

1.1

ECOSYSTEM DIVERSITY

INTRODUCTION

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

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

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

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

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



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

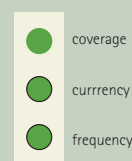
Extent of forest area by forest type and tenure

Indicator 1.1a

Extent of area by forest type and tenure

Rationale

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



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

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

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

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

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

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

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

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

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

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

Source: National Forest Inventory (2003)

¹ National Plantation Inventory (2003)² 'Total forest' area for Tasmania is sourced from the Tasmanian RFA Review (2001) and does not include more recent NPI 2003 plantation figures. Therefore the total native forest area for Tasmania is a slight overestimate due to some clearing of native forest for plantation establishment after June 2001.³ Australian Yearbook (1997)⁴ The Australian Capital Territory has 180 hectares of hardwood plantation (fuelwood) which was planted between 1988 and 1990.

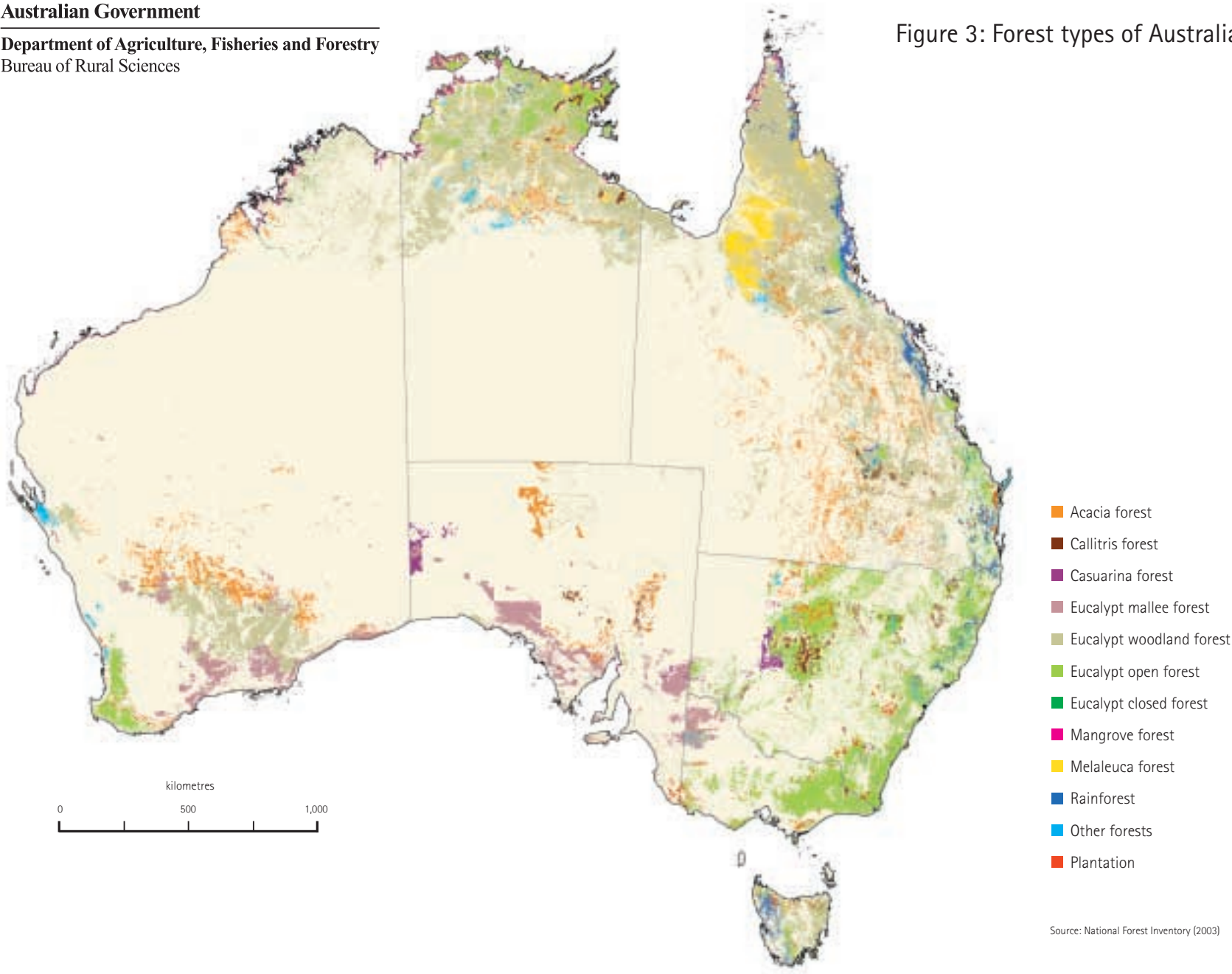
Note: All values have been rounded, hence, column and row totals may not tally exactly.



Australian Government
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Figure 3: Forest types of Australia



A photograph of a forest scene. In the foreground, a large, light-colored, textured log lies horizontally across the frame. To the left of the log is a large, dark tree trunk. In the background, a person stands among tall, thin trees. The image is partially obscured by a large, light green, curved shape on the right side.

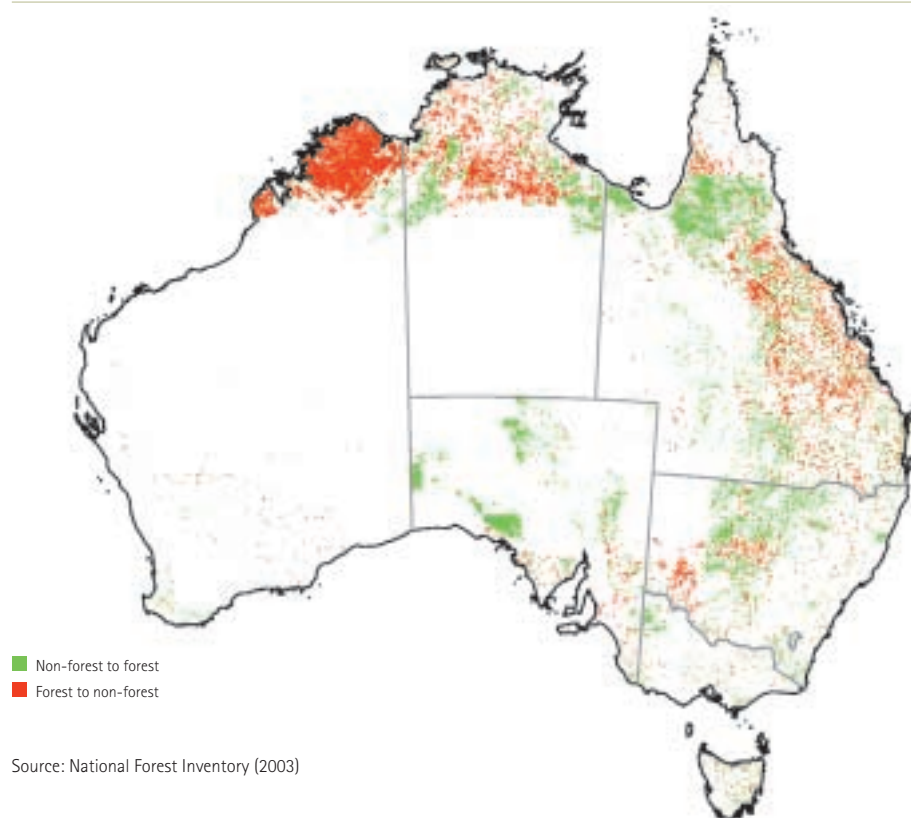
Figure 3: Forest types of Australia
(fold out)

