Australian Government
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ABARES

Australia's State of the Forests Report 2013

Criterion 1

Conservation of biological diversity

Kookaburra. iStockphoto

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

Criterion 1
Conservation of biological diversity

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

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

Ecosystem diversity

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

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

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

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

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

Species diversity

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

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

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

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

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

Genetic diversity

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

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

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

Key findings

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

Ecosystem diversity

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

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

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

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

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

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

Species diversity

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

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

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

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

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

Genetic diversity

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

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

Eucalypt mallee woodland forest, Eyre Peninsula, South Australia.

Indicator 1.1a

Area of forest by forest type and tenure

Rationale

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

Key points

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

Table 1.1: Australia's forest area, by jurisdiction

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

[a] Reported through the National Plantation Inventory.

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

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

Note: Totals may not tally due to rounding.

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

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

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

Australia's forest area

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

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

There are three broad categories for Australia's forest:

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

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

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

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

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

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

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

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

[a] DCCEE (2012a).

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

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

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

Forest types

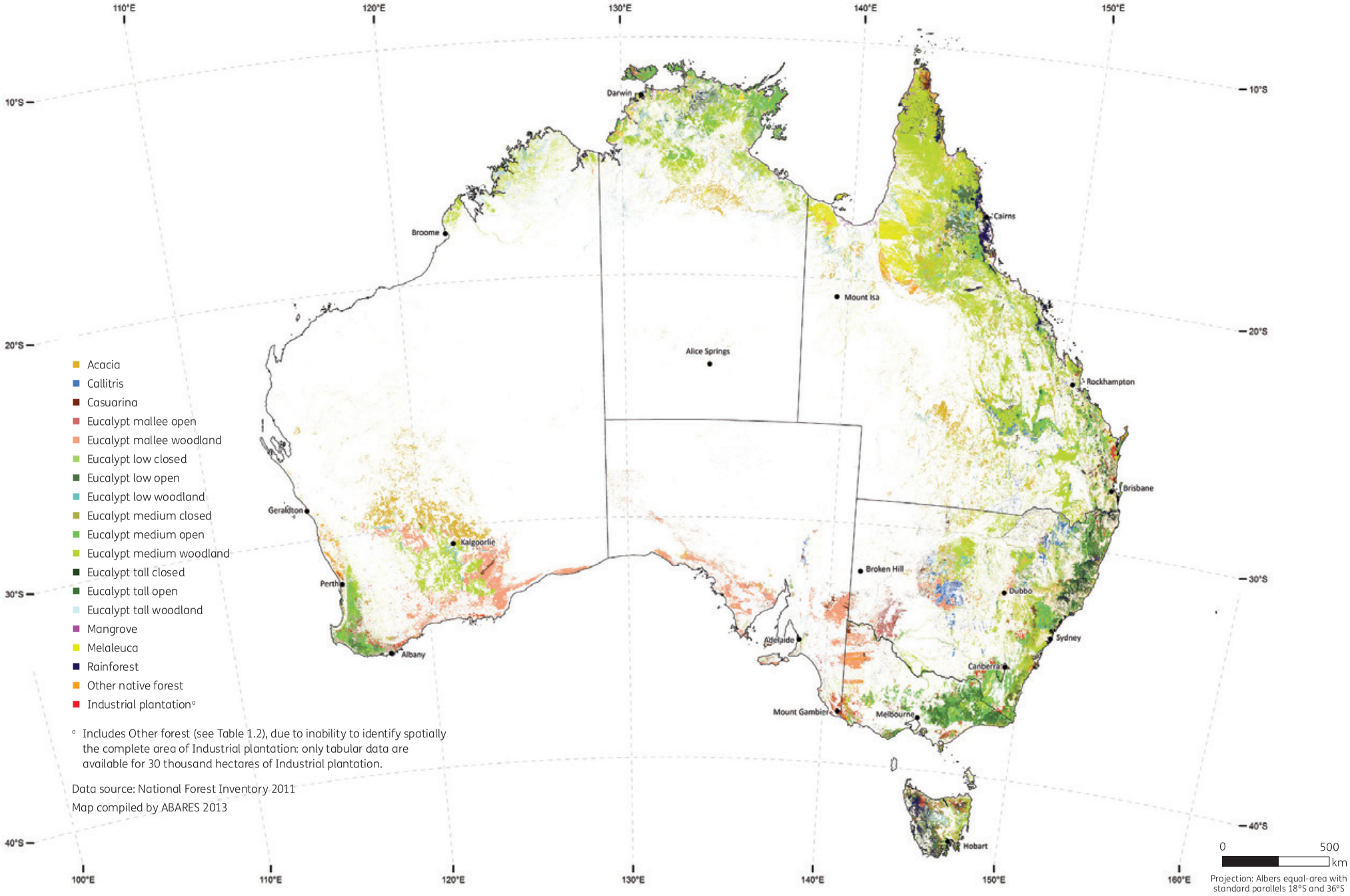
The vast majority of Australia's native forest area is hardwood species (evergreen broadleaf tree species). For national reporting, the NFI groups Australia's native forests into eight broad forest types defined by dominant species and structure (as described in the Introduction). The first seven distinctive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

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

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

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

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



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

Data source: National Forest Inventory 2011

Map compiled by ABARES 2013

Figure 1.4: Australia's forest extent by tenure

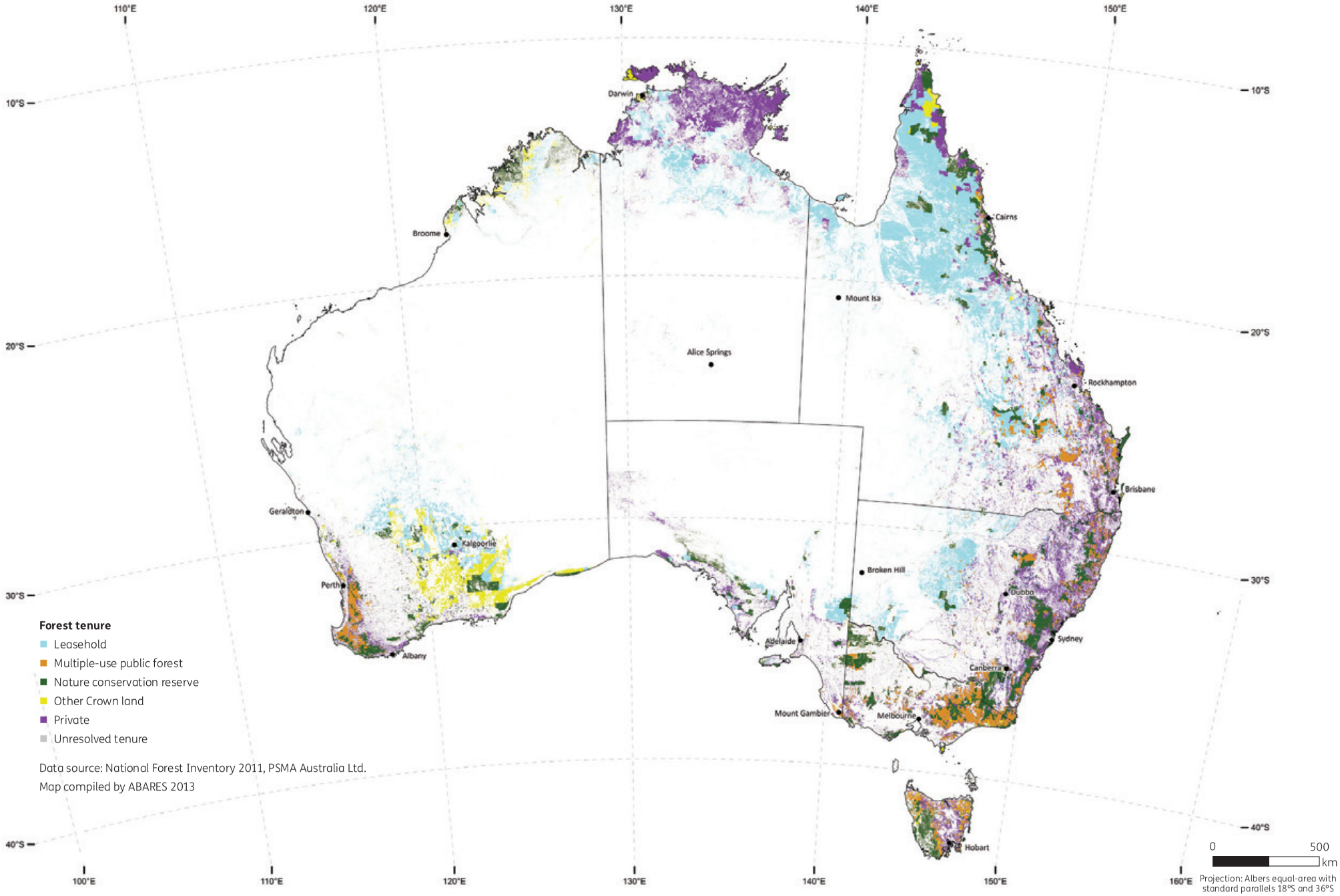


Table 1.2: Australia's forest area, by forest type

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

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

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

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

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

Note: Totals may not tally due to rounding.

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

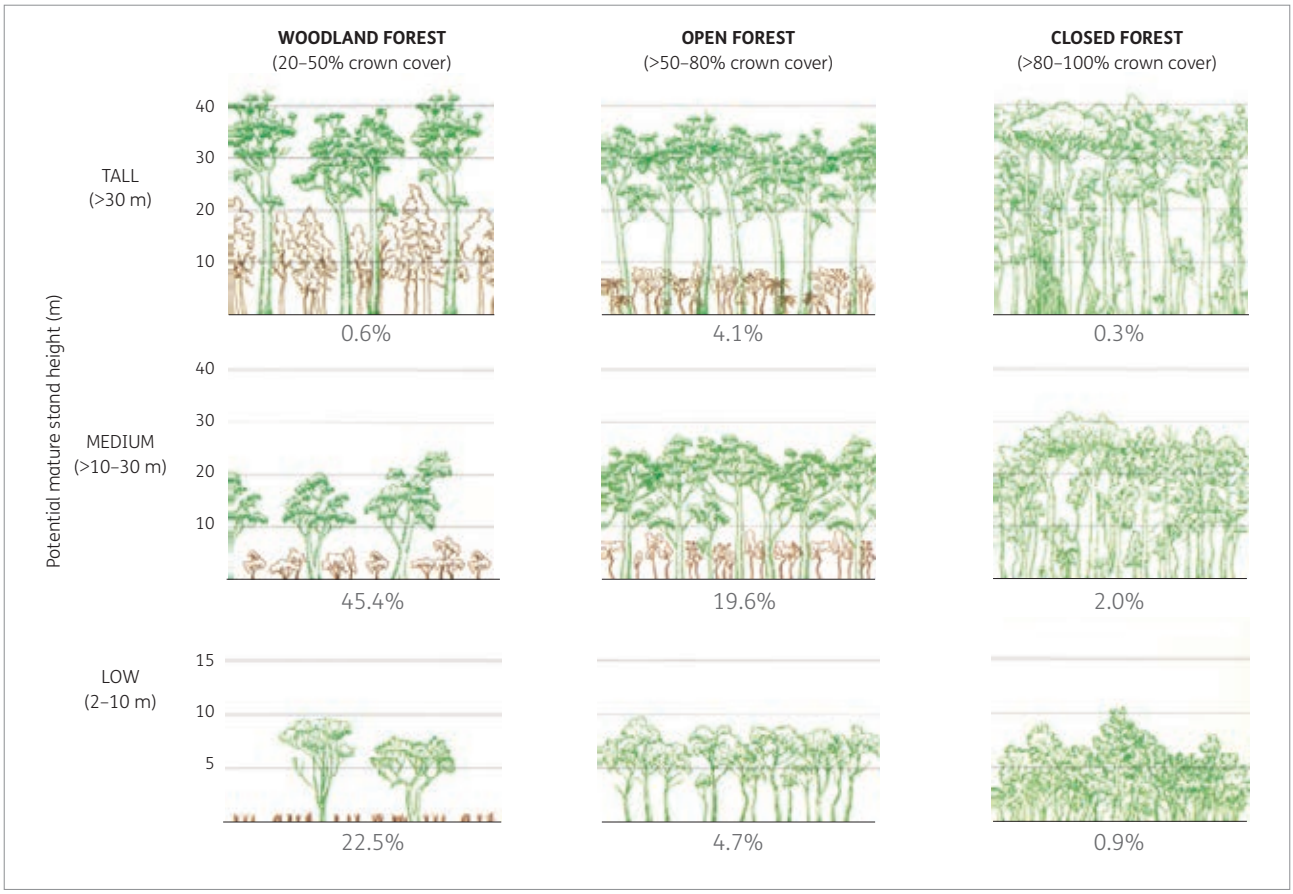
Tall eucalypt forest, Victoria.

Crown cover and height

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

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

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



Note: Percentages are area proportions of each height class/cover class combination in Australia's total native forest area (National Forest Inventory).
Source: Adapted from Australian Land Information Group and JA Carnahan (1990). *Atlas of Australian Resources, Vegetation*. Australian Government Publishing Service, Canberra.

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

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

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

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

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

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

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

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

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

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

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

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

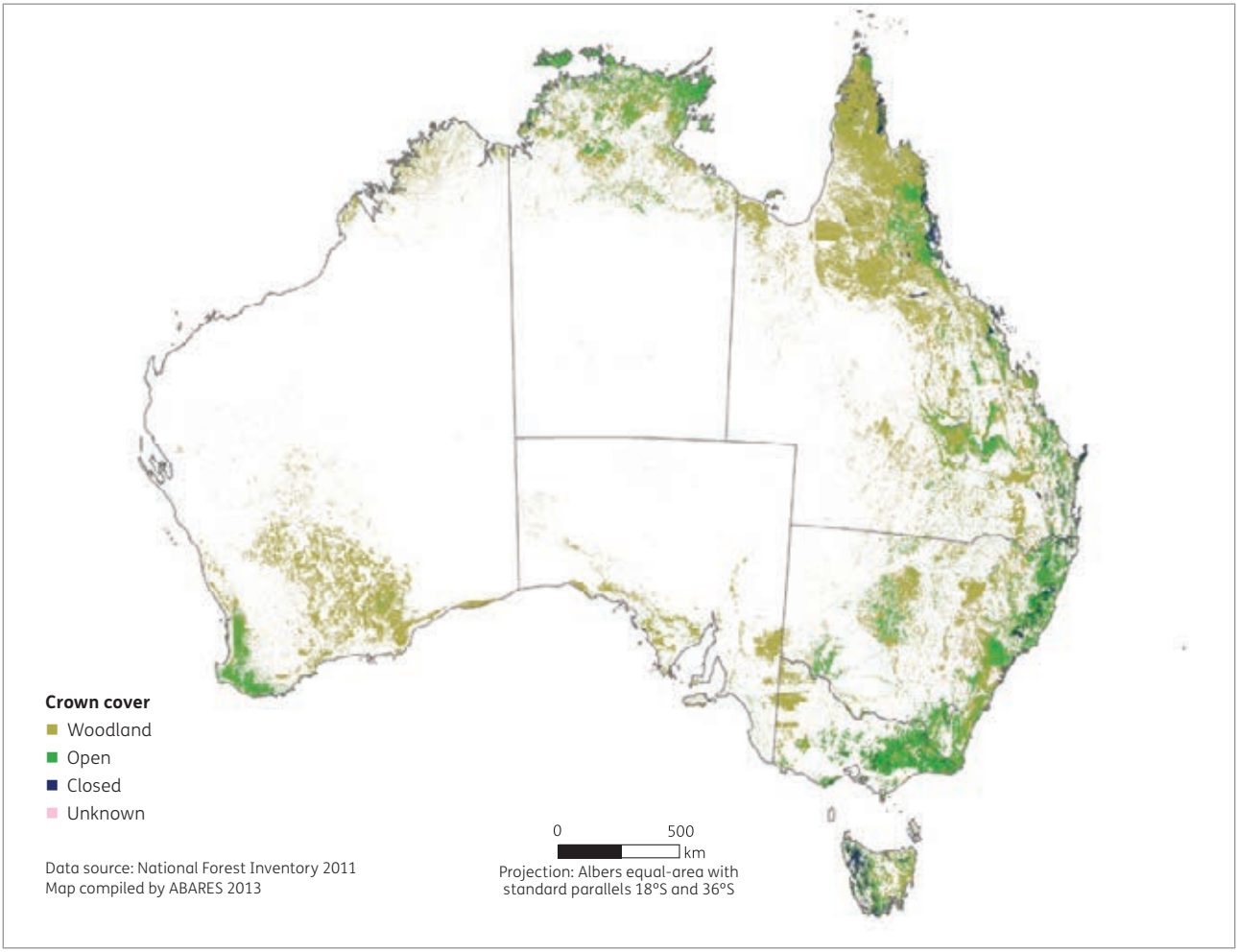
Victoria's forests are dominated by Eucalypt forests (7.2 million hectares—87% of the state's forest area). The largest component is Eucalypt medium open forests (3.1 million hectares), with just over 1 million hectares each of Eucalypt mallee woodland, Eucalypt medium woodland and Eucalypt tall open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

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

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

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

Figure 1.3: Native forest, by crown cover class



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

Tenure

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

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

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

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

Table 1.5: Forest area, by forest type and jurisdiction

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

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

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

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

Note: Totals may not tally due to rounding.

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

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

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

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

Note: Totals may not tally due to rounding.

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

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

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

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

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

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

Note: Totals may not tally due to rounding.

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

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

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

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

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

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

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

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

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

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

Industrial plantations

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

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

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

Other forest

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

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

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

Forest cover in Regional Forest Agreement regions

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

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

View from Tahune Airwalk, southern Tasmania.

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

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

RFA = Regional Forest Agreement

[a] Industrial plantations and Other forest.

Note: Totals may not tally due to rounding.

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

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

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

RFA = Regional Forest Agreement

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

Note: Totals may not tally due to rounding.

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

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

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

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


Claire Howell

Rainforest, far north Queensland.

