4 *Uses and Disturbances*

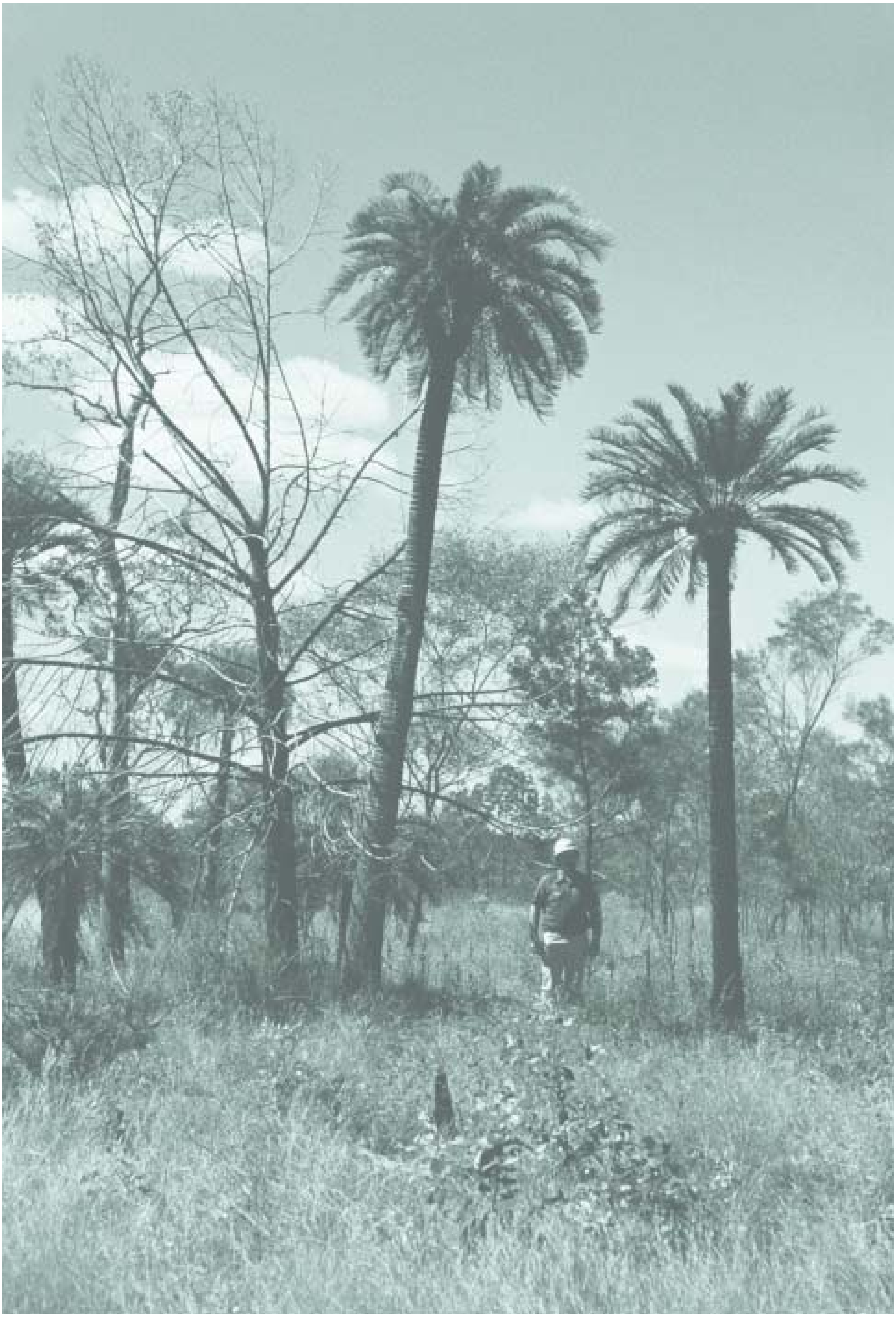


Photo: R Hnatiuk *Cycas* sp & mixed deciduous spp (dry scrub)

Uses and Disturbances

Many disturbances are a natural part of forest ecosystems. Fire, for example, has played a role in the Australian bush for millions of years, and forest cover has advanced and retreated over geological time as the climate has warmed or cooled.

Before Europeans, Indigenous peoples used the forests and disturbed them as they did so, particularly with their use of fire as a management tool. The nature of disturbance has changed in recent times, as we clear for agriculture and settlement and extract from the forests a wide range of products and services, and as we unwittingly introduce weeds, feral animals, pests and pathogens. This chapter describes and quantifies, where possible, the uses to which we put forests and the range of disturbances we impose upon them.

Changes in forest cover

Historical trends in forest cover change

Determining the historical rate of forest cover change is a difficult task, given that pre-European forest cover can only be estimated from information available today.

Land considered to have a high capability for agriculture was preferentially cleared after European settlement, resulting in remnant forests not being representative of the full range of forest types. It seems likely that about 36 per cent of Australia's forests were converted to agricultural land between the time of settlement and 1980 (Table 25). This gross figure can be broken down by State and Territory (Table 26). The areas of modern forest shown in these tables differ from those given earlier in this report, due partly to differences in the definition of forest and partly to improvements in data gathering, but the general trends in forest loss are still reasonable. Forest cover has increased in some regions, either through plantation establishment or through a reduction in pressures such as grazing, but these have not been sufficient to offset the large amount of clearing that has taken place.

Forests may change in character while retaining their status as forests. Table 27 shows that an estimated 1.1 million hectares of forest have increased in density since 1788 and 7.5 million hectares have decreased in density. The causes of these changes are not documented across the forest resource.

Table 25: Estimated change in forest cover in Australia

	(million ha)		Change
Forest type	**1788**	**1980**	**(%)**
Closed forest	4.6	2.9	– 37
Open forest	65.0	35.0	– 45
Woodland	182.0	122.0	– 33
Total forest	**251.6**	**160.0**	**– 36**

Source: derived from AUSLIG (1990).

Table 26: Estimated forest cover change, by State and Territory, 1788 to 1980

State/	('000 ha)		Reduction
Territory	**1788**	**1980**	**(%)**
ACT	236	124	47
NSW	54 710	22 910	58
NT	27 565	27 474	0
Qld	80 609	55 963	31
SA	18 417	9 058	51
Tas	5 604	3 871	31
Vic	18 513	7 538	59
WA	46 346	32 934	29
Australia	**252 000**	**159 872**	**37**

Notes: The data presented here are the only national estimates of forest cover change since European settlement. The areas differ from others used in this report due to differences in the definition of forest and improved data now available.
Source: derived from AUSLIG (1990).

Table 27: Estimated change in forest density, 1788 to 1980

Type of change	Area changed (million ha)
Forest to non-forest	95.0
Non-forest to forest	1.7
Increase in density	1.1
Decrease in density	7.5

Source: derived from AUSLIG (1990).

Contemporary trends in forest cover change

Comprehensive assessments of forest cover change at regular intervals are not routinely carried out in Australia because of the high cost. Various initiatives at the Commonwealth, State and Territory levels have gathered information on an ad hoc basis on changes in vegetation cover over time, but these measures are not always equivalent to changes in forest cover or are limited in scope to specific States, Territories or regions.

In 1995 the Commonwealth Government committed funds to a joint project between the Commonwealth and the States and Territories to develop a national land clearance database using high-resolution satellite information and covering the period 1990–95. This project is due for completion at the end of 1998.

Forest fragmentation

Forests are naturally fragmented by rock outcrops, rivers, lakes, swamp, patches of non-forest such as shrubland, as well as the distribution of forest types and successional stages with the forest boundaries. But human activities, particularly clearing, can add to this fragmentation. Since European settlement, many of Australia's forested landscapes have been converted to a patchwork of remnants separated by a variety of non-forest land uses.

Forest fragmentation has potential implications for conservation: ecological theory and some field data suggest that small populations of species are more likely to become extinct than are large populations. Small remnants of vegetation are also more vulnerable to clearing and to edge effects, in which habitat quality deteriorates at the boundary between the forest and cleared land. Small habitat remnants have proportionally more 'edge' than large tracts.

Measures of fragmentation

Little work has been done to measure fragmentation at a regional or national scale, due largely to a lack of suitable map information. Nevertheless, a broad indication of the level of fragmentation was obtained for this report by analysing satellite images of the landscape. Three measures provide insight into fragmentation: patch size class, same-edge proportion, and Shannon contagion. These last two are useful because they can be repeated objectively through time for whole regions, thus providing measures of fragmentation change.

Patch size classes

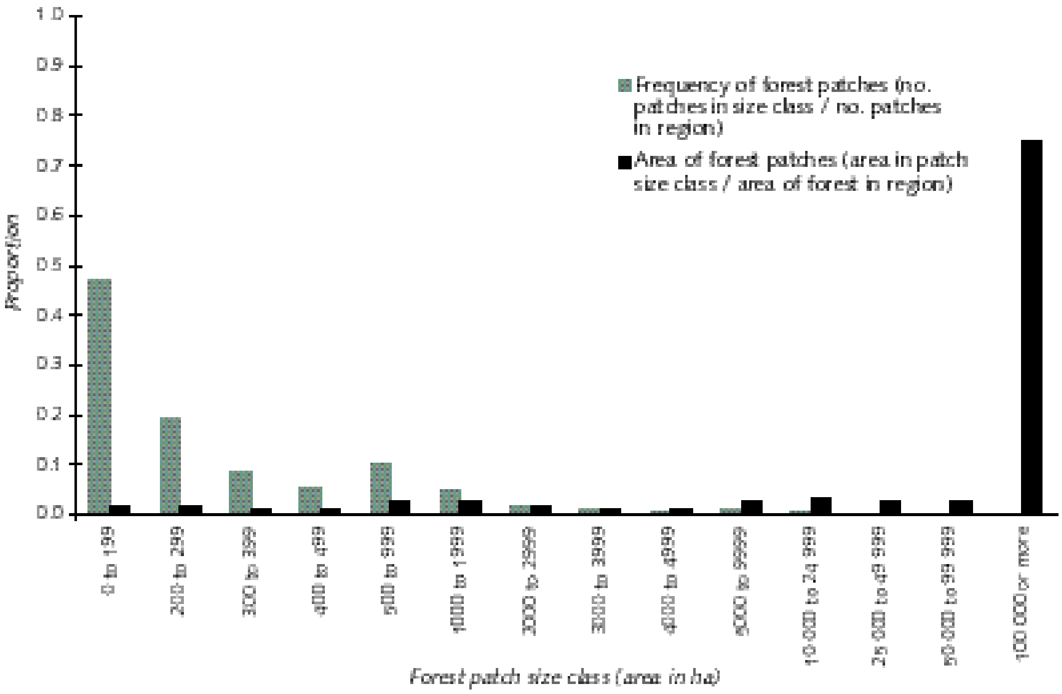
Most of the total forest area occurs in relatively large patches (about 76 per cent in patches greater than 100 000 hectares), but there are also a disproportionately large number of very small patches of forest (Figure 13). Note that estimates at the national level could significantly underestimate the number of small forest patches less than 200 hectares in size due to the low resolution of much of the mapping.

On a regional basis, the patch size results suggest that the larger the proportion of a region that is forested, the larger the average patch size will be for that region. Regions with the largest average patch size are distributed along the east coast, across the north-east and central north coasts, and in the north-western and south-eastern parts of Western Australia. Patch size generally decreases from the moister to the drier regions, with exceptions in south-western Australia and parts of the agricultural zones of south-eastern and central northern Australia.

Same-edge proportion

Same-edge proportion is determined using characteristics of individual pixels of satellite imagery. It is calculated by the number of forest-to-forest edges in the region as a

Figure 13: Statistics on the number and area of forest patches in Australia, by patch size class



Source: Montreal First Approximation Report (1997).

Box 9: Case studies in vegetation fragmentation

The national trend of natural vegetation fragmentation is reflected in Victoria, the only State that has mapped all vegetation patches greater than 1 hectare. Over 80 000 vegetation patches have been identified, with more than 90 per cent smaller than 50 hectares. These patches, however, only make up about 7 per cent of the total native forest area, with 45 per cent of the total area made up of patches greater than 100 000 hectares.

The pattern of fragmentation within South Australia is very different. Approximately 90 per cent of the State has been mapped with a minimum patch size of 10–100 hectares. The remainder has been mapped with a minimum patch size of 1 hectare. Statewide, about 400 000 vegetation patches have been identified, with almost 99 per cent of these less than 100 hectares in size. These smaller patches constitute at least 18 per cent of the total native forest area, making them extremely important at the State level.

A high proportion of South Australia's remnant forest patches occurs in that State's portion of the Murray-Darling Basin. This region hosts the State's most intensive agriculture and supports about 25 per cent of its native forests. All vegetation was mapped at a 1-hectare scale: over 300 000 forest patches were recorded. Of these, 99.5 per cent are less than 50 hectares in size. These small patches of forest make up about 60 per cent of the total native forest area in the region.

Similar estimates have also been made for forests with private tenure in south-west Western Australia. In the Southern, Central and Swan regions (within which the private forests constitute 9 per cent – 198 000 hectares – of the total forest area), 91 per cent of private forests occur in patches less than 50 hectares in size. These make up more than 40 per cent of the total native forest on private land within the region.

proportion of the total number of forest edges in the region. High values indicate large patches with few islands, while low values indicate a fine dispersion of small forest areas among prevailing non-forest.

Map 9 (see colour section in back of book) shows the distribution of same-edge proportion by a number of biogeographic regions (these, based on the Interim Biogeographic Regionalisation of Australia, are called IBRA regions, and have been developed by Commonwealth agencies in collaboration with State and Territory agencies; see Map 11). Forest patches are mostly clumped in the coastal forested regions, declining towards the interior of the continent. Some regions in the agricultural zone show similar values to those further inland, which may be indicative of the impact of forest clearing for agriculture.