Changes in national forest mapping between 1998 and 2003

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

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

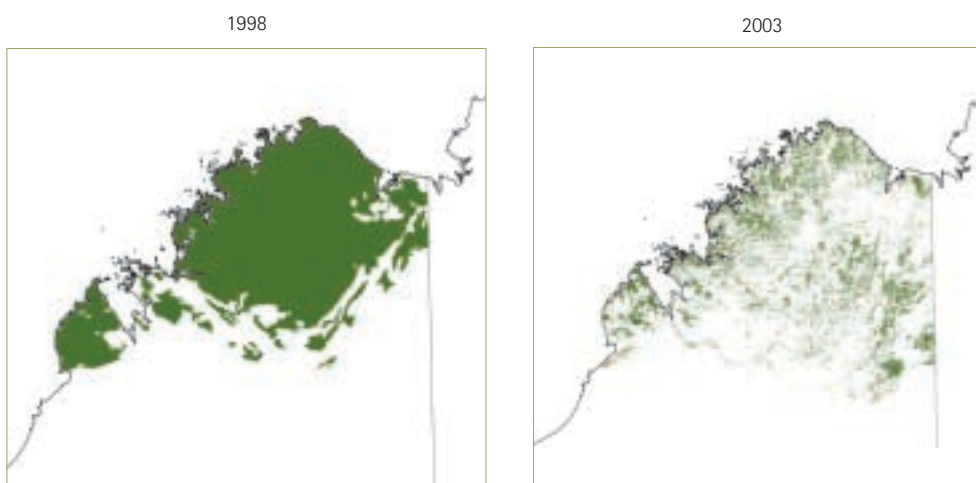
Figure 4: Changes in forest mapping between 1998 and 2003



Source: National Forest Inventory (2003)

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

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



Source: National Forest Inventory (2003)

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

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

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

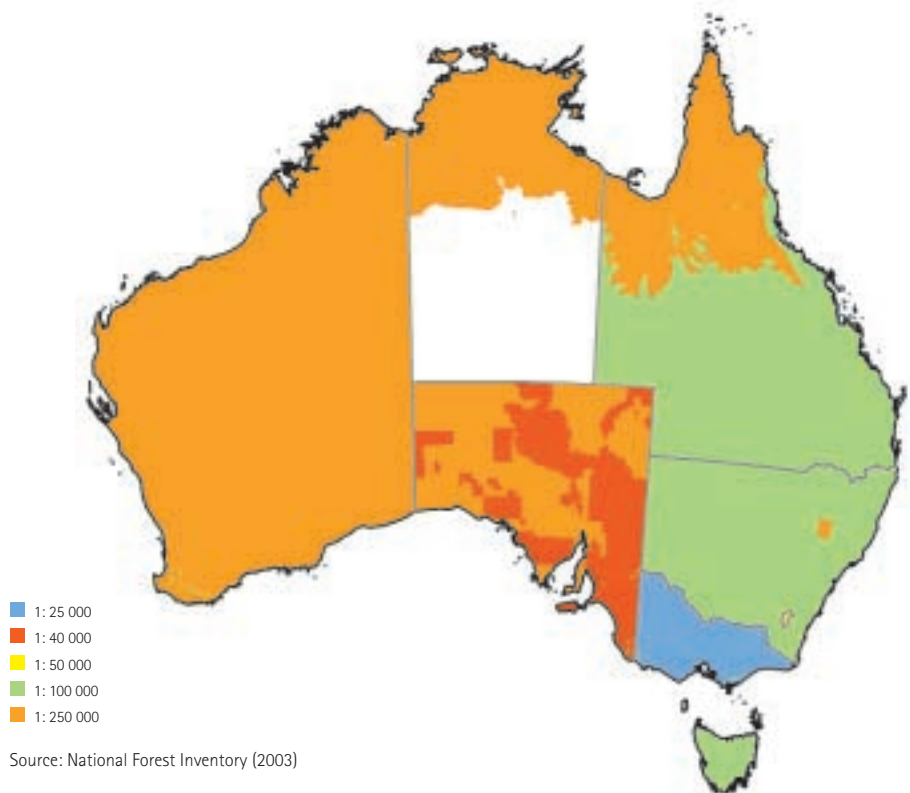


A mosaic of cleared land, pine and eucalypt forests

Scale of data compilation

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

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



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

Crown cover and height

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

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

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

Figure 7: Forest according to crown cover and height classes

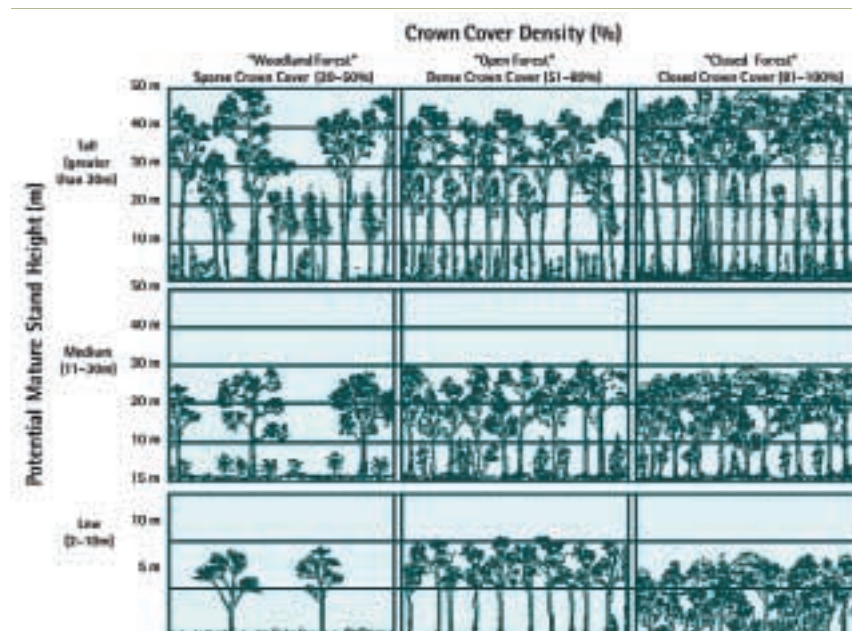


Table 4: Area ('000 ha) of forest type according to crown cover

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

Source: National Forest Inventory (2003)