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

Change in forest cover

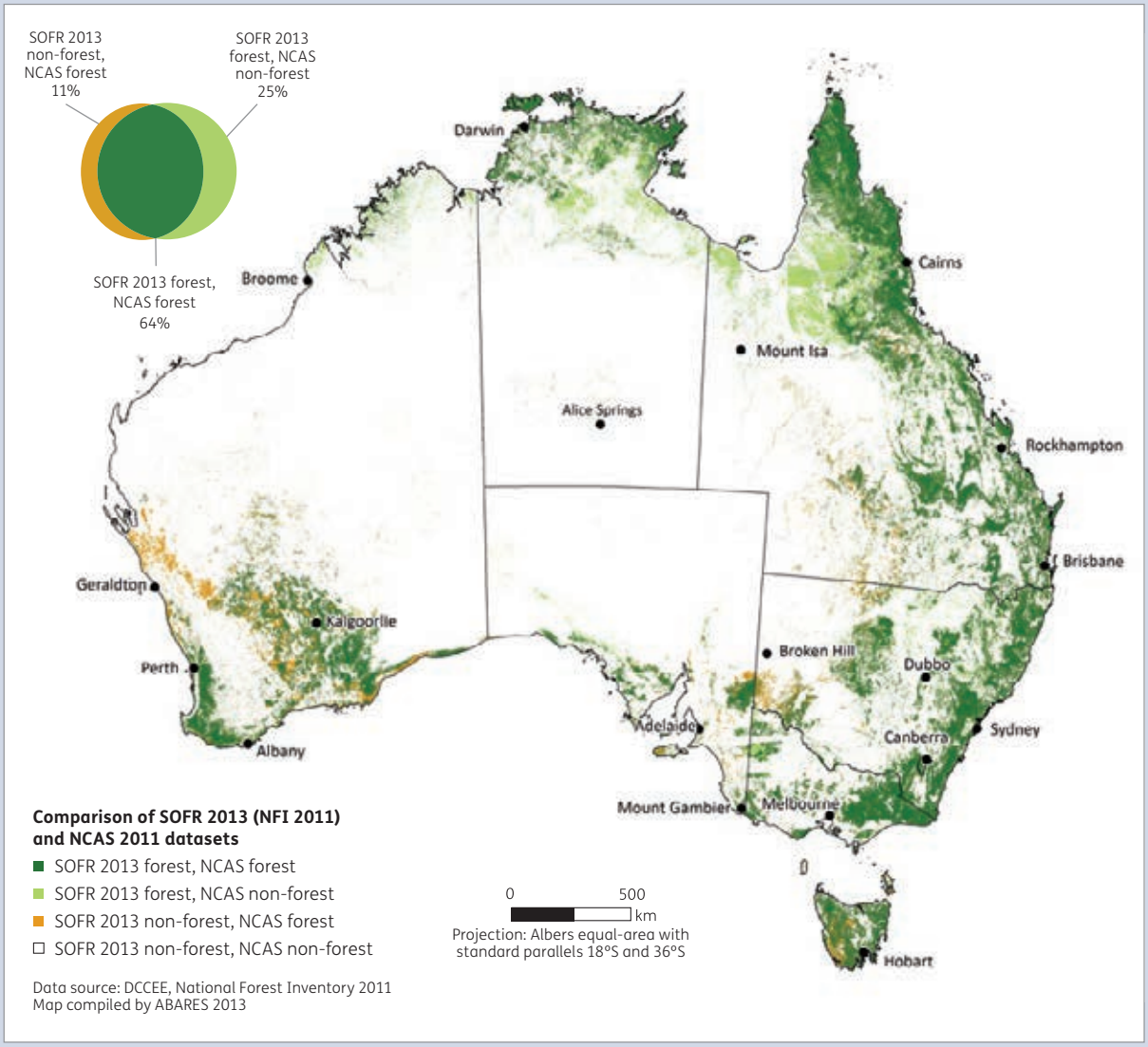
The best estimate of change over time in forest cover is obtained from the annual forest area estimates for the NCAS, managed by the former Australian Government Department of Climate Change and Energy Efficiency[20]. The NCAS area figures are derived using a national methodology that has been consistent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

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

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

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

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



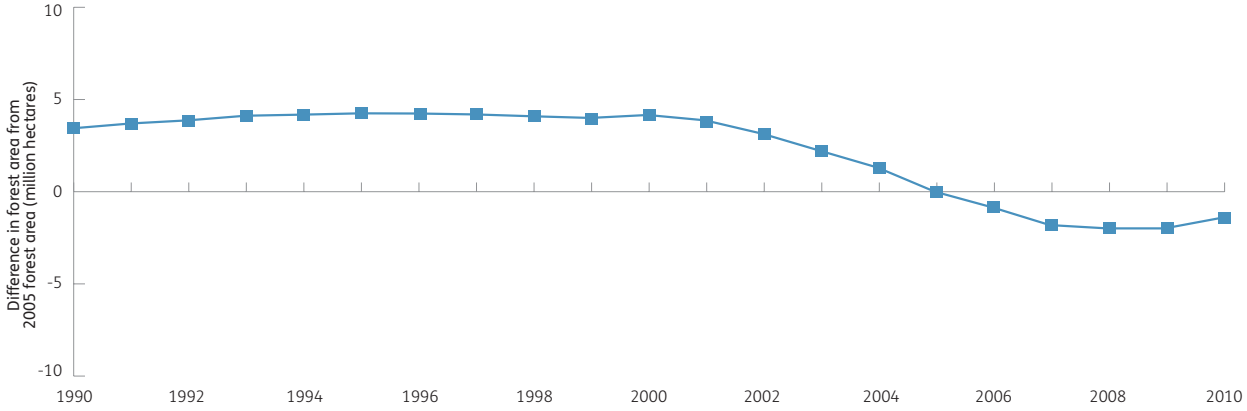
Note: The % figures on the diagram are based on the area derived from a spatial union of the SOFR 2013 (NFI 2011) and NCAS 2011 forest coverages.

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

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

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

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



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

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

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

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

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

Changes in forest mapping

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

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

The Multiple Lines of Evidence process

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

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

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

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

Outcomes from the Multiple Lines of Evidence process

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

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

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

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

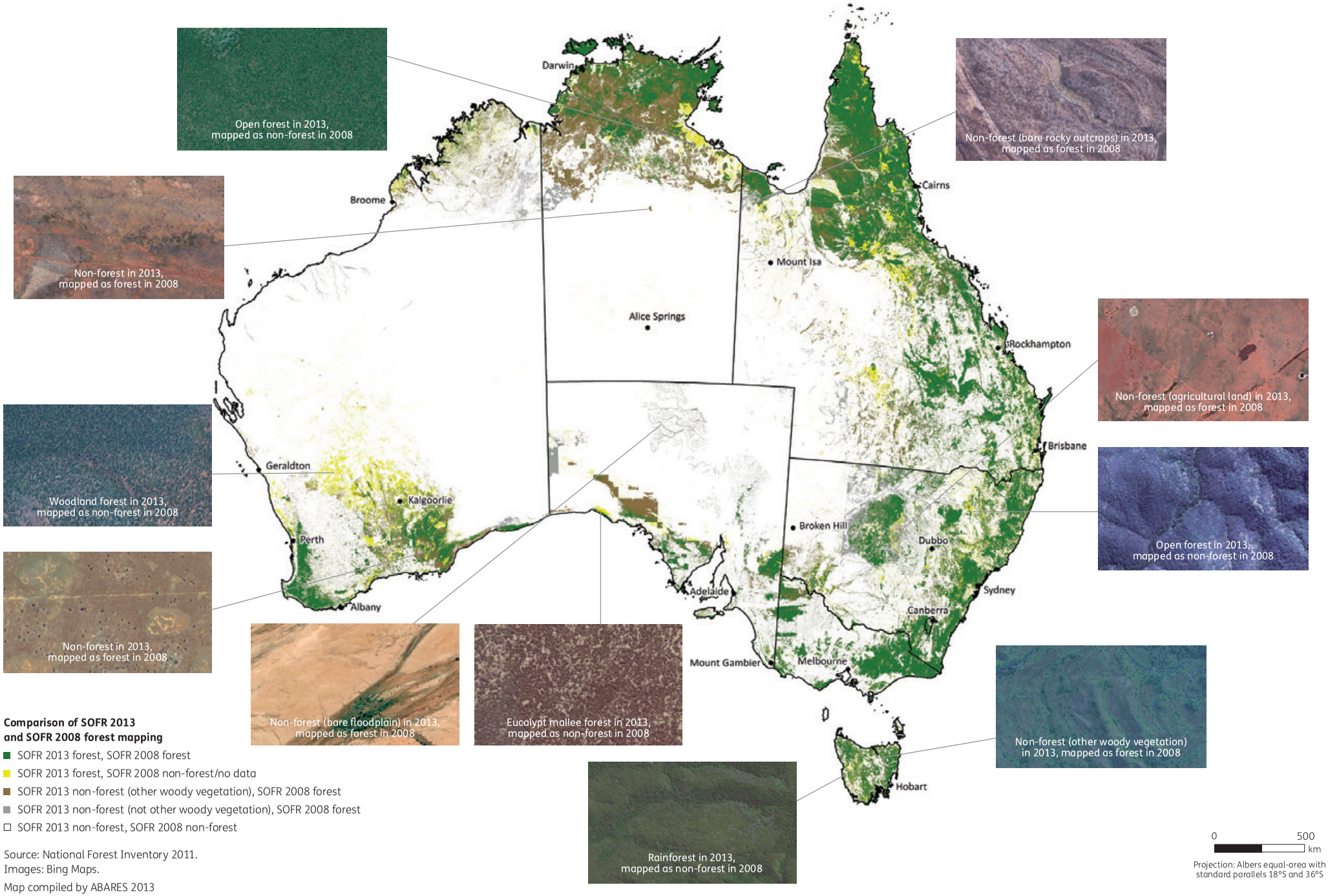
[a] Analysis to distinguish non-forest that carries other woody vegetation (<20% cover) from non-forest that does not carry other woody vegetation is less complete outside Qld and NT.

Note: Totals may not tally due to rounding.

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

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

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

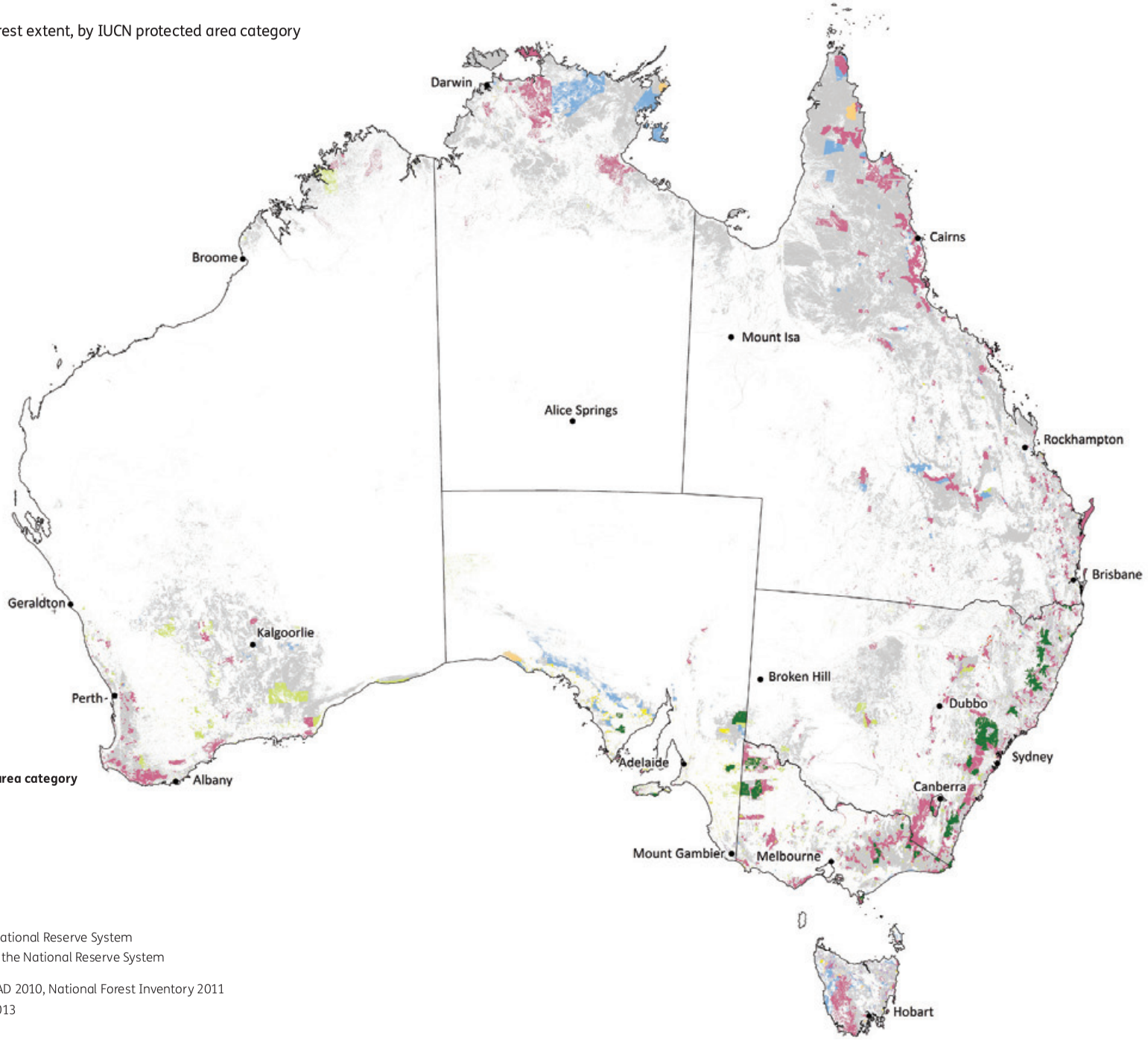


Source: National Forest Inventory 2011.
Images: Bing Maps.

Map compiled by ABARES 2013

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

(See p. 72)



Data source: DSEWPaC CAPAD 2010, National Forest Inventory 2011

Map compiled by ABARES 2013

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

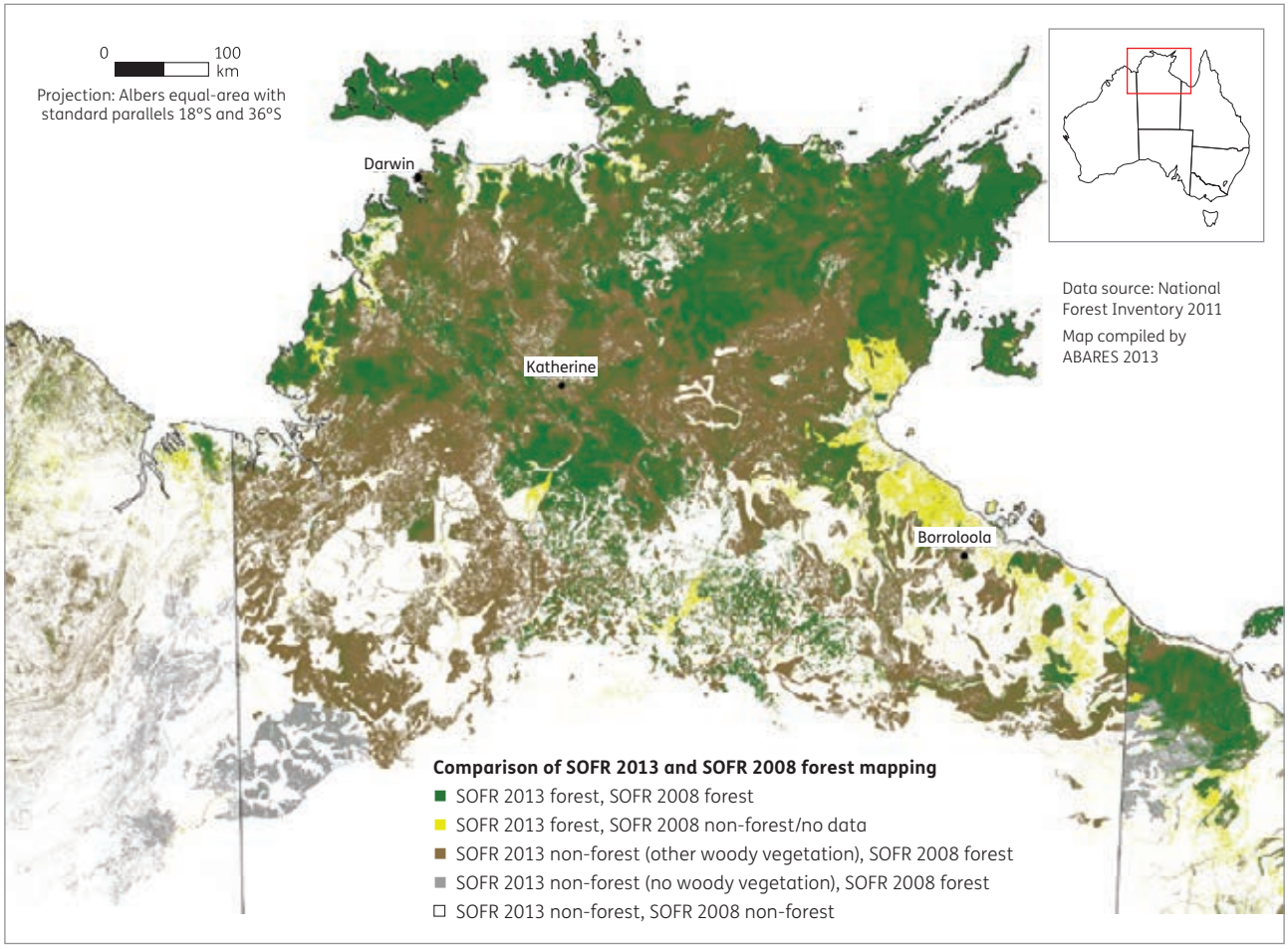


Table 1.12: Difference in areas of reported forest in Regional Forest Agreement regions between 2008 and 2013