Shannon contagion

Shannon contagion is a measure of an entire region rather than of just forested areas. As for same-edge proportion, it has been applied to IBRA regions here. Shannon contagion measures the texture of a region: low values denote 'fine' texture (forest patches occur in small units across the landscape) and high values denote 'coarse' texture (forest patches are large and clumped).

Map 10 (see colour section in back of book) shows the distribution of Shannon contagion values by IBRA region. It suggests that patches are large and close together in coastal areas (contagion values are high) and more widely separated and smaller further inland and in the agricultural zones.

Research is under way to develop a clear understanding of fragmentation of forests from local to regional to national scales, and how to report meaningfully on it.

Water yield

The tall and medium height eucalypt forests are most commonly found in those areas of the continent that come under the regular influence of rain-bearing weather systems and where mountainous topography reinforces rainfall due to the forced uplift of moisture-laden air. These forests make important contributions to streamflow: for example, the forested mountains of the upper Murray River comprise only 2 per cent of the total Murray-Darling catchment area, yet provide 25 per cent of the streamflow. The woodlands and mallee forests of relatively dry inland areas are not important in terms of streamflow (and thus water yield), although their high water use characteristics (compared to those of annual plants) help to maintain a low water table and thus aid the prevention of surface salinity.

Figure 14 illustrates the importance of forests in the high rainfall zone to streamflows. Not surprisingly, most research into the understanding of forest/water relationships has been devoted to the forests of the higher rainfall zones, and they form the basis of the following discussion.

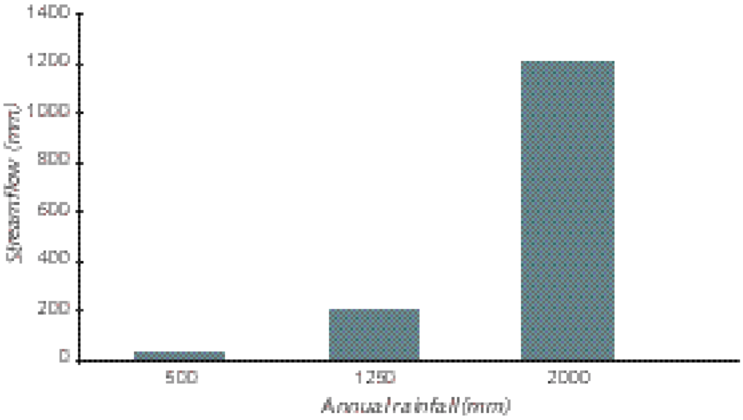
Forest soils, particularly in the higher rainfall forests, can be over 10 metres deep and can store large amounts of water that are slowly released to streams. For example, in the ash-type forests of Victoria, 80 per cent of annual streamflow is a base flow; this percentage falls to 20 per cent in an urban environment. The steady-state flow characteristic of forested catchments reduces the need to build regulating dams and reservoirs and reduces flood peaks.

A number of characteristics of particular forests, such as age, structure and type, can affect streamflow. For example, streamflows from dense regrowth stands in ash-type forests can fall to 50 per cent of those derived from an old-growth forest of the same forest type. These effects are recognised in some codes of forest practice: for example, the Victorian code requires that forest managers take steps to avoid significant streamflow declines.

Forests and streamflow quality

Except for periods of high streamflow during and following major rainfall events, the quality of water draining from undisturbed forests is high due to its low levels of turbidity, dissolved solids and nutrients. Forest litter protects the soil from raindrop splash erosion and helps prevent overland flow. The incorporation of the litter in the soil as organic matter helps aggregate the soil into a stable crumb structure that resists dispersion and allows water to

Figure 14: The influence of increasing average annual rainfall on streamflow volume (indicative values)



Sources: Cornish (1969).
Nandakumar and Mein (1993).

infiltrate. The abundance of old root channels increases the infiltration of water to allow the transfer of surface water to deeper layers. Repeated high-intensity fuel reduction burning that destroys the litter layer can reduce water infiltration by affecting the fine structure of surface soils. Fuel reduction burning, which aims at reducing but not eliminating the litter layer, is unlikely to have this kind of unwanted impact.

In the multiple-use forests of all States, codes of forest practice or other management prescriptions require that road location, construction, drainage and maintenance practices are carried out according to specifications that reduce the level of disturbance and control road and logging track drainage. No-entry buffer zones are demarcated alongside streams, creating an undisturbed zone for the settlement of suspended material in overland flow. In some States, codes of forest practice also apply to private commercial forestry.

Stream and streamside habitat

Forest streams and the vegetation on their banks provide habitat for insects, crustaceans, amphibians, fish and mammals. Long-term and permanent increases in the amount of sediment have been shown to reduce species diversity and population levels in aquatic environments. Codes of forest practice aim to prevent the loss of water quality and changes in stream-bed morphology. Buffer strips along streams maintain a forest cover that protects the stream from direct sunlight, and therefore extreme temperatures, while the canopy cover provides a continuous leaf fall that can be a source of food for aquatic inhabitants.

National-level reporting on water in forests

There are few nationally collated data on the water supply and protection functions of forests. Research is under way via the Montreal Process Implementation Group to develop indicators that will assist in reporting on water in forests.

Cultural values

Forests today are valued by communities and individuals for the wide range of cultural values they hold, both tangible and intangible. Indigenous peoples have lived in and used forested areas for thousands of years as hunting grounds, places for ceremony and learning, and as a source of bush tucker, medicines and raw materials. For non-Indigenous settlers of more recent times, the forests have formed an important economic resource as well as a source of contemporary cultural meaning. For both Indigenous and non-Indigenous peoples, the cultural significance of forests stems from their material, spiritual, aesthetic and historic values. The use of the forests over time has influenced the biological shape and form of forests as well as creating an archaeological record of considerable historical interest. The cultural significance of our forests today has been formed through a complex intertwining of natural and social processes, meanings and values.

The cultural significance of Australia's forest estate varies between community groups and between different levels of community – local, regional and national. Accordingly, various approaches have been developed to enable the appropriate and effective identification of cultural values. Community consultation, primarily in the form of interactive workshops, is increasingly being used to collect information about places of cultural value. Information gathered through field survey, archival research and other community-based investigations such as oral history interviews is also used. The significance of a place may be formally determined through the application of evaluative criteria, such as those developed by the Australian Heritage Commission. The systematic survey of cultural values in forests at a regional level conducted in recent years as part of regional forest agreement processes (see Chapter 5) has greatly enhanced communication and understanding of these values and led to improved identification and assessment techniques.

Forest conservation

The general aim of forest conservation is to ensure that forest ecosystems and the natural processes that sustain them remain intact for their own sake and for the benefit and enjoyment of future generations. This is undertaken across all tenures to some extent. In the conservation reserve system, the overriding consideration is the management of forest systems to maintain a state as close as possible to their natural condition. Multiple-use forests afford protection to many conservation values, although timber production and other resource uses are permitted. While significant conservation values exist on other tenures, including other crown land and leasehold land, these are seldom actively managed for. Recently, efforts have been undertaken to provide mechanisms and incentives to achieve conservation outcomes on private tenures.

Forest conservation outcomes fall into three broad categories:

1. realising the economic, scientific, cultural and/or social benefits derived from the retention of intact forest systems;
2. meeting obligations to inter-generational equity in natural capital; and
3. recognising the intrinsic values of forests and their associated biodiversity that transcend human utility.

The economic benefits of forest conservation include the provision of ecological services (such as water production and carbon sinks), ecotourism, wood products, recreation and pharmacological and other products. Broad economic analyses concern themselves with how to make choices that provide the greatest net benefit to the community, where 'benefit' implies consideration of all economic, social and environmental values. The Australian community recognises a form of social dividend or value coming from a knowledge that forests are protected, even if particular individuals might make little or no direct use of those forests. This suggests that there is considerable social comfort in the knowledge that forest areas will continue to exist, regardless of their conventional economic value. The various aesthetic and intangible values attached to forests, while difficult to define, are nevertheless real and significant for many people.

Natural capital includes natural ecosystems, ecological processes and natural resources. Use of natural capital requires management to try to prevent possibly irreversible changes to ecosystems that may have adverse consequences for future generations. Conservation of forest capital is part of the responsibility of the present generation of forest users for the health, diversity and productivity of the forests so that they can also be used by future generations.

While forest management and our understanding of the natural processes that underpin it have progressed far, there is still much to learn: what are now accepted as sustainable practices may, in hindsight, prove otherwise. Retention of some forests in their natural state can thus be seen as a prudent precaution against possible impacts that may occur due to the incomplete state of our knowledge. Land clearing and other practices have caused the extinction of forest species, although the extent to which this has occurred is not documented on a national basis.

Comprehensive, adequate and representative reserve systems

Individual States and Territories have developed reserve systems based on a range of conservation principles. In 1992 the National Forest Policy Statement, which set out principles and a national framework for forest use and conservation, advocated the development of a comprehensive, adequate and representative reserve (CAR) system for Australia's forests. A nationally agreed set of criteria for such a system has been developed and is currently being applied to forest areas subject to comprehensive regional assessments. These assessments are used to develop regional forest agreements (RFAs; see Chapter 5), covering much of the nation's productive forest estate.

One of the primary aims of the CAR reserve system is the reservation, where still practicable, of 15 per cent of the pre-1750 extent of those forest ecosystems where the Commonwealth and States have agreed to undertake comprehensive regional assessments. Other targets are specified for the protection of old-growth and forested wilderness and require the protection of adequate high-quality habitat for forest species, particularly those considered endangered. These objectives will be most efficiently and effectively achieved through the development of integrated regional conservation strategies that provide for the establishment and effective management of conservation reserves and complementary management of adjoining forest areas. Here, the current extent of the reserve system is used as one indicator of current conservation use.

The RFA process does not extend to all of Australia's forests: its scope is limited largely to regions with forests intensively managed for timber production (Map 15). For this reason, the process will not address a comprehensive reserve system for the entire forest estate. Nevertheless, it is likely to result in changes to land tenure categories on that part of the estate to which it is applied. Pending the completion of the process, Table 6 shows the current extent of forest in formal conservation reserves.

Biodiversity

Biodiversity (biological diversity) refers to the variety or diversity of all life forms, plants, animals and microorganisms, their gene pools and the ecosystems they inhabit. Given the broadness of the term and the range of diversity in Australian forests, quantifying biodiversity is an extremely difficult task. Australia's unique forest ecosystems are a global asset, a rich repository of the history of life in Gondwana that has only partially been investigated. Australia is considered one of the world's 12 'megadiverse' countries; it is the high level of endemism in the Australian biota that makes it of particular significance. We still know little about many forest species, particularly lower plants and invertebrates.

Biodiversity is recognised at three levels: ecosystem diversity, species diversity and genetic diversity.

Ecosystem diversity

Ecosystem diversity refers to the variety of habitats, biotic communities and ecological processes, as well as the diversity between and within ecosystems. At the landscape level, the Interim Biogeographic Regionalisation for Australia (IBRA) has been developed (Map 11 see colour section in back of book). This defines, maps and describes the major ecosystems of Australia based on an integrated classification of biotic and abiotic variation. Attributes included in the IBRA classification are climate, geomorphology, landform, lithology and characteristic soils, flora and fauna.

At the level of plant communities, Specht and his co-authors recognised 457 native forest communities in their 1995 conservation atlas.

Species diversity

Species diversity refers to the variety of living species. Approximately 2300 species of native vertebrate fauna have been recorded in Australia. Of these, 1239 were reported to occur in forests in various States and Territories. Some 13 622 of the approximately 18 000 species of vascular plants in Australia have been recorded in forests (Table 28). There are few data on the degree to which such species are forest-dependent. There are lists of non-vascular plants, fungi and microbes occurring in Australia, but they are not summarised by habitat of occurrence, thus comprehensive lists of these occurring in forests are not available.

Figure 15 presents information on animal species known to occur in forests of various structures, although it is acknowledged that this information is far from complete and, indeed, almost non-existent for some forest structural types. Invertebrate species numbers are vastly underestimated, while estimates for mammals and birds are probably reasonably accurate.

Rare or threatened species

Rare or threatened species are listed for many plant and animal groups, although these have not been classified according to the habitats in which they occur at the national, State or Territory level. This makes it difficult to report on which rare or threatened species are forest-dependent. Map 12 (see colour section in back of book) shows forested sites where rare or threatened vascular plant species have been collected during mostly ad hoc surveys. The sites depicted represent individual records and not the spatial extent of the species.

There are no recorded extinctions of species from forests due to timber harvesting or other disturbances from which the forest has time to recover. However, some species have been recorded as being sensitive to certain kinds of forestry operations. Maintenance of these species depends on appropriate forest management practices. Forest clearing for other land uses such as intensive agriculture replaces forest habitats, posing a significant threat to species dependent on those habitats.

According to estimates provided by three States and Territories for this report, 37 forest-dependent fauna species occupy a reduced range compared to their pre-European distribution. No national data are available for plant species; Tasmania reported an indicative 66 of 1537 plant species as having a significantly reduced range.

Genetic diversity

Genetic diversity refers to the variety of genetic information contained in all individual plants, animals and microorganisms. It occurs within and between populations of species as well as between species. Empirical data on genetic variation are sparse and generally restricted to a small number of species, primarily vertebrates and vascular plants. As knowledge of intra-specific variation and techniques for assessing it improve, it will be necessary to review the strategies for ensuring the preservation of genetic variation.

Species assessments

Species assessments are carried out primarily for rare or threatened species. State, Territory and Commonwealth governments use recovery programs to assist in protecting such species or to remove threats to them. Such programs in Western Australia have resulted in the recovery of the woylie (*Betongia penicillata*) the quenda (*Isoodon obesulus*) and Tammar wallaby (*Macropus eugenii*) to a point where they have been removed from the rare and endangered list.

Species assessments are also carried out as part of the RFA process. These consider:

- the current distribution of rare and threatened forest-dependent species;
- threatening processes affecting these species;
- the conservation requirements of these species, including on-reserve and off-reserve management; and
- the minimum area that must be managed to maintain a viable population of each species.