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

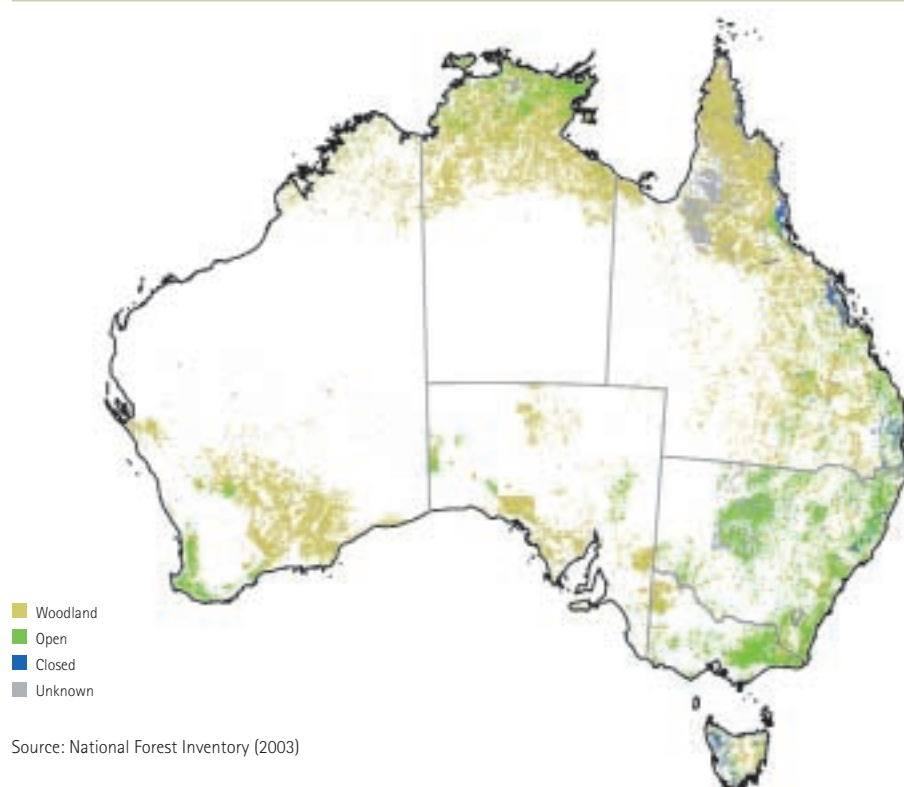
Table 5: Area ('000 ha) of native forest according to crown cover

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

Source: National Forest Inventory (2003)

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

Figure 8: Native forest according to crown cover



Source: National Forest Inventory (2003)

Tenure

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

- *Multiple-use forest* – State forest, timber reserves and other forest areas on which a range of forest values are managed including timber harvesting, water supply, conservation of biodiversity, recreation and environmental protection. They are managed by State and Territory agencies in accordance with State/Territory Acts and regulations.
- *Nature conservation reserves* – Crown lands that are formally reserved for environmental, conservation and recreational purposes. They include national parks, nature reserves, State and Territory recreation and conservation areas, formal reserves on State forest and Crown lands reserved to protect water supply catchments. This does not include informal reserves and those pending gazettal.
- *Private land* – Land held under freehold title and under private ownership. It includes land held under freehold title with special conditions attached for designated Indigenous communities.
- *Leasehold land* – Crown land held under leasehold title and generally regarded as ‘privately managed’. It includes land held under leasehold title with special conditions attached for designated Indigenous communities.
- *Other crown land* – Crown land reserved for a variety of purposes including utilities, scientific research, education, stock routes, mining, use by the defence forces, and use by Indigenous communities.
- *Unresolved tenure* – Areas identified where tenure is unknown or for which there are no data. Most of these are methodological rather than tenure issues.

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

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

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

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

¹ The National Plantation Inventory classifies plantations by ownership classes that recognise land ownership, tree ownership and joint ownership. These cannot be aggregated into the tenure classes used for native forest.

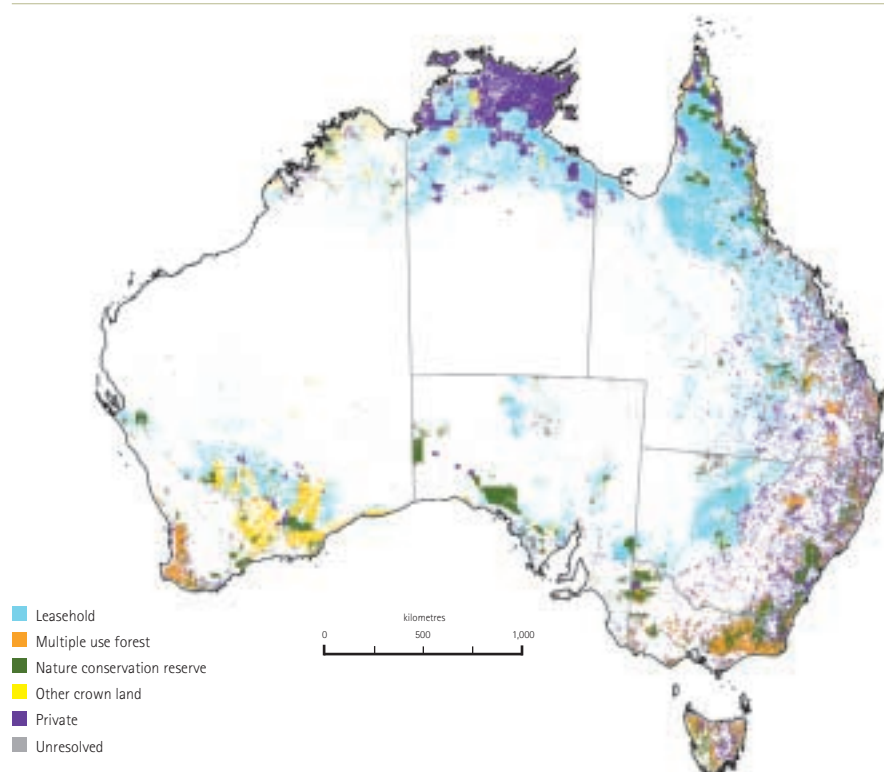
² 'Total forest' area for Tasmania is sourced from the Tasmanian RFA Review (2001) and does not include more recent NPI 2003 plantation figures. Therefore the total native forest area for Tasmania is a slight overestimate due to some clearing of native forest for plantation establishment after June 2001.

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

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

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

Figure 9: Forest according to tenure



Source: National Forest Inventory (2003)

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

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

Source: National Forest Inventory (2003)

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

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

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

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

Source: National Forest Inventory (2003)

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

Changes to tenure as a result of the Regional Forest Agreements

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

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

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

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

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

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

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

Source: National Forest Inventory (2003)

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

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

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

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

Protected areas

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

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

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

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

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

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

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

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

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

Source: National Forest Inventory (2003)

