their capacity to clearly distinguish the area and impacts in forests from those in vegetation types such as heathlands.

As many as 2 000 of the estimated 9 000 native plant species in the south-west of Western Australia are susceptible to *P. cinnamomi*. In Tasmania 181 species have been identified as hosts for *P. cinnamomi* and at least 39 threatened species are currently identified as being susceptible to the species. Tasmania further identifies areas for protection from *P. cinnamomi* incursion. *Phytophthora* is listed as a 'key threatening process' under the *Environment Protection and Biodiversity Conservation Act 1999* and a national Threat Abatement Plan for *P. cinnamomi* was released in 2001. Each State has their own approach to *Phytophthora* management under the national Threat Abatement Plan. *P. cinnamomi* spread is controlled through hygiene protocols and management zones for the protection of threatened flora. Forestry, nature conservation reserve 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 designate protectable areas that are free of the pathogen.

A wide range of chronic or periodic crown dieback syndromes, often with significant tree mortality and accompanying impacts on ecosystems occur to some degree in native forests in all States. Dieback is usually of complex origin—associated with combinations of factors such as climatic stresses, land management practices, severe insect attacks, and imbalance in insect predator levels. Pathogenic fungi are not generally the primary factors, but canker-causing fungi—including *Cryphonectria eucalypti* (formerly *Endothia gyrosa*) and *Botryosphaeria* spp.—often have a significant secondary role. Definition of the syndromes and causal agents is often difficult. It is also hard to clearly delineate the affected areas because a wide range of land tenures is involved.

Jarrah (*Eucalyptus marginata*) dieback, south west Western Australia

Rapid expansion of native hardwood plantations in Australia has seen defoliating diseases become more significant. Major outbreaks are infrequent and depend on factors such as local climatic conditions, age and genetic composition of plantations. Few fungal leaf diseases of eucalypts are economically damaging in commercial or environmental plantations, but significant exceptions include several native *Mycosphaerella* spp.—the most serious being *M. cryptica* and *M. nubilosa* in young blue and shining gum (*E. globulus* and *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. Control measures include selection for genetic resistance to these foliar pathogens in plantations. Such diseases are less debilitating in natural forests and woodlands, where inoculum levels are usually low.

In cool temperate rainforest and mixed forest in Tasmania and Victoria, myrtle wilt disease—caused by the native pathogenic fungus *Chalara australis*—attacks myrtle (*Nothofagus cunninghamii*), through wounds in stems and branches. Although, myrtle wilt disease is widespread in undisturbed forest, damage to trees associated with road-building and harvesting can increase the activity of this disease.

Root and butt rots caused by *Armillaria* spp., most significantly *A. luteobubalina*, in eucalypt forest predominantly in southern Australia, cause small patch deaths of a range of plant species. *Ganoderma* spp., *Rigidoporus vinctus*, and *Phellinus noxius* in Queensland kill a low, but increasing, percentage of trees in a similar way. Species affected include young hoop pine (*Araucaria cunninghamii*), rainforest species, eucalypts and acacias—especially in regrowth forests or second rotation plantations.

Acacia species in a wide range of land tenures and forest ecosystems are affected by species of the native gall or phyllode rust fungi *Racospermyces* and *Uromycladium*. These can cause severe defoliation, affect tree form, and even cause death. Impacts in natural stands are usually small, whereas in plantations—for example of *Acacia mangium* in northern Australia—severe levels of phyllode rust have warranted investigations for disease resistance.

In areas where climatic, topographic and stand conditions are suitable, the exotic needle-cast fungus *Dothistroma septospora*, first recorded in Australia in 1975, is able to cause severe needle loss in *Pinus radiata* plantations up to 15 years of age. The northern tablelands of New South Wales and small areas in south-eastern Queensland are worst affected, but the disease is also sometimes significant in the tablelands of southern New South Wales and in north-eastern Victoria. Thinning of stands is used as an ameliorative measure, but aerial spraying with low concentrations of copper-based fungicide is occasionally undertaken. The disease is absent from South Australia and Western Australia and, although present, causes little damage in Tasmania. Relatively little significant needle blight has occurred during the past 5 years because of drought conditions over much of the *P. radiata* estate. Planting of disease-resistant stock is currently undertaken to reduce disease impacts in highly prone locations in northern New South Wales. The fungus *Sphaeropsis sapinea* is associated with top death and occasional mortality of *P. radiata*, usually on drought-prone sites and needle-cast associated with the fungi *Cyclaneusma minus* and *Lophodermium* spp. also occurs in many *P. radiata* growing regions.

Mundulla yellows have the potential to have significant impact on eucalypts, having been associated with the death of trees within several species. The disease occurs in both old and young vegetation. Research is underway to identify the cause of Mundulla yellows. It is unknown whether the cause is pathogenic.

River regulation

River regulation, usually by means of dams, is widespread in Australia. Rivers are regulated for irrigation, hydroelectric generation, urban and rural water supply, or diversion to other catchments. This can have dramatic impacts on water quality and quantity and hence the values of forests reliant on periodic flooding.

Michael F. Ryan

Case study: Murray-Darling River system

Australia's largest river system, encompassed by the Murray-Darling Basin, drains an area of more than one million square kilometers across five different states and territories in eastern Australia. The States and Territories are Queensland, New South Wales, the Australian Capital Territory, Victoria and South Australia. The Murray-Darling Basin accounts for 30–40 per cent of Australia's total primary production. Almost 2 million people live in the Basin and it supports more than 4 million people beyond its boundaries.

River regulation within the Basin can significantly affect water flow, natural inundation cycles and water quality. It has reduced the outflow of the Murray-Darling River system from a mean of 13 700 gigalitres per year to 4 900 gigalitres per year. About 90 per cent of the water is used for irrigation.

The Barmah and Millewa group of forests, in the floodplain of the River Murray, cover an area of approximately 70 000 hectares, forming the largest river red gum forest in Australia. Contained within these forests are 3 300 hectares of wetlands. When construction of the Hume Dam was completed in 1936, flooding patterns within the forest changed drastically and unseasonal and unnatural wetting and drying patterns significantly affected plant and animal communities.

As a result of this impact, a water management strategy has been developed for the forest with the aim to enhance forest, fish and wildlife values whilst limiting adverse effects on other areas. An annual Environmental Water Allocation of 100 gigalitres is used to supplement natural floods to encourage breeding of forest flora and fauna.

River red gum (*Eucalyptus camaldulensis*) regeneration at high flood level, Barmah State Forest, Victoria

Climatic events

Drought

Australia is the driest inhabited continent and also experiences extreme variability of rainfall over much of the country. Droughts somewhere in the country are frequent and many continue for several years. The most drought-prone regions are the marginal areas away from the coasts and ranges.

Drought stresses native forests directly and causes production losses in native and exotic timber plantations. It is also a frequent precursor to fires, dust-storms, and general land degradation. Additionally, drought-stressed flora are more susceptible to pests and diseases, and suffer increased browsing pressure as food sources become scarce for fauna in the affected regions.

During late 2002, drought stress was associated with a marked increase in the extent and severity of chronic eucalypt decline in coastal New South Wales. At the same time there was extensive 'drought scorch' of trees and stands, especially on skeletal soils over rock, on the south coast. Although there was some overlap, the accelerated decline was mostly on somewhat sheltered slopes, whereas drought scorch was mostly on exposed ridgetops. Drought scorched trees recovered rapidly. In central Queensland large areas of eucalypt-dominated forest experience extensive canopy die back and death associated with the periodic (30–50 years) occurrence of major periods of drought.

Wind damage

There is no formal means of collecting information on wind damage across Australia. However, damage in forest plantations is monitored through systematic forest health surveys and some areas in northern Australia collect data on cyclone damage to native forests. The Australian Government Bureau of Meteorology monitors and reports significant climatic events and may include information about wind damage to forested areas. Cyclones and tornados can cause catastrophic incidents of wind damage to forests. Less forceful winds may still blow out the young growing shoots of trees, causing bud loss, flattened crowns and unwanted forking. This is particularly prevalent at higher altitudes and in exposed areas.

Storm damage in manna gum (*Eucalyptus viminalis*) forest, Braidwood, New South Wales

Clearing

Forest clearance has direct and indirect impacts on landscape and ecosystem health. Clearance and associated habitat loss is the most significant threat to species and ecosystems in eastern Australia. In addition forest clearing impacts on a range of other values including run-off and infiltration rates, soil compaction and associated soil erosion, salinisation and soil acidification.

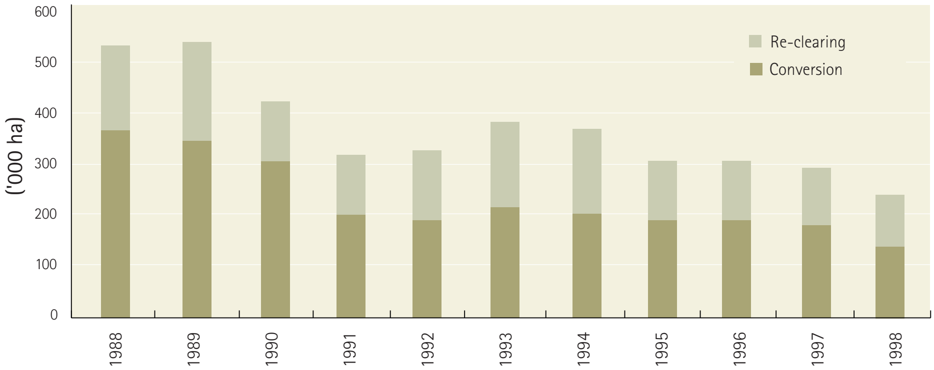
About 40 per cent of Australia's native forest has been cleared to make way for settlement, agriculture and grazing. Forest clearing records suggest that the annual rate of clearing has declined from 0.54 million hectares in 1988 to 0.24 million hectares in 1998 (Figure 35). Over the period 1991 to 1995, 77 per cent of the land cleared (irrespective of vegetation cover) was for pasture development, principally in Queensland, although smaller areas in other States and Territories were also cleared. The majority of this land clearance occurs on privately managed land—freehold and leasehold—and mostly within the more open woodland forest types. A recent survey by the Queensland government identified a significant increase in land clearing in Queensland in 1999–2000, which was then followed with a return to a near 10-year average rate of land clearing in the following year.

While State and Territories have constitutional responsibility for the management of natural resources, they are signatories with the Australian Government to a number of national statements on native vegetation clearance, including the National Framework for the Management and Monitoring of Australia's Native Vegetation, the Intergovernmental Agreement on a National Action Plan for Salinity and Water Quality, and the framework for the extension of the Natural Heritage Trust.

State government agencies are now establishing plantations on cleared agricultural lands in preference to areas covered by native forest. In Tasmania some plantations continue to be established on land cleared of native forest, in accordance with State undertakings in the Tasmanian Regional Forest Agreement. Australia-wide, the majority of the current plantation estate is on land previously used for agricultural purposes, 20 per cent is second rotation plantings on land previously under plantation and 21 per cent is on land that was converted from native forests for plantation establishment. These latter areas were planted prior to 1990. Reforestation of harvested areas for public multiple-use native forests is now a requirement in all State and Territory codes of forest practice.

All governments have agreed to reduce the national rate of land clearance to zero—meaning that the area of native communities cleared per year should not exceed the area being revegetated as native vegetation communities over the same period—to prevent land-clearing that might lead to unacceptable land and water degradation, and to prevent the clearing of endangered or vulnerable vegetation communities or critical habitat for threatened species. Most States and Territories now have legislation in place that regulates the clearing of native vegetation on all land tenures.

Figure 35: Annual clearing of forest cover by year



Source: Australian Greenhouse Office (2002)

Note: Conversion is the clearance of forested areas to clear land for farming activities; re-clearing is the clearance of regrowth from areas that have previously been cleared

Case study: Queensland land clearing moratorium—a landmark decision

In the period 1991 to 1995 over two-thirds of land clearance in Australia occurred in Queensland. The clearing of vegetation on freehold, leasehold and other State land in Queensland is regulated through a permit system that aims to conserve native remnant vegetation and ensure that clearing does not contribute to land degradation. In most cases a permit is required to undertake any clearing of remnant vegetation, however, a number of exemptions apply as to when a permit is not required, for example, to maintain existing fences and other infrastructure.

Persons caught clearing illegally without a permit may be prosecuted and if found guilty may be required to revegetate the illegally cleared areas and be disqualified from applying for a clearing permit for 5 years. Re-vegetation orders also attach to the land and bind successors in title.

In May 2003, the Queensland government announced a halt on the acceptance of new applications for clearing permits while they and the Australian Government negotiate with key stakeholders on a proposal to further reduce the current rate of clearing. The proposal involves phasing out broadscale clearing by 2006 and providing a financial assistance package for affected landholders.

The halt does not affect exemptions or existing permits. It also allows applications to continue to be accepted for certain activities, such as clearing for weed control or public safety.

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Grazing

There were no hoofed animals in Australia before Europeans arrived, and the subsequent introduction of these animals at high stocking densities has caused land degradation in many parts of the country. The impact of domestic stock—mainly sheep and cattle—on forests includes changes in structure and composition, particularly in ground layers, loss of biodiversity and degradation of soil. Grazing also has considerable indirect impacts on ecosystem health, especially in drier areas, through the impact that grazing animals have on fuel loads and hence fire regime.

Grazing in multiple-use forests is managed in similar ways in all States and Territories. Queensland serves as an example. Grazing in nature conservation reserves is generally against the legislation and policies of conservation agencies. Grazing predominantly occurs on private or leasehold lands. In Queensland, cattle are currently grazed in the south-eastern part of the State, either under a Stock Grazing Permit (SGP) or a Term Lease. SGPs are issued by the Department of Primary Industries (DPI) Forestry on multiple-use forests for a period not exceeding seven years and provide greater management control than Term Leases. Most of the areas of forest on freehold and leasehold lands are grazed by domestic stock. State agencies have a variety of regulatory and non-regulatory programs to address the impacts of overgrazing and associated degradation. Grazing by domestic stock is generally prevented in nature conservation reserves by legislation and/or policy.

Sheep grazing in woodland

Salinisation

Dryland salinity is a widespread and rapidly growing problem in Australia. It occurs predominantly on cleared agricultural land but can also affect adjacent woodland forests. One contributing factor to salinisation is the widespread clearing of deep-rooted native tree species, which has resulted in rising water tables mobilising salt in the soil. The increased salt concentrations and waterlogged soils stresses or kills plants. An estimate of the area of land affected by induced salinity was conducted in 2000 during the National Land and Water Resources Audit (Table 64) but focussed predominately on agricultural land, as forested land was considered to be at minimal risk.

Biodiversity is under threat from salinisation in some areas. In Western Australia, an estimated 16 per cent of the south-western agricultural region is affected by salinity threatening 450 endemic plant species with extinction.

Reforestation in salinity-affected and salinity-prone areas is frequently cited as an appropriate means of addressing the salinity problem. Blue gum plantations in the south-west of Western Australia have had some success in this respect (see case study). At the same time, the impact of large-scale afforestation can vary widely. While reforestation may be effective against dryland salinity, in the same area it can potentially increase river salinity levels until the hydrological regime achieves a new equilibrium.

Table 64: Area of land ('000 ha) with a high potential to develop induced salinity in Australia

State/Territory	1998–2000	Predicted 2050
Australian Capital Territory	Minor	–
New South Wales	181	1 300
Northern Territory	–	–
Queensland	48	3 100
South Australia	390	600
Tasmania	54	90
Victoria	670	3 110
Western Australia	4 363	8 800
Total	5 658	17 000

Source: National Land and Water Resources Audit, 2000.

Case Study: Commercial reforestation to control salinity in Western Australia blue gum plantations

In Western Australia, induced salinity is the State's biggest environmental threat. It is estimated that 30 per cent of the 18 million hectares of cleared farmland in south-west Western Australia needs to be returned to perennial vegetation to control salinity. This push for revegetation has provided an opportunity for new industries in rural areas and has had a major impact on reversing land degradation.

The State's Forest Products Commission (FPC) has coordinated the blue gum program. Unlike earlier plantation programs that were developed on Government land to supply local industries, the blue gum program started with the combined objectives of meeting world demand for wood fibre, and helping to solve serious land degradation problems without the requirement of purchasing land for plantation establishment.

Blue gums (*Eucalyptus globulus*) are one of Australia's fastest-growing native trees, well suited to Western Australian conditions. An intensive breeding program by FPC scientists has developed the Western blue gum that produces premium wood fibre for the paper industry.

The FPC demonstrated the potential of blue gum crops to landowners and investors by planting 4 000 hectares on farms along the west and south coasts of Western Australia in 1988 and 1989. This generated significant interest and investment from private investors within Australia and internationally. Blue gum plantations in the Albany region provided $46 million directly and indirectly in wages and other income in 1997.

By the end of 1998, the Government and private investors had established 100 000 hectares of blue gums across hundreds of south-western properties. FPC predicts that by the year 2020, 800 000 hectares of tree crops will be established on Western Australian farms.

Trees affected by salinity on the shores of Lake Dumbleyung, Western Australia

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Soil acidification

Slow soil acidification is a natural process in some areas, but is largely balanced by deposition of plant material and organic matter in the soils. Australia's soils are old and highly weathered and can be naturally quite acidic on the surface as well as deep in the profile. Surface and subsoil acidity exists in all States and Territories and affects an area up to nine times that of dryland salinity. The largest areas of acid soils are in New South Wales, Western Australia, Victoria and Queensland.

Accelerated soil acidification is a serious soil degradation problem. When land is developed for agriculture or forestry the combination of disturbance and changes to the nitrogen and carbon cycles causes soil acidification rates to increase. When soils and sediments that contain iron sulfides are drained or disturbed, sulfuric acid is formed. The impact of forest plantations on soil acidity has yet to be examined.

There is a national strategy for the management of acid sulphate soils which involves risk mapping; avoiding disturbance of coastal acid sulphate soils; education of the agricultural sectors; policy, planning and development strategies; mitigating impacts when disturbance is unavoidable; remediation in the form of neutralisation of acid; revegetation of acid scald areas; and modification of drains and floodgates.

Mining

The extent of forest areas affected by mining exploration is exemplified by a case study for Victorian box-ironbark forests, while a Western Australian case study illustrates the requirements and controls that generally apply to mining exploration.

Case study: Box-ironbark forests in Victoria

A draft report on gold mining in the box-ironbark ecosystems of Victoria assessed the level of disturbance in forested areas contributed by mining operations. The survey was based on a sample of 185 mining tenements active sometime during the period from 1976–1996, covering an area of approximately 11 900 hectares.

The study identified disturbance on 108 tenements (58 per cent). The area disturbed by mining was estimated to be about 1 000 hectares, or 0.4 per cent of the total box-ironbark ecosystems on public land (about 254 300 hectares). Of the disturbed area, 140 hectares was classified as highly disturbed or un-recoverable to the original condition of the Ecological Vegetation Class, mainly due to tailing dams (60 hectares) and open cut voids (70 hectares).

Source: Environment Conservation Council (2000).

Case study: Mining exploration in Western Australia

In Western Australia, the *Mining Act 1978* requires the agreement of the Minister for the Environment and Heritage before access is given to multiple-use forest and timber reserves, nature conservation reserves or A class nature reserves. In A class parks and reserves the approval of both houses of Parliament is required before Mining Leases and General Purpose Leases are granted and mining can occur.

All proposals for operations that may potentially cause a significant environmental impact must be referred for the consideration of the Environmental Protection Agency (EPA) under section 38 of the Western Australian *Environmental Protection Act 1982*.

Mineral exploration is conducted on exploration licences or prospecting licences. These are granted with rigorous conditions to protect the environment, specific to the nature of the land, and are designed to ensure that the activities do not cause unacceptable impacts.

Currently, major developments are usually facilitated through State Agreements that are ratified by Parliament as State Agreement Acts. These Acts relate to bauxite and coal extraction. While these Acts are not subject to the *Conservation and Land Management Act 1984*, they include requirements to protect forest values and facilitate recovery of harvestable timber before mining. The projects are subject to environmental assessment by the EPA and ongoing activities are reviewed by inter-agency environmental review committees. Rehabilitation of forest values after mining and the re-establishment of sustainable productive timber harvesting is a key goal of these committees. It has been usual for companies to pay compensation to the EPA based on areas affected. This is intended to pay for the loss of productive timber from affected areas and to cover the costs incurred in supervisory or inspection activities by EPA officers.

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Climate change

An assessment by the CSIRO in 2001 estimated that most of Australia will warm 0.4° to 2.0°C by 2030, and 1° to 6°C by 2070 (Figure 36), with slightly less warming near the coast. This is expected to result in:

- more evaporation, more hot days and fewer cold days
- rainfall decreasing in the south and east (mainly winter/spring)
- some inland and eastern coastal areas experiencing wetter summers
- some inland areas becoming wetter in autumn
- extreme rainfall and tropical cyclones becoming more intense.

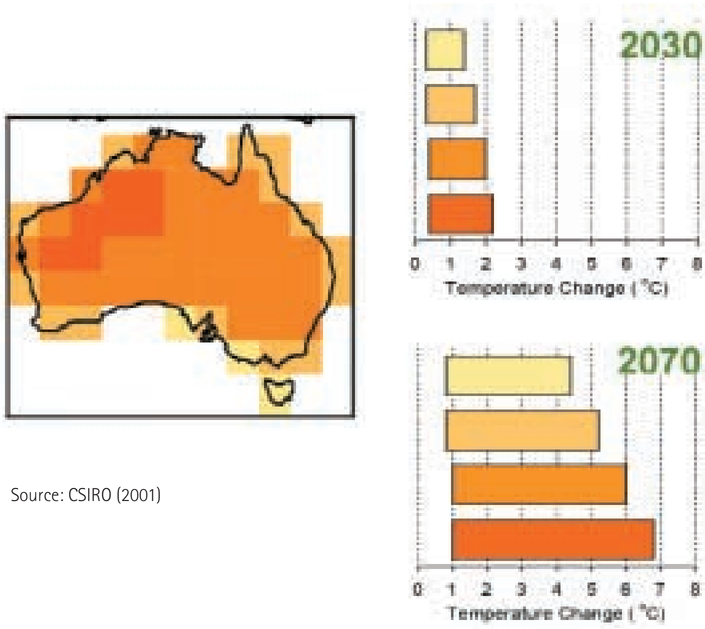
Overall this means that less water will be available.

Future forest productivity will depend on the balance between the benefits of increased carbon dioxide and the patterns of change in rainfall and temperature. A doubling of carbon dioxide with a warming of 3°C and no rainfall change, possible by 2070, would increase tree growth across much of southern Australia, particularly in the wheat belt and semi-arid regions. Increases are likely to be more marked (25–50 per cent) in southern Australia near the more marginal wheat-growing areas and the fringes of the pastoral zone.

However, a reduction in winter and spring rainfall in southern Australia (Figure 37), and increased fire frequency, would offset some of these benefits. The benefits will also be affected by changes in pests and in the longer term by limited nutrient supply. Modest increases (0–25 per cent) in tree growth are likely to occur in parts of the semi-arid tropics. However, in the monsoon tropics of far north Queensland, the Northern Territory and the north of Western Australia, the adverse effect of warming on tree growth will more than offset the gains from a doubling of carbon dioxide, leading to declines of 25–50 per cent in tree growth. Anticipating the changes up to several decades ahead might assist Australia's forest planners and managers to establish plantations in areas where the climate conditions will be suitable for the life of the trees.

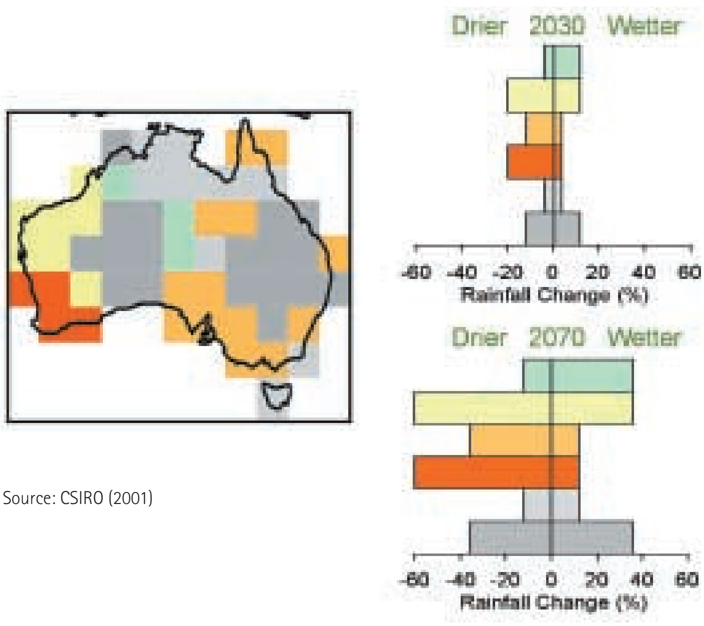
Changes in climate will be associated with changes in fire region. Future climates are expected to affect the components of forest ecosystems differently. A landscape study of refugia and future climate in the tall, wet forests of the Central Highlands of Victoria provides a model for the integrated investigations that are needed for other regions.

Figure 36: Projected changes in annual temperature



Source: CSIRO (2001)

Figure 37: Projected changes in annual average rainfall



Source: CSIRO (2001)

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Air pollution

coverage
currrency
frequency

Indicator 3.1b

Area and per cent of forest land subjected to levels of specific air pollutants (e.g. sulphates, nitrate, ozone) or ultraviolet-B radiation that may cause negative impacts on forest ecosystem health and vitality

Rationale

Changing atmospheric constituents have the potential to affect forest ecosystem health, particularly where forests occur in high risk areas, such as downwind from certain industries.

Compared to much of the northern hemisphere, air quality is good across most of Australia most of the time. The global phenomenon of increased ultraviolet irradiation due to stratospheric ozone depletion is likely to affect all vegetation to a certain extent. Acid rain is not a problem in Australian forests. Risks to ecosystem health and vitality are greater near major metropolitan areas, and around particular industrial plants in more remote areas.

Changing atmospheric constituents have the potential to affect forest ecosystem health, particularly where forests occur in high risk areas, such as downwind from certain industries or cities.

Air pollutants occur on a range of temporal and spatial scales. Assessing the impacts on forests of pollutants from a point source requires intensive monitoring of both emissions and forest health not currently undertaken in Australia. The National Pollutant Inventory (NPI) requires industries generating more than specified amounts of polluting substances to report on their emissions, however, there are no long-term data for the impact of these emissions on Australian forests. The major pollutants that could have an impact on parts of Australia's forests are photochemical smog, sulphur dioxide, fluorides and increased amounts of ultraviolet-B radiation resulting from ozone depletion in the stratosphere.

Photochemical smog has the potential to impact on local and regional scales depending on climatic conditions, such as prevailing winds, and the topography of the land. Photochemical smog is formed when emissions of nitrogen oxides and hydrocarbons (mainly from vehicle emissions) react with sunlight to form ozone (O_3). Fine particulates—less than 10 micrometres in diameter—and other noxious chemical emissions are also of concern and may become trapped in smog layers or caught in naturally occurring inversion layers forming in valleys. The constituents of most concern in smog are ozone, which is highly reactive with all biological materials, causing disruption of cell membranes and oxidisation of nitrogen. At low levels plants are able to assimilate nitrogen oxides and growth may be enhanced, but at higher concentrations, growth is inhibited.

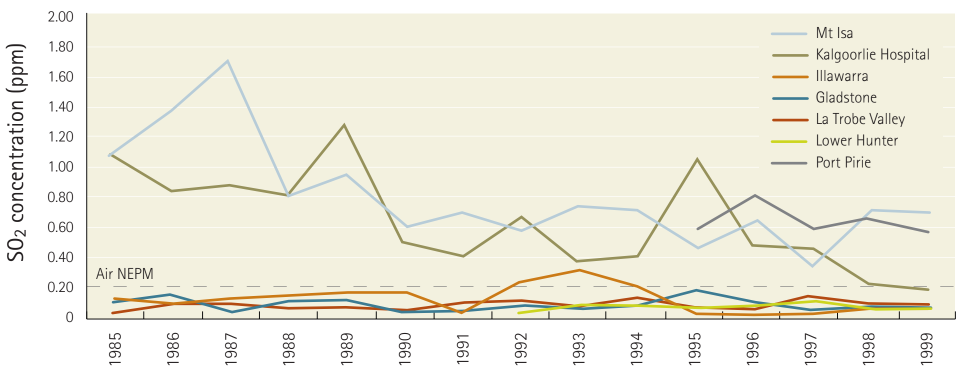
Fine particulates may also affect plants through deposition on leaves and possible blockage of stomata. In addition, metropolitan air contains so-called 'air toxics', which are organic compounds that are known or suspected to damage animal, and possibly ecosystem, health if present in sufficient quantity.

Sulphur dioxide (SO_2) is another emitted pollutant of concern. This can come from coal-fired power stations (if the coal being used has a high sulphur content), from desulphurisation of metals and from vegetation burning. It reacts with water in the atmosphere to form sulphuric acid (H_2SO_4), which is the chief constituent of acid rain. The gas can also be absorbed by leaves and reacts with moist surfaces within foliage to form sulphurous acids. These compounds dissociate to toxic ions which damage the photosynthetic apparatus resulting in yellowing, necrosis and leaf drop. Acid rain can reduce pH in soil and water bodies, and affect the function of plant roots and, in severe cases, leaves. In general, Australia's urban areas are free of this problem, but certain operations in other locations—such as ore-roasting—may release sulphur dioxide. Acidic rain can also fall naturally at times, for example, after bushfires and because of the release of formic acid from vegetation in northern Australia.

Air emissions from an industrial processing plant

Industrial processing facilities are the main sources of airborne fluoride, especially aluminium smelters and steel plants. There are six aluminium smelters located in eastern Australia, one of the largest and most modern being at Tomago in the Hunter Valley, New South Wales. Eucalypts growing in the vicinity of aluminium smelters can be susceptible to damage and there are significant differences in susceptibility between individual species. Excess fluoride inhibits photosynthesis and respiration, causing yellowing and in some species, reddening of leaves. At Tomago approximately 99 per cent of emissions are removed before release of residual fumes into the atmosphere and monitoring of native vegetation for fluoride levels is carried over a radius of 20 kilometres from the point source. However, not all industrial activities meet such high standards, and air pollution exceeding national environmental protection measures (NEPMs) occurs in the vicinities of mining towns, for example, Mount Isa, Kalgoorlie and Port Pirie (Figure 38).

Figure 38: Highest one-hour averages of sulphur dioxide since 1985 in regional centres of Australia



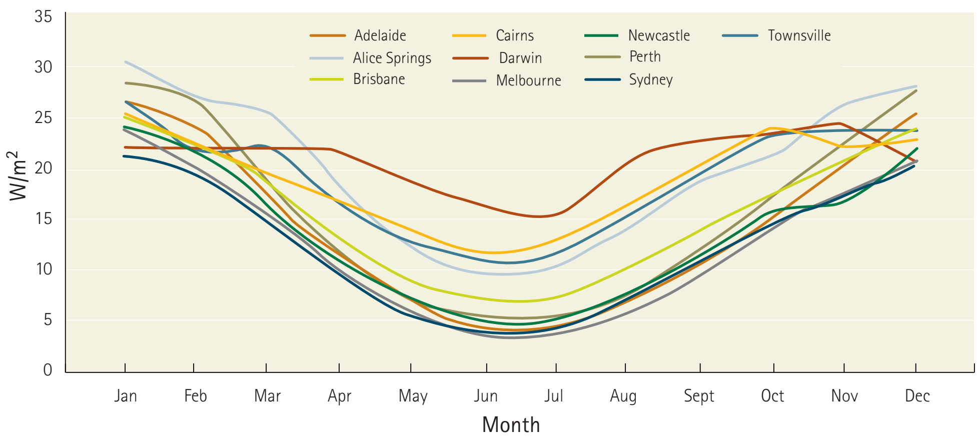
Source: Manins *et al* (2001)

Ultraviolet-B (UV-B) radiation

Reduced concentrations of ozone in the stratosphere have allowed increased penetration of UV-B radiation to ground level. The intensity of irradiation varies with latitude and cloud cover, being greater closer to the equator and in areas with reduced cloud cover. The change in UV irradiation following stratospheric ozone depletion is greatest for temperate latitudes, while the absolute amount of UV received remains greatest in equatorial latitudes.

Irradiation with UV-B can cause cellular damage in plants, thereby reducing productivity. As species can be expected to vary in their sensitivity to irradiation, there could be secondary effects on forest ecosystems as inter-species competition may be altered. Although UV-B exposure in Australia is known to have increased in the last decade (Figure 39), there have been no reports of significant impacts of UV-B radiation on forest species and ecosystems.

Figure 39: Total daily average biologically effective UV radiation in major Australian centres weighted to UV-B 1996–2002



Source: Australian Radiation Protection and Nuclear Safety Agency

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Changes in forest ecology as indicated by changed biophysical and chemical components

coverage
currrency
frequency

Indicator 3.1c

Area and percentage of forest land with diminished or improved biological, physical and chemical components indicative of changes in fundamental ecological processes

Rationale

This indicator is useful because it provides a measure of the status of fundamental ecological processes that underpin the maintenance of ecosystem health and vitality.

Little information is available on changes in areas and percentages of biophysical components. However, research is underway on ways of assessing conditions such as eucalypt crown dieback and on possible causes.

This indicator provides a measure of the status of fundamental ecological processes that underpin the maintenance of ecosystem health and vitality. Compared to most of the ecosystems that characterise Australian landscapes, forests rarely display the chronic degrading processes such as salinisation, acidification or water erosion on a large scale. By comparison, agricultural woodlands and retained trees in paddocks in many rural regions—especially the wheat–sheep belt of southern and south-western Australia and irrigated areas of the Murray-Darling Basin—are often in poor health. Tree planting in these areas is an integral part of catchment management initiatives.

Forested lands have been subjected to widespread and selective clearing and have changed substantially in area and composition over the past 200 years. In terms of the condition of the tree layer and with some notable exceptions, the remaining native forests and the expanding plantation estate are generally in a healthy condition. Fires, storms, drought, diseases and pests cause intermittent and sometimes severe damage—however, native vegetation is well adapted to respond to such events, and affected forest sites usually regrow or are recolonised. Unless particularly frequent, these events generally have little effect on the longer term vitality of native forests and are reported on under indicator 3.1a. However, other factors such as harvesting and agricultural practices, grazing and fire regimes have had a broad impact on floristic and structural characteristics of forests and associated habitat values and ecological processes. These latter issues are also reported on under indicator 3.1a.

Information on deterioration in the health and vitality of Australia's forests is almost entirely based on changes in tree health, usually canopy condition. At a workshop held in Canberra in 1980, all States with the exception of the Northern Territory reported localised declines in the health and vigour of their forests and woodlands, characterised by symptoms of eucalypt crown dieback and eventually widespread tree death. Some of these conditions have been related to drought, disease or insect attacks, others remain unexplained or of complex causes. Some attempts have been made to map the occurrence of eucalyptus dieback on a continental scale, but the heterogeneity of data, the variety of causes and lack of spatial information limit the usefulness of this information for national reporting.

Changes in the forest ecosystem, to the extent that deterioration occurs in fundamental ecological processes, are likely to be long-term and require indicators that can be monitored at appropriate temporal and spatial scales. The area requiring such monitoring is very large, more than 16 million hectares, often encompassing some of the most rugged terrain of our continent. Considering the predominance of eucalypts in Australian forest communities, indicators based on eucalypt crown condition appear to offer the best opportunity for reporting on forest health and vitality. Indicators derived from additional components of the ecosystem, for example responses of functional groups of the forest biota, could be built in at some future date. Currently no State has the capacity to monitor the health and vitality of forest ecosystems on this scale and suitable indicators are still being developed for future reporting.

Australia is in the process of developing remote assessment capabilities for data collection on this indicator (3.1c). Changes in tree crown condition integrate responses of vegetation communities to a wide range of environmental influences—physical, biological and anthropogenic—and are quite generic across eucalypt species and forest types. Assessments of degrees of crown dieback in plantations and some high value native stands have been used to assess impacts of drought and disease, but they require intensive observation by trained staff and are not suited to broad-scale native forest monitoring. Also, national standards for reporting on levels of damage sustained by tree crowns in plantations affected by pests and diseases are only now under development.

Advances in acquisition and processing of remotely assessed data from airborne or space platforms appear to offer solutions appropriate to the scale and diversity of the native forest resource. A research program, initiated by State Forests New South Wales and CSIRO Forestry and Forest Products, with additional funding from the Australian Government, has developed an indicator designed to meet the needs of State of the Forests reporting. The indicator does not identify cause and effect relationships, but aims to assess crown condition efficiently and objectively so that deterioration or recovery of forest health can be detected over time.

The Eucalypt Crown Condition Indicator

Canopy of Karri (*Eucalyptus diversicolor*) and Jarrah (*Eucalyptus marginata*) forest, south west Western Australia

The Eucalypt Crown Condition Indicator incorporates physiological and structural changes in eucalypt canopies and was developed at a research site in coastal tall, mixed species eucalypt forest at Olney State Forest south of Newcastle, New South Wales, a portion of which is severely affected by so-called ‘bellbird dieback’ (see case study). Eucalypt forest decline, often with bell miner ‘invasion’, occurs in patches of eastern coastal forests from Victoria to southern Queensland. It is estimated that there are now 10 000 hectares of native forest affected by the syndrome and the problem is spreading. The chosen area of forest was traversed at low altitude by a fixed wing aircraft bearing a high resolution spectrometer, which collected digitised reflectance images in selected narrow wavebands of the visible and infra-red spectra. An existing comprehensive dossier of information on the crown condition of individual trees made it possible to relate the reflectance of tree crowns to canopy health. Spectral indices were derived which could be correlated with leaf, shoot and branch characteristics of individual tree crowns. Methods were then developed to aggregate information from trees across several hectares of diseased and healthy forest to provide an accurate picture of the extent of dieback.

A derivative of this approach has been used successfully to assess impacts of a long established psyllid outbreak on mountain ash (*Eucalyptus regnans*) in the Central Highlands of Victoria. Research in progress seeks to reduce the costs of acquisition of remotely-sensed data and to enable this form of spatial information to be integrated into GIS-based forest management. Research has also been extended to include remote assessment of the health of pine plantations in southern New South Wales. Acceptance of the approach and its incorporation into future State of the Forests reporting will depend on further proving its application to a range of forest types with significant health problems, and the availability of suitable spectrographic equipment and air- or space-borne platforms and cost–benefit factors.

Case study: Bellbird dieback—an example of forests in decline

One of the pleasures of visiting Australia's coastal forests from southern Queensland to East Gippsland, Victoria, is hearing distinctive call of native bell miners (*Manorina melanophrys*) (also known as bellbirds), often near a creek where rainforest elements mix with eucalyptus overstorey. These native, insectivorous birds seem to prosper where forests are opened up by walking or logging tracks, especially if dams or creeks are nearby. The patches of forest in such valleys often contain some of our fastest growing and valuable timber species, like Sydney blue gum (*Eucalyptus saligna*), black butt (*E. pilularis*), flooded gum (*E. grandis*), angophoras or turpentine (*Syncarpia glomulifera*).

Unfortunately considerable areas of these forests are affected by severe crown dieback, which appears to signify a fundamental change in the vitality and sustainability of the vegetation community. Some dominant tree species, such as Sydney blue gum which occurs from the south-east forests of New South Wales to Queensland, suffer extreme insect defoliation, leading eventually to crown decline and tree death.

The common feature of such dieback patches is a large increase in the population of the native bell miner. They live in colonies of up to 200 individuals and occupy patches of forest extending to several hectares. Bell miners are very aggressive individuals and chase other insectivorous birds from the area. Research has suggested that the loss of most bird species from these areas triggers very high populations of leaf-attacking insects to establish. Foremost among these are psyllids, a family of sap-sucking species endemic in native forests. Sydney blue gum appears to be particularly attractive to psyllids, and 16 different psyllid species have been found on this tree in only two study sites in New South Wales.

Several other factors may contribute to this problem—for example, climate variation, site quality, burning practices, harvesting history and other forms of site disturbance. Indeed, the bell miner 'invasion' is likely to prove a symptom rather than a cause of the dieback. Further research is needed.

Nevertheless, the association of bell miners with this form of dieback and the undoubted contribution of insect damage to the disease seem to be two critical factors. At present no control measure has been developed that is consistent with the multiple-use objectives of these highly valuable mixed eucalypt forests. Remotely assessed methods of data acquisition as described here provide the opportunity for accurate mapping of diseased forests and monitoring changes in forest health—prerequisites for the development of options for management of this complex problem.

Source: Stone (1999)

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Timber trestle bridge

4

CONSERVATION AND MAINTENANCE OF SOIL AND WATER RESOURCES

INTRODUCTION

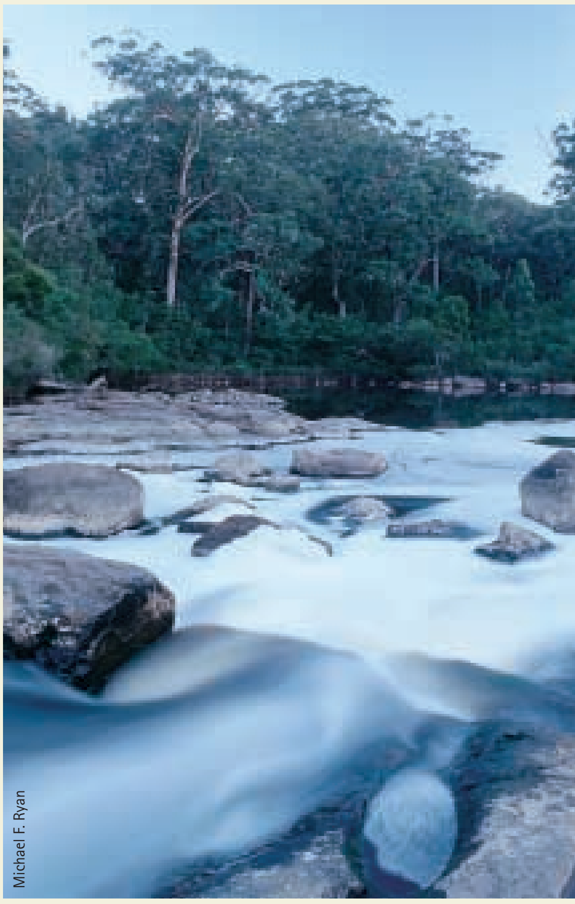
This criterion concerns the most fundamental resources of a forest environment—soil and water. The seven indicators grouped under this criterion measure soil and water biodiversity, and factors in forest management such as soil erosion hazard and protective mechanisms, changes in soil bulk density, and organic matter, and alterations in stream flows. The purpose is to monitor changes stemming from forestry operations. However, inadequate or non-existent baseline data are a serious impediment to the development of a national data set. Data collection and analysis on these subjects is undoubtedly difficult and has, to date, been largely confined to particular regions or catchments where it has been collected for specific and often localised reasons. While this data is very useful it is limited in its capacity to inform a set of national indicators.

Forests cannot exist without water, soil and nutrients. Water here does not just refer to rainfall. It means rivers, creeks and lakes that provide habitat for forest-dwelling creatures and, often, a source of drinking water for human communities. In forests, soil, water, trees and their understorey form an interdependent triangle. Good soil and water are essential to healthy forests and of inestimable value to society.

The many different types of forest in Australia are in part caused by the enormous differences in soil type across the country. Soils supporting the tall wet sclerophyll forests of the south-east are, for example, very different to the shallow, nutrient-deficient soils and sands supporting mallee and callitris forests in the dry inland. The different soil types are a product of the country's bio-geographical history.

We primarily conserve our water resources to provide potable water for human populations and to maintain normal terrestrial and aquatic ecosystems in forested areas. Many of Australia's watersheds and catchments are in forest and montane environments. Some tall wet eucalypt forests and rainforests are very close to major urban centres, and are the source of clean drinking water. A significant area of these forests has been set aside for conservation but others are multiple-use forests subject to intensive management and to public scrutiny.

Small and gradual changes to the quality of soil and water may go unnoticed until a point of crisis is reached. This is why governments in Australia apply a variety of measures to protect soil and water. Forest managers know that the long-term productivity of a forest is dependent upon the appropriate level of soil oxygen, nutrients and organic matter as well as the forest's capacity to produce clean water. They know that they must often take special measures to protect sensitive sites and ecosystems but they also know that construction of access roads and infrastructure, the use of toxic substances for timber production, or a range of other activities in forests, can cause crucial natural values to decline in quality. It is essential, for example, to regenerate a forest soon after harvesting so that soil moisture and nutrient levels are maintained. Rapid regeneration will also reduce the processes of soil erosion, silting of streams and associated disruption to stream flow rates.



Circular Pool, Walpole, Western Australia

Although land managers strive to maintain the best soil and water quality in forests, it is difficult to assess their success. Data are certainly collected and collated, and monitoring is conducted, but it is usually done to meet the particular needs of a State or Territory government, regional authority or private plantation company. All Australian jurisdictions legislate to ensure that watersheds, streams and rivers, and areas subject to erosion, as well as chemical use in forestry, are properly managed. Codes of forestry practice across the country complement legislation. However, even where data collection might naturally flow from legislation or codes, it is rarely mandatory and soil and water protection is almost never the sole reason for a legal framework.

Attempts to achieve some nationwide consistency in data collection on these subjects have so far met with only limited success, partly because of these difficulties and the often very localised rationale for data collection in the first place, but also because attempts to do so nationally have turned out to be very expensive. Research over recent years has produced theoretical frameworks for data collection and analysis, which look promising but which do not easily fit the indicators as they are currently written. This is why several of these indicators—4.1a, 4.1d and 4.1e—were designed to be interim only. That is, they were developed to ask important questions about forest management in the knowledge that current data and methods could not fully do this. These interim indicators could be refined over coming years to provide useful information on the quality of forest soil and water resources.

Of all these indicators, measurement of biodiversity in water bodies (indicator 4.1f) has, perhaps, the greatest potential to provide a picture of a forest's fundamental resources over time. Even so, biodiversity tends to be assessed only in major water bodies and long-term monitoring is quite rare. All the other indicators under this criterion suffer from absence of satisfactory frameworks and methods for attributing numerical measures to them. For example, damage to soil structure and fertility from human activities (indicator 4.1e) is nowhere measured consistently, although in most jurisdictions codes of practice are designed to limit these impacts. Upwards of 50 per cent of the nation's forested land may be managed for reasons of environmental and landscape protection but any data pertaining specifically to soil and water tends to be incidental (indicator 4.1b). Moreover, data collection and monitoring infrequently occurs across an entire forested catchment, which might be a mix of nature conservation reserve and multiple-use forest. Thus, results can be biased towards the area where most of the monitoring occurs or are methodologically inconsistent with data collected from another part of the catchment set aside or used for a different purpose.

Measurement of a soil profile in a forested catchment

Soil erosion hazard

coverage
currrency
frequency

Indicator 4.1a (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

Rationale
This indicator aims to demonstrate that soil erosion risk has been explicitly addressed in forest management planning and field operations.

At the national level there is no numerical measure of the area of forest assessed for soil erosion. Jurisdictions apply various measures to protect soil and water values to suit differing conditions.

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. Knowledge of the causes of soil erosion and trends in its severity can be used to adapt forest management practices so as to limit erosion to acceptably low levels. Systematic assessment of soil erosion hazard and the implementation of site-specific measures to protect soil and water values demonstrate a commitment to the protection of these values. The target for this indicator is therefore all of the forest estate, with the initial focus on areas of high erosion risk.

It is important to realise that this indicator aims to demonstrate that soil erosion risk has been explicitly addressed in forest management planning and field operations. In other words, it records efforts to protect soils from erosion, not whether the efforts have actually been effective. Progressively, the effectiveness of any protective measures will need to be assessed, with modifications applied as required.

Soil erosion hazard is the term used to describe how likely it is for soil in a given area to erode. It depends on the inherent properties of the soil, the topography, vegetative cover and soil disturbance, and rainfall intensity.

Limited data exists nationally for the area systematically assessed for soil erosion hazard. In some States—such as New South Wales, Victoria and Tasmania—data are available for all areas of harvested native forest. In the Australian Capital Territory, New South Wales and South Australia, plantations are also assessed.