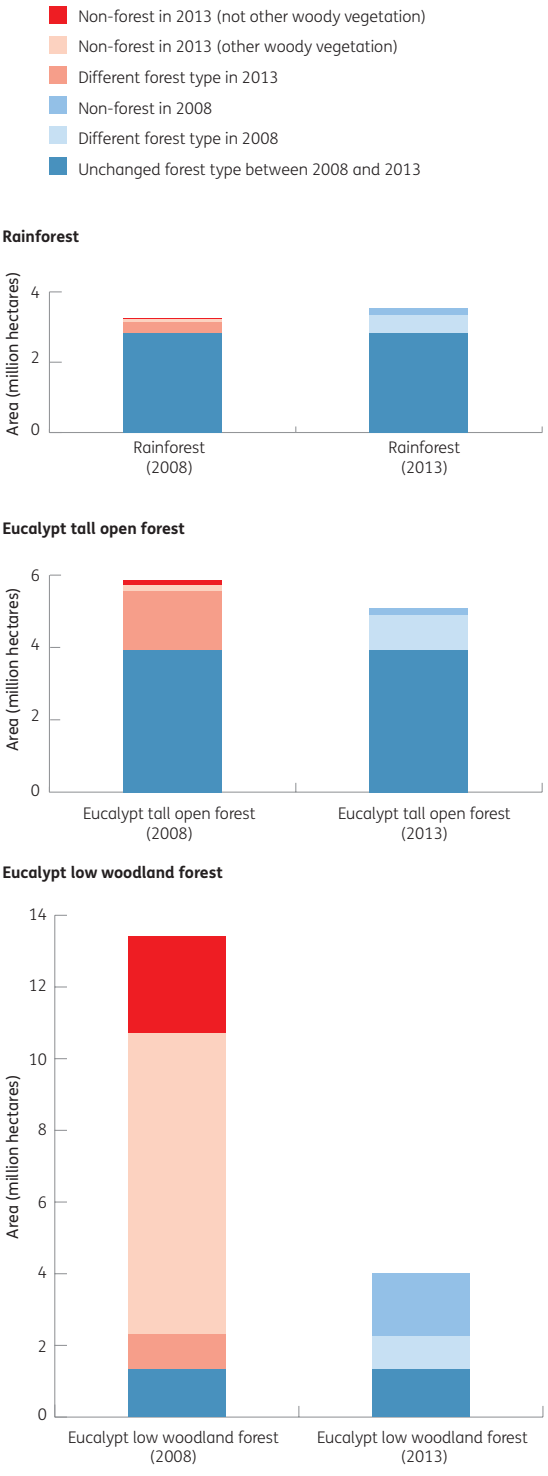
		SOFR 2008		SOFR 2013		Difference	
RFA region	Region area ('000 hectares)	Forest area ('000 hectares)	Proportion of RFA region area (%)	Forest area ('000 hectares)	Proportion of RFA region area (%)	Forest area ('000 hectares)	Proportion of RFA region area (%)
New South Wales							
Eden	814	592	73	603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

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

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

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

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



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

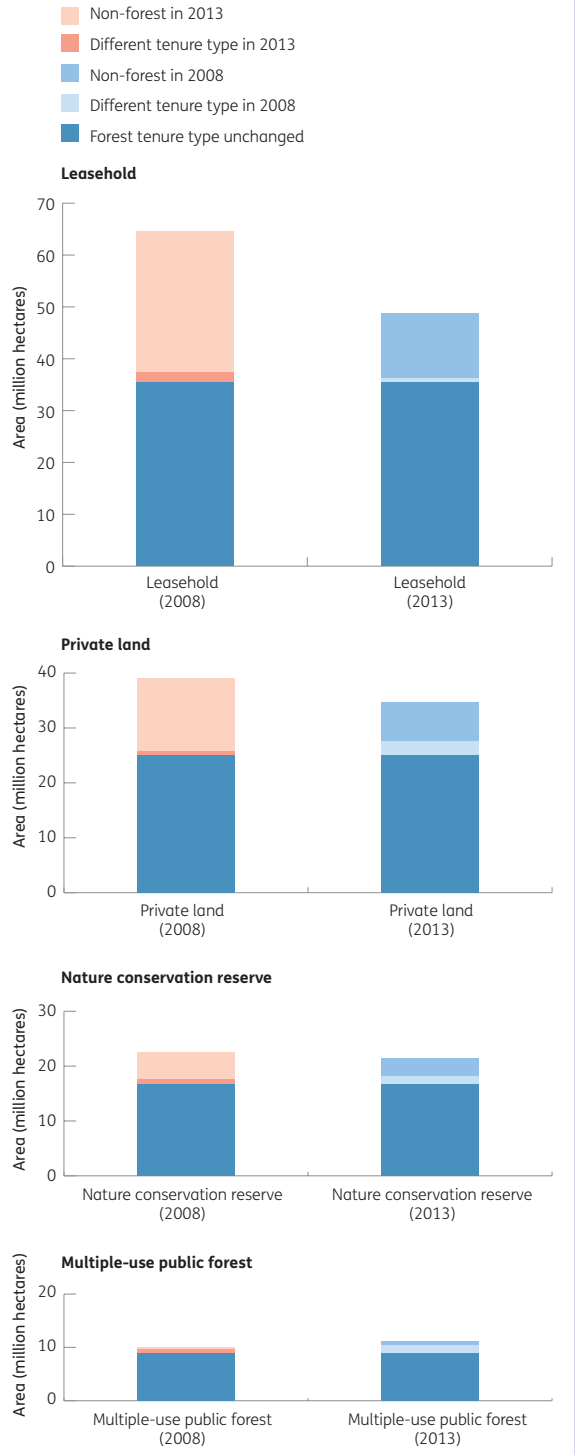
Of the 3.3 million hectares reported as Rainforest in SOFR 2008, 86% is reported as Rainforest in SOFR 2013, 11% is reclassified to other forest types, and very little is reclassified to either non-forest category.

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

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

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

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



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

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

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

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

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

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

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

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

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

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

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

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

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

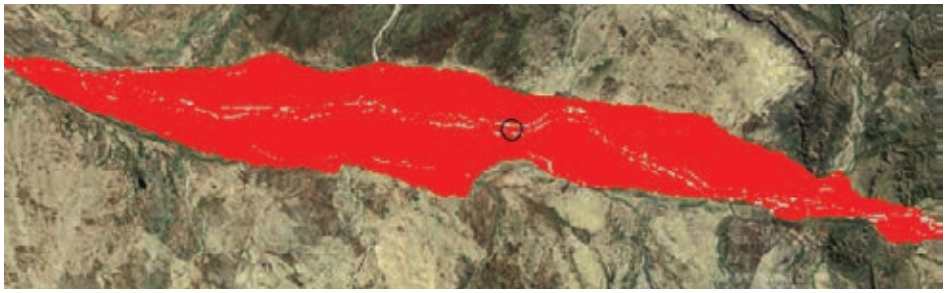
Reclassification due to use of finer-scale source data

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

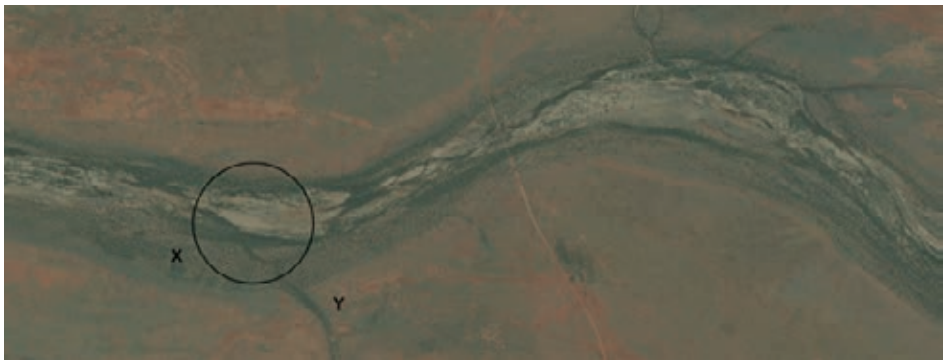
The use in the MLE approach of remote-sensing products with improved resolution, such as SLATS, NCAS and DLCM, has enabled more accurate delineation of forested areas at a finer scale. This improved accuracy of mapping accounts for most of the reductions in reported forest area in the Northern Territory,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

Agricultural land bordering native forest in Queensland.

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

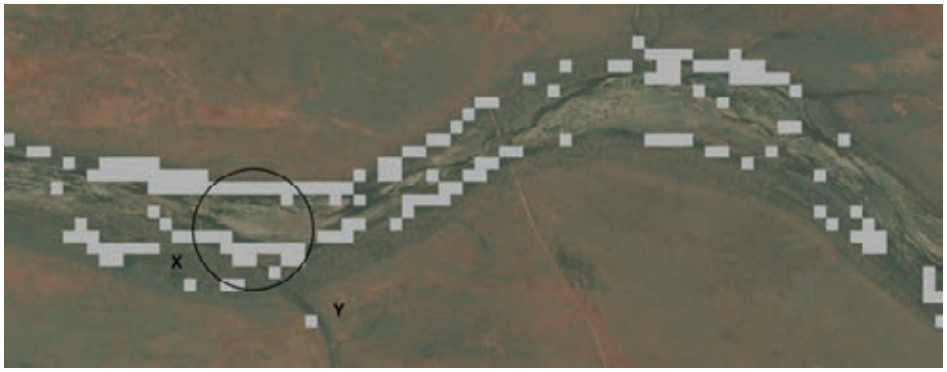


A. Single NVIS vegetation polygon (red) along De Grey River, east of Port Hedland, Western Australia, classified as 'Eucalypt low woodland of *Eucalyptus camaldulensis* and *Melaleuca leucadendron*' (20–30% crown cover), and reported as 27,279 hectares of forest in SOFR 2008. A total of 1,097 hectares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



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

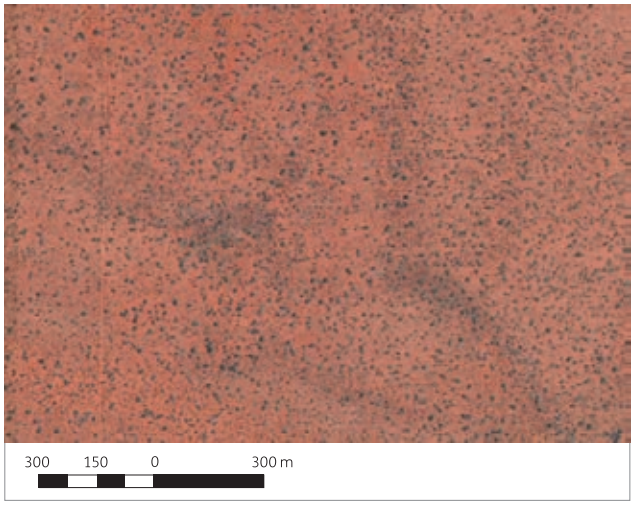
C. Same field of view as Figure B, showing area reported as forest in SOFR 2008 (red). The circle from A is also shown to scale.



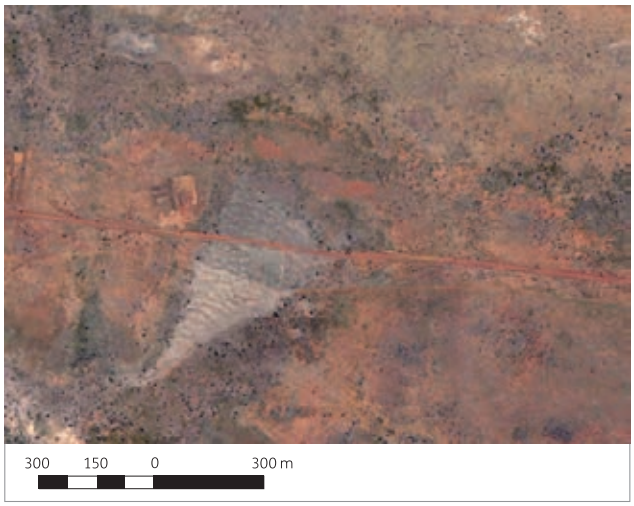
D. Same field of view as Figure B, showing area reported as forest in SOFR 2013 (grey). Grey pixels are 1 hectare each and more accurately track the distribution of riparian forest. The circle from A is also shown to scale.

Images source: Bing Maps.

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



A. Land in central Australia carrying other woody vegetation.



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

Images source: Bing Maps.

Reinterpretation of vegetation mapping data for forest classes

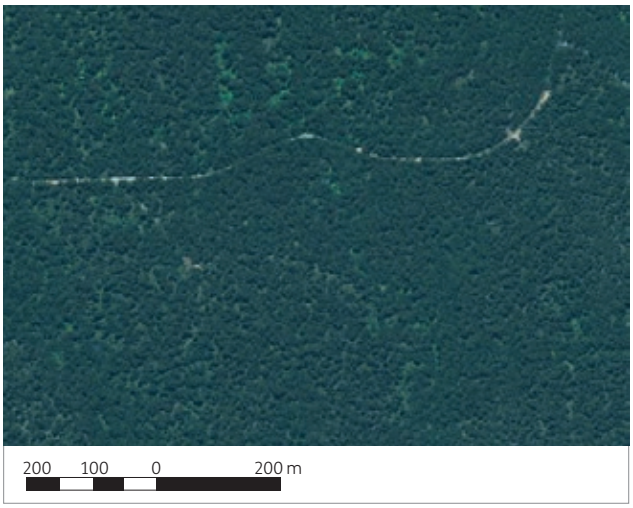
Development of the SOFR 2008 dataset used state and territory data provided using the NVIS vegetation framework at Level III (Broad Floristic Formation). This provides information on the dominant growth form, genus, cover and height of the uppermost canopy or dominant stratum. The analysis for SOFR 2013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

Correction of out-of-date data

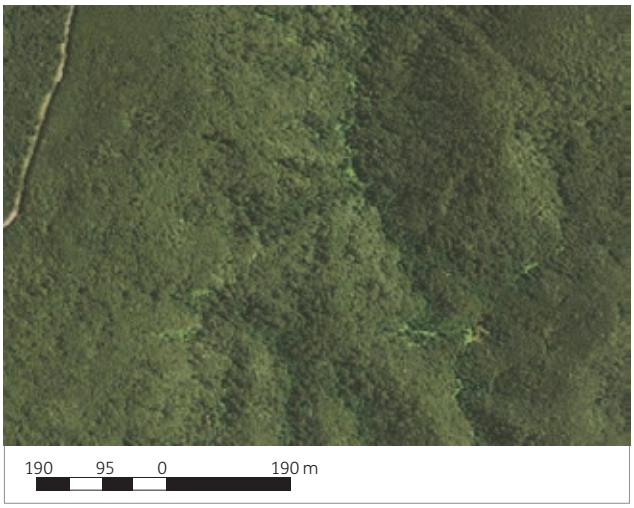
The NVIS mapping of floristic, structural and spatial attributes, underpinning the data supplied to the NFI by state and territory agencies, ranges in date stamp from the 1960s to 2009, although the majority of the data have a 1990s or later date stamp. Nevertheless, the age of much of these data precedes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

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

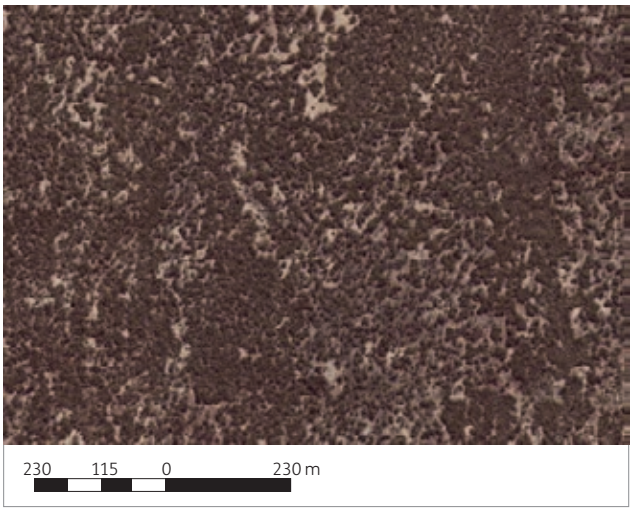
Figure 1.13: Examples of areas of reported as non-forest in SOFR 2008 but as forest in SOFR 2013



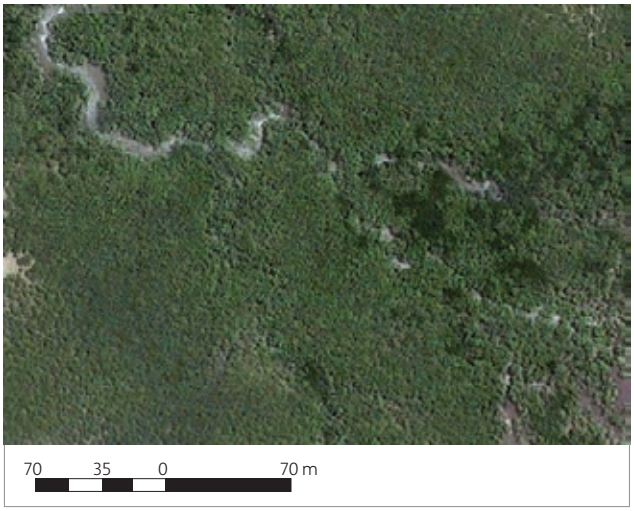
A. Eucalypt medium open forest, Captains Flat, southern New South Wales



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



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

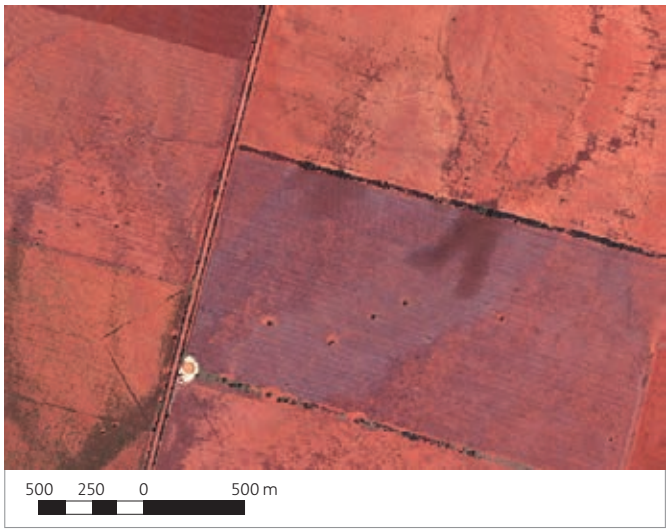


D. Mangrove forest, north-west Northern Territory

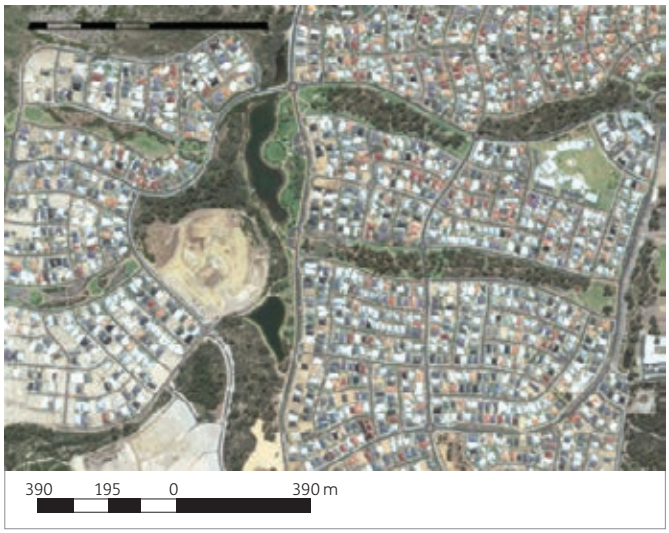
Images source: Bing Maps.