¹ All nature conservation reserve tenure, except Tasmania

² Available for RFA regions only

³ Data available for Queensland only

⁴ On tenures other than nature conservation reserve only

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

International Union for Conservation of Nature and Natural Resources categories

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

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

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

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

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

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

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

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

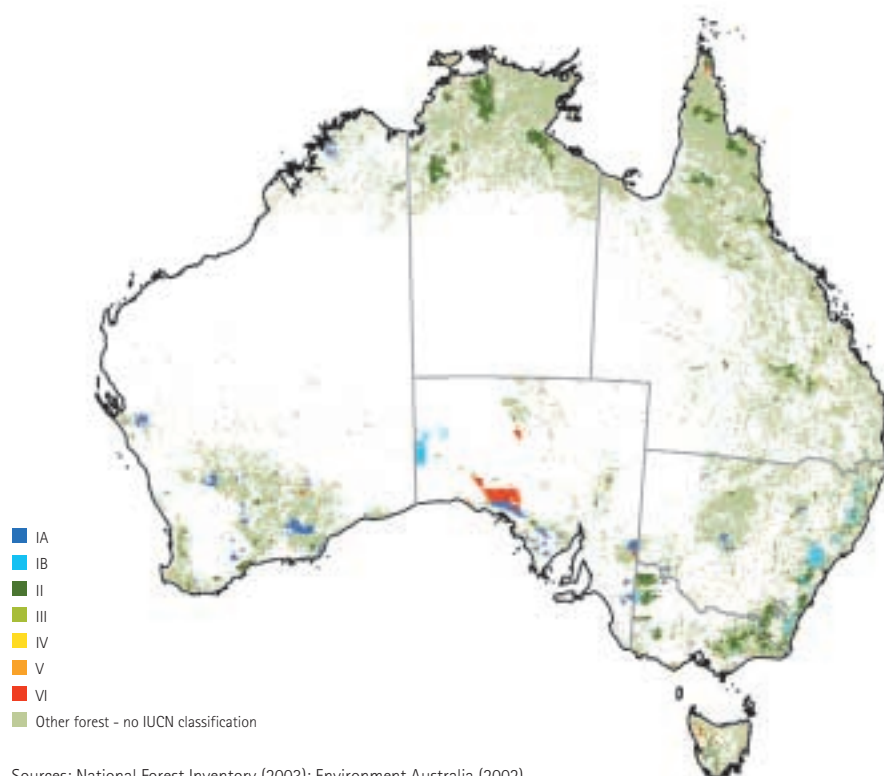
Category V – Protected Landscape/Seascape: Protected area managed mainly for landscape/seascape conservation and recreation

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

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

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

Figure 10: Areas of forest according to IUCN classification



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

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

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

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

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

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

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

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

National Estate and World Heritage Areas

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

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

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

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

From July 2000, Australia's World Heritage is protected as matter of national environmental significance under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act provides automatic protection for World Heritage Areas by ensuring that an environmental impact assessment process is undertaken for proposed actions that

will, or are likely to, have a significant impact on the World Heritage values of a declared World Heritage Area.

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

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

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

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

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

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

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

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

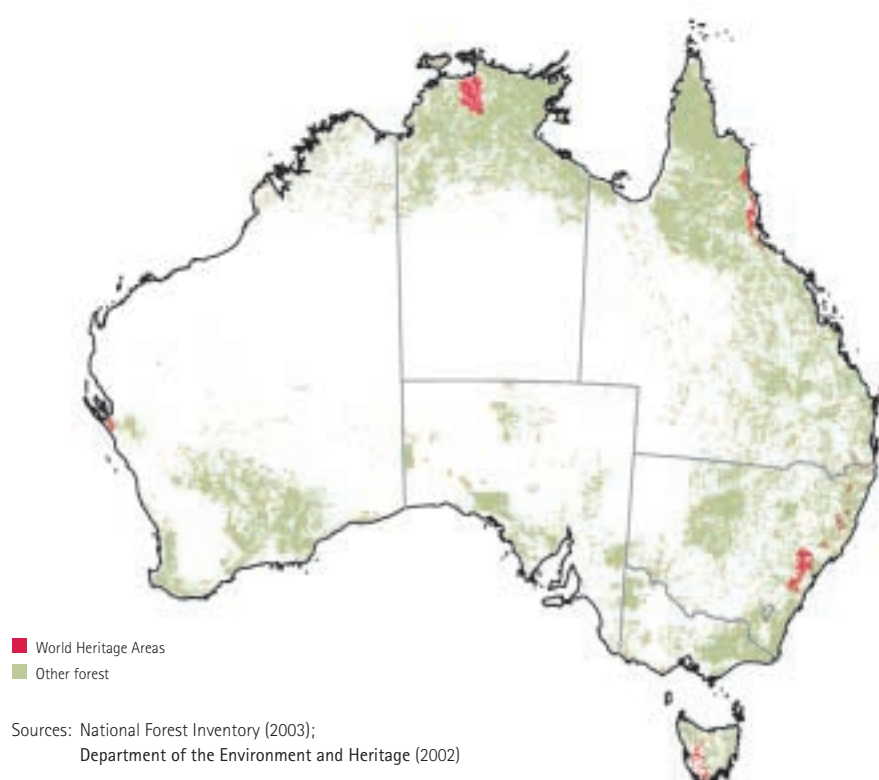
Table 16: Area ('000 ha) of native forest, by tenure, in World Heritage Areas and National Estate listed places

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

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

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

Figure 11: Australia's Forests within World Heritage Areas



Further reading

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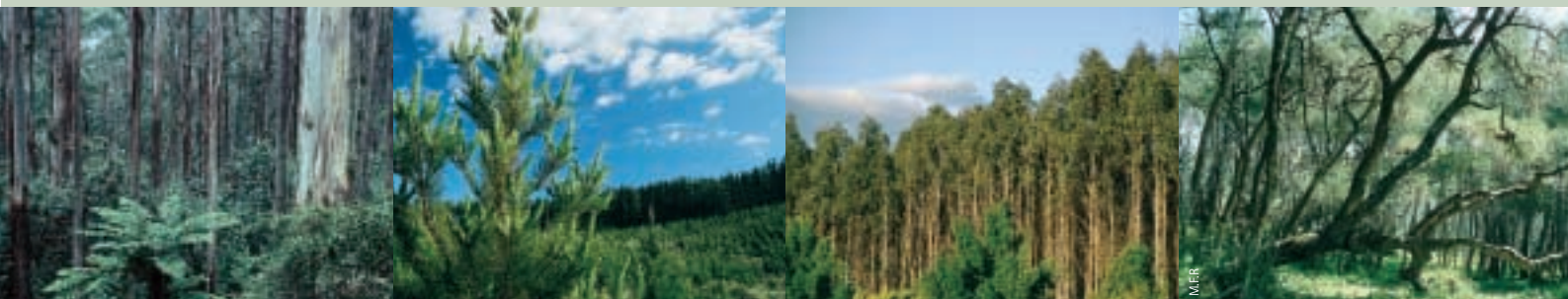
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Australia's forest types



Acacia forest

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

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

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

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

Source: National Forest Inventory (2003)

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

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

Acacia phyllodes and leaves

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

Distribution

Figure 12: Acacia distribution



Source: National Forest Inventory (2003)

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

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

in all habitats. They are especially common and conspicuous in arid, semi-arid and dry subtropical areas.