Evaluation could consist of field observations such as the extent of sheet or rill erosion, research findings, or targeted monitoring focusing on situations of high erosion-risk.

Scale is an important factor in relation to soil erosion. From a soil fertility point of view, even downslope movement of soil within a

Snig track with erosion control barriers harvesting area is detrimental. Management prescriptions, such as the use of cross-banks (drains) on log extraction tracks, can minimise downslope movement. For this reason, the spacing between cross-drains is reduced in high-risk situations.

Buffer and filter strips along watercourses and drainage lines can be used to prevent the transport of soil into streams, which might otherwise damage aquatic ecosystems. Undisturbed buffers protect larger streams and, where there is minimum ground disturbance, filter strips shield drainage lines. Buffers are increased where there is an increased risk of erosion—such as with high overland flow or on steep slopes.

In production environments of New South Wales, filter strips are placed on all streams, which are not to be disturbed during harvesting, and buffer strips are placed on unmapped drainage depressions, which allows tree felling operations and machinery access. Other states and territories use similar methods.

Fire can greatly increase the susceptibility of soils to erosion by reducing the protective cover that accumulated litter and vegetation provide. Judicious fuel reduction burning or effective fire suppression can limit the spread and impact of wildfires and thus soil erosion hazard. On the other hand, fuel reduction burns on impermeable soils in steep terrain may increase soil erosion risk. Careful assessment of erosion risk is thus important in nature conservation reserves as well as in multiple-use forests and plantations.

Where soil erosion hazard is high, special management considerations or exclusions are implemented as part of the planning and conduct of operations. Roads are a point source of sediment in catchments, so that particular attention is given to planning and maintaining road networks. Recreation activities in multiple-use forests and nature conservation reserves can contribute to erosion—for example, from vehicle tracks and walking trails—and are managed in some jurisdictions. Codes of forest practice generally require that the more erodible portions of harvesting areas—landings, snig tracks and access roads—are rehabilitated after completion of harvesting operations. For example, in Queensland, Victoria and Tasmania, log landings are drained, bark heaps dispersed, soils ripped and topsoil replaced prior to the commencement of regeneration or replanting activities. Audits are used to assess compliance with the codes of forest practice.

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Protection of soil and water by forests

coverage

currrency

frequency

Indicator 4.1b

Area and per cent of forest land (including plantations) managed primarily for protective functions, for example, watersheds, flood mitigation, landslide prevention and riparian zones

Rationale

Forests provide many ecosystem services and functions. The provision of soil and water protection is one of them. Management activities should ensure these are maintained.

Some figures suggest that up to 50 per cent of forested land may be managed for protective functions. However, many of these areas may have other primary functions, with soil and water protection being ancillary. Forest protective functions are rarely mapped and therefore are difficult to quantify.

This indicator refers to the area and proportion of forested land managed primarily for soil and water protection. In this context 'primary' is defined as a legal designation for soil and water protection, and does not include areas under general management, of which soil and water protection are one of a set of multiple management outcomes. Forest management responsibilities rest with the State and Territory governments, all of which have legislation in place requiring management standards relating to watershed protection, areas vulnerable to erosion and slope instability, and riparian zones to be met. In addition to legislation, codes of practice set out activities to be undertaken in or near waterways, in erosion hazard areas or in water management catchments. Table 65 indicates the area of forest managed primarily for protective functions. This shows that, in the States included, historically more than 50 per cent of forested land is collectively managed for protective functions.

Table 65: Forest managed primarily for protective functions in multiple-use forest in New South Wales, Victoria, Western Australia and Tasmania ('000 ha)

	Area protected	Area of forest for which data are available
Multiple-use forest	3 562	6 654

Source: Commonwealth of Australia (1997)

Designated water supply catchments provide water for urban and rural use. To maintain water quality, legislation exists in each State and Territory to control land use activities in these catchments, which are generally public land, such as nature conservation reserve or multiple-use forest.

Restrictions may be imposed on:

- the level, type and location of recreational activities;
- timing of forest management practices (such as during wet weather);
- methods of road construction and spatial distribution of roads; and
- management of fuels, grease and oils.

Table 66: Examples of area (ha) by sample forest protection categories

	Tasmania	New South Wales	Victoria
Protection category			
Water supply	–	9 102	51 000
Slope	150 000	77 580	538 000
Riparian	35 000	221 460	488 000

Source: National Forest Inventory (2003)

In Victoria, 51 000 hectares of forest are protected as water supply catchments and in New South Wales 9 100 hectares of multiple-use forests are zoned primarily for water catchment protection (Table 66). Data are not available from other States and Territories.

Compared to open woodland or grassland, forested areas are characterised by higher leaf area and evapotranspiration rates and deeper organic soil layers and rooting systems. As a result, runoff is generally reduced in forested catchments and the mean annual streamflow and mean annual flood peaks are less. Flooding is a function of climatic and biophysical controls at a catchment scale, including drainage density, slope, shape, soil type and depth, and vegetation type/density. Mitigation of flooding through forest management in vulnerable catchments will relate to harvesting patterns, intensity and timing relative to the hydrological year. However, there are no data from routine monitoring on which to report.

The delivery of sediments to waterways can occur in response to erosional and/or slope instability processes. Erosion is a function of catchment morphology, soil properties, rainfall factors and slope gradient. Slope instability is determined by increased loads (including water and snow), soil moisture content, loss of soil structure due to shock or vibration, undermining, loss of soil cohesion, and the gradient of the slope. Forest codes of practice and management plans, or specific legislation in each State and Territory, define appropriate measures to minimise risk. These include practices which limit or prohibit harvesting during periods of high rainfall or on steep slopes. In some codes of practice, steep slopes associated with high hazard risks for erodibility and slope instability may be specified (for example, 30° in Victoria and New South Wales), while others vary according to parent material (11° to 19° in relation to landslide susceptibility in Tasmania). Data are not available for most States and Territories. However, in Victoria 538 000 hectares of steep forested land is protected, in multiple-use forests of New South Wales 77 600 hectares are protected from water pollution hazard or extreme erosion risk, and the area mapped in Tasmania for landslide protection is 150 000 hectares.

Riparian zones comprise the vegetation and soils immediately adjacent to streams. These zones are important for maintenance of habitat and biodiversity, streambank stabilisation and the trapping of sediment mobilised from upslope positions. The removal of riparian vegetation can have profound effects in terms of water quality, stream morphology, habitat and biodiversity—both at the site and beyond. In forested areas, particularly where harvesting occurs, riparian zones are considered to be buffer or filter strips that protect waterways. The width of these strips, which should take account of soil properties and slope, varies between the States and Territories according to the forests codes of practice (indicator 7.1d), licences, and plans of management, but is generally 5–60 metres.

The width of buffers will affect the proportion of forest set aside to protect waterways. However, it should be noted that the condition of the riparian zone—and hence its capacity to protect waterways—is not only dependent on width, but also on the type of cover and its composition, connectivity and structural integrity. There is also a relationship with the intensity of disturbance created by the activity being undertaken. Generally data are not available for reporting, although in Victoria 9.8 per cent (488 000 hectares) of riparian vegetation in forests within Regional Forest Agreement areas is protected from forestry activities. In Tasmania 35 000 hectares have been mapped as streamside reserves and this area is expected to increase as a result of future planning. In New South Wales, 184 500 hectares of multiple-use forests are reserved from harvesting as filter strips, with another 37 000 hectares in which modified harvesting is permitted. Furthermore, specific set-back distances apply in certain areas not specified by the New South Wales Integrated Forestry Operations Approvals. Additional information referring to condition of riparian zones is available in New South Wales through the Stressed Rivers Report at a catchment scale; however, this is not quantified according to land tenure or use.

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Native forest and plantations for production and water quality maintenance, Cotter Dam, ACT

coverage
currrency
frequency

Stream flow in forested catchments

Indicator 4.1c

Percent of stream kilometres in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation

Rationale

This indicator aims to measure the effects of forest management and other factors on water flow and variation in flow. This is important for stream health and for water supply for human use.

Studies show that stream flow increases after forest harvesting, decreases with regrowth or plantation establishment and increases again in older forests. Attempts to quantify changes in stream flow in forested catchments are problematic.

Human activities since European settlement have altered the natural flows of many river systems with resulting environmental and economic effects. Some of the consequences include reduced stream flow or changes to the seasonality of flows, including the length of time during which there are low flows or no flows.

Catchments in Australia are used for more than water supply and storage. Although streams may rise in forested or wooded uplands, they can also flow through private and public land, which may be forested, agricultural, grazed or urban. It should also be noted that while forest management practices such as harvesting may occur in one part of a catchment, other land use and management practices may be going on elsewhere in the same catchment.

In some cases, the impacts of one form of land use may add or subtract to the impacts of another, such as when increased runoff after forest harvesting is offset by farm dam development. Under these circumstances, it is difficult to isolate the impacts of one type of land use on stream flow. In addition, the occurrence of bushfires and the high degree of rainfall variability—which may result in stream flow varying between years by as much as 70 per cent—complicate the difficulty of trying to characterise the system. In some States, streams have been monitored for several decades; however, there has been no systematic and consistent analysis that provides an assessment of the temporal and spatial variability of stream flow.

Studies have been undertaken in forested areas in which the impacts of forest management in one catchment are measured and compared with an adjacent, undisturbed catchment. Although most studies have focussed on mountain ash forests in Victoria, other studies have been undertaken on mixed species forests, and are in progress in hoop pine plantations in Queensland. These studies demonstrate that:

- stream flow increases after forest harvesting, in response to higher runoff after the removal of vegetation from ground surfaces; and
- stream flow decreases in proportion to the density of regrowth in the catchment and returns to pre-harvesting levels after 4–8 years, depending on forest type.

However, other studies show that forest management has little impact on stream flow. Significant variations of flow have occurred in three streams out of a total of 14 monitored in a Victorian study, although the conclusions drawn suggest that the major impact on yield is probably wildfire—dating from 1939—rather than forest management. It should be noted that there are a number of significant constraints in this study due to problems with data reliability and continuity.

In addition to impacts imposed during harvesting in forested catchments, stream flow may be modified by the construction of storage dams. These structures retain water until controlled releases contribute water downstream, and affect the timing of flows.

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Dead river red gum (*Eucalyptus camaldulensis*) following flooding of Murray river for Yarrawonga Dam, Mulwala, NSW

coverage
currrency
frequency

Soil organic matter

Indicator 4.1d (interim indicator)

The total quantity of organic carbon in the forest floor (greater than 25 millimetres diameter components) and in the surface 30 centimetres of soil

Rationale

The quantity and type of soil organic matter helps describe a soil's physical, chemical and biological status, which in turn affect many important ecosystem processes. This indicator aims to measure soil organic matter that can impact on soil fertility.

There are no broad operational data available for soil carbon or organic matter change in Australian forests. Certain forest practices can alter soil organic matter.

Soil organic matter is important because it provides for the storage and release of key nutrients and is important in ecosystem carbon cycling. It also affects soil physical and hydrological properties and provides substrates for soil biota. Broad scale land clearing, primarily for agriculture, has had the most dramatic impact on soil organic matter but many forest operations may also change the quantity and features of soil organic matter. Characteristics of soil organic matter are particular to each forest ecosystem. The interim indicator aims to provide a surrogate for the physical, chemical and biological properties important for soil fertility.

Protecting soils in forested areas is critical to maintaining most other forest values and thus is an essential part of sustainable forest management. To assist in this, the plantation forest industry has developed chopper rolling as standard practice. Chopper rolling is used to crush the residues from clear felling operations *in situ* to retain nutrients and organic matter.

Knowledge of the trends and causes of change in organic matter and other important soil chemical properties can be used to adapt management practices where required. However, for the following reasons, there are no broad operational data available for soil carbon or organic matter change in Australian forests.

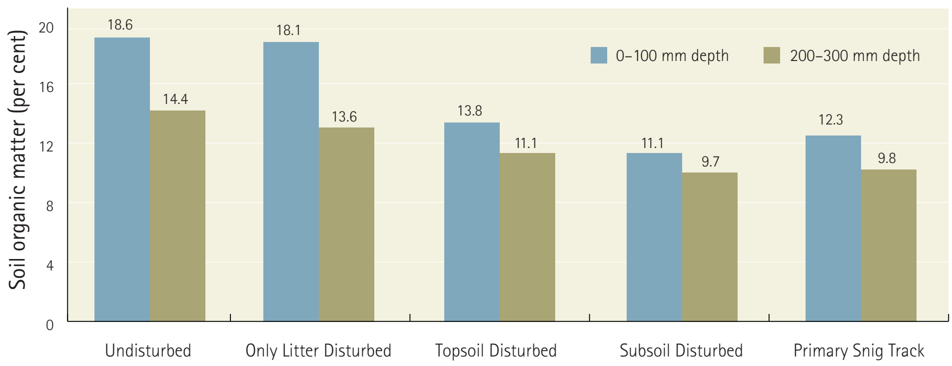
Chopper rolling to retain organic matter, South Australia

Total soil organic carbon is composed of several components that vary greatly in their properties and contribution to soil fertility. Australian forest soils may contain significant quantities of relatively inert (stable) carbon in the form of charcoal, and there is no simple and cheap way of separating this from the organic components when total soil carbon is measured. Direct measurements of carbon are a better indicator of change in the productivity of plantations than 'loss-on-ignition', which is sometimes used.

Soil organic matter (SOM) is also costly to monitor, and changes are not simple to interpret in terms of ecosystem functioning (apart from impacts on soil carbon stocks, which are important for greenhouse accounting). The importance of a change in soil organic matter varies with forest ecosystem type and management objective.

There appears to be good potential to use soil disturbance classes as a surrogate for SOM change (Figure 41 and case study). This would be a more cost-effective approach to monitoring, but it needs further calibration.

Figure 40: Relationship between soil disturbance category and soil organic matter content on the general harvest area and snig tracks 10 years after clearfelling mountain ash (*Eucalyptus regnans*) forest

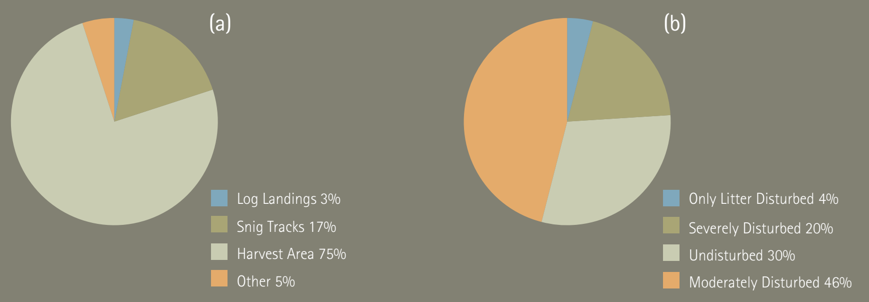


Source: Lacey *et al.* (2002)

Case study

Research during the last decade in mountain ash forest in the Victorian Central Highlands has provided a potential means to monitor soil change in harvested forests in the future. A field survey technique for assessing soil disturbance during harvesting and regeneration has been developed. This method has been used to survey the proportion of harvesting areas affected by operational categories (Figure 41a) and varying levels of associated soil disturbance (Figure 41b). Results show that clearfelling affects most of a site, causing about 66 per cent of the area to experience moderate to severe soil disturbance.

Figure 41: Proportion of logging coupe area (mean of 20 operational coupes) occupied by (a) different operational categories or (b) soil disturbance categories, following clearfelling of mountain ash forest in the Victorian Central Highlands



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Sampling organic matter

Soil physical damage

coverage
currrency
frequency

Indicator 4.1e (interim indicator)
Proportion of harvested forest area with significant change in bulk density of any horizon of the surface (0–30 centimetres) soil

Rationale
To measure the extent of soil physical change induced by human activities that might adversely affect soil fertility and thus other ecosystem processes.

Certain forest operations can result in changes to soil bulk density, but there is insufficient data to report fully on this indicator. Codes of practice in most jurisdictions limit these impacts.

Protecting soils in managed forests is critical to maintaining most other forest values and thus is an essential part of sustainable forest management. Knowledge of the trend and causes of detrimental soil compaction can be used to adapt management practices to avoid further soil damage, or to guide ameliorative activities.

This indicator measures the extent of soil physical change induced by human activities that might adversely affect soil fertility and thus other ecosystem processes. Balancing soil physical properties is important in maintaining soil fertility and hydrological processes.

Changes in soil physical properties can affect important ecosystem processes such as infiltration of water, aeration and growth of plant roots. The indicator focuses on bulk density (which reflects soil pore space), and the impacts of forest harvesting, because these are recognised as having the potential to adversely affect soil physical properties.

Recovery from significant soil compaction is slow in the field. This raises concerns about the potential for cumulative impacts between rotations.

The intensity of harvesting can influence the level of impact on soil physical properties. Roads, tracks and log landings have the greatest potential to impact on the soil physical properties and should therefore be minimised. Severely compacted areas may need to be re-habilitated following completion of harvesting. Codes of practice are in place in most jurisdictions to minimise these impacts.

Research based on this indicator has shown that bulk density may be a valuable measure of soil disturbance but it is too costly at the operational level for practical application. It has been proposed that a target of 20 per cent of harvested areas in a management unit be surveyed for soil disturbance.

Currently there are no comprehensive national data on the effects of forest harvesting on soil bulk density. However, the degree of soil disturbance can be calibrated with soil density and carbon content for contrasting forest ecosystems and harvesting regimes (e.g., Table 67; Figure 42).

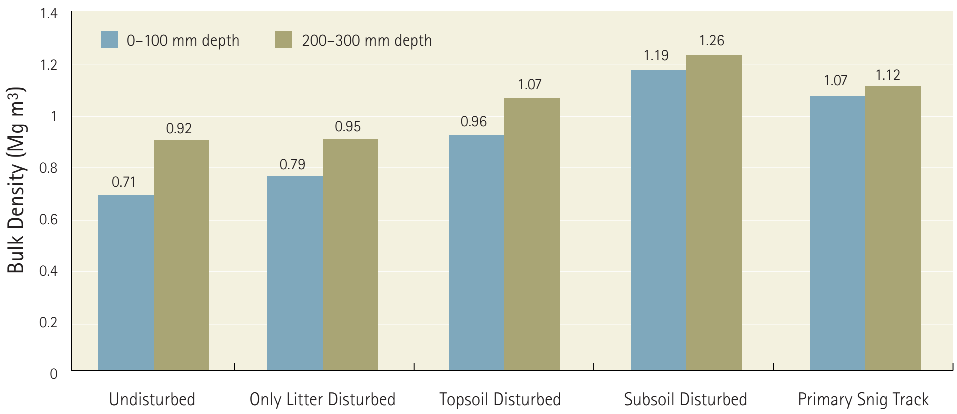
Cording of snig track to avoid rutting by machinery

Table 67: Effects of soil disturbance on bulk soil density following harvest of two mature messmate stringybark (*Eucalyptus obliqua*) forests in Tasmania

	Disturbance Level		
	None/Light	Moderate (Topsoil)	Severe (Subsoil)
		(i) Dolerite soil	
Fine earth bulk density (g cm^{-3})	0.61	0.62	0.80
Organic C (%)	*4.5*	*4.6*	*3.3*
		(ii) Granite soil	
Fine earth bulk density (g cm^{-3})	0.60	0.70	0.85
Organic C (%)	*6.8*	*6.5*	*3.9*

Source: Pennington and Laffan (2001)

Figure 42: Relationship between soil disturbance category and soil bulk density on the general logging area 10 years after clearfelling mountain ash (*Eucalyptus regnans*) forest



Source: Lacey *et al.* (2002)

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Biodiversity of water bodies

coverage
currrency
frequency

Indicator 4.1f

Per cent of water bodies in forested areas (e.g., stream kilometres, lake hectares) with significant change in biological diversity from the historic range of variability

Rationale

The in-stream fauna reflects the quality of the habitat and water. This in turn, reflects the impacts of off-stream management activities, so that aquatic biodiversity is a good measure of the success of protective management prescriptions.

Biodiversity in water bodies can be assessed in various ways. Most jurisdictions assess biodiversity in major water bodies, but often these give 'snapshot' results and longer term monitoring is needed to establish temporal and spatial trends.

There are several different rapid appraisal methods by which the ecological health of a river or stream can be assessed. However, several States and Territories use the interactive computer package AusRivAS (Australian River Assessment System). AusRivAS was developed under the National River Health Program of the Commonwealth Government in 1994. It involves the environmental protection agencies at a State level and is centrally administered by the Australian Government Department of the Environment and Heritage and Land and Water Australia.

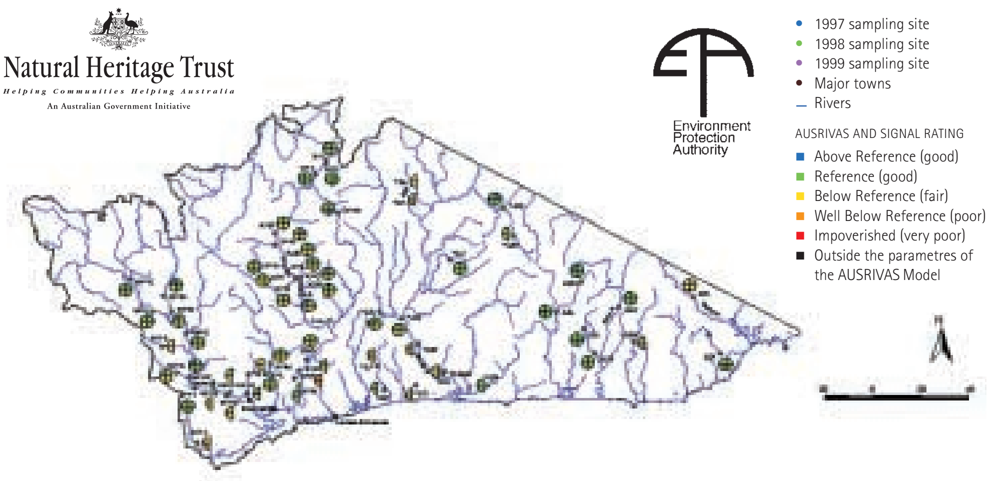
AusRivAS is based on comparisons between test and reference sites. The reference sites are selected to represent the best available sites for each type of river, but do not necessarily represent pristine conditions. In some cases reference sites may refer to rivers with modified hydrology, water quality and in-stream habitat. An additional limitation is that models are developed for bioregions and not for catchments. Medium to long-term data are not yet available to distinguish variance in biological diversity from the historic range of variability. Importantly, stream monitoring does not specifically target forested areas and sites are often located within regions with multiple land uses where off-site impacts from other landuse and land management practices can be expressed. One-third (21 900 kilometres) of the total river length assessed at a national scale, and including all land uses, is to some degree impaired. Impairment refers to a loss of between 20 per cent and 100 per cent of the various kinds of aquatic invertebrates that should live there.

Examination of the data at a State-by-State/Territory level suggests that New South Wales has the poorest aquatic biota condition—approximately 50 per cent of the river length is assessed as having impaired biota. This compares with greater than 35 per cent in the Australian Capital Territory and Western Australia, and between 12–24 per cent of the river length assessed in the remaining States and Territories having impaired biota.

It should be noted that aquatic habitat condition is related to water quality and water quantity in terms of sediment and nutrient loads, and to the delivery of pollutants from upslope or up-catchment locations. Therefore, impacts to river health will be particularly evident in catchments characterised by low tree density and/or ground cover, erodible soils, high rainfall erosivity, intensive agriculture or urban development. In addition, where salinisation or soil acidification is widespread, water quality may be impacted by the inflow of surface or shallow groundwater with high salt loads or low pH. Therefore, the distribution of specific catchment conditions needs to be identified both spatially and temporally in order to assess any direct correlations between river health, soil characteristics, climate and/or landuse.

In Victoria, SIGNAL (Stream Invertebrate Grade Number – Average Level method) is also used to measure river health by indicating the nature of disturbance or impact at a site in terms of the sensitivity of macroinvertebrates to stream salinisation and organic pollution. Index of Stream Condition benchmarking—which is partly based on AusRivAS and SIGNAL data and includes other criteria relating to hydrology, channel morphology and the riparian zone—has been undertaken in Victoria. Results for the overall condition of streams—with condition of biota representing only one set of criteria—indicate that 34 per cent of Victoria's major rivers and streams are in very poor or poor condition and only 22 per cent are in good or excellent condition. However, this assessment does not identify forested areas specifically. Mapping of the biological health of streams in the East Gippsland region (1997–99) provides some data for largely forested catchments (Figure 43), which can be compared with a multiple land-use catchment dominated by agriculture and grazing (Figure 44).

Figure 43: AusRivAS and SIGNAL monitoring results for stream health in East Gippsland, Victoria

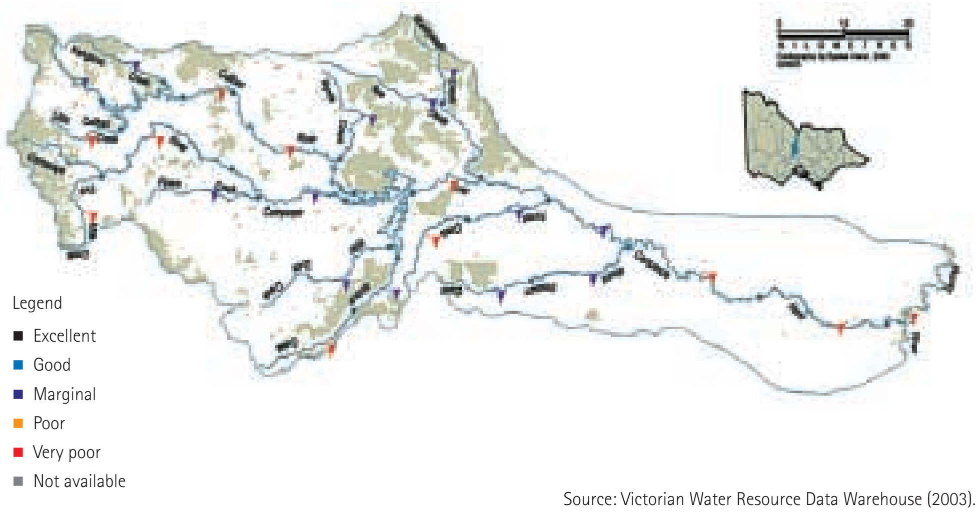


Source: Victoria, Environmental Protection Authority (2002).

In the south-east region of New South Wales, single snap shot AusRivAS monitoring indicates that Local Government Areas with a significant proportion of forested catchments—for example, Snowy River Shire, Bega Valley Shire and Bombala Shire—have a majority of their streams in good condition. This is in contrast to Local Government Areas characterised by agricultural, grazing or urban landuses.

AusRivAS monitoring represents, at best, broad comparative information for river health and biodiversity in multiple land use catchments where certain landuse or land tenure is dominant. In South Australia, AusRivAS monitoring of invertebrates, one-off surveys of fish in specific areas, and annual censuses of frogs are undertaken. However, it is estimated that fewer than 15 per cent of streams and lakes within forested areas in South Australia are monitored for biological diversity, with no data currently available to determine any temporal changes with reference to the historic range of variability.

Figure 44: AusRivAS ratings on stream health for the Campaspe catchment, Victoria



Source: Victorian Water Resource Data Warehouse (2003).

Overlaid mapping of landuse and tenure with longer term AusRivAS data is required before meaningful relationships and trends will be evident. Since AusRivAS is a national program co-ordinated through the Australian Government Department of the Environment and Heritage, overlaid mapping of landuse and land tenure for forest coverage on a State/Territory basis should be possible in the future. However, longer term data are required to establish temporal as well as spatial trends in river health (as defined by biodiversity). The limitations of AusRivAS also need to be acknowledged and addressed.

Willows (*Salix* spp.) planted for stream bank stabilisation

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Physio-chemical properties of water bodies

coverage
currrency
frequency

Indicator 4.1g

Per cent of water bodies in forest areas—e.g., stream kilometres, lake hectares—with significant variance from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation or temperature change

Rationale

To use the physio-chemical parameters to assess the health of the aquatic environment and the quality of water for human use (drinking, irrigation, recreation) and ecosystem health.

Although some monitoring is carried out in most jurisdictions there are insufficient data to report fully on this indicator.

Monitoring and analysis of certain key physical and chemical variables in water can provide information on the ecological health of water bodies and how forestry operations or management practices are affecting water quality. This is important both because of human use of water, and in determining the health of the aquatic environment in a forested area. This indicator is closely related to indicator 4.1f.

Water quality is monitored across the States and Territories to assess river condition and health and to determine whether water for different uses, including drinking water, satisfies set criteria. Guidelines, which define threshold values of physico-chemical parameters, are provided in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Responsibility for monitoring and/or analysing data is varied and includes State/Territory agencies, statutory authorities, catchment management authorities, local government and community groups—such as those participating in Waterwatch.

In Victoria, the environmental condition of 950 stream reaches, representing 18 000 kilometres of major rivers and tributaries, has been assessed using the Index of Stream Condition (ISC). Assessment is based on 19 indicators relating to hydrology, streamside zone, physical form of the channel, water quality and aquatic life. Results show regional differences but, in general, pH is decreasing, there is a slight increase in turbidity, a decrease in salinity and a slight decrease in total nitrogen. Only 56 of the total 950 stream reaches fully meet the criteria for ecologically healthy rivers as defined by the ISC classification.

In New South Wales, the Stressed Rivers Report and the Interim Environmental Objectives developed by the Environment Protection Authority provide frameworks for either describing the current health of river systems or for developing management tools to optimise river health in the future (Figure 45 and Table 68). Although some data provide snapshots of the current status for some rivers, temporal trends are not evident yet due to the limited time series available. Regional State of the Environment reporting for the Australian Capital Region including the Australian Capital Territory and the south east region of New South Wales has compiled data for water quality since 1990. Some trends are beginning to emerge, particularly in relation to

Michael F. Ryan

Water sampling

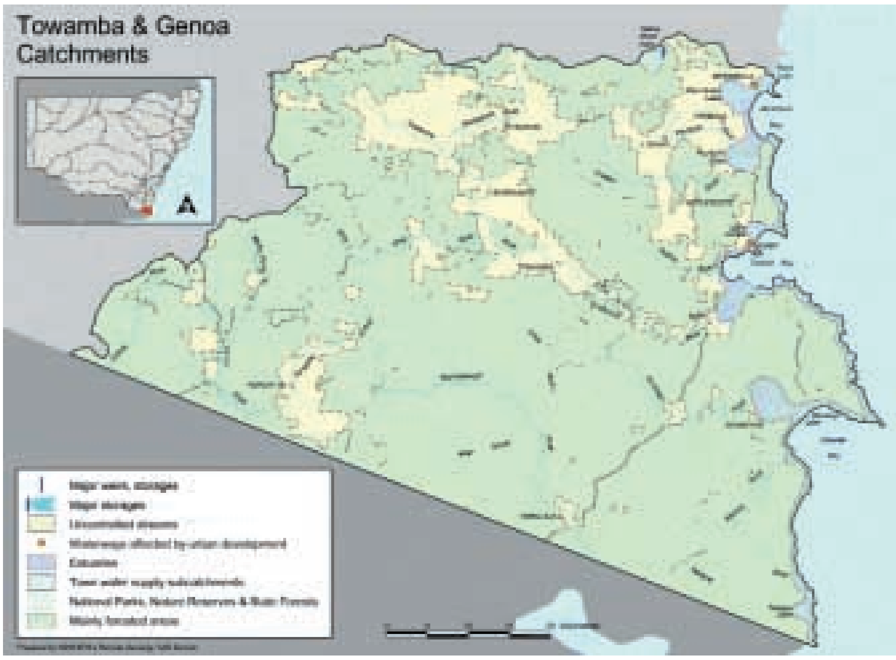
temperature, nutrients and salinity, but these are not conclusive without appropriate analysis using tools which take into account variability that may be due to seasonality, climate, landuse and non-constant variance.

State Forests of New South Wales has been conducting hydrology research projects for more than 25 years, investigating the impacts of forest management activities on water quality and quantity. At present State Forests operates more than 35 stream gauging and water quality monitoring stations in a number of State Forests' regions. Results of research projects and water quality monitoring have shown that runoff containing fine sediment from unsealed roads is the major potential source of water pollution in a managed forest environment.

Further research by State Forests, universities, CSIRO and the Cooperative Research Centre for Catchment Hydrology has demonstrated that due to strict sediment control measures State Forests' management activities do not have an adverse impact on water quality.

In Queensland, the State of the Rivers project uses the Anderson Method of rapid appraisal of stream condition. However this does not assess hydrology, water quality or aquatic biota. In Western Australia, ongoing Statewide monitoring is being undertaken, and increasing trends have been identified in relation to salinity, but there are no measurement programs to record changes in other chemical properties relating to this indicator, or sedimentation.

Figure 45: Land tenure and water resources in the Towamba/Genoa River catchment, New South Wales



Source: New South Wales Environment Protection Authority (2000).

It is clear from the data and additional information available that while water quality monitoring is undertaken in each of the States and Territories, and catchment management planning is a major activity, there is no specific focus on the contribution of forest to catchment condition at a broad scale. Research undertaken in small forested catchments indicates that water quality varies in response to the design, spatial distribution and use of roads, harvesting, wildfire and climate. The effects of these activities vary according to soil erodibility, rainfall erosivity, slope, antecedent soil moisture conditions and vegetation characteristics. State codes of practice and licenses provide prescriptions to protect water quality through appropriate design, use and distribution of roads and water crossings.

Table 68: Stress classifications for Towamba catchment, New South Wales for selected streams shown in Figure 32

Sub-catchment	Overall stress classification	Full development stress classification	Hydrology stress rating	Environmental stress rating
Pambula River	S3 (medium environmental stress, high extraction)	Unresolved	High	Medium
Towamba River	S5 (high environmental stress, low extraction)	S5	Low	High
Mid Towamba River	U3 (medium environmental stress, low extraction)	U3	Low	Medium
Mataganah Creek	U3 (medium environmental stress, low extraction)	S4	Low	Medium
Wonboyn River	U3 (medium environmental stress, low extraction)	U2	Low	Medium
Nullica Creek	U4 (low environmental stress, low extraction)	Unresolved	Low	Low
Wog Wog River	Unresolved	Unresolved	Low	Low

Source: Department of Land and Water Conservation, New South Wales (1998)

However, system responses to complex processes operating in multiple land use large catchments have not been investigated, so extrapolation of these research findings is not feasible. Relevant research has also not been undertaken in forested catchments where minimal disturbance occurs.

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coverage
currrency
frequency

Persistent toxic substances

Indicator 4.1h

Area and per cent of forest land experiencing an accumulation of persistent toxic substances

Rationale

Toxic substances can adversely affect important ecological processes in forest ecosystems. They may also be transported in water or sediments. Knowledge of the trend and cause of accumulated toxic substances can be used to design corrective measures that lower future risks.

While guidelines have been developed that deal with the use of toxic and persistent substances, no national data are collected for this indicator.

Currently there is no systematic monitoring of forest soil pollution in Australia, except for limited areas where bio-solids and treated effluent are applied.

An important mechanism to avoid soil pollution in forests is outlined in guidelines contained in codes of forest practice. These guidelines in codes deal with the use of pesticides, chemicals, the application of fertilisers and the careful storage and use of fuel or oil.

In forested areas one issue of concern is the impact on the environment of the application of heavy loads of fire retardant chemicals, as part of fire suppression activities. Fire retardants contain high concentrations of nutrients—nitrogen, phosphorus and sulphur—as well as very small amounts of performance additives. Minimising the use of retardants in areas where there is a high risk of transport to streams following fires, or where there are sensitive ecosystems and water supply catchments, can mitigate risks to the environment.

Case study

The New South Wales Environment Protection Authority (EPA) has produced comprehensive environmental guidelines for the use and disposal of bio-solid products. Bio-solids can be applied to forests, but in doing so, there is a strong emphasis on the protection of soil and water values, particularly from nitrate leaching. The guidelines require analysis of the bio-solid to determine the pathogen and heavy metal contamination levels. This is followed by the requirement to meet appropriate application and management practices. Ongoing monitoring of soil and water contaminant levels is required. Land application is varied according to the sensitivity of the area to loss of ecological, natural, cultural or heritage values. Buffer zones are required around sensitive areas, and there are limits on the quantity and frequency of bio-solid application. Each application must be licensed by the EPA.

Guidelines for the disposal of bio-solid products are being refined, based on research by State Forests New South Wales. Research has been conducted on the effects of bio-solid application rate on growth and soil nutrient change in pine plantations. It determined that the release of organic nitrogen from decomposing bio-solids under a pine stand were much higher than indicated in the EPA guidelines. Significant leaching of nitrate occurred from aerobically-digested bio-solids at one site, indicating the need for monitoring to provide data to support more site-specific management.

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5

MAINTENANCE OF FOREST CONTRIBUTION TO GLOBAL CARBON CYCLES

INTRODUCTION

Forests occupy roughly one-third of the Earth's land surface and account for almost 60 per cent of the carbon that exists in vegetation and soils on land. Because of their extent and dynamic nature, forests play a major role in the functioning of the biosphere. Global ecological cycles are a complex web of self-regulating processes responsible for recycling Earth's limited supply of water, carbon, nitrogen and other life-sustaining elements.

International concern about the effects on climate of increased atmospheric concentrations of greenhouse gases (such as carbon dioxide) has focused attention on the dynamics of carbon cycles in terrestrial vegetation and soils. Understanding the role forests play in these cycles is essential for the management of potentially dangerous impacts from climate change.

Carbon accounting or budgeting involves estimating carbon stored and emitted in different land-use or industry sectors, including forests and forest products. This criterion examines the contribution of forests to the global carbon cycle.

Like all green plants, trees absorb the gas carbon dioxide (CO_2) from the air and convert it to carbon in plant matter during photosynthesis. Some of this is kept within the plant for as long as it lives. Because of the quantity of woody tissue, forests contain the highest density of carbon in living biomass of any terrestrial ecosystems and carbon stored in wood can remain there for many years, sometimes for centuries. When the plant matter decomposes or is burnt, carbon is returned to the air, mainly in the form of CO_2.

As well as carrying out photosynthesis, living plants also respire. This releases CO_2 back to the atmosphere. During active growth, photosynthesis exceeds respiration, so a growing plant is a net sink rather than a source of carbon. On balance, global terrestrial ecosystems—mainly forests—have been a comparatively small net source of carbon over the past 150 years because regrowth in temperate forests has balanced conversion of forest to other land uses.

The three indicators in this section address the role of forests in storing and releasing carbon from biomass in various forest types. Net carbon dioxide or equivalent emissions from land-use change and forestry account for about 7 per cent of the total national emissions. Net emissions from this sector are estimated to have declined over the last 10 years. There has been considerable advancement in carbon accounting for terrestrial ecosystems in Australia, with the development of the National Carbon Accounting System and the Cooperative Research Centre for Greenhouse Accounting. Much of the assessment effort has gone into quantifying carbon fluxes associated with land-cover change processes—afforestation and deforestation—and there is still uncertainty about estimates of carbon stock and uptake and release of carbon across the forest estate.

Michael F. Ryan

Stored carbon in sawn timber

coverage ●
currrency ●
frequency ●

Forest biomass and carbon stocks

Indicator 5.1a

Total forest ecosystem biomass and carbon pool and, if appropriate, reported by forest type, age class, and successional stages

Rationale

Estimates of total forest biomass allow changes in total carbon pool over time to be assessed. Estimation by forest type and age class allows better understanding of these changes.

Estimated total biomass in Australian forests, including above-ground biomass, roots and the forest floor, is 23 400 million tonnes (Mt or 10^{12} grams). Estimated total mass of carbon, excluding soil carbon, is 10 500 Mt. About 0.8 per cent of the total biomass is in plantations and the remainder is in native forest. Eucalypt woodlands account for 46 per cent of total biomass and carbon stock.

Forests are an important component of the global carbon cycle, and forest carbon stocks are a key indicator of sustainable forest management at the national level.

Forests account for almost 60 per cent of the carbon that exists in the vegetation and soils of the earth's land surface. International concern about the effects on climate of increased atmospheric concentrations of greenhouse gases such as carbon dioxide has focused policy attention on the dynamics of carbon in terrestrial vegetation and soils. Forests absorb carbon dioxide (CO_2) from the atmosphere during photosynthesis and release it during respiration and the decay of dead plant material. Forests remove CO_2 from the atmosphere and store the carbon in woody tissue when actively growing. The rate of carbon absorption and hence the magnitude of the carbon sink, is greatest in the earliest stages of regeneration and declines as forests mature.

The amount of carbon stored in forests can change over time because of:

- natural variation in climatic factors such as temperature and rainfall;
- the natural developmental or successional dynamics of vegetation; or
- disturbances such as fires, storms, or pest and disease outbreaks.

Forest management activities such as timber harvesting, site preparation and fire management also influence the uptake and release of greenhouse gases.

On balance, global terrestrial ecosystems—mainly forests—have been a comparatively small net source of carbon over the past 300 years. Between 1850 and 1990, an estimated 212 000 Mt of carbon was emitted to the atmosphere from fossil fuel combustion and 121 000 Mt of carbon from forest clearing. About 82 000 Mt of carbon was removed from the atmosphere in regrowth, resulting in an estimated net source from forests over this period of 39 000 Mt.

Total forest carbon stock in Australia is estimated to be 10 500 Mt (Table 69). Almost all (99.2 per cent) of total carbon stock is in native forests. Estimates of above-ground, below-ground and forest floor biomass were provided by the Australian Greenhouse Office (AGO) using data and methods from the National Carbon Accounting System (Australian Greenhouse

Office, 2002). Estimates are provided for areas meeting Australia's definition of forest (greater than 20 per cent canopy cover and greater than 2 metres tall) and are presented by forest classes in the National Vegetation Information System, which differ slightly from those used by the National Forest Inventory. The forest area base for these estimates differs from other parts of the report because of different technical approaches to assessing forest extent such as differences in the scale of mapping used by the AGO.

Only values with high level of certainty are included in the analysis, providing a conservative estimate of the extent of forest and amounts of biomass. The total is less than the estimate in the 1998 State of the Forests Report. The estimate of plantation carbon stock is lower because in this report each age class was estimated separately assuming different average rates of carbon accumulation for hardwood and softwood plantations. They are considered to underestimate total biomass.

Table 69: National forest type by area and carbon biomass

Major Vegetation Group	Above Ground Biomass (MtDM)	Root Biomass (MtDM)	Forest Floor Biomass (MtDM)	Total Biomass (MtDM)	Total Carbon (MtC)
Rainforest and Vine Thickets	844	84	403	1 331	599
Eucalyptus Tall Open Forest	670	94	429	1 193	537
Eucalyptus Open Forest	4 091	1 841	1 853	7 785	3 503
Eucalyptus Low Open Forest	35	16	14	64	29
Eucalyptus Woodland	3 206	1 315	851	5 372	2 417
Tropical Eucalyptus Woodland/Grassland	1 242	509	378	2 130	958
Acacia Forest and Woodland	445	200	300	945	425
Callitris Forest and Woodland	66	30	24	119	54
Casuarina Forest and Woodland	33	15	24	72	32
Melaleuca Forest and Woodland	311	140	76	526	237
Mallee Woodland and Shrubland	311	298	73	682	307
Low Closed Forest and Closed Shrubland	60	57	4	121	54
Other Forest and Woodlands	1 512	916	477	2 905	1 307
Total Native Forest	12 824	5 515	4 905	23 244	10 460
Softwood Plantation	82	57	3	142	71
Hardwood Plantation	23	9	1	33	17
Total Plantation	105	66	4	176	88
Total Forest	12 929	5 581	4 909	23 420	10 548

Source: Australian Greenhouse Office (2003)

In order to reduce CO_2 emissions, the forests from which wood is harvested need to be managed so as to maintain total forest carbon stocks. That is, these forests need to be regenerated following harvesting and left to grow long enough to reach previous levels of carbon stock. Removing trees for wood products from forests with a high carbon stock and replacing them with regrowth forests may result in a temporary loss of carbon stock in the forest, and a reduction in the overall stock in forests and products.

Estimates of total biomass and carbon stock remain uncertain. The National Carbon Accounting System was established by the Commonwealth Government, primarily to reduce uncertainties in reporting greenhouse gas emissions from land use change and forestry. This initiative, while still continuing to develop, has significantly reduced reporting uncertainties in carbon stocks and emissions estimates through a variety of field studies, data synthesis and modelling processes, with field verification supporting the accuracy of approaches.

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Long term carbon storgage in a decaying tree

Forest contribution to the carbon budget

coverage
currrency
frequency

Indicator 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)

Rationale

This indicator provides information on emissions and removals of carbon from forest ecosystems over time for comparison with other land cover types or other sectors of the economy.

Net carbon dioxide (or equivalent) emissions from land-use change and forestry account for about 7 per cent of total national greenhouse gas emissions. The net emissions from this sector are estimated to have declined over the last ten years. There is still considerable uncertainty about estimates of uptake and release of carbon across the forest estate.

Net carbon dioxide equivalent emissions, including emissions of methane, from the 'land-use change and forestry sector' were estimated to be 42.3 million tonnes (Mt) of carbon dioxide equivalents (CO_2-e) in 2000 (Australian Greenhouse Office 2000b). This is about 7 per cent of the net national CO_2-e emissions (Table 70). The category 'changes in forest and other woody biomass stocks' comprises emissions and removals from changes in managed native forests, plantations, commercial harvest, and fuelwood consumption. In 2000, this is estimated to have constituted a net sink of 23.7 Mt CO_2-e. 'Forest and grassland conversion' comprises emissions and removals from deforestation, estimated to be 64.8 Mt CO_2-e in 2000. It includes emissions from the burning and decay of cleared vegetation and from soil disturbed in the clearing process, and removals due to the subsequent regrowth of vegetation.

Table 70: Estimated carbon dioxide emissions and removals from Australian forests

	Carbon dioxide (CO_2) equivalent emissions (Mt)			
Greenhouse gas source and sink categories	CO_2	Methane (CH_4)	Nitrogen dioxide (N_2O)	Total
Changes in forest and other woody biomass stocks	-23.7	–	–	-23.7
Forest and grassland conversion	60.8	3.5	0.4	64.8
Non-CO_2 emissions from wildfire and prescribed burning	–	0.9	0.3	1.2
Total				42.2

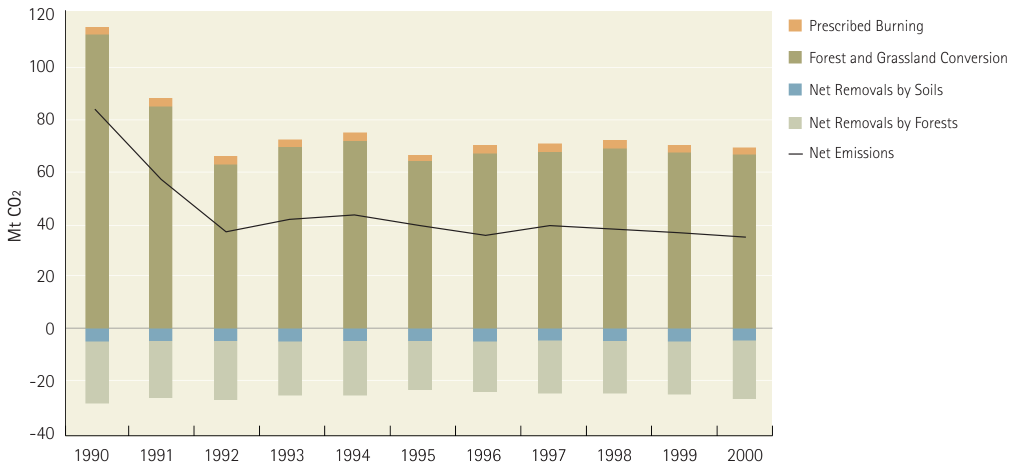
Source: Australian Greenhouse Office (2002)

Note: Does not include CO_2 emissions and removals from agricultural sources

Net carbon dioxide (or equivalent) emissions are estimated to have declined over the last 10 years from 85.9 Mt in 1990 (Figure 46). Figure 47 shows the total CO_2 removals associated with the growth of plantations and managed forests were 77.9 Mt CO_2 in 2000, an increase of 6.6 Mt (9.2 per cent) from 1990.