The information collected for these species will be used in the design of the CAR reserve system. Those species that are most vulnerable to off-reserve threatening processes will be given priority, where possible, for inclusion into this reserve system.

Table 28: Plant and animal species recorded as occurring in forest, by State and Territory

(1)	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia(2)
Vertebrate animals	**ND**	**504**	**449**	**582**	**ND**	**125**	**485**	**239**	**1 227**
rare or threatened	ND	7	4	76	ND	4	9	57	81
mammals	ND	96	87	104	ND	27	94	29	217
birds	ND	281	198	303	ND	77	253	150	561
reptiles	ND	73	134	122	ND	14	102	45	319
amphibians	ND	54	30	49	ND	7	36	15	126
fish	ND	0	0	4	ND	0	0	12	16
Higher plants	**ND**	**ND**	**1 691**	**7 830**	**ND**	**1 043**	**2 959**	**2 639**	**13 622**
rare or threatened	ND	ND	ND	ND	ND	ND	ND	319	ND

ND – No data.

(1) Data for vertebrates and higher plants were provided by State agencies during the production of the Montreal First Approximation Report (1997). The national (ANZECC) vertebrate list, with 1995 revisions by Environment Australia, was used as a base for State input.

(2) The Australian total represents a minimum number of unique species names derived from State lists from NSW, NT, Tas and Vic, plus partial data from Qld. The remainder of data from Qld and WA are not included as they are not in a form suitable for aggregation nationally.

The NT provided 38 additional flora species that may or may not be synonymous with the national list of species. Qld provided 1986 additional flora species that may or may not be synonymous with the national list of species. WA provided total flora numbers only, rather than species lists – these numbers are not reflected in the national total.

No flora data were received from the ACT, SA or NSW.

NSW were revising their fauna data when it was collected in April 1997.

Qld provided 116 additional fauna species that may or may not be synonymous with the national list of species.

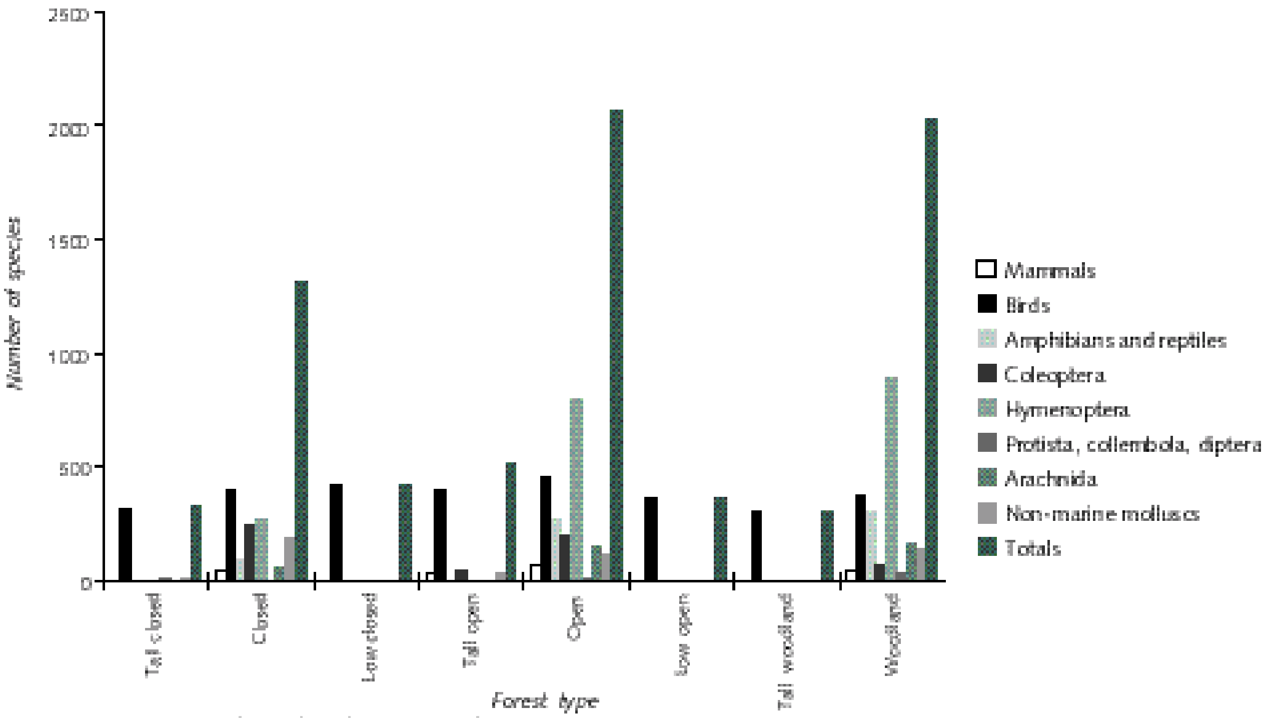
Tas provided 2 additional fauna species that may or may not be synonymous with the national list of species.
WA provided fauna numbers only, rather than species lists – these numbers are not included in the national total.
No fauna data were received from the ACT or SA.
Sources: National Forest Inventory (1997).
Environment Australia (1998).

Table 29: Species numbers in the forests of north-east New South Wales

Species group	Number of species
Higher plants(1)	**2211**
Vertebrate animals(2)	**405**
frogs	46
reptiles	85
birds	181
non-flying mammals	64
bats and flying foxes	29
Invertebrate animals (2)	**526**
spiders	242
ants	185
carabid beetles	47
drosophilids	52

Sources:
(1) NSW National Parks and Wildlife Service (1994b).
(2) NSW National Parks and Wildlife Service (1994a).

Figure 15: Number of animal species known to occur in Australian forests, by various forest structural types



Sources: *Australian Biological Resources Study.*
Royal Australasian Ornithologists Union (1995).

Box 10: Biodiversity case study

Current knowledge about Australia's forest biodiversity is based largely on 200 years of ad hoc species collections as well as detailed surveys. Some modern surveys currently under way aim to use a systematic approach to the collection of biodiversity information to enable the prediction of species distribution through modelling techniques.

The New South Wales North East Forests Biodiversity Study (NEFBS) is a recent example of such a survey. The information gained from it allows us to understand more clearly how biodiversity is distributed across this region.

The survey identified more than 2200 species of flowering plants, conifers, cycads and ferns. Among them are 431 species that have been introduced to Australia since European settlement. The survey also identified 405 species of vertebrate animals and 526 species of invertebrates (Table 29).

Even a survey as detailed as this underestimates species diversity because uncommon species are likely to be missed more often than common species. Nevertheless, the rigour with which it was conducted makes it possible to develop computer-based models to predict species and community distributions. These models are useful in conservation planning and management as well as for designing more efficient surveys in the future.

Old-growth forest

Old-growth forests constitute a major determinant for identifying and developing a national forest reserve system. The CAR criteria set a target for reservation of old-growth at 60 per cent of the extant old-growth forest for each forest ecosystem, rising to 100 per cent for those old-growth elements identified as rare or depleted.

The national criteria, guided by the National Forest Policy Statement, define old-growth forest as 'ecologically mature forest where the effects of disturbances are now negligible'. The following principles have been applied as an integral part of the definition:

- ecological maturity is defined by the characteristics of the older growth stages;
- if data are available on the structural, floristic and functional qualities that would be expected to characterise an ecologically mature forest ecosystem, these data should be used in the assessment of the significance of disturbance effects; and
- negligible disturbance effects will be indicated in most forests by a significant proportion of trees with age-related features and a species composition characteristic of an ecologically mature forest ecosystem.

For application in RFAs, this been interpreted to mean that:

- ecological maturity is a characteristic of older growth stages. Trees exhibiting characteristics of maturity are usually large in terms of height or girth and experiencing slow to almost negative growth rates (this would be evident from shrinking tree crowns, dead and broken branches in the crown and branch stubs on the trunk). They may possess attributes such as burls, galls and hollows;
- features such as forest structure or the composition of flora and fauna can be used to assess the significance of disturbance; and
- forests containing a large number of trees showing characteristics of over-mature forests can themselves be evidence that the effects of past disturbance (on that ecosystem) are now negligible.

In applying this definition, additional information relating to the conservation value of forest is also used. This will include the role of the forest as breeding or foraging habitat for fauna, as protection for flora, and its value in aesthetic or cultural terms.

Old-growth forest is considered important to the conservation of biodiversity because some plants and animals are restricted to the old-growth stages or are dependent on old-growth forest for some of their habitat requirements. For example, one of the most significant characteristics of the older stages of eucalypt forests is the development of tree hollows necessary for the survival of a range of fauna.

Assessing old-growth

Table 3 shows that growth stage is known for about half of Australia's multiple-use forests (some 6.8 million hectares). Table 4 shows that growth stage is known for about 6 per cent of forests in conservation reserves (some 1.1 million hectares), of which 475 000 hectares are classified as 'mature' forest (aged 100–200 years). The RFA process is expected to provide further data for that part of the forest estate within the scope of the process. At present, there is no comprehensive program to do similar old-growth data-gathering in forests outside the RFA areas.

Wilderness

The National Forest Policy Statement gave a significant commitment to the protection of forest wilderness. It defined wilderness as:

> *land that, together with its plant and animal communities, is in a state that 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.*

The National Wilderness Inventory has produced, cooperatively with States and Territories, a continental-scale map of wilderness quality covering most of Australia (Map 13). This work has been implemented by measuring variation in wilderness quality across the landscape using four wilderness quality indicators:

- remoteness from settlement;
- remoteness from established access routes (for example, roads and tracks);
- apparent naturalness: the degree to which the landscape is free from the presence of permanent structures associated with modern technological society; and
- biophysical naturalness: the degree to which the natural environment is free from biophysical disturbance caused by the influence of modern technological society.

Wilderness quality is assessed by the National Wilderness Inventory on a scale ranging from zero, which equates to cleared land, to 20, which equates to an area that has experienced no measurable modern development disturbance. Over 90 per cent of Australia has been assessed in this way.

The reserve criteria agreed by States, Territories and the Commonwealth set a target for the reservation of wilderness in forest areas other than those in northern Australia:

> *Ninety per cent, or more if practicable, of the area of high quality wilderness that meets minimum area requirements should be protected in reserves.*

Some wilderness areas have been delineated within RFA areas and by some States under their own processes (Map 13) (see colour section in back of book).

Geological sites

While nature conservation commonly focuses on biological resources, many forests exhibit geodiversity, or a diversity of geological, landform and soil sites. Like plant and animal species, some landforms are common and some are rare, some are robust and some are fragile. Some sites of important geodiversity may be significant for their intrinsic value; for the role they play in sustaining natural processes, including ecological processes; or for their value to the human population in terms of scientific, recreational, educational, inspirational or economic opportunities. There are no national data on geodiversity.

Timber use in native forests

Native forest is available for the harvesting of timber in the following tenures: multiple-use, some leasehold, some other crown land, and private. Forests with tenure as conservation reserves are excluded from harvesting.

Multiple-use forests

Net harvestable area

Nationally, 86 per cent, or 13.3 million hectares, of the 15.6 million hectares of land designated as multiple-use forests is actually forested. The remainder is rock outcrop, lakes, swamps, non-forest vegetation types or cleared lands purchased for plantation establishment within the forest envelope. The percentage of unforested area varies between States and Territories (Table 30).

Not all forests with multiple-use tenure are available for harvesting. Several factors reduce the harvestable area, notably:

- distance from mills, which may make harvesting uneconomic;
- terrain – access too difficult for vehicles, slopes too steep for machinery, or soils too fragile to work on;
- areas where productivity is low (that is, the number of harvestable trees per hectare is low) or the forest tree species are unsuitable for timber production;
- areas protected from harvesting for environmental or conservation reasons:
  - buffer zones (for example, to protect stream water quality)
  - steep slopes and fragile soils
  - flora, fauna and other conservation areas; and
- areas set aside because of their scenic, cultural or recreation values.

These factors reduce the net forest area available for harvesting by about 45 per cent nationally, although the proportion varies from State to State (Table 31).

Table 30: Area of native forest under multiple-use forest tenure available for harvesting, by State and Territory

	ACT	NSW	NT	Qld	SA[3]	Tas	Vic	WA	Australia
Total forested MUF ('000 ha)[1]	5	3 095	0	3 983	27	1 285	3 346	1 612	13 351
(% of total MUF)[2]	20.2	81.1	0.0	91.7	21.0	79.0	90.2	82.1	85.5
Total MUF area ('000 ha)[2]	**23**	**3 814**	**0**	**4 346**	**126**	**1 627**	**3 710**	**1 962**	**15 608**

Note: Column or row total may not add up due to rounding.
MUF – Multiple-use forest.
[1] Forested portion of multiple-use forests. Percentages relate to exact figures, not the rounded figures given in this table.
[2] Includes unforested areas.
[3] No harvesting of publicly owned native forest takes place in SA.
Source: National Forest Inventory (1997).

Table 31: Partial estimate of net area of forest available for timber production (excluding plantations)

	('000 ha)								
Tenure	**ACT**	**NSW[1]**	**NT**	**Qld**	**SA**	**Tas[2]**	**Vic**	**WA**	**Australia**
Multiple-use	N/A	1 825	ND	2 367	N/A	730	1 215	1 135	7 272
Other	ND	550	ND	2 340	N/A	25	ND	ND	2 915
Private	ND	2 000	ND	ND	N/A	1 146	ND	ND	3 146

Note: Column or row total may not add up due to rounding.
N/A – Not applicable.
ND – No data.
[1] Private net harvestable area is estimated.
[2] Private harvestable is gross area only as net area is not available.
Source: Montreal First Approximation Report (1997).

Standing timber volume

Table 32 shows an estimate of the total volume of standing timber present in native forest with multiple-use tenure. This volume represents that part of the timber resource that was available for timber harvesting in 1995, after the exclusion of areas that are set aside for general environmental protection purposes. No national data are available for the non-merchantable part of the growing stock.