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

A. Mining development, south-west Western Australia



B. Agricultural land north of Condobolin, New South Wales



C. Urban development, south-west Western Australia

Images source: Bing Maps.

Indicator 1.1b

Area of forest, by growth stage

Rationale

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

Key points

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

Growth stage

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

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

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

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

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

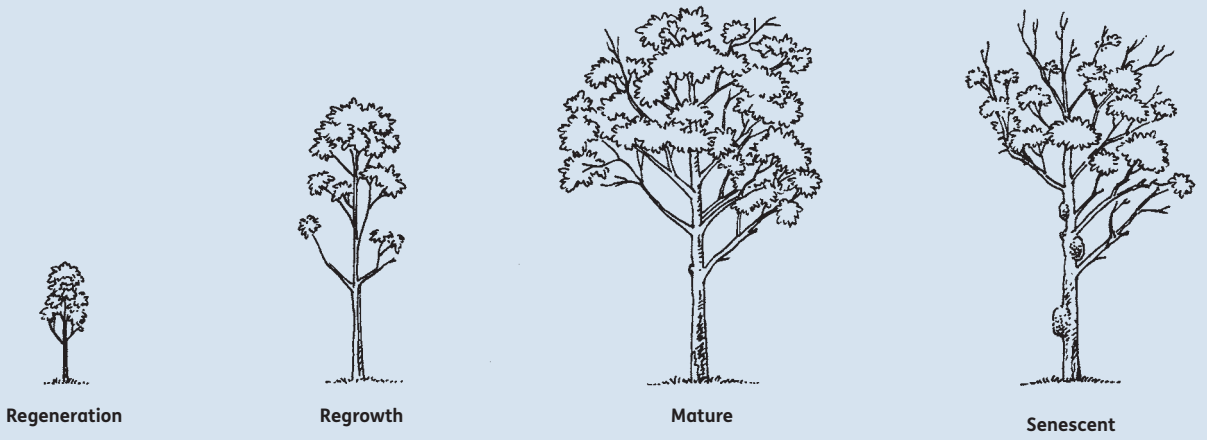
presents the level of data available for reporting against this indicator for 2006–11.

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

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

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

Figure 1.15: Classification of growth stages in native forests



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

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

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

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

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

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

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

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

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

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

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

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

‘Old growth’

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

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

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

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

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

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

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

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

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

Old-growth forest, Victoria.

[23] Pages 17–19 in SOFR 2008.

Case study 1.1: Forest growth stages in Tasmania

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

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

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

continued overleaf

Case study 1.1: Forest growth stages in Tasmania continued

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

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

RFA = Regional Forest Agreement

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

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

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

[d] Includes multiple-use forest.

[e] Differs from forest area for Tasmania reported in Indicator 1.1

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

Source: FPA (2012).

Indicator 1.1c

Area of forest in protected area categories

Rationale

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

Key points

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

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

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

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

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

Formal public nature conservation reserves

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

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

The Comprehensive, Adequate and Representative (CAR) reserve system

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

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

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

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

[24] www.cbd.int/convention/text/default.shtml.

[25] International Union for Conservation of Nature.

[26] http://www.environment.gov.au/topics/land/nrs/science/capad/2010.

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

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

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

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

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

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

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

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

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

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

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

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

Murramarang National Park, New South Wales.

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

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

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

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

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

CAR = Comprehensive, Adequate and Representative

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

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

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

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

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

CAR = Comprehensive, Adequate and Representative

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

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

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

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

Note: Totals may not tally due to rounding.

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

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

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

CAR = Comprehensive, Adequate and Representative

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

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

Note: Totals may not tally due to rounding.

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

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

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

CAR = Comprehensive, Adequate and Representative

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

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

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

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

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

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

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

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

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

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

Conservation covenants on privately managed land

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

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

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

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

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

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

31 www.trustfornature.org.au.

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

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

34 From September 2013, the Department of the Environment.

35 http://asdd.ga.gov.au/asdd/tech/zap/basic-full.zap?&target=ea-1&syntax=html&cclfield1=all&cclfield2=phrase&cclfield3=any&ccltem1=wetland&ccltem2=&ccltem3=&start=3&number=1.

36 www.bushheritage.org.au.

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

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

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

Note: Totals may not tally due to rounding.

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

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

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

CAPAD = Collaborative Australian Protected Area Database

Note: Totals may not tally due to rounding.

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

Protected areas comprising the National Reserve System

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

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

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

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

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

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

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

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

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

IUCN = International Union for Conservation of Nature

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

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

Note: Totals may not tally due to rounding.

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

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

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

Forest in areas protected for biodiversity conservation

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

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

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

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

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

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

Register of the National Estate

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

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

National Heritage List and Commonwealth Heritage List

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

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

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

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

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

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

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

IUCN = International Union for Conservation of Nature

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

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

Note: Totals may not tally due to rounding.

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

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

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

Note: Totals may not tally due to rounding.

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

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

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

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

UNESCO[41] World Heritage List

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

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

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

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

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

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

[a] World Heritage areas as at 2011

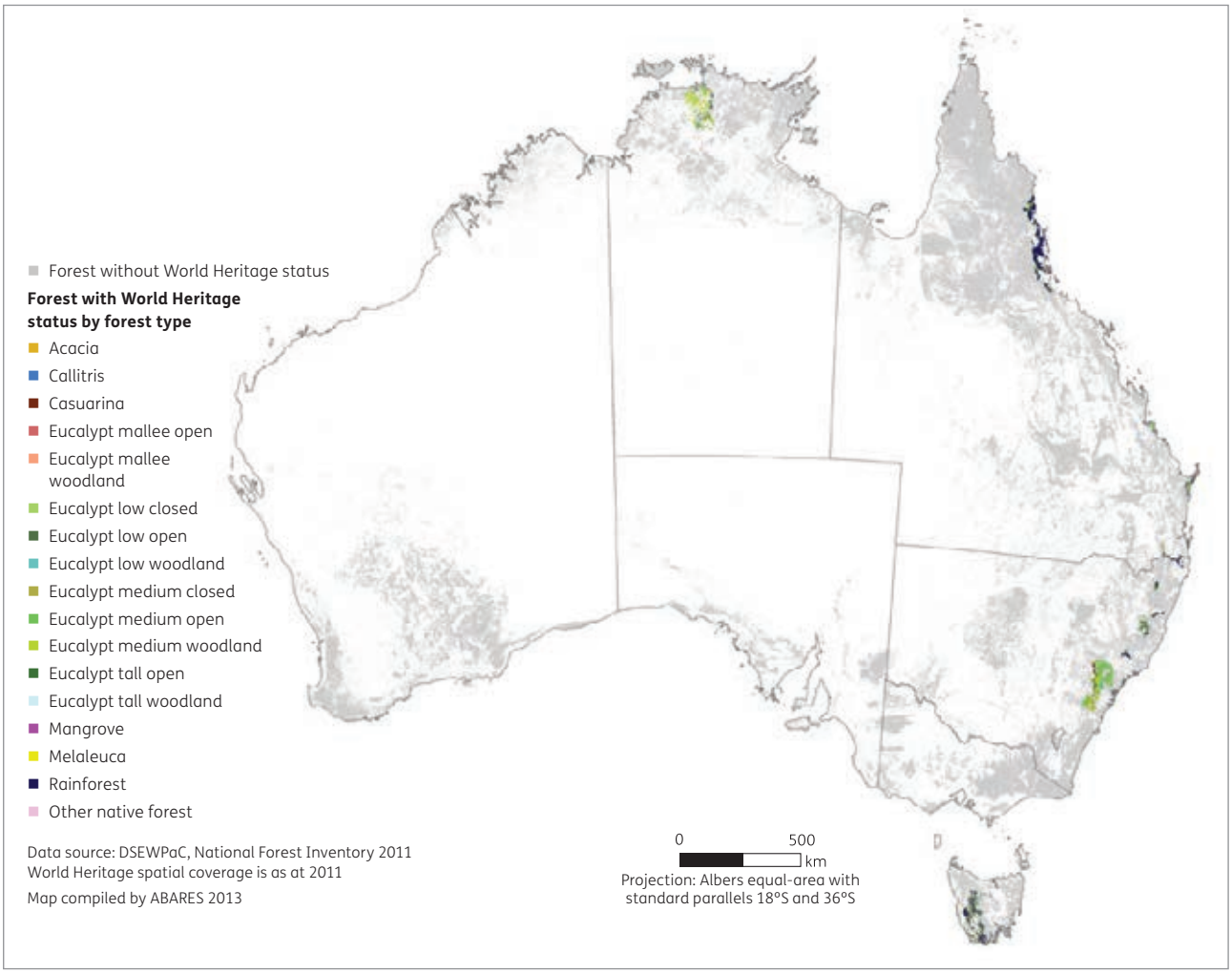
Note: Totals may not tally due to rounding.

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

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

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

Figure 1.17: Native forest areas with World Heritage status



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

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

Indicator 1.1d

Fragmentation of forest cover

Rationale

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

Key points

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

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

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

Michael F Ryan

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

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

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

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

Measuring fragmentation

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

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

Table 1.28: Parameters of landscape fragmentation

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

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

[43] www.umass.edu/landeco/research/fragstats/fragstats.html.

[44] www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html.

Tasmania

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

Nature conservation reserves

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

Multiple-use public forests

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

Private forests

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

South-east Queensland

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

Nature conservation reserves

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

Multiple-use public forests

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

Private forests

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

Case study 1.2: Strategic Biodiversity Corridors Project

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

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

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

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

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

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

Indicator 1.2a

Forest dwelling species for which ecological information is available

Rationale

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

Key points

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

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

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

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

Forest-dwelling and forest-dependent vertebrate species

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

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

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

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

– = not available

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

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

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

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

[e] Suspected incorrectly reported in SOFR 2008.

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

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

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

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

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

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

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

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

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

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

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

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

Notes:

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

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

Totals may not tally due to rounding.

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

Forest-dwelling and forest-dependent vascular plant species

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

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

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

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

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

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

[a] South-west Western Australia only.

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

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

Level of ecological knowledge

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

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

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

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

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

[47] www.tfic.net.au.

[48] www.warra.com.

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

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

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

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

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

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

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

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

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

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

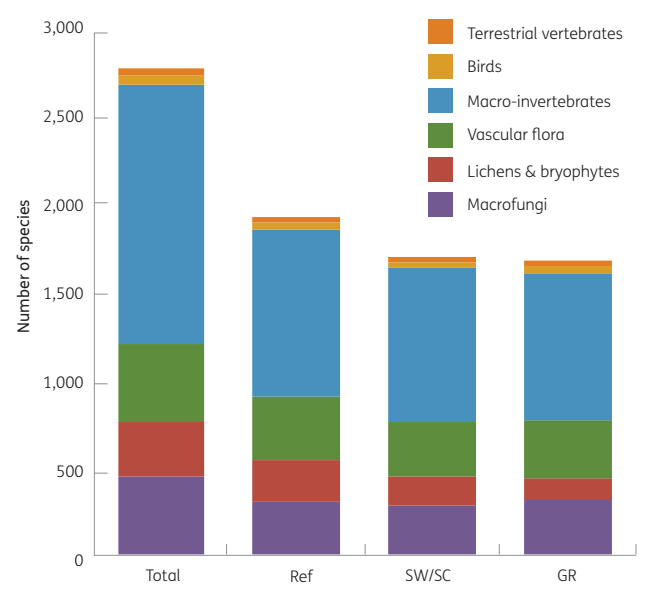
Case study 1.3: The Forestcheck project: integrated biodiversity monitoring in jarrah forest

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

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

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

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



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

Source: Western Australian Department of Environment and Conservation.

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

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

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

Indicator 1.2b

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

Rationale

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

Key points

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

Protecting listed threatened species and ecological communities

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

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

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

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

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

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

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

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

Distribution of threatened forest-dwelling and forest-dependent species

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

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

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

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

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

[a] Now known as *Rhinella marina*.

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

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

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

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

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

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

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

Notes:

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

Figures include species found on forested islands.

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

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

Threatening processes relating to forest fauna and flora

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

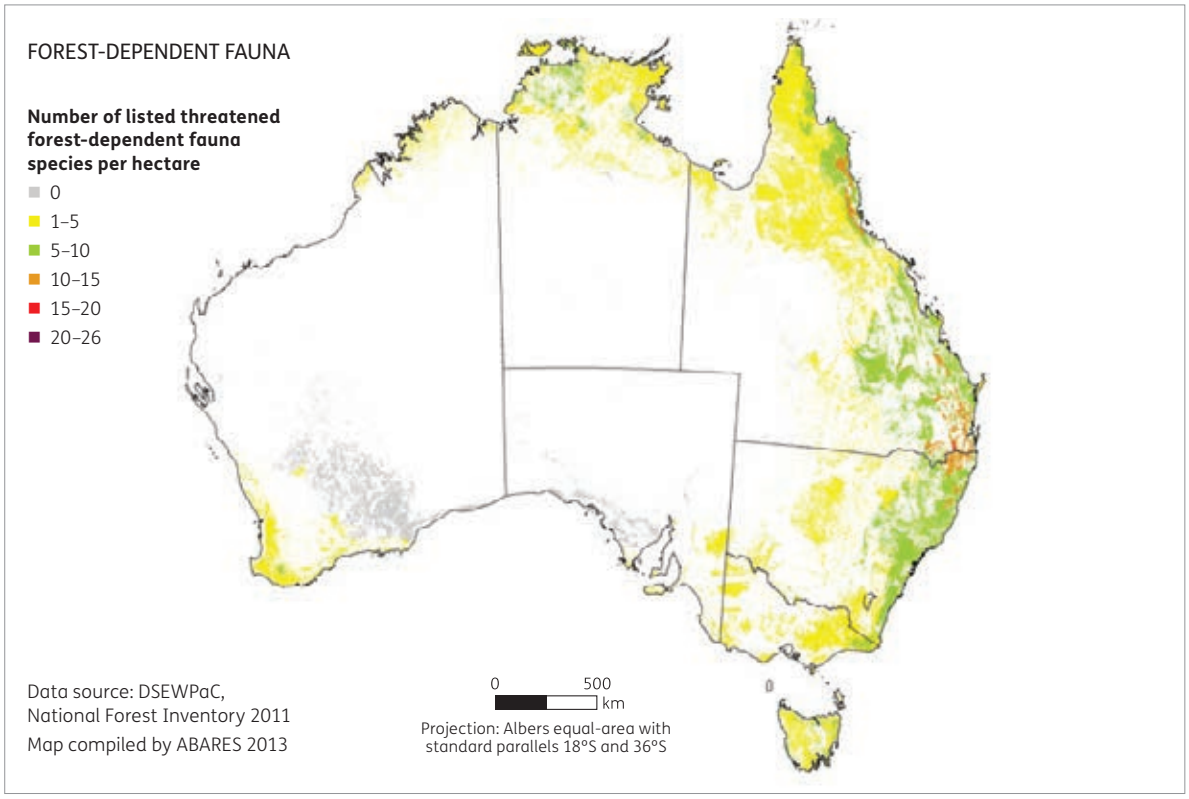
Land-use change and forest loss caused by clearing for agriculture, grazing, urban and industrial development has been the most significant threat for fauna species, followed by predation from introduced predators (e.g. fox, cat, rat and trout). Other significant threats are population size and localised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