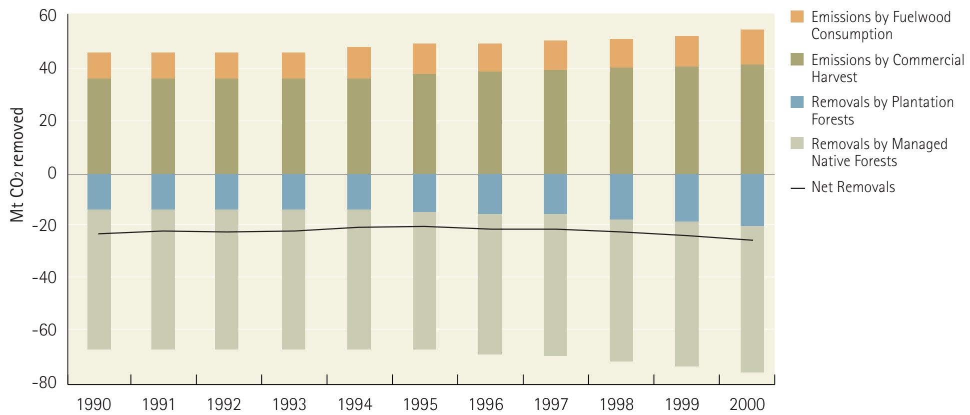
All of the increase occurred after 1994 and was attributed to plantations; CO_2 removals by managed native forests were assumed to be constant. The increase in removals was more than offset by a 7.5 Mt CO_2 increase in emissions from commercial harvesting (17.7 per cent) and fuelwood gathering (10.8 per cent), between 1990 and 2000. Therefore net removals actually declined by 3.6 per cent, from 24.6 Mt CO_2 in 1990 to 23.7 Mt in 2000. Growth in removals by plantations was associated with an increase in the area of plantations. Plantations established since 1990 are estimated to have sequestered approximately 10 Mt of CO_2 in 2000.

Figure 46: Emissions from land-use change and forestry, 1990–2000



Source: Australian Greenhouse Office (2002c)

Figure 47: Carbon dioxide emissions and removals by plantations and managed forests, 1990–2000



Source: Australian Greenhouse Office (2002c)

CSIRO Scientists studying emisssions and uptake of greenhouse gases

Estimating uptake of carbon and emissions in forests is difficult due to inherent uncertainties associated with measuring anthropogenic and natural exchanges of greenhouse gases between the biosphere and the atmosphere. There is currently no comprehensive monitoring system for forests in Australia that covers all forest types and tenures. Areas of continuing high uncertainty include growth rates of privately managed forests and native forests that are managed either for commercial harvest or fuelwood gathering. The area of forest that is actually managed for wood production is also uncertain.

The estimates included here are based on a relatively small proportion (9 per cent) of the total area of native forests that included all known-age multiple-use forests and forests available for timber production on other Crown land and Private land. The focus on emission estimation to date by the National Carbon Accounting System has been on areas of deforestation and plantation establishment. Over the coming period the available information will be supplemented and analysed to provide more certain estimates of carbon stock changes in native forest across all forest tenures (Australian Greenhouse Office, 1999). They do not include forest in nature conservation reserves and exclude some public forest and large areas of privately managed forests that are currently used, or have been used in the past, for timber production or that have been subjected to other forms of anthropogenic disturbance likely to affect carbon stocks and fluxes. The fluxes of soil carbon under land-use change are also uncertain, and are subject to ongoing research by the CRC for Greenhouse Accounting and other groups.

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coverage
currrency
frequency

Forest products and the global carbon budget

Indicator 5.1c

Contribution of forest products to the global carbon budget

Rationale

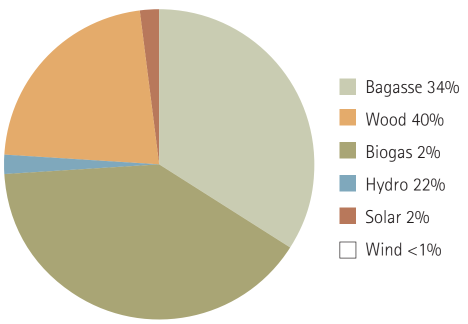
This indicator provides information on the amount of carbon stored in wood products and the extent to which use of wood products is reducing or increasing atmospheric carbon dioxide concentration.

Initial studies indicate that the carbon stock in wood products, including imports, in Australia was 69 million tonnes (Mt) in 1998 and is currently increasing by about 0.4–0.5 Mt per year.

A considerable proportion of the carbon in forests is contained in the woody trunks of trees. When trees are harvested and converted to wood products, carbon remains stored in these products for varying lengths of time depending on the nature of the product and the means of its disposal.

The generation of energy by burning firewood or processing waste from sustainably managed native forests and plantations—often called biomass energy or bioenergy—may replace energy generated from fossil fuels and result in an overall reduction in emissions of carbon dioxide to the atmosphere. It is estimated that in 2000–2001 wood supplied 40 per cent of Australia's renewable energy (Figure 48), or 2.1 per cent of the total energy supply. This could increase under the Australian Government Mandatory Renewable Energy Target of 9 500 gigawatt hours of extra renewable electricity per year by 2010.

Figure 48: Australian renewable energy use in 2000-2001



Source: ABARE (2003)

For this indicator, estimates of carbon stocks in wood products were derived from studies undertaken for the Australian Greenhouse Office National Carbon Accounting System, which were based on national forest product statistics. Estimates of decay of different product classes were derived from industry surveys and published literature.

Accounting for carbon in wood products is complicated by the fact that products are traded internationally. Australia imported about 1.64 Mt of wood products (mainly paper) in 1998, with an estimated carbon mass of 0.82 Mt, and exported 4.48 Mt of mainly hardwood and softwood woodchips with an estimated carbon mass of 2.24 Mt. The total estimated carbon stock of 69.2 Mt in 1998 includes products made from imported wood products and wood removed from Australian forests that remains here.

The estimated stock in wood products is only a small proportion (0.2 per cent) of the estimated stock in forests. About 80 per cent of the wood products stock is in the long-lived pool that is assumed to take 90 years to decay (Table 71). Carbon stock in wood products in Australia is currently increasing by about 0.4–0.5 Mt per year (Figure 49), although this rate has decreased from previous years.

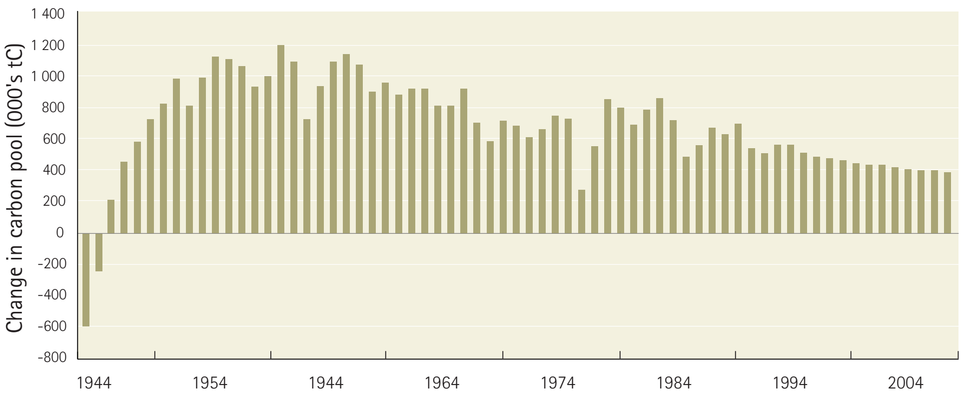
Table 71: Estimates of carbon stocks in different product pools based on historical production data

Product pool	Assumed years to decay	Estimated carbon stock (Mt)
Softwood pallets, cases, plywood form board, paper and paper products	3	5.2
Hardwood pallets, palings, particle and fibre board used in shop-fitting and DIY, and hardboard packaging	10	1.0
Plywood, particle and fibre board in kitchens and bathrooms	30	4.5
Preservative treated pine, softwood furniture and hardwood poles, piles and girders	50	2.8
Softwood and hardwood framing, flooring lining and furniture timber particle and fibre board used for flooring and lining	90	55.7
Total		69.2

Source: Jaako Poyry Consulting (2000)

Note: This includes carbon in products produced from Australian forests and imported

Figure 49: Estimated annual change in carbon stocks in wood products in Australia since 1944



Source: Jaako Poyry Consulting (2000)

Estimates of energy use reported here are considered accurate. However, estimates of carbon stocks in wood products are regarded as preliminary. They are based on relatively untested assumptions about the average service life and decay rates post service of different wood products such as sawn timber, panelboard, plywood and pulp and paper products. Further research to determine the carbon concentration of different timber species is ongoing, and work on improved estimates of the lifespan of different timber products and to investigate the fate of wood products after disposal is also progressing in collaboration between the CRC for Greenhouse Accounting and the National Carbon Accounting System. For example, initial studies suggest that wood and paper products disposed of in closed landfills have decomposed little after many years.

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Michael F. Ryan

Long-term carbon storage in furniture

6

MAINTENANCE AND ENHANCEMENT OF LONG TERM MULTIPLE SOCIO-ECONOMIC BENEFITS TO MEET THE NEEDS OF SOCIETIES

INTRODUCTION

The report now moves on from the environmental and biophysical aspects of forest management to discuss and assess the ways people and their communities derive social and economic benefits from Australia's forests. The perspective of Indigenous people is addressed wherever possible, often in separately assessed indicators.

The indicators are grouped around the sub-themes of production and consumption, recreation and tourism, investment (including research and development), culture and spiritual benefit (including Indigenous values), and employment and community needs.

Socio-economic data are important barometers of human interaction with Australia's forests—how they contribute to the economy, how they benefit personal and community well-being, how they support Indigenous and non-Indigenous cultural values and so on. Some of these data are relatively easily quantified—for example, monetary values and volumes of timber product and employment in the wood production industry. Even so, the figures are often not conclusive because indirect beneficiaries of particular activities can often only be estimated. Data can be much more difficult to obtain when human economic and other activities in a forest are informal rather than formal, when they relate to a 'value' or recreation rather than a quantity of material, or when the only available data cannot easily be extrapolated to specifically represent forests in general or those of particular types. Moreover, not all the available data can be applied nationally. State and Territory Governments collect data on subjects relevant to their particular forest management needs; while some extrapolation of the statistics can be made for national reporting purposes the end result could misrepresent the actual situation. For example, there is likely to be much more passive recreation occurring in our forests than the available figures would indicate.

Difficulties of data collection and interpretation aside, the information provided under these indicators gives us an extremely valuable snapshot of our place in the forests and a good basis for future decisions for their continued good management.

The first group of indicators (6.1a–f) cover the things we produce and consume from Australia's forests. The importance of forests in sustaining the customary economy of Indigenous people is also considered. The data show the trends in value and volume of wood production and how this compares to non-wood products, such as honey and tree seed. It also shows overall and *per capita* consumption of wood and wood products, and confirms that Australia's appetite for imported high value wood based products is undiminished, despite the trend towards import replacement in sawn timber and panel wood. The data also shows us how well we recycle used timber-based product, confirming that we are energetic paper recyclers but less successful at recycling wood wastes.

The second group of indicators focuses on recreation and tourism (6.2a–c). Many Australians use forests for recreation and tourism, and the data indicate that the variety of these pursuits is almost unbounded. Forest areas that are set aside specifically for conservation purposes generally attract those with interests compatible with that environment—nature study, bush camping and walking, astronomy and rock-climbing. Multiple-use forests, on the other hand, attract a very broad clientele with interests ranging from camping and bush-walking to orienteering, running, bush-cycling, horse-riding and motor sports. Forests are also favourite destinations for day visitors on picnic and touring outings, especially in those forests like the Dandenong Ranges, on the outskirts of Melbourne (Victoria).

With such a wide variety of pursuits comes human impact; this is not always desirable or acceptable and negative impacts can quickly devalue the natural attributes of a forest. Little hard information is available to substantiate how serious a problem this is, but it is an issue that forest managers are having to consider more frequently and indicator 6.2d should provide a baseline for monitoring in future reporting periods.

The next four indicators (6.3a–d) look at investment, and the economics of investment in the forest industry sector. We include research and development and education expenditure in this group, both because it is substantial in dollar terms but also because it is critical to industry progress and to sustainability of the natural environment, which fundamentally underpins the industry. Research and development spending on the environment in forest areas has traditionally been the poor relation to industry-related spending but has increased quite dramatically over recent years. New and improved technology as a measure of investment is also examined. More than $6.5 billion of new investment in the industry has occurred since the early 1990s, although the figure does not necessarily represent clear investment trends over the long-term. The indicators provide a good framework for more comprehensive data collection over time.

Indicators 6.4 a and b examine the kinds of cultural and social values we attribute to Australia's forests, including those many non-consumptive pursuits, from horse riding and eco-tourism to car rallies. Very little hard data are available to quantify these uses because many of them are intangible, although data on permit systems in some jurisdictions give an indication of the variety and intensity of use. Some quantification of the area of forest managed specifically for the cultural and religious needs of Indigenous people is possible. While approximately 13 per cent of all forest land is subject to Indigenous stewardship, there is marked disparity in apportionment between the north and west and the south of the country. Places of cultural value for both the Indigenous and non-Indigenous communities are frequently listed in heritage registers and surveys and assessments of such places continue across the country. However, the purposes and methods of assessment vary widely between jurisdictions. The Register of the National Estate lists places of national significance but there are many thousands of other places, even within the forest estate, that are of local, regional or State and Territory significance.

The next set of indicators (6.5a–d) discusses and attempts to measure the needs of communities in forest areas, particularly employment and the viability of those communities, including Indigenous communities, especially in times of rapid economic change. The data show a continuing decline in direct forest industry employment (although wages and salaries are increasing), but the level of indirect employment, though much more difficult to quantify, is still considerable and is likely to be understated. Forest work is still relatively dangerous but the statistics show improvement in occupational health and safety.

The last indicator, 6.5d, looks at the relationship to the land of Australia's Indigenous peoples, and their opportunities to gain access to traditional forest areas for subsistence and to meet their basic needs. This access has been measured through Native Title Applications and related legal determinations and Indigenous Land Use Agreements.

6.1

PRODUCTION AND CONSUMPTION

INTRODUCTION

These six indicators are concerned with the supply, consumption, recycling and value-adding of wood and other forest products. The indicators consider the volume of these products and their value to the economy.

The total value of primary forest production has increased in the last five years, and stood at nearly $1.3 billion in 2001. The estimated value of the country's standing timber is about $10.6 billion. In addition, forests provide other vital benefits that are less easily measured. For example, many of metropolitan Australia's water supply catchment areas are in forests. For example, forests in water supply catchment areas are integral to maintaining water quality. Indigenous people maintaining customary lifestyles gain a large proportion of their non-cash income from forests. The production and consumption of forest-related products play an important part in the country's economy and in meeting the socio-economic needs of society.

Stacking jarrah boards for export, Greenbushes, south west Western Australia

Wood product values and volume

coverage
currrency
frequency

Indicator 6.1a

Value and volume of wood and wood products production, including value added through downstream processing

Rationale

Enables socio-economic benefits to be monitored by ascertaining trends in value and volume of wood production against management objectives.

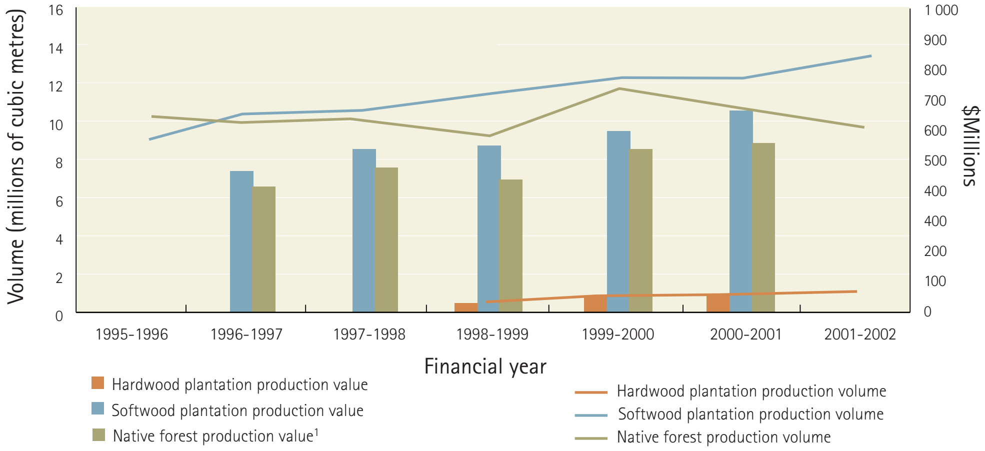
The value of logs harvested from Australia's native forests and plantations has increased significantly. Australia is a net importer by value of wood and wood products and, since 1995–1996, a net producer and exporter by volume. The volume of sawnwood produced has increased significantly due to production from softwood plantations. Production and exports of wood based panels and woodchips has increased significantly. Australia remains a net importer of pulp and paper products.

The *value* of timber in plantations and native forests is reported in the National Accounts. The volume of production of wood and wood products and the value of products imported and exported are available. However, data on the *value* and *value-added* of domestic production are not publicly available.

In 2000–2001, the National Accounts reported the estimated value of timber in plantations and native forests at $10.6 billion (ABS 2001). In real terms, the value of timber in plantations increased from 70 per cent of the total value in 1991–1992 to more than 77 per cent in 2000–2001. This is due to the increasing area and maturity of plantations.

In the five years from 1996 to 2001 the estimated combined value of native and plantation logs harvested rose in real terms from $894.2 million to $1.3 billion (Figure 50). During this time, the volume from plantations increased, while the production from native forests declined slightly. This trend will become more evident in the future as plantations mature and native forests contribute less to production. The volume of softwood plantation timber harvested increased from 9 million cubic metres in 1995–1996 to 13.5 million cubic metres in 2001–2002. The volume of hardwood plantation harvested increased from 580 000 cubic metres in 1998–1999 to 1.11 million cubic metres in 2001–2002, representing an increased harvest of over 90 per cent.

Figure 50: Estimated real value and volume of logs harvested from native and plantation forests



Source: ABARE (2002a), ABARE (2003)

Notes: Real value is calculated using the Wood and Wood Product Price Index; the base year for this index is the 2001–2002 financial year

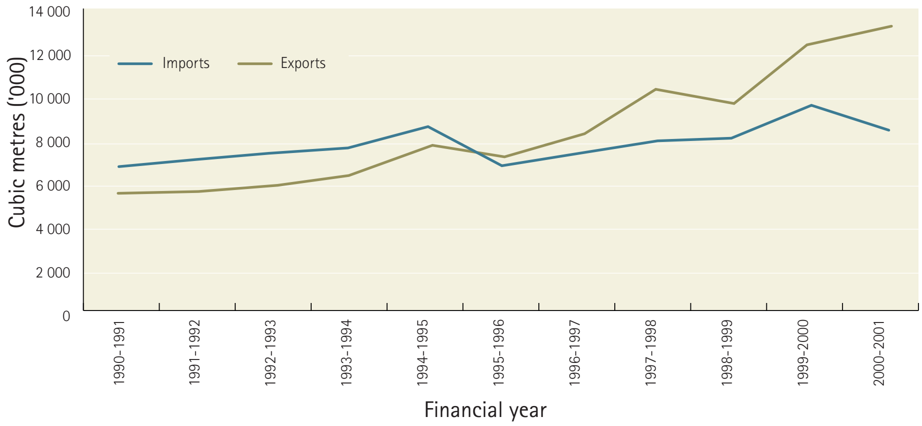
[1] Native forest production value figures for 1996-1997 and 1997-1998 include small amounts of hardwood plantation production value

In volume terms, Australia has become both a net producer and a net exporter of timber since 1995–1996 (see indicator 6.1c and Figure 51 below). However, in value terms, Australia imports more wood and wood products than it exports—by about $1.7 billion per year. This imbalance is because exports are primarily low value raw materials, in particular woodchips, but imports are primarily high value wood manufactures, such as paper products. This pattern continues that reported in the 1998 State of the Forests Report.

Skateboards built from Australian timbers at East Gippsland Forestech, Victoria

The production of major wood and wood products over the past decade is summarised in Table 72. This shows an increased processing capacity in the industry, which suggests a considerable increase in Australian competitiveness in the production of sawnwood and woodbased panels. Further evidence is provided by the decreasing contribution of woodchip exports to the total value of exports, from 57 per cent in 1991–1992, to 38 per cent in 2001–2002. Furthermore, in the last decade there has been an expansion in Australia's exports of wood products, in particular woodbased panels, and a growth in the proportion of paper and paperboard exports (from 10 per cent in 1990–1991 to 19 per cent in 2000–2001).

Figure 51: Volume of wood traded in gross roundwood equivalents



Source: ABARE (2002a)

Note: Gross roundwood is the volume of logs actually removed from the forest. 'Equivalent' refers to the estimated volume that is required to make a specific forest product

Sawnwood

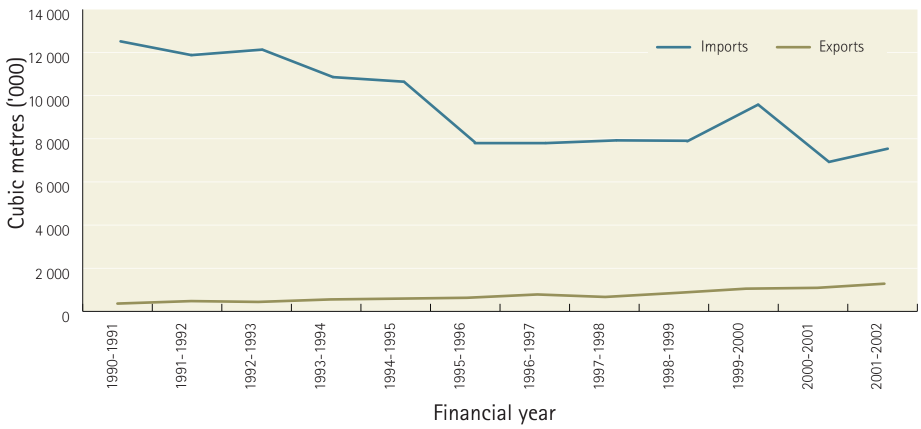
The volume of sawnwood produced has increased by over 30 per cent in the ten years to 2002. Softwood sawnwood production increased by 80 per cent in that period while hardwood production declined by 30 per cent (Table 72). Increased sawnwood production has displaced imports, which decreased by 40 per cent in ten years. Exports of sawnwood increased five-fold, although the volumes are relatively small (Figure 52).

Table 72: Production of wood and selected wood products

Commodity	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Sawnwood ('000 m^3)										
Softwood	1 660	1 898	2 118	2 054	2 1120	2 338	2 338	2 637	2 351	3 011
Hardwood	1 440	1 533	1 555	1 406	1 424	1 328	1 268	1 346	1 174	1 108
Wood based panels ('000 m^3)										
Plywood	122	138	145	131	151	170	169	192	157	201
Particleboard	726	828	864	826	790	882	902	978	904	965
Medium density fibreboard	318	421	436	377	434	501	495	621	712	732
Paper and paperboard ('000 tonnes)										
Newsprint	434	426	444	445	421	444	405	464	465	395
Printing and writing	396	386	365	351	364	424	497	535	554	624
Household and sanitary	165	170	173	180	181	191	187	232	204	198
Packaging and industrial	1 164	1 255	1 312	1344	1 452	1 483	1 475	1 605	1 449	1 679

Source: ABARE (2002b)

Figure 52: Trade in sawn timber

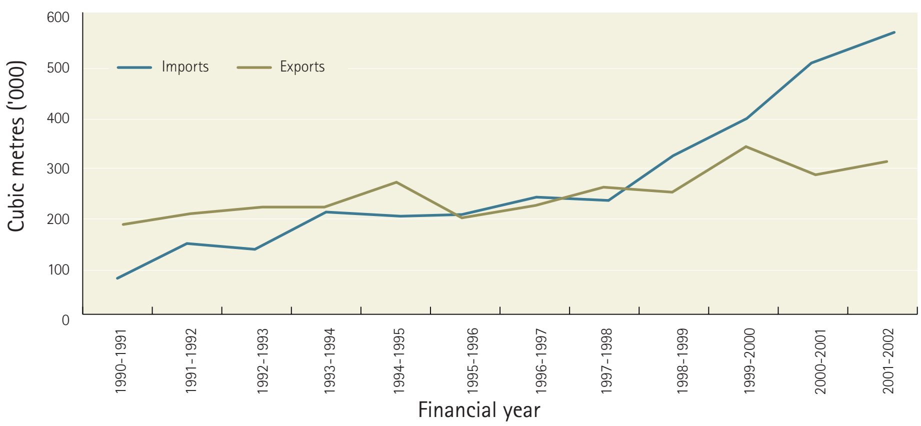


Source: ABARE (2002a)

Wood based panels

Production of wood based panels increased by over 70 per cent in the ten years to 2002 (Table 72). The volume of wood based panels exported has exceeded imports since 1997–1998 (Figure 53). This is mainly due to exports of medium density fibreboard, which have increased four-fold and now exceed domestic consumption. The value of wood based panel exports has therefore increased from 6 per cent to 11 per cent of the total earnings from wood and wood products and totalled $216 million in 2001–2002.

Figure 53: Trade in woodbased panels

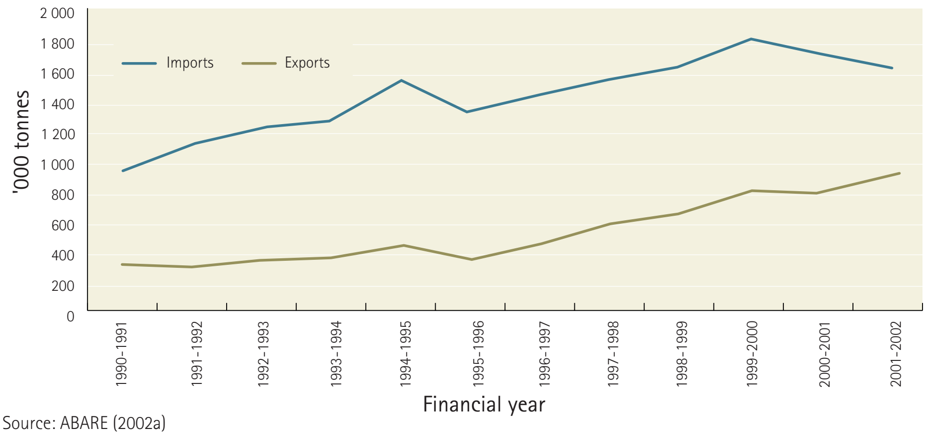


Source: ABARE (2002a)

Paper, paperboard, wastepaper and pulp

Production of paper and paper products has increased by over 30 per cent in the past ten years. Despite this increase, pulp and paper products continue to be a major contributor to Australia's trade deficit in wood and wood products. Over the past decade, imports of paper and pulp products have accounted for an average of 69 per cent of the total value of imports of wood and wood products. The value of paper and pulp product imports increased by 54 per cent (from $1.6 billion to $2.4 billion) in the ten years to 2001–2002. On the other hand, the value of exports increased by 166 per cent (from $276 million to $735 million) over the same period (Figure 54 and Table 72).

Figure 54: Trade in paper, paperboard waste paper and pulp

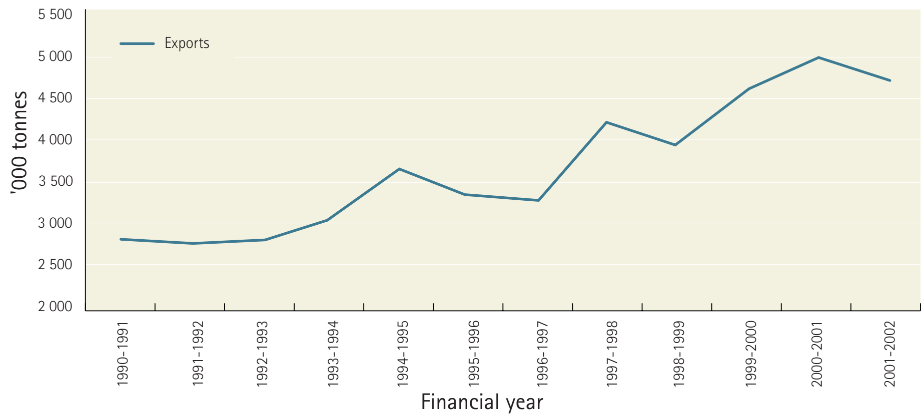


Source: ABARE (2002a)

Woodchips

Woodchip exports are a major component of Australia's trade in wood and wood products, and have expanded in volume over the last decade. In 2001–2002 the volume of woodchips exported was 4 722 000 tonnes, valued at $712 million (Figure 55). Over the same period, the contribution of woodchip exports to the total value of wood and wood product exports decreased from 52 per cent to 38 per cent.

Figure 55: Trade in woodchips



Source: ABARE (2002a)

Note: Imports of woodchips have ranged from 0.05 Kt in 1990–1991 to 3.1 Kt in 2000–2001. These figures are too small to be depicted at the scale above.

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Non-wood product value and quantities

Indicator 6.1b

Value and quantities of production of non-wood forest products

Rationale

Enables socio-economic benefits to be monitored by ascertaining trends in value and quantities of non-wood production against management objectives.

There are several products, apart from wood, that come from Australian forests. These include minerals, water, honey, various animal products (meats and skins), plant oils, grazing opportunities, native wildflowers and some bush foods.

Forests and trees provide a broader range of products and services than simply wood and wood-products. This indicator deals specifically with these non-wood forest products. The annual removal of non-timber forest products is more fully described in indicator 2.1e. Supply and consumption of non-wood products are captured in indicator 6.1f.

Minerals

Data about mining in forests are hard to separate out, as most figures apply to mining on forested and non-forested land together. Mineral extraction in general is a major economic enterprise in Australia, and accounts for a significant portion of the country's export earnings.

Water

A large portion of the water consumed in the highly populated regions of Australia originates in forested catchments. As well as its use for domestic consumption, water from forested catchment areas is essential for many industries and agriculture.

Several forest ecosystems in Australia—for example, river red gums (*Eucalyptus camaldulensis*) and mangroves—are dependent upon water availability for regeneration and health. The impact of agricultural activities, land clearing and forest management on water quality and quantity is an increasingly important issue for Australia.

Bee-keeping and honey

The apiary industry in Australia is significant in servicing domestic and overseas markets. Products supplied by the industry include honey, beeswax, queen bees (for new colonies), royal jelly and pollen.

The apiary industry is highly dependent on native forests. Victorian data, for example, suggest that 75 per cent of that State's apiary industry uses forest areas for production. Across Australia in 2000–2001, almost a quarter of the honey produced came from public forests. In addition, these areas provide a safe feeding area for rebuilding the strength and health of hives. States and Territories have different restrictions on the production of apiary products in multiple-use forests and nature conservation reserves.

Changes in land tenure such as transfer from multiple-use forests to nature conservation reserves, which can become protected and unavailable for commercial bee keeping, or changes in forest species composition have the potential to impact on honey production.

Tables 73 and 74 summarise the production of the apiary industry in Australia. New South Wales produces substantially more bee-related products than other States or Territories.

Table 73: Beekeeping (year ended June 2001)

Beekeeping	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Beekeepers (no.)	n.p.	407	n.p.	200	100	28	174	59	971
Productive ('000)(a)	n.p.	127	n.p.	39	36	12	57	17	289
Unproductive ('000)	n.p.	30	n.p.	20	3	2	6	5	68
Total ('000)	n.p.	157	n.p.	59	40	14	63	23	357
Beeswax (t)	n.p.	209	n.p.	47	53	12	76	33	430

Source: Australian Bureau of Statistics (2002)

Note: Australian Bureau of Statistics' data for Victoria refer only to full-time beekeepers, although part-time beekeepers contribute to a large percentage of the industry.

n.p.: no producers

This trend is also evident in Table 74, which shows honey production by State and Territory. In addition, the sale of bees and beeswax are each worth $3–4 million nationally.

Table 74: Honey production by State and Territory

Honey produced	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
				2000				
Quantity produced (t)	n.p.	8 775	n.p.	2 069	3 008	944	4 971	1 596
Gross value ($m)	n.p.	14.5	n.p.	3.4	5.1	2.0	8.3	2.7
Gross unit value ($/kg)	n.p.	1.7	n.p.	1.6	1.7	2.1	1.7	1.7
				1999				
Quantity produced (t)	n.p.	8 921	n.p.	3 287	1 959	686	2 477	1 508
Gross value ($m)	–	15.1	–	5.5	3.3	1.4	4.2	2.5
Gross unit value ($/kg)	1.5	1.7	1.5	1.7	1.7	2.0	1.7	1.7
				1998				
Quantity produced (t)	n.p.	8 232	n.p.	3 721	3 274	741	4 266	1 781
Gross value ($m)	–	13.7	–	6	5.7	1.4	7.3	2.7
Gross unit value ($/kg)	–	1.7	–	1.6	1.7	2	1.7	1.5

Source: Australian Bureau of Statistics (2002)
n.p.: no producers

Animal products

Animal products from forests include game meat from wallabies, kangaroos, wild boar (*Sus scrofa*) and deer; skins from brush tailed possums (*Trichosurus vulpecular*) and kangaroos (*Macropus* spp.); and carcasses from brush tailed possums. However, not all States and Territories permit commercial harvesting of native animals. Analysis suggests that commercial use of kangaroo, on both forested and cleared land, is the largest native animal industry in Australia.

The Indigenous customary economy, particularly in remote northern Australia, depends substantially on animals taken from forests. Recent research indicates that, in some locations, more than half of total protein intake continues to come from wild animals. Further detail about Indigenous use of animal and other products is provided below.

Grazing

Grazing on public land is conducted under permits provided by district authorities. The process allows agisting of animals on a short-term basis with fees being paid per head. Excessive grazing can have negative impacts on forests. Policies for grazing differ between States and Territories.

Vegetative bush foods

Examples of forest bush foods include quandongs (*Elaeocarpus grandis*), wattle seeds (*Acacia* spp.) and native herbs. A major factor in the success of marketing bush foods is their acceptance by the wider community. Recently, some bush foods have become available in supermarkets, but most bush foods are expensive for the consumer when compared with other similar products. Table 75 summarises some of the bush foods and products available in the Australian market.

Table 75: Native foods production

Species	Type	Total product used by processors, 1995–1996 (tonnes)
Bush tomatoes	Whole, dried	5.0
Illawarra plum	Fresh, frozen	2.5
Kakadu plum	Fresh, frozen	2.5
Lemon aspen	Fresh, frozen	3.6
Lemon myrtle	Dried, ground	2.5
Lemon myrtle	Whole leaf, dried	2.5
Muntries/munthari	Fresh, frozen	5
Native herbs	Dried Aniseed, Mint or Thyme	0.04
Native mountain pepper	Dried leaf and berry	2.5
Quandong	2nd grade dried halved	5.0
Riberry	Fresh, frozen	2.5
Warrigal greens	Fresh	0.22
Wattle seed	Clean, roasted	6.0
Wattle seed	Clean, roasted, ground	
Wild lime	Fresh, frozen	0.71

Source: Graham and Hart (1997)

Eucalyptus and tea tree oil

Eucalyptus oil comes from a number of eucalypt species including the blue mallee (*Eucalyptus gamophylla*) and is used for a variety of purposes. These include medicinal, industrial (oils, solvents), as a perfume and for flavouring. Australia produces approximately 120 tonnes of eucalyptus oil per year (5–10 per cent of the world's supply), of which 60–70 per cent is exported.

Tea tree (*Melaleuca* spp.) oil is a commercial forest product, addressed in the following case study.

Case study – Tea tree oil

Tea tree oil and its products are used for a variety of medicinal purposes and products including lip balm, soaps, shampoo, deodorant and toothpaste. Recently there has been extensive research into the properties of natural medicine and demand has risen.

Thursday Plantations, in northern New South Wales, is an Australian company trading tea tree oil products. The company currently has a projected turnover of $22 million and expects to reach $40 million by 2005. Such is the demand for tea tree oil products that Thursday Plantations has expanded internationally.

Wildflowers

Wildflowers may be grown in controlled environments or picked from native woodlands. Each State and Territory implements its own policy for native flower picking. In Western Australia, for example, picking wildflowers is prohibited without a license.

Exporters are required to obtain authority from the Australian Government before entering the Australian native wildflower export market. In 1995, Australia produced between $5 and $6 million worth of wild flower and stem products of which $1–2 million was consumed domestically leaving a large proportion for export. Western Australia exports the largest percentage of wild flower and stem products in Australia, contributing almost 60 per cent of the value of Australian exports annually (Table 76).

Table 76: Wildflower and stem products from Western Australia

	Wild: Crown Land	Wild: private land	Unknown source	Total bush harvest	Estimated value ($)
Number of stems	13 608 000	7 881 000	1 574 000	23 063 000	3 053 000

Source: Karingal Consultants (1997)

Seed

Tree seed plays a large role in planting forests for the future, and Australian tree seeds are also exported. Considerable expense may be incurred in financing the collection, storage, testing and despatch of seed. Collection is also a seasonal and extremely variable exercise. Many types of seed are also consumed as food.

Alpine ash (*Eucalyptus delegatensis*) seed, Orbost seed store, Victoria

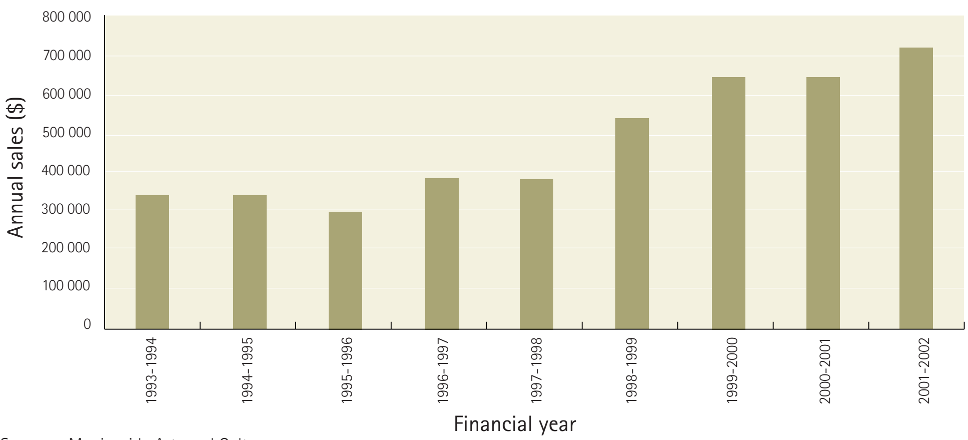
Indigenous use

Indigenous people in many parts of the nation require access to wild plants and animals from native forests to maintain customary economic practices (see also indicator 6.1.f). However, in common with other segments of Australian society, they differ in their views of acceptable levels and modes of exploitation that have the potential to cause substantial change in forested landscapes. Some entirely reject enterprises that would cause significant change in biophysical structure or function, or that would conflict with customary obligations for management of land. Nonetheless, there is increasing and widely shared interest in exploring local enterprise based on commercial use of native plants and animals.

At present, production of Arts and Crafts is arguably the only forest-dependent industry in which Australia's Indigenous people play a decisive role. Most arts-based products, whether for customary or commercial use, include non-wood items (dyes, ochres, pigments, fibres) taken from forest or woodland sites. The industry and its spin-off social benefits (see indicator 6.1f) are fundamentally dependent on Indigenous access to healthy, floristically diverse forests. Many products also use woody (but non-timber) material, including bark for paintings, hollow limbs or stems for didgeridoo, and poles for carvings. Total national production of Indigenous visual art is estimated to be worth $100–300 million per year, and is increasing. Whilst modest at the national level, this activity is critical in economically depressed, remote regions. Research on tourism in the Northern Territory indicates that 58 per cent of international visitors purchase Aboriginal arts and crafts (estimated at $38 million in 2001–2002) or seek related cultural experiences. Most of this work is produced on land owned by Aboriginal people.

Recent trends in the value of arts production at one site in Central Arnhem Land are illustrated in Figure 56. Most of the materials used in the production of these artworks and crafts originate in forests. The income from these sales represents a large proportion of the cash income earned by 300–400 artists from a total adult population of less than 1 200.

Figure 56: Income from arts based on plant products, Maningrida region

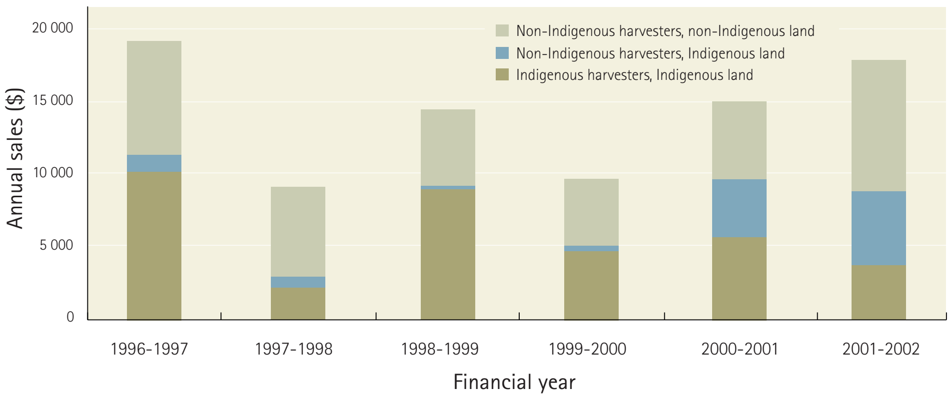


Source: Maningrida Arts and Culture

Other plant-based production includes harvest of whole plants (e.g. cycads and grass trees) and seeds for the nursery and landscaping trades. Most of these industries are presently small. Some native fruits (e.g. Kakadu plum *Terminalia ferdinandiana*) are harvested from the wild by both Indigenous and non-Indigenous people and there is scope for this use to expand. However, information on trends is difficult to obtain in this area and such imperfect data as are available rarely separate Indigenous from non-Indigenous use. Many Indigenous communities are actively exploring additional options, including supply of additional fruits and nuts to expanding native food markets and supply of botanical medicines. Economic utilisation of such forest-based enterprise is likely to increase in the future as remote communities seek to develop sustainable economic bases.

Commercial harvests of animals by Indigenous people are also relatively small at present, but there is increasing interest in exploring a wide range of options. Examples include farming of crocodiles and freshwater turtles. Eggs are often taken from forested (*Melaleuca*) wetlands, where nests tend to be more successful because they are less likely to overheat than in open habitats. Lizards and snakes may be taken for the pet trade. These options are being most actively pursued in the Northern Territory under the Government's 'Strategy for Conservation through Sustainable Use of Wildlife'. Comprehensive information is difficult to obtain, except where use is authorised under formal species management plans, which usually require authorities to make data on use publicly available. Figure 57 shows figures on use of crocodiles in the Northern Territory. Approximately 60 per cent comes from Indigenous lands and an unmeasured, but substantial, proportion from swamp forests.

Figure 57: Crocodile eggs harvested in the Northern Territory



Source: Parks and Wildlife Service, Northern Territory

In addition to these direct harvests of non-wood products, Indigenous landowners and residents receive incomes from resource rentals paid in a variety of ways when non-renewable resources are extracted from their land. From 1997 to 2001 amounts paid to the Aboriginal Benefits Account established under the *Aboriginal Land Rights (Northern Territory) Act 1976* (ALRA) ranged from $33.8 to $38.0 million per year. In other States that lack the formal frameworks provided by the ALRA, arrangements are more *ad hoc* and often confidential. It is likely that resource rentals in Queensland and Western Australia also total several millions per year.

Case study – Use of forests for Indigenous artwork

Aboriginal people in central Arnhem Land have over the last few decades expanded manufacture for commercial sale of a range of carvings based on distinct regional subject matters and styles. Larger carvings are created from stems of the tree *Bombax ceiba*, which occurs in relatively high densities in mostly small patches of rainforest or monsoon vine thicket scattered through the region's savanna landscapes. The species was mainly used in the past for dugout canoe manufacture and some other material culture. The carvings have proved to be commercially popular and artistically important, so that harvest for sale has risen to several hundred stems annually.

Studies completed to date suggest that risk of over-harvest at a regional scale is small, although there is some threat of local shortages, especially at more accessible sites close to the region's major township of Maningrida. Studies are continuing to develop a detailed population model for the species and to specify harvest limits.

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Warm temperate rainforest, New South Wales

Wood supply and consumption

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frequency

Indicator 6.1c

Supply and consumption of wood and wood products, including consumption *per capita*

Rationale

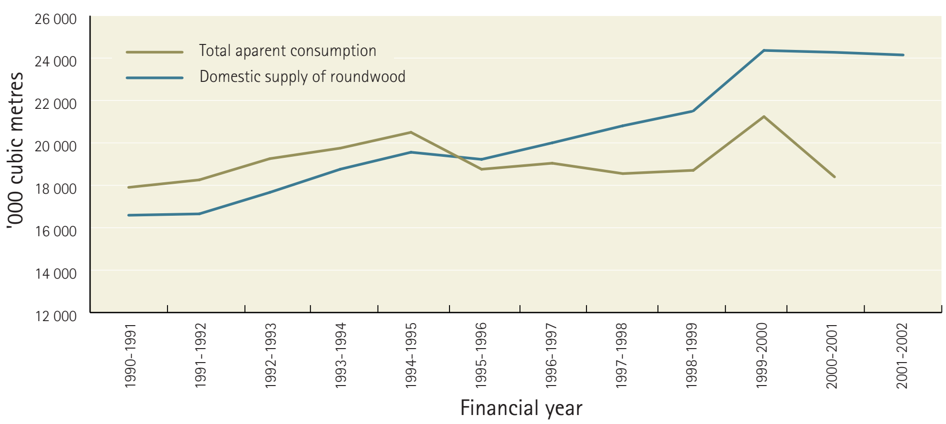
This indicator measures the trends in the consumption of wood and wood products in Australia, and the sources of supply. It also illustrates the ability of Australia's forests and timber industries to meet society's demand for wood products, and the demand pressures faced by Australia's forest resources.

Domestic supply of wood and wood products in Australia has increased over the past decade, largely due to the maturing softwood plantation estate. While the total consumption has fluctuated, it has increased slightly over the past decade. Consumption per capita, however, has fallen due to population growth and some substitution away from timber products in the housing sector.

Domestic supply of wood and wood products has increased over the last decade (Figure 58). This has been due largely to the maturing softwood plantation resource, which provides an additional source of wood to native forests. Substitution of wood from native forests by plantation wood is a feature of the domestic market and is likely to continue into the future as Australia's plantation resource continues to develop.

Despite cyclical fluctuations, the total consumption of wood and wood products in Australia has increased slightly over the past decade (Figure 58). *Per capita* consumption, on the other hand, has declined over the past 20 years (Figure 59). This is largely attributed to population growth and some substitution of wood products in the construction industry with non-timber products that offer a range of advantages other than price.

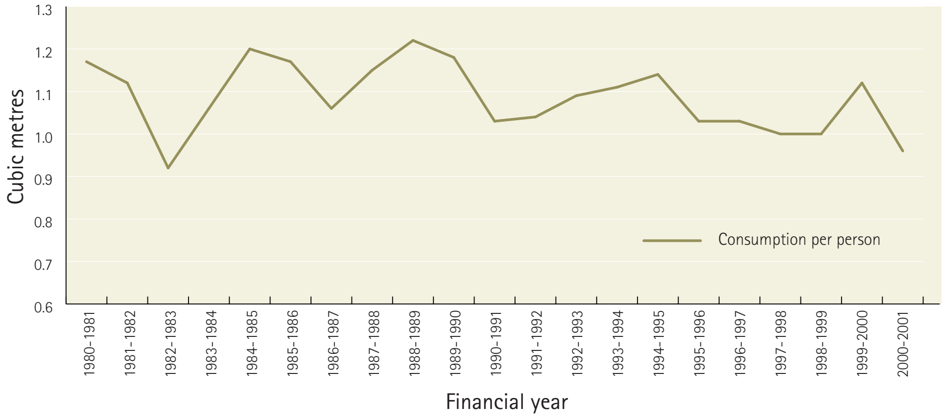
Figure 58: Apparent consumption of wood and wood products; domestic supply of roundwood



Source: ABARE (2001c)

Notes: 'Apparent consumption' is an estimate of national level of consumption; it is the sum of total production plus imports minus exports. 'Production' does not include firewood

Figure 59: *Per capita* consumption of wood products



Source: ABARE (2001c)

There is a clear trend towards import replacement in the consumption of sawn timber and woodbased panels, but imported high value paper and paper products continue to provide a significant share of domestic consumption. In 2001–2002, the total value of imports was $3578.4 million with 68 per cent attributed to paper, paperboard, paper manufactures, wastepaper and pulp imports.