Area harvested annually

The area of multiple-use forest harvested in any one year is determined through planning processes that take into account the range of resources available and constraints placed on harvesting by such things as slopes, soils, and conservation and cultural heritage objectives. Table 33 shows the areas harvested each year in the States of New South Wales, Queensland, Tasmania, Victoria and Western Australia (South Australia and the two Territories do not have or do not harvest their native multiple-use forests). An average of 0.8 per cent (110 000 hectares) of the gross area of native forest with multiple-use tenure (13.3 million hectares) is harvested in any one year; this is about 1.5 per cent of the net area available for harvesting in multiple-use forests. Note that area harvested means different things in different places because of the differing silvicultural systems used. Thus, the area clear cut is not fully comparable to the area lightly selectively logged. As presented here, these figures indicate the area of forest that is affected to some extent by harvesting activities.

Sustainable yield

Sustainable yield (also known as sustained yield) is the quantity of timber that can be harvested on a non-declining basis from a forest based on:

- the proportion of forest suitable for timber production;

Table 32: Total growing stock of merchantable tree species available for timber production in native multiple-use forests, by broad forest type, by State and Territory

	Total merchantable volume ('000 m^3)								
Forest Type	**ACT**	**NSW**	**NT**	**Qld**	**SA**	**Tas**	**Vic**	**WA**	**Australia**
Rainforests						43 092			43 092
Tall open eucalypt forests		29 875		4 000		149 787	7 251	15 295	206 208
Medium open eucalypt forests		23 398		2 850		64 000	9 965	125 328	225 541
Low open eucalypt forests									
Tall eucalypt woodlands									
Medium eucalypt woodlands									
Low eucalypt woodlands		5 214							5 214
Eucalypt mallee forests and woodlands									
Callitris forests and woodlands				6 800					6 800
Acacia forests and woodlands									
'Other' forests and woodlands						12 851			12 851
Total	**N/A**	**58 487**	**ND**	**13 650**	**N/A**	**269 730**	**17 216**	**140 623**	**499 706**

N/A – Not applicable.
ND – No data.
Notes: Some States provided merchantable volume in cubic metres per hectare and area in hectares – this was used to calculate total merchantable volume.
The ACT and SA do not harvest native timber.
Column or row total may not add up due to rounding.
Source: Montreal First Approximation Report (1997).

- the area available for timber production after the protection needs of flora, fauna, water and other environmental values have been met;
- the estimated growing stock and its future growth rates under a particular silvicultural system; and
- any predicted losses to growing stock due to fire or other causes.

The long-term sustainable yield represents the theoretical maximum rate that can be achieved based on a balanced tree age-class distribution over the forest.

All States have long-term plans in place for achieving sustainable yield of timber products. Some allow annual harvest levels to fluctuate around the sustainable yield rate, but reconciliation with sustainable yield is necessary to ensure that future availability is not compromised.

Each State has its own method of forecasting sustainable yield for its multiple-use native forests. The variation in methodology between States is due to differences in available inventory information and to regional differences in the nature of the timber products harvested. Most States forecast sustainable yield for sawlogs, but few do for pulplogs as these are generally seen as a by-product of sawlog production. Table 34 shows the sustainable yield rates forecast for sawlogs from multiple-use native forests in New South Wales, Queensland, Tasmania, Victoria and Western Australia. In 1994–95, the combined sustainable yield of sawlogs was 2.7 million cubic metres, of which 2.5 million cubic metres were harvested.

A broader concept than sustainable yield is that of ecologically sustainable yield; what this constitutes is yet to be determined. In practice, multiple-use forest planning of wood yield in all States incorporates a wide range of economic and conservation values. The extent to which this meets the expectations of ecologically sustainable management is being considered in the RFA and Montreal Process activities.

Table 33: Area of native forest under multiple-use forest tenure harvested annually, by State and Territory

Financial year	ACT[1] (ha)	ACT[1] (%)	NSW[2] (ha)	NSW[2] (%)	NT[3] (ha)	NT[3] (%)	Qld (ha)	Qld (%)	SA[1] (ha)	SA[1] (%)	Tas (ha)	Tas (%)	Vic (ha)	Vic (%)	WA[4] (ha)	WA[4] (%)	ha	Area harvested nationally (% of total forested MUF)
	Area harvested (in hectares and as a percentage of forested multiple-use forests (MUF) in each State and Territory)																	
1989–90	0	0	37 500	1.2	0	0	33 644	0.8	0	0	6 000	0.5	12 200	0.4	15 060	0.9	104404.0	0.8
1990–91	0	0	37 500	1.2	0	0	44 226	1.1	0	0	4 700	0.4	10 800	0.3	13 060	0.8	110286.0	0.8
1991–92	0	0	37 500	1.2	0	0	49 523	1.2	0	0	4 200	0.3	9 900	0.3	15 870	1.0	116993.0	0.9
1992–93	0	0	37 500	1.2	0	0	32 637	0.8	0	0	5 800	0.5	9 300	0.3	16 000	1.0	101237.0	0.8
1993–94	0	0	37 500	1.2	0	0	53 196	1.3	0	0	5 600	0.4	7 000	0.2	15 540	1.0	118836.0	0.9
Average	*0*	*0*	*37 500*	*1.2*	*0*	*0*	*42 645*	*1.1*	*0*	*0*	*5 260*	*0.4*	*9 840*	*0.3*	*15 106*	*0.9*	*110351.2*	*0.8*
Rotation length (nominal years)	N/A		60–150		N/A		50–200		N/A		80–100		65–140		100–200			20–200

Notes: This table contains areas harvested by any technique. States utilising different techniques cannot be directly compared, for example, Qld and NSW use selective harvesting where a large area is harvested lightly. This cannot be compared to Vic, where the area harvested is done by clear-fall, which harvests almost the entire area.
N/A – Not applicable.
(1) No harvesting occurs on MUF native forest in SA or the ACT.
(2) Estimate only.
(3) The NT does not have any MUF.
(4) In WA, about 1500 ha is clear-felled annually and the remainder is selectively logged.
Source: National Forest Inventory (1997).

Table 34: Calculated sustained yield of sawlogs and actual harvest of sawlogs from multiple-use forests, 1992–93 to 1994–95

('000 m^3)

Financial year	ACT Sustained yield	ACT Harvested volume	NSW Sustained yield	NSW Harvested volume	NT Sustained yield	NT Harvested volume	Qld Sustained yield	Qld Harvested volume[1]	SA Sustained yield	SA Harvested volume	Tas [2] Sustained yield	Tas [2] Harvested volume	Vic [3] Sustained yield	Vic [3] Harvested volume	WA [4] Sustained yield	WA [4] Harvested volume	Australia Sustained yield	Australia Harvested volume
1992–93	N/A	N/A	791	729	N/E		116	118	N/A	N/A	300	292	743	632	758	636	2 708	2 407
1993–94	N/A	N/A	791	782	N/E		113	107	N/A	N/A	300	209	743	660	758	615	2 706	2 373
1994–95	N/A	N/A	801	781	N/E		112	111	N/A	N/A	300	309	743	664	758	689	2 714	2 554

N/E – Not established.
N/A – Not applicable.
(1) Applies to higher quality sawlogs meeting 'quota' sawlog specifications.
(2) Applies to category 1 & 3 eucalypt sawlogs from all Tasmanian crown forests.
(3) Sustainable yields and harvested volumes are expressed in C+ log grades plus net volumes.
(4) The overall harvest is set by a long-term management plan.
Source: National Forest Inventory (1997).

Annual harvested volume

Data on harvested volumes are not collected nationally for native versus plantation forests; rather, they are subdivided into hardwood and softwood. Until recently, when hardwood plantations became more widespread, it was reasonable to assume that total hardwood volumes were almost identical to total volumes harvested from native forests, since Australian native forests consist mostly of hardwood species (with *Callitris* species being the notable exceptions in terms of timber production). Similarly, values for softwood harvests can generally be assumed to consist mostly of timber derived from plantations. The discussion below, and for plantations, makes the reasonable assumption that these rules of thumb apply for the period under discussion.

Figure 16 shows that the total volume of hardwoods harvested for all purposes from the total forest estate, including private land, in the period 1970–97 was reasonably steady. This was despite a decline in the annual harvest of hardwood sawlogs (Figure 17), which was offset by a fourfold increase in the hardwood pulplog harvest (Figure 18). Native forests have consistently provided 60 per cent or more of the total pulpwood harvest. Table 34 shows the volume of sawlogs harvested from multiple-use forests by State compared to the calculated sustainable yield over the period 1992–95.

Other tenures

In all, there are 81.7 million hectares of native forest on leasehold and other public land beyond the multiple-use and conservation reserve systems. In addition, there are 42 million hectares of native forest on private land.

Leaseholders of forested land do not automatically have the right to harvest the forest for commercial purposes – governments generally retain ownership of all vegetation on leased land – but harvesting may be permitted under licence or other arrangements. In New South Wales and Tasmania, where some leases are considered akin to private ownership, regulations governing forest clearing apply. In Queensland, a potentially extended process of converting leasehold to freehold (private) land may give the landowner immediate property rights to timbers.

Forests on other crown lands are not excluded from harvesting, although clearing regulations and, in some States, codes of practice apply. However, the occupants are generally not involved in timber production, being bodies such as the defence forces, scientific and education facilities, and utilities. On Aboriginal reserves, both the occupants and the government must agree to forest harvesting before it may occur. There are few legal constraints to the harvesting (as opposed to the clearing) of native forests on private lands.

Net harvestable area

There are few data on the area of harvestable native forest on private land or other crown land for most States and Territories, and no data for leasehold land. Table 31 uses incomplete data to estimate the net harvestable area of native forest on the other crown land and private tenures.

Standing timber volume

No national data on the timber volume occurring in native forests with tenure as private, other crown land, conservation reserve or leasehold land currently exist, and therefore cannot be summarised here.

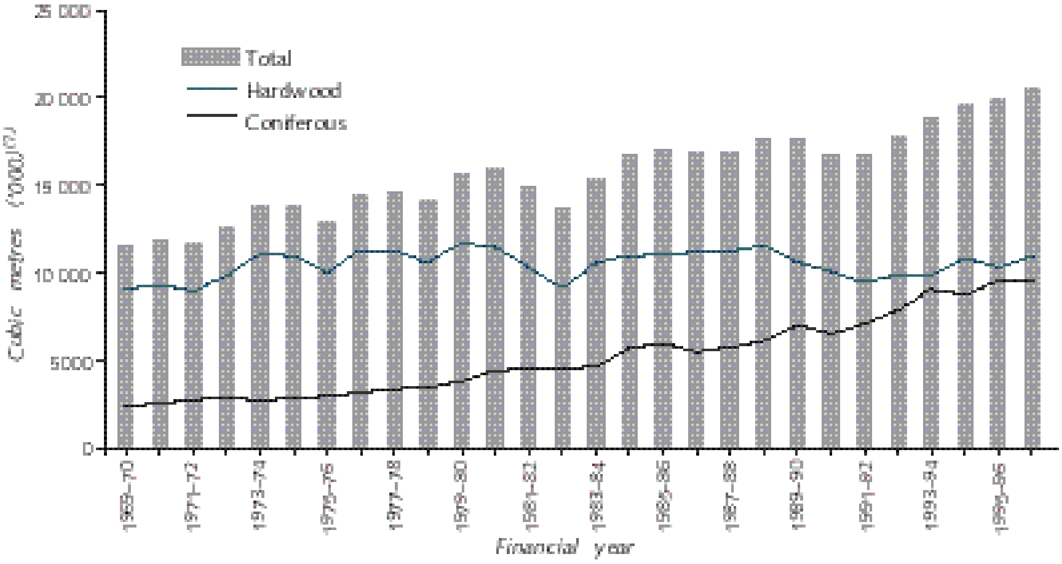
Sustainable yield

With only a few known exceptions, sustainable yield estimates are not part of management on forests other than those with multiple-use tenure.

Annual harvested volume

No data on annual harvested volume are available for forests with leasehold or other crown land tenures. Figure 19 shows the estimated production of sawlogs from private lands up to 1991, while Figure 20 shows how the harvest of sawlogs from private lands has declined as a proportion of the total harvest of native forest sawlogs in most States over the period 1951 to 1991.

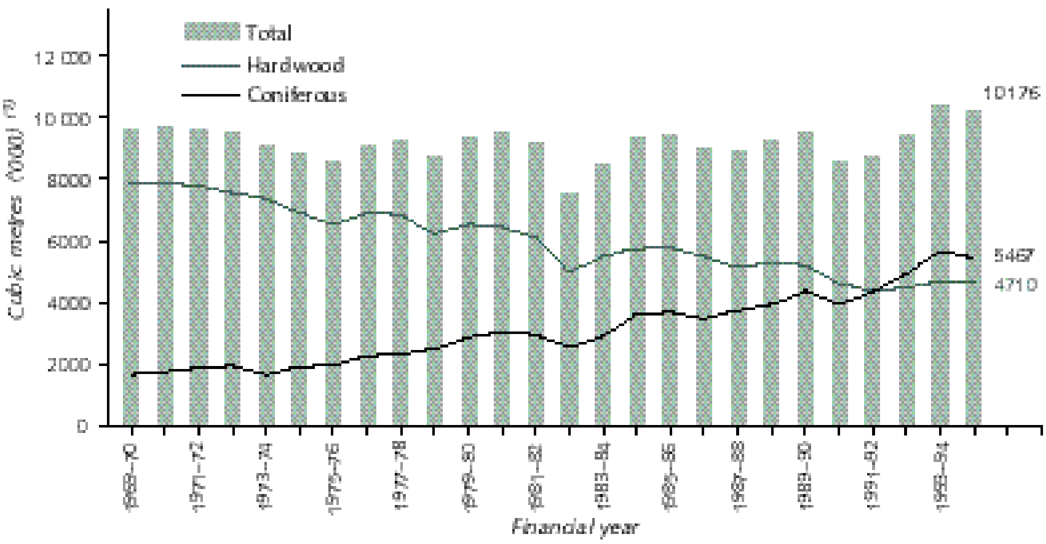
Figure 16: Annual timber harvest from the Australian forest estate, 1969–70 to 1996–97



(1) Gross roundwood equivalents

Sources:
Forest Resources (1975).
Australian Forest Resources (1976–1991).
Quarterly Forest Products Statistics (1992–1996).