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

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

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

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



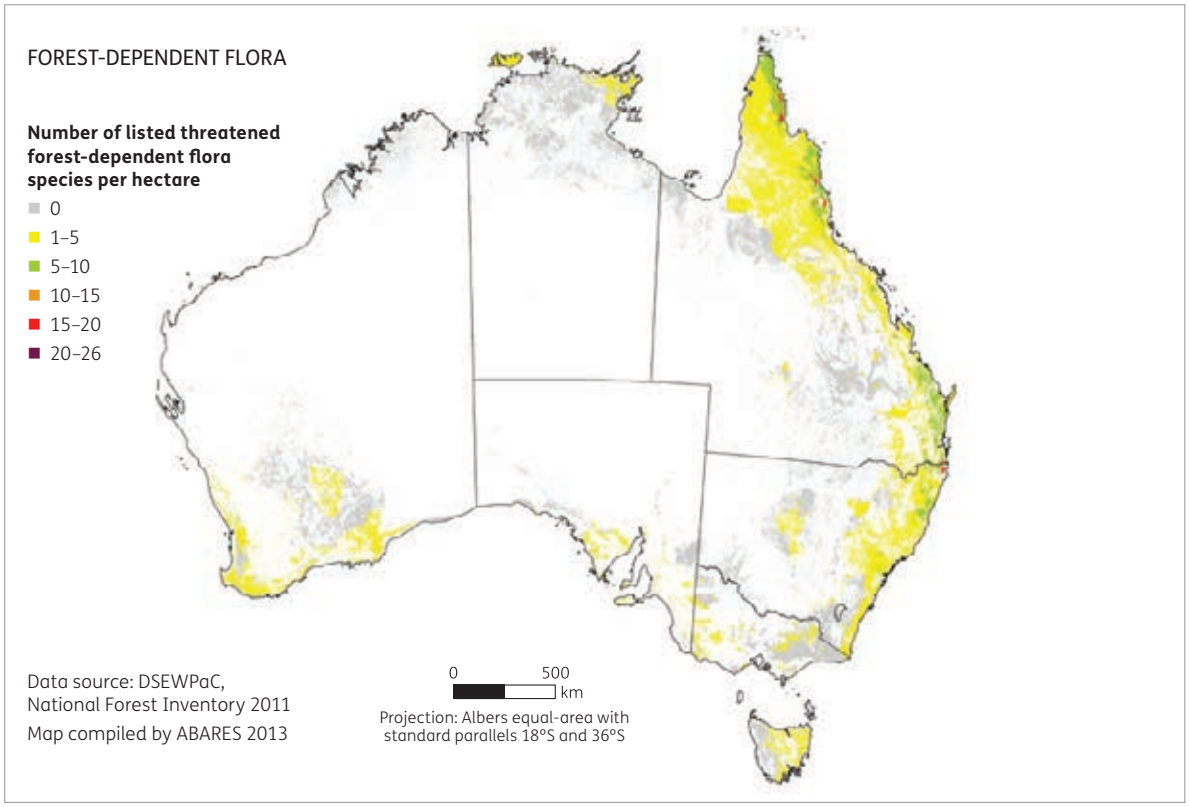
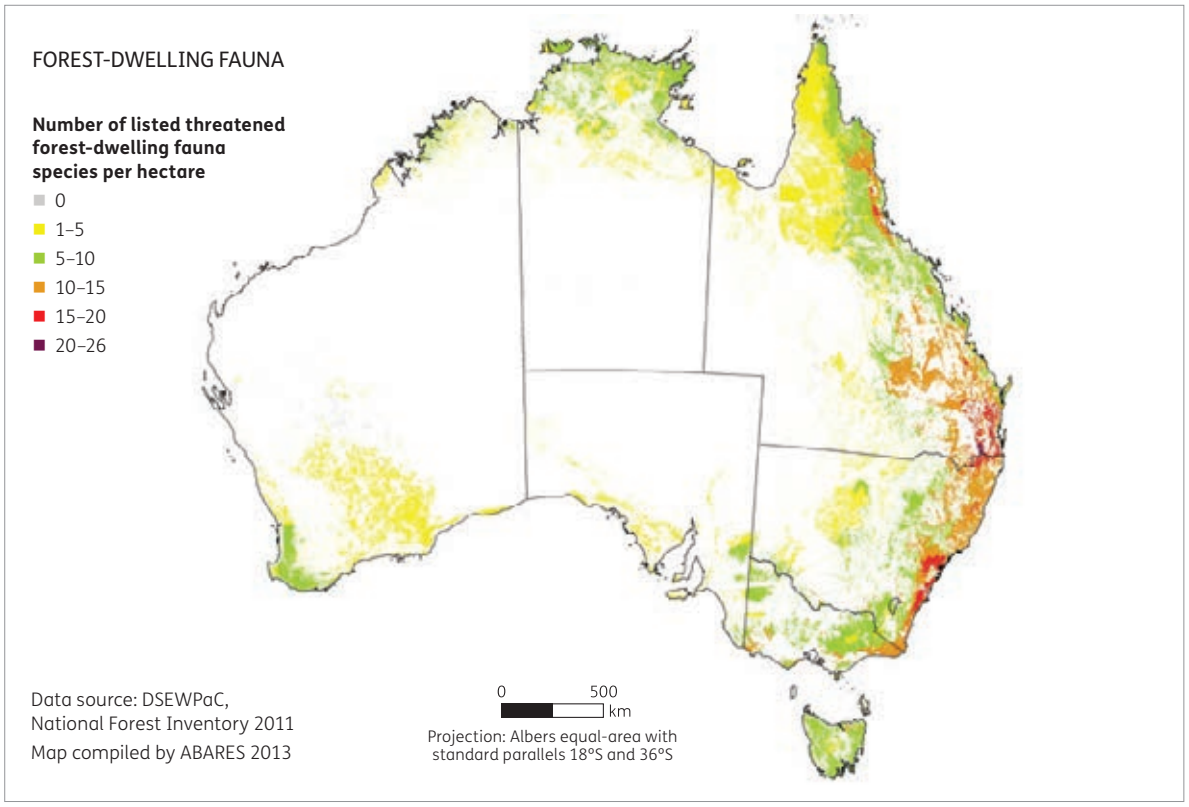
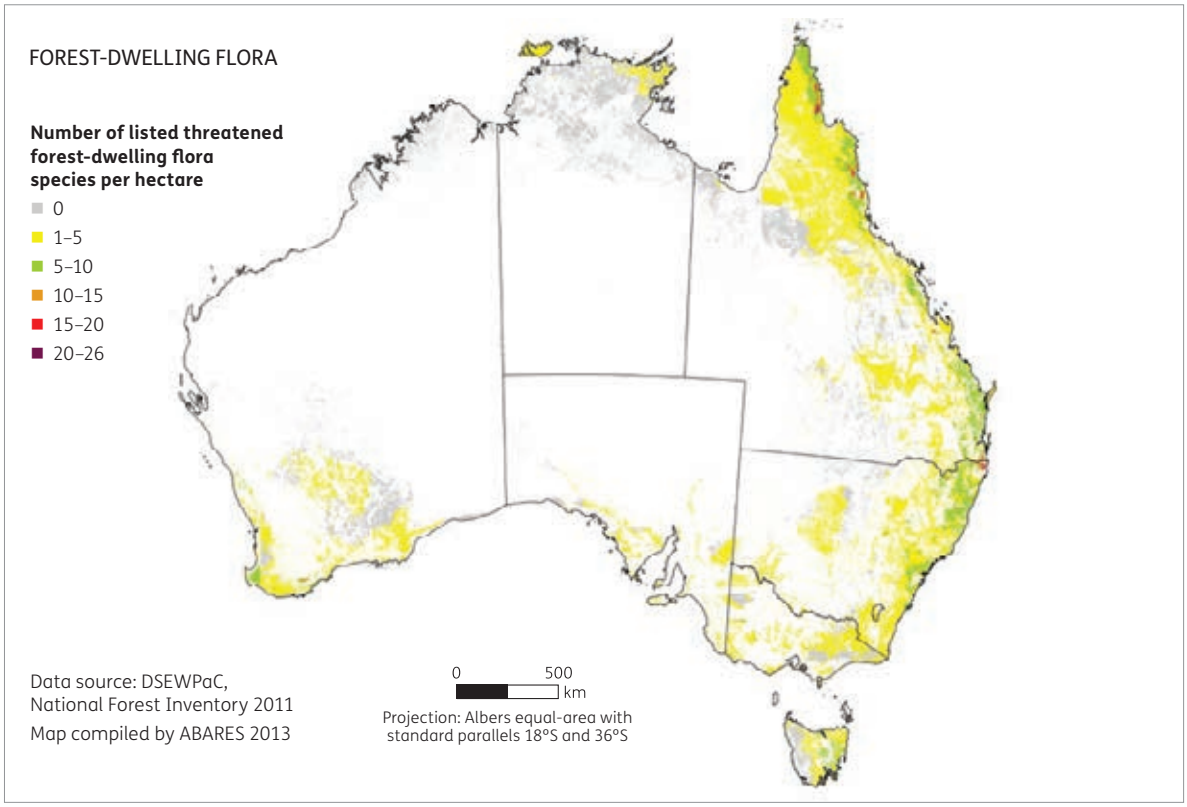


Figure 1.20: Distribution of threatened forest-dwelling and forest-dependent fauna and flora species continued





Notes:

Fauna include both vertebrate and invertebrate taxa.

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

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

Table 1.36: Threats to forest-dwelling threatened species

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

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

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

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

[c] 'Competition from introduced fauna' can include Australian fauna introduced to a locality.

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

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

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

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

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

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

[j] 'Predation and grazing' includes grazing by introduced and native herbivores, and vertebrate predation of seeds or plants.

Notes:

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

Totals may not tally due to rounding.

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

Changes in conservation status in reporting period

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

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

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

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

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

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

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

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

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

Notes:

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

Figures include species found on forested islands.

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

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

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

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

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

Notes:

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

Figures include species found on forested islands.

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

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

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

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

Notes:

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

Only one primary reason is given for each delisting.

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

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

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

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

Notes:

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

Figures include species found on forested islands.

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

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

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

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

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

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

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

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

[a] More than one primary threat may affect a species.

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

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

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

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

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

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

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

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

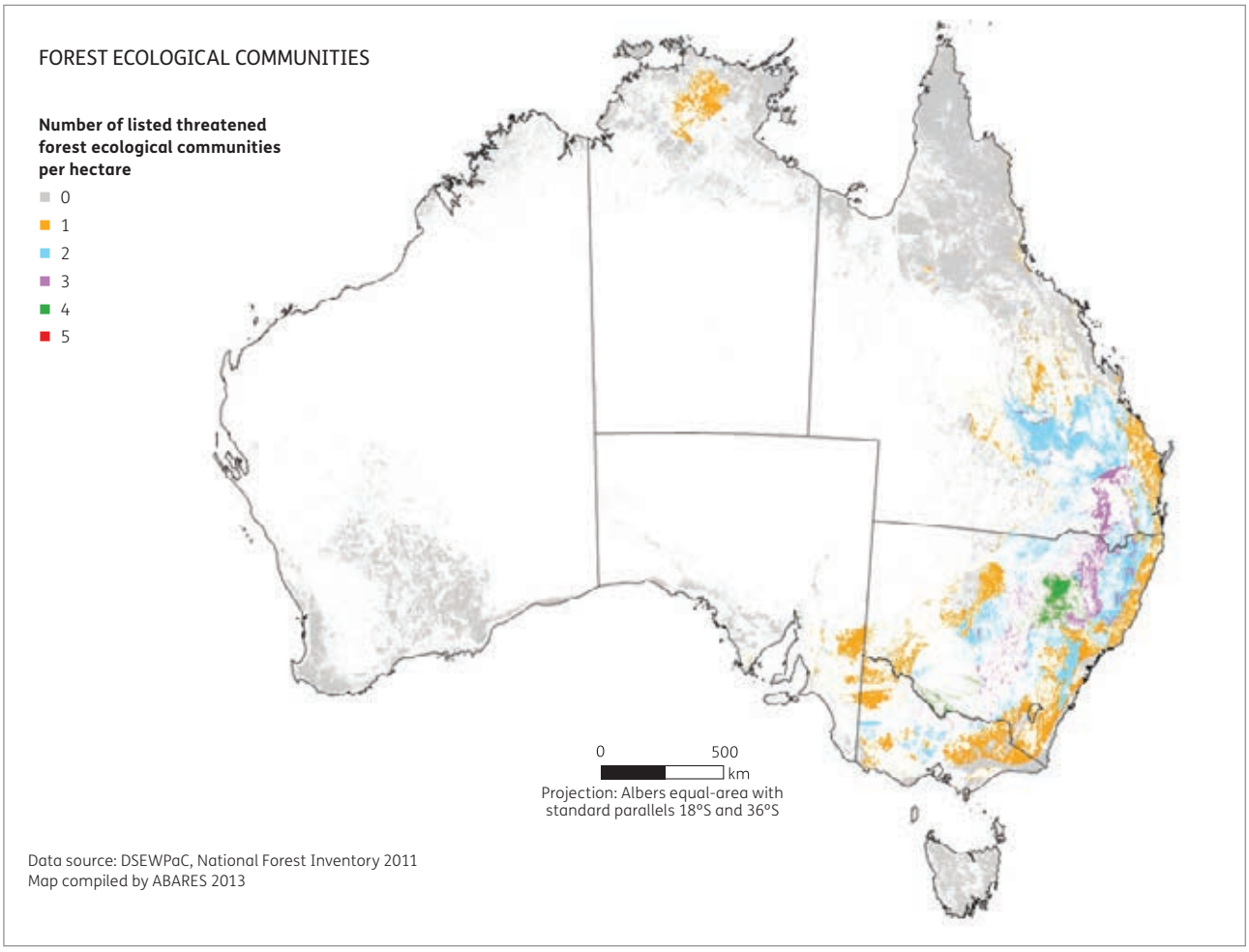
Threatened ecological communities

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

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

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

Figure 1.21: Distribution of listed threatened forest ecological communities



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

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

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

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

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

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

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

Notes:

Individual listings can cover more than one state or territory.

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

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

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

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

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

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

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

Case study 1.4: Red-tailed black-cockatoo

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

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

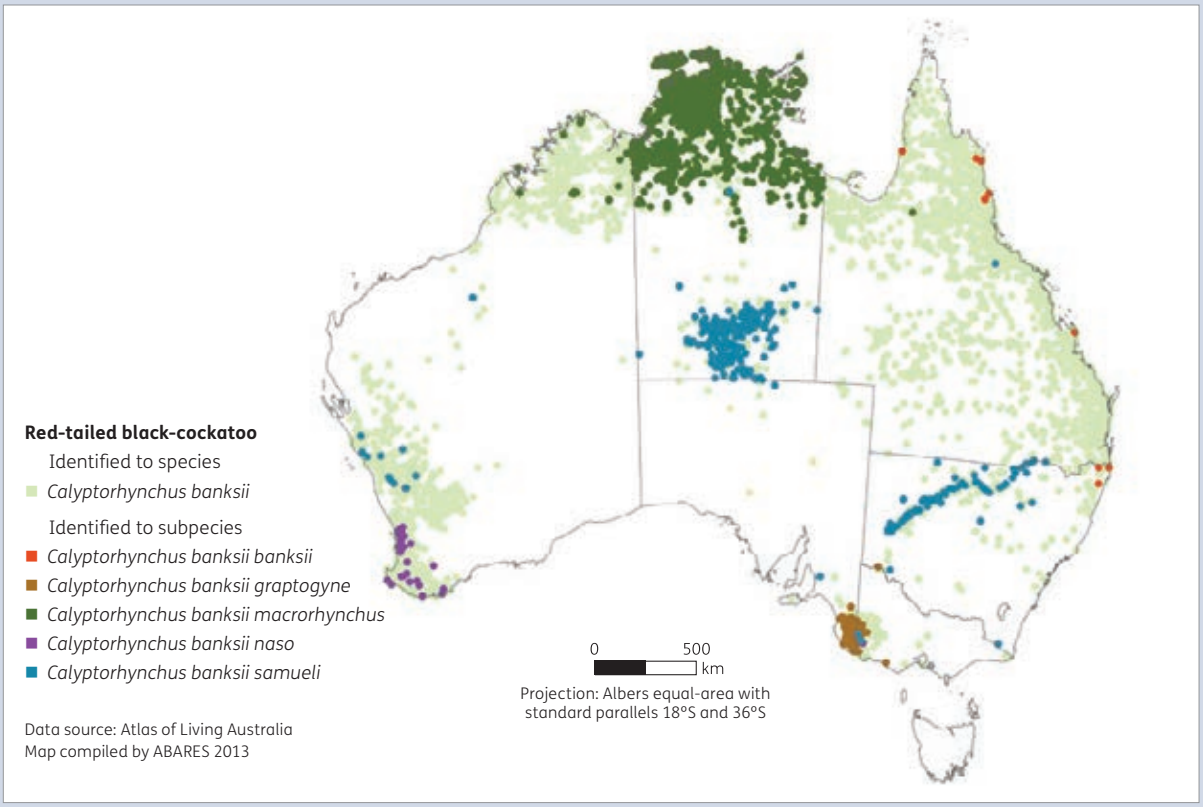
The population of the Vulnerable forest red-tailed black-cockatoo *C. b. naso* was estimated in 2006 to be approximately 15,000 birds (TSSC 2009a), inhabiting the dense jarrah (*Eucalyptus marginata*), karri (*E. diversicolor*) and marri (*Corymbia calophylla*) forests of south-west Australia. This subspecies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

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

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

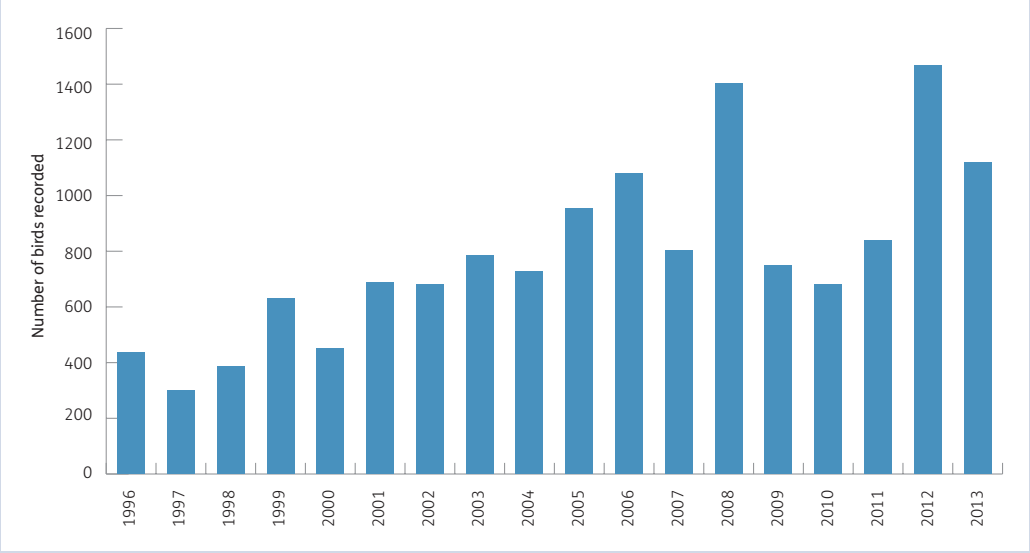
Case study 1.4: Red-tailed black-cockatoo continued

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



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

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



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

Indicator 1.2c

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

Rationale

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

Key points

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

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

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

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

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

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

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

Table 1.44: Taxonomic groups for which representative species are being monitored

	Mammals	Birds	Reptiles	Amphibians	Fish	Invertebrates	Vascular plants	Non-vascular plants
Jurisdiction	Level of monitoring							
ACT	■	■	■	■	■	△	■	△
NSW	■	■	△	■	■	△	■	△
NT	■	■	△	△	△	△	■	△
Qld	■	■	■	■	■	△	■	△
SA	■	■	△	■	■	△	■	△
Tas.	■	■	△	△	△	■	■	△
Vic.	■	■	■	■	■	△	■	■
WA[a]	■	■	■	■	△	■	■	■
Australia[b]	■	■	■	■	■	△	△	△
Jurisdiction	Change in effort and capacity							
ACT	s	+	s	s	s	△	+	△
NSW	s	–	△	s	n	△	s	△
NT	s	s	△	△	△	△	s	△
Qld	s	s	s	s	+	△	s	△
SA	s	s	△	–	n	△	–	△
Tas.	+	+	△	△	△	s	s	△
Vic.	s	s	s	s	n	△	+	+
WA[a]	s	s	s	s	△	s	s	s
Australia[b]	s	s	n	s	n	△	△	△

Level of monitoring: ■ = at least one species of the taxonomic group is being monitored to detect changes in population size at a scale relevant to forest management; ■ = more than 10 species are being so monitored; △= no species in the taxonomic group is being so monitored, or no data available on monitoring effort

Change in effort and capacity since SOFR 2008: + = increased level; – = decreased level; n = new program; s = stable

[a] http://naturemap.dec.wa.gov.au/default.aspx and Forestcheck (see Case study 1.3 in Indicator 1.2a).