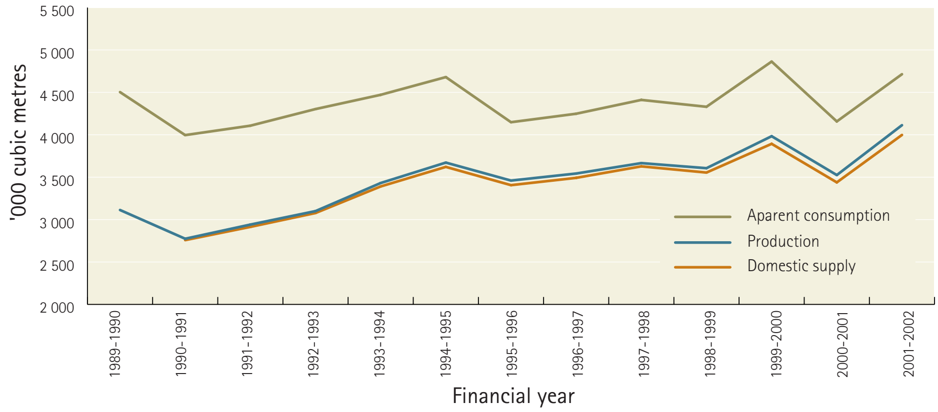
In 2000–2001, Australia's apparent consumption of paper and paperboard was 3.7 million tonnes, equivalent to 192 kilograms per person. Imports of paper and paper products in 2000–2001 were more than double those in 1990–1991, and it is expected that consumption will increase in the near future, in line with rising incomes.

Radially sawn timber weatherboard house

Sawnwood

Domestic supplies of sawnwood have been increasing over the last 10 years (Figure 60), with a trend towards import replacement. The proportion of demand met by domestic supply rose from 56 per cent in 1990–1991 to 79 per cent in 2000–2001.

Figure 60: Apparent consumption and production of sawnwood



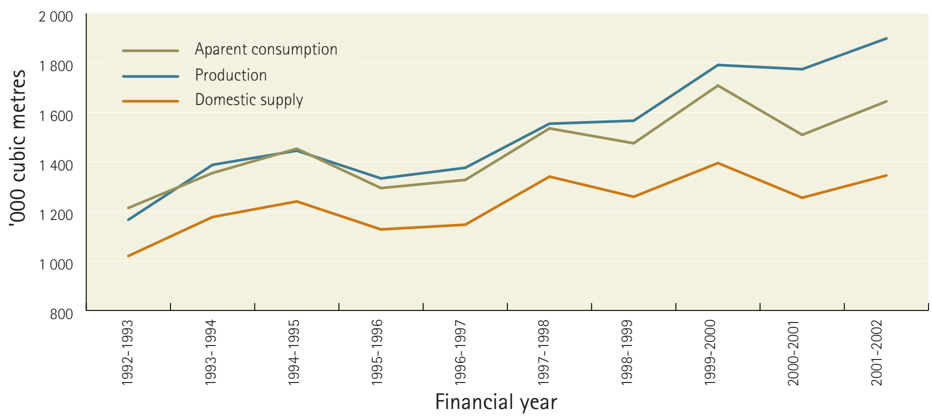
Source: ABARE

Wood and woodbased panels

The production of wood and woodbased panels has expanded over the last decade, (Figure 61), driven primarily by an expansion in exports, particularly of particleboard and medium density fibreboard. In 2000–2001, domestic supply of wood and woodbased panels accounted for 83 per cent of domestic consumption, after a peak of 87 per cent in 1997–1998. Over the last two years, exports of woodbased panels have increased by 100 per cent.

Further increases in the domestic demand for woodbased panels will probably be met by imports, as the size of mills required for economic production may exceed the likely requirements of Australia's small market.

Figure 61: Apparent consumption and production of wood and woodbased panels

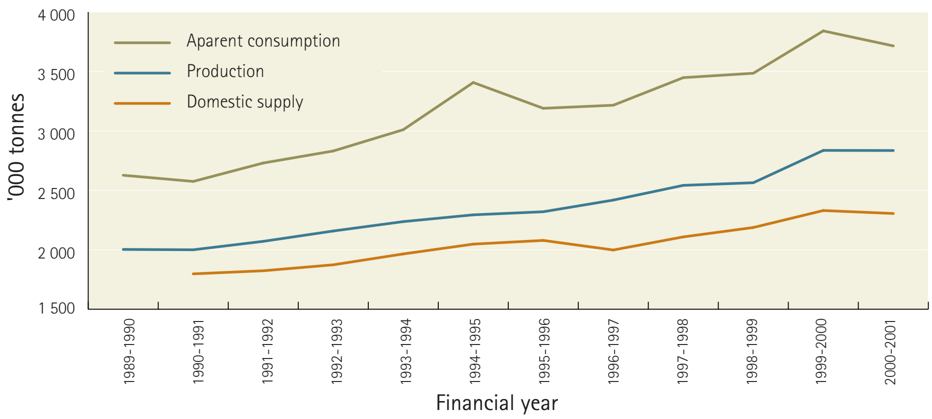


Source: ABARE

Paper and paperboard

Paper and paperboard production rose steadily over the last decade, but was outgrown by consumption (Figure 62). The proportion of domestic supplies consumed locally decreased from 70 per cent in 1990–1991 to 62 per cent in 2000–2001. In 2000–2001, printing and writing paper accounted for about half the total volume of paper and paperboard imports, with 760 000 kt imported at a value of $1.18 billion. The proportion of printing and writing paper imported as a share of total paper and paperboard imports increased from 58 per cent in 1991–1992 to 61 per cent in 2000–2001.

Figure 62: Apparent consumption and production of paper and paperboard



Source: ABARE

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Value of forest products

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Indicator 6.1d

Value of wood and non-wood products production as percentage of regional value of production

Rationale

This indicator would be a useful measure of the contribution of the forest industries to regional economies.

Over the nine years to 2001–2002, the value of wood products to the Australian economy increased from $5.9 billion to $6.6 billion. Although the value increased, the contribution to gross domestic product during this period remained relatively stable, between 1 and 1.3 per cent.

While the value of timber is clearly defined and well known, the economic role of non-wood products is more difficult to ascertain. Data collection for these products is *ad hoc* and not always coordinated. It is difficult to separate out certain products and services that may be produced in both forest and non-forest areas. In addition, various environmental services (such as water catchment) and human and aesthetic values (such as recreation) are hard to quantify.

The size of the forest sector's contribution to Australia's economy can be estimated by the value of the sector's inputs to other areas. For example, in 1995–1996 the forest sector contributed 2.9 per cent of all inputs to other industries. The largest user was the construction industry, with forest inputs to the value of $2.8 billion (which represents 8 per cent of the total value of inputs for this industry). Next was the printing and publishing industry, with forest product inputs to the value of $2 billion (17 per cent of the total value of inputs in this industry).

Wood production in the forest sector includes primary production (timber harvesting) and downstream processing. In 1993–1994 the sector contributed an estimated $5.9 billion (1.3 per cent) to Gross Domestic Product (GDP); by 2001–2002, this contribution was $6.6 billion, which represented only 1 per cent of GDP. In this same year, the timber harvesting component of the forest sector contributed an estimated $562.7 million to industry gross value added (IGVA), or 0.1 per cent to GDP (Table 77). IGVA is a measure of output derived from items based on a national accounting concept. Adjustments are made to exclude changes that result from processes not associated with the production of goods and services, for example, changes in the value of inventories due to price fluctuations. Additional value accrues to a commodity after production, harvesting and processing.

The wood and paper-manufacturing component of the forest sector makes the most significant contribution to economic growth, with a contribution of about $6 billion to IGVA or 0.9 per cent to GDP. The Australian Bureau of Statistics defines the manufacturing component of the forest sector to include sawmilling, other wood product manufacturing and paper and paper product manufacturing. These industries account for all primary and secondary processing of wood and wood products.

The timber harvesting component of the forest sector's declining contribution to GDP is consistent with other primary industries for which economic growth may be restricted by physical and climatic constraints as well as biological growth rates.

Table 77: Industry gross value added and contribution of the forest sector to gross domestic product (GDP)

Year	Forestry and fishing ($m)	Timber harvesting[1] ($m)	Wood and paper manufacturing ($m)	Gross value added at basic prices ($m)	Forest sector contribution to GDP (%)
1993–1994	1 294	427	5 460	467 897	*1.3*
1994–1995	1 387	458	5 622	487 467	*1.2*
1995–1996	1 372	453	5 743	508 581	*1.2*
1996–1997	1 520	502	5 541	527 848	*1.1*
1997–1998	1 579	521	5 602	549 884	*1.1*
1998–1999	1 612	532	5 552	578 866	*1.1*
1999–2000	1 640	541	6 303	602 021	*1.1*
2000–2001	1 681	555	5 688	614 061	*1.0*
2001–2002	1 705	563	6 041	638 256	*1.0*

Source: ABS (2002a)

1 Assumes output to value-added ratio applies to forestry and fishing, and takes a value of 33 per cent for forestry production (timber harvesting component)

The increase in the absolute value of primary production relative to manufacturing in the forest sector, however, suggests a greater rate of expansion in the timber-harvesting component of the sector relative to manufacturing. This is likely to be due to government-funded plantation establishment.

During the six years to 2000–2001, wood and paper product manufacturing made the most significant contribution to the value adding process of the timber industry. It contributed between 67 per cent and 75 per cent to industry value added (IVA)—the value added to commodities as they undergo processing—within the forest sector (see Table 78). In 1999–2000 more than half of all value adding in wood and paper product manufacturing was recorded in New South Wales and Victoria.

Wood production was of greatest significance in Tasmania, where wood and paper product manufacturing contributed 6.6 per cent of Australia's total IVA in wood and paper product manufacturing, compared to the 2.4 per cent contribution this State makes to Australia's total IVA in the manufacturing sector. However, in Tasmania IVA in wood and paper product manufacturing has been decreasing in relative and absolute terms over the last four years to 2000–2001. This trend has been paralleled by an expansion in the resource establishment and increases in Tasmania's woodchip exports.

Table 78: Value added to wood and paper products ($ million)

Year	Forestry and logging	Wood and paper product manufacturing	Sawmilling and timber dressing	Other wood product manufacturing	Paper and paper product manufacturing	Total
1995–1996	355	3 987	1 154	832	2 000	8 328
1996–1997	521	4 240	898	1 372	1 970	9 001
1997–1998	589	4 657	1 141	1 548	1 967	9 902
1998–1999	658	4 971	988	1 650	2 333	10 600
1999–2000	681	5 203	1 142	1 817	2 244	11 087
2000–2001	n/a	4 929	961	1 504	2 465	9 859

Source: ABS (2002c)

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Export woodchip mill, Burnie, north east Tasmania

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currency
frequency

Recycling

Indicator 6.1e

Degree of recycling of forest products

Rationale

This indicator identifies the extent to which recycling or reuse of forest products occurs.

Paper is the main recycled forest product, and the rate of paper recycling has been steadily increasing, although it appears to be levelling off. Timber waste is recycled to a much lesser extent.

As the domestic and worldwide demand for forest products increases, so too does the opportunity and need for recycling. The timber industry produces highly recyclable products, such as paper and wood. Recycling forest products conserves the forest resource base, reduces the volume of solid waste going to landfill, and has implications for the atmospheric carbon balance.

Paper products

Data suggests that waste paper recovery rates have almost doubled in the past 15 years, rising from 23.4 per cent (557 000 tonnes) recovered in 1985 to 44.2 per cent (1.6 million tonnes) in 2000. This can be attributed to improved environmental awareness and access to recycling facilities.

Most of the waste paper collected each year is used in the re-production of paper. National Association of Forest Industries (NAFI) figures published in 2001 claimed that 57 per cent of raw materials used in the pulp and paper industry were recycled. As Table 79 shows, these figures are high compared to international standards.

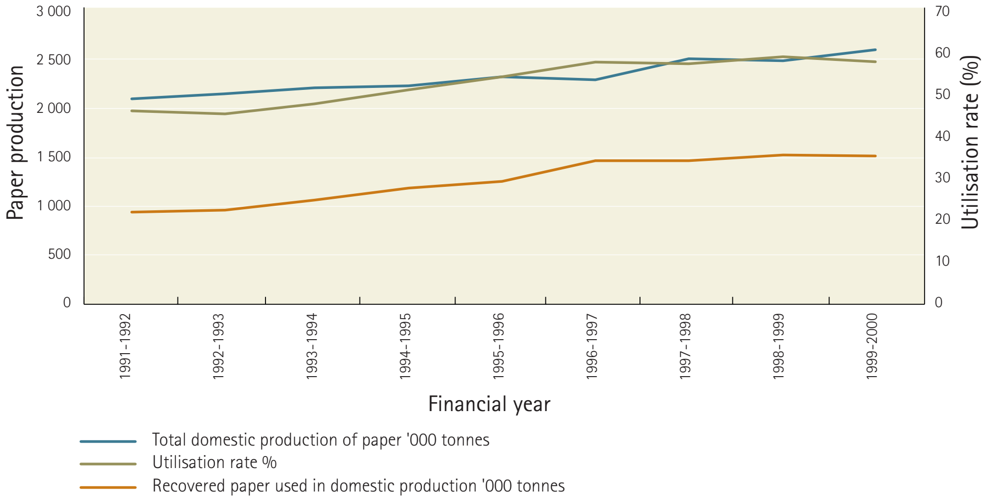
Table 79: Wastepaper component in paper production

Country/Region	Wastepaper component (%)
Australia	62
Western Europe	50
United States of America	45

Source: Recycling, APIC (2002)

Figure 63 shows the amount of recovered paper used in paper production as compared with the total paper production over a number of years. It also illustrates the utilisation rate of recovered paper. It indicates an overall increase in the recovered paper use since 1991–1992 although there appears to be a plateau in recent years. As paper production has recently experienced a slight increase without an increase in recovered paper usage, the utilisation rate has experienced a slight decline following a peak in 1997.

Figure 63: Utilisation of recovered paper in domestic paper production



Source: Australian Bureau of Statistics

Different varieties of paper are recycled and reused to different extents (see Table 80). According to NAFI, of the raw materials used, packaging and industrial papers utilise 100 per cent recycled fibre, newsprint utilises 24 per cent, tissue paper uses 12 per cent, and printing and writing papers use 6 per cent.

Table 80: Recovered paper use ('000 tonnes)

Recovered paper type used	Packaging and industrial	Newsprint	Printing and writing	Tissues	Total
Packaging papers	1 120	0	0	0	1 120
Printing/writing woodfree	63	0	36	20	120
Printing/writing other	14	0	0	5	19
Newsprint	280	96	0	0	380
Total recovered paper used	1 480	96	36	25	1 600
Yield[1] (per ent)	*90*	*85*	*70*	*70*	*88*
Recycled fibre content	1 330	82	18	18	1 440
Virgin fibre and additives	150	290	350	190	1 100
Paper production	1 470	370	370	210	2 540
Utilisation rate[2] (per cent)	*100.0*	*24.2*	*6.1*	*12.4*	*61.5*

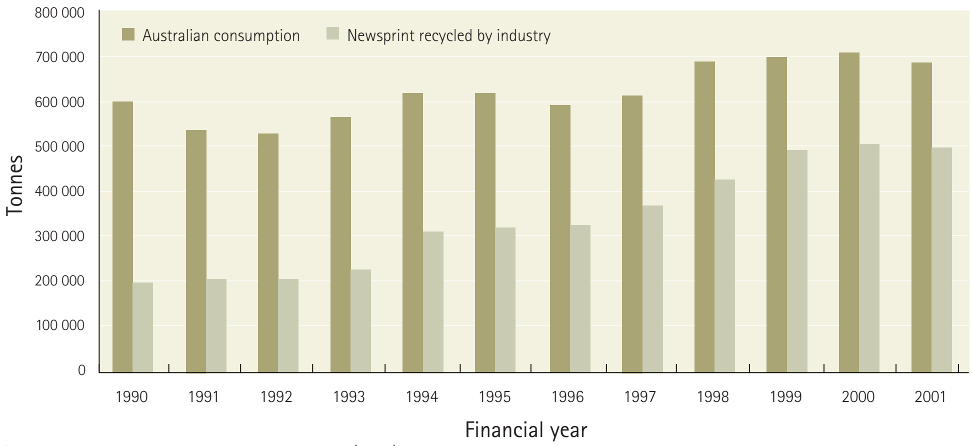
Source: Australian Paper Industry Council (2001)

1 'Yield' is the percentage of fibres used from recovered paper once ink and other waste products have been extracted.

2 'Utilisation rate' is total recovered paper used as a percentage of total domestic paper production.

Newspaper recycling in Australia has increased greatly in recent years. Of 725 974 tonnes consumed in 2000 about 70 per cent was recycled. In 1990, just 30 per cent of newspaper consumed was recycled. Figure 64 demonstrates this trend.

Figure 64: Consumption and recycling of newsprint, 1990–2001



Source: Publishers National Environment Bureau (2002)

Recycling of Australian printing and writing paper is at a lower level than that of newsprint. According to the Pulp and Paper Manufacturer's Federation of Australia (PPMFA) 16 per cent of printing and writing paper was recycled in 2000. However, nearly 85 per cent of Australian households recycled paper in 2000, an increase from 55 per cent in 1992.

Waste paper is an exportable product. Table 81 shows the income from wastepaper exports as compared with that of other paper products. This table shows a significant increase in wastepaper exports in the last year. Waste paper is the only paper product with a trade surplus (Table 82).

Table 81: Waste paper and associated exports ($million)

Product	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002
Wastepaper	14.9	43.7	26.2	10.8	17.88	25.1	39.9	39.7	55.5
Newsprint	1.8	0.8	1.3	0.1	7.45	6.9	1.6	2.6	1.3
Printing and writing	62.1	43.6	49.4	55.1	65.99	81.5	121.1	145.6	197.9
Household and sanitary	29.0	7.9	47.9	58.8	63.93	59.7	80.1	80.4	94.8
Packaging and industrial	122.5	141.0	146.9	235.6	236.99	207.2	287.9	300.1	297.6
Paper manufactures[1]	6.0	6.4	6.0	8.3	66.51	61.7	65.9	83.8	83.5
Pulp	–	0.2	0.7	1.7	0.6	0.9	1.6	4.6	2.9

Source: ABARE (1996, 1997, 2001, 2002); Australian Bureau of Statistics (2002)

[1] includes boxes, bags, letter trays, paper bags, notebooks, letter pads and other paper articles that have had some further processing

Table 82: Balance of paper trade ($million, 2001-2002)

Product	Exports	Imports	Trade balance
Paper and paperboard	593	1 841	- 1 248
Waste paper	56	5	+ 51
Pulp	3	221	- 218
Paper manufactures	84	374	- 290
Total	735	2 441	- 1 706

Source: ABARE (2002a)

Timber products

Timber recycling is less common than paper recycling in Australia, but data about the re-use of timber waste are available. The demand for recycled hardwood is predicted to exceed the supply within the next ten years.

In 2001, approximately 23 per cent of timber waste generated by Melbourne industries was recycled/reused and about 16 per cent of timber waste was recycled in Sydney. Recycled timber is used by a number of specialist furniture companies. While information on the market is limited, these companies appear to have identified a niche market, using recycled inputs as a major selling point. Woodcarving and other wood related art is very popular amongst artisans. This creates an excellent opportunity for the use of recycled timber products.

More than 70 per cent of Australia's newsprint is recycled

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coverage

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frequency

Non-wood supply and consumption

Indicator 6.1f

Supply and consumption/use of non-wood products

Rationale

Communities within a region can derive socio-economic benefits from non-wood products.

Major non-wood products from forests in Australia are honey and other apiary products, for which international demand is increasing; tree seeds, which continue to be in demand domestically and internationally; and grazing rights. Bush foods, animal skins and plant oils are relatively small scale and low-demand activities. Indigenous people in many parts of Australia make significant use of non-wood products from forested landscapes.

Bees on honeycomb

Data on the supply and demand of non-wood products are sparse. Many of these products are also produced in environments outside forests, so the figures are aggregated. This makes it difficult to separate the forest specific information. The annual removal of non-timber forest products is more fully described in indicator 2.1e. Value and quantities of production of non-wood products are captured in indicator 6.1b.

Apiary

International demand for honey has been increasing. While it is difficult to ascertain the actual value of supply and demand for forest-produced honey, Table 83 shows the distribution of honey production nationally and the proportion of honey produced on public land, including production in multiple-use forests.

Bush foods

Australian bush foods are produced primarily in farms or other controlled environments with only a small proportion being produced in native forests.

There is a lack of current information regarding demand for the product and there is potential for oversupply. This limits the entry of potential new suppliers into the market. The following table demonstrates the capacity to supply and recent demand for native foods.

It has been argued that the last five years has seen an increase in supply that has not been matched by demand. The high price of bush foods may be constraining demand. Public awareness and acceptance, as well as ready availability of the foodstuffs, might also be contributing factors.

Table 83: Distribution of honey production in Australia, 2000–2001

Honey production	NSW	Qld	SA	Tas	Vic	WA	Australia
Percentage of honey in 2000–2001 from[1]:							
Northern New South Wales	*70*	*6*	*0*	*0*	*0*	*0*	*23*
Southern New South Wales	*27*	*0*	*0*	*0*	*15*	*0*	*12*
Victoria	*1*	*1*	*1*	*0*	*85*	*0*	*19*
Queensland	*2*	*93*	*0*	*0*	*0*	*0*	*22*
South Australia	*0*	*0*	*99*	*0*	*0*	*0*	*13*
Western Australia	*0*	*0*	*0*	*0*	*0*	*100*	*8*
Tasmania	*0*	*0*	*0*	*100*	*0*	*0*	*3*
Producers use of public land							
Used public land in last five years (per cent)	*67*	*71*	*33*	*100*	*48*	*89*	*62*
Percentage of honey in 2000–2001 from:							
Multiple-use forests	*20*	*26*	*1*	*58*	*26*	*40*	*23*
Nature conservation reserves	*4*	*2*	*1*	*13*	*5*	*4*	*3*
Other crown land	*5*	*4*	*0*	*3*	*2*	*8*	*4*
Privately managed land	*71*	*68*	*98*	*26*	*67*	*48*	*70*

Source: ABARE (2003)

[1] For producers who operate in more than one State, the table shows the proportions of production from the region in which they are based and adjoining regions where they also operate.

Table 84: Capacity to supply current native food processors through commercial cultivation

Species	Plant density per hectare	Yield per plant (kg)	Yield/ hectare (tonnes)	Known plantings (plants)	Potential yield (tonnes)	Demand 1995-1996 (tonnes)
Bush tomatoes	8 000	0.5	4.0	12 000	6.0	5.0
Muntries/Munthari	2 000	1.5	3.0	5 000	7.5	5.0
Warrigal	3 000	2	6.0	5 000	10.0	0.22
Native herbs (pot culture)	8 000	0.2	1.6	–	–	0.04
Native mountain pepper	1 200	–	–	5 000	–	2.5
Lemon myrtle	625	2	1.250	5 000	10.0	5.0
Quandong	850	1	0.85	40–50 000	40.0	5.0
Illawarra plum	275	6	1.65	500	3.0	2.5
Kakadu plum	275	10	2.75	–	–	2.5
Lemon aspen	275	10	2.75	5 000	50.0	3.6
Riberry	275	15	4.125	5 000	75.0	2.5
Wattle seed	625	1.5	0.93	–	–	6.0
Wild lime	625	2	1.25	500	1.0	0.71

Source: Graham and Hart (1997)

Tree seed

Tree seeds are used primarily in the establishment and expansion of plantations. Supply of quality seeds from native forests is seasonal and variable. Seeds and genetic material of native trees are also important export products.

Eucalyptus oil

Eucalyptus oil is supplied to consumers as pure oil or as a component of other products—for example, medicinal preparations. Global demand for oil is currently static, with countries such as China producing enough to meet demand. Current demand is approximately 2500–3000 tonnes per year, but world supply exceeds this. Australia produces approximately 120 tonnes per year. A difference in character of the oil, resulting from different variations in eucalypt forests, allows Australia to maintain a market share despite a relatively high price. Tea tree oil is described in indicator 6.1b.

Animal products

Supply of native animal products from forests is limited by legislation. While there is a larger market for captive-bred animal products, there is a commercial market for wild animal products. Products come from a range of species including kangaroo (*Macropus* spp.), brush-tailed possum (*Trichosurus vulpecula*) and mutton birds (*Puffinus* spp.), along with deer, and feral pigs and goats.

Grazing

The supply of grazing on public forests varies considerably between States and Territories. Grazing sites in New South Wales and Victoria are identified in the following table.

Table 85: Grazing area (hectares) on public land in New South Wales and Victoria

State	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002
New South Wales	768 950	727 210	764 380	711 540	644 970
Victoria	–	–	–	810 670	810 670

Source: National Forest Inventory (2003)

Bee hives in private native forest

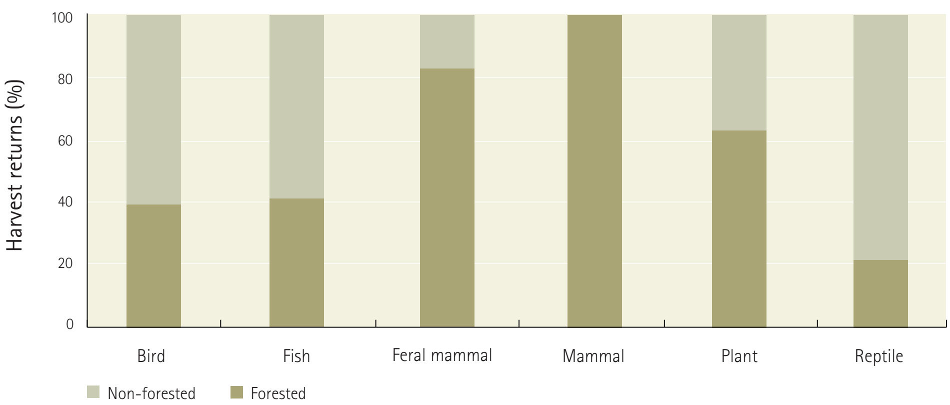
Indigenous use

Indigenous people in many parts of Australia make significant use of non-wood products derived from forested landscapes. For example, the Kuninjku people of central Arnhem Land were found in a year-long study 1979–1980 to derive over 60 per cent of their total (cash and imputed) income from use of wild plants and animals. More recent research in 2002 and 2003 indicates that the customary economy has remained both robust and sustainable over the last 2 decades. Many items are obtained direct from forested landscapes, but even when harvested elsewhere, important animal products often depend for part of their life cycle on forests (Figure 65). This utilisation is maintained at various levels across much of northern Australia, including the Top End of the Northern Territory, Cape York in north Queensland and the Kimberley in Western Australia. Direct reliance on forests is lower in many other parts of the nation, especially where people have been unable to maintain access to their lands and resources and where landscapes have been more modified for other purposes.

In addition to direct economic value, access to these products contributes strongly to the sustainability of Indigenous cultures and identities, which in turn are critically important for the sound management of north Australian forests and much other economic activity. People engaged in customary activities on country maintain favourable fire regimes, reduce feral animals and weed infestations, and can provide early warning of entry of exotic plants, animals or diseases. High standards of catchment management maintain water quality in freshwater or estuarine spawning and nursery grounds (see indicator 7.1.e) and so help sustain productive fisheries, such as the inland and near shore barramundi and prawn fisheries of northern Australia. These and other usually un-remunerated ecosystem services deriving from well-managed forests are critical to the maintenance of both Indigenous and regional economies and social systems, which are underpinned by use of renewable resources.

Artworks, handicrafts, and implements are often constructed from forest products, including non-wood items such as dyes, ochres, pigments and fibres. In addition to their commercial value (see indicator 6.1.b) such items play roles in transmission of knowledge and perspectives both within and outside Indigenous societies, are used in ceremony, or have more utilitarian value in harvesting or preparing food. Temporary and permanent dwellings

Figure 65: Sources of foods taken by Kuninjku people, central Arnhem Land



Source: A.J. Griffiths and J. Altman, unpublished data

Notes: From a sample of 585 animals harvested over a 5 week period in 2002 and 2003 in wet and dry seasons. Many animals use forest and open habitats and are harvested from different habitats in different parts of the seasonal cycle. The separation is therefore somewhat arbitrary, but does indicate a genuine dependence of harvest returns on healthy forest. Indigenous management is in part aimed at maintenance of a habitat mosaic that favours both the animals and harvesting processes.

are constructed from forest products. For instance, the locally-manufactured mud bricks used in many permanent dwellings in the Maningrida region are made from soils found in forest sites, and superstructure includes poles from the same forests. Removal of bark for painting and, within walking distance of outstations, fuel for cooking, has limited impact on exploited species in landscapes which have not been disturbed, for example, by agriculture.

Diverse, healthy forests remain critically important to those Indigenous people who retain access to them, and especially in northern Australia make an irreplaceable contribution to a vibrant and regionally significant 'hybrid' economy. Some senior artists use the income from commercial art sales to underwrite continued presence on their country, carrying out the land and natural resource management work that sustains the forests (see indicator 7.1.e).

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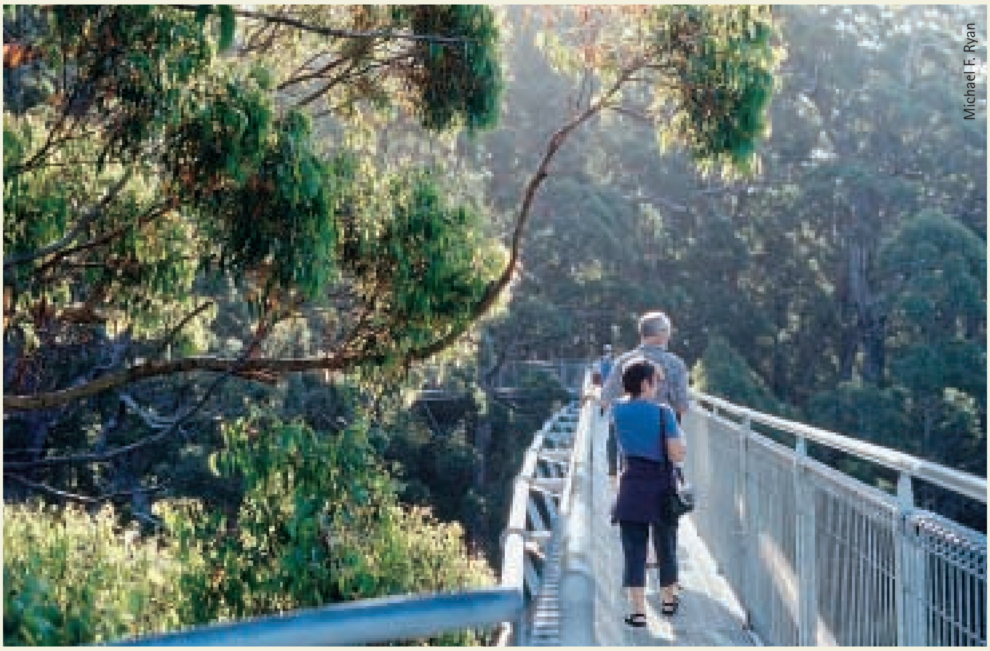
Karri tree (*Eucalyptus diversicolor*) south west Western Australia

6.2

RECREATION AND TOURISM

INTRODUCTION

Australian forests provide a diversity of settings for visitors seeking outdoor recreation and tourism. The vast majority of publicly owned forests are accessible to visitors, subject mainly to safety and operational considerations. While available data are far from comprehensive, they suggest that visitor numbers are increasing in most jurisdictions. Forest management agencies cater for different types of visitor activities by varying the mode of access—foot, bicycle, boat, horse or vehicle—and the location and design of facilities, and by regulating the type and duration of use. However, excessive visitor use or inappropriate behaviour may result in detrimental site impacts that can only be contained by proactive or remedial measures.


Michael F. Ryan

The Tree Top Walk in tingle forest, near Denmark, Western Australia

Forests for recreation and tourism

coverage
currrency
frequency

Indicator 6.2a

Area and per cent of forest land available for general recreation and tourism

Rationale

The indicator provides information on access for recreational and tourism uses of forests. It also provides a fairly coarse measure of the extent to which forest management is providing for the recreational needs of the community.

Most publicly owned forested lands, irrespective of tenure, are available for recreation or tourism. There are some temporary closure— mainly for safety reasons—and some permanent exclusions for scientific reasons.

Forested areas are used extensively for outdoor recreation and tourism-related activities in Australia. As such they are of tremendous economic value to the nation and greatly enhance the quality of life of all visitors and adjacent urban communities. They provide opportunities for a wide range of recreation and tourism experiences and will continue to do so, provided they are managed to sustain the increasing pressures that growing urban population centres can exert.

Most publicly owned forested lands, irrespective of tenure, are available for general recreation and tourism activity (see Tables 86 and 87). Policy decisions taken by the land manager—be it Australian, State or Local Government, commercial or private—determine the area available and types of recreation and tourism permitted. Where management plans are in place, detailed guidelines are usually specified regarding the types of visitor opportunities that will be provided, the recreation and tourism activities that will be permitted (or prohibited) and the conditions of use.

Typical forest areas permanently closed to the public include designated scientific reference and conservation areas, some water catchment areas, highly significant Indigenous cultural sites, defence training areas, and areas of forest subject to particular threats, for example the fungus *Phytophthora cinnamomi*. However, recreation and tourism exclusions only cover a small proportion of the total area of multiple-use forests. For example, in Queensland recreation and tourism are permanently excluded from designated Scientific Areas (20 245 hectares) within multiple-use forests (2.5 million hectares).

Forest areas can be temporarily closed if they are subject to harvesting, extreme fire danger, fuel reduction burning, control of feral animals or weed eradication, special events or bad weather. Thus the area of forest from which recreation and tourism are excluded varies depending on the forest operations underway at any given time.

Bird watching

Table 86: Forest area managed for recreation and tourism within each State/Territory (hectares)

State/Territory	Year	Multiple -use forests	Nature conservation reserves	Other crown land	Private land	Total
Australian Capital Territory	2000	–	–	–	–	–
New South Wales	2001	1 706	3 625[1]	–	0	5 331
	2000	877	3 800[1]	–	0	4 677
Northern Territory	2002	n/a	3 462	–	0	3 462
	2000	n/a	2 450[2]	–	0	2 450
Queensland	2000	2 447	4 350	–[3]	0[4]	7 797
South Australia	2001–2002	n/a	3 943	–	0	3 966
Tasmania	2000	1 105[5, 7]	960[6, 7]	–	0	2 065
Victoria	2000	663	2 957	103	13	3 737
Western Australia	2000	–	–	–	–	–

Source: National Forest Inventory 2003

1 The area within nature conservation reserves for New South Wales for 2001 includes formally dedicated reserves that are managed by State Forests and excludes wilderness and nature conservation reserves that are managed by National Parks and Wildlife Service but are not actively managed for recreation and tourism. The area for nature conservation reserves for New South Wales for 2000 includes all land managed by National Parks and Wildlife Service.

2 This is the total amount of IUCN Category 2 land in Northern Territory, that is, nature conservation reserve or equivalent. Most of this is freehold or crown land tenure, therefore management intent is complex and recreation/tourism may only comprise a component of the total estate listed.

3 In Queensland, other crown land contains reserves for community purposes (including camping reserves, recreation reserves, reserves for travelling stock, etc., as declared under the *Land Act 1994* but no data are easily accessible on the area of these reserves located in forests.

4 Some local governments and State agencies in Queensland are buying increasing amounts of private freehold land, which is not identified as public land on the Queensland Government Land Register.

5 This includes all multiple-use forest other than coupes currently being harvested and Phytophthora cinnamomi management areas.

6 Assumed to include Forest reserves, Wellington Park and all reserve types under the Tasmanian *National Parks and Wildlife Act 1970* except nature conservation reserves that are not managed for tourism and recreation.

7 Includes all land available for recreation and tourism.

Case study – Inter-agency cooperation for forest tourism in Tasmania

Forested lands span many tenures and administrations, and so Tasmanian agencies have established an Interagency Committee for Recreation and Tourism to coordinate projects, share information and develop joint brochures and activities. Agencies involved are Tourism Tasmania, Forestry Tasmania, Parks and Wildlife, Hydro Tasmania, Sports and Recreation, Transport Tasmania and the Tasmanian Outdoor Recreation Council.

The Interagency Committee has several sub-groups including a Visitor Research Working Group, a Recreational Vehicle Working Group, a Tasmanian Walking Track Strategy Working Group, a Tasmanian Trail Committee and an occasional group to coordinate interagency brochures. There is also a joint Commercial Visitor Services Licence system, which administers all commercial tourist operators carrying out tours and similar activities on State-owned land.

Table 87: The percentage of the total forested area managed for recreation and tourism within each State/Territory compared against the 1998 State of the Forests Report

State/Territory	Year	Multiple -use forests	Nature conservation reserves	Other crown land	Private land
Australian Capital Territory	1998	*100*	*100*	–	*0*
New South Wales	2001	*67*	*85*[1]	–	*0*
	1998	*100*	*100*	–	*0*
Northern Territory	2002	–	–	–	–
	2000	–	–	–	*0*
Queensland	2000	*85*	–	–	*0*
	1998	*99*	*87*	–	*0*
South Australia	2001-2002	*n/a*	*100*	–	*0*
Tasmania	2000	*97*[2]	*87*[2]	–	*0*
	1998	*99*	–	–	*0*
Victoria	2000	*20*	*97*	*50*	*1*
	1998	*20*	*30*	*49*	*1*
Western Australia	1998	*99*	*100*	*90*	*0*

Source: National Forest Inventory 2003

1 For nature conservation reserves for New South Wales National Parks and Wildlife Service 1997 it was 100 per cent because the whole estate was included.

Since 1997, some States and Territories have changed the way in which information is reported. This has created gaps in the data that make it difficult to analyse emerging trends in the availability of forest land for recreation and tourism. The following issues have the potential to significantly alter the amount of forest land apparently available for recreational and tourism use within each region:

- *Area of forests* – most State or Territory land management agencies record recreation and tourism use by tenue or park type, but not by forest cover. Therefore, extracting statistics relating only to forested land is problematic.
- *Corporatisation of multiple-use forest and water management organisations* – some corporations do not accept an obligation to continue to provide for recreation and tourism activities as these are no longer considered part of their core business.
- L*and tenure changes as a result of Regional Forest Agreements* – former forest-lands containing significant conservation values are being afforded a higher level of protection against high impact activities by having their tenure changed to nature conservation reserves and/or wilderness areas. High impact activities include those requiring vehicles, mountain bikes or horses.
- *Public risk and liability* – increasing recognition of the responsibilities associated with the duty of care of land managers is forcing many agencies to rethink how, when and where they cater for recreation and tourism activities. In many cases users themselves are required to have appropriate insurance cover before activities will be permitted. Where the cost of insurance is prohibitive, groups are cancelling activities. This situation is currently subject to government review in most regions.

coverage
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frequency

Visitor activities

Indicator 6.2b

Number, range and use of recreation/tourism activities available in a given region

Rationale

This indicator is useful because it provides information on the diversity of recreation opportunities.

Data are available on a range of recreational uses across the country. However, the lack of reliable time series, or of evaluations of the usage rates or public perceptions of the facilities, prevents further national level comment on the indicator.

Forests provide a wide range of settings within which a variety of recreational and tourist activities will occur. Forest management in Australia aims to provide a balanced range of recreational opportunities and facilities, appropriate for each forest setting and consistent with demand and resources. Two measures are used in this indicator, namely, the number of areas, tracks and sites, and the total number of recreation/tourism related facilities located in all sites.

Some agencies undertake comprehensive visitor surveys and have a good understanding of visitor needs and expectations. Others tend to provide sites and facilities in response to local demand and patterns of existing use. Table 88 indicates the number of sites available for forest-based tourism and recreation activities. Table 89 indicates the types and number of facilities available in each State or Territory. These figures are very conservative, as they do not include sites and facilities managed by local governments, or by the commercial and private sectors.

Michael F. Ryan

Mountain bike racing, ACT Forests, ACT

Table 88: Recreation and tourism sites by activity

Activity group		ACT 2001	NSW[1] 2001	NT[2] 2002	SA[3] 2002	TAS 2000	Vic 2000
Riding and walking animals	Areas/Tracks	–	17	5	15	11	5
Cycling	Tracks	–	25	3	19	–	3
Motor vehicle use	Tracks	–	13	14	–	50	13
Walking and running	Tracks	–	267	60	17	1 441	1 058
Aerial activities: motorised	Sites	–	–	1	–	–	–
Aerial activities: non-motorised	Sites	–	–	–	–	–	5
Caving	Sites	–	–	1	–	4	–
Climbing	Sites	–	24	1	–	–	–
Cultural heritage appreciation	Sites	–	37	12	2	–	15
Events and festivals	Sites	–	0	3	2	–	–
Fishing	Sites	–	105	17	1	11	–
Nature study	Sites	–	225	38	10	97	52
Over-night stays	Sites	7	379	35	15	145	286
Picnicking and playing	Sites	–	213	37	17	1354	390
Snow activities	Sites	–	12	–	–	2	10
Swimming and diving	Sites	–	107	21	6	–	–
Watercraft: motorised	Sites	–	26	12	1	5	26
Watercraft: non-motorised	Sites	–	26	6	1	4	20
Weapons use	Sites	–	3	–	2	–	–

Source: National Forest Inventory 2003
1 Multiple-use forests and nature conservation reserve estate
2 Protected areas managed by Parks and Wildlife Commission Northern Territory (2.5% of Northern Territory lands)
3 For the area managed by Forestry South Australia
4 Department of Primary Industries, Water and the Environment category 'day use areas', which may include other facilities such as boat ramps.
Note: No information available for Queensland and Western Australia.

Case study – Recreation and Tourism Information System in Western Australia

The Western Australian Department of Conservation and Land Management (CALM) has developed a sophisticated Recreation and Tourism Information System (RATIS) to provide decision-makers, planners and managers with ready access to all relevant information at the State, region, district or site level. The system comprises of 50 separate databases, that can be easily accessed by staff anywhere in the State using the internet.

For example, one of the databases provides detailed information on CALM's 1230 nature-based recreation sites, detailing 660 walking tracks, 260 camping areas, 11 800 furniture assets (such as rubbish bins, picnic tables, signs, seats), 1160 buildings (such as visitor centres, shade shelters, information shelters, toilets) and 1300 structures (including boardwalks, steps, bridges, lookout platforms) across the State. Another provides data relating to the number of visits to Parks/Reserves managed by the Department at a State, region, district and park/reserve level.

RATIS is supported and maintained by CALM's Recreation and Information Management Unit that also produces comprehensive user manuals and regular training programs. Information regarding the system can be obtained from CALM.

The following issues may affect the number and range of recreation and tourism activities available in given regions, and the ability to report these trends:

- *Consistent data* – the information supplied needs to be standardised across all agencies so that there is a consistent method of reporting.
- *Changing patterns in recreational and tourist use* – there appears to be little information regarding the likely changes in recreational and tourist use resulting from such factors as population ageing, changing ethnic composition and increasing ownership of motorised vehicles including 4WDs and trail bikes.
- *Loss of access* – many traditional recreational and tourist uses are being displaced because of tenure changes, particularly where Regional Forest Agreements result in tenure changes from multiple-use forest to nature conservation reserve.
- *Lack of funding and resources* – many forest management agencies lack the resources (staff, funding and equipment) to manage and maintain all existing facilities in a reasonable condition, or to develop the new areas and facilities required for additional visitors or changing visitor priorities.

Dhanyah Forest Visitor Centre, Barmah Forest, Victoria

Table 89: Number of recreation and tourism related facilities by State/Territory compared with those reported in 1998

Tenure/Facility	ACT	NSW		NT	Qld		SA		Tas	Vic		WA
	1998	1998	2001[1]	2002[2]	1998	2000	1998	2002[4]	1998	1998	2000	1998
Multiple-use forest												
Picnic sites with little development	139	239	87	n/a	65	62	n/a	n/a	94	450	200	212
Developed campsites with toilets	5	112	23	n/a	31	32	n/a	n/a	32	78	60	49
Visitor centres	0	35	3	n/a	0	0	n/a	n/a	0	1	1	2
'Grandstand' developments > $1m	0	1	0	n/a	0	1	n/a	n/a	0	1	1	2
Number of tracks	–	–	70	n/a	–	70	n/a	n/a	–	–	–	–
Length of tracks (km)	32	114	–	n/a	620	–	n/a	n/a	700	250	250	1 711
Nature conservation reserve												
Picnic sites with little development	6	281	214	17	144	–	7	17	11	900	499	–
Developed campsites with toilets	3	128	69	17	81	–	10	11	53	350	209	–
Visitor centres	1	14	5	4	19	–	2	2	4	10	10	–
'Grandstand' developments > $1m	0	6	–	1	9	–	0	0	6	2	10	–
Length of tracks (km)	184	1 296	–	256[3]	986	–	15	270	2 849	2 400	3 723	–
Other												
Picnic sites with little development	–	–	–	–	–	–	–	–	26	1 800	1 800	–
Developed campsites with toilets	–	–	–	–	–	–	–	–	37	600	600	–
Visitor centres	–	–	–	–	–	–	–	–	1	50	50	–
'Grandstand' developments > $1m	–	–	–	–	–	–	–	–	1	5	5	–
Length of tracks (km)	–	–	–	–	–	–	–	–	–	1 000	1 000	–
Private land												
Developed campsites with toilets	–	–	–	–	–	–	–	–	–	200	200	–
Visitor centres	–	–	–	–	–	–	–	–	–	2	2	–

Source: National Forest Inventory 2003

1 New South Wales' data only covers tenures managed by State Forests and the National Parks and Wildlife Service (NPWS). For 2001 the nature conservation reserve data only includes the area in the Southern Directorate of the NPWS tenure.

2 Only covers protected areas managed by Parks and Wildlife Commission Northern Territory (2.5% of Northern Territory).

3 Walking tracks only.

4 Only includes land managed by ForestrySA.

Note: No data are available on recreation and tourism facilities on leasehold land.

coverage
currrency
frequency

Visitor numbers

Indicator 6.2c

Number of visits per annum

Rationale

The indicator is useful because it provides an indication of the level of overall recreation use and the demand. It is a key variable in determining the sustainability of recreation and tourism.

Available data are far from comprehensive but suggest that visitor numbers are increasing in most jurisdictions.

The number of visitors to the forest is difficult and costly to measure because most forested areas possess many entry points, and visitor use is dispersed throughout the forest. In addition, the pattern of visitor usage varies tremendously between weekday, weekend, vacation periods and seasons. Where a visit includes an overnight stay, the type of support facilities and the nature of the visitor-related impacts increase significantly. Sites that are well signposted and promoted in various media receive greatly increased visitation over less known sites where usage is dependent on word of mouth.

Methods currently used for monitoring visitor numbers in forests are a mixture of actual counts and estimates. The counted data are based on entry fees, traffic counters, camping permits and surveys and are relatively accurate. The remaining information, based on staff estimates, is less accurate and may be an underestimate.

Table 90 shows the number of recorded visitors from 1995–1996 to 2000–2001 for each reserve type. The vast majority of forest visits occur in nature conservation reserves. There appear to be significant differences in some States and Territories between the 1995–1996 data and that from later years, but this is a reflection of changed methods of reporting and improved accuracy of measurement. No consistent changes are evident although the number of visitors to accessible, attractive forest sites appears to be increasing rapidly—at least in Victoria.