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

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

Tenure

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

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

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

Source: National Forest Inventory (2003)

Values and uses

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

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

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

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



Gidgee (*Acacia cambagei*) woodland, Central Queensland

Callitris forest

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

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

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

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

Source: National Forest Inventory (2003)

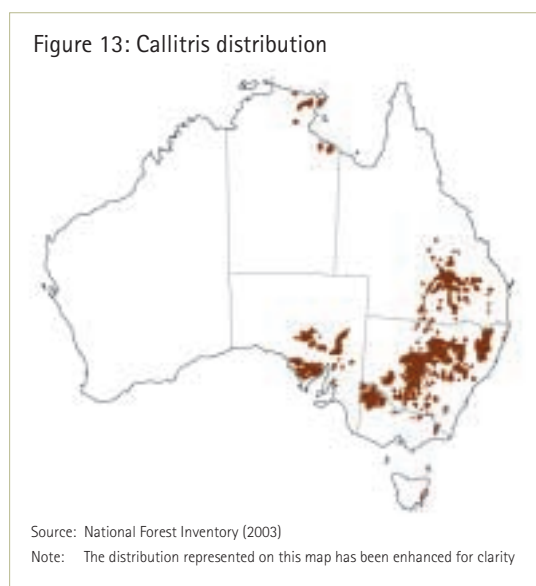
¹ The unknown crown cover category is mainly *Callitris* forest in New South Wales and Queensland, most of which is likely to be evenly distributed between the woodland and open crown cover categories

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

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

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

Distribution



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

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

The most common species of callitris is white cypress pine (*C. glaucophylla*). Changes in fire frequency and land management have enabled white

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

Tenure

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

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

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

Source: National Forest Inventory (2003)

Values and uses

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

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

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

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



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

Casuarina forest

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

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

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

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

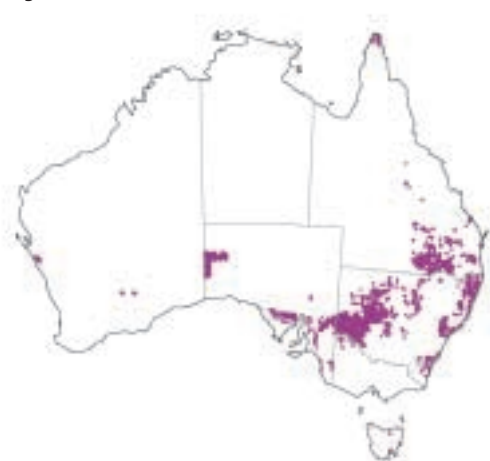
Source: National Forest Inventory (2003)

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

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

Distribution

Figure 14: Casuarina distribution



Source: National Forest Inventory (2003)

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

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

The largest extent of casuarina forest in Australia is in western New South Wales, extending as a band into semi-arid zones in South Australia and Queensland. There are also extensive areas in coastal New South Wales.

They occur primarily on rocky sites across Australia and near water bodies and streams. Belah (*Casuarina cristata*) forests have the widest distribution, occurring in habitats varying from stony slopes to calcrete to heavy clay soils.

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

Tenure

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

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

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

Source: National Forest Inventory (2003)

Values and uses

The wood of some casuarina species is used in flooring, cabinet making and other ornamental woodworking, such as Western Australian she-oak (*A. fraseriana*) for furniture in Western Australia and forest oak (*A. torulosa*) for shingles and shakes in eastern Australia. The quantities used are very small because the resource is small, but the product is keenly

sought after and very expensive. The wood of most casuarinas is very hard and provides excellent fuel. Coast she-oak is used for timber, poles, pulpwood, mulch, windbreaks, and in soil reclamation and erosion control. It has reputedly the best fuel wood in the world as it is relatively smokeless when it burns. It also produces high quality charcoal. The foliage of species, such as river she-oak, is used as fodder for stock during drought. Belah is often used for fence posts, firewood, and as windbreaks on agricultural land.



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

Eucalypt forest overview

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

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

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

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

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

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

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

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



Argyle apple (*Eucalyptus cinerea*) blossom

Distribution

Figure 15: Eucalypt distribution



Source: National Forest Inventory (2003)

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

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

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

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

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

Source: National Forest Inventory (2003)

Values and uses

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

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

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

Eucalypt mallee forest

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

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

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

Distribution

Figure 16: Eucalypt mallee distribution



Source: National Forest Inventory (2003)

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

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

In South Australia, prominent and widespread mallee species include white mallee (*Eucalyptus anceps*), gilja

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

Tenure

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

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

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

Source: National Forest Inventory (2003)



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

Eucalypt woodland forest

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

Distribution

Figure 17: Eucalypt woodland forest distribution



Source: National Forest Inventory (2003)

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

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

The tropical woodland forests grade from very tall to very low and are often widespread. For example, low woodland forest dominated by northern white gum (*Eucalyptus brevifolia*) occurs on sandstone or

quartzite ridges from the Ord River in north-western Australia, through to the Leichhardt River in the Gulf of Carpentaria (Queensland), whereas silver box (*E. pruinosa*) woodland tends to occur on heavier soils over the same range. A number of locally endemic eucalypts also occur in those landscapes. This is particularly so in three separate areas of high-rainfall across northern Australia, where *Corymbia abergiana* and *C. stockeri* are endemic to the north-east, *C. arenaria* and *C. collina* to the north-west and *C. oocarpa* and *C. arnhemensis* to the north. The understorey of eucalypt woodlands in northern Australia may include palms, cycads and grasses.

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

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



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

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

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

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

Tenure

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

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

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

Source: National Forest Inventory (2003)

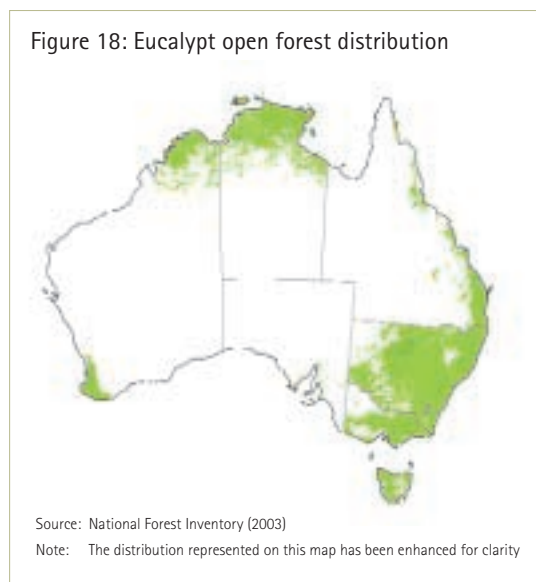
Eucalypt open forest

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

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

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

Distribution



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

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

Tall open forests are distributed in a discontinuous arc of high rainfall

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

Tenure

The largest proportion of eucalypt open forests occur on private land (38 per cent) although the distribution by State and Territory on private land varies considerably, from 0 per cent in the Australian Capital Territory to 88 per cent in the Northern Territory (Table 26).

Nationally, about 20 per cent of eucalypt open forest occurs on leasehold land, multiple use forest or nature conservation reserve tenures, while 4 per cent is on other crown land. The States with the largest areas of eucalypt open forest in nature conservation reserves are New South Wales (17 per cent) and Victoria (28 per cent). The Australian Capital Territory and South Australia, which have much smaller total areas of forest, have the highest proportions in nature conservation reserves (93 per cent and 39 per cent, respectively).