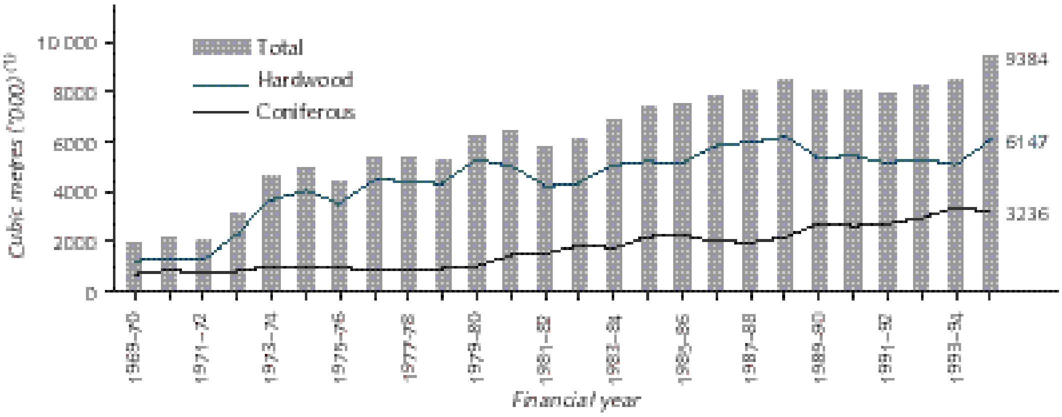
Figure 17: Annual sawlog harvest from the Australian forest estate, 1969–70 to 1995–96



Notes:
Figure includes veneer timbers, sleepers and other products.
Data not published after 1994–95.
(1) Gross roundwood equivalent

Sources:
Forest Resources (1975).
Australian Forest Resources (1976–1991).
Quarterly Forest Products Statistics (1992–1996).

Figure 18: Annual pulplog harvest from the Australian forest estate, 1969–70 to 1994–95



(1) Gross roundwood equivalent

Notes: Data is not published after 1994–95.

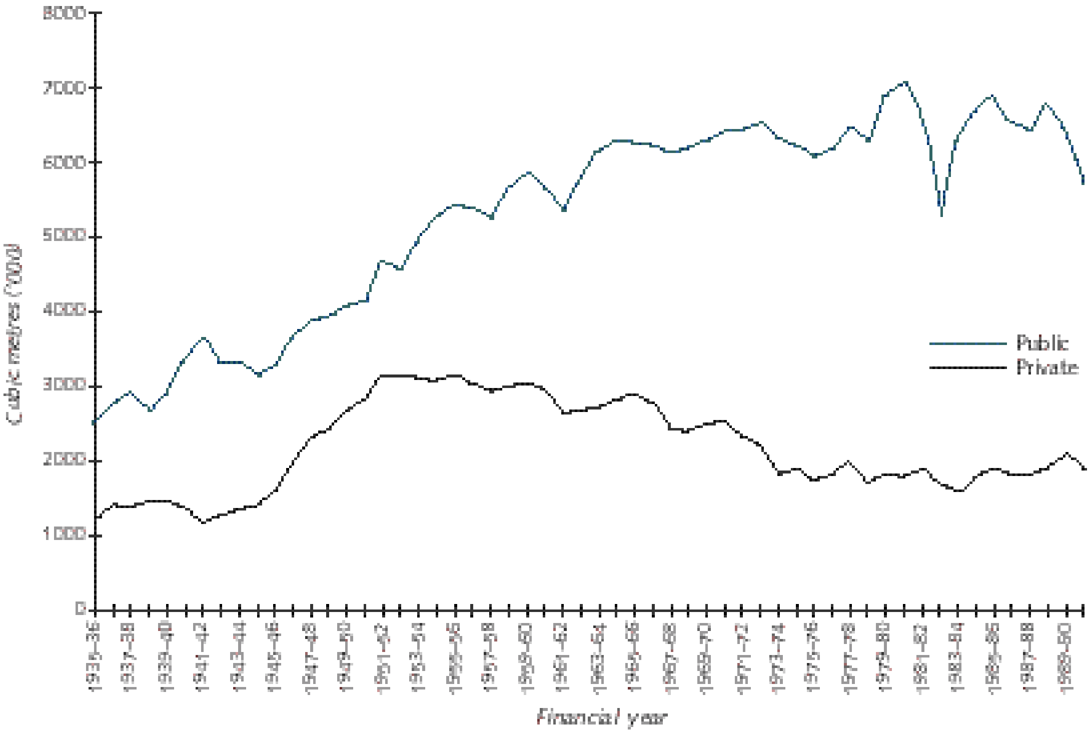
Sources:

Forest Resources (1975).

Australian Forest Resources (1976–1991).

Quarterly Forest Product Statistics (1992–1996).

Figure 19: Production of sawlogs from public and private land, 1935–36 to 1990–91

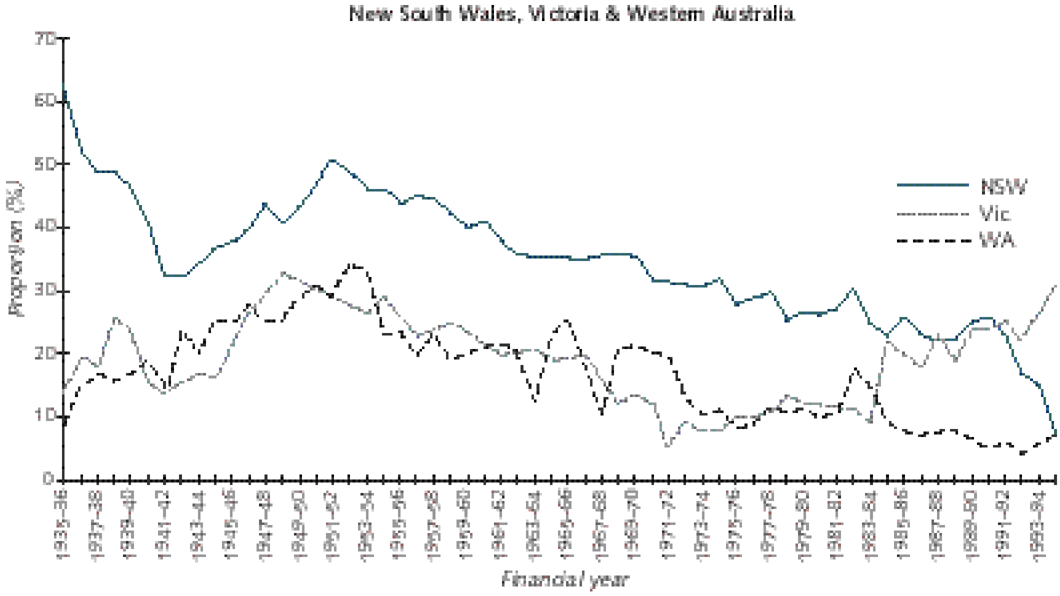


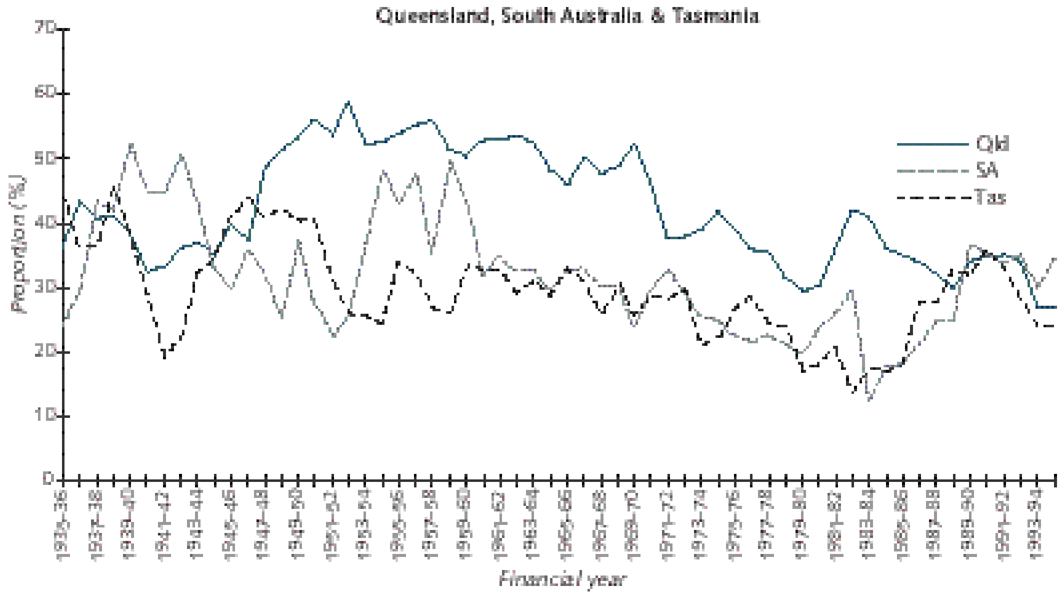
Sources:

Compendium of Australian Forest Product Statistics (1969).

Quarterly Forest Product Statistics and equivalents.

Figure 20: Proportion of sawlogs from private land, 1935–36 to 1993–94





Notes:
Data not published after 1995–96.
Sources:
Compendium of Australian Forest Products Statistics (1969).
Forest Resources (1975).
Australian Forest Resources (1976–1991).
Quarterly Forest Products Statistics (1992–1996).

Timber from plantations

Future yields

Forest managers traditionally use estimated future yields for describing potential plantation harvesting rather than timber volume of growing stock (future yields in native forests are based either solely on timber volume or a mixture of the two). A number of such estimates have been made based on a range of methods, assumptions and available data (some data are not widely available due to issues of commercial confidentiality). Table 35 shows one estimate of future yields from the softwood and hardwood plantation estates based on current plans for expansion. Other estimates vary by 10–20 per cent, due to differences in methods and available information.

Table 35: Estimated future yield of plantation timber products, 1995–99 to 2035–39

	('000 m^3/year)								
Source	**1995–99**	**2000–04**	**2005–09**	**2010–14**	**2015–19**	**2020–24**	**2025–29**	**2030–34**	**2035–39**
Softwood									
Pulpwood	4 857	4 792	3 965	3 904	3 693	3 774	3 887	3 674	3 954
Sawlogs	5 530	6 904	8 334	7 857	8 137	8 582	8 982	8 663	8 956
Veneer	175	220	251	324	333	332	330	341	335
Total	**10 462**	**11 916**	**12 550**	**12 085**	**12 163**	**12 688**	**13 199**	**12 678**	**13 245**
Hardwood									
Pulpwood	687	2 344	3 821	5 922	6 901	8 626	9 228	9 867	10 330
Sawlogs	5	15	94	120	120	120	120	120	120
Total	**692**	**2 359**	**3 915**	**6 042**	**7 021**	**8 746**	**9 348**	**9 987**	**10 450**

Note: Figures based on growers' plans for plantation expansion in January 1996
Source: National Plantation Inventory (1997).

Harvestable area

About 0.7 million hectares of plantations are managed by public forest agencies, and about 0.3 million hectares are privately owned. Taken together, Australia has a total harvestable plantation estate of just over 1 million hectares nationally.

Annual harvested volume

Annual removal of softwood (which can be assumed to represent the plantation estate during the period, although a small proportion of softwoods originate from native forests) has risen steadily from nearly 2.5 million cubic metres (about 20 per cent of the total harvest) in 1970 to almost 9 million cubic metres (just under half the total harvest) in 1994 (Figure 16).

Figure 17 shows that the annual harvest of softwood sawlogs rose from 18 per cent of the total sawlog harvest in 1970 to 54 per cent in 1994. Figure 18 shows that the volume of softwoods directed towards the manufacture of pulp increased quite steadily in the same period, from just under three-quarters of a million cubic metres in 1970 to 3.3 million cubic metres in 1994.

Grazing

Livestock grazing is the predominant form of land use over leasehold and privately owned forests, which comprise in excess of 108 million hectares or nearly 70 per cent of the total forest estate. Grazing is also practised widely on other crown land and in the multiple-use forests of Queensland and northern New South Wales. In Queensland, the Forestry Act specifically requires managers of the publicly owned forest estate to pay due regard to 'the benefits of permitted grazing'. Consequently, approximately 3.2 million hectares are currently grazed and have been in most areas since the late 1800s. In some circumstances, grazing by feral animals and native animals may affect forest health and structure.

There is an extensive body of literature relating to pasture and grazing productivity, only some of which relates to forested environments. Broadly based ecological studies are only now beginning to shed light on the ecological impacts and sustainability of grazing in Australian forests.

Depending on stocking rates, vegetation may be physically damaged or killed through excessive browsing, rubbing and crushing; soil may be compacted and eroded; water sources may be polluted; fire frequencies may be changed; vegetation may be cleared to enhance fodder production; and weeds may spread. Young trees and understorey species can be damaged, affecting recruitment and consequent forest structure.

In some circumstances, controlled grazing can be used to provide a cost-effective means of reducing fire hazard and controlling unwanted or surplus vegetation, particularly in cypress pine forests.