The following issues will have a significant affect on the number of recorded visitors to forest area over the coming years:

- *Adoption of a more useful unit of measurement* – the 'number of visits' is a very coarse measure of visitor use, as it does not relate in any way to the length of stay.
- *The lack of reliable visitor figures* – prevents agencies from quantifying the extent of demand as well as the benefits that accrue to an area as a result of recreation and tourism use, thus limiting the ability of the agency to attract increased funding and resources.
- *Greater emphasis on active living* – the Australian population is becoming more obese and unhealthy because of changing lifestyles. There is a concerted effort underway by many health agencies to reverse this trend by emphasising the need for increased physical activity. Forests close to cities can expect to cater for a significant proportion of the increased demand, where people choose to exercise in a natural setting.
- *Increasing demand for recreational walking and cycling trails* – many Australian towns and cities are considering connecting urban pedestrian and cycle trail networks with surrounding forested areas so as to reduce reliance on motorised vehicles for people wanting to recreate in non-urban settings.

- *Marketing and promotion of forest attractions* – uncontrolled marketing and promotion can raise the level of visitation to attractive forest sites beyond the ability of an agency to sustain the level of use with existing funds and resources.
- *Group size* – there appears to be an increasing tendency for large groups to congregate at some venues for cultural and family-related activities, particularly near cities.
- *Events* – forests are increasingly used for a wide range of events that attract a large number of participants and/or spectators crowds, such as orienteering, fun runs, rally car driving and rock concerts.

Table 90: Number of visitors to forested areas each year ('000)

State/Territory and reserve type	Year 1995–1996	1999–2000	2000–2001
Multiple-use forests ('000)			
Australian Capital Territory	735[1]	1 050[2]	–
New South Wales	4 000	–	–
Northern Territory	n/a	n/a	n/a
Queensland	2 000	–	–
South Australia	206	230	188
Tasmania	129	–	171
Victoria	3 500	3 600	–
Western Australia[3]	7 215	–	–
Nature conservation reserves ('000)			
Australian Capital Territory	140	–	–
New South Wales	20 148	21 000	7 116[4]
Northern Territory[5]	1.7	2.3	2.2
Queensland[6]	701	14 700	–
South Australia	–	2 895	–
Tasmania	980	–	1 343
Victoria	12 960	12 195	–
Western Australia[3]	960	–	–

Source: National Forest Inventory 2003

1 Derived from the Commonwealth Data Request and are from the years 1995 or 2000.
2 Montreal Process Category A reporting for the year 2000 – Australian Capital Territory.
3 Includes only the area managed by the Department of Conservation and Land Management and within the Regional Forest Agreement region.
4 Includes only Regional Forest Agreement areas.
5 Only covers land managed by the Parks and Wildlife Commission, which does not include major nature conservation reserves such as Kakadu National Park.
6 Includes only the land under Queensland nature conservation reserve tenure.

coverage
currrency
frequency

Unacceptable visitor impacts

Indicator 6.2d

Proportion of forest sites available for recreation and tourism which are impacted unacceptably by visitors

Rationale

This indicator provides a broad measure of forest sites being used for recreation that are experiencing extreme visitor impact.

Little information is available on the unacceptable impact of visitors. It was reported that visitors are impacting unacceptably on 10 per cent of the multiple-use forest managed for recreation and tourism in Victoria and 3 per cent of the area managed by Forestry South Australia.

Australia's forest management agencies have the role of developing strategies to ensure sustainable levels of visitor uses. Many of these organisations define unacceptable impacts as the outcomes of visitor activities that increase the cultural, social, environmental and economic impacts that lead directly to site deterioration. The same level of visitor use will affect different forest values in different ways. Some aspects of a forest are more sensitive than others. In addition, the level of visitor impact will vary depending on such things as visitor behaviour, provision of facilities including interpretation and education, on-site supervision, degree of vehicle control, time of year and weather conditions. It should be noted that acceptable levels of impact vary with the objectives of particular management units—for example, wilderness areas have much lower tolerance levels than high use visitor areas.

Examples of unacceptable impacts include:

- damage to or removal of vegetation cover;
- erosion and/or siltation;
- destruction of animal habitat;
- reduction in water quality;
- conflicts between different user groups;
- overcrowding;
- litter and rubbish;
- vandalism;
- trespass onto a designated sacred site; and
- excessive costs to clean up after an event.

Many forest recreation and tourist activities tend to be concentrated around prime attractions that are designed and managed to withstand anticipated levels of visitor use and behaviour. Forest management agencies employ a range of direct and indirect strategies to actively manage these areas. Direct strategies include zoning, rationing use intensity, restricting activities and enforcement. Indirect strategies include facility and infrastructure design (walkways, restrooms, outdoor cooking facilities, etc.), information dissemination

Case study – Survey and assessment in Queensland

The Queensland Parks and Wildlife Service, Queensland Environmental Protection Agency, undertook an assessment of visitor impacts on 100 frequently used routes and sites throughout the Great Sandy Region World Heritage Area in 1997 and followed this with a site capacity study in 2002. Readily assessable visitor-related impacts such as site erosion, site compaction, modification of waterways and water systems, vehicle damage (track rutting and braiding), weed invasion, vegetation disturbance or removal, litter, vandalism, crowding, noise and inappropriate mix of visitors were recorded for each site or route and categorised as high, moderate or low. The level of acceptable impact varied, depending on the management objectives for the zone within which each route or site was located, that is, the levels of acceptability were more stringent in natural (minimal use) areas than they were in developed (high use) areas.

The study found that approximately half of all sites and routes were showing evidence of physical impacts beyond acceptable limits, while about 30 per cent were being managed in a fashion consistent with management objectives contained in the management plan. However, the majority of sites and routes were experiencing a level of visitor use that could not be sustained at the 1997 levels of management and infrastructure provision.

(provision of maps and brochures) and cost recovery mechanisms. Recreation surveys are now being used to target areas under active management in order to refine active management strategies.

The case study suggests that visitor-related impacts are common and likely to be greatest where there is inadequate site management, particularly where vehicle movement is uncontrolled. This situation will worsen over time unless appropriate visitor infrastructure and site management mechanisms are put in place.

The following issues are likely to have an effect on the areas of forest where tourism and recreation activities have been identified as having an unacceptable impact:

- *Processes for determining unacceptable impacts* – there is lack of agreement between agencies regarding realistic ways to determine how unacceptable impacts should be defined and measured for various forest settings and management regimes.
- *Inappropriate behaviour* – a greater understanding of the causes of vandalism and unacceptable visitor behaviour are required so that proactive measures can be put in place to deter offenders.
- *Lack of adequate resources* – many land management agencies lack sufficient resources (funding, staff and equipment) to ensure that appropriate levels of visitor infrastructure and control are in place to manage sites before problems develop.

Impacts from vehicles on a forest floor in a campground

- *High impact sports* – the recent upsurge in the popularity of extreme sports has dramatically increased the numbers of people participating in activities such as mountain-biking, motorcross, car rallying and horse riding. All land management agencies are experiencing difficulties finding additional areas to cater for the demand within reasonable distance of population centres. Consequently much informal use occurs in inappropriate areas, resulting in severe impacts.
- *Codes of behaviour* – encouraging codes of ethics such as 'Tread lightly' and 'Leave no trace', which foster personal responsibility for behaviour when recreating outdoors.

Blackbutt (*Eucalyptus pilularis*) regrowth

6.3

INVESTMENT IN THE FOREST SECTOR

INTRODUCTION

The four indicators in this section examine the economics of investing in the forest sector, as well as the importance of research and development, new technologies and education. In the decade since the early 1990s the forest sector, in particular the plantation sector, has attracted new domestic and foreign investment. Forest-related research and development expenditure in Australia has been steadily increasing over the last decade, and in 2000–2001 totalled $216 million. At the same time, new and improved technologies have allowed forestry operations to become more efficient and sustainable.

Indigenous people in remote Australia invest considerable effort in applying customary management to maintain forest values. Some of this activity, especially in regard to fire management, is supported by Australian and State Government research and development and other grants. Economic returns are not easily quantified, but important contributions to conservation of biodiversity and ecosystem services are increasingly recognised.

Michael F. Ryan

New Visy pulp mill, Tumut, New South Wales

Value of investment

coverage
currrency
frequency

Indicator 6.3a

Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation and tourism

Rationale

Provides an indication of the long-term and short-term commitment to forest management, further processing and other forest uses.

Since the early 1990s the forest sector, and in particular the plantation sector, has attracted new domestic and foreign investment to the value of more than $6.5 billion. New forest and wood-processing investments have occurred in each State and Territory.

The value of investment in wood processing, plantation establishment, and native forest management, health, recreation and tourism indicates investors' commitment to Australian forest-based industries. Australia's ability to meet its own wood and non-wood product needs into the future depends on the sustainable use of its forests and continued investment in forest industries.

Since the early 1990s the forest sector, and in particular the plantation sector, has attracted new domestic and foreign investment to the value of more than $6.5 billion. This investment consists of take-overs and acquisitions of existing processors, new processing equipment, rebuilding existing production lines, and investment in plantations. Leading international forest product companies have featured highly in all three major areas of investment in the forest sector.

During the last decade:

- Takeovers and buyouts of existing processing facilities totalled 19, and reached a value between $3.5 and $4 billion.
- There were 25 new forest and wood processing investments in Australia valued at $1.7 billion (Table 91).
- Major forest resource investments totalling $1.6 billion included acquisitions of public plantations in Victoria and Tasmania, and expansion of the national hardwood plantation estate.

There are two main drivers for investment. First, Australia's strong domestic market, in particular for structural wood products, has provided opportunities for efficiency gains. This has attracted investment from multinational companies seeking to capture market share and profits through global knowledge and economies of scale. Second, Australia's proximity to Asia provides opportunities for producers to enter new and emerging markets in the region, as well as the Japanese pulp and paper industry.

Table 91: New forest and wood-processing investments in Australia since early 1990s

State	Number of projects	Value ($million)
New South Wales	5	660
Queensland	4	155
South Australia	2	70
Tasmania	3	175
Victoria	10	680
Western Australia	1	10
Total	25	1 750

Source: URS Forestry/Ausnewz 2002

Indigenous forest managers make an important contribution to forest health, especially in northern Australia. For example, The Bawinanga Aboriginal Corporation in Central Arnhem Land, Northern Territory, estimates that it spends about $160 per square kilometre per year in land management work that contributes to maintenance of forest values.

Further reading

ABARE (2000). Sustainability Indicator 6.3a – Survey of the value of investment in forest industries in Tasmania. December 2000. Australian Bureau of Agricultural and Resource Economics, Canberra.

ABS (2000). Manufacturing Industry. Catalogue No. 8221.0. Australian Bureau of Statistics, Canberra.

Biggs, P. (2002). The Economic Sustainability of Plantations: Maintaining Investment for Replanting and Expanding Australia's Plantation Resource. Presented at Bureau of Rural Sciences conference on plantations 2002.

Kelly M. and Bull L. (2002). *International market prospects and the changing structure of the Australian Plantation Industry*, (Presented at BRS conference on plantations 2002).

URS Forestry/Ausnewz (2002). The Australian Forest and Wood Products Review 2002. URS Australia Pty Ltd, Hobart.

Case study – Tasmania

The forest sector is a dominant element of the State's economy. In 2000, the Australian Bureau of Agricultural and Resource Economics surveyed investment in forest-based activities in the four years following the signing of the Tasmanian Regional Forest Agreement. The forest-based activities included: forest-growing, forest harvesting, sawmilling, panel products, pulp and paper manufacture, timber manufacturing, tourism and recreation, and other forest contact industries.

The survey was designed to measure the long and short-term commitment to the forest industry through investment. It found that total investment averaged around $195 million per year between 1996 and 2000 (see Table 92).

Other key findings were:

- Market value of forest sector companies more than doubled from $360 million in 1996–1997 to $731 million in 1999–2000.
- The greatest increases were observed in: sawmills; pulp and paper manufacturing; panel manufacturing; harvesting and plantation establishment contracting; and forest growing, which was not included but available data indicate significant increase.

Since the 2001 survey was completed, Gunns Limited has become the dominant company in the Tasmanian forest sector and has a market value now approaching $1 billion.

Table 92: Market capitalisation of Tasmanian forest sector by business category, 1996 and 2000 ($million)

Total	30 June 1996		30 June 2000	
	Total	Average per business	Total	Average per business
Forest management	9.8	0.5	12.8	0.7
Harvesting and plantation establishment contractors	126.4	0.7	281.2	1.5
Pulp, paper and panel manufacturers	25.3	6.3	182.7	45.7
Sawmills	171.6	1.8	209.1	2.2
Craftwood industries	3.2	0.6	6.7	1.3
Secondary processors	7	1.1	12	1.9
Tourism and recreation operators	12.8	0.3	19.2	0.4
Other forest contact industries	5.8	0.3	7.8	0.4
All business categories	362.0		731.3	

Source: ABARE (2001)

Note: Data on forest growers are not available.

coverage
currrency
frequency

Research and development expenditure

Indicator 6.3b

Level of expenditure on research and development, and education

Rationale

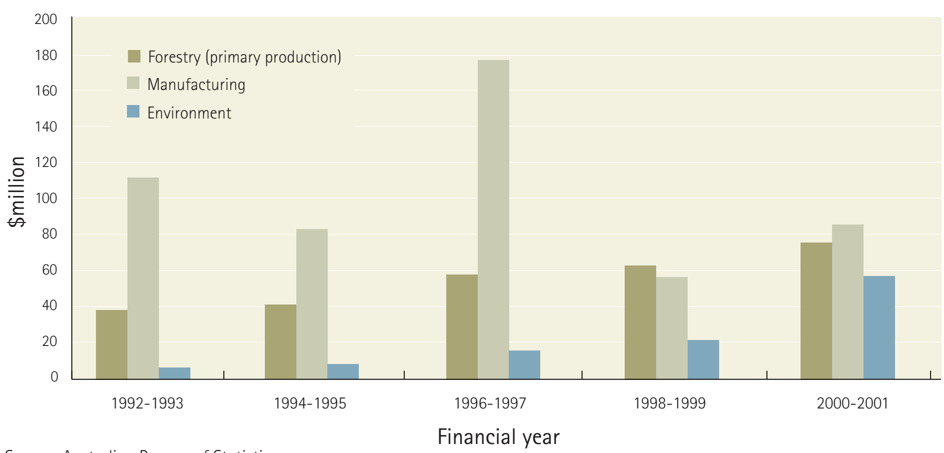
This indicator provides a measure of the level of expenditure on forest-related research and development.

Forest-related research and development expenditure in Australia has been steadily increasing over the last decade and in 2000–2001 totalled $216 million.

In general, expenditure on forest-related research and development is steadily increasing in real terms. Figure 66 summarises total levels of research and development expenditure since 1992–1993.

In 2000–2001, forest-related research and development expenditure in Australia totalled $216 million. The largest amount was spent on manufacturing, followed by primary production and environment (see Table 93).

Figure 66: Total public and private research and development expenditure in the forest sector



Source: Australian Bureau of Statistics

Table 93: Research and development expenditure by objective, 2000–2001 ($'000)

Socio-economic objective	Public sector	Private sector	Total
Forestry (primary production)	71 188	3 786	74 974
Manufacturing (wood, wood product and paper)	6 333	78 620	84 953
Environmental management (forest and wooded lands)	55 709	480	56 189
Total	133 230	82 886	216 116

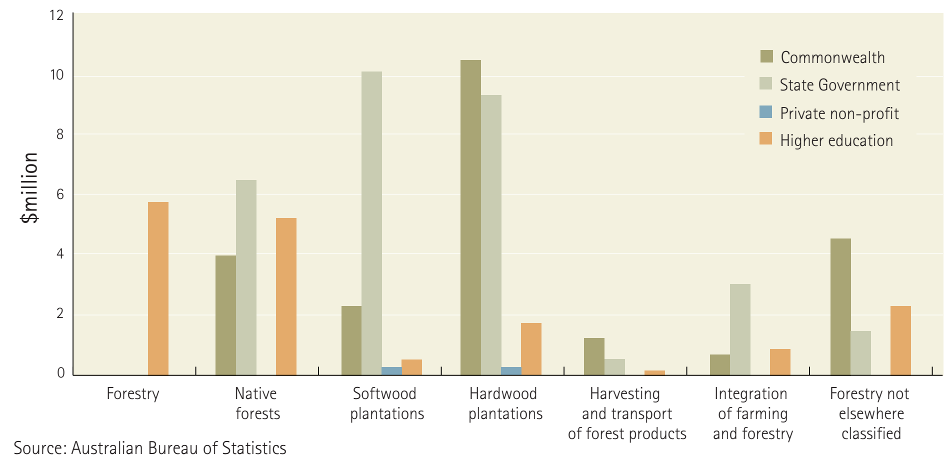
Source: Australian Bureau of Statistics

Note: Figures for 2000-2001 are reported for a new classification; whereas primary production and manufacturing remain unchanged. The new classification ('environmental management, forest and wooded lands') is broader.

Public sector

The public sector includes Governments, private non-profit organisations, and higher education institutions. The major focus of the public sector expenditure on research and development is primary production and environmental management (Figure 67). The public sector provided 94 per cent of all expenditure on primary production research. Australian and State governments reported the highest research and development expenditure for primary production-oriented forestry, of $23.7 million (33 per cent) and $30.7 million (43 per cent), respectively. Higher education institutions followed with a reported $16.2 million (23 per cent).

Figure 67: Public sector research and development expenditure on primary production 2000–2001



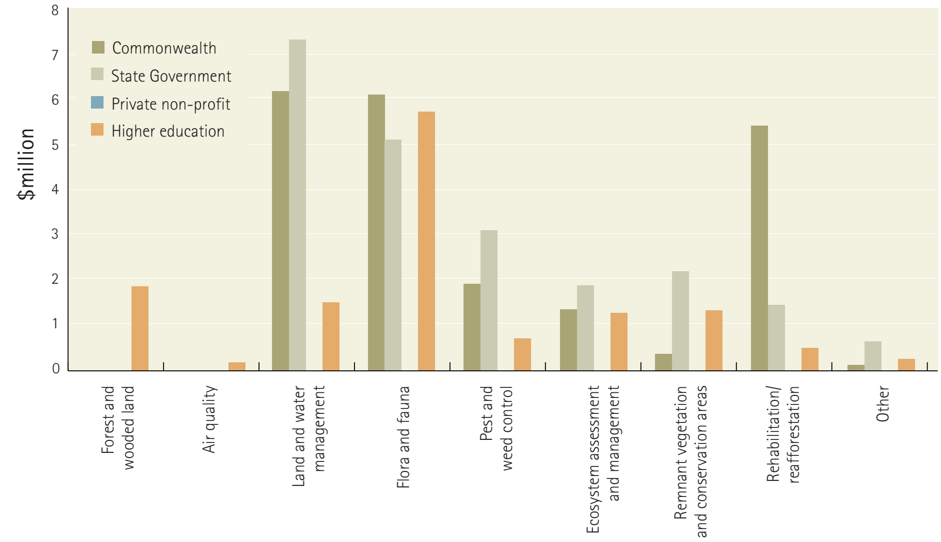
Source: Australian Bureau of Statistics

The public sector also reported that 99 per cent of all research and development expenditure was for environmental management of forest and wooded lands (Figure 68). Of this funding, Commonwealth and State governments reported the highest research and development expenditure for environmental management of forest and wooded lands, with $21.2 million (38 per cent) and $21.6 million (39 per cent) respectively. The third largest level of public sector expenditure in environmental management was reported by the higher education sector with $12.8 million (23 per cent) spent.

These figures do not include substantial additional expenditure that contributes indirectly to maintenance of forest values, such as improved fire management, and support for Indigenous land managers to develop infrastructure and training to protect forest values.

Identification of timber and timber properties, CSIRO Forestry and Forest Products, Clayton, Victoria

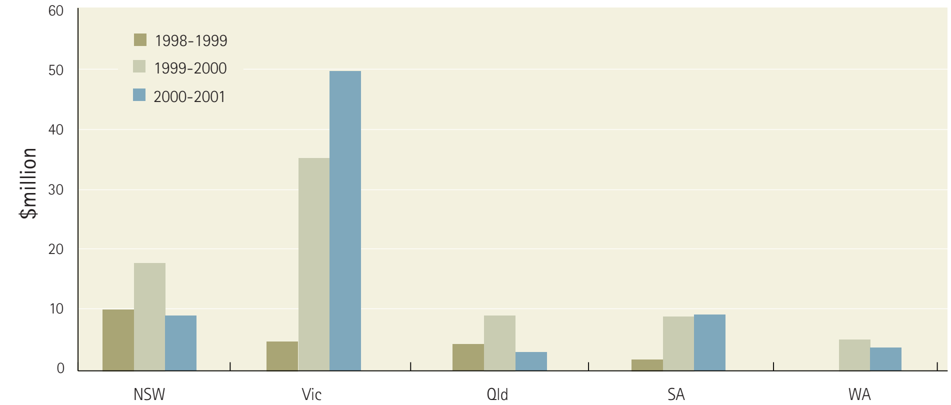
Figure 68: Public sector research and development expenditure in environmental management, 2000–2001



Source: Australian Bureau of Statistics

Note: Amounts reported under the general heading 'Forest and wooded lands' are those reported by survey respondents who were unable to breakdown expenditure into the lower classification levels

Figure 69: Private sector research and development expenditure in manufacturing of wood, wood products and paper



Source: Australian Bureau of Statistics

Private sector

The major focus of the private sector's research and development expenditure was in manufacturing of wood, wood products and paper. Data for this sector are available at the national level, and for primary production and environmental management are confidential in some States. The private sector was responsible for 92 per cent of all expenditure in the manufacturing of wood, wood products and paper. Most of this expenditure took place in Victoria (Figure 69).

Further reading

ABS (2002). Research and Experimental Development. Catalogue Nos. 8104.0, 8109.0, 8111.0 and 8112.0. Australian Bureau of Statistics, Canberra.

New technologies

coverage
currrency
frequency

Indicator 6.3c

Extension and use of new and improved technologies

Rationale

This is an indicator of continuous improvement in forest management and in forest-based industries relevant to the sustainability of forest use.

The indicator lists the main technologies that have improved forestry and forest-based industries. There are no quantitative data.

The goal of managing forests sustainably for production purposes relies on continuous improvement in management skills and in the development and adoption of new technologies to allow for more efficient resource use. Identifying the growth and use of technologies is a useful indicator of progress in forest management. New technologies involved in conservation forest management or recreation are not considered in this indicator.

Improvements in forest management have arisen through improved knowledge in several areas. The major areas of improvement are:

- the roles of components of forest ecosystems;
- forest regeneration processes;
- tree-breeding enhancements;
- improved assessment techniques leading to superior seed collections; and
- knowledge of the fire ecology of forest vegetation.

Improved tree-breeding has led to lower planting densities, which match more closely the final stocking rates at time of harvest and thereby reduce impacts on soil and water quality during the growing period. Similarly, improved planting machinery, herbicides and pesticides have led to reduced site preparation and therefore reduced site impact in plantation establishment. Tree breeding for improved growth rates, tree form and salinity tolerance have made possible greater plantation establishment by farmers, resulting in broader soil and water protection.

The development and use of remote sensing and computing technologies has led to improved knowledge about forest extent, type, health and ecosystems, including more cost-effective approaches to mapping, field surveys, and forest modelling—especially in remote parts of Australia. These advances—along with improved communication networks and advances in protective clothing, personal safety systems on fire tankers, fire support aircraft and fire suppressants—have also led to more effective, responsive and safer bushfire management. Advances in the role of biological controls, such as blackberry rust, pest controls and disease management have led to an improvement in forest health.

New forest harvesting technologies have been adopted to address the changing types of forest being harvested; there are now more even-age native regrowth forests and plantations. The new technologies also conform with more stringent occupational health and safety standards, economic pressures, and more rigorous codes of forest practice, especially for soil and water

Monitoring of forests is enhanced by using Global Positioning System technology to define ground plot location

protection. Cording and matting are used on tracks within coupes to reduce soil disturbance, minimise sediment runoff into streams and enable harvesting to continue during wet weather. Similarly, improvements in harvesting equipment and techniques reduce soil compaction and water degradation. Enclosed climate-controlled cabins, responsive driving mechanisms, and safety protection such as rollover bars, improve the health and safety of harvesting operators.

Changing consumer preferences, a change in the resources such as plantation grown and regrowth timber, and new products, have seen considerable advances in timber-processing over the past ten years in Australia. New sawing methods, including a change from back-sawing to quarter-sawing to process small diameter logs, radial sawing, and new drying techniques to process regrowth native forests, are being tested to enable existing mills to adjust to the changing resources, especially to provide high quality timber for the wood furniture industry. Computing technology such as infrared scanning is now used in mills to maximise the timber cut from an unprocessed log.

Return on investment

coverage
currrency
frequency

Indicator 6.3d
Rates of return on investment

Rationale
An acceptable internal rate of return on investment in forests and forest-based industries indicates that society values its forests enough to invest in them.

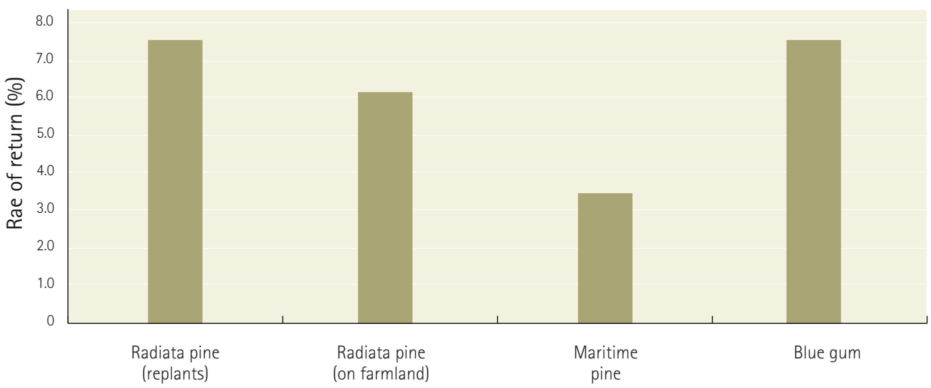
Rates of return vary with a range of factors but are generally higher with good site quality and product options, as well as desirable plantation species.

An increasing demand for wood and wood products, and Australia's proximity to the emerging markets of Asia, have driven the recent growth in the forest sector over the past decade. Australia's forests present investors with viable investment opportunities and attractive rates of return.

A key measure of the rates from investment is the internal rate of return (IRR). IRR is the rate at which capital invested grows over the life of the investment, and it allows comparisons between investment opportunities. In Australia, 7 per cent is the target for public sector forest enterprises. In the private sector, the IRR is considered commercial-in-confidence and is not readily disclosed.

Return on investment in the forest industry depends on several factors including site cost, productivity, management and its costs, and the market price of the final products. The species used in a plantation can also affect growth rates and market prices. Figure 70 displays the variance in the IRR among a number of different species.

Figure 70: Internal rate of return with different plantation species



Source: Forestry Pacific Pty Ltd (2000)

Site quality, distance to the mill, and product options all have a substantial effect on the IRR (Table 94). A good quality site will increase the IRR. Proximity to the mill will also increase the IRR, as it will decrease transport and associated costs. The study also found that wood for paper or pulp markets produced the highest potential returns to growers.

Table 94: Effect of site quality and distance to mill on Internal Rate of Return (percentage)

Distance from mill (km)	50	50	50	200	200	200
Site quality	Poor	Average	Good	Poor	Average	Good
Domestic market						
Printing and writing paper	*3.0*	*8.6*	*12.2*	*1.1*	*5.6*	*8.5*
Export market						
Hardwood bleached kraft pulp	*2.6*	*8.0*	*11.5*	*0.5*	*4.7*	*7.3*
Printing and writing paper	*2.2*	*7.4*	*10.8*	–	*3.7*	*6.0*
Hardwood pulp logs	*0.7*	*3.8*	*9.1*	–	–	–
Hardwood woodchips	–	*3.4*	*5.7*	–	–	–

Source: ABARE (1994)

Further reading

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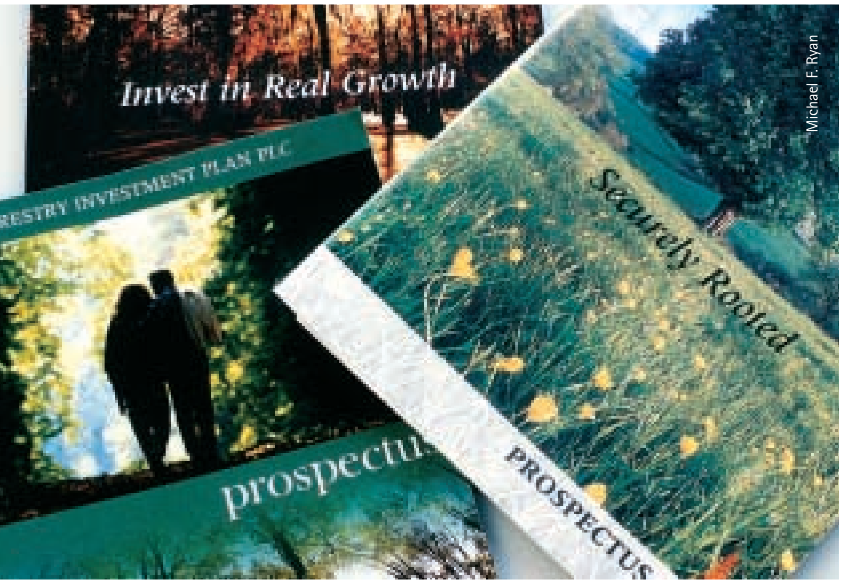


Prospectuses for forestry industry investment

6.4

CULTURAL, SOCIAL AND SPIRITUAL NEEDS AND VALUES

INTRODUCTION

This section focuses on how forests provide for uses that do not involve consuming a tangible product. These uses include a range of values that people place on forests.

Indigenous people have close ties to their land and forests are an integral part of expressing their cultural, social, religious and spiritual values. For non-Indigenous Australians there are also many places of cultural value located in forested areas. Forests need to be managed to take these into account.

Non-consumptive uses include visiting forests for recreation and pleasure. These intangible uses are hard to measure—as are the benefits received—but they are no less real than timber or clean water.

Pukumani poles surround a ceremonial site on Bathurst Island, Northern Territory. The burial poles are uniquely Tiwi and highly regarded as art and tourist attractions

Areas formally managed to protect indigenous values

coverage
currrency
frequency

Indicator 6.4a(i)

Area and per cent of forest land in defined tenures, management regimes and zonings which are formally managed in a manner which protect Indigenous peoples' cultural, social, religious and spiritual values, including non-consumptive appreciation of country

Rationale

To ensure that adequate land is placed appropriately under the range of tenure classifications and/or dedicated management regimes to protect Indigenous peoples' values associated with forests. These values include access and custodial rights, cultural maintenance and ceremony and education.

There is no comprehensive national database of Indigenous land holdings. More than 18 per cent of Australia's total land and about 13 per cent of forested land is under Indigenous ownership, mostly in the Northern Territory, South Australia and Western Australia.

Australia is committed to legal and management arrangements designed to protect Indigenous peoples' values associated with forests. To achieve this, there needs to be access and recognition of custodial rights, and maintenance of the essential features of Indigenous cultures through ceremony and education. Australia acknowledges the cultural, spiritual, and religious connection between Indigenous communities and forests.

The area of land that is brought under Indigenous tenure is one component of this indicator. The intent of the indicator is to monitor and report levels of Indigenous ownership of forested land and so be accountable for the protection of Indigenous peoples' cultural, religious, social and spiritual needs and values.

This indicator provides details of the area of lands where the full range of values important to Indigenous people are most strongly protected by formal Indigenous ownership under land title law. Native Title issues, where Indigenous interests do not hold formal title in land, are reported under Indicators 6.5d and 7.1a.

Despite unique forms of legal ownership, Indigenous people's land management objectives and practices remain subject to environmental or resource allocation laws made by States or Territories and the Australian Government. Environmental or resource allocation laws made by States or Territories and the Australian Government have effect across all tenures. Nonetheless, full legal title in land has permitted re-establishment of large measures of customary control and so allowed obligations to the land to be met to varying extents in all jurisdictions. However, the Indigenous title varies markedly by jurisdiction, and with geographical location and formal land valuations.

About 18 per cent of Australia's total land or more than 1.3 million square kilometres, and 13 per cent of its forested land, was under Indigenous ownership of some sort in 2000 (Figure 71 and Table 95). The vast majority of Indigenous land is in the Northern Territory, South Australia and Western Australia, where 32 per cent of the Indigenous population resides. By contrast, the States of Victoria, Tasmania and New South Wales, with a somewhat larger proportion of the Indigenous population (39 per cent), have only about 1 per cent of their land area under Indigenous ownership.

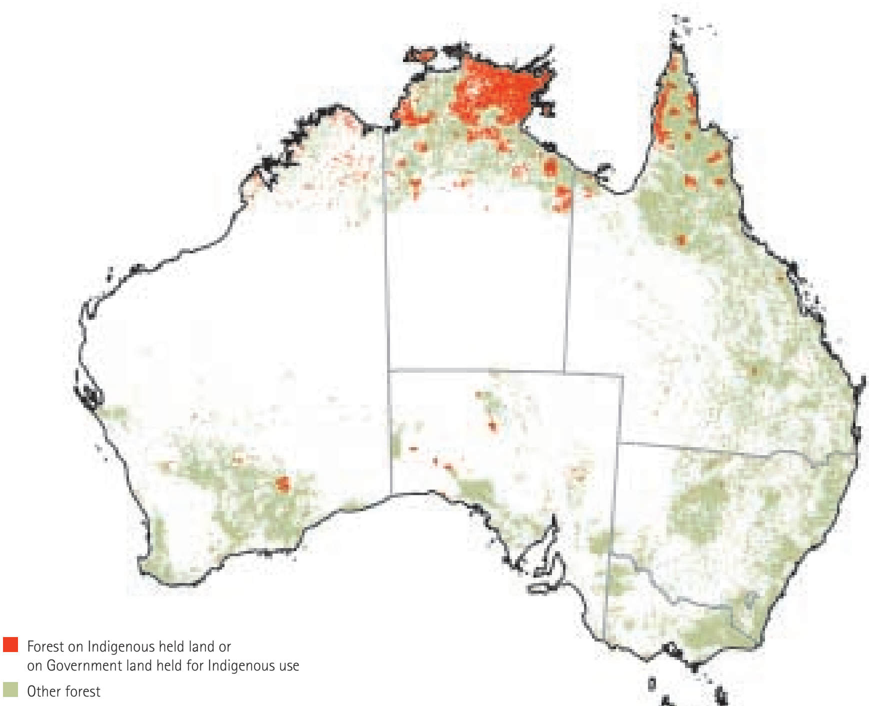
Table 95: Estimates of the proportion of Australia under Indigenous ownership

Year	Proportion (per cent)	Comments	Source
1993	*14.3*	Excluded some smaller landholdings	Australian Land Information Group
1996	*15.1*	Did not include all recent purchases	Indigenous Land Corporation (Regional Indigenous Land Strategies)
1997	*15.2*	Some anomalies in New South Wales and Victoria	Department of Prime Minister and Cabinet
2000	*16–18*	Most recent published comprehensive assessment	Pollack (2001)

Source: Pollack (2001)

Note: These figures do not include Native Title determinations or Indigenous Land Use Agreements except where formal title has been granted.

Figure 71: Indigenous forest land in Australia, 2002



Source: National Forest Inventory 2003

Tables 96 and 97 show the extent of Indigenous land ownership arising from land purchases and claim processes over the last few decades. There remains some ambiguity about the classes of title or ownership. Thus, the values in Table 96 are best regarded as a starting point for future reporting of trends, rather than as a definitive statement of the precise area of Indigenous lands.

These data and the associated map illustrate strong bias towards central and northern Australia, and the relatively weak representation of forested sites in areas where commercial forestry is most concentrated. The Indigenous Land Corporation (ILC), purchases land on behalf of Indigenous people (Table 97). For example, a property capable of commercial timber production has been purchased in Western Australia and two purchases planned in Central Queensland include farm forestry in business plans.

Indigenous title over large areas in arid parts of the country differs markedly from Indigenous title to land in forested lands alienated following European settlement. Significantly there are various heritage protection mechanisms employed by Governments. The use of these provisions to protect Indigenous values is dealt with under indicator 6.6a.

Table 96: Land and forest area under Indigenous tenure

Jurisdiction	Area (hectares)	Indigenous tenure across all lands (per cent)	Indigenous tenure in forested lands (per cent)
Australia	768 500	*21*	*13*
New South Wales[1]	80 400	–	*1*
Northern Territory	134 800	*45*	*47*
Queensland	172 700	*3*	*7*
South Australia	98 400	*21*	*5*
Tasmania	6 800	*0.3*	–
Victoria	22 800	*0*	*0*
Western Australia	252 600	*14*	*7*

Source: National Forest Inventory 2003

[1] Includes the Australian Capital Territory

Table 97: Land acquired for divestment to Indigenous people, 1997–2002

Jurisdiction	No. properties	Total area ('000 hectares)
New South Wales	40	183
Northern Territory	10	572
Queensland	30	1 230
South Australia	25	835
Tasmania	4	20
Victoria	24	4
Western Australia	27	2 278
Total	160	5 121

Source: National Forest Inventory 2003

Note: While the area acquired represents only 0.7% of Australian land, purchasing is able to focus on sites where claims of continuing connection may be strong but which are unavailable for claim under land rights legislation.

Further reading

Pollack, D. (2001). Indigenous land in Australia: a quantitative assessment of Indigenous landholdings in 2000. Discussion Paper 221/2001. Centre for Aboriginal Economic Policy Research, Australian National University, Canberra.

coverage
currrency
frequency

Areas formally managed to protect places of non-indigenous value

Indicator 6.4a(ii)

Proportion of places of non-Indigenous cultural value in forests 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.

Wherever known non-Indigenous heritage places are located in multiple use forests or nature conservation reserves, formal mechanisms are in place to manage them. However, the extent of surveys and heritage significance assessments varies widely between jurisdictions.

Australia's forests are significant repositories of heritage places associated with the diversity of human activity since the earliest days of non-Indigenous occupation of the country. Places of non-Indigenous cultural value include sites, features, structures and landscapes assessed as having some cultural significance at local, regional or state level in each State or Territory.

Heritage places found in Australia's forests are evidence of the complex interaction between people and forest landscapes and reflect the many changes in life and work experienced over the last two centuries. Forest heritage includes places associated with Indigenous contact and conflict, pastoral and agricultural settlement, exploration and survey, forestry and timber production, mining, graves and cemeteries, railways and tramways, travel routes, transport and telecommunications, recreation, social life and natural places of aesthetic value.

At present nationally consistent protocols for identifying and measuring non-Indigenous cultural heritage values in forest areas have not been developed. All States and Territories have carried out some inventory surveys of heritage places. However, the purpose, definitions, criteria and methods used to identify and record them vary according to each jurisdiction's statutory responsibilities and management practices.

Most jurisdictions have adopted a risk management approach based upon the effective management of threatening processes such as fire, development, timber harvesting and road-building. For example, Victoria, New South Wales, Tasmania and Queensland all conduct inspections or surveys before timber-harvesting operations may proceed, and have conducted targeted and comprehensive cultural heritage place surveys and heritage studies.

In all States and Territories, where known non-Indigenous heritage places are located in multiple-use forests or nature conservation reserves, formal mechanisms are in place to manage the places for protection. Sites on leasehold, other public lands, or on freehold tenure, might not be formally protected unless listed on the relevant State/Territory or Commonwealth Heritage Register (Table 98).

The degree to which surveys and heritage significance assessments have been conducted varies widely between the States and Territories. All jurisdictions have focused their inventory survey efforts on multiple-use forests and nature conservation reserves. Victoria has surveyed 5.9 million hectares, 90 per cent of its total public native forest estate. Queensland has surveyed 4.45 million hectares (10 per cent). Taken alone, these figures are somewhat deceptive. While Victoria's public native forests comprise over 83 per cent of its total forest estate, Queensland's native forests (55.7 million hectares) include leasehold and private land tenures accounting for 45.7 million hectares (or 82 per cent) of its total forest area. More than 56 per cent of Queensland's 7.9 million hectares of protected area forest estate has been subject to some form of heritage inventory survey and assessment.


David Cameron, Qld Parks and Wildlife Service

Damco's slab hut c. 1900, Barakula State Forest, Queensland

Table 98: Number of places of non-Indigenous cultural value in forests formally managed to protect their values

Number of:	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Commonwealth
Places formally managed through legislation or codes of practice	–	2 123	–	1 852	–	140	2 800	–	3 (2 Qld; 1 Jarvis Bay Territory)
Places in production forests on public land	–	–	–	1 068[1]	–	112[1]	1 428[1]	–	0
Places in conservation forests on public land, including nature conservation reserves	–	–	–	784[2]	–	28[2]	1 372[2]	–	–
Places in forests on other public land, including leasehold	–	–	–	249[3,4]	–	2 378	–	–	–
Places in forests on freehold and other private land	–	–	–	147[5]	–	–	–	–	–
Cultural heritage surveys undertaken in context of timber harvesting plans	–	Surveys for all timber harvesting operations	–	Pre-harvest inspections	–	–	–	–	–
Percentage of forests of all tenures surveyed	–	–	–	*8*	–	–	*90*[6]	–	–
Total area of forest ('000 ha)	118	26 658	32 837	55 734	10 866	3 169	5 953	25 365	–

Source: National Forest Inventory 2003
1 Multiple-use forest
2 Nature conservation reserve
3 Leasehold land
4 Other State lands
5 Freehold land
6 Public native forest only

Case study – Clermont Area State Forests, Central Queensland

Sixty thousand hectares of predominantly narrow leaf ironbark (*Eucalyptus crebra*) forest near Clermont in Central Queensland were surveyed for a Queensland Parks and Wildlife Service cultural heritage inventory project in 2001.

Explorer Ludwig Leichhardt traversed the Clermont district during his 1844–1845 expedition to Port Essington, and shortly thereafter the first pastoralists settled in the district. Conflict between the Indigenous peoples and the pastoralists ensued as they battled for control of the natural resources of the area. Gold and copper were discovered in the Clermont area in 1861 and it became Queensland's first viable goldfield. Timber-cutting developed to service the pastoral and mining industries and to supply railway sleepers for new lines in central and north Queensland. The government established a sleeper mill in the State forest at Birimgan in 1912.

A total of 110 places (Table 99) with cultural heritage value were identified as a result of the inventory project. Places recorded include numerous gold mine workings, timber getter's camps and huts, a section of the inland telegraph line, the Birimgan sleeper mill, township and tramway sites and pastoral homesteads, stockyards and camps.

Sleeper cutters and families at the 20 mile camp, Blair Athol, Queensland 1924. These cutters supplied ironbark slabs for the government sleeper mill at Birimgan (Photo courtesy of Keith James, Belyando Shire Council, Clermont)

Table 99: Cultural heritage sites identified

Place category (type)	Number
Forestry	7
Mining	24
Pastoral	17
Rail and tramways	32
Timber industry	14
Settlement	4
Other	12

Non-consumptive use forest values

coverage
currrency
frequency

Indicator 6.4b

Non-consumptive use forest values

Rationale

This indicator recognises the breadth of values that communities place upon forests and is designed to measure the accessibility and availability of forest areas for non-consumptive uses such as recreation and aesthetic appreciation.

There are little data on the value of non-consumptive uses as many of these are intangible and hard to measure.

This indicator recognises the breadth of values that communities place upon forests, and measures the accessibility and availability of forest areas for non-consumptive uses. These uses include conservation, recreation and education. The indicator also includes community satisfaction with existing use and opportunities for expression of non-consumptive and non-use forest values including cultural and spiritual values.

There is no national measure of community satisfaction. There are, however, some limited data available that can give a basic indication about the non-consumptive uses of forests.

Table 100 shows some of these activities in the multiple-use forests of New South Wales. The financial value of these activities cannot be quantified but the educational and recreational value to participants is significant. The list is not comprehensive and other forest uses include fishing, bird watching and nature studies.

Table 100: Non-consumptive activities in multiple-use forests, New South Wales

Activity	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002
Eco-tourism/4x4 Tours	54	42	87	50	41
Horse, trail, endurance rides	32	32	32	45	32
Car rallies/go carts	38	36	36	34	30
Motor bike rallies	6	8	6	5	6
Mountain bike rallies	30	6	5	20	17
Orienteering/mountain runs/ triathlon	37	37	34	21	16
Education	27	45	272	575	20
Training/exercises	152	77	84	79	68
Marked drives	30	34	31	24	19
Camping sites	308	225	266	115	160
Marked forest walks	90	61	61	46	48
Filming and documentary permits	3	5	6	3	3

Source: State Forests of New South Wales (2002)

Conservation

The main purpose of conservation is to ensure that ecosystems are maintained. Conservation values are frequently acknowledged by communities as a major reason for wanting to preserve forested landscapes. Many people are content in the knowledge that a forest exists with conservation and other values intact, even without visiting the area personally. Non-commercial photographing and filming is often encouraged as it is seen to increase community awareness and an appreciation of forest conservation.

In 2003 approximately 13 per cent (21.4 million hectares) of Australian native forests were in nature conservation reserves. This figure may be understated as reserves may also be within leasehold land, multiple-use forests or private land, via covenants. There are little available data on the amount of money spent on conservation. Funding comes from primarily government bodies, but there are also community contributions in the form of donations, bequests and membership fees.

The Department of Conservation and Land Management, Western Australia, provided some conservation expenses in its 2001–2002 Annual Report (see Table 101). These figures may be understated because funding contributing to conservation may be grouped under other outputs.

Table 101: Conservation expenditure by output ($'000)

Output	2000–2001	2001–2002
Nature conservation	47 991	55 061
Sustainable forest management	89 103	33 333
Resources and services provided to the Conservation Commission of Western Australia	287	684
Parks and visitor Services	38 745	50 297
Astronomical services	1 010	1 187
Total cost of outputs	177 136	140 562

Source: CALM (2002)

Hiking and bushwalking

Bushwalking is a popular form of recreation. Nature conservation reserves and multiple-use forests contain developed walking trails. Bushwalks increase community awareness, education and interest in conservation. Marked bushwalks often contain information on the local forest species. There are many hiking clubs throughout the country that use forests regularly.

Education

Community education is a major beneficiary of non-consumptive uses in forests. For example, some forest managers run education and awareness programs throughout the year, especially during school holiday periods. In addition a number of organisations work with members of the public to conduct research and monitoring of flora and fauna in forests.

Further reading

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CALM (2002). Annual Report, 2001–02. Department of Conservation and Land Management, Perth.

6.5

EMPLOYMENT AND COMMUNITY NEEDS

INTRODUCTION

The five indicators in this sub-criterion measure a range of factors connected with employment in the forest industry and related sectors. The indicators also assess the viability of communities dependent on forests. From 1993 to 2001, direct employment in the forest sector increased in total number but declined from 0.98 per cent of the national workforce to 0.86 per cent. However, the forest sector also generates considerable employment in other related industries.

In addition, this section considers how Indigenous people are able to exercise their rights to meet their needs from forested land to which they may hold no formal title.

The third theme to this section concerns workers within the forestry industry, and measures wage and injury rates. The average injury rate for the forest, wood-milling and manufacturing sectors is 39 per 1000 employees per year, compared with 24 for all Australian industry. Many injuries are connected with activities involved in harvesting. The number of employees involved in the sector is declining, but in the three years to 2001 the spending on wages increased.

Logging crew in alpine ash (*Eucalyptus delegatensis*) forest

Employment

coverage
currrency
frequency

Indicator 6.5a

Direct and indirect employment in the forest sector and forest sector employment as a proportion of total employment

Rationale

Employment is an important measure of the contribution of forests in meeting community needs.

From 1993 to 2000, direct employment in the forest sector declined from 0.98 per cent to 0.81 per cent of the Australian workforce, rising to 0.86 per cent in 2000–2001. However, the forest sector generates considerable employment elsewhere, with the multiplier effect ranging from 1.57 in South Australia to 2.35 in Victoria.

Employment is one measure of the contribution of forests to meeting community needs. Employment in the forestry sector can be direct or indirect. Direct employment refers to employment in the wood and wood product industries and to those commercial activities in direct contact with forests—for example, beekeeping, grazing, eco-tourism or forest reserve rangers. Indirect employment is employment in other sectors generated by direct forest employment. It indicates the potential multiplier effect of direct forest employment.