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

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

Source: National Forest Inventory (2003)



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

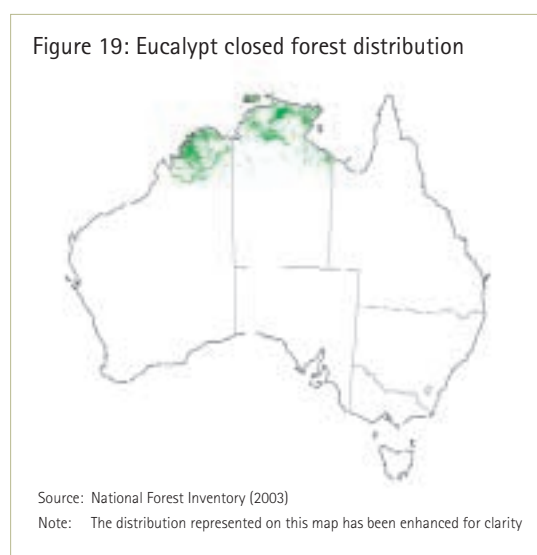
Eucalypt closed forest

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

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

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

Distribution



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

Tenure

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

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

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

Source: National Forest Inventory (2003)

Mangrove forest

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

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

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

Source: National Forest Inventory (2003)

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

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

The total Australian mangrove flora consists of 40 species from 19 families. White mangrove (*Avicennia marina*) is the most widespread and common. Several other salt tolerant species may occur in mangrove forests. For example, the mangrove palm (*Nypa fruticans*) occurs in tropical mangrove forests, while the mangrove fern (*Acrostichum speciosum*) inhabits the

mangrove forest floor. Other ferns and orchids grow on the trunks and branches of mangroves in tropical areas. Species composition of mangrove varies with tidal inundation and latitude.

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



Grant Wardell-Johnson

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

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

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

Distribution

Figure 20: Mangrove distribution



Source: National Forest Inventory (2003)

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

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

Mangrove roots

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

Mangrove forest, Northern Territory



Tenure

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

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

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

Source: National Forest Inventory (2003)

Values and uses

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

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

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



The transition from mangrove forest to rainforest

Melaleuca forest

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

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

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

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

Source: National Forest Inventory (2003)

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

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

Distribution

Figure 21: Melaleuca distribution



Source: National Forest Inventory (2003)

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

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

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



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

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

Melaleuca forests occur on a wide range of sites throughout non-arid Australia, and display marked variability in the dominant species. Northern Australian melaleuca forests are dominated by broad-leaved paperbark (*M. viridiflora*), weeping paperbark or long-leaved paperbark (*M. leucadendra*), silver paperbark (*M. argentea*), blue paperbark (*M. dealbata*) and yellow-barked paperbark (*M. nervosa*). In southern and eastern Australia, melaleuca forests tend to be confined to more permanently wet

watercourses and swamps. The most common coastal species is paperbarked tea-tree (*M. quinquenervia*). In Western Australia, melaleuca forests are restricted to small pockets in specific sites, such as Preiss's paperbark (*M. preissiana*) in near-coastal swampy areas, and freshwater or swamp paperbark (*M. raphiophylla*) on creek lines and watercourses.

Tenure

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

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

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

Source: National Forest Inventory (2003)

Values and uses

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

Rainforest

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

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

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

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

Source: National Forest Inventory (2003)

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

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

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

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

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

Distribution

Figure 22: Rainforest distribution



Source: National Forest Inventory (2003)

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

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

High annual rainfall is an important factor controlling rainforest distribution. Rainfalls vary from over

3 600 millimetres per annum in the wet tropics of Queensland and 3 500 millimetres in western Tasmania down to 1 000 millimetres per annum in other regions. Average annual rainfalls lower than 1 000 millimetres are generally not suitable for rainforest.

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

Tenure

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

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

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

Source: National Forest Inventory (2003)

Values and uses

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



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

Other forest

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

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

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

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

Source: National Forest Inventory (2003)



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

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

Examples of 'other forests'

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

Queensland (1 059 000 hectares):

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

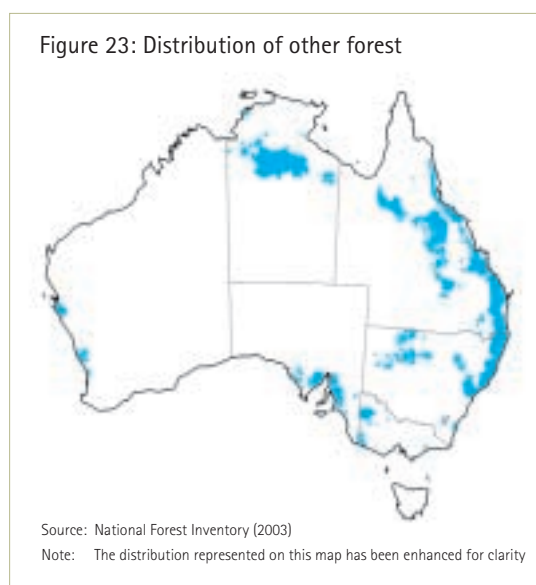
Northern Territory (740 000 hectares):

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

New South Wales (415 000 hectares):

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

Distribution



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

Tenure

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

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

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

Source: National Forest Inventory (2003)

Values and uses

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

Plantation forest

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

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

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

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

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

Distribution

Figure 24: Plantation distribution



Source: National Forest Inventory (2003)

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

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

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

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

Source: National Plantation Inventory (2003)

Note: The impact of the 2002/2003 fire season is not included in this table

Tenure

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

Plantation of exotic radiata pine (*Pinus radiata*)

Softwood plantations

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



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

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

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

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

Values and uses

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

Australian native softwood plantations

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

Hardwood plantations

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

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

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

Values and uses

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



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

Oil mallee plantations in Western Australia

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

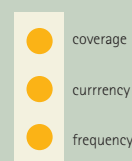
The total area of plantations in 2000 was almost 6 000 hectares. Eucalyptus oil is used in pharmaceuticals, cleaning products and perfumery. Currently, Australia produces 200 tonnes of oil for specialty markets (e.g., fragrances). World production is about 3 000 tonnes per year, mainly from China, Portugal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

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

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Forest growth stage by tenure



Indicator 1.1b

Area of forest type by growth stage distribution and tenure

Rationale

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

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

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

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

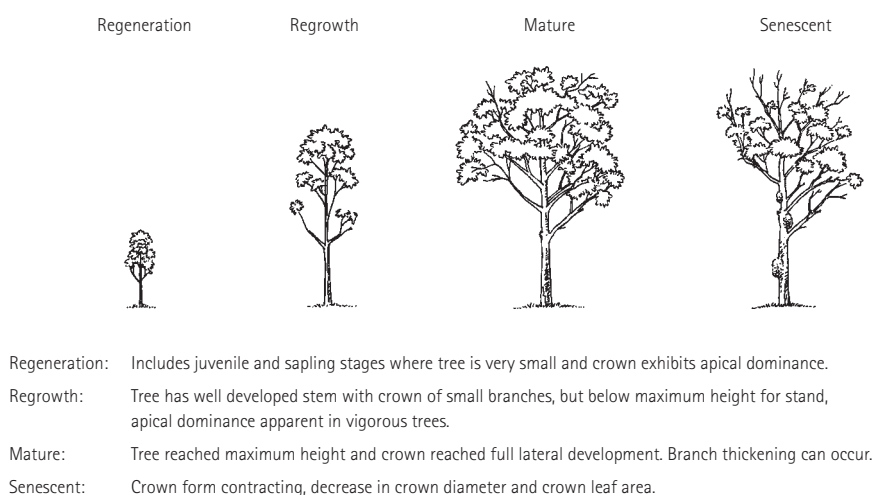
The total area for which growth stage is known is almost 14 million hectares, or 8 per cent, of Australia's native forest estate. This is an increase of 7 million hectares subsequent to the 1998 State of the Forests Report. The largest gaps in the data are on private, leasehold and other crown land tenures.