[b] Includes non-government mechanisms through Birdata (www.birdata.com.au), FrogWatch and ReptileWatch (www.frogwatch.org.au and www.frogwatch.org.au/index.cfm?action=cms.page&section=2), and fish monitoring (Davies et al. 2012).

Note: Studies of monitoring of forest ecosystems are not included. No data were available for the ACT or Qld for reporting in SOFR 2008, however change in effort and capacity reflects change since SOFR 2008 reporting period. Monitoring of fish is based on Davies et al. (2012); in Queensland, monitoring includes Murray–Darling Basin and coastal freshwater waterways.

Source: Australian Government, state and territory agencies.

Recognising the value of a structured, broad-based monitoring program in assisting long-term management, Western Australia established Forestcheck, a comprehensive approach to monitoring species in the state's south-western forests (McCaw et al. 2011). Forestcheck (Case study 1.3 in Indicator 1.2a) is one of only a few programs in the world collecting regional-scale information on mosses, lichens, fungi and invertebrates, as well as the better known components of forest biodiversity (vertebrates and vascular plants). A similar intensity of biodiversity monitoring has been carried out at the Warra Long-term Ecological Research site in the Huon region of southern Tasmania (see Case study 1.8). The Victorian Forest Monitoring Program[55] is being implemented to monitor and report changes in the extent, state and condition of Victorian public forests and parks, as well as changes in biodiversity (see Indicator 7.1d).

Sustainable forest management requires an understanding of ecological trends over long timescales. Long-term monitoring programs such as Forestcheck in Western Australia and the Warra study in Tasmania will deliver some of that information and thereby contribute to continuous improvement of sustainable forest management in those states. In general, there is more monitoring of species and their habitats on multiple-use public native forests than on other tenures.

Species that are commercially harvested for non-wood forest products are also monitored. Harvesting of tree ferns (*Dicksonia antarctica*), common brushtail possums (*Trichosurus vulpecula*), Bennetts wallaby (*Macropus rufogriseus*) and Tasmanian pademelon (*Thylogale billardierii*) in Tasmania are examples (see Indicator 2.1d).

[55] http://www.depi.vic.gov.au/forestry-and-land-use/forest-management/forest-sustainability/victorian-forest-monitoring-program#thevfmp.

Case study 1.5: Island Ark program

The cane toad (*Rhinella marina*, previously *Bufo marinus*) was first sighted in the Northern Territory in 1984. By 2001, the toads had reached southern Kakadu National Park and were in the river catchments surrounding the park. By 2004–05, they were detected in Darwin.

The northern quoll (*Dasyurus hallucatus*; Figure 1.25), which occurs in forested environments, is one of the Northern Territory's native mammals most threatened by the spread of cane toads. Quolls disappear from most areas colonised by cane toads soon after the toad's arrival. The northern quoll is now listed as endangered under the *Environment Protection and Biodiversity Conservation Act 1999*.

In 2003, to prevent the possible extinction of northern quolls in the Northern Territory, a small number of northern quolls were captured from the Northern Territory mainland and relocated to two islands off the Territory coast that do not contain cane toads, under the Northern Territory Government's Island Ark program. The founding population size of 64 individuals had increased to more than 5,600 by December 2007. In 2009, the population had stabilised on one island, at just under 3,000 individuals, and slightly declined on the other, smaller island. All other forest fauna on the islands appear healthy despite the large numbers of quolls.

This translocation program has ensured the ongoing survival of northern quolls in the Northern Territory. In the future, there is the possibility of relocating quolls from these islands back to their mainland habitat.

Quolls are now known to occur naturally on 11 Northern Territory islands, providing some further security from the threat posed by cane toads. Their persistence on these islands is heavily dependent on keeping cane toads from colonising the islands.

Figure 1.25: Northern quoll (*Dasyurus hallucatus*), which occurs in the tropical forests of northern Australia

Case study 1.6: Swift parrot

The swift parrot (*Lathamus discolor*) breeds only in Tasmania. It migrates to the Australian mainland in autumn to spend the winter foraging for lerps and nectar in flowering eucalypts, mainly in Victoria and New South Wales (Figure 1.26). In Tasmania, the bird's breeding range is mostly restricted to the east coast within the range of the Tasmanian blue gum (*Eucalyptus globulus*) (Figure 1.27). The breeding season coincides with the blue gum's flowering, when the tree's nectar provides the parrot with its main food source.

Persistence of the swift parrot is mainly threatened by loss and alteration of habitat as a result of clearing for residential, agricultural and industrial developments; forestry activities, including firewood harvesting; attrition of old-growth trees in the agricultural landscape; suppression of forest regeneration; and frequent fire. The species is also threatened by the effects of climate change, competition for food and nest sources, flight collision hazards, psittacine beak-and-feather disease, and illegal capture and trade (Saunders and Tzaros 2011).

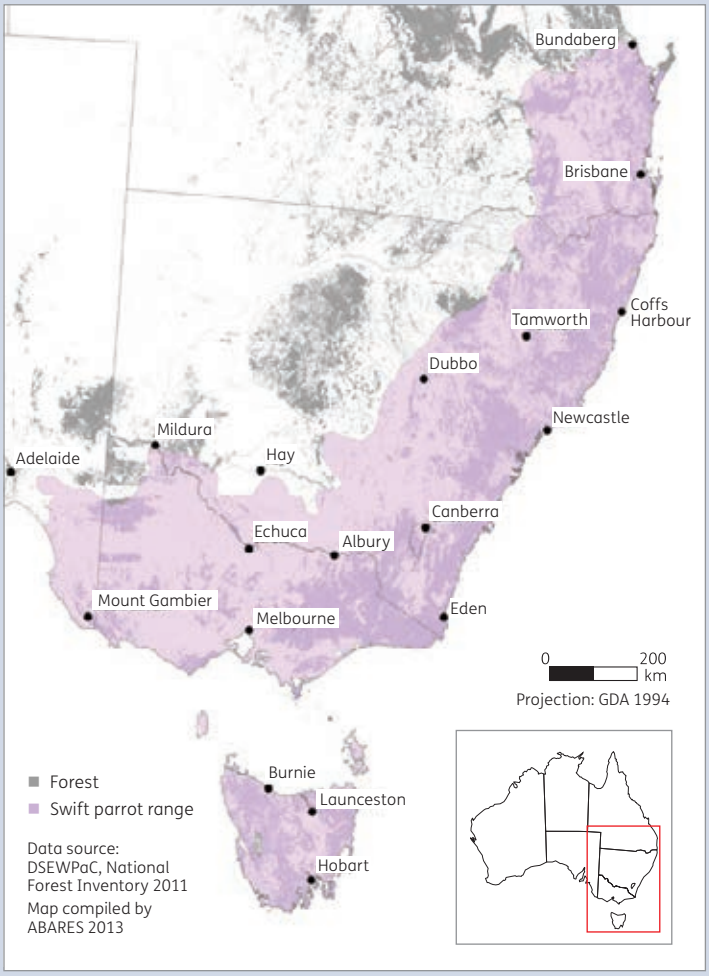
The Tasmanian forest practices system provides protection of the swift parrot's key habitats (forests containing *E. globulus* or *E. ovata*) from clearing and conversion of forests on both public and private land. Prescriptions for the management of swift parrot nesting and foraging habitat have been updated, with the aim of improving the management of nesting habitat (particularly as the species tends to exhibit aggregated nesting behaviour) and foraging habitat in wet forest types, especially near-coastal *E. globulus* forest.

In 2010, the Australian and Tasmanian governments initiated the Regional Forest Agreement (RFA) Priority Species Project to implement a strategic landscape approach to the management of RFA priority species, including the swift parrot and its habitats in Tasmania. The primary objective of the project is to develop a strategic plan and guidelines to support improved conservation management of swift parrot breeding habitat. This will include population and habitat monitoring.

A monitoring program was established to determine the extent of the population and to monitor population trends. The first season of population monitoring was conducted in the 1987–88 breeding season in Tasmania, which located an estimated 1,320 pairs (Brown 1989). Another survey was carried out during the 1995–96 breeding season, which located an estimated 940 pairs. These surveys attempted to locate and count a portion of all breeding birds. During the breeding seasons from 1999 to 2004, fixed-stationary observer techniques were used at 55 sites to estimate the density of swift parrots across the range of dry, grassy blue-gum forest in eastern Tasmania. The results from these surveys suggest that the swift parrot population was, at best, stable during that time (Saunders et al. 2010).

Breeding season surveys from 2004 to 2009 focused on the distribution of nesting and habitat use. These surveys recorded the annual variation in the spatial characteristics of breeding events. They have documented sites being used extensively by breeding swift parrots, followed by several years of little or no breeding activity at these sites. The finding of a large breeding event in the wet forests of southern Tasmania (Webb 2008) confirmed that wetter habitats provide an important alternative to areas dominated by dry forests and may serve as an important refuge habitat during drought.

Figure 1.26: Distribution of the swift parrot in Australia

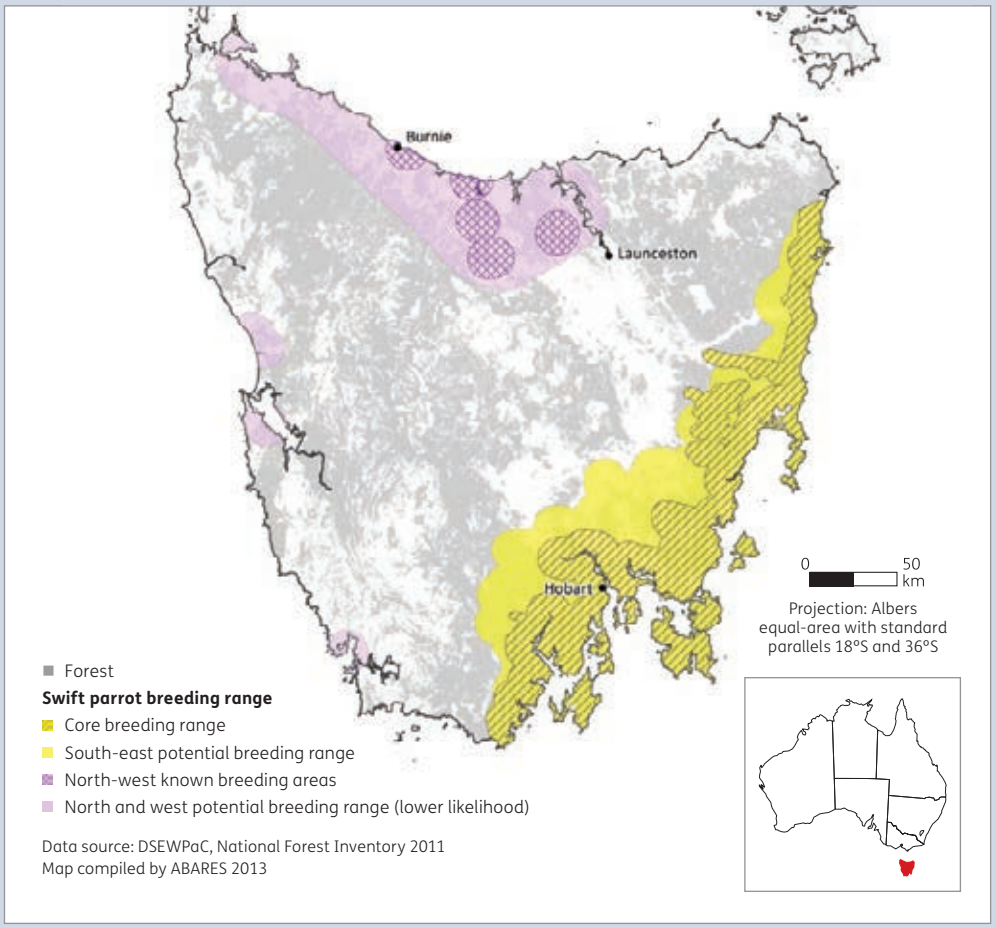


Note: Distribution of the swift parrot is compiled using a range of datasets of varying quality and should only be used as a guide. The presence of the species or its habitat should be confirmed using local information services.

continued overleaf

Case study 1.6: Swift parrot continued

Figure 1.27: Swift parrot breeding range



Note: Map shows the potential breeding range of the swift parrot in Tasmania, based on current information. The breeding range is divided into the core breeding range (the area, within the south-east potential breeding range, thought to be of highest importance for the maintenance of breeding populations), the south-east potential breeding range (areas in the south-east of Tasmania where breeding could occur based on the occurrence of breeding habitat and foraging habitat), north-west known breeding areas (sites in the north-west of Tasmania where nest sites are known to occur), and the north and west potential breeding range (areas in the north-west of Tasmania where breeding could occur based on the occurrence of small breeding habitat and foraging habitat, but is less likely to occur than areas in the south-east).

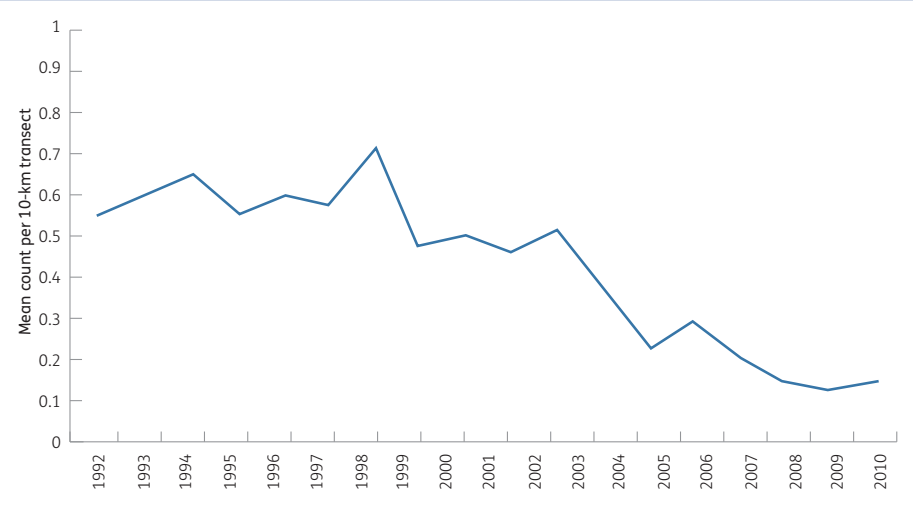
Source: Tasmania Department of Primary Industries, Parks, Water and Environment, adapted from FPA and Threatened Species Section (DPIPWE) (2012)[a].

[a] www.dpipwe.tas.gov.au/inter.nsf/WebPages/LJEM-8JN6YE?open.

Case study 1.7: Tasmanian devil

The Tasmanian devil (*Sarcophilus harrisii*), endemic to Tasmania, is the world's largest extant marsupial carnivore. Devils are found across Tasmania in a range of habitats, including open forests and woodlands. From being considered common and stable in 1992, the Tasmanian devil is now considered Endangered under the *Tasmanian Threatened Species Protection Act 1995* (since 2008) and under the *Environment Protection and Biodiversity Conservation Act 1999* (since 2009). The population has declined dramatically over the past decade (Figure 1.28), due to a fatal, contagious cancer—devil facial tumour disease (DFTD). Signs resembling symptoms of the disease were first reported in 1996 in north-east Tasmania, and the disease has since spread across more than three-quarters of the state.

Figure 1.28: Tasmanian devil population estimated from spot-light transects



Source: FPA (2012).

DFTD is a lethal cancerous disease, which to date has only been recorded in devils. The disease takes the form of tumours on the head of the devil, and these may spread to other parts of the body. It is an infectious disease that is believed to spread largely through biting, typically affecting only adults, and death occurs within months of the first signs. There is as yet no evidence to suggest that the spread of DFTD in Tasmania will cease, or that populations can recover once infected. However, Tasmanian devils still exist throughout the mainland of the state, in all rural habitats, and no local extinctions have yet been detected.

In response to the threat of DFTD to Tasmanian devils, the Save the Tasmanian Devil Program[a] was established as a joint initiative between the Australian and Tasmanian governments, with the long-term strategic goal of an enduring and ecologically functional population of Tasmanian devils in the wild. At the completion of the first phase in 2008, both governments committed to a second five-year phase, from 2008 to 2013, with a total investment of $25 million. The Save the Tasmanian Devil Program has made substantial progress in securing the species from extinction by establishing an insurance population, investigating novel approaches to manage populations in the wild, funding scientific research to advance understanding of the disease, and establishing major partnerships.