Table 36: Proportion of forests managed for recreation and tourism, in relation to the total native forest area

Tenure category	Total area of forest and woodlands in Australia (excluding plantations) (ha)[4]	Area of forested land reported by States as managed for recreation (ha)[1]	Percentage of forested land managed for recreation(%)[1]
State forests	13 350 989	10 584 513	79.28
Nature conservation reserves	17 580 191	10 825 947	61.58
Other crown land	15 596 781	11 966 731	76.73
Private land[2]	42 017 712	10 384	0.02
Leasehold land[3]	66 102 940		
Unresolved tenure	1 186 035	N/A	N/A
Total	**155 834 648**	**33 387 576**	**21.43**

Note: No data are available for the NT.
N/A – Not applicable.
[1] *These totals represent the area available for recreation.*
[2] *Very little data was returned for this tenure.*
[3] *No States or Territories reported information regarding leasehold lands.*
[4] *National Forest Inventory (1997).*
Sources: Montreal First Approximation Report (1997).

Tourism and recreation

The majority of urban Australians seeking forest-based recreation do so primarily in multiple-use forests and conservation reserves because these tenures are generally available for a wide range of recreation activities.

In principle, all public forested lands – except for some scientific reserves, cultural areas, or where current timber harvesting operations preclude it – are available for general recreation and tourism. However, data on public, leasehold or private forests managed for recreation are not available. Table 36 shows the area and percentage of forests available for general recreation and tourism, although these data are incomplete.

Table 37 shows the facilities available for forest-based recreation and tourism by tenure. The two most populous States, Victoria and New South Wales, have the greatest number of recreation facilities. South Australia, which is less populous and whose production forests are primarily pine plantations, reports the smallest number of facilities.

There is as yet no standard method for reporting visitor use of forested areas. Moreover, parks that offer both forest and non-forest facilities may collect data on the number of users at the point of entry but not on which attribute of the park was used. Table 38 shows the amount of visitor use that forests in national parks, multiple-use forests and other crown land received in 1995. These figures, while incomplete and of variable reliability, due partly to the factors noted, give some indication of the role that forests play in providing opportunities for recreation.

Mining

Map 14 (see colour section in back of book) shows the known locations of mineral deposits on forested land. There are no nationally collated data on the amount of forest subject to mining or quarrying. Most mining activity in forests is restricted to access corridors and relatively small areas at the mine site. Some types of mine, such as surface mines for bauxite and coal, convert rather larger areas to non-forest, but most regenerate tree cover after mining ceases. The nature of the rehabilitation is usually different from the forest it replaced, although local species are often used.

Table 37: Recreation and tourism facilities related to forests (partial summary)

Tenure / **Facility**	ACT				NSW				NT				Qld			
	Facilities		Trails		Facilities		Trails (1)		Facilities		Trails		Facilities		Trails	
	Number	Number per million of population	Kilometres	Kilometres per million of population	Number	Number per million of population	Kilometres	Kilometres per million of population	Number	Number per million of population	Kilometres	Kilometres per million of population	Number	Number per million of population	Kilometres	Kilometres per million of population
Multiple-use																
Picnic sites with little development	139	457			239	39			ND				65	20		
Developed campsites with toilets	5	16			112	18			ND				31	9		
Visitor centres	0	0			35	6			ND				0	0		
"grandstand" developments > $1m	0	0			1	0			ND				0	0		
Walking Trails			32	105	114	19	(2)				ND		620	189	(2)	
Conservation Reserves																
Picnic sites with little development	6	20			281	46			ND				144	44		
Developed campsites with toilets	3	10			128	21			ND				81	25		
Visitor centres	1	3			14	2			ND				19	6		
"grandstand" developments > $1m	0	0			6	1			ND				9	3		
Walking Trails			184	605			1 296	212			ND				986	301
Other																
Picnic sites with little development	ND				ND				ND				ND			
Developed campsites with toilets	ND				ND				ND				ND			
Visitor centres	ND				ND				ND				ND			
"grandstand" developments > $1m	ND				ND				ND				ND			
Walking Trails			ND				ND				ND				ND	
Private																
Picnic sites with little development	ND				ND				ND				ND			
Developed campsites with toilets	ND				ND				ND				ND			
Visitor centres	ND				ND				ND				ND			
"grandstand" developments > $1m	ND				ND				ND				ND			
Walking Trails			ND				ND				ND				ND	
Leasehold																
Picnic sites with little development	ND				ND				ND				ND			
Developed campsites with toilets	ND				ND				ND				ND			
Visitor centres	ND				ND				ND				ND			
"grandstand" developments > $1m	ND				ND				ND				ND			
Walking Trails			ND				ND				ND				ND	
Population ('000)(6)			**304**				**6 115**				**174**				**3 277**	

SA				Tas				Vic				WA				Australia(7)			
Facilities		Trails		Facilities		Trails		Facilities		Trails		Facilities		Trails		Facilities		Trails	
Number	Number per million of population	Kilometres	Kilometres per million of population	Number	Number per million of population	Kilometres	Kilometres per million of population	Number	Number per million of population	Kilometres	Kilometres per million of population	Number	Number per million of population	Kilometres	Kilometres per million of population	Number	Number per million of population	Kilometres	Kilometres per million of population
7	5			(3) 94	199			450	100			212	122			1 206	67		
10	7			32	68			78	17			49	28			317	18		
2	1			0	0			1	0			2	1			40	2		
0	0			0	0		(4)	1	0			2	1			4	0		
		15	10			700	1 480			250	56			1 711	988			2 708	319
ND				11	23			900	200			ND				1 342	91		
ND				53	112			350	78			ND				615	42		
ND				4	8			10	2			ND				48	3		
ND				6	13		(5)	2	0			ND				23	2		
		ND				2 849	6 023			2 400	533			ND				7 715	526
ND				26	55			1 800	400			ND				1 826	367		
ND				37	78			600	133			ND				637	128		
ND				1	2			50	11			ND				51	10		
ND				1	2			5	1			ND				6	1		
		ND				(5)				1 000	222			ND				1 000	222
ND				ND				ND				ND				ND			
ND				ND				200	44			ND				200	44		
ND				ND				2	0			ND				2	0		
ND				ND				ND				ND				ND			
		ND				ND				ND				ND				ND	
ND				N/A				ND				ND				ND			
ND				N/A				ND				ND				ND			
ND				N/A				ND				ND				ND			
ND				N/A				ND				ND				ND			
		ND				N/A				ND				ND				ND	
1 474				473				4 502				1 732				18 054			

Footnotes from table 37

Notes: Column or row total may not add up due to rounding.
ND - No data
N/A - Not applicable
MUF - Multiple Use Forests
(1) Does not include management trails used by walkers.
(2) New South Wales and Queensland MUF walking trails are reported in number rather than kilometres.
(3) Defined as any area which has any more facilities than a carpark eg. interpretation, tracks, picnic tables—sites with little infrastructure or development.
(4) Approximate length.
(5) Trails on Other Crown Land have been included with Nature Conservation Reserves.
(6) Australian Bureau of Statistics (1997) Year book Australia, 1995 data.
(7) Averages are calculated for states with data only.
Source: Montreal First Approximation Report (1997).

Table 38: Visitor use of forests in 1995

	Number of visitor days in 1995 ('000)								
Tenure	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Conservation reserves	140	20 148		701	ND	900	12 960		34 708
Multiple-use	735	4 000		2 000	180	400	3 500		10 080
Other	ND	ND		ND	ND	500	30 000		30 500
Total	**875**	**24 148**		**2701**	**180**	**1800**	**46 460**	**960**	**76 248**

ND - No data
Source: Montreal First Approximation Report (1997).

Table 39: Estimated total forest biomass and carbon pool

Forest type	Forest area (ha)	Average biomass weighted by area (tonnes/ha)	Total forest ecosystem biomass (million tonnes)	Total forest eco-system carbon pool (million tonnes)	Published source
Closed forest	4 627 299	377	1 744	873	1
Open forest	39 174 675	245	9 616	4 809	1, 2
Woodland	112 032 674	131	14 652	7 327	1, 2
Plantation	1 042 570	244	254	127	3
Total	**156 877 218**	**167**	**26 266**	**13 136**	

1 = Gifford et al. (1992).
2 = Grierson et al. (1992).
3 = National Plantation Inventory (1997); National Greenhouse Gas Inventory (1996).
Source: Montreal First Approximation Report (1997).

Other forest uses and products

There are no national, State or Territory processes for systematically recording the use of non-wood forest products. Many native forests and some plantations are used for the production of firewood. The quantity of firewood extracted is significant. It has increased steadily from 6.8 million tonnes in 1988 to 8.1 million tonnes in 1995.

Exotic honeybees are widespread in the forests of all States except South Australia, often supporting industries based on honey and beeswax. In some areas, honeybees pollinate native forest tree species during part of the year and agricultural crops at other times. Australian wildflower, foliage and live-plant sales, including many species from forests, have reached significant levels, both domestically and internationally. Australian bush foods and bush medicines are also growing in popularity.

Some animal species are also being used commercially: for example, the brushtail possum is harvested in Tasmania under an approved management plan. Other non-timber products harvested from forests include berries and game.

Awareness of the economic potential of non-wood forest products such as these is growing, but information about them is generally available by product sector (such as honey production) rather than by the vegetation type from which they originate. Thus, it is difficult to distinguish forest from non-forest production.

Contribution to the carbon cycle

Observed levels of atmospheric carbon dioxide (CO_2) have increased globally from 280 parts per million in 1750 to over 350 parts per million in the 1990s. The majority of this additional CO_2 has been emitted through the burning of fossil fuels and clearing of vegetation, particularly in tropical regions, and has been accelerated by industrial development and population growth. The weight of scientific evidence suggests that increased levels of atmospheric CO_2 and other greenhouse gases such as methane cause an 'enhanced greenhouse effect' that may lead to global climate change.

Australia's forests are estimated to store 13.1 billion tonnes of carbon (Table 39). Although most forests are absorbing carbon through growth, carbon is also released to the atmosphere through processes of decomposition. 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. Substantial contributions of carbon to the atmosphere occur through clearing and burning.

Estimating Australia's CO_2 sinks and emissions from forest management and clearing is made difficult by numerous uncertainties in the data. Australia's most recent national greenhouse gas inventory (NGGI) report was produced in 1997; it estimated that land use change and forest management activities caused the annual release of 75 million tonnes of CO_2 (or CO_2 equivalents) into the atmosphere. This estimate was considerably lower than the 1990 NGGI estimate of 153 million tonnes, due mainly to reduced vegetation clearing and a revision of the estimates of carbon in the vegetation removed. The greatest proportion of emissions in the forest sector is due to permanent clearing of forest in favour of other land uses.

Table 40 presents data on the contribution of multiple-use forests to global atmospheric carbon reported in 1997. These suggest that such forests were a net sink in that year, absorbing a net amount of about 19.5 million tonnes of CO_2.

Table 40: Contribution of multiple-use forest growth and harvesting to global atmospheric carbon

Contribution	Emissions ('000 tonnes) C	CO_2
Total annual growth increment	-20 396	-74 786
Total annual harvest	+13 462	+49 361
Net emissions	-6 394	-25 425

Note: Negative values indicate net absorption from the atmosphere; positive values indicate net additions to the atmosphere.
Source: National Greenhouse Gas Inventory Committee (1997).

Fire

Australia is particularly fire-prone due to the nature of its vegetation and climate. Variation in climates and soils produces forests with different rates of fuel accumulation and flammabilities and different ignition frequencies. Wet forests can have a high fuel load but a low probability of ignition; woodlands in northern Australia can have low fuel loads but frequent fires due to high levels of ignition during the dry season. Within a region, different locations can experience different fire intensities and frequencies.

Fire regimes have varied over geologic time. The wetter, rainforest-clad continent of 45 million years ago has dried out. The vegetation has changed to a sclerophyllous flora in many areas and fire frequency (time between fires) and intensity have increased. Climatic oscillations produce drier periods with opportunities for fire and the contraction of wetter plant communities; these communities expand during wetter periods with few fires.

Indigenous occupation increased the frequency of fire as Indigenous peoples used fire as a tool to assist hunting and other activities. This deliberate burning appears to have been highly selective – frequent in some areas and virtually absent in others. European settlement altered existing fire regimes, initially through increased fire frequency associated with land clearing and, more recently, through large-scale hazard-reduction and other burning to assist with fire suppression in settled areas and to achieve forest management objectives, such as removing debris before forest regeneration and managing habitat. In some areas, such as conservation reserves, fire has been artificially excluded, which also has impacts on forest structure and diversity. There is debate over the extent to which present-day fire regimes reflect the regimes in place in pre-European times.

The frequency of hazard-reduction burning mainly depends on the forest type, fuel accumulation and the location of forests in relation to assets. It ranges from a 2-year interval for northern woodlands to 6–8 years in some dry eucalypt forest. Most agencies managing forests use a flexible approach to burn rotations and burning season.

Ecological effects

The ecological effects of a given fire regime vary depending on intensity, frequency, the season of burn and the nature of the forest. Plants and animals in any particular region have evolved with the pre-existing fire regime, so alterations to this regime may have ecological impacts. In temperate fire-prone forests, a single high-intensity fire may have less long-term impact on the biota than several low-intensity fires in quick succession. In rainforests, a single fire can cause local extinctions. In some eucalypt forests, fuel build-up during a long period without fires can lead to high-intensity fires, while long-unburnt forest areas are crucial as habitat for some fauna and flora. The northern woodlands are adapted to high-frequency, low-intensity fires.

A characteristic of fire in the Australian landscape is its great spatial and temporal variability. In any single fire event, whether a wildfire or a prescribed fire, there is considerable variation in fire intensity, and some areas do not burn at all. These unburnt areas can be important refugia for some plants and animals, allowing the recolonisation of burnt areas.

Many Australian plant species have adapted to survive a wide range of fire regimes, having features such as woody fruits, hard-coated seeds and epicormic buds protected by thick bark or lignotubers located below ground. Most eucalypts readily survive fire, and some may require it periodically for their continued persistence. Periodic fire is also important for the regeneration of hard-seeded *Acacia* and other legume species that are important for nitrogen recycling and replenishment.