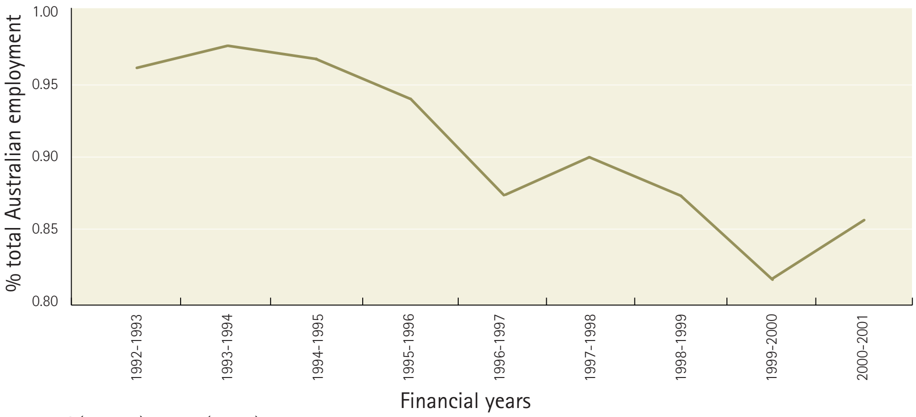
Direct employment

Currently the data collected by statistical agencies have a number of limitations. The main limitation is that forest management staff working in production or conservation are not included; neither are recreation staff or log truck drivers. Therefore, while the reported figures for this indicator under-estimate the total numbers employed by the Australian forestry sectors, the changes in relation to total employment in Australia are relative to what would be expected for all participants in forests and forestry.

From 1993 to 2000, direct employment reported in forest sector industries as a proportion of total Australian employment declined from 0.98 per cent to 0.81 per cent. However, latest figures show a rise to 0.86 per cent for the year ended June 2001 (Figure 72; Table 102).

Log truck refuelling, Numeralla, Victoria

Figure 72: Forest industry employment as a percentage of total employment in Australia



Source: ABS (2002a,b); ABARE (2002a)

Note: derived from data in Table 103.

Table 102: Direct employment in the forest sector ('000 employees)

Year	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001
Forestry and harvesting[1]	11.3	12.4	11.4	10.9	14.0	14.1	8.8	13.4
Wood and wood products								
Log sawmilling	8.3	9.0	8.1	7.1	7.0	5.6	6.5	5.3
Resawn and dressed timber	6.7	7.1	6.4	6.9	7.4	6.2	6.2	7.9
Veneers, plywood and fabricated wood manufacturing	5.6	6.2	5.9	5.6	4.9	5.0	4.9	5.5
Wooden structural fittings and other joinery	18.0	17.2	17.1	16.4	18.7	20.1	22.2	20.2
Hardwood woodchips	0.7	0.8	0.9	0.9	0.9	0.7	0.8	0.6
Other wood products	7.6	7.8	7.4	6.7	6.5	5.7	6.2	5.7
Total	46.9	48.1	45.8	43.8	45.4	43.4	46.8	45.3
Paper and paper products								
Pulp, paper and paperboard	5.8	5.6	5.8	5.2	4.8	4.4	4.3	5.1
Paper bags (including sack)	1.0	0.9	1.0	1.2	1.2	1.3	1.4	1.2
Solid fibreboard containers	2.4	2.3	4.1	2.4	2.4	2.5	2.6	2.9
Corrugated fibreboard containers	4.8	5.3	5.7	5.6	5.4	5.5	4.9	5.9
Other paper products	3.8	3.6	3.5	3.4	3.5	3.7	3.6	4.6
Total	17.9	17.8	20.0	17.9	17.2	17.3	16.9	19.7
Total forestry and wood products sectors	76.1	78.3	77.2	72.6	76.6	74.8	72.4	78.4
Total manufacturing industries	1 092.3	1 115.3	1 111.5	1 129.3	1 121.2	1 083.5	1 114.9	1 131.0
Total employees	7 755.2	8 056.6	8 289.2	8 354.8	8 461.3	8 647.4	8 906.6	9 090.0
Forest and wood products as a proportion of total employees (per cent)	*0.98*	*0.97*	*0.93*	*0.87*	*0.91*	*0.86*	*0.81*	*0.86*

Source: ABS (2002); ABARE (2002a,b, 2003)

[1] Does not include truck drivers, managers or conservation staff.

Table 103 shows employment of foresters and park rangers in Australia from 1996–2001. It can be assumed that these employees were not accounted for in Table 102.

Improved estimates of direct employment in non-wood forest industries have been obtained as part of the economic and social assessments for Regional Forest Agreement areas. Data were collected for the beekeeping, tourism and grazing industries.

Table 103: Park ranger and forester employment (total numbers)

1996	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Other	Total
Forester	62	483	9	309	74	227	386	217	0	1 767
Park ranger	38	333	168	435	106	84	351	169	6	1 690
2001										
Forester	59	427	10	309	98	342	418	272	0	1 935
Park ranger	21	382	145	399	92	53	421	78	8	1 599

Source: Space Time Research (1996, 2000)
Note: The terms forester and park ranger were defined by the individuals completing the census.

Indirect employment

Indirect employment is usually measured at a national or State/Territory level using macro-economic models since they capture the broad structure and linkages between the different sectors of the economy.

State/Territory and national employment multipliers have been generated (Table 104). The State multipliers represent the overall State employment that is generated by an increase in employment in that State's forestry, logging, wood and paper industries.

For example, in Western Australia the State employment multiplier in the forestry and logging sector of 1.97 indicates that 100 people employed in that State's forestry and logging sector would generate additional employment of 97 people in the rest of the State's economy. Similarly, the national employment multiplier of 3.61 for the same sector implies that an increase of employment of 100 people in that industry in Western Australia provides additional employment of 261 people in the national economy. As direct employment is understated, it is likely that indirect employment is also understated.

Table 104: Employment multiplier effects of forest-related industries

	Forestry and logging		Wood and paper manufacturing		Total forest -based industries	
	State	National	State	National	State	National
New South Wales	2.25	4.20	1.66	1.24	1.88	2.72
Queensland	2.25	4.20	1.49	1.19	1.64	2.31
South Australia	1.57	3.70	1.43	1.02	1.65	2.86
Tasmania	2.26	3.77	1.29	0.61	1.44	2.24
Victoria	2.35	3.85	1.61	1.25	1.80	2.79
Western Australia	1.97	3.61	1.44	1.15	1.67	2.38

Source: ABARE (2002b)

Case study – Small communities

Forest sector employment is especially significant in a number of small rural Australian communities. Livelihood in these communities can often rely on the employment provided by the forest sector. The Queensland Department of Primary Industries has researched the impact of forest industry employment on a small town. The town, Injune, is in Southern inland Queensland and has a population of roughly 400. Statistics suggest that approximately half of the population 'directly relies on the forest industry for all or part of their livelihood'. Approximately 70 families in Injune derive at least one income from direct employment in the forestry sector. Furthermore, around three-quarters of these families are single income families, therefore relying wholly on the forestry sector for income. Further information on forest industry-dependent communities is in indicator 6.5c.

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Wage and injury rates

coverage

currrency

frequency

Indicator 6.5b

Average wage rates and injury rates in major employment categories within the forest sector

Rationale

A sustainable industry will ensure high levels of workforce health and welfare and wage rates comparable with other rural industries.

Employment and spending on wages in the forestry sector increased in the three years to 2001. The average injury rate for the forest, wood-milling and manufacturing sectors is higher than the national average. The fatality rate for the forest sector is considerably higher than the national average.

A sustainable industry will strive to safeguard the health of its workforce and maintain wage rates comparable with similar industries. Changing injury or wage rates reflect on employment quality and desirability, and so affect the future of forest management as well as the larger community.

Table 105 provides employment data for the forestry sector. It is not practical to ascertain average wages from these data, as it does not allow for part-time workers, contractors and seasonal variation. Overall the forestry sector has seen a greater increase in spending on wages than in employment. This may be attributed to an increased emphasis on positions of a higher skill level, resulting in higher associated wages and a possible reduction of lower skilled positions. General wage increases would also have contributed to this trend.

Required safety equipment for harvesting operations

Table 105: Wages in the forest products sector ($million)

Sector	1998–1999	1999–2000	2000–2001
Log sawmilling and timber dressing			
Log sawmilling	156	170	134
Wood chipping	37	39	19
Timber re-sawing or dressing	222	211	298
Sub-total	416	420	451
Other wood product manufacturing			
Plywood and veneer	53	53	34
Fabricated wood	143	138	191
Wooden structural component	533	654	562
Other wood products	137	145	148
Sub-total	866	990	935
Paper and paper products			
Pulp, paper and paperboard	265	270	296
Solid paperboard containers	107	120	140
Corrugated paperboard containers	–	273	353
Paper bag and sack	–	60	43
Other paper products	142	142	238
Sub-total	864	865	1 070
Total forest products sector wages	2 146	2 274	2 456
Total manufacturing industry wages	–	39 900	38 746
Proportion in forest products sector (per cent)	–	*5.7*	*6.3*

Source: ABARE (2002); ABS (2001)

Injury rates

Some 2.36 per cent of fatal injuries and 0.27 per cent of non-fatal injuries in the Australian workplace are directly attributable to the forestry sector. While the rate of fatal injuries in the forestry sector is high and has remained fairly steady in recent times, there has been a significant drop in non-fatal injuries.

The average injury rate for the forest and wood-milling and manufacturing sectors is 39 per 1000 employees per year compared with 24 for all Australian industry (Table 106). The pulp and paper industries perform better than the average for Australian industry, again reflecting the more capital-intensive and controlled manufacturing environment for that sector. Logging and paper bag and sack industries have a very high rate of injury.

Table 107 refers to the average fatality rates in the sector. The data show a high level of fatality, particularly when compared with the figure for the Australian workforce in general, of 8.1 fatalities per 100 000 workers. It identifies logging as one of the most dangerous industries within Australia. Explanations for the high fatality rate include isolation, poor work practice, errors of judgement and equipment problems.

Table 106: Annual injury rates in the forestry sector

Sector	Injuries per 1000 employees
Forest sector (1991–1992)	
Logging	68.1
Forestry	21.2
Log sawmilling and timber dressing	
Log sawmilling	52.4
Timber re-sawing and dressing	28.3
Wood chipping	6.2
Other wood product manufacturing	
Wooden doors	56.2
Plywood and veneer	51.8
Other	51.7
Wooden containers	44.8
Wooden structural components	28.2
Average of above industries	39.3
Paper and paper-product manufacturing	
Paper bag and sack[1]	135.7
Other	35.9
Corrugated paperboard container	35.6
Pulp, paper and paperboard	17.6
Comparative industries (1992–1993)	
Services to agriculture	75.2
All agriculture	49.1
Agriculture	47.1
All Australian industry (1991–1992)	23.7
All Australian industry (1992–1993)	25.5

Sources: NOHSC (2000); Driscoll *et al.* (1995)

[1] This is a small industry and the data are based on a small sample size (19.5 per cent of the industry).

Table 107: Annual fatality rates

Position/Job Title	Deaths per 100 000 employees
Loggers	396
Forest service workers	52
Sawmill workers	30
Mining and quarrying	70
Agriculture	19
Commercial fishing	143
National average	8.1

Source: Driscoll *et al.* (1995)

The National Occupational Health and Safety Commission completed a study on activities undertaken and the mechanisms causing fatal injuries in the forestry sector. Tables 108 and 109 clearly show that felling or clearing is the most dangerous activity.

Table 108: Type of fatal incident

Mechanism	Proportion (per cent)
Hit by falling objects	64
Hit by moving objects	14
Rollover of moving machinery	9
Vehicle accidents	5
Hitting stationary objects	2
Contact with electricity	2
Insect bites and stings	2
Not known	2
Total fatalities	100

Source: NOHSC (1998)

Table 109: Activity performed at the time of fatal incident

Activity	Proportion (per cent)
Felling or clearing	73
Transport	9
Observing	5
Moving goods	5
Work break	4
Eradicating weeds	2
Working – context unclear	2
Total fatalities	100

Source: NOHSC (1998)

Further reading

ABARE (2002). Australian Forest and Wood Product Statistics, Australian Bureau of Agricultural and Resource Economics, Canberra.

ABS (2002). Manufacturing Industry: Catalogue No. 8221.0. Australian Bureau of Statistics, Canberra.

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NOHSC (2000). National Workers' Compensation Statistics Database. National Occupational Health and Safety Commission, Canberra.

State Forests of New South Wales (2002). Seeing: Social, Environmental and Economic Report 2001/02. State Forests of New South Wales, Pennant Hills.

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Viability of forest-dependent communities

coverage
currrency
frequency

Indicator 6.5c(i)

Viability and adaptability to changing social and economic conditions of forest-dependent communities

Rationale

Communities with a high economic and cultural dependence on forest and forest-related industries should be sustainable into the future.

This indicator provides a measure of the extent to which communities are able to respond and adapt to change successfully.

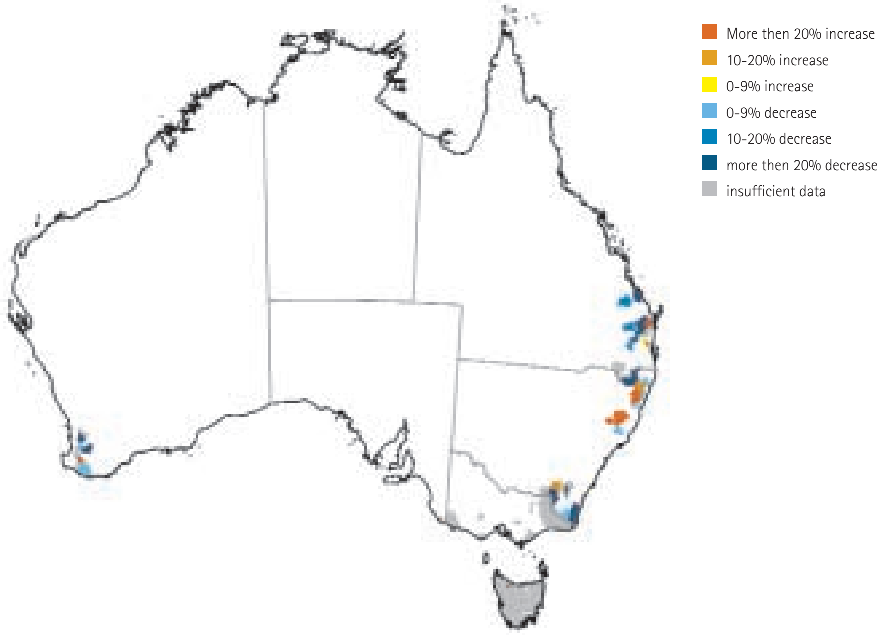
Currently there are few specific data available to measure this indicator, though employment trends may provide a guide. The results of a nationwide survey suggest forest-dependant communities may have a decreased ability compared to other communities to respond and adapt to a changing forest industry, all other influences being equal.

Communities rely on forests for employment, food, raw materials and cultural ties. Ensuring communities with high economic and/or cultural dependence on forests and forest industries remain viable into the future is an important part of sustainable forest management. This indicator provides a measure of the extent to which communities are able to respond and adapt to change successfully.

Presently there are few specific data available with which to measure this indicator. However, shifts in employment over time provide a partial gauge. All areas in Australia that had more than 0.1 per cent employment in 'forestry' and 'logging' were identified. A 'forestry sector-dependent' community was defined as one where forestry and logging accounted for 5 per cent or more of total employment. The employment data included growing trees for timber in native forests, plantations or timber tracts, felling trees, shaping trees for rough-hewn products such as mine timbers, posts, railway sleepers; and cutting trees and scrub for firewood. It also included gathering other forest products or distilling eucalyptus oil in the forest, along with services such as forest reafforestation, conservation or plantation maintenance on a fee or contract basis, or providing forest fire-fighting services.

Figure 73 depicts an overview of the changes in forestry and logging employment between 1991 and 1996. Overall, the main feature evident through combining employment and change in employment is that the majority of areas with forestry have also experienced a reduction in employment.

Figure 73: Change in forestry and logging employment (1991–1996)



Source: Brooks *et al.* (2001)

Note: due to changes in the boundaries of Statistical local areas in Victoria and Tasmania, comparative data are not available for these two states. The terms 'forestry' and 'logging' are categories in the Australia and New Zealand Industry Classification, used by the Australian Bureau of Statistics

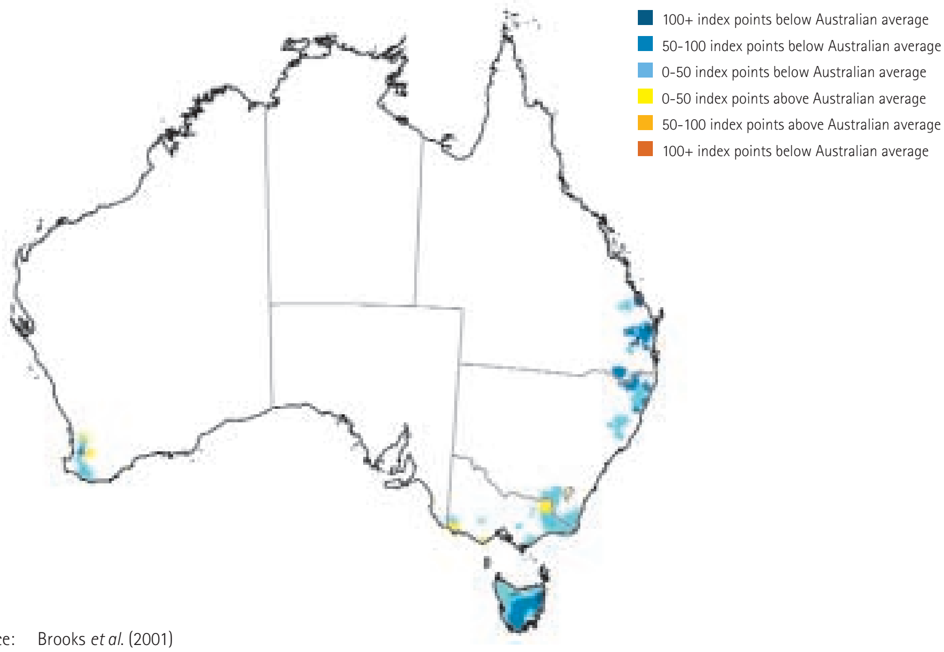
Southern New South Wales and southeast Queensland have been most affected by employment reductions during the period 1991 to 1996. These regions experienced reductions in forestry employment of 20 per cent or more, both in local areas and in the urban centres. On the other hand, Victoria had the highest number of urban centre localities that experienced increases in employment in the sector.

Interestingly, five areas in Queensland and New South Wales experienced increases. However, in each case these were adjoined by areas that concurrently displayed equivalent decreases in employment, possibly resulting from a shift in employment between areas rather than the creation of jobs in the industry. The reverse of this trend was featured in Inglewood in southern Queensland. This was the only area that experienced an increase in employment (up to 9 per cent), while the town itself experienced a reduction of more than 20 per cent in its forestry employment.

To compare the viability and adaptability of forestry communities to changing social and economic conditions, the Socio-economic Index for Areas (SEIFA) was used to determine the degree to which forestry communities differed from the wider environment (Figure 74). Produced by the Australian Bureau of Statistics, SEIFA is an index of relative disadvantage, with 1000 being set as the Australian standard. A low SEIFA index indicates an area where economic opportunities for people to seek alternative employment are low, and where people are less financially independent. Conversely, the least disadvantaged areas—those above the standard—have higher proportions of high-income earners, professional workers and more highly qualified people, as well as low unemployment rates.

Of the 66 areas where greater than 5 per cent employment in forestry and logging was identified, 58 areas fell below the SEIFA standard, placing them in the category of disadvantaged. This suggests forest-dependent communities may have a decreased ability compared to other communities in these regions to respond and adapt to a changing forest industry, all other influences being equal.

Figure 74: Index of socio-economic disadvantage

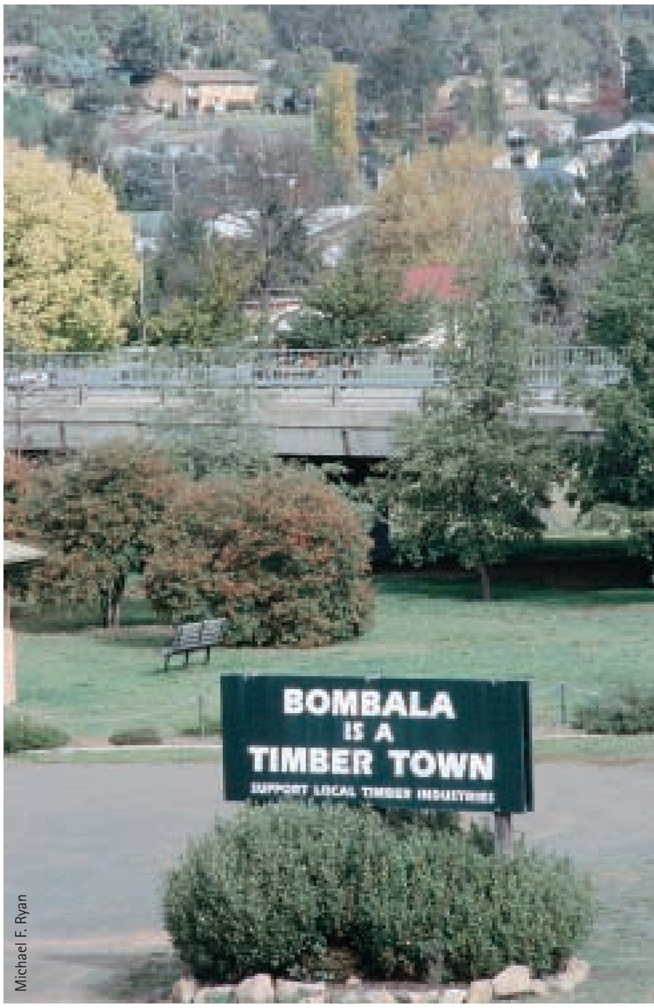


Source: Brooks *et al.* (2001)

Further reading

ABS (1998). Australia in Profile: A Regional Analysis. Catalogue No. 2032.0. Australian Bureau of Statistics, Canberra.

Brooks, K., Kelson, S. and Tottenham, R., (2001). Summary of Australian Regional Forest Agreement Social Assessments and a Recommended Assessment Methodology. Report for Forest Industries Branch, Agriculture, Forest and Fisheries – Australia, Canberra.



More than 11 per cent of the workforce in Bombala, New South Wales were employed in forestry and logging in 1996

coverage
currrency
frequency

Viability of forest-dependent Indigenous communities

Indicator 6.5c(ii)

Viability and adaptability of forest-dependent Indigenous communities

Rationale

It is important for societal benefit to know how much Indigenous communities are dependent on forest resources for their viability and for the maintenance of their traditional values and cultural heritage.

Indigenous people are employed in mainstream forest industries at about the same rate as the non-Indigenous population. However, there are other forest-dependent activities that not only provide cash and non-cash income, but strengthen social cohesion.

Indigenous communities draw on resources in forests to meet a wide range of needs, including subsistence, maintenance of cultural norms, and access to markets. Many Indigenous communities in turn provide land and resource management services and maintain attributes of forests valued by the wider Australian society.

This indicator provides data on the level of dependence of Indigenous communities on forest resources for viability. It complements information reported under indicators 6.1b and 6.1f. Indigenous people have taken up mainstream employment in forestry industries at about the same rate as the non-Indigenous population (Table 110). In the large forested areas of northern Australia, Indigenous people in mainstream forestry employment number less than 50. Employment has remained relatively consistent over a 5-year period.

Many Indigenous communities seek options to engage with the market economy in ways that are sensitive to obligations to land. Examples include:

- adults engaged regularly in producing arts and crafts for sale; and
- Community Development Employment Program (CDEP) places devoted to land management activities contributing to forest condition.

Application of customary skills and knowledge in CDEP-funded work to maintain forest values makes cost-effective and socially-valuable contributions to resource and biodiversity conservation. For example, annual costs of land management programs in the Maningrida region (Northern Territory), including CDEP expenditures, average $1.60 per hectare, comparing favourably with costs of servicing the region's major nature conservation reserves, which average $10 per hectare to achieve equivalent conservation outcomes.

Table 110: Mainstream employment of Indigenous and non-Indigenous people in forestry-related industries

State/Territory	Total Indigenous population of employment age (15–64 years)		Number of Indigenous and non-Indigenous people employed in forestry industries			
			1996		2001	
	1996	2001	Indigenous	Non-Indigenous	Indigenous	Non-Indigenous
New South Wales	59 300	70 703	63	2 155	60	2 723
Northern Territory	27 602	30 993	0	52	39	66
Queensland	54 102	64 504	31	2 005	31	2 005
South Australia	11 828	13 750	15	755	3	868
Tasmania	7 942	9 099	66	1 730	64	1 916
Victoria	12 463	14 589	19	1 774	18	1 882
Western Australia	29 089	33 832	22	1 101	19	1 426
Total	202 326	237 470	216	9 572	234	10 700

Source: ABS (1996, 2001)

Note: Employment categories include forestry and logging as well as forestry support services (ABS categories 0300-0303)

Further reading

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Space Time Research Pty Ltd (2003b). ABS 2001 Census of Population and Housing. Australian Bureau of Statistics, Canberra.

Opening the fruit case of a screw palm (*Pandanus spiralis*) to extract the kernel

coverage ●
currrency ●
frequency ●

Land for Indigenous needs

Indicator 6.5d

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

Rationale

To measure the opportunities for cultural and traditional lifestyles and access to country in accordance with native title or other rights.

Native title applications to date have resulted in about 900 000 hectares of forested areas being available and accessible to Indigenous people.

Australian Indigenous cultures are defined by their relationships with the lands. This indicator summarises opportunities for Indigenous people to access land and to use the resources of forested lands to meet basic needs. It does not deal directly with commercial use (see indicator 6.1b) or the formal regulation of tenure and land use that protects primacy of Indigenous interests (see indicator 6.4a(i)). Issues regarding native title law, are discussed in indicator 7.1a.

Useful indicators of the extent to which Indigenous people can access and use resources on land to which they hold no formal land title are determinations under the Commonwealth's *Native Title Act 1993* (Table 111) and Indigenous Land Use Agreements (ILUAs) made under the same legislation. ILUAs are voluntary agreements between Indigenous native title claimants and the formal owners of sites subject to claim. The Federal Court determines whether native title exists and the ILUA specifies parameters for the exercise of native title rights. Increasingly, parties are seeking ILUAs or other forms of agreements to provide clarity and certainty. Many deal with 'future acts' that the formal owner of land or other interest may be contemplating. ILUAs are accordingly a tangible expression of Indigenous people influencing, in a legally binding way, activities that have the potential to affect customary or other use.

Figures given for applications resolved may differ from determinations made because claims may be settled in other ways, with the assistance of the Native Title Tribunal.

Access by Indigenous peoples to nature conservation reserves varies across Australia. Parks and reserves where Indigenous people have been recognised as owners and are engaged in joint management or similar arrangements are dealt with in indicator 6.4a(ii).

Bark stripping stringybark (*Eucalyptus tetrodonta*) forest for use in Indigenous artworks, Northern Territory

Table 111: Applications for recognition of Native Title and determinations in the Federal and High Courts over the period 1994 to May 2003

Jurisdiction	Native Title applications			Determinations by Courts				Indigenous Land Use Agreements		
	Filed	Resolved	Number recognised	Number accepted	Area recognised ('000 ha)	Per cent in forested areas	Number rejected	Number	Area recognised ('000 ha)	Per cent in forested areas
Australian Capital Territory	4	3	0	0	0	0	0	0	0	*0*
New South Wales	370	254	11	1	12	*0*	8	4	863	*4*
Northern Territory	211	21	2	4	1 727	*37*	0	15	4 782	*12*
Queensland	407	189	10	17	846	*66*	2	45	13 375	*10*
South Australia	47	17	1	0	0	0	1	1	0	*0*
Tasmania	5	3	0	0	0	0	0	0	0	*0*
Victoria	69	47	1	0	0	0	1	10	1	*10*
Western Australia	466	315	3	8	36 043	*<1*	1	1	4 744	*<1*
Federal land[1]	17	2	0	–	–	–	–	–	–	–
National total	1 551	851	28	30	38 616	*3*	13	76	23 766	*11*

Source: National Forest Inventory 2003

[1] Figures for determinations and ILUAs are included in those given for the State/Territory in which the claim was lodged.

6.6

INDIGENOUS PARTICIPATION AND MANAGEMENT

INTRODUCTION

The sole indicator in this section considers the extent to which forest management frameworks maintain and enhance Indigenous values. It tracks the ways in which Indigenous people participate in decisions about active forest management regardless of where it occurs. The indicator summarises the opportunities for Indigenous values to be recognised as significant on lands not under Indigenous ownership, and ways in which management frameworks can maintain those values.

A Tiwi Islander measures a tree in a plantation of mangium (*Acacia mangium*) owned by Sylvatech on Tiwi Aboriginal land

Maintaining and enhancing Indigenous values

coverage
currrency
frequency

Indicator 6.6a

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

Rationale

This indicator measures the extent to which Indigenous people participate in forest management. Ultimately, active participation in management reflects the relationship of people with the land.

There are 62 national heritage areas, totalling more than 10 million hectares, formally recognised as possessing both Indigenous and forest values that warrant protection.

This indicator tracks the ways in which Indigenous people participate in decisions about active forest management regardless of where it occurs. It summarises the opportunities for Indigenous values to be recognised as significant on lands not under Indigenous ownership, and ways in which management frameworks can maintain those values. Engagement may extend to facilitation of access to permit use of resources and other activities to meet customary obligations to the land. It complements measures of protection discussed in indicators 6.4a(i), 6.5d and 7.1a.

Present recognition of Indigenous heritage values is summarised in lists and registers maintained by the States, Territories and Australian governments (Table 112). Given Indigenous peoples use of a wide range of forest resources and sites, these figures reflect under-recognition of Indigenous values as not all heritage localities are currently identified or listed. Regional forest agreements commit to promoting appropriate management of Indigenous heritage in forest areas.

Table 112: Heritage places formally recognised as having Indigenous and forest values that warrant protection (Department of the Envronment and Heritage 2003)

State/Territory	Number of sites listed		Both forest and Indigenous values	
	Indigenous values	Natural values	Number	Area ('000 hectares)
Australian Capital Territory	35	52	1	7.6
New South Wales	329	753	19	950
Northern Territory	131	203	4	3 550
Queensland	189	543	14	2 340
South Australia	233	529	1	35
Tasmania	87	670	10	1 954
Victoria	136	550	4	414
Western Australia	105	617	9	807
Australia	1 245	3 945	62	10 057

Source: National Forest Inventory 2003

Further reading

Environment Australia (2003). Australian Heritage Commission: Register of the National Estate. Canberra. http://www.ahc.gov.au

7

LEGAL, INSTITUTIONAL AND ECONOMIC FRAMEWORK FOR FOREST CONSERVATION AND SUSTAINABLE MANAGEMENT

INTRODUCTION

Australia is a modern, innovative and democratic society that enjoys a relatively high standard of living. The nation places great value on maintaining political stability and improving social equality, economic prosperity and environmental standards. The maintenance of these is underpinned by formal and informal social contracts and business practices, as well as legal, institutional, economic and scientific frameworks.

These frameworks extend to the management of Australia's forests, in which clearly defined systems apply to a range of environmental, economic and social elements. The subsections in this chapter describe the five major frameworks that apply to the management of forests in Australia.

Laws, regulations and guidelines for all forests—including private ones—are covered by the *legal framework* subsection. The section also describes formal mechanisms for security and certainty of ownership to provide for long-term planning in forest management—including by Indigenous people—and public participation.

The principle of continuous improvement is included in the *institutional framework* in managing Australia's forests. This is underpinned by a demonstrated commitment to public involvement and increased awareness, periodic planning, assessment and policy review, and maintenance of an appropriate level of human resource skills and a physical infrastructure to support forest management. Enforcement of laws, regulations, and guidelines are also included in the institutional framework.

The ability to attract money into a sector provides an important mechanism to reinvest into that sector. This is especially relevant for forest-related industries where long-term planning is needed. The *economic framework* provides the basis to identify economic impediments and opportunities afforded through policies and regulatory environments, including trade.

There are a wide range of values associated with forests, many of which are complementary but some of which conflict. To this end, information is especially important for informed planning and decision-making. The processes available to provide up-to-date information, and the scope and reliability of that data, are described in this chapter. Australia's compatibility with other countries in *measuring, monitoring and reporting* helps to demonstrate both the strengths and areas for improvement in this activity.

Continuous improvement in environmental, economic and social components of forest management is largely made through scientific, economic and policy *research and development*. An assessment of the progress in these areas demonstrates the level of continuous improvement in forest management.

7.1

LEGAL FRAMEWORK

INTRODUCTION

This sub-section details how and to what extent the country's legal framework—laws, regulations, guidelines—supports the conservation and sustainable management of forests. The legal framework includes regulations, mechanisms to clarify property rights, codes of practice, periodic planning and review, and public participation. One indicator (7.1.e) also deals with special values—environmental, cultural, social and scientific—and this includes the participation of Indigenous people.

A key element of the approach adopted in the 1992 National Forest Policy Statement involved negotiating 10 Regional Forest Agreements (RFAs) between the Commonwealth and State Governments. Operating for 20-years, RFAs provide for a reserve system, and for harvesting in forests outside the reserve system to comply with ecologically sustainable forest management (ESFM) principles, which provide resource certainty to industry; ensure that harvesting is at sustainable rates; and protect wildlife habitats, biodiversity, water quality, soils and heritage values. This is backed up by a Forest Industry Structural Adjustment Package (FISAP) funded at the Commonwealth and State Government levels to help forest industry businesses and workers adjust to changes in the native forest resources available to industry resulting from the RFA process.

RFAs are based on scientific assessments of forest values and uses in a region, and on consultation with stakeholders. One of the key achievements of the RFAs was the establishment of comprehensive, adequate and representative (CAR) reserve systems, based on nationally agreed criteria, also known as the 'JANIS criteria'.

The JANIS criteria set out targets for the conservation of ecosystems:

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

This level of protection in RFA regions is very high by world standards. The application of the reserve criteria takes into account a range of regional priorities, including social and economic considerations. The criteria are guidelines rather than mandatory targets, designed to deliver good conservation as well as acceptable social and economic outcomes.

Further reading

JANIS (1996) Proposed Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia. Joint ANZECC/MCFFA National Forest Policy Statement. Implementation Sub-committee, Australian Nature Conservation Agency, Canberra

Indigenous peoples' property rights

coverage
currrency
frequency

Indicator 7.1a

Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it 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

Rationale

The indicator is useful as it identifies changes to:

- the legal system and frameworks for land ownership and management, including self management;
- the legal system and frameworks for Indigenous land; and
- ownership and other inherent rights relating to land, particularly the rights and interests of Indigenous peoples.

The Commonwealth Government enacted the Native Title Act 1993 *and established an Indigenous Land Corporation in 1996 to purchase land for Indigenous groups displaced from their lands. States and Territories passed complementary native title legislation. The* Regional Forests Agreement Act 2002 *specifies that agreements between the States and Commonwealth Government about the management of forests must include the protection of Indigenous heritage values.*

This Indicator identifies and analyses mechanisms for strengthening the rights of Indigenous people through laws relating to land tenure and also by clarifying property rights in resources. It complements quantitative measures of title and other interests in indicators 6.4a(i) and 6.5d.

This State of the Forests Report is based on the five tenure categories described in indicator 1.1a. Some Indigenous tenures are contained within them, whereas native title rights can apply across them all.

The first Commonwealth law providing for Indigenous statutory title was the *Aboriginal Land Rights (Northern Territory) Act 1976*, which applied only to public land in the Northern Territory. It provided that a communal and inalienable title could be claimed where continued traditional occupation and use could be proved. Between 1981 and 1995, South Australia, New South Wales, Queensland and Tasmania passed broadly similar Acts. Western Australia has a process for transferring leasehold title to Indigenous communities.

The High Court of Australia recognised the existence of native title in 1992 and the Commonwealth Government enacted the *Native Title Act 1993* to provide mechanisms for determining it and give it statutory effect. Claimants must show continued association with land and the application of customary law. Applications are handled by an independent National Native Title Tribunal, which seeks mediation in preference to litigation.

The High Court decision on Cape York Wik Aborigines vs Queensland

The Commonwealth Government established an Indigenous Land Corporation in 1996 to purchase land for Indigenous groups displaced from their lands and consequently unable to show continued association. The States and Territories passed complementary Native Title legislation, the scope of which is summarised in Table 113. The *Regional Forests Agreement Act 2002* specifies that agreements between the States and Commonwealth Government about the management of forests must include the protection of Indigenous heritage values.

Table 113: Legal framework of property, customary and traditional rights of Indigenous peoples

Legal framework	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	C'wlth
Land rights									
Clarifies property rights	–	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Establishes land tenure that recognises traditional management practices and self management	–	Yes	Yes	Yes	Yes	Yes	No	–	Yes
Native title									
Existence of native title	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cultural heritage									
Recognises customary and traditional rights of Indigenous peoples	–	Yes	–	Yes	Yes	Yes	Partly	Yes	Yes
Allows traditional management on relevant public land (e.g., joint management)	–	Yes	–	Partly	Yes	Partly	Partly	No	Yes
Allows access to public land for traditional activities (foraging, hunting, ceremonial)	–	Yes	Yes	–	Yes	Partly	Partly	Yes	–
Allows access to sacred sites on public land	–	Yes	Yes	–	Yes	Yes	Partly	Yes	–
Allows access to sacred sites on private land	–	Yes	Yes	–	Yes	Partly	No	Yes	–
Allows access to sacred sites on leasehold land	–	Yes	–	–	–	Partly	No	–	–
Protects Indigenous peoples' cultural heritage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intellectual property rights									
Protects Indigenous intellectual property	–	Yes	–	Partly	Partly	Partly	No	–	–

Where information is available:
Yes: Indicates that the legislation or mechanism exists and is fairly comprehensive
Partly: Indicates that the legislation or mechanism exists but does not cover all aspects or is limited in its application.
No: Indicates that the legislation or mechanism does not exist

Planning, assessment and review

coverage
currrency
frequency

Indicator 7.1b

Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it provides for periodic forest-related planning, assessment, and policy review that recognises the range of forest values, including coordination with relevant sectors

Rationale

This indicator shows how the legal framework demonstrates a regional commitment to achieving sustainable forest management.

Australia has four main national forest policy documents. All States and Territories have formal requirements for periodic review of forest-related planning processes for all publicly managed forests—generally every 10 years. Mechanisms exist in all States and Territories for vegetation management on private forests.

This indicator shows how Australia's legal framework demonstrates a commitment to achieving sustainable forest management. The indicator is similar to 7.2 b, which contains further relevant information. Laws, regulations and guidelines that encourage appropriate management and use of our forests form an essential part of the practice of sustainable forest management.

Forest policy framework

Australia's national forest policy framework is set out in four main documents.

National Forest Policy Statement

The National Forest Policy Statement provides a framework for the management of forests, in particular native forests. It has an underlying goal to develop an economically viable and ecologically sustainable forest industry. One of the key outcomes of this policy was the development of Regional Forest Agreements.

Regional Forest Agreements

The Regional Forest Agreements aim to create a balance between the environmental, social, economic and heritage values of the forests and provide certainty for the forest industries.

Plantations for Australia: the 2020 Vision

This policy seeks to enhance regional wealth creation and international competitiveness through a sustainable increase in Australia's plantation resources. It has a target of 3 million hectares of commercial plantations by 2020. Average annual plantings of 75 000 hectares are required to meet the target and current average plantings indicate that Australia remains well on track.

Forest and Wood Products Action Agenda

The vision of this Agenda is 'maximising sustainable and profitable activity for tree growing, value adding and marketing of Australian forest and wood products'. To achieve this, the Action Agenda identifies twelve strategic imperatives that industry, governments and other stakeholders need to address.

Australia's States and Territories have primary responsibility for forest management. Legislated procedures exist in all States and Territories for native forests and plantations on public and private land. Some of these procedures are administered by, and require coordination between State and local governments, statutory authorities and regional management authorities. In Victoria for example, mechanisms, overseen by local government and Catchment Management Authorities, are in place for vegetation management on private land.

The National Forest Policy Statement recommends regular inventory and review procedures for the range of forest values. The Australian Government enacted the *Regional Forest Agreements Act 2002*. It requires Annual Reports and amendments to RFAs to be tabled in the Federal Parliament. Complimentary legislation does not yet exist in all States where RFAs are in place, except for Tasmania which enacted the *Regional Forest Agreement (Land Classification) Act 1998*. Similarly, the New South Wales *Forestry and National Parks Estate Act 1998* provides for the New South Wales Forest Agreements.

Reviews of planning and assessment occur periodically at the regional level through the Regional Forest Agreement (RFA) process in those States where Regional Forest Agreements are in place (New South Wales, Victoria, Tasmania and Western Australia). The first review was completed for Tasmania in December 2002. Reviews of the other regions will be made between 2003 and 2006.

Regular reviews are also required under a range of legislative and regulatory instruments. Examples of forest related values incorporated in these reviews are listed in Table 114. This table includes both public and private forests. Reviews of forest management and other plans at the sub-regional or district level also occur at regular intervals and are described in indicator 7.2b.

Table 114: Legislation that provides for periodic forest-related planning, assessment, policy review and coordination with relevant sectors for all forest land tenure

	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	C'wlth
Biological diversity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Productive capacity	–	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Ecosystem health and vitality	–	Yes	–	Yes	–	Yes	Yes	Yes	Yes
Soil and water	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Socio-economic	–	Yes	–	Yes	–	Yes	Yes	Yes	Yes
Periodic policy review	Yes	Yes	–	Yes	Yes	Yes	No	Yes	Yes
Coordination with relevant sectors	–	Yes	–	Yes	Yes	Yes	Partly	Yes	Yes

Where information is available:
Yes: Indicates that the legislation or mechanism exists and is fairly comprehensive
Partly: Indicates that the legislation or mechanism exists but does not cover all aspects or is limited in its application.
No: Indicates that the legislation or mechanism does not exist

Further reading

Commonwealth of Australia (1992). National Forest Policy Statement: A New Focus for Australia's Forests, 2nd edition. Australian Government Publishing Service, Canberra.

TRPDC (2002). Inquiry on the Progress with Implementation of the Tasmanian Regional Forest Agreement (1997): Background Report. Tasmanian Resource Planning and Development Commission, Hobart.

TRPDC (2002). Inquiry on the Progress with Implementation of the Tasmanian Regional Forest Agreement (1997): Final Recommendations Report. Tasmanian Resource Planning and Development Commission, Hobart.

Public participation

coverage
currrency
frequency

Indicator 7.1c

Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it provides opportunities for public participation in public policy and decision-making related to forests and public access to information

Rationale

To assess whether the legal framework ensures transparency and participation in public policy and decision-making at the regional level.

The environmental impact and planning legislation of the Commonwealth and State Governments contains various requirements for public consultation, and the National Forest Policy Statement calls for public consultation in forest planning. Avenues for public involvement in the management of forests on privately owned or leasehold land exist through planning legislation.

Australia has well-established practices for providing opportunities for public participation at several levels, from public policy to public forest management. The model generally adopted in Australia follows one established by the Land Conservation Council in Victoria in 1970 for a review of the use of public land. It consists of:

- Announcement of plan or review to be made.
- Publication of a factual document describing the geographical, ecological, resource and social attributes of the area.
- Request for submissions about how the area should be used.
- Draft Plan issued, usually containing a statement of the number and nature of the submissions received.
- Draft Plan explained in public meetings and to stakeholders and individuals.
- Request for second submissions.
- Final Plan prepared and submitted for approval.

In all States and Territories, the processes for public consultation and participation extend to the management planning level for publicly managed forests. They include providing information on resources, impacts, uses and values, discussion papers on alternative plans, invitations to provide comment or written submissions, discussion forums and public meetings.

Public participation in the use of private forests is facilitated under planning legislation administered by local government. For example, planning consent may be required for activities that impact on forest and non-forest values—such as water, heritage sites. Indicator 7.1b describes some of the planning processes.

The effectiveness of public participation in influencing final decisions has not been assessed, but is thought to vary widely. Consultation is thought to have been least effective with the Indigenous community, due to the longer lead times required for consultation and to reach consensus within the community.

The RFA process included extensive consultation with the various forest management agencies, stakeholders and the public. Reports and maps resulting from assessments of the natural, cultural, social, resource and economic values were produced for public comment. Governments and stakeholders then negotiated options for forest use, which were reported and displayed for public comment. The nature of the consultation varied between States. For example, Consultative Forums were established for the regions in New South Wales to bring the general community, stakeholders and Government representatives together. Various stakeholder groups also had formal representation on the various technical committees, supporting the assessment process.

Case study – Namadgi National Park

Nature conservation reserves in the Australian Alps extend across adjoining areas in Victoria, New South Wales and the Australian Capital Territory. With the Commonwealth, these Governments entered a Memorandum of Understanding to formulate policies and management practices that were consistent across jurisdictions.

The Namadgi National Park at the northern end of the Australian Alps has an area of 106 000 hectares, representing 48 per cent of the area of the Australian Capital Territory. It has many natural values, significant Indigenous and non-Indigenous cultural sites, provides an important water resource, and is widely used for recreation. In 2001 the Australian Capital Territory Government entered into a joint management agreement with the local Indigenous people. It appointed an Interim Management Board with an Indigenous Chairperson to provide strategic advice on the preparation of a new management plan.

A discussion paper was released in March 2002 that set out the important values and the key issues. Seventy written submissions were received from the public over the next three months.

In January 2003, bushfires burnt more than 70 per cent of the Park's area. Nevertheless, preparations for the new Namadgi National Park plan continued. A report that combined the scientific literature and community submissions was issued in June 2003. It contained a statement of the Park's significance and a detailed elaboration of the values at world, national, alpine region and Australian Capital Territory levels.

Workshops were held in June 2003 in the Australian Capital Territory and in a community in nearby New South Wales to seek agreement on a framework of objectives, goals and principles from which the final plan will be prepared.

Further reading

Commonwealth of Australia (1992). National Forest Policy Statement: A New Focus for Australia's Forests, 2nd edition. Australian Government Publishing Service, Canberra.

Best practice codes

coverage
currrency
frequency

Indicator 7.1d

Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it encourages the development and application of best practice codes for forest management

Rationale

Codes of practice indicate a commitment to compliance with environmental management systems and continuous improvement in forest management practices.

All the States and Territories have legislation or administrative arrangements that specify management plans or codes of practice, or both, for forest management and use. Some have codes relating to fire management. Private sector forest managers have also developed codes. Local governments may use codes for forest planning purposes.

Until recently, codes of forest practice concentrated on timber production in native multiple-use forests. Codes of forest practice are being developed for nature conservation reserves, and the trend in private forest management is towards the adoption of voluntary codes of practice, in line with standards set for public lands.

The development of many of the codes has incorporated a public consultation phase. Some States and Territories—for example, Victoria—incorporate processes for periodic independent scientific review.

There are codes covering public forests in Western Australia, the Australian Capital Territory, Queensland and New South Wales. South Australia and Western Australia have joint private/public sector codes for plantations developed and used by the parties. In Tasmania and Victoria arrangements are legislated for both public and private native forests and plantations.

The *Tasmanian Forest Practices Act 1985* was amended in 2002 to require the development of forest practice plans for all relevant forestry operations including forest clearance across tenures, regardless of whether the purpose is timber harvesting or conversion to another land use. The five-year review of the Regional Forest Agreement recommended that the State complete a Reserve Management Code of Practice for its conservation reserves. This is being developed for release and implementation in 2003.

Victorian code of forest practice

Private sector forest managers have developed codes. Local governments may use codes when considering planning permits for forest-based activities. There are two major projects underway to develop new statewide codes: one covering all plantations in New South Wales and the other for all private forests in Queensland.

For private forests in New South Wales, the expectations of government and the community are reflected in the CRA process and complementary land management legislation such as the *Native Vegetation Conservation Act 1997*. This Act applies to native vegetation management on private lands and provides for:

- the conservation and management of native vegetation on a regional basis;
- encouragement and promotion of native vegetation management in the social, economic and environmental interest of the State;
- protection of vegetation of high conservation value;
- improvement of the condition of existing native vegetation;
- the encouragement of revegetation of land;
- prevention of inappropriate clearing of vegetation;
- promotion of the significance of vegetation;
- recognition of social, environmental and economic values.