In 2011, a monitoring strategy was developed by the Save the Tasmanian Devil Program to streamline and coordinate monitoring activities and to align with the program business plan. Monitoring includes the use of remote-sensor camera technology, which is capable of assessing populations at a regional level. The monitoring strategy describes three different monitoring streams, with the first stream 'status of the devil populations' aiming to address the following questions:

- Is there local extinction or recovery in a diseased population?
- Are there devil populations that are demonstrating an atypical response to the disease?
- What is the population status of devils across the state?
- Where is the current disease front?

continued overleaf

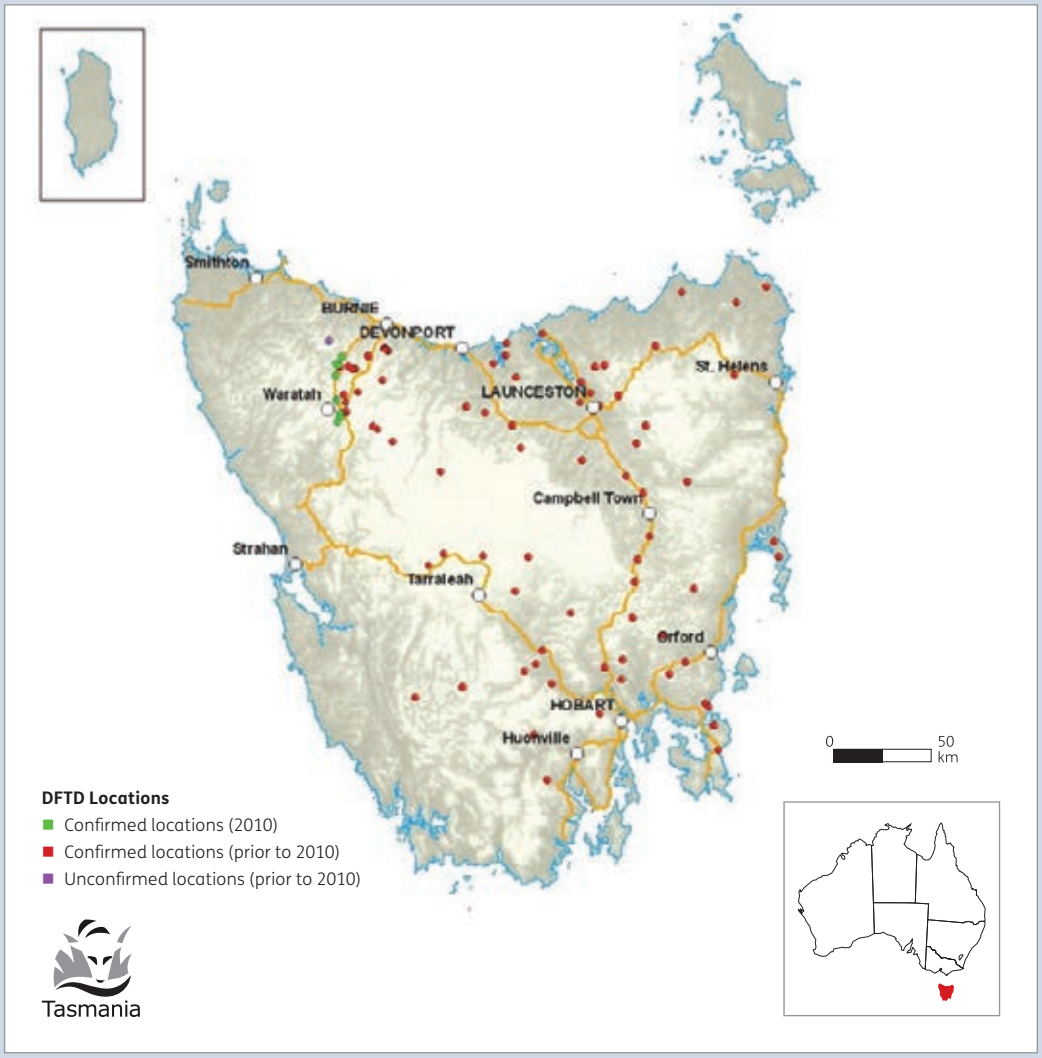
[a] Further information on the program can be found at www.tassiedevil.com.au/tasdevil.nsf.

Case study 1.7: Tasmanian devil continued

The spread of the disease across Tasmania is measured annually by detecting the disease front—the point at which disease is first detected in healthy populations. The disease, having started in the north-east corner of the state, has continued to spread west and south, and now affects 75% of the state. There has been an 84% decline in average sightings of devils across Tasmania during the annual spotlight surveys and at the original site of infection they have decreased by 97%. Figure 1.29 shows the distribution of the disease in 2010 (FPA 2012).

Monitoring the status of the devil populations and understanding the progression and impact of DFTD on wild Tasmanian devil populations is informing how the program manages the impacts of the disease on devil populations and plans for future actions, such as fencing and the possible reintroduction of devils into parts of Tasmania.

Figure 1.29: Devil facial tumour disease distribution in 2010



Source: Tasmania Department of Primary Industries, Parks, Water and Environment, adapted from FPA (2012).
Shading represents relief, with higher altitudes being a paler colour.

Case study 1.8: Monitoring changes in plants and beetles up an altitudinal transect

A series of altitudinal transects in the Warra supersite (see www.warra.com, Figure 1.30), southern Tasmania, is being monitored to investigate how plant and animal communities change with altitude, and whether those altitudinal patterns shift over time. The aim is to look for early indications of how climate change is affecting biodiversity in the cool temperate parts of Australia.

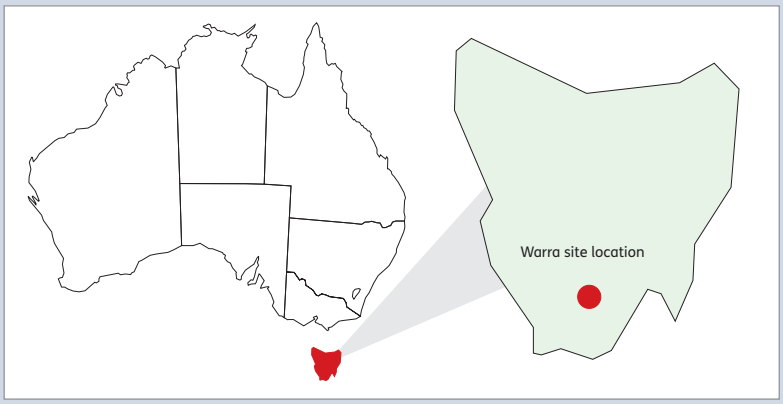
The two main transects run from lowland *Eucalyptus obliqu*a forest on the banks of the Weld River at an altitude of 100 metres, through temperate rainforest and subalpine *E. coccifera* forest, to alpine heath on the summit of Mount Weld at 1,300 metres. Permanent plots have been located at every 100 metre altitude increment along the transects (Grove et al. 2004).

An initial survey of birds, vascular plants and arthropods in the plots was done by staff from the Department of Primary Industries, Parks, Water and Environment, and Forestry Tasmania, during the summer months of 2000 and 2001 (Figure 1.31). This survey has provided a baseline for comparison with future surveys.

The initial survey identified points along the altitudinal gradient where community composition changed rapidly with altitude (discontinuities). Interestingly, the altitudes corresponding with these discontinuities differed for different groups of species (Figure 1.32). The distributions of particular groups of species are expected to be most sensitive to climate change at these discontinuities.

A second survey of vascular plants and ground-dwelling arthropods in the altitudinal transects was done during the summer of 2011–12. Initial analysis found that no significant change in vascular plant communities had occurred since 2000–01.

Figure 1.30: Location of Warra Long-Term Ecological Research (LTER) site



Source: Fusebox Design.

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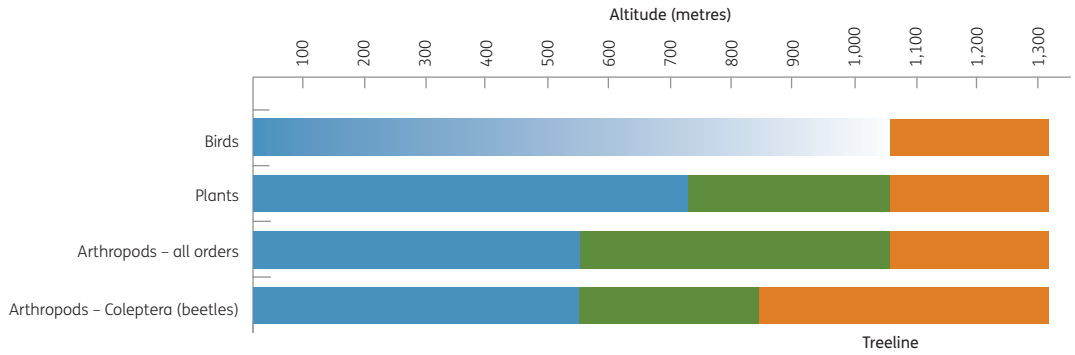
Case study 1.8: Monitoring changes in plants and beetles up an altitudinal transect continued

Figure 1.31: Malaise trap for sampling flighted arthropods, installed in the 600-metre altitude plot at Warra

Figure 1.32: Discontinuities in community composition with altitude



Note: Four species groups were sampled in 2000–01 in plots at 100-metre intervals along the Warra altitudinal transects. Arthropod data relate only to ground-dwelling species captured in pitfall traps. Altitude ranges corresponding to communities of similar composition are coloured similarly; discontinuities in community composition are represented by changes in colour. The decrease in intensity of the blue shading for birds with increasing altitude represents a decrease in diversity and abundance with increasing altitude up to the tree line (1,100 metres), without a distinct change in community composition; there is then a distinct change in community composition at the tree line.

Source: Forestry Tasmania.

Indicator 1.3a

Forest associated species at risk from isolation and the loss of genetic variation, and conservation efforts for those species

Rationale

This indicator assesses the risks to loss of forest genetic variation and describes the formal measures designed to mitigate this risk. A loss of genetic diversity in species can result in a decreased ability to adapt to future environmental change, and thus a higher risk of extinction.

Key points

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

The distributions of many Australian species before European settlement are not well known. Historical records, expert opinion and analysis, evidence of major changes in species distributions over the past few decades and incidental observations have been used to compile maps of, or to model, the former distributions of species. For example, the comprehensive regional assessments used in Regional Forest Agreement (RFA) processes provided pre-1750 estimates of the extent of forest ecosystems within the main production forest estate across RFA regions. Estimates of the historical distribution of species are required to determine whether reductions in distribution could increase the risk of loss of genetic variation.

Risk to forest genetic variation

Species with a reduced level of genetic variation are widely held to be less able to withstand unexpected threats, and so to face a higher risk of extinction (although, naturally, many other factors are relevant in individual cases). In practice, it is difficult to determine how much of the genetic variation within a species has been lost historically. However, it is possible to identify whether certain threatened species are becoming endangered by the increased isolation of populations due to habitat depletion and fragmentation, and threatening biotic factors such as those discussed in Indicator 1.2b.

Forest fragmentation (see Indicator 1.1d), mainly caused by clearing for agriculture and urban expansion, is a significant contributor to a reduction in genetic variation of certain species. Many threatened plant populations that have become fragmented are increasingly identified in new or updated conservation advice and recovery plans as having genetic inbreeding and fecundity risks. Native populations at greatest risk and of greatest concern are those that are already small or fragmented and also have high conservation value. A change in climate, such as that predicted from the increasing atmospheric concentrations of greenhouse gases, is also likely to contribute to a reduction in forest genetic variation (Doley 2010).

Several institutions have programs to measure genetic diversity in forest fauna, but nationally conclusive results are available for only a few species.

Changes over time in the genetic diversity of forest-associated flora also have been little measured, although several studies have documented genetic variation and the distribution of this variation within existing populations at a single point in time. These studies suggest that a reduction in range is less likely to cause significant loss of genetic variation in species with a high level of diversity within populations and a low level of diversity between populations. This type of population genetic structure has been found for most of the limited number of tree species that have been surveyed to date. A reduction in range is more likely to reduce genetic variation in species that exhibit low genetic diversity within populations and high variability between populations, such as that typically encountered in species with naturally restricted ranges (e.g. narrow-leaved mallee, *Eucalyptus angustissima*).

Knowledge of genetic variation in Australia's native species, and conservation measures to maintain that variation, are greatest in non-threatened species of economic importance, such as southern or Tasmanian blue gum (*E. globulus*) (Thavamanikumar et al. 2011). The number of forest-dwelling species for which data on genetic variation are available has not greatly changed since SOFR 2008, when data were available for 10 faunal and 13 floral species.

Threatened species

The states and territories and the Australian Government maintain lists of threatened species; the Australian Government list is at the national level (see Indicator 1.2b).

Species with populations that are low in numbers, small in geographic extent or fragmented, and that have low genetic variability, hybridisation and fecundity issues, are candidates for listing as 'threatened'. Table 1.45 summarises the genetic-related reasons associated with listing species as threatened on the national threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Recent population decline and population fragmentation (resulting in population isolation and reduced genetic variation) contributed to the recent listing of the koala (*Phascolarctos cinereus*) as Vulnerable under the EPBC Act (see Case study 1.9). The change in listing status of the Tasmanian devil (*Sarcophilus harrisii*) to Endangered because of the threat posed by devil facial tumour disease also related in part to the low level of genetic variation in that species (TSSC 2009b; see Case study 1.7 in Indicator 1.2c).

For Tasmania and the Northern Territory, Tables 1.46 and 1.47 report by degree of risk the number of forest-dwelling species potentially at risk from isolation and loss of genetic variation as a result of past human-induced or natural events, based on the research and knowledge of state and territory agencies. A total of 277 forest-dwelling threatened and priority species in Tasmania were rated as potentially at risk from isolation and loss of genetic variation; half of these, mostly higher plants, were at potentially moderate and high risk. A total of 789 forest-dwelling threatened and priority species in the Northern Territory were rated as potentially at risk from isolation and loss of genetic variation, but it was not

Table 1.45: Threatened forest-dwelling species in Australia with conservation concerns about isolation or genetic capacity

	Genetic-related reasons associated with listing species as threatened[a]				
Taxonomic group	**Small population[b]**	**Fragmented population**	**Low genetic diversity**	**Hybridisation**	**Fecundity issues**
Plants	654	262	250	8	324
Mammals	32	15	12	0	0
Birds	42	4	6	3	9
Reptiles	11	1	0	0	1
Amphibians	14	0	0	0	0
Fish	2	0	0	0	0
Invertebrates	18	1	0	0	0

[a] Includes species that have become extinct where a genetic reason was identified.

[b] Includes populations low in numbers, small in geographic extent, or comprising only a few subpopulations (e.g. island species).

Source: National Forest Inventory; listing statements on the Australian Government Department of Sustainability, Environment, Water, Population and Communities database (www.environment.gov.au/biodiversity/threatened/index.html).

Table 1.46: Number of forest-dwelling threatened and priority species in Tasmania potentially at risk from isolation and loss of genetic variation

Taxonomic group	**Potential high and moderate risk**	**Potential low risk**	**Unknown risk**	**Total**
Vertebrate fauna				
Fish	5	5	–	10
Amphibians	2	–	–	2
Reptiles	–	–	2	2
Birds	7	5	–	12
Mammals	2	1	–	3
Total	16	11	2	29
Vascular plants				
Dicotyledons	89	92	10	191
Monocotyledons	11	22	7	40
Pteridophytes	10	5	–	15
Gymnosperms	2	–	–	2
Total	112	119	17	248
Total (vertebrate fauna and vascular plants)	**128**	**130**	**19**	**277**

– = inferred zero

Note: Level of risk was estimated qualitatively for vertebrate fauna and vascular plant groups (excluding orchids) that are listed as threatened in Tasmania, or are identified as Regional Forest Agreement priority species.

Source: FPA (2012).

Table 1.47: Number of forest-dwelling species in the Northern Territory potentially at risk from isolation and loss of genetic variation

Taxonomic group	Potential high and moderate risk	Potential low risk	Unknown risk	Total
Vertebrate fauna				
Fish	1	–	–	1
Amphibians	1	1	3	5
Reptiles	2	10	21	33
Birds	8	7	3	18
Mammals	12	9	2	23
Total	24	27	29	80
Invertebrate fauna				
Total	2	1	1	4
Vascular flora[a]				
Total	47	162	496	705
Overall total	**73**	**190**	**526**	**789**

– = inferred zero

[a] Includes dicotyledons, monocotyledons, pteridophytes and gymnosperms.

Source: Northern Territory Department of Natural Resources, Environment and the Arts.

possible to allocate a risk category to most of these. Minimal data are available for the other states and the Australian Capital Territory.

Formal measures to mitigate risk

Australia's Biodiversity Conservation Strategy 2010–2030 (NRMMC 2010) is a guiding policy framework for conserving the country's biodiversity, which includes genetic diversity. This framework uses a diverse mix of Australian, state, territory and local government and private sector approaches to biodiversity conservation. Formal measures are in place across state and territory jurisdictions to address the risk of loss of genetic variation in threatened species. These measures include recovery plans, habitat restoration, wildlife corridors, engineered animal movement mechanisms, seed-collecting programs, and management of habitat and populations under forest management systems. The overall status of Australia's forest genetic resources is described by Singh et al. (2013).

Claire Howell

Possum bridge, to allow animals to move between forest fragments and maintain connectivity of populations.

Case study 1.9: Koala

The koala (*Phascolarctos cinereus*) is one of the most distinctive and iconic wildlife species in Australia. Koalas occur in the Australian Capital Territory, New South Wales, Queensland, South Australia and Victoria. They inhabit a range of open and woodland forest and other woody non-forest vegetation communities containing their preferred food species from the genus *Eucalyptus* (Figure 1.33).

The main threats to the koala are loss and fragmentation of habitat, vehicle strike, disease and predation by dogs. Drought and extreme heat are also known to cause very significant mortality. Post-drought recovery can be substantially impaired by other threatening factors (TSSC 2012a, 2012b). Genetic issues have also been raised as threats to the koala (SECRC 2011).

Victoria and South Australia have large koala populations, with an overabundance in some areas (e.g. Kangaroo Island) that can result in damage to ecological communities. The majority of these koalas are from reintroductions using limited genetic stock. As a result, the adaptive capacity is potentially limited, despite the numbers of individuals. Population fluctuations (cycles of population abundance and crashes) are associated with rainfall variation and overbrowsing—this makes determining natural population benchmarks difficult (TSSC 2012b).

Koala populations in the Australian Capital Territory, New South Wales and Queensland (northern populations; Figure 1.33) were listed in May 2012 as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) because a combination of factors had caused these populations to decline substantially over three generations (TSSC 2012a). The Threatened Species Scientific Committee (TSSC) advised that koalas in New

continued overleaf

Case study 1.9: Koala continued

South Wales (including the Australian Capital Territory) and Queensland can be sensibly grouped together on both biological and threat/management grounds (TSSC 2012b). In both states, inland koalas are threatened by the combination of habitat fragmentation and drought/climate change, while coastal populations are threatened by habitat loss and urban development. Populations in South Australia and Victoria (southern populations; Figure 1.33) were not listed under the EPBC Act. The TSSC (2012b) commented that the southern population would not be eligible for listing in any category.