The site and weather conditions following fire are also important factors that help determine the species of plants that survive the fire. For example, ash on the ground and increased exposure to light and warmth create a situation in which regrowth from seed will be stimulated if good rains occur soon after fire. However, if germination is not initiated quickly, seed predation may alter forest composition.

The extent of fire

There are no consistent continental-scale data on the amount of forest burned annually by either bushfire or prescribed burning: statistics for this were reported until recently, but their collection was discontinued because of problems with consistency and meaning.

Forest health

Animal pests, weeds and pathogens can cause degradation of forests, even to the extent of changing their structure and species composition on a long-term basis. They can also change the capacity of the forest to provide clean water or defect-free timber and to act as habitat for native flora and fauna. Control measures are often difficult, costly or impractical.

Australia's native forests are affected by a range of indigenous pests and pathogens, the

Box 11: Fire disasters

On 27 December 1790, two years after the British settled in Sydney, the first recorded 'blow-up' or fire disaster occurred, giving the new settlers a taste of the hazards posed by Australia's fire-prone environment.

In the last 60 years, several bushfires have caused levels of loss and damage that have profoundly affected Australian society. Some of the most devastating were:

1939:	Black Friday bushfires in Victoria
1951–52:	summer bushfires in south coastal New South Wales
1957:	bushfires in the Blue Mountains, New South Wales
1961:	Dwellingup bushfires, Western Australia
1967:	7 February bushfires in Tasmania
1968:	severe widespread fires in coastal New South Wales
1983:	Ash Wednesday bushfires in Victoria and South Australia
1994:	bushfires surrounding Sydney.

The losses in these fires have been considerable. For example, in the Ash Wednesday fires, 77 people were killed, and 2528 houses, 5 sawmills and 23 000 hectares of plantation timber were destroyed. The direct cost was estimated to be $400 million.

In January 1994, fires in eastern New South Wales burned more than 800 000 hectares of forest, prompting the largest fire suppression operation in Australia's history. Fires burned through urban parkland to within 7 kilometres of Sydney's central business district. Four people died in the fires and 205 properties were burnt.

populations of which may fluctuate depending on the growth stage of the forest and climatic conditions. They may cause damage ranging from short-term reductions in growth rate to the killing of trees, leading to progressive stand degeneration. Some native animals (such as possums) may cause defoliation while others (such as wallabies) may reduce the success of regeneration. Conversely, the loss or diminution in range or abundance of some species, particularly those that play key roles in ecosystem processes within the forest, may adversely affect forest health.

Native forests may be invaded by organisms that have been introduced to Australia. These include various weed species that may invade communities and displace native species, fungal species such as *Phytophthora cinnamomi* that may kill a wide range of understorey and overstorey species (leading to changes in structure and species composition of the forest), and exotic animals such as foxes and feral cats that can decimate populations of native animal species. These introduced species can impact on the conservation and commercial values of forests: appropriate international quarantine measures are necessary to limit further introductions of organisms that may adversely affect the health of forest communities.

Exotic tree species used in plantation forestry in Australia (mainly *Pinus* species) have been maintained relatively free of pests and diseases. A small number of insects and pathogens (such as the Sirex wasp, *Dothistroma* needle cast, and several species of bark beetles) have been introduced accidentally from overseas; these can cause tree death and growth losses. Native species of insects or pathogens are not known to have adapted to exotic plantation species to the extent of causing serious damage.

Determining the extent to which pests and pathogens affect forest health is of considerable importance in assessing the state of the forests, but it is also an extremely difficult task. Currently, there are no quantitative national data on the pest and pathogen impacts that occur in Australia's forests. However, there are national threat abatement plans being prepared for serious pests such as foxes and diseases such as *P. cinnamomi*.

For this report, conservation and production forest agencies in every State and Territory were asked to identify animal and plant pests in the forests they manage and to assign a subjective score of severity. Private forest and plantation owners were not surveyed.

The agency responses, along with additional information taken from their annual reports, have been summarised by State and Territory in Table 41, which lists some of the major animal pests that occur in Australian forests, and Table 42, which lists some of the major plant pests negatively affecting the forests. Scientific names are given alongside common names in the tables.

Some consequences of major pests and diseases are discussed below.

Dieback in native forests

Dieback is a frequently used term in relation to forest health. A number of specific pests and pathogens cause non-specific crown symptoms of progressive shoot, twig and branch dieback. Likewise, our forests are sometimes affected by dieback resulting from a complex interaction of factors, none of which is necessarily the primary cause. Combinations of factors associated with dieback include some or all of drought, exposure to frost and heat through clearing, soil and water changes through pasture management, insect defoliation, secondary pathogens and tree age. Lack of regeneration through grazing may prevent stand replacement when the stress factors abate. The term 'dieback' should be restricted to those conditions of complex origin where there is not necessarily one primary cause of disease.

Dieback of non-specific origin occurs in forests and undoubtedly occurs in all States and Territories from time to time. Notable examples of diebacks of complex origin include regrowth dieback of ash-type eucalypts in parts of Tasmania in the 1960s and 1970s; and dieback of mixed eucalypt woodlands and scattered trees in the tablelands of eastern Australia from southern Queensland to Victoria, extending into Gippsland and drier areas of central Tasmania. An extreme example of such a syndrome in the northern tablelands of New South Wales in the 1960s and 1970s was called New England dieback.

Major pathogens in native forests

Two of the most widespread pathogens in Australia, *Phytophthora* and *Armillaria* species, cause dieback-like diseases. *Phytophthora*, especially *P. cinnamomi* or cinnamon fungus, which was probably introduced not long after European settlement, is extremely damaging. This fungus causes the roots of trees and other plants to rot, often to such an extent that the plant dies because it is unable to obtain sufficient moisture from the soil to survive. In highly susceptible genera (such as *Banksia*, *Grevillea* and *Dryandra*), over 80 per cent of individuals may die. *P. cinnamomi* is widespread in the *Eucalyptus marginata* (jarrah) forests, heaths and coastal sand plain vegetation of south-west Western Australia. Together with some other *Phytophthora* species, it causes serious disease in low-elevation forests and heath communities in southern Victoria and Tasmania.

Native *Armillaria* species also cause significant problems in south-eastern Australia and south-west Western Australia: many eucalypt and understorey species are vulnerable to infection and killing. *Armillaria luteobubalina*, a native fungus, is the most widespread. It is considered to be the primary cause of dieback in the mixed species dry forests of central Victoria and is damaging *E. diversicolor* (karri), *E. marginata*, *E. wandoo* (wandoo) and coastal dune forests in south-west Western Australia and drier forests in eastern Tasmania. It also affects orchards and amenity trees in various parks and gardens around the country. Other *Armillaria* species may be involved in other dieback syndromes, where they act as secondary pathogens, killing trees stressed by drought or insect defoliation.

Leaf pathogens are very common in eucalypt forests. They may cause extensive defoliation under some seasonal conditions, but generally do not cause long-term problems. Foliage fungi may also cause losses in plantations. Although most concern has been for the potential impacts of *Mycosphaerella* foliar disease on *E. globulus* (Tasmanian or southern blue gum) plantations, a severe epidemic occurred in *E. nitens* (shining gum) plantations in north-west Tasmania in 1996. *Aulographina eucalypti*, another fungus associated with defoliation and severe leaf spotting, was reported to be a problem in some eucalypt plantations in higher rainfall areas of New South Wales. This species has also been associated with occasional significant defoliation events in some forests in south-eastern Australia.

In cool temperate rainforests in Tasmania and Victoria, the dominant tree species *Nothofagus cunninghamii* (myrtle beech) can be affected by a sapstreak disease caused by the native fungus *Chalara australis*. The pathogen is dispersed aerially and by root contact and kills patches of trees, leading to subsequent regeneration of the affected areas by *N. cunninghamii* and other rainforest species.

Pathogens in plantations of exotic species

Needle blight or needle cast disease caused by the fungal pathogen *Dothistroma septospora* is widespread in eastern Australia and has been locally severe in *Pinus radiata* plantations in New South Wales and north-eastern Victoria. Unlike in New Zealand, where the higher annual rainfall and more consistent seasonal distribution of precipitation favours epidemic disease every year, *Dothistroma* needle blight in Australia has required relatively infrequent control measures. The disease can be controlled efficiently by aerial application of fungicide; in addition, growers in high hazard areas are moving to *Dothistroma*-resistant genotypes developed in New Zealand.

Cyclaneusma minus causes needle cast in *P. radiata*. Disease severity is variable and is highest in cool, moist environments. *Sphaeropsis sapinea* is also widely distributed in pine plantations, causing shoot death in crowns of all age-classes, and is typically most severe after stem damage caused by fire, insects, mechanical wounds, hail or drought. The fungus also causes blue stain of timber after harvest. Root rots caused by both native and introduced pathogens may be locally important.

Nursery diseases

Numerous pathogens may affect planting stock grown in nurseries. They may cause damping-off, root rot and defoliation of both hardwood and softwood species. Important genera include *Fusarium*, *Phytophthora*, *Pythium* and *Botrytis*. These problems are controlled by a combination of nursery hygiene, nursery management and chemical application.

Weeds

Nationwide, 48 plants are widespread or serious pests in native production forests and plantations. Of these, *Rubus fruticosus* (blackberry) is the most extensive and damaging, occurring in every State and Territory except the Northern Territory. Rubber vine (*Cryptostegia grandiflora*), originally a native of Madagascar, now densely covers more than 700 000 hectares of land in tropical and sub-tropical Queensland and threatens dry rainforest remnants in the monsoonal belt. Gamba grass (*Andropogon gayanus*) is considered to pose a risk to some woodlands and forests in the Northern Territory by virtue of its ability to drastically alter fire ecology.

Species of several Australian genera, particularly *Acacia*, *Eucalyptus*, *Melaleuca* and *Leptospermum*, are widespread in pine plantations and are often regarded as weeds there.

Insect pests

A number of native and exotic insects are considered pests in plantations and native forests managed for timber production. These can be grouped into broad categories:

- *Defoliators and leaf miners*: many moth, beetle and sawfly species eat eucalypt leaves, particularly new growth, at some stage of their life cycle. For this reason, they can sometimes cause extensive damage in young plantations and regrowth forests, as well as harm young trees in mature forests.
- *Sap-suckers*: this group of insects comprises two broad types: scale insects and psyllids that secrete protective coverings (lerps), and bugs. Scale insects may also secrete ant-attracting honeydew which, in turn, may promote fungal growth. Psyllids defoliate some tree species by sucking the sap from growing shoots, often infesting frost-damaged trees.
- *Wood and bark borers*: some insects eat the wood of trees or set their larvae in it. Wood boring pests in Australia include termites and the larvae of beetles, moths and wasps.

Some exotic species used by industry may have deleterious ecological effects. Exotic honeybees (*Apis mellifera*), for example, may compete

Table 41: Animal pests in Australian forests, by State and Territory.

	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
Mammals								
Cats	★	–	–	◆	–	*	–	★
Deer	–	–	–	*	*	–	■	–
Dingoes	■	■	*	■	–	–	*	–
Dogs	■	■	■	■	–	–	*	–
Donkeys	–	*	■	*	–	–	–	–
Foxes	◆	★	*	◆	■	–	■	◆
Goats	*	*	■	■	*	***	*	–
Hares	■	*	–	■	◆	–	*	–
Horses	***	–	–	–	–	–	*	–
Kangaroos	◆	■	■	■	■	–	■	–
Mice	■	■	■	■	■	–	*	–
Other	–	■	–	–	–	–	–	–
Pademelons	–	■	–	■	–	★	–	–
Pigs	◆	■	◆	◆	–	–	*	■
Possums	■	■	■	■	*	◆	*	–
Rabbits	◆	★	■	■	◆	★	■	■
Rats, exotic	■	*	■	*	*	–	–	*
Rats, native	*	*	■	★	–	★	■	–
Wallabies	*	■	■	★	■	◆	◆	*
Invertebrates								
Army worms (Noctuids)	–	*	■	*	–	*	–	*
Autumn gum moth (*Mnesampela privata*)	*	■	–	–	–	–	–	–
Bees	★	–	■	■	–	■	■	■
Beetle, African black	–	*	–	*	–	–	–	–
Beetle, Christmas (*Anoplognathus spp*)	■	★	■	■	–	*	■	–
Beetle, five-spined bark (*Ips grandicollis*)	*	*	–	★	★	–	–	■
Beetle, leaf / flea (Chrysomelids)	–	■	■	■	–	◆	■	*
Beetle, longicorn (Cerambycids)	–	–	–	–	–	–	–	■
Beetle, white fringe	–	*	–	■	–	*	–	–
Borers	–	–	–	–	–	–	★	–
Borers (Cerambycids)	–	■	–	–	–	*	–	–
Budworm	–	–	■	*	–	*	–	*
Cup moths (Limacodids)	–	■	–	–	–	–	–	–
Cut worm	–	–	–	*	–	–	–	–
Grasshoppers (Acridids)	*	–	■	◆	■	■	*	◆
Gumleaf skeletoniser (*Uraba lugens*)	–	■	–	–	–	–	★	*
Leaf miner	*	–	■	*	–	■	■	◆
Lerps (Psyllids)	★	★	■	■	–	■	◆	*
Millipedes	*	–	■	–	–	■	■	–
Mosquitoes (Culicids)	*	–	■	■	–	■	■	■
Saw fly (*Perga dorsalis, Pergagrapta bella*)	–	■	–	–	–	–	–	*
Stick insects (Phasmatids)	*	*	■	■	–	*	*	*
Termites (*Cryptotermes* spp, *Coptotermes* spp)	–	–	–	–	–	–	◆	■
Wasp, European (*Vespula germanica*)	■	–	■	–	–	★	*	–
Wasp, Sirex (*Sirex noctilio*)	■	■	–	*	◆	■	***	–
Weevils (Curculionids)	*	–	■	■	–	■	■	*
Wingless grasshoppers (Acrididads)	*	*	–	*	■	–	*	*
Birds								
Blackbirds	◆	*	–	–	–	–	*	–
Brush turkeys	–	–	–	■	–	–	–	–
Cockatoos	–	–	–	–	–	–	■	–
Indian mynahs	■	–	–	–	–	–	–	–
Parrots	–	–	–	–	–	–	–	◆
Starlings/sparrows	*	*	–	◆	–	–	*	–
Amphibians								
Cane toads	–	*	*	◆	–	–	–	–