Growth stage information is available for:

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

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

Figure 25: National classification of growth stage for native forest



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

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

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

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

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

Source: National Forest Inventory (2003)

Note: Growth stage class definitions vary between States

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

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

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

Source: National Forest Inventory (2003)

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

Old-growth forest

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

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

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

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

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

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

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

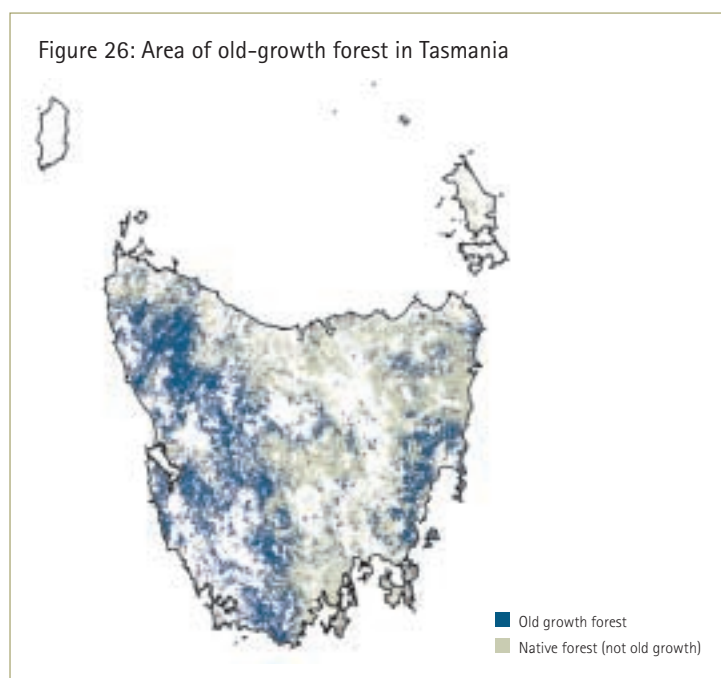
Table 39: Old-growth forest in RFA/CRA regions ('000 ha)

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

Source: National Forest Inventory (2003)

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

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





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

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coverage



currency



frequency



Fragmentation of forests

Indicator 1.1e

Fragmentation of forest types

Rationale

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

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

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

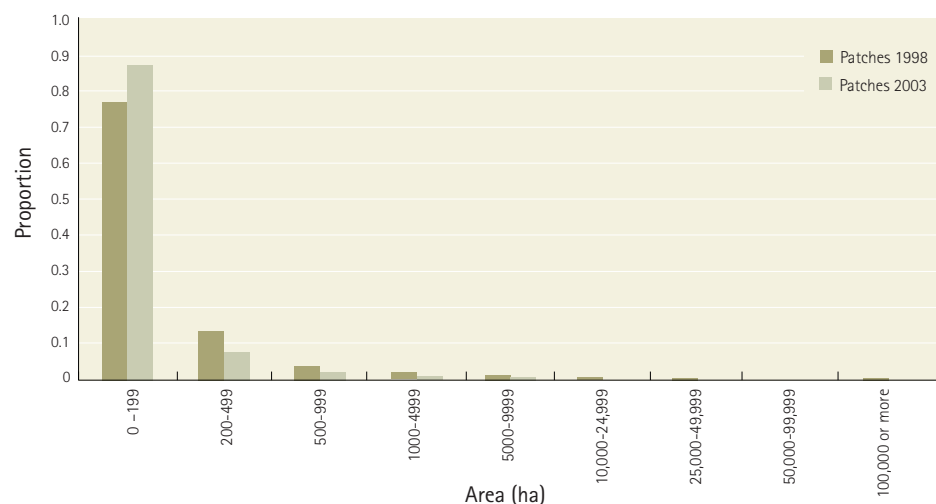
Detailed research into fragmentation has identified a correlation between the size of forest habitats and their ability to support viable populations of certain species. Some forest fragments are too small to maintain viable breeding populations of some species. Species dependent on the interior regions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

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

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

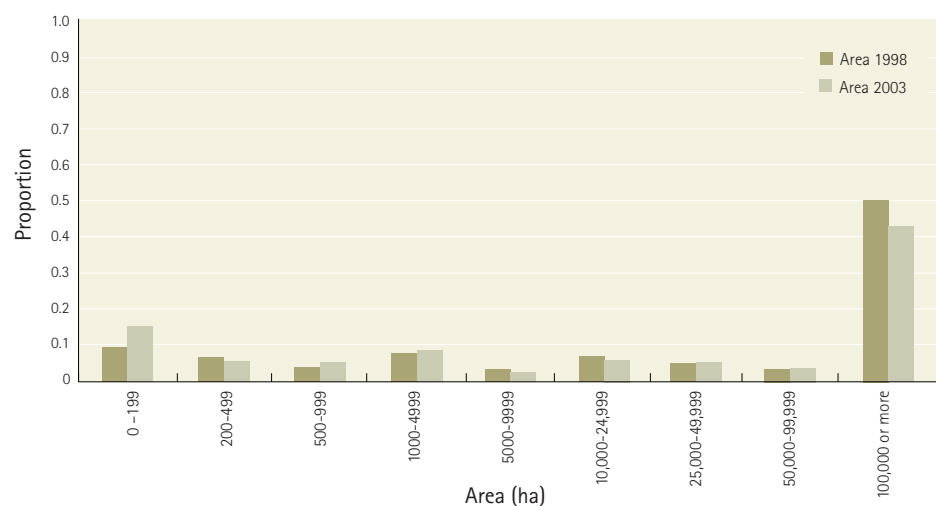
Within the IBRA regions the study demonstrated an increase in forest patches smaller than 200 hectares and a decrease in the number of large patches (exceeding 100 000 hectares) over the five year period 1998–2003.