Public forest agencies in most States and some of the major forestry companies have implemented or are currently developing environmental management systems. These are likely to play an important complementary role to codes and other forms of regulation. The case study below provides an example of the complementarity between the Australian Forestry Standard and the environmental management system process. Tables 115 and 116 outline the details of the application of codes according to tenure and the range of themes they cover.

States where Regional Forest Agreements are in place report progress annually. The Tasmanian Forest Practices Board audits compliance with 122 questions on a 15 per cent sample of all forest harvesting, roading and quarrying operations in that State. Average compliance on multiple-use forests has fallen from 97.3 per cent in 1998–99 to 96.7 per cent in 2001–2002. For non-RFA regions, assessment of progress takes place through annual reports by State and Territory forest agencies.

Table 115: Legislative requirement to apply codes of practice by tenure by State and Territory

Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
Multiple-use forest	Compulsory	Compulsory	Not developed	Compulsory	Not developed	Compulsory	Compulsory, Fire management	Compulsory
Nature conservation reserves	Not developed	Fire management	Not developed	Not developed	Not developed	Compulsory	Fire management	Not developed
Other crown land	Not developed	Compulsory	Not developed	Voluntary	Voluntary	Compulsory	Compulsory, Fire management	Voluntary
Leasehold land	Not developed	Compulsory	Not developed	Voluntary	Voluntary	Compulsory[1]	Compulsory	Voluntary
Private land	Not developed	Compulsory	Voluntary	Bring developed	Voluntary	Compulsory[1]	Compulsory	Voluntary
Plantations	Compulsory	Compulsory	Voluntary	Bring developed	Voluntary	Compulsory[1]	Compulsory	Voluntary

Source: National Forest Inventory (2003)
[1] The code of Fire Practice does not apply on these tenures

The Australian Forestry Standard (AFS) is based on internationally agreed criteria, and embodies forest management performance requirements, which support continuous improvement toward sustainable wood production in Australia. The Standard is voluntary and will help promote access to both domestic and international markets for timber products from certified forests. It is applicable to all forests managed for wood production, regardless of type and scale of ownership.

A voluntary Chain of Custody (CoC) standard has been developed to complement the implementation of the AFS. The idea is to track the movement of wood from certified forests through various processing stages and then to the eventual delivery of products to wholesalers or retailers.

Independent and specialist certification bodies undertake certifications, assessments and audits against either the AFS or the CoC standard. In Australia, the Joint Accreditation System of Australia and New Zealand (JAS-ANZ) accredits certification bodies to audit and certify compliance with either the AFS of the CoC standard. This provides an assurance that certification bodies are both competent and independent in regard to their certification activities. Certification marks or labels related to the AFS or the CoC standard can be fixed to a product to indicate that the product originated from a forest certified to the AFS.

Table 116: Range of content themes in codes of practice used in forests, by State and Territory, 2000

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 siting roads	✓	✓	–	✓	–	✓	✓	✓
Road design and construction	✓	✓	–	✓	–	✓	✓	✓
Upgrading existing roads and tracks	✓	✓	–	✓	–	✓	✓	✓
Rock quarries and gravel pits	✓	✓	–	D	–	✓	✓	✓
Bridge, causeway and ford construction	✓	✓	–	✓	–	✓	✓	✓
Road maintenance	✓	✓	–	✓	–	✓	✓	✓
Harvesting			✓					
Design, planning and equipment	✓	✓	–	✓	–	✓	✓	✓
Wet weather	✓	✓	–	✓	✓	✓	✓	✓
Snig tracks and landings	✓	✓	–	✓	–	✓	✓	✓
Water quality and stream protection	✓	✓	–	✓	✓	✓	✓	✓
Salvage operations	✓	✓	–	✓	–	✓	✓	
Steep country	–	✓	–	✓	–	✓	✓	✓
Conservation of other values								
Flora	✓	✓	–	✓	✓	✓	✓	✓
Fauna	✓	✓	–	✓	✓	✓	✓	✓
Rare or endangered species	–	✓	–	✓	✓	✓	✓	✓
Landscape	✓	✓	–	✓	✓	✓	✓	✓

continued over

Table 116: Range of content themes in codes of practice used in forests, by State and Territory, 2000

Content theme	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
continued from previous page								
Archaeology (cultural heritage)	✓	✓	–	✓	✓	✓	✓	✓
Geomorphology	–	✓	–	–	✓	✓	–	–
Forest establishment								
Reforestation	✓	✓	–	–	✓	✓	✓	✓
Maintaining forests								
Fire management	✓	✓	–	D	✓	✓	✓	✓
Pest, disease, weed control	✓	✓	–	✓	✓	✓	✓	✓
Use of chemicals	✓	✓	–	✓	✓	✓	✓	✓
Thinning	✓	✓	–	✓	✓	✓	✓	✓
Non-wood products/uses								
Apiary	–	✓	–	D	–	–	–	✓
Grazing	–	✓	–	D	–	–	✓	–
Tree ferns	–	–	–	–	–	✓	–	–
Recreation	–	✓	–	D	–	–	–	✓
Socio-economic								
Occupational Health and Safety	–	✓	–	–	–	✓	✓	–

✓ = The content theme exists in a code of practice that is used in the State/Territory but it is not necessarily covered on all land tenures. This table should be read in conjunction with Table 116

D = Draft Code of Practice

Note: Some of the content themes listed above are not in the main forestry-related code of practice for the State/Territory but are in a separate document—e.g., Code of practice for fire management

Further reading

Davies, P., Hart, R., Mitchell, C., Laffan, M., Wright, D. and Smethurst, P. (1999). Forest Practices Code Review of Soil and Water Provisions. Report to the Forest Practices Advisory Council. Forest Practices Board, Tasmania, 150 pp.

Department of Natural Resources and Environment (1996). Code of Forest Practices for Timber Production. Department of Natural Resources and Environment, Melbourne.

Forest Practices Board (2000). Forest Practices Code. Forest Practices Board, Hobart.

Gerrand, A.M., Miller, R.J., Joslin, A. and Catton, C. (2002) Incentives for forest plantations in Australia. Country report, part of a 9 country study presented to FAO Asia–Pacific Forestry Commission in Mongolia – Aug 2002. 48pp.

Specific values and participation by Indigenous people

coverage
currrency
frequency

Indicator 7.1e

Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it 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

Rationale

This indicator provides for qualitative and quantitative measurement of the legal framework to include special environmental, cultural, social and/or scientific values in forest management; including the recognition and inclusion of Indigenous perspectives and value systems. It allows for Indigenous self-determination through the articulation of values by Indigenous people.

This indicator is designed to provide an analysis of the legal framework through data collected for other indicators.

The assessments of Indigenous heritage, economic values and social values, including community needs, are part of the Regional Forest Agreement process. Processes for formally securing Indigenous engagement in active forest management for timber production vary between jurisdictions.

This indicator concerns the involvement of Indigenous peoples in the planning and management of forests so as to consider the special values of importance to them. It covers several levels from Commonwealth legislation to Indigenous management of their own lands.

The Comprehensive Regional Assessment process (part of the Commonwealth-State Regional Forest Agreements process) includes assessments of Indigenous heritage, economic values and social values. Written agreements provide explicitly for mechanisms of consultation to identify and protect Indigenous heritage and to incorporate Indigenous views in management. Agreements are subject to the Commonwealth Government's *Native Title Act 1993* (see indicator 7.1.a).

Processes for formally securing Indigenous engagement in forest management vary between jurisdictions. For example, in New South Wales:

- Aboriginal Land Councils, elders and other groups are consulted during the preparation of management plans and identification and protection of sites and artefacts of Indigenous significance.
- Aboriginal Cultural Heritage Officers are employed in many forest regions to manage heritage values in forests and facilitate communication with local Indigenous groups.
- Memoranda of Understanding document local procedures for the management of Indigenous issues.
- Co-operative Management Arrangements provide for management of shared forest by State agencies and local Indigenous communities.
- There are joint ventures with local Indigenous communities.

Aboriginal site identification near Bellbrook Community, Kempsey, New South Wales

Part 4A of the New South Wales *National Parks and Wildlife Act 1974* allows for specified reserves to be transferred to Indigenous people, leased back to the Government and managed jointly. Other States and Territories have structures in place to facilitate transfer of lands to Indigenous people. Provisions also exist for land to be leased back to the government.

Large areas of forest in Australia used for purposes other than timber production are not subject to RFAs. The Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* may apply in these areas (the Act still applies in RFA regions, except for Part 3 of the Act which requires 'environmental approvals'). The principal objects of the Act include:

- recognising the role of Indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity;
- promoting use of Indigenous peoples' knowledge of biodiversity with the involvement of, and in co-operation with, the owners of the knowledge; and
- promoting a co-operative approach to protection and management of the environment involving governments, the community, land-holders and Indigenous peoples.

These goals are pursued in collaboration between the Commonwealth and the States and Territories. Bioregional plans—similar in principle to RFAs—have been developed to integrate broad-scale socio-economic, cultural and biodiversity conservation goals, with customary fire management regimes being re-established in western Arnhem Land, Northern Territory. More recently, regional natural resource management plans under the National Action Plan on Salinity and Water Quality and the Natural Heritage Trust (NAP/NHT) have been developed and these provide for participation by Indigenous communities and encourage the use of Indigenous knowledge where appropriate to reverse land degradation

Cultural differences can present challenges to effective involvement of Indigenous people in forest planning and management. It is important to recognise that Indigenous people acknowledge that the use of forest resources is not necessarily incompatible with the maintenance of customary practice and protection of culturally important values.

Case studies – Indigenous fire management and maintenance of forest and associated values in Northern Australia

- *Fire behaviour and wildlife status in an actively managed clan estate*

The clan estate centred on the outstation Korlorbirrahda in Central Arnhem Land is one of the few places where Indigenous management has not been interrupted. A study of fire behaviour and an inventory of flora and fauna found that the fauna was more abundant than elsewhere, the flora was as rich as in the nearby World Heritage areas of Kakadu National Park, and stands of the fire-sensitive native cypress pine (*Callitris intratropica*) were larger and healthier than elsewhere. Moreover, the fire sensitive monsoon vine thicket and rainforest was preserved so that the vegetable foods important to Indigenous people remained abundant.

The traditional owners coordinated the activity among neighbouring clans to reduce the risk of wildfire and protect sites. Full restoration of the benefits of customary management is likely to require restoration of similar levels of coordination. The Caring for Country Unit of the Northern Land Council is seeking to build that coordination.

- *Adaptive management of fire for the partridge pigeon in Kakadu National Park*

The sedentary partridge pigeon (*Geophaps smithii*) uses small territories of only a few hectares in eucalypt forests. Although foraging birds favour sites that have been burned, they nest on the ground among patches of unburned vegetation during the dry season.

Maintaining burned and unburned patches in a few hectares is dependent on fine scale use of fire, preferably beginning early in the dry season when patchy burns are easiest to achieve. The forest habitat most used by partridge pigeons is the area burned first in the customary seasonal sequence of Indigenous fire managers. Implementing such fine scale burning over large areas is a challenge for land managers, even in such comparatively well-resourced sites as Kakadu National Park.

A small-scale adaptive fire management experiment that drew on the knowledge of traditional owners and other Indigenous people was conducted. This provided a forum for a valuable exchange of information and opportunities for collaboration for non-Indigenous park managers, traditional owners and other Indigenous land managers.

Further reading

Fraser, F., Lawson, V., Morrison, S., Christophersen, P., McGreggor, S. and Rawlinson, M. (2003). Fire management experiment for the declining Partridge Pigeon, Kakadu National Park. Ecological Management and Restoration 4: 93–101.

Yibarbuk, D.M. and Whitehead, P.J. (2001). Fire ecology and Aboriginal land management in central Arnhem Land, northern Australia: a tradition of ecosystem management. Journal of Biogeography 28 (3): 325–344.

7.2

INSTITUTIONAL FRAMEWORK

coverage
currrency
frequency

Public information and education

Indicator 7.2a

Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to facilitate public involvement and provide public education, awareness and extension programs that make forest-related information available

Rationale

An institutional commitment to building community awareness and support is essential for the sustainable management of forests.

There are many opportunities for public involvement in forest-related matters, and governments are committed to public participation in forest management, extension activities and provision of information.

Most States and Territories have a legislative and institutional commitment to allowing public participation in the management of both native multiple-use forests and nature conservation reserves. The commitment is often less in plantations that are publicly managed as corporate or commercial enterprises. There is no similar commitment in private forests.

All States and Territories have forest extension and education programs. Some of these have a legislative basis. The level of implementation varies, depending on the available resources. In New South Wales a program for monitoring progress and achievement in environmental education has begun. The 'Learning for Sustainability' program, which includes forests, was developed and released by the New South Wales Government in December 2002. The plan was developed through wide consultation with the environmental education community.

All public forest-management agencies publish forest-related information and technical research papers. New South Wales and Tasmania each prepare annual reports on their performance. The Australian Government coordinates both the national State of the Forests Report and the State of the Environment Report. Much of this information is available on State, Territory and Australian Government agency websites, and through national programs including the National Land and Water Resources Audit, the Natural Heritage Trust and the Australian Greenhouse Office.

The Australian Government and some States and Territories have developed formal processes for facilitating communication between conservation and industry organisations and relevant government Ministers and agencies. These provide an avenue for contributing to the development of sustainable forest-management policies.

Table 117 shows the extent of opportunities for public involvement in forest-related matters. Actual visitor numbers to the various forest attractions—e.g., guided/interpretative walks, world forestry and environment days, and similar activities—could be used to gauge the level of public involvement, but these figures are not readily recorded or available. It is therefore impossible to measure the use of the services noted in the table. However, in New South Wales there is an annual reporting requirement for State Forests and for National Parks and Wildlife Services that provides greater detail on these activities.

Table 117: Number of public involvement opportunities, public education, awareness and extension programs, 1999–2000

	ACT	NSW[1]	NT	Qld	SA	Tas[1]	Vic[2]	WA
Number of public involvement opportunities								
Interpretation centres/walks	–	21	–	–	–	7	120	–
Guided interpretative walks	–	3 534	–	–	–	45	20	–
Displays in public places	–	266	–	2	–	12	117	–
Volunteer programs	–	2 507	–	1	–	5	16	–
Public Forums	–	1 606	–	–	–	–	42	–
Number of public education/awareness segments								
Radio	–	2 500	–	–	–	–	–	–
TV	–	500	–	–	–	–	–	–
Press	–	750	–	7	–	–	–	–
Number of reports/publications for:								
General public	–	295	–	6	–	82	80	–
Primary schools	–	29	–	4	–	14	5	–
Secondary schools	–	107	–	10	–	14	5	–
Tertiary institutions	–	222	–	–	–	14	–	–
Extension programs	–	38	–	–	–	–	–	–
Number of extension programs								
Forestry related	–	62	–	3	–	–	1	–
Vegetation management/conservation	–	4	–	7	–	–	3	–
Number of people using forest related website	–	216 000	–	–	–	50 000	–	–
Expenditure on public involvement, awareness and extension ($'000)								
School/children programs	–	600	–	40	85	–	240	–
Communication with general public	–	300	–	1 201	-	–	220	–
Extension programs	–	200	–	498	-	–	12	–
Other	–	5 400	–	3	-	–	–	–
Total expenditure ($'000)	–	6 500	–	1 742	85	–	472	–

Source: National Forest Inventory (2003)

1 Nature conservation reserves and Multiple-use forests

2 Multiple-use forests and some Nature conservation reserves programs

Case study – Community engagement: outcomes and opportunities on the Central Coast of New South Wales

In 2002 an association of community groups, an Aboriginal Land Council and a plant nursery business from the Central Coast of New South Wales contacted State Forests. The groups were interested in forests and the debate regarding their management. Of particular interest was the relationship between native forest harvesting in the Watagans forests, and the water supply for the growing Central Coast community.

State Forests has since undertaken a formal facilitated process, which has resulted in the development of a community engagement protocol (The Ourimbah Protocol) and an action plan of projects to be undertaken.

Conservation planning, Willis Reserve, Smiths Gully Landcare Group members, Victoria

Planning and review

coverage

currrency

frequency

Indicator 7.2b

Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to undertake and implement periodic forest-related planning, assessment, and policy review including cross-sectoral planning and coordination

Rationale

Periodic regional planning, assessment and policy review by the responsible institutions provide the basis for continuous improvement in forest management.

All jurisdictions undertake planning, assessment and review for public forests. There are limited planning and assessment processes for private native forests, except in Tasmania. Planning and assessment for plantations is generally comprehensive. The National Forest Inventory provides continental-level forest-related information.

This indicator concerns the processes of planning and review for forest policy and management. It is closely related to indicator 7.1b.

Planning for public forest land is conducted at several levels. At the national level, the Primary Industries Ministerial Council, the Natural Resource Management Ministerial Council, the Forest and Forest Products Council and the Land and Water Biodiversity Council co-ordinate policy and planning for all natural resources. Policy is set out in agreed documents such as the National Forest Policy Statement and the Plantations for Australia: The Vision 2020. The former, released in 1992, takes account of cross-sectoral issues. The latter was reviewed and re-launched in 2003 and focuses on issues for the plantation sector.

The National Forest Inventory—a cooperative program of the Commonwealth and the States and Territories—provides continental-level forest-related information. More detailed resource inventories are carried out by State and Territory agencies.

All jurisdictions, except the Northern Territory, have formal requirements for periodic reviews of planning for public forested lands. However, coordination between the public and private sectors is limited in all States and Territories except Tasmania. Detailed planning is undertaken in the multiple-use forests and nature conservation reserves. The hierarchy of planning in Tasmania's multiple-use forests, for example, is set out in Table 118.

Table 118: Hierarchy of planning in Tasmania's multiple-use forests

Authority or plan	Planning period	Review period
Forests Act	Indefinite	As required
Regional Forest Agreement	20 years	Within every 5-year period
District Forest Management Plan	10 years	Annually
Wood Production Plan	3 years	Annually
Coupe Harvesting Plans	Few months	Inspected when finished

Fire management plans are prepared jointly by forest agencies, conservation agencies and rural fire services in most States and Territories.

There is no legislated requirement on private owners to prepare forest management plans, except in Tasmania where all harvesting and clearing is subject to plans prepared under the Forest Practices Code. Some land owners make plans for their wood-lots, often as a part of general farm plans. Local communities sometimes develop regional vegetation management plans. In New South Wales these can be administered under the *Native Vegetation Act 1997* that controls forest clearing. Community approaches to planning are fostered in the Landcare movement, and in some cases through Regional Plantation Committees or similar bodies. Private corporations make detailed plans for their own plantations.

Case study – Western Australia: development of a new forest management plan

Western Australia has a long history of forest planning. Following the restructure of State agencies and their responsibilities in 2000, a new forest management plan is being developed. New legislation separated responsibility for the management of forests from the conduct of commercial timber operations. Nature conservation reserves, multiple-use forests and timber reserves are vested with the Conservation Commission of Western Australia, which is responsible for their planning. The Forest Products Commission is responsible for the harvesting and regeneration of the forest, the sale of forest products and associated industry development issues.

The new management plan has the objectives of achieving or promoting conservation, recreation, timber production on a sustained yield basis, water catchment protection, and some other prescribed uses. The focus is on the management of multiple-use forest where disturbance activities are permitted. Planning is for a 10-year period.

Opportunities for public participation in the development process for the new forest management plan have been significantly increased. These included a series of public forums and a stakeholder roundtable to provide input to a discussion paper, released in January 2002. Comments received in response to the discussion paper were incorporated in the draft plan. A second round of public forums was held during the statutory 2-month public comment period for the draft plan. Public submissions are being considered in finalising the Conservation Commission's proposed plan, which will then be assessed by the State's Environmental Protection Authority.

A Draft Forest Management Plan for the Swan, South West and Warren Regions was released in 2002. Planning for all land categories together allows the Commission to take a broad approach—in particular with strategies for the conservation of biological diversity.

Further reading

Ministerial Council on Forestry, Fisheries and Aquaculture (1997). Plantations for Australia: The 2020 Vision. Department of Primary Industries and Energy, Canberra.

Developing skills

coverage
currrency
frequency

Indicator 7.2c

Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to develop and maintain human resource skills across relevant disciplines

Rationale

Appropriate levels of human resource skills are required to implement sustainable forest management.

The full range of training in the skills required for effective forest management is available in Australia. On offer are graduate and post-graduate degrees, diploma and certificate courses, operational competency certificates and refresher courses. There are also extension services, education and training available for landholders and community groups.

This indicator can be measured by identifying opportunities for obtaining formal qualifications, traineeships or their equivalents, and on-the-job training.

Graduate and post-graduate degrees: Australia provides the full range of training in the skills required for effective forest management for all values. Four universities provide specific professional-level forest science training: the Australian National University, The University of Melbourne, Southern Cross University and James Cook University (tropical forestry). Universities throughout Australia provide courses in natural resource management, environmental management, ecology, social sciences, economics, legal and information management disciplines.

Diplomas and certificates: Diploma and certificate courses are provided by tertiary Institutes of Technical and Further Education (TAFE) for field-based forest officers and operational staff. Increasingly, these are replacing the training traditionally provided by forest-management agencies. Tertiary education is becoming more readily available in regional centres. As a result of the increasing sophistication of forest operations, technical training has tended to replace on-the-job training.

Operational competency certificates: Traditionally, experienced workers provided on-the-job training for forest workers. This is becoming formalised in short on-site training courses that provide certificates of competency. These cover operations such as chain-saw operation and first aid. They are mandatory for harvesting workers in several States. A national training package is being developed that covers quality assurance and product care in the forest industries.

Refresher courses: Existing staff in public and private sectors maintain or enhance their skills through short refresher courses on topics such as remote sensing, planning, occupational health and safety and first aid, fire management and other operational skills.

Consultants: There is a growing private forest and land-management consultancy capacity that provides skills to the domestic and international forest sectors. Agencies are increasingly contracting work to private consultants, which broadens the skill base of the agency beyond its own staff. There is a growing tendency to employ people with a wider range of skills whilst outsourcing specialist skills.

Australian National University forest science students in callitris forest, Forbes, New South Wales

Farmers, small landholders and community groups: Australia has a long history of providing farmers and small landowners with government extension services including information and informal training through field days, tree seedlings and, in some cases, with financial assistance to establish small plantations, wood-lots and shelter belts.

Australia now has diverse programs for delivering forest extension information. The programs have been greatly expanded to capture both commercial and environmental goals, and given a community focus.

Commercial planting by farmers and small landholders is encouraged as part of the overall Vision 2020 policy of expanding the area of Australia's commercially productive plantations. Australian Forest Growers is an association of plantation owners dating from 1969 that provides training for its members through publications, conferences and field days. The Australian Master TreeGrower Program run by The University of Melbourne provides more formal training. The program consists of an eight-week course tailored to the needs of different regions.

Conservation planting and the protection of remnant vegetation in rural areas are encouraged as part of policies to counter the effects of salinity and preserve biodiversity. Community Landcare and Bushcare groups undertake many projects in this area, nationally. Greening Australia is an apolitical, non-profit membership-based organisation dedicated to managing and repairing native vegetation. Its extension services provide technical support, training and resources for community groups. It has been operating for 20 years and is mainly funded by Governments. It has 75 paid staff and 6 600 volunteers across Australia.

Infrastructure

coverage
currrency
frequency

Indicator 7.2d

Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and support forest management

Rationale

The development and maintenance of physical infrastructure underpins efficient forest management and use.

Australia's native forests and plantations are well serviced with infrastructure.

Australia is a modern, mature economy with good infrastructure. Forest management agencies build and maintain infrastructure for a range of purposes including timber harvesting, conservation and fire management. This infrastructure includes:

- road and trail networks;
- fire towers;
- buildings (workshops, sheds, etc.);
- bridges;
- dams and pumps;
- fences and gates;
- water points;
- helipads and air strips;
- signs;
- bush cottages for employees; and
- telecommunication facilities.

Construction of the South Face Road, Victoria

The road and trail networks allow visitors ready access to forests. More developed infrastructure for visitors includes information centres, picnic and camping facilities, interpretive walking trails and, in some instances, walks in the forest canopy (e.g., Tahune Airwalk in southern Tasmania).

Some road and port facilities were developed specifically for the export of timber products—for example, at Eden, New South Wales. The majority of log haulage and distribution of processed timber products occurs by road.

As a result of the Regional Forest Agreements, many nature conservation reserves now have roads that were originally constructed for timber harvesting purposes. Some of these have been closed if they are not required for management purposes. Commercial plantations are also well supplied with roads. However, roads in private plantations may not be available for public use. In remote areas of Australia, access is limited by road quality and seasonal conditions.

All forest and conservation management agencies maintain an efficient communications infrastructure to facilitate activities such as fire management, daily operational activities, law enforcement and for public safety.

coverage
currrency
frequency

Enforcement

Indicator 7.2e
Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to enforce laws, regulations and guidelines

Rationale
Enforcement of laws, regulations and guidelines mean that plans are implemented effectively.

For timber harvesting on public lands, compliance with the relevant legislation is generally high. Monitoring timber harvesting in private forests is probably not widespread, except perhaps in Tasmania. General public usage of public forests can also breach regulations. Monitoring and compliance vary.

States and Territories, in their capacity as land managers, use the following measures, singly or in combination, to investigate breaches of legislation and guidelines and to monitor compliance:

- enforcement officers;
- regionally-based specialist staff;
- field staff, including police officers and other departmental staff with special training as conservation officers;
- legally constituted bodies such as tribunals.

There can be prosecutions for non-compliance.

For harvesting on public lands, compliance with the legislation, regulations and guidelines is generally high and supported by public opinion. However, for recreational use on public lands and for harvesting on private lands monitoring is less extensive.

Table 119 demonstrates enforcement of regulations and guidelines for public forests in 1999–2000. These figures do not cover private forests. The regulatory system is different in each State and Territory and therefore the definition of a breach also varies. For example, 1 533 of the reported breaches in multiple-use forests in New South Wales were breaches of the agency's guidelines, rather than of State regulations.

Table 119: Number of officers involved in and breaches relating to enforcement of laws, regulations and guidelines in 1999–2000

	ACT	NSW[1]	NT	Qld	SA	Tas	Vic[1]	WA
Number of officials who enforce laws, regulations and guidelines in:								
Multiple-use forests	–	458	–	–	26	250	247	–
Nature conservation reserves	–	–	–	–	120	74	318	–
Private land	–	–	–	–	–	106	52	–
Leasehold land	–	–	–	–	–	–	–	–
Other crown land	–	–	–	–	–	–	–	–
Total number of officials who enforce laws, regulations and guidelines	27	826	–	305	146	430	617	5
Number of breaches of Codes of Practice in:								
Multiple-use forests	–	1 538	–	49	–	21	100	–
Nature conservation reserves	–	–	–	38	–	–	–	–
Private land	–	–	–	–	–	23	–	–
Leasehold land	–	–	–	18	–	–	–	–
Other crown land	–	–	–	23	–	–	–	–
Total number of forest management related breaches	–	1 538	-	128	-	33	100	–
Number of breaches relating to general public								
Animals (bringing into areas where they are not allowed)	–	104	–	44	40[2]	–	122	–
Behaviour	–	26	–	29	–	–	5	4
Camping in unauthorised areas	–	31	–	82	2	–	32	–
Fee avoidance	–	691	–	–	–	–	1	15
Removal of flora and/or fauna	–	–	–	–	–	–	–	66
Resource protection (dumping rubbish, soil disturbance, fires)	–	76	–	–	20	–	99	4
Damaging signs	–	–	–	7	–	–	18	–
Theft of forest produce	–	–	–	–	–	20	57	7
Unauthorised vehicle access	–	802	–	274	50	–	178	–
Others	–	–	–	13	–	–	117	2
Total number of breaches related to the general public	–	–	–	449	112	364	629	98

1 For 2000–2001

2 This includes fee avoidance

Further reading

Forest Practices Board (2002). Annual Report 2001-2002. Forest Practices Board, Hobart.

Case study – Enforcement by Tasmania's Forest Practices Board in 2001–2002

The emphasis of the forest practices system is to achieve high environmental standards through planning, training and education. Where problems arise, the Board expects that they will be dealt with through early detection and corrective action.

Corrective action may mean remedial treatment in the forest. However, it also means reviewing and improving systems to ensure that similar errors do not arise in the future. From time to time, serious errors occur that generally reflect inadequate systems or insufficient care. In these cases, penalties are appropriate to reinforce the importance that all parties must strive for full compliance with the requirements of the *Forest Practices Act 1985*. Legal enforcement may be taken in several ways.

- Forest Practices Officers may give verbal or written notification to require persons to take corrective action in order to comply with the Act or a forest practices plan.
- The Board may prosecute for failure to have operations covered by a forest practices plan, for failing to comply with a forest practices plan or for failing to lodge a certificate of compliance.
- The Board may impose fines as an alternative to prosecution.

The Board investigates all complaints relating to alleged breaches or poor practice and administers the Act. In the last two years 83 notices and prosecutions have been issued under this Act (Table 120).

Table 120: Notices and prosecutions under the *Forest Practices Act 1985*, 2000–2002

	2000–2001	2001–2002
Notices issued by Forest Practices Officers	37	39
Fines imposed by the Board:	1	5
Prosecutions completed	0	1

Fines imposed for offences under the Act during the year 2001–2002 were as follows:

- A landowner and contractor were fined $1 000 by the Board for offences related to the harvesting of 70 tonnes of timber without a current forest practices plan (FPP). The land was previously covered by an FPP but operations did not commence during the term of the FPP. When harvesting did begin, it was carried out within the streamside reserve of a class 3 stream, causing environmental harm.
- A forest manager was fined $1 000 by the Board for offences related to the harvesting of trees within a streamside reserve. The class 3 streamside reserve was incorrectly marked, resulting in the harvesting of trees to within 5 m of the stream over a 50 m section of the reserve. The offences did not result in substantial environmental harm.
- A forest company was fined $1 000 for offences related to the application of herbicide to an area excluded from treatment under a forest practices plan. The error was the second incident involving the application of herbicides to areas excluded within the plan. There was no evidence of any environmental harm as a result of the spraying.
- Firewood contractors were fined $1 750 for offences related to the harvesting of firewood on Multiple-use forest outside the boundary of a forest practices plan. The Board found that the contractors had not taken adequate care.
- A firewood cutter was convicted for cutting firewood on private land in an area reserved from harvesting under a forest practices plan. The reserve was originally included in the plan in order to protect a threatened species of stag beetle. The illegal cutting had been detected by a forest practices officer who had stopped the operation before any major harm was done to the beetle's habitat. The cutter was fined $1 500 plus $900 in costs.

Source: Forest Practices Board (2002).

7.3

ECONOMIC FRAMEWORK

INTRODUCTION

This sub-section is concerned with the economic environment and how factors such as investment levels, taxation policies and trade conditions affect forest management.

Forests provide a range of products that can be traded. The economics of this trade may affect whether the products are harvested and traded sustainably. In addition, funds are required for any form of conservation, management, or investment in and by the timber industry.

Indicators in this sub-section allow some tracking of the economic and fiscal framework in which forests meet the marketplace. They also provide a snapshot of policies affecting import and export of forest products.

Plantation forest planning

Investment and taxation

coverage
currrency
frequency

Indicator 7.3a

Extent to which the economic framework (economic policies and measures) supports the conservation and sustainable management of forests through 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

Rationale

Government investment and taxation policies can affect investment in forest growing and timber processing industries.

Australia's investment policies enable domestic and international investment in forest growing and timber processing. The National Competition Policy aims to promote efficient competition between public and private businesses. Taxation law does not discriminate against investment in forestry. However, the long-term, capital-intensive nature of this sector has led to the inequitable treatment of forestry operations. Over the past few decades, the Commonwealth government has introduced a number of tax changes to address this. Funding has been provided to assist restructuring of timber industries affected by government forest use decisions.

This indicator is concerned with the fiscal regulations and economic policies that control the flow of money in and out of the forest sector.

The National Forest Policy Statement, Regional Forest Agreements, Plantations for Australia: the 2020 Vision, and the Forest and Wood Products Action Agenda, which are also relevant to investment in the forest and forest products industries, are described under indicator 7.1b.

Investment

Australia has stringent controls over land use changes and industrial development that aim to protect environmental cultural and amenity values. These controls generally apply equally to all land use change and developments. Provided those values are protected, private investment in the forest and forest products industries in Australia is generally free from industry-specific legal and regulatory constraints.

Australia's foreign investment policy aims to encourage foreign investment that is consistent with community and economic interests. Foreign investment in Australia is regulated primarily through a regime established under the *Foreign Acquisitions and Takeovers Act 1975*. The Commonwealth provides information and facilitation services and incentives to attract projects with significant net economic and employment benefits.

State government forestry agencies and large industrial companies have played major roles in the development of plantations for many years. State governments still dominate softwood plantation forestry in the Australian Capital Territory and in all States except Victoria. In contrast, most investment in hardwood plantations has been undertaken by the private sector.

Investment by superannuation funds and other financial institutions has become a significant factor in Australia. The Hancock Timber Resource Group, an institutional funds manager based in Boston, United States of America, and a consortium of Australian funds managers acquired the assets of the Victorian Plantations Corporation in 1998. In 1999, GMO Renewable Resources—another American-based funds manager—acquired a 50 per cent interest in Forestry Tasmania's softwood plantations.

Investment in forest products manufacturing is described in indictor 6.3a.

The Kyoto Protocol has the potential to enable investment in the forest sector. The Protocol allows companies and countries to offset greenhouse emissions by capturing, or sequestering, carbon dioxide in biomass. The New South Wales *Carbon Rights Legislation Amendment Act 1998* aims to facilitate trading in carbon sequestration rights. A number of Australian and foreign companies, including the Tokyo Electric Power Company, have undertaken small forestry investments in anticipation of securing carbon sequestration rights.

National Competition Policy

In 1995 the Council of Australian Governments agreed to a National Competition Policy to improve the efficiency of government business activities. This policy aims to promote efficient competition between public and private businesses and to ensure that government businesses have no competitive advantages or disadvantages compared with their private competitors.

Taxation on forestry

Since the classification in 1961 of forestry activities as primary production for taxation purposes, the treatment of forestry activities by tax legislation has created unintended inequities for small scale private investments in forestry. The main tax related issues are related to the seasonal and long-term nature of forestry, and the irregular cash flows associated with forestry investments over time.

Establishment and maintenance activities in forestry operations are highly seasonal dependent. For example, the usual cycle of plantation establishment operations in temperate regions of Australia is to begin site cultivation in spring or summer and complete planting when rain permits the following winter or early spring. While expenditure is often spread between two financial years, investors incur costs as a single event. The 12-month prepayment rule[1] generally allows investors in prospectus based forestry schemes to deduct the costs they incur from plantation establishment expenditure, against income in the same year that these costs are incurred, but gives managers 12 months within which to carry out these management activities. This deduction provision is confined to prospectus based forestry schemes, and is the only significant tax treatment for forestry investments in managed schemes that are different to investment in other sectors. It is designed to eliminate the inequitable tax treatment of such forestry schemes.

The decisions of individual investors to invest in forestry are also influenced by the treatment of selling the rights to harvest timber, rather than selling forested land. In order to secure a buyer, forest owners sometimes contract to sell logs from immature forests at some time in the future when the trees are ready for harvest. Current tax provisions treat such a contract as

[1] In 2002, the 12-month prepayment rule was introduced to provide certainty to investors in recognition of the long term nature of forestry.

creating and disposing of an asset. This creates a tax liability on the potential value of the contract at the time that the contract is made, even though no income will be received until the proposed time of sale.

'Period inequity' is another factor that influences individual's decisions to invest in forestry. This issue arises because individuals who invest in forestry receive no income for many years and then receive the returns from selling timber in one or a few large amounts. Such income is then likely to be taxed at the maximum marginal tax rate irrespective of the many years in which no income was received. Income averaging schemes (for example farm management deposits) designed to address the irregularity of income derived from primary production are of limited use for this problem.

Forest Industries Structural Adjustment Program

Following the Regional Forest Agreement (RFA) process, the Commonwealth in conjunction with States where RFAs exist have allocated nearly $100 million to the Forest Industry Structural Adjustment Program (FISAP). The aims of this program are to assist the continuing development of a competitive, sustainable and value adding native forest timber industry and help businesses and workers in the industry who have been directly and adversely affected by the operation of the RFA process.

Governments recognise that the RFA process has required significant adjustments in the native timber industry, and FISAP provides assistance to businesses and workers who have been forced to leave the industry as a result of RFAs. FISAP also provides financial assistance to existing and potential participants in the native forest hardwood timber industry. This is to encourage investment in capital equipment that will improve the performance of the harvesting and haulage sector and enhance the ability of the industry to process and add value to Australian native forest timber, and to increase marketing and promotional skills in the industry. Table 121 summarises assistance provided by the program to date.

Table 121: Commonwealth assistance provided through the Forest Industry Structural Adjustment Program

State	Commonwealth expenditure to 31 December 2002 ($ million)	Total Industry Development Assistance ($ million)
New South Wales	30.4	112.3
Queensland	2.2	12.5
Victoria	14.6	67.5
Western Australia	0.1	-
Totals	47.3	192.3

Source: National Forest Inventory (2003)

Further reading

Cummine, A. (2002). Plantations in the landscape – tax is not the villain. Australian Forest Growers 2002 National Conference. Australian Forest Growers, Deakin, Australian Capital Territory.

CCNCO (2001). Competitive Neutrality in Forestry. Commonwealth Competitive Neutrality Complaints Office Research Paper. Productivity Commission, Canberra.

coverage
currrency
frequency

Trade policies

Indicator 7.3b
Extent to which the economic framework (economic policies and measures) supports the conservation and sustainable management of forests through non-discriminatory trade policies for forest products

Rationale
Non-discriminatory trade policies provide equitable access to international markets

Australia's export industries operate in a trade environment where they continue to face barriers to market entry. Australia supports a policy that will lead to the removal of tariffs in wood and wood products and is pursuing WTO-consistent Free Trade Agreements. For countries not party to multilateral or bilateral treaties, Australia's tariffs on imports of forest and forest products range from 0 per cent to 5 per cent. However, Australia grants preferential tariff treatment for developing country products.

This indicator is concerned with the manner in which trade policies influence sustainable forest management. Such policies can be discriminatory or can encourage trade liberalisation.

Discriminatory trade policies include domestic price support, quotas, tariffs and other barriers, export subsidies, subsidies on inputs such as power, transportation and processing. Measures that distort market signals are import and export quotas. Another example is 'escalating tariffs', where countries impose relatively low import duties on minimally processed forest products such as logs, but progressively higher duties on more processed products.

Trade liberalisation can have positive and negative effects, depending on the accompanying environmental, economic and social policies. They are considered by some economists to be more appropriate than discriminatory policies in achieving environmental goals. Non-discriminatory trade policies for the forest sector are important as they provide access to international markets, allowing producers on all the benefits of sustainable forest management and ensuring true valuation of forest resources.

Exports

Australia's export industries operate in a trade environment where they continue to face barriers to market entry, such as tariffs, restrictions on import volumes and adverse domestic regulations. Australia's approach to opening markets uses a combination of bilateral, regional and multilateral strategies.

Over the past decade, Australia has taken a market-oriented approach to its economic and trade reform, with a general aim of increasing efficiency in the allocation of resources. This is evident in the recent reductions in production subsidies for various industries, particularly in the primary sector. Efficient allocation of resources is crucial for the development of an internationally competitive forest industry.

Given the export focus of Australia's forest sector, Australia supports a policy that will lead to the removal of tariffs in wood and wood products. Access to overseas markets is one of the many challenges to the development of a strong forest industry in Australia, and is currently being addressed through Australia's participation in various forums for multilateral trade negotiations, such as the World Trade Organisation (WTO), the Asia–Pacific Economic Co-operation (APEC) and the Association of South East Asian Nations (ASEAN). The WTO Doha round of negotiations on non-agricultural products aims to reduce or eliminate tariffs and non-tariff barriers. The negotiations commenced in November 2001 and are scheduled to conclude by January 2005. Forest products, including wood and paper products, are included.

Since the introduction of the Regional Forest Agreement framework, Australia has markedly reduced its restrictions on exports of forest products. Export controls are now restricted to hardwood woodchips derived from areas outside Regional Forest Agreements, and unprocessed timber destined for further processing.

Imports

Australia is also pursuing WTO-consistent Free Trade Agreements (FTAs) in order to complement multilateral negotiations and to build momentum for multilateral liberalisation. The Australia–New Zealand Closer Economic Relations is one of the world's most comprehensive FTAs. In 2001-02, nearly 20 per cent of all imports of timber products came from New Zealand.

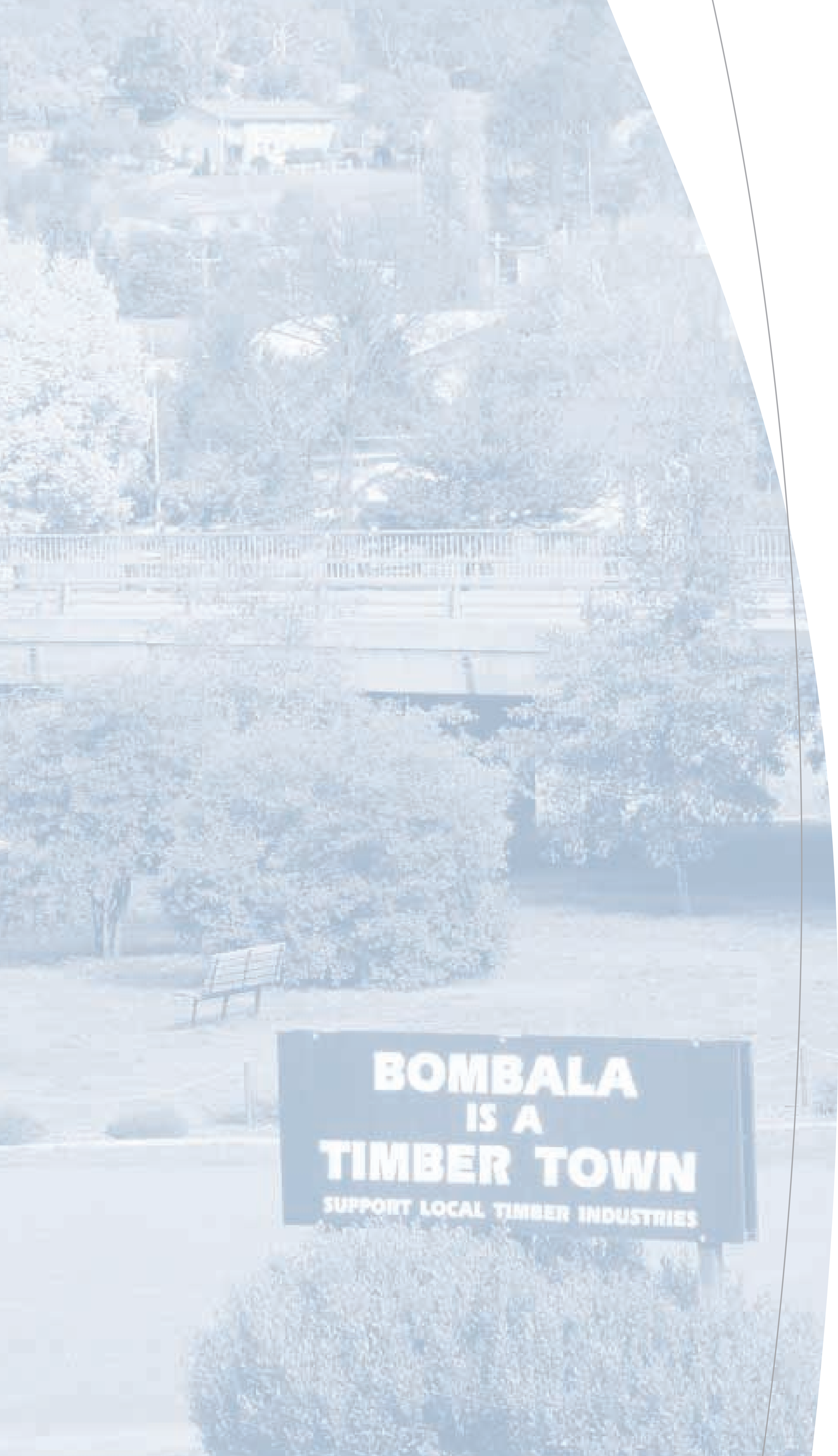
For countries not party to multilateral or bilateral treaties, Australia's tariffs on imports of forest and forest products range from 0 per cent to 5 per cent. Australia, however, grants preferential tariff treatment for products from developing countries under the Australian System of Tariff Preferences for Developing Countries, the Papua New Guinea–Australia Trade and Commercial Relations Agreement and the South Pacific Regional Trade and Economic Cooperation Agreement. The average tariff rate applied on products from developing countries is 3.9 per cent. Since 1 July 2003, Australia provides tariff and quota-free entry for all goods from all least developed countries, and a number of small island developing countries. For determining least developed countries, the three United Nations criteria are applied, which relate to level of income, human resource weakness and economic vulnerability.

To protect against pests and diseases that are constraints to trade, Australia is committed to ensuring quarantine standards and regulations that are consistent with the WTO agreements.

Further reading

Bhati, U.N. (2001). Import Tariffs – An Impediment to Market Access. Forestry Market Reports Series, 19. Forestry School of Resources, Environment and Society, The Australian National University, Canberra.

Silvertop ash (*Eucalyptus sieberi*) forest


BOMBALA
IS A
TIMBER TOWN
SUPPORT LOCAL TIMBER INDUSTRIES

7.4

CAPACITY TO MEASURE AND MONITOR CHANGES

INTRODUCTION

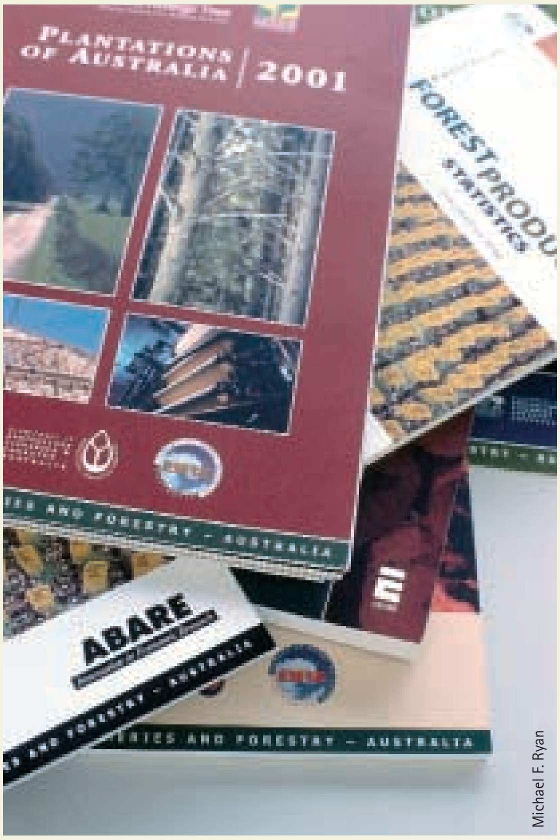
Australians expect that trends in the condition of their forests are monitored and reported to help with decision-making and sustainable forest management.

These three indicators are concerned with the capacity to measure and monitor changes in the conservation and sustainable management of forests. This involves assessing, monitoring and measuring forests and the reliability of the statistics that are thereby produced.

At a national level, the National Forest Inventory—a partnership between the Australian Government, State and Territory governments—is primarily responsible for undertaking national forest assessment and reporting. State and Territory agencies and private forest owners and managers also collect forest data.

However, data are far from comprehensive. Much assessment has focused on areas managed for commercial timber production. As a result, the main gaps in our forest information are for privately managed forests or concern non-timber attributes. Moreover, collecting data does not always guarantee its reliability. The statistical reliability of forest inventories, assessments and monitoring—as well as their frequency— varies across the country.

The issue of compatibility of assessments is central to indicator 7.4c, which considers Australia's compatibility with other countries in measuring and reporting on indicators. Compatible protocols for measuring and reporting improve the efficiency of data gathering by sharing information. Compatibility also enhances the accuracy and usefulness of global assessments.



Forest-related publications from the Bureau of Rural Sciences and the Australian Bureau of Agricultural Resource Economics

Availability of data

Indicator 7.4a

Capacity to measure and monitor changes in the conservation and sustainable management of forests, including availability and extent of up-to-date data, statistics and other information important to measuring or describing indicators associated with criteria 1–7

Rationale

To summarise data availability and currency under the regional framework of indicators.