* *Occurs, but is not widespread, has little impact and requires little or no control*
*** *Extent and impact is limited, but control measures are extensive*

– *Not reported*
■ *Widespread or impacting adversely*
★ *Widespread and impacting adversely*
◆ *Very widespread and having severe adverse impact*

Table 42: Plant pests in Australian forests, by State and Territory

	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
Bathurst burr *(Xanthium spinosum)*				★			*	
Bone seed	–	*	–	*	■	*	*	–
Boxthorn, African *(Lycium ferocissimum Miers)*	***	–	–	–	–	–	–	–
Bracken fern *(Pteridium esculentum)*	■	–	–	■	◆	■	■	–
Briar - Blackberry *(Rubus fruticosus)*†	◆	◆	–	■	*	★	◆	■
Briar *(Rosa rubiginosa)*	★	***	–	–	–	*	–	–
Broadleaved weeds	*	–	■	◆	★	*	–	–
Broom / Brome ††	***	★	–	–	■	■	*	–
Cobbler's Peg / Canadian Fleabane (*Erigeron canadensis*)	–	–	–	★	–	–	–	–
Cotoneaster	★	–	–	–	–	–	–	–
Crofton weed / Mist-Flower *(Eupatorium spp)*†	–	*	–	◆	–	–	–	–
Dodder / Australian Dodder *(Cuscuta australis)*	–	***	■	■	–	–	■	–
Eucalypt *(Eucalyptus spp)*	–	–	■	■	■	–	–	–
Garden escapees *(non-specific)*†	★	–	*	–	–	*	■	–
Gorse *(Ulex europaeus)*†	–	–	–	–	■	★	■	–
Grasses, exotic *(unidentified)*†	★	***	■	◆	★	*	*	★
Grasses, gamba *(Andropogon gayanus)*	–	–	★	–	–	–	–	–
Grasses, giant rats tails	–	–	–	◆	–	–	–	–
Grasses, kikuyu	*	–	–	■	–	–	*	–
Grasses, native	–	–	■	◆	–	■	–	*
Grasses, pampas†	*	–	–	–	–	■	*	–
Grasses, serrated tussock *(Nassella trichotoma)*†	*	***	–	–	–	–	*	–
Grasses. other	–	–	–	–	–	–	■	–
Groundsel bush *(Baccharis halimofolia)*†	–	*	–	■	–	–	■	–
Horehound *(Marrubium vulgare)*†	–	*	◆	–	–	–	–	–
Lantana *(Lantana camara)*†	–	■	*	◆	–	–	*	–
Melaleuca	–	–	*	■	–	–	–	–
Mimosa†	–	–	◆	–	–	–	–	–
Mistletoe	*	–	–	–	–	–	■	–
Noogoora burr *(Xanthium spp.)*†	–	***	■	◆	–	–	–	–
Paterson's curse / Salvation Jane *(Echium plantagineum)*†	*	*			■		*	
Pines *(Pinus spp)*	◆	–	–	*	■	*	■	*
Ragwort *(Senecio jacabaea)*	–	–	–	–	–	■	***	–
She-Oak *(Casuarina)*	–	–	*	■	–	–	–	*
Sollya heterophylla	–	–	–	–	■	–	–	–
St John's Wort *(Hypericum perforatum augustifolium)*†	*	***	–	–	–	*	■	–
Stinging nettle / Dwarf nettle *(Urtica urens)*	*	–	–	■	–	–	–	–
Sweet briar *(Rosa rubiginosa)*†	–	–	–	–	–	–	■	–
Tea tree *(Leptospermum)*	–	–	*	■	–	–	■	–
Thistle *(many spp)*	*	***	–	–	***	■	■	*
Tree of heaven *(Ailanthus altissima)*	***	–	–	–	–	–	–	–
Vines, creepers - Bridal	–	–	–	–	■	–	*	–
vines/creepers	–	–	*	■	–	*	*	–
Wattles *(Acacia spp)*	*	■	*	■	■	■	■	*
Willow *(Salix spp)*	★	–	–	–	–	■	*	*
Others	■	–	–	–	–	–	–	–

* *Occurs, but is not widespread, has little impact and requires little or no control*
*** *Extent and impact is limited, but control measures are extensive*

– *Not reported*
■ *Widespread or impacting adversely*
★ *Widespread and impacting adversely*
◆ *Very widespread and having severe adverse impact*

† *Garden escapees including -*
Ox-eye daisy (Chrysanthemum leucanthemum)
Calliopsis/Coreopsis (Coreopsis lanceolata)
Prickly pear (Opuntia spp)
Water hyacinth (Eichhornia crassipes)
One-leaved Cape Tulip (Humeria breyniana)
Blue Morning Glory (Ipomoea indica)
Groundsel, variable/fireweed (Senecio lautus)

†† *Broom / Bromes including -*
Great Brome (Bromus diandrus), *soft* (B. molliformis),
Madrid (B. madritensis), *red* (B. rubens),
Cape Broom (Teline monspessulana)
Chess or Choat (B. secalinus)

Source: National Forest Inventory (1997).

with indigenous bees and other native pollinators and limit pollination of some native forest plant species.

Vertebrate pests

Several native and introduced browsing animals are regarded as pests in regrowth forests and plantations. Of the introduced species, rabbits are the most destructive, causing damage to both eucalypts and pines, although goats, hares and rats also cause serious damage in some places. Among the native animals, kangaroos, pademelons, possums, native rats and wallabies are all extensive and sometimes serious browsing pests in regenerating native forests and eucalypt plantations.

Many mammals are regarded as pests in forests in which a major land use is grazing. Deer, donkeys, goats, horses, kangaroos, mice, rabbits, rats and wallabies all may compete for resources with livestock, while young, sick or injured sheep and cattle are vulnerable to predation by dingoes, foxes and wild dogs.

Foxes and cats are regarded as serious pest species in many forests. They kill significant numbers of native animals, radically altering faunal community structure and threatening the survival of some species. The now greatly reduced number of specialised native animals that feed on and disperse certain soil fungi has suggested disruptions to ecological processes involving these fungi and other ecologically related organisms.

Birds can damage trees by stripping bark from branches and shoots – often destroying the lead shoot – and by ringbarking young shoots. While this type of damage has little effect on mature trees, it can cause extensive damage to young growth in native production forests and plantations, leading to sapling loss, stunting and deformity.

Galahs (*Cacatua roseicapilla*) remove bark from their nest trees; their distribution and abundance has increased, principally in response to increased availability of crops and water. In Western Australia, preliminary studies of damage caused to new *E. globulus* plantations by parrots known as twenty-eights *(Barnardius zonarius*) indicate that silvicultural treatment to rectify all except severe damage may be economically viable.

Chemical use in forests

Where feasible, non-chemical control measures are used to control pests, feral animals, weeds and pathogens in forests. Nevertheless, the use of chemicals in some circumstances is unavoidable, although such use may have unintended consequences for other forest values.

Chemicals used in agriculture and forestry are registered and regulated up to the point of retail sale by the National Registration Authority for Agricultural and Veterinary Chemicals, a Commonwealth statutory authority established in 1993. Control-of-use programs run in each State and Territory aim to ensure that insecticides, fungicides, herbicides and other chemicals are used safely and appropriately in accordance with label directions in forestry operations. The management of pesticides in Australia is a responsibility shared by Commonwealth, State and Territory governments, users and the chemical industry. Efforts to develop a national strategy for agricultural and veterinary chemicals are currently under way.

A survey of forest-related chemical use for pest control, undertaken in 1991, found that most State and Territory forest agencies do not report on chemical use in their forests beyond qualitative assessments. An even greater and currently unaddressed problem of data collection relates to the extent of chemical use for pest control in forests with private, leasehold or other crown land tenure.

Tables 43 and 44 present information recorded in 1996 on the chemicals used by various government agencies to control pests and diseases, mostly on land with multiple-use or conservation reserve tenure. The tables give estimates of how widely, frequently, and at what concentration, such chemicals are applied.

Herbicides

Chemicals used widely in forests include glyphosate, hexazinone, metasulfuron methyl, atrazine, clopyralid and triclopyr. Use of chemicals often varies with State or Territory: atrazine, for example, is not used in multiple-use forests in Tasmania, although it is still used on private land. Most of these chemicals are used during the establishment phase of plantations and native forest regeneration to suppress competitive grasses and weeds.

Other pesticides

Table 44 shows the extent to which pesticides (other than those used against weeds) are used by forest agencies. The most heavily applied is sodium fluoroacetate (1080™), a vertebrate pesticide commonly used to control rabbits, foxes, pigs and cats. This chemical occurs naturally in some native species of plant, particularly *Gastrolobium* species. Some native animals have therefore acquired a resistance to it, allowing the poisoning of feral animals without affecting native populations.

Roads

A properly designed system of roads is essential for general access, fire protection and cost-effective transportation of forest products to market. In some areas, forest roads form an important component of the public rural road network, while their absence is important to wilderness experiences. The intensity of road development varies with land use; for example, there are more roads in plantations, less in

Table 43: Herbicides and fungicides most used in native forests and plantations, as reported by various State and Territory agencies

Chemical	Trade name or use (example only)	Hazard rating	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
2,4,5-T		2	•	•	•	★	•	•	•	•
2,4-D - Amine	Amicide	1	•	•	■	●	•	•	•	•
2,4-D ethyl ester		1 – 2	•	•	■	•	•	•	•	•
2,4-D ethyl ester 2,4,5-TB	road weed mix	2	•	•	■	•	•	•	•	•
Amitrol, Atrazine, Simazine		1	•	◆	•	•	•	•	•	•
Amitrole		1	•	◆	•	•	■	•	■	◆
Atrazine	Gesaprim	ND	•	★	■	●	■	•	■	■
Benomyl	Benlate	ND	•	■	•	•	•	■	●	•
Clopyralid	Lontrel	1	•	★	•	■	■	■	◆	■
Copper oxychloride	Leaf curl spray	ND	•	◆	•	•	•	■	◆	•
Fluazifop-P, Butyl	Fusilade	2	•	★	•	★	•	■	★	■
Flupropanate	Frenock	2	★	•	•	■	•	•	•	•
Glyphosate	Roundup	1	●	★	■	●	■	◆	◆	◆
Haloxyfop	Verdict	2	•	•	•	★	•	■	●	■
Hexazinone	Velpar	1	●	★	■	■	■	◆	◆	■
Metsulfuron methyl	Ally, Brushoff	ND	●	◆	■	■	■	■	★	◆
Non-ionic wetter	Plus 50	ND	•	◆	•	•	•	◆	◆	◆
Petroleum oil	DC Trate	ND	•	■	■	•	•	•	★	■
Picloram	Tordon	1 – 2	•	■	•	◆	•	•	■	■
Propazine	Grazon, Gesamil	ND	•	★	•	■	•	■	•	•
Simazine	Gesatop	ND	★	◆	•	●	•	•	★	●
Sulfometuron methyl	Oust	1	•	■	•	■	•	■	•	●
Triclopyr	Garlon	2	■	◆	•	★	•	■	■	■
Triclopyr,butoxy		2	•	◆	•	•	•	■	•	•
Triclopyr,Butoxy,Picloram	Grazon DS	2	•	◆	•	•	•	■	★	•

Note: concentration of the active ingredient varies between products

ND - No data

Hazard rating:
1 Hazardous
2 Poisonous
3 Extremely dangerous, requiring special precautions

• *Not reported*
■ *rare or limited, low-volume use*
★ *limited use at medium–high volumes*
◆ *widespread use at low volumes*
● *widespread use at medium to high values*

Source: National Forest Inventory (1997).

Table 44: Pesticides most used in forests and plantations, as reported by various State and Territory agencies

Chemical	Trade name or use (example only)	Hazard rating	ACT	NSW	NT	Qld	SA	Tas	Vic	WA
Sodium fluoroacetate	1080	3	★	★	•	■	◆	•[2]	★	●
Carbaryl	Carbaryl[1], Waspkil	1–2	•	■	•	•	•	■	•	•
Chloropicrin	Bromatuma	3	■	■	•	■	•	•	•	
Warfarin	Ratsak	2	◆	■	•	•	•	■	•	•
Alphamethrin	Dominex[1]	1	•	•	•	•	•	★	•	◆
Aluminium phosphide	Phostoxin	2	★	•	•	•	◆	•	•	•
Alpha-cypermethrin	Fastac	1	•	•	•	•	•	•	•	★
Chlorpyrifos	Peststrips, Lorsban	2	•	■	•	•	•	•	•	◆[3]
Trichlorfon	Dipterex	2	•	•	•	•	•	•	•	■

• *Not reported*
■ *Rare use*
★ *Limited use, volume varies from low to high*
◆ *Widespread use, volume varies from low to high*
● *widespread use at medium to high volumes*

Note: concentration of the active ingredient varies between products

[1] Some forms of this chemical are toxic to bees.
[2] 1080 is used in Tasmanian forests and plantations, but the extent and frequency are unknown.
[3] Toxic to bees in the form used.

Hazard rating:
1 Hazardous
2 Poisonous
3 Extremely dangerous, requiring special precautions

Source: National Forest Inventory (1997).

native multiple-use forests, and less again in conservation reserves.

Roads have been identified as the major source of soil erosion and water sedimentation in timber harvesting operations. They may also provide access routes for vertebrate pests such as foxes and cats, and facilitate the movement of weeds and some diseases. The extent and distribution of the road network has been used in countries such as Canada as a measure of disturbance in forests.