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



Source: National Forest Inventory (1998, 2003)

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



Source: National Forest Inventory (1998, 2003)



Fragmented forest in agricultural landscape

Further reading

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1.2

SPECIES DIVERSITY

INTRODUCTION

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

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

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

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



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

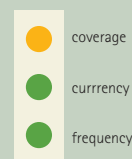
Forest-dwelling species

Indicator 1.2a

A list of forest-dwelling species

Rationale

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



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

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

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

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

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

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



Southern hairy-nosed wombat (*Lasiorhinus latifrons*)

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

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

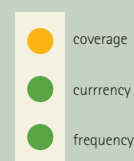
Source: National Forest Inventory (2003)

¹ The Australia Capital Territory only includes rare and endangered species, rather than a comprehensive list of forest-dwelling species² The New South Wales data on invertebrates only includes those species listed as endangered or vulnerable under the New South Wales *Threatened Species Act 1995*³ Western Australia includes only species documented in the Regional Forest Agreement region (south-west Western Australia) rather than the entire StateGreen tree frog (*Litoria caerulea*)

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

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

Status of forest-dwelling species



Indicator 1.2b

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

Rationale

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

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

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

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

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

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

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

Source: Environment Australia (2003)

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

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

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

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

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

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

Source: Williams *et al.* 2001

Rare and threatened forest-dwelling species

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

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

Figure 29: Distribution of rare and threatened fauna

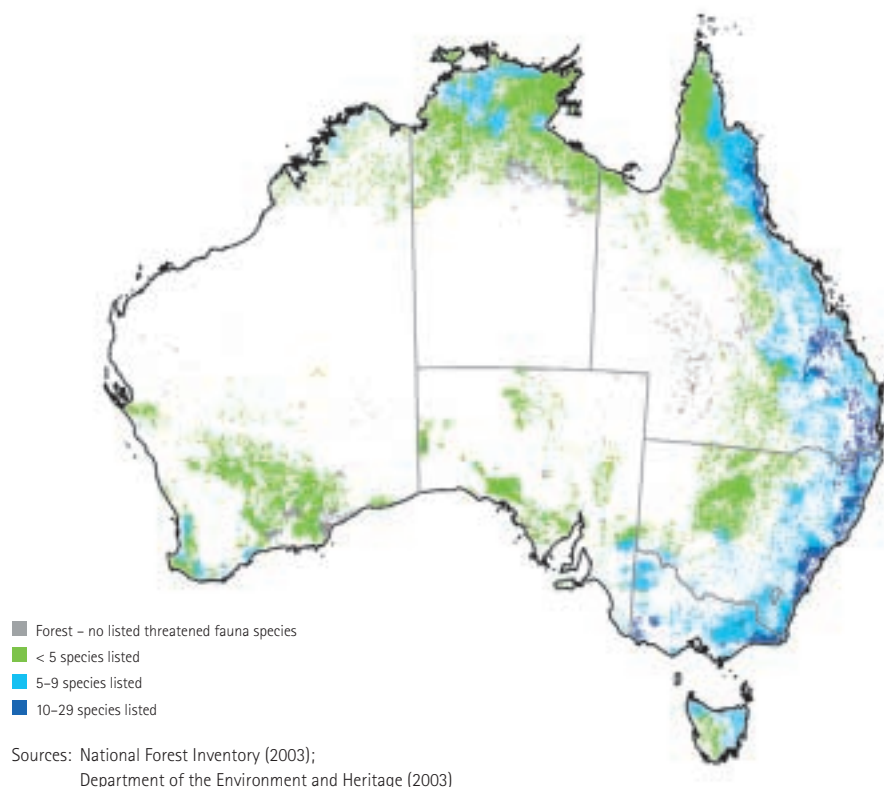
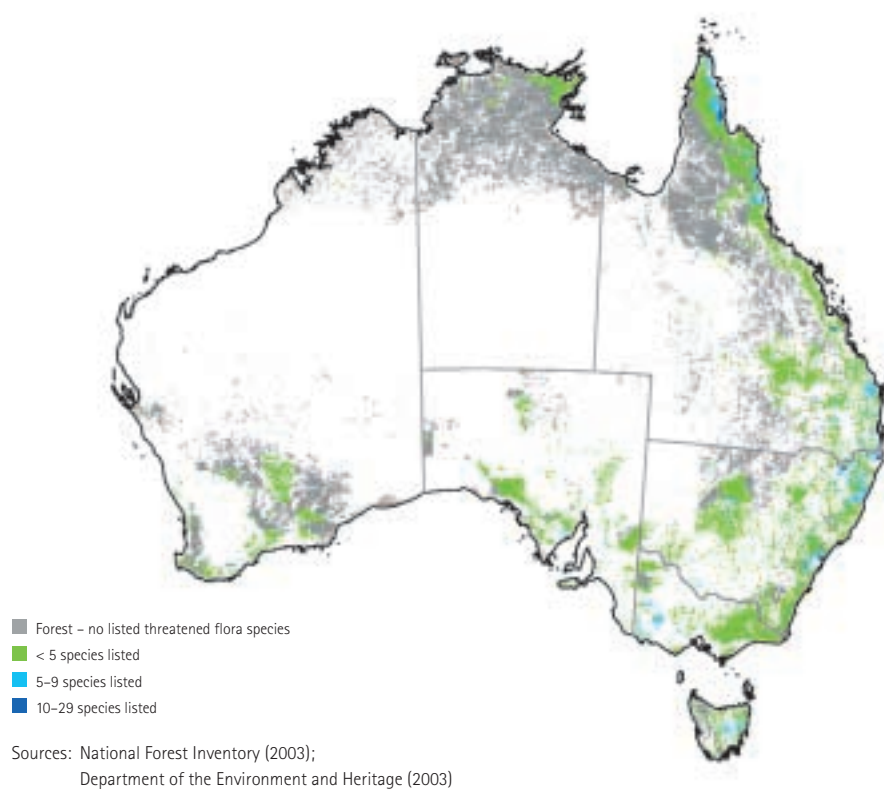


Figure 30: Distribution of rare and threatened flora



Further reading

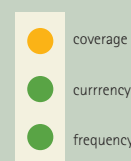
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White Beauty Spider-orchid (*Caladenia argocalla*), a threatened native orchid of the Mount Lofty Ranges

Species monitoring



Indicator 1.2c

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

Rationale

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

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

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

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

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

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

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

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

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

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

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

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

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



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

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

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1.3

GENETIC DIVERSITY

INTRODUCTION

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

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

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

This section also considers the extent of native forest and plantations of indigenous species for which genetic resource conservation plans have been prepared and implemented. The forest management plans and guidelines established in most States and Territories have

recognised the significance of conserving the genetic diversity of our forests. As new and more cost-effective methods of monitoring genetic variation in forests are developed, forest management plans will incorporate this information and management practices are expected to change in accordance with the results.

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



Smooth barked apple (*Angophora costata*)

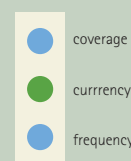
Genetic variation in forest-dwelling species

Indicator 1.3a

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

Rationale

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



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

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

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

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

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

Flora

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

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



Tasmanian quoll (*Dasyurus maculatus maculatus*)

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

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

Fauna

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

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

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Genetic resource conservation



Indicator 1.3c

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

Rationale

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

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

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

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

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

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

Also important is monitoring and controlling genetic flow from native plantations into native populations, where such flows could result in a diminution of the full range of

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

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

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

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

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

Source: National Forest Inventory (2003)

Minimising genetic pollution

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

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

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

Rare species

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



Jaime Plaza

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

Case Study: Wollemi Pine Recovery Plan

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

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

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

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Argyle apple (*Eucalyptus cinerea*) blossom