There is a wide variation in the nature of data and other information used to describe the 74 indicators in this report, from detailed statistical data through to limited case studies. This report reveals there are 16 indicators with comprehensive data for coverage, currency and frequency, 2 indicators that do not have any data and 56 indicators with intermediate data.

Measuring and monitoring Australia's forests is necessary to assess sustainable forest management. For the purposes of this report, 7 criteria and 74 indicators are used. An understanding of the extent to which relevant and up-to-date information about the forests is available to report against the indicators, provides a measure of the capacity to demonstrate sustainable forest management. In turn, this allows for forest managers to review and prioritise data collection activities for relevant and timely measurement and monitoring.

This indicator provides a cursory data overview for each of the other 73 indicators (Table 122); the reader should refer to each respective full indicator description for a more comprehensive discussion of the nature of the data. It is not appropriate to make a comparison of the data status of indicators against one another. While some indicators depend on data for reporting, others are more narrative in nature. Similarly, some indicators rely on regional level data while others are only relevant at the national level.

In reporting the availability of data it is important to recognise that the level of reporting varies significantly between the States and Territories. For the purposes of this report Tasmania, Victoria and New South Wales reported comprehensively against the indicators in 2002. The remainder of the States and Territories contributed partial data in 2002 to supplement the comprehensive reporting that had occurred against a number of the indicators in 2000.

Legend for indicator coverage for Table 122

Key		Coverage	Currency[1]	Frequency[2]
Data complete at the national level	●	Whole country assessed	1998+	Annual to 5 yearly
Partial data	●	Incomplete data	1980 - 1997	Greater than 5 Years
Scientific studies or limited work available, or only required once	●	Case study	Incomplete	Once only
No data available	●	No data	No Data	No Data
Range of data coverage, currency and frequency[3]	○	Range	Range	Range

1 Currency of available coverage
2 Frequency of which the available coverage is updated
3 The predominant response appears in the relevant background colour but is also a mix from other possible responses

Table 122: Data availability, coverage and currency to address each indicator

		Coverage	Currency	Frequency	Main Data Source
Criterion 1: Conservation of biological diversity					
1.1	**Ecosystem diversity**				
1.1a	Extent of area by forest type and tenure	🟢	🟢	🟢	State and Territory agencies
1.1b	Forest growth stage by tenure	🟡	🟡	🟡	State and Territory agencies
1.1e	Fragmentation of forests	🟢	🟢	🟢	National analysis on State and Territory data
1.2	**Species diversity**				
1.2a	Forest dwelling species	🟡	🟢	🟢	National analysis on State and Territory data
1.2b	The status of forest dwelling species	🟡	🟢	🟢	National analysis on State and Territory data
1.2c	Species monitoring	🟡	🟢	🟢	State and Territory agencies and public research organisations
1.3	**Genetic diversity**				
1.3a	Genetic variation in forest dwelling species	🔵	🟢	🔵	State and Territory agencies
1.3c	Genetic resource conservation plans	🟡	🟢	🔵	State and Territory agencies
Criterion 2: Maintenance of productive capacity of forest ecosystems					
2.1a	Forest available for timber production	🟡	🟢	🟢	State and Territory agencies
2.1b	Growing stock in native forests available for timber production	🟡	🟢	🟢	State and Territory agencies
2.1c	Plantations of native and exotic species	🟢	🟢	🟢	State and Territory agencies and private industry
2.1d	Annual removal of wood products	🟡	🟢	🟢	State and Territory agencies
2.1e	Non-timber forest products	🟡	🟢	🟢	State and Territory agencies and public research organisations
2.1f	Effectiveness of plantation establishment	🔵	🟢	🟢	State agency
2.1g	Effective native forest regeneration	🟡	🟢	🟢	State and Territory agencies
2.1h	Genetic resources in exotic plantations	🟢	🟢	🟢	State and Territory agencies and research organisations
Criterion 3: Maintenance of ecosystem health and vitality					
3.1a	Factors affecting forest health	🟡	🟢	🟢	State and Territory agencies and research organisations
3.1b	Air pollutants	🟢	🟢	🟢	Australian government organisations
3.1c	Changes in forest ecology as indicated by changed biophysical and chemical components	🔵	🟢	🟢	State agencies
Criterion 4: Conservation and maintenance of soil and water resources					
4.1a	Soil erosion hazard	🔴	🔴	🔴	None
4.1b	Protection of soil and water by forests	🟡	🟢	🟢	State and Territory agencies
4.1c	Forest stream flow	🟡	🟢	🟢	State and Territory agencies
4.1d	Soil organic matter	🔵	🟢	🔵	State agency
4.1e	Soil physical damage	🔵	🟢	🔵	State agency
4.1f	Biodiversity of water bodies	🟡	🟢	🟢	State and Territory agencies
4.1g	Physio-chemical properties of water bodies	🟢	🟢	🟢	National analysis on State and Territory data
4.1h	Persistent toxic substances	🔵	🟢	🟢	State agency

Table 122: Data availability, coverage and currency to address each indicator

		Coverage	Currency	Frequency	Main Data Source
Criterion 5: Maintenance of forest contribution to global carbon cycles					
5.1a	Forest biomass and carbon stocks	🟢	🟢	🟢	Australian Government analysis
5.1b	Forest contribution to the carbon budget	🟢	🟢	🟢	Australian Government analysis
5.1c	Forest products contribution to the carbon budget	🟢	🟢	🟢	Australian Government analysis
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	🟢	🟢	🟢	Australian Government agencies
6.1b	Value and volume of non-wood forest products	🟠	🟢	🟢	State and Territory agencies and research organisations
6.1c	Wood supply and consumption	🟢	🟢	🟢	Australian Government agencies
6.1d	Value of forest products as a % of GDP	🟢	🟢	🟢	Australian Government agencies
6.1e	Recycling	🟠	🟢	🟢	Australian Government agencies and industry
6.1f	Non-wood supply and consumption	🟠	🟢	🟢	State and Territory agencies and public research organisations
6.2	**Recreation and tourism**				
6.2a	Forest for recreation and tourism	🟠	🟢	🟢	State and Territory agencies
6.2b	Visitor activities	🟠	🟢	🟢	State and Territory agencies
6.2c	Visitor numbers	🟠	🟢	🟢	State and Territory agencies
6.2d	Unacceptable visitor impacts	🔵	🟢	🔵	State and Territory agencies
6.3	**Investment in the forest sector**				
6.3a	Investment in forests	🟠	🟢	🟢	Industry
6.3b	Expenditure on research, development and education	🟠	🟢	🟢	Australian Government agency
6.3c	Utilisation of new technologies	🟠	🟢	🟢	Australian Government agencies
6.3d	Return of investment	🔵	🟢	🔵	Australian Government agencies and industry
6.4	**Cultural, social and spiritual needs and values**				
6.4a(i)	Areas formally managed to protect indigenous values	🟢	🟢	🟢	State and Territory agencies and public research organisations
6.4a(ii)	Areas formally managed to protect places of non-indigenous values	🟠	🟢	🟢	State and Territory agencies
6.4b	Non-consumptive use of forest values	🟠	🟢	🟢	State agencies
6.5	**Employment and community needs**				
6.5a	Employment	🟢	🟢	🟢	Australian Government agencies
6.5b	Wage and injury rates	🟢	🟢	🟢	Australian Government agencies and industry
6.5c(i)	Viability of forest dependant communities	🟢	🟠	🟢	Australian Government agencies
6.5c(ii)	Viability of forest dependant indigenous communities	🟠	🟢	🟢	Australian Government agencies
6.5d	Land for Indigenous needs	🟢	🟢	🟢	Australian Government agencies

continued over

Table 122: Data availability, coverage and currency to address each indicator

		Coverage	Currency	Frequency	Main Data Source
continued from previous page					
6.6	**Indigenous participation and management**				
6.6a	Maintaining and enhancing Indigenous values	green	green	green	Government agencies
Criterion 7: Legal, institutional and economic framework for forest conservation and sustainable management					
7.1	**Legal framework**				
7.1a	Indigenous peoples' property rights	orange	green	green	State and Territory agencies
7.1b	Planning, assessment and review	green (outlined)	green	green	State and Territory agencies
7.1c	Public participation	green	green	green	Australian, State and Territory government agencies
7.1d	Best practice codes	green	green	green	Australian, State and Territory government agencies
7.1e	Special values and Indigenous people's participation	green (outlined)	green	green (outlined)	Australian, State and Territory government agencies
7.2	**Institutional framework**				
7.2a	Public information and education	orange	green	green	Australian, State and Territory government agencies
7.2b	Planning and review	green	green	green	Australian, State and Territory government agencies
7.2c	Developing skills	green	green	green	Australian, State and Territory government agencies
7.2d	Infrastructure	red	red	red	Australian, State and Territory government agencies
7.2e	Enforcement	orange	green	green	State and Territory agencies
7.3	**Economic framework**				
7.3a	Investment and taxation	green	green	green	Australian Government agencies and industry
7.3b	Trade policies	green	green	green	Australian Government agencies
7.4	**Capacity to measure and monitor**				
7.4a	Availability of data				
7.4b	Monitoring and reporting	orange	green (outlined)	green (outlined)	Australian Government agencies and industry
7.4c	Compatibility with other countries	green	green	green	Australian Government agencies
7.5	**Capacity to conduct and apply research and development**				
7.5a	Scientific understanding	orange	green	green	State and Territory agencies
7.5b	Assessing environmental and social forest values	orange	green	green	Australian Government agencies
7.5c	New technologies and their consequences	blue	green	blue	State agency
7.5d	Predicting human impacts	orange	green	green	State and Territory agencies
7.5e	Predicting impacts of climate change on forests	green (outlined)	green	green	State and Territory agencies and public research organisations
7.5f	Silviculture and utilisation research	orange	green	green	State and Territory agencies and public research organisations

Monitoring and reporting

coverage
currrency
frequency

Indicator 7.4b

Capacity to measure and monitor changes in the conservation and sustainable management of forests, including scope, frequency and statistical reliability of forest inventories, assessments, monitoring and other relevant information

Rationale

A comprehensive and current inventory provides the basis for all forest planning.

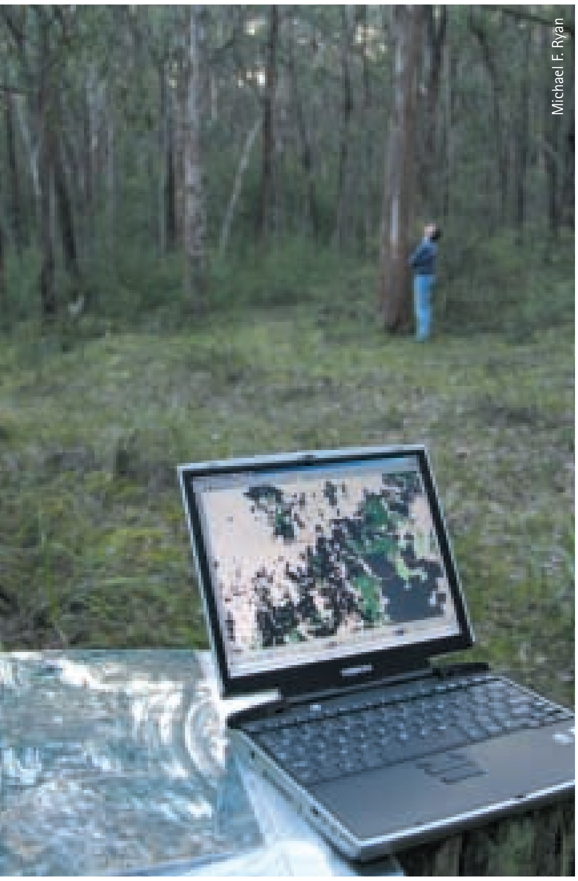
At a national level, the National Forest Inventory is primarily responsible for undertaking national forest assessment and reporting. State and Territory agencies and private forest owners and managers collect primary forest data. The majority of inventory and monitoring activities in native forests have focused on areas managed for commercial timber production. Australia's largest gaps in forest information are in privately managed forests and for non-timber attributes.

Australians increasingly expect that trends in the condition of forests are monitored and reported to support sound policy decision-making and sustainable forest management. The data collected under this indicator should demonstrate the timeliness and completeness of the information available at a range of scales from a national overview to forest management units.

National overview

State and Territory agencies and private forest owners and managers collect primary forest inventory data in Australia. The frequency and scope varies across the States and Territories and with the tenure. Some States and Territories only undertake inventories when new data are required and money is available for selected regions, while other States and Territories have regular programs. The inventories of States, Territories and private commercial companies are based predominately on spatial inventories underpinned by aerial photography, remote sensing and Geographic Information Systems (GIS) verified through ground-truthing and surveys. For all public forests managed for timber production, inventory and assessment are regularly undertaken, both for management purposes and to monitor and report performance. The highest statistical reliability in inventory undertaken in Australia occurs where there is consistent annual monitoring, which is most common for plantations.

All multiple-use forest management agencies are committed to sustainable forest management. To this end, many are moving towards measuring and reporting performance using a 'triple bottom line' approach, recognising that a balanced triple bottom line maintains economic prosperity, environmental quality and social responsibility. This approach is building on existing approaches to inventory and assessment in those States. Some State managers of public conservation forests are also adopting this approach. For example, in New South Wales, State Forests of New South Wales produce an annual report called the Seeing report for their public multiple-use forests and National Parks of New South Wales are producing a State of the Parks reports for the conservation forests. In Tasmania sustainable forest management reports have been developed for multiple-use forests for the last two years.



Ground truthing spatial data for forest inventory

At a national level, the National Forest Inventory—a partnership between Commonwealth, State and Territory governments—is primarily responsible for undertaking national forest assessment and reporting through the compilation and integration of disparate state supplied data into national classification schemas and national databases. This substantial undertaking involves integrating data with differing spatial scales, quality, classification methods and attributes, both within and between States. This process involves periodic calls for data to enter or update the National Forest Inventory and national forest resource assessments at least once every five years. Plantation forests are inventoried annually due to their dynamic changing nature and reported at both the state and territory level and nationally, and then in detail at a regional level every five years.

Australia's wide variety of forest types and their distribution results in varying data collection techniques ranging from coarse-scale remotely sensed data with low levels of accuracy (e.g., remote areas such as the Kimberley in northern Western Australia), through to data obtained from aerial photograph interpretation, to finer-scale field data of high accuracy (e.g., Tasmania). Inventory data based on permanent plots under State management represents the minority, and is likely to decrease further as reduced funding results in many of these plots no longer being maintained.

In addition to traditional forest inventory, broader forest assessments require a variety of social and economic data. This necessitates data collation from a wider range of sources including Commonwealth agencies (e.g., employment and production data from Australian Bureau of Statistics and Australian Bureau of Agricultural Resources Economics, salinity data from the National Land and Water Resources Audit, carbon data from the Australian Greenhouse Office) and research agencies (e.g., pests and diseases and soil health data from Commonwealth Scientific Industrial Research Organisation and the universities).

The majority of current inventory, assessment and monitoring activities in native forests have focused on the relatively small area of Australia's public forests managed for commercial timber production. Fewer resources have been allocated to the inventory of nature conservation reserves. Australia's largest gaps in forest information are in privately managed forests and for non-timber attributes. In the last five years information has been enhanced by the substantial investment in public forest inventory, which included environmental, social and economic data, through the Comprehensive Regional Assessment process. Private native forest managers do not have access to the same level of resources to undertake forest mapping or inventory, although, in New South Wales access to natural resources data for private land managers is being improved through the Community Access to Natural Resources Information (CANRI) Program. Commercial plantation forests have regular inventory, assessment and monitoring, however, public access to private inventory information is considered sensitive and is limited through data confidentiality agreements.

Two factors have recently had a significant impact on increasing the scope, frequency and quality of forest inventory, assessment and monitoring in Australia, in particular in improving information levels for the private forest estate. The first being advances in low and high resolution remote sensing technologies and sampling techniques, which offer opportunities to report and monitor forest attributes with greater accuracy and frequency and at a lower cost. The second is the increase in levels of interest and investment in collecting and monitoring ecosystem data for natural resource management.

National assessments, as listed in Table 123, include national reporting on some criteria where the State of the Forests report has not been able to provide comprehensive information. The national reporting of these assessments across all land classes and vegetation types make it difficult, if not impossible, to extract data for forests alone, and therefore the information could not be used for this report. It is, however, worth referring to the reports to get an impression of the state of these criteria across Australia, even if it is not possible to restrict the information to forests.

Table 123: National sources of data for assessing the state of Australia's forests

Agency	National Assessment	Scope	Collation frequency
Bureau of Rural Sciences (in partnership with other Australian, State and Territory agencies)	National Forest Inventory (spatial)	Forest type, extent, land-use and tenure	Annual updates (as required) to 5-yearly
	National Forest Inventory	Conservation indicators	5-yearly
	State of the Forests Report	Production indicators	5-yearly
	Montreal Process Country Report	Ecosystem health indicators	
	FAO Global Forest Resource Assessment	Soil and water indicators	
	Various other reporting	Carbon indicators Socio-economic indicators Legal and institutional indicators	
	National Plantation Inventory	Plantation forest inventory Farm forestry inventory Resource projections Wood availability	Annual and detailed 5-yearly
	Agricultural Land Cover Change (spatial)	Land cover change mapping	1990 and 1995
	Australian Land Use Mapping program (spatial)	Land-use survey	2000
Environment Australia	State of the Environment Report	Atmosphere, coast and oceans, biodiversity, land, inland waters, natural and cultural heritage and human settlement	5-yearly
National Land and Water Resources Audit	National Vegetation Information System (spatial)	Vegetation type and extent	5-yearly
Australian Greenhouse Office	National Greenhouse Gas Inventory National Carbon Accounting System (spatial)	Woody extent, land cover change monitoring and Biomass inventory	1970–2000
ABARE	Forest and Wood Products Statistics	Economic and resource data on native forest and plantation industry	Bi-annual
Australian Bureau of Statistics	Australian National Accounts National Balance Sheets Agricultural Survey/Census Labour Force Survey Agricultural Finance Survey Environmental Issues and Trends Report	Various employment, economic and environmental data on industry and resource	Annual
	National Census of Population and Housing	Various demographic, employment, education and other data for local areas and regions	5-yearly

[1] Only the NFI is designed specifically to analyse forest data; it is difficult to extract forest-only data from the other listed data sources

The scope of assessments and monitoring is generally increasing as the level of interest in forest ecosystems increases and broadens to include a range of non-timber attributes. There is a continuing need to balance interest in knowing against the capacity to pay for acquiring the knowledge. This balance also determines the scope and statistical rigour of the work.

In response to these shortcomings and the need for statistically reliable information for national level monitoring and reporting, a Continental Forest Monitoring Framework (CFMF) trial is being developed by the National Forest Inventory to provide the capacity to monitor and report on trends in the condition of a range of forest values including: biodiversity; timber and non-timber resources; soil and water; carbon; forest health (insect pests, diseases, weeds); and fire fuel status.

Further reading

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Compatibility with other countries

coverage

currrency

frequency

Indicator 7.4c

Capacity to measure and monitor changes in the conservation and sustainable management of forests, including compatibility with other countries in measuring, monitoring and reporting on indicators

Rationale

Compatible protocols for measuring and reporting enhanced co-operation and collaboration, and increase the efficiency of data gathering. Compatibility enhances the accuracy and usefulness of global assessments and improves global dialogue. Further, similar data sets allow for adjacent countries to assess their shared ecosystems.

Australia is a member of the Montreal Process and has been involved in scientific and technical co-operation with other member countries. Australia also reports forest-related activities to the United Nations Food and Agriculture Organisation (UN FAO) and other bodies collecting and reporting forest data internationally

Australia is actively engaged with the global community in measuring, monitoring and reporting indicators for sustainable forest management (Table 124). As a member of the Montreal Process, Australia has participated in annual Montreal Process Working Group and Technical Advisory Group meetings since 1993, and has reported progress with developing criteria and indicators of sustainable forest management for the Montreal Process countries. Australia has been involved in significant scientific and technical co-operation with member countries on all issues of criteria and indicator reporting. This has guided national report planning, reduced national reporting costs by the sharing of information, techniques and resources, and helped clarify international expectations for sustainable forest management reporting.

Australia has reported forest-related activities to the United Nations Food and Agriculture Organisation (UN FAO) since its establishment in 1945. Currently Australia is a member of the UN FAO Global Forest Resources Assessment Advisory Group and UN Economic Commission for Europe-FAO (UNECE-FAO) Team of Specialists. These groups collect and make available forest data for all countries and for industrialised countries, respectively. Involvement with the FAO Forest Resources Assessment ensures that Australia is engaged in resolving a range of global forest inventory issues, including forest definitions, and is able to contribute to them with current national reporting processes, such as this report.

Through these activities, the definition of forest used in Australia's State of Forests Reports is now more compatible with international forest definitions. However, due to Australia's unique forest ecosystems, there are still differences with regard to the UN FAO forest definition. These include a sparser cover of trees, with a lower threshold of 10 per cent crown cover under the FAO definition compared to the 20 per cent crown cover used by Australia. However, the FAO threshold of 5 metres height excludes some areas of Australia's forest-forming mallee and mangrove; Australia's National Forest Inventory definition of forest has a 2 metre minimum height boundary.

In seeking to implement a Continental Forest Monitoring Framework (CFMF), Australia has consulted widely with international forest agencies that have undertaken a similar approach to forest inventory and monitoring. Many countries, such as the USA and some in Europe, have had such frameworks in place for some time and can offer insights and experience. Others—such as New Zealand, Canada and Japan—are in the process of establishing similar forest monitoring systems. Australia has invited representatives from the United States of America, Canada and New Zealand to sit as members alongside domestic experts on the CFMF Technical Advisory Group.

Table 124: International processes or agencies to which Australia reports forest information

International agency	Lead Australian body	Frequency
Montreal Process	Montreal Implementation Group/ National Forest Inventory	5-yearly
UNECE/FAO Temperate and Boreal Forest Resource Assessment and forest product statistics	National Forest Inventory	5-yearly
FAO Global Forest Resources Assessment	National Forest Inventory	5-yearly
Organisation for Economic Co-operation and Development (OECD)	Australian Government Department of the Environment and Heritage	Yearly
International Tropical Timbers Organisation	Australian Government Department of Department of Agriculture Fisheries and Forestry	Yearly
Convention on International Trade in Endangered Species	Australian Government Department of the Environment and Heritage	Annual
Convention on Biological Diversity	Australian Government Department of the Environment and Heritage	variable determined by decision
UN Framework Convention on Climate Change	Australian Greenhouse Office	Annual

Further reading

Montreal Process Working Group (2003) Montreal Process First Forest Overview Report 2003, Canada

United Nations Food and Agriculture Organisation (2001). Global Forest Resources Assessment 2000 Main Report. FAO Forestry Paper 140. United Nations Food and Agriculture Organisation, Rome.

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7.5

CAPACITY TO CONDUCT AND APPLY RESEARCH AND DEVELOPMENT

INTRODUCTION

This sub-criterion measures Australia's capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services. The six indicators focus on research, its application and its consequences.

Effective forest policies rely on a good scientific understanding of the forest ecosystem. Many Australian forests are quite different from those found in other countries and so knowledge of them depends almost entirely upon Australian research. Australia conducts scientific research on forest ecosystems and forest products in several public research institutions, universities and companies in a wide range of disciplines. The results are disseminated by publication in scientific journals and research reports, in professional meetings and through extension programs.

Another area under study concerns Australia's ability to predict impacts of human intervention on forests. For example, the extent to which management of native forests for wood production or for water yield or recreation can be compatible with, say, conservation of biodiversity or heritage values. Also, the interactions between forest and climate in relation to global warming and the carbon cycle.

But research and development is not just about the biophysical aspects of forests. It may also concern new technologies used in the forest industry. As with any industry, the arrival of new technologies can bring a mix of advantages and disadvantages to society, the economy and the people in the industry. Australia has so far not fully assessed the socio-economic consequences of introducing new technologies into the forest sector.

Another form of research is devising procedures for assessing the environmental and social values of forest. These have been developed and applied for some public forests under the Comprehensive Regional Assessment process. Methods are now being developed to include environmental values in national accounting systems.

Assessing timber regrowth in a stand of callitris

Research on forest ecosystems

coverage
currrency
frequency

Indicator 7.5a

Capacity to conduct and apply research and development aimed at improving forest management, including development of scientific understanding of forest ecosystem characteristics and functions

Rationale

A scientific understanding of Australian forest ecosystem characteristics and functions is needed to underpin sustainable forest management.

Australia conducts scientific research on forest ecosystems and forest products in several public research institutions, universities and companies in a wide range of disciplines. The results are disseminated by publication in scientific journals and research reports, in professional meetings and through extension programs.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia's major national research body. Its Forestry and Forest Products, Sustainable Ecosystems, and Land and Water, are the main divisions concerned with forests. The Forest and Wood Products Research and Development Corporation provides a national, integrated research and development focus for the Australian forest and wood products industry, funded primarily through industry levies and government appropriation. The Rural Industries Research and Development Corporation funds research by other organisations into rural questions including forestry. The Australian Bureau of Agricultural and Resource Economics conduct economic research into the forest and other sectors. The Bureau of Rural Sciences, Australian Greenhouse Office and the Department of the Environment and Heritage also fund and conduct forest-related research. A considerable body of research on forests is undertaken in Australia's universities. State and Territory government research agencies also conduct extensive research on forests under their respective jurisdiction.

Most public land management agencies and several public companies have research branches that focus on forests. Some non-government organisations conduct research on risks to forest ecosystems. Australia also has a comprehensive set of tertiary institutions where research is undertaken that contributes to the knowledge and understanding of forest ecosystems and management.

The Australian government encourages research bodies including universities, CSIRO and other government laboratories, to cooperate with industries, government and clients as a means of seeing that collaborative research is focused on needs. Such research is often applied through Cooperative Research Centres, generally known as CRCs. CRCs dealing with forest related issues include:

- Sustainable production forestry;
- Catchment hydrology;
- Freshwater ecology;
- Greenhouse accounting;
- Tropical rainforest ecology and management;
- Tropical savannahs; and
- Innovative wood manufacturing.

Research issues, priorities and outcomes of State, Territory, Australian Government agencies, research bodies and private industry associations are further supported through a series of committees, working groups and taskforces which report to the national Forestry and Forest Products Committee, and similarly to the national Land and Water Biodiversity Council.

The total forest research effort has not been calculated because research is spread among many bodies and disciplines—biophysical, social and economic—and many research projects are not specific to forests. Research themes include fire, water, pests, diseases, tree physiology, genetics, tourism, indigenous use, soil, carbon, flora, fauna and ecoservices.

The forest-related research conducted by State and CSIRO agencies, and their investment, is shown in Tables 125 and 126.

Table 125: Number of forest-related research projects by State agencies

Field	ACT	NSW	NT	Qld[1]	SA	Tas	Vic	WA
Year		2000–2001		1999–2000		2000-2001	2000–2001	2000-2001
Biodiversity	–	82	–	7	–	19	43	11
Productive capacity	–	13	–	10	–	56	37	4
Ecosystem health	–	55	–	6	–	28	24	6
Soil and water	–	7	–	7	–	2	15	2
Global carbon	–	7	–	–	–	–	1	–
Socio-economic	–	26	–	2	–	2	1	0
Total		183		32		107	121	23

Source: National Forest Inventory (2003)

1 Data are for multiple-use forest management and Department of Natural Resources vegetation management only. Research papers may include scientific papers, published reports and other unpublished or internal reports in 1999–2000.

Table 126: Staff and expenditure in research and development by State and Territory agencies

Field	ACT	NSW	NT	Qld[1]	SA	Tas	Vic	WA
	2000–2001	2000–2001		1999–2000	2000-2001	2000-2001	2000–2001	2000-2001
Staff employed in research and development	10	1402	–	145	25	143	58	17
Expenditure on research and development ($ m)	1	7.13	–	13.94	2.5	2.6	4.5	1.1

Source: National Forest Inventory (2003)

1 For multiple-use forest management and Department of Natural Resources vegetation management only

2 Includes data from both State Forests of New South Wales and National Parks and Wildlife Service

3 Expenditure by State Forests only—does not include scholarships for post-graduate programs

4 Queensland's expenditure on research and development includes non-State-provided funds of $6.4 million and State-provided funds of approximately $7.5 million

Assessing environmental and social forest values

coverage
currrency
frequency

Indicator 7.5b

Capacity to conduct and apply research and development aimed at improving forest management, including 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

Rationale

This indicator addresses methods that enable the environmental and social values of forests to be assessed against economic values to ensure sustainable forest management is achieved.

Procedures for assessing the environmental and social values of forests have been developed and applied for some public forests under the Comprehensive Regional Assessment process. Methods are being developed to include environmental values in national accounting systems.

Timber and other commercial forest products are traded and so it is relatively easy to determine their market prices. As the prices can be determined, the impacts on supply of commercial forest products of alternative policy decisions can be compared readily in monetary terms. Similarly, national accounting systems can, theoretically, include the value of commercial forest products and therefore monitor whether that value is increasing or decreasing.

Environmental and social values of forests are sometimes referred to as 'non-market' values and are consequently difficult to price. This distinguishes them from traded products, such as timber. While methods for estimating non-market values are improving and are being used more in environmental policy development processes, such as the choice modelling exercise as part of the Living Murray program, issues remain that inhibit widespread acceptance and use.

Indigenous peoples' customary use of landscapes, including forested areas, remains important as a source of non-cash income in many parts of remote Australia, but the operation of the customary economy is not routinely measured. As a result, comparisons of customary and non-market values with commercial values are difficult when policy options are assessed, and their inclusion in national accounting systems is limited.

Measuring coarse, woody debris in tall open eucalypt forest at Warra Long Term Ecological Research site, Tasmania

Case study – Market Based Instruments

As part of the National Action Plan for Salinity and Water Quality, under the Market Based Instruments (MBI) Pilots Program 10 natural resource management pilot projects are funded. The projects will take place over 3 years and aim to test more flexible arrangements for integrating economic activity with environmental outcomes, such as salinity mitigation and biodiversity conservation, and their ability to deliver these outcomes in a more cost-effective manner in comparison to standard regulation or grants programs.

Case study – BushTender Agreements, Victoria

BushTender is a new approach offering landholders the opportunity to receive payment for entering into agreements to provide management services that improve the quality or extent of native vegetation on their land. These services are based on management commitments over and above those required by current obligations and legislation.

The BushTender program enables landholders to establish their own price for the management services they are prepared to offer to improve their native vegetation. This price forms the basis for their bid, which is compared with the bids from all other landholders participating in the process. The successful bids are those that offer the best value for money.

The first BushTender Trial was conducted during 2001–2002 in two areas of Victoria—the north central region between Bendigo and Ballarat and in the north-east between Wangaratta and Wodonga. In June 2002 the BushTender Trial was extended to Gippsland.

Public forests

The managers of publicly owned forests in Australia have, for many years, developed and applied forest management planning procedures. Some of these are supported by computer-based modelling systems and assess the affects of forest management options on environmental, social and commercial values. While these procedures do not usually aim to measure non-market values, they provide ways to compare the different levels of output of market and non-market values resulting from options for forest management.

Economists have developed methods to enable market and non-market values to be integrated into decision-making processes. One of the main methods that can be applied to proposed policies or projects is 'benefit-cost analysis'. The Resource Assessment Commission tested the application of several methods, including benefit-cost analysis, to forest values in Australia during its Forest and Timber Inquiry. That inquiry led to the development of the National Forest Policy Statement.

The National Forest Policy Statement introduced Regional Forest Agreements. These were supported by Comprehensive Regional Assessments where all forest values were assessed to provide balanced management of environmental, social and commercial values, often with the aid of computer-based modelling systems—for example C-Plan and Forest Resource Assessment Management Systems (FRAMES) in New South Wales. The community consultation involved with the Comprehensive Regional Assessments is addressed in criterion 7.1c. The management of the identified environmental, social, cultural and other values is addressed in criterion 7.1e.

As the preceding examples show, various methods have been developed to integrate environmental and social costs and benefits into the development of public policy for forest use in Australia. However, their application is mainly to public native forests managed for multiple uses including timber production and represents only a small proportion of public native forests.

Private forestry

Harvested river red gum logs (*Eucalyptus camaldulensis*)

Environmental and social values of some privately owned native forests were assessed during the Comprehensive Regional Assessment process in some regions. Public policy for management of environmental and social values of private native forests is based on regulatory approaches such as planning legislation and codes of practice with no requirement to report on their outcomes. However, some of the larger private forestry companies include a level of environmental and social reporting of their operations as a part of their policy for ecologically sustainable development.

The forests owned by Indigenous people (see indicator 6.4.a(i)) are held under a form of communal title, but are most reasonably treated as private lands. Their owners have in some cases chosen to enter the mainstream economy through orthodox commercial forestry, and in other cases to seek options dependent on smaller-scale use of a wider range of resources (see case study below). Where orthodox forestry is preferred, tradeoffs in reduced options for the customary economy, or alternative enterprise based on non-wood products, have not been formally considered because the information needed is not readily available. Better understanding of the value of the customary economy and impacts of conventional forestry on other Indigenous values will require additional study.

National accounts

Including environmental and social values in national accounts is a relatively new concept. The Australian Bureau of Statistics is developing methods for accounting for environment values in the national accounts. National accounts that include environmental assets were published in 2002 (Table 127).

The environmental assets included in Table 127 are land (84 per cent of the total), sub-soil assets (minerals, oil and gas) and native standing timber. Many important assets relevant to sustainable forest management, such as soil and native flora and fauna, are not yet included. Concepts underlying how native forests are valued from a number of different perspectives clearly require further development.

Table 127: Australia's total assets ($ billion)

Asset category	1993	1994	1995	1996	1997	1998	1999	2000	2001
Financial	145	169	185	193	230	300	316	396	440
Buildings and structures	934	973	1 024	1 067	1 107	1 159	1 236	1 318	1 399
Machinery and equipment	251	257	265	268	274	291	301	312	317
Other produced assets	96	101	107	104	106	111	118	129	138
Environmental assets	631	676	721	736	816	882	966	1 062	1 160
Total	2 057	2 176	2 301	2 368	2 533	2 742	2 937	3 221	3 459

Source: Australian Bureau of Statistics (2002)

Further reading

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Red stringybark (*Eucalyptus macrorhyncha*) and long-leaf box (*Eucalyptus goniocalyx*) forest

New technologies and their consequences

coverage

currrency

frequency

Indicator 7.5c

Capacity to conduct and apply research and development aimed at improving forest management, including new technologies and the capacity to assess the socio-economic consequences associated with the introduction of new technologies

Rationale

New technologies can have positive or negative effects on the forest sector. It is important to assess these potential effects, in order to determine their consequences. The forest sector should be broadly defined to include forest research, management, protection, education, recreation, and tourism in addition to the wood and non-wood forest products industries.

Australia has not comprehensively assessed the socio-economic consequences of introducing new technologies into the forest sector.

Employment and economic development in regional (or non-urban) areas is an important social issue in Australia, and one in which the forest sector can be an important player. As in any industry, new technologies can affect the forest sector in many ways. These effects may include:

- Decreased employment, replacing labour with technology;
- Increased certainty—some technologies may remove the impact of seasonal variations;
- Changes to employment;
- People with different skills may be required;
- Different jobs may be created;
- There may be reduced physical hardship;
- Increased safety;
- Improved production efficiency;
- Increased contribution to economic growth; and
- Increased profits for those in the industry.

However, there is little information on whether any changes in the forest sector are attributable specifically to the introduction of new technologies. Although there have been significant changes in employment and location of the wood harvesting and processing industries, the effects of introducing new technologies are confounded with concurrent effects of concentration of production into few sites and a major shift of production from native forests to plantations.

The spatial distribution of Australian industries that rely on forests creates a more difficult overall problem. In most local areas, agriculture is a more important industry than wood processing so that changes in the two industries may confound local effects. The proportion of agriculture that is dependent on forests, as opposed to cleared land, is unknown. While there is a capacity to assess the consequences of new technologies, these assessments are not commonly carried out. As a result, the data on this indicator are limited.

Case studies – New technologies, Tasmania and Victoria

Victoria has provided information on a number of new technologies and their socio-economic impact.

Cording and matting

Definition: according to the Forest Practices Code, cording and matting is the use of suitable logs, bark or vegetation to spread the weight of the load and separate machine tyres of tracks from direct soil contact during harvesting operations, thus reducing ground pressure and rutting. With matting a complete cover over the soil is created using an excavator before machinery operates over the site.

This technique aims to minimise soil disturbance by reducing ground pressure, compaction, rutting and puddling caused by machinery during harvesting operations. The major benefits of this technique include:

- Enabling harvesting to continue in wet weather;
- The possibility of extending harvesting periods into winter;
- Minimisation of dust in summer;
- Improved safety;
- Cost savings on machinery; and
- Improved efficiency and effectiveness in the restoration of the coupe following the completion of harvesting operations.

These benefits have significant socio-economic consequences. Contractors will be guaranteed continual employment throughout their contract period as well as having the potential for work during winter.

Shovel logging

Definition: Shovel logging is any harvesting system that uses excavators or tracked loading machines with log grabs to lift and move logs while the harvesting machine is stationary.

This technique minimises soil compaction and disturbance on harvesting coupes. It has similar advantages and socio-economic impacts to those of cording and matting.

Mechanical harvesting

Definition: Using tractors and other available technologies to improve the efficiency of harvesting, hence replacing manual harvesting.

Mechanical harvesting has a number of advantages. These include:

- Increased productivity;
- Increased competitiveness in global markets;
- Improved safety in harvesting operations; and
- The ability to operate in a broad range of environmental conditions.

The major socio-economic effect of this technology may be a decrease in employment. It has been suggested that increased adoption of productive mechanical devices can often lead to a decrease in employment, however, there has not yet been any evidence to support this view.

Source: DNRE (1996) and Wilkinson (2001)

Mechanisation, such as the introduction of machinery in thinning operations, may cause employment levels to drop even during periods of increased production

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coverage
currrency
frequency

Predicting human impacts

Indicator 7.5d

Capacity to conduct and apply research and development aimed at improving forest management, including enhancement of ability to predict impacts of human intervention on forests

Rationale

The ability to predict impacts is required to ensure that long-term objectives are likely to be met.

Models relating to predicting the impacts of human intervention on the six recognised forest values are available or under development for the majority of States and Territories. Models are most advanced for wood production and carbon, and to a lesser degree for soil and water conservation, and impacts on biodiversity.

Australia's forests are, to a significant extent, the products of human intervention, both before and after European settlement. The nature of interventions and impacts on forests has changed, along with socio-economic demands. In addition, plantation forests have been established on an increasing scale over the past 130 years.

This indicator is closely related to the development of scientific understanding (indicator 7.5a), which underlies any predictive ability. It should also be read in conjunction with indicator 7.5e, which is concerned with predicting impacts from human-induced climate change.

In order to manage Australia's forests sustainably, prediction of the likely effects of management actions on forest values is helpful. Examples include:

- The extent to which management for wood and non-wood production (for example harvesting, water yield, fire control, grazing and recreation) are compatible with conservation of biodiversity, soil, water and heritage values.
- The rate of growth of wood production forests and hence the sustainable yield.
- The effect of changing fire regimes on the forest ecology and on the risk to life and property.
- The interactions between forest ecology and climate in relation to global warming and the carbon cycle.

Table 128 summarises the current state of models for predicting the impacts of human activities on forests. Models are most advanced for wood production, with some available for soil and water conservation, and impacts on biodiversity. This bias is also reflected by information provided in indicator 7.5.a. Predictive ability depends on the availability and accuracy of data.

Productive capacity of forests

The traditional empirical approach to predicting how well trees will grow on particular sites has been to establish permanent plots across a range of sites that differ in factors affecting growth, for example rainfall, evaporation, water table depth and soil properties. Tree performance was then predicted by extrapolating these permanent plot data to a landscape scale. Over the past decade or so, however, a number of physiologically, or hybrid empirical-physiologically based models of tree growth have been developed and are being tested for their capacity to predict forest growth. For example, the model known as 3PG (Physiological

Table 128: Availability of models to predict impacts of human intervention on forest properties

	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Biodiversity	UD	UD	–	✓	–	UD	UD	UD	–
Productive capacity	–	UD	–	✓	✓	✓	✓	✓	–
Ecosystem health	–	UD	–	✓	–	UD	–	UD	UD
Soil and water	–	✓	–	UD	–	UD	✓	UD	–
Carbon	–	UD	–	UD	✓	–	–	–	✓
Socio-economic	–	✓	–	UD	–	–	UD	–	–

UD = Model under development
✓ = Model available

Processes Predicting Growth) calculates the sun's energy absorbed by forest canopies and from this deduces the biomass production of leaf, stem and below-ground parts. The efficiency of these conversions is modified by site and environmental factors and stand age.

Growth models at the stand level are used in plantation forestry, and in some regrowth native forests managed for wood supply. A notable example is STANDSIM, which has been used in Victoria for the past two decades. This model was developed to predict growth of fast-growing eucalypt forests undergoing self-thinning. It has been modified to predict how mechanical thinning of young stands concentrates log volume on fewer trees, thereby reducing rotation lengths and increasing the value of individual logs. In Western Australia, growth models are available for the jarrah (*Eucalyptus marginata*) and karri (*E. diversicolor*) forests. Predictions of growth and timber yield in uneven-aged native forests are also made with models.

Soil and water

A large effort is made by forest and land management agencies to monitor catchments and assess the effects of disturbance at different sites on erosion, sediment movement and water quality. In New South Wales, the forests in the Eden region have been a main focus for modelling. Models of the effect of stand age on the quantity of water yielded from forested catchments have been made for mountain forests in Victoria.

Biodiversity and forest health

Models to predict impacts of human activity on forest biodiversity take several forms, including the prediction and mapping of vegetation distribution and wildlife habitat. Queensland is well advanced in this regard with a wide range of models to predict forest grazing intensity, habitat quality, flora and fauna distribution and old growth. Data analysis or case studies have been undertaken for all models, largely concentrated in the Brigalow and South East Queensland biogeographic regions with the intention to apply them progressively to other forested regions. In Western Australia, FORESTCHECK, an integrated forest monitoring system, is under development to yield data suitable for modelling a range of human impacts.

Modelling of the distribution and responses to disturbance of individual species may aim to assist in the conservation of threatened species. For example, in Tasmania, forest snails, velvet worms, freshwater crayfish and the swift parrot (*Lathamus discolor*) are subjects of this approach. Another example is to model so called keystone species—such as, forest owls in the south-eastern Australian forests—with the expectation that prescriptions for such species will assist in conserving other sensitive species and the forest environment as a whole. In Victoria, Population Viability Analysis models have been developed that rank management options for arboreal mammals at risk of extinction.

Predicting impacts of climate change on forests

coverage
currrency
frequency

Indicator 7.5e

Capacity to conduct and apply research and development aimed at improving forest management, including ability to predict impacts on forests of possible climate change

Rationale

The ability to predict impacts of climate change is required to ensure that long-term sustainability objectives are met.

Australia has a well-developed climate forecasting and modeling capacity. There have been few studies, however, to link this to the possible impacts of predicted climate changes on forests

Australia has a well-developed climate forecasting and modeling capacity and can forecast potential future climates for different regions of the country based on current scientific understanding (refer to indicator 3.1.a). However, few studies have been done on the possible impacts of predicted climate changes on forests. Further research is required on the impacts of climate change on the distribution of major tree species, forest ecosystems and fire regimes.

An example of a study that does link climate forecasting to forest impacts is one carried out by CSIRO and the Rainforest Cooperative Research Centre. This research analysed the environmental controls on tropical forest distributions within the humid tropics of north Queensland and used these relationships to estimate likely past distributions under late Pleistocene to Holocene climates, and to provide spatially explicit assessments of their sensitivity to future climate change.

Detailed modelling of climate change has produced estimates for decreased rainfall and higher temperatures in much of southern Australia, while part of the north-west may receive higher cyclonic falls. However, further research is required on the impacts of climate change on the distribution of major tree species and forest ecosystems and on fire regimes.

Rainforest, Osborne Island, Western Australia

Silviculture and forest utilisation research

coverage

currrency

frequency

Indicator 7.5f

Capacity to conduct and apply research and development aimed at improving forest management, including per cent of native forests and plantations that are formally supported by silvicultural and utilisation research

Rationale

Targeted research is required to support the forest industry. This indicator concerns the scientific basis for silviculture and harvesting in native forests and plantations managed for production of timber and other products.

In many jurisdictions production native forests and plantations are formally supported by silvicultural and utilisation research.

The capacity for research in forest ecosystems is covered in indicator 7.5a. In addition to this, it is appropriate for specific research relating to forest products industries to be undertaken. This will ensure long-term viability of the resource and its marketability. A wide range of research funded by governments and the private sector provides that basis (Table 129). It is important to note that although the figures in Table 129 identify the area of forest in which silvicultural and utilisation research is formally supported, this does not imply that research is undertaken across all forest types or all localities.

Table 129: Per cent of production forests and plantations formally supported by silvicultural and utilisation research

	ACT[1]	NSW[2]	NT	Qld	SA	Tas	Vic	WA
Native forests								
Public land	*na*	–	–	*100*	–	*100*	*100*	*100*
Private land	*na*	–	–	*5–10*	–	*100*	–	[3]
Plantations								
Public land	–	–	–	*100*	*100*	*100*	–	*100*
Private land	–	–	–	*90–100*	–	*100*	*100*	[3]

1 There is no harvesting of native forests in the Australian Capital Territory
2 Research priorities and needs are under review
3 Exact amount not given

The Forestry and Forest Products Committee, comprising the heads of Australian and New Zealand Government agencies responsible for forestry, administers the Research Priorities and Co-ordination Committee that coordinates and prioritises forestry research nationwide. It is advised by groups of researchers and managers from the public and private sectors concerned with:

- Genetic resources;
- Forest measurements and information;
- Land and water resources;
- Native forest management;

- Plantation management;
- Fire management;
- Forest health.

While private sector companies commission some research, governments fund most. One major source is the Forest and Wood Products Research and Development Corporation, which receives funds from the private and public sectors. Most of the research results are in the public domain and freely available to all forest owners and managers

Public native forests and plantations managed by government agencies employ scientifically and technically trained people who apply the results of research, as do the larger private sector forest and plantation owners. Government extension services advise smaller private sector forest and plantation owners.

Identified areas for future industry related research include:

Native forests:

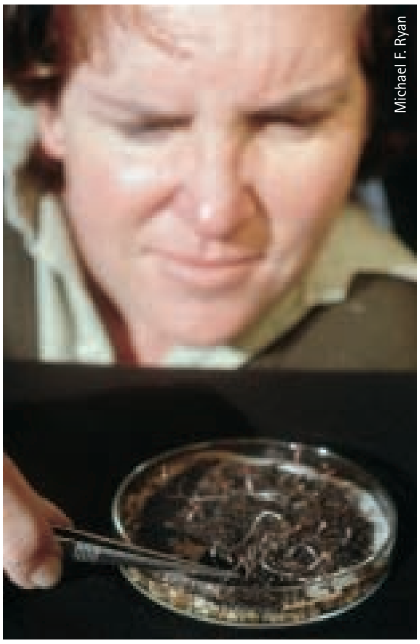
- ecological and hydrological impacts of timber harvesting;
- regeneration techniques for particular forest types and species; and
- management of wildfire.

Plantations:

- hydrological impacts of timber harvesting;
- selection of species for particular regions and sites;
- silvicultural techniques, such as cultivation, fertilisation, thinning and pruning;
- breeding to improve productivity; and
- use of timber plantations to provide environmental services such as salinity mitigation and carbon emission reductions.

Native forests and plantations:

- protection from pests and diseases;
- harvesting systems and machinery;
- occupational health and safety for forest workers; and
- management systems and techniques.



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INDEX

A

B

Q

R

Y

ACKNOWLEDGEMENTS

The preparation of Australia's State of the Forests Report 2003 has only been possible through the enormous contribution and dedicated support by a large number of people from States, Territories, the Australian Government, and private consultants. The list below is not exhaustive – the contribution by many others, especially in data compilation and research, is also gratefully acknowledged.

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