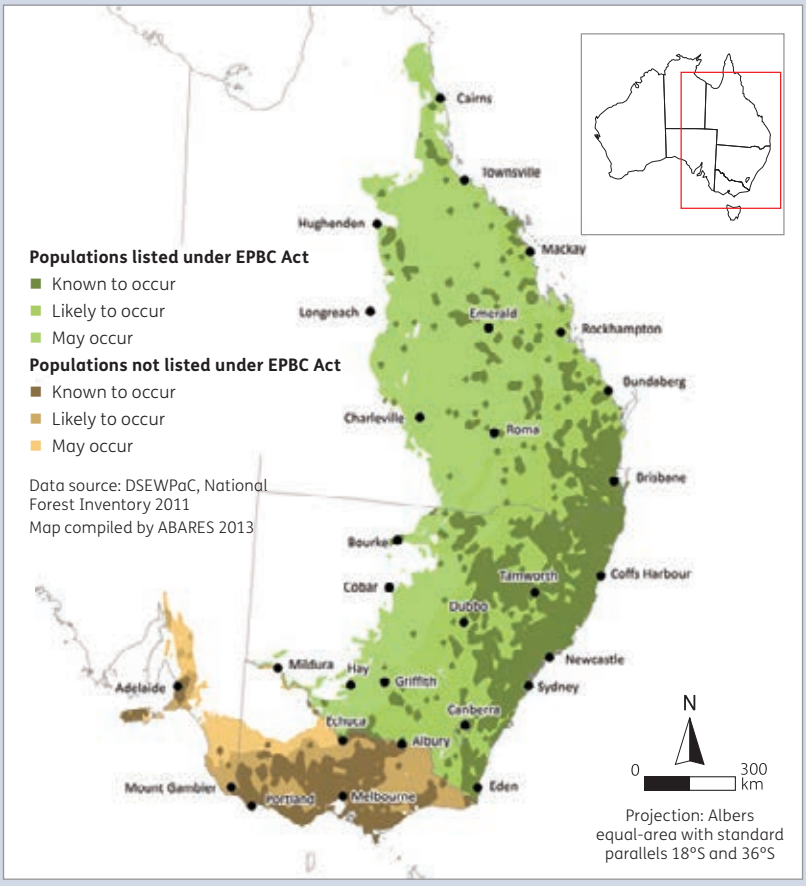
Koala populations have low levels of genetic differentiation, which reflect adaptations to different climates and environments (TSSC 2012b). Although southern populations of koalas are larger than those in the Australian Capital Territory, New South Wales and Queensland, they are not as genetically diverse because the majority of populations were founded from a small number of individuals. There are, however, a few populations that exhibit higher levels of genetic diversity, such as those in South Gippsland in Victoria (Lee et al. 2012), and which should therefore be prioritised for conservation. As a consequence of having low genetic variability, southern koala populations may have a reduced ability to adapt to change, which may exacerbate the risk of extinction of the population due to the effects of disease, loss of habitat through over-browsing or climate change (SECRC 2011).

Koala populations in New South Wales and Queensland possess greater genetic diversity than koala populations in Victoria and South Australia. However, these populations are becoming increasingly fragmented and isolated due to threats arising mainly from urban encroachment, which causes habitat loss, habitat fragmentation, and mortality from vehicle collisions and dog attacks. Stresses on individuals from these human-induced threats can exacerbate the effects of disease, drought and bushfires, and could reduce the capacity of populations to adapt to the effects of climate change.

The TSSC reported to the Australian Senate (SECRC 2011) that there is no evidence at present that population growth in southern populations is being affected by low genetic diversity. It reported that southern populations mostly show far greater population increase than the more genetically variable populations in parts of Queensland and New South Wales (SECRC 2011).

Koala and her joey in a eucalypt tree, New South Wales.

Figure 1.33: Indicative distribution of the koala in Australia



Note: Distribution maps of koala are compiled using a range of datasets of varying quality and should only be used as a guide. The presence of the species or its habitat should be confirmed by using local information services.

Indicator 1.3b

Native forest and plantations of indigenous timber species which have genetic resource conservation mechanisms in place

Rationale

This indicator uses the coverage and implementation of formal genetic resource conservation mechanisms as a measure of the degree to which timber species' genetic resources are managed and conserved.

Key points

- Australian native forest genetic resources are primarily conserved in Australian extant native forest, and to a lesser degree in arboreta, seed banks, seed orchards and plantations. Most states and territories have guidelines and management plans for conservation of the genetic diversity of forest species, often as part of broader programs for biodiversity conservation.
- Tree-breeding and genetic conservation and/or improvement programs exist for more than 30 native wood and oil-producing species and varieties. The infrastructure of tree-breeding and genetic improvement programs, such as arboreta and seed orchards, expands the scope for conserving native forest genetic resources, including non-commercial endangered species.
- Australia's native forest species are a dominant part of the hardwood plantation industry in many other countries, as well as Australia.
- The Australian, state and territory governments, research organisations, seed banks, arboreta and the private forestry sector all contribute to the conservation and sustainable management of forest genetic resources.

Conservation of native forest genetic resources

The level of conservation of forest genetic resources is linked to the level of conservation of forest biodiversity. There are significant ongoing activities for the conservation of native forest species and communities in Australia, including in protected areas such as nature conservation reserves or national parks. For forest covered by Regional Forest Agreements, state governments have developed a set of criteria that include broad benchmarks for the in-situ conservation of forest biodiversity (see Indicator 1.1c).

In addition to genetic resource conservation through forest reservation, a range of organisations, including the Australian Tree Seed Centre (ATSC), have established ex-situ seed orchards and undertaken conservation plantings for several rare and endangered species. Species in these conservation seed orchards include Queensland western gum (*Eucalyptus argophloia*), Barber's gum (*E. barberi*), Camden white gum (*E. benthamii*), Brooker's gum (*E. brookeriana*), Miena cider gum (*E. gunnii* subsp. *divaricata*), Risdon peppermint (*E. risdonii*), varnished gum (*E. vernicosa*), spinning gum (*E. perriniana*) and Morrisby's gum *(E. morrisbyi*) (Singh et al. 2013; SOFR 2008).

Australian forest genetic resources are generally highly accessible, and a very large amount of material has been dispersed throughout Australia and the world (Singh et al. 2013). Many Australian organisations, including botanic gardens, continue to contribute to global collections of Australian native forest genetic materials. Since the early 1960s, the ATSC has supplied more than 200,000 certified seed lots from more than 1,000 tree or shrub species to researchers in more than 100 countries. Seed lots also have been exported for research purposes through various institutions, including state forest services, botanic gardens, universities and private seed collectors. Australia is a partner in the Millennium Seed

Bank Project run by the United Kingdom's Royal Botanic Gardens—this is the largest ex-situ conservation project in the world. The Tasmanian Government has established the Tasmanian Seed Conservation Centre at the Royal Tasmanian Botanical Gardens, and has also entered into an agreement with the Millennium Seed Bank Project for seed storage (Harris et al. 2009). Similarly, the Botanical Gardens of Adelaide have established a partnership project with the Millennium Seed Bank Project, known as the South Australian Collection of Rare and Endangered Seeds (SACRED Seeds) Project. The Victorian Conservation Seedbank is situated in the National Herbarium of Victoria at the Royal Botanic Gardens, Melbourne.

Most states and territories have guidelines and management plans for conserving the genetic diversity of native forest wood species of commercial significance. In the regeneration of native production forest, the aim is to maintain local gene pools and the approximate composition and spatial distribution of the species (including non-wood product and understorey species) that were present before harvesting. Codes of forest practice, such as those in Victoria and Tasmania, therefore require harvested native forest to be resown with a species mix that approximates the natural mix of canopy trees present before harvest, while allowing for species that will regenerate naturally; seed to be sown is usually collected either from the stand to be harvested or from the nearest similar ecological zone. Management plans also include specifications for selection of seed trees of good form and health. In Western Australia, silvicultural guidelines specify the seed sources to be used in the rehabilitation of landings within all harvested coupes and areas cleared for bauxite mining in jarrah (*E. marginata*) forest (SOFR 2008).

Conservation and use of plantation genetic resources

Australia's forest genetic resources play an important role in maintaining and improving plantation forest productivity. For example, this can occur through selection of tree genotypes of higher growth rate and improved wood quality; genotypes that are potentially better adapted to projected warmer and drier conditions, as might be associated with climate change (Byrne et al. 2013); or genotypes that are resistant or tolerant to increases in pests and diseases, as could result from climate change or breaches of Australian quarantine. A substantial proportion of the genetic base of Australian native forest trees used in commercial plantations has been brought into collections (Table 1.48), seed orchards (plantations specifically planted and managed for seed production) (Table 1.49), and improvement and breeding programs (Table 1.50). Information on tree species included in improvement trials is reported in Table 1.51, and an example is shown in Figure 1.34.

Arboreta and private collections focus on species that are widely cultivated, including species of *Eucalyptus*, *Corymbia* and *Acacia*. Some collections of plantation genetic resources are held by forest industry agencies and companies, and some by industry cooperatives and research organisations.

The ATSC, based in Canberra, maintains a national collection of more than 900 species in some 75 genera, including more than 240 *Acacia*, 19 *Allocasuarina*, 11 *Casuarina*, 25 *Corymbia*, 330 *Eucalyptus* and 38 *Melaleuca* species. It provides a high-quality, representative, ex-situ sample of Australia's tree and shrub genetic diversity. Initially, the ATSC collected and stored seed mostly on a population or provenance basis, but the emphasis has increasingly shifted to collecting seed from individual parent trees. These genetically distinct acquisitions are important for ex-situ genetic resource conservation.

Table 1.48: Plantation species with reproductive material available in seed collections in Australia

Species	Type of material
Acacia auriculiformis	Seed (improved)
A. crassicarpa	Seed (improved)
A. mangium	Seed (improved)
Acacia other species	Seed (wild)
Casuarina various species	Seed (wild)
Corymbia maculata	Seed (improved)
C. citriodora subsp. *variegata*	Seed (improved)
Eucalyptus botryoides	Seed (improved)
E. camaldulensis subsp. *simulata*	Seed (improved)
E. camaldulensis var. *camaldulensis*	Seed (improved)
E. camaldulensis var. *obtusa*	Seed (improved)
E. cladocalyx	Seed (improved)
E. dunnii	Seed (improved)
E. globulus	Seed (improved)
E. grandis	Seed (improved)
E. nitens	Seed (improved)
E. occidentalis	Seed (improved)
E. pellita	Seed (improved)
E. saligna	Seed (improved)
E. tricarpa	Seed (improved)
E. tereticornis subsp. *tereticornis*	Seed (improved)
E. viminalis	Seed (improved)
Eucalyptus other species	Seed (wild)
Grevillea robusta	Seed (improved)

Source: Adapted from Singh et al. (2013).

In addition to the national ATSC collection, various institutions and forest and research agencies maintain their own forest seed collections. Some of these organisations are listed in Singh et al. (2013). The ATSC also has a number of provenance progeny tests (many in partnership with state governments and private growers) that serve as repositories of genetic material for species, including thick-podded salwood (*Acacia crassicarpa*), brown salwood (*A. mangium*), spotted gum (*Corymbia maculata* and *C. citriodora* subsp. *variegata*), large-leaved spotted gum (*C. henryi*), river red gum (*E. camaldulensis*), Dunn's white gum (*E. dunnii*), swamp yate (*E. occidentalis*), large-fruited red mahogany (*E. pellita*), red ironbark (*E. sideroxylon* and *E. tricarpa*), Sydney blue gum (*E. saligna*) and sugar gum (*E. cladocalyx*) (Singh et al. 2013).

The Southern Tree Breeding Association (STBA), formed in 1983, runs cooperative national tree improvement programs for the Australian species *E. globulus* and *E. nitens*. The program for *E. globulus* has been running since the amalgamation in 1994 of genetic material and data from eight selection and breeding programs previously managed by individual organisations. Grafted trees of *E. globulus* have been planted in the National Genetic Resource Centre for plantation forestry at Mount Gambier, South Australia, which was launched in August 2005 with support from the Australian and South Australian governments. Control-pollinated *E. globulus* seed is collected and stored in refrigerators, and diversity is maintained in numerous field trials spread across temperate Australia. The TREEPLAN® genetic evaluation system[56] is being used to update genetic values in *E. globulus* and *E. nitens*. This system was developed by the STBA in collaboration with the Animal Genetics and Breeding Unit (a joint unit of the New South Wales Department of Primary Industries and the University of New England).

Although breeding populations are maintained mainly for improving commercial wood production, they have an important spin-off in conserving genetic resources. Plant breeding strategies require a base population with wide-ranging genetic diversity. Normally, seeds are collected from native forest whenever new genetic material is needed. However, several of the best seed-source provenances of some eucalypts are no longer available in situ because the original populations no longer exist. For example, important parts of the genetic material for southern (Tasmanian) blue gum (*E. globulus*) and shining gum (*E. nitens*) are now held only in existing Australian plantations and special-purpose field trials.

Various state forest management agencies maintain tree improvement programs (Table 1.50). Forests NSW[57] manages a 45 year old hardwood tree improvement and breeding program that incorporates propagation and breeding facilities in conjunction with a production nursery. Clonal seed orchards include lemon-scented gum (*Corymbia citriodora* subsp. *variegata*), Dunn's white gum (*Eucalyptus dunnii*), shining gum (*E. nitens*) and blackbutt (*E. pilularis*). The Department of Environment and Conservation in Western Australia[58] runs provenance trials of karri (*E. diversicolor*) and associated wood species used for site restocking after wood harvesting.

Gene flow from plantations

The area of tree plantations of native species has been rapidly expanding in Australia (see Indicator 2.1b). Gene flow from these plantations into surrounding native forest (a phenomenon called 'introgression', in which infiltration of genes occurs from one species into another through hybridisation) could change the genetic make-up of local populations of native trees. Breeding strategies and genetic resource management plans aim to avoid gene flow that could damage the overall genetic resource. Strategies include careful selection of species and provenances; manipulation of flowering times and flower abundance; and silvicultural practices such as isolation distances, the use of buffer zones of non-interbreeding species, and closer planting to reduce the area of crowns able to produce flowers.

Table 1.49: Plantation species present in seed orchards in Australia

	Seed orchards		
Species	**Number**	**Generation[a]**	**Area (hectares)**
Araucaria cunninghamii	10	1, 1.5 and 2	29
Corymbia maculata	5	1 or 2	12
Eucalyptus botryoides	1	–	2
E. cladocalyx	14	1	30
E. dunnii	8	1,2	16
E. globulus	CSOs	1, 2 and 3	30
E. grandis	4	1	10
E. nitens	3	1 and 2	12
E. occidentalis	6	1	12
E. pellita	2	–	4
E. pilularis	CSOs	1	4.9
E. saligna	5	1	10

– = no data; CSO = clonal seed orchard

[a] Generation refers to first, second, third, etc. breeding cycle in the seed orchard.

Source: Adapted from Singh et al. (2013).

[56] http://www.stba.com.au/page/treeplan.

[57] From January 2013, the Forestry Corporation of NSW.

[58] From July 2013, the Department of Parks and Wildlife.

Table 1.50: Plantation species in tree improvement and breeding programs in Australia

Species	Agency
Acacia crassicarpa	CSIRO – Queensland DERM[a]
A. mangium	CSIRO – Queensland DERM
Araucaria cunninghamii	HQPlantations Pty Ltd[b]
Corymbia maculata	Australian Low Rainfall Tree Improvement Group
C. henryi	Queensland DERM, Forests NSW[c]
C. citriodora subsp. *variegata*	Queensland DERM, Forests NSW
C. citriodora subsp. *citriodora*	Queensland DERM
C. torelliana	Queensland DERM
Eucalyptus argophloia	Queensland DERM, CSIRO
E. benthamii	CSIRO
E. biturbinata	Queensland DERM
E. camaldulensis	Australian Low Rainfall Tree Improvement Group, Queensland DERM
E. cladocalyx	Australian Low Rainfall Tree Improvement Group
E. cloeziana	Queensland DERM
E. dunnii	CSIRO – Forests NSW, SeedEnergy, Queensland DERM
E. grandis	Queensland DERM, Forests NSW
E. grandis × *E. robusta*	Forests NSW
E. globulus	Southern Tree Breeding Association Inc, Forest Products Commission Western Australia, Australian Bluegum Plantations, HVP Plantations
E. longirostrata	Queensland DERM, CSIRO
E. moluccana	Queensland DERM
E. nitens	Private industry, Forestry Tasmania
E. occidentalis	Australian Low Rainfall Tree Improvement Group
E. pellita	CSIRO – Queensland DERM
E. pilularis	Forests NSW, Queensland DERM
E. propinqua × *E. resinifera*	Forests NSW
E. robusta × *E. grandis*	Forests NSW
E. robusta × *E. tereticornis*	Forests NSW
E. saligna	CSIRO
E. saligna × *E. grandis*	Forests NSW
E. sideroxylon × *E. tricarpa*	Australian Low Rainfall Tree Improvement Group
E. tereticornis	Queensland DERM
Grevillea robusta	CSIRO – Queensland DERM

CSIRO = Commonwealth Scientific and Industrial Research Organisation; DERM = Department of Environment and Resource Management

[a] From April 2012, the Queensland Department of Agriculture, Fisheries and Forestry (DAFF).

[b] Before 30 June 2010, Forestry Plantations Queensland.

[c] From January 2013, the Forestry Corporation of NSW.

Source: Adapted from Singh et al. (2013).

Table 1.51: Tree improvement trials in Australia

	Plus trees[a]	Provenance trials		Progeny trials		Clonal testing and development	
Species		No. of trials	No. of provenances	No. of trials	No. of families	No. of tests	No. of clones tested
Araucaria cunninghamii	876 of first generation	20	50	~100	~900	–	–
Eucalyptus dunnii	n.a.	–	–	3	150	–	–
E. globulus	n.a.	91	30	87	3,836	~20	~100
Eucalyptus hybrids	n.a.	–	–	–	–	~10	~100
E. nitens	n.a.	–	–	4	150	–	–

– = not available; n.a. = not applicable

[a] Number of plus trees (superior trees) listed if program is beginning and only first-generation seed orchards have been established.

Note: This table shows the subset of species listed in Table 1.50 for which trial data were available.

Source: Adapted from Singh et al. (2013).

International collaboration and engagement

Australia is a party to many international organisations, agreements, treaties, conventions or trade agreements that are directly or indirectly relevant to genetic resource conservation (Singh et al. 2013). These include the Food and Agriculture Organization of the United Nations and its Commission on Genetic Resources for Food and Agriculture; the United Nations Forum on Forests; the Convention on Biological Diversity; the World Intellectual Property Organization and its Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore; the International Union for the Protection of New Varieties of Plants, established under the International Convention for the Protection of New Varieties of Plants; the Convention on International Trade in Endangered Species of Wild Fauna and Flora; and the International Plant Protection Convention.

In November 2010, the Conference of the Parties to the Convention on Biological Diversity adopted the 'Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization'. The Nagoya Protocol establishes a legally binding framework for biotechnology researchers and other scientists to gain access to genetic resources. It also establishes a framework for researchers and developers to share any benefits from genetic resources, or traditional knowledge associated with those resources, with the provider country. Australia signed the protocol on 20 January 2012.

Figure 1.34: Plant health experts observing superior red mahogany (*Eucalyptus pellita*) trees in a forest species trial in north Queensland

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