

## Defining Australian forests

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### Summary

The definition of a forest in Australia has changed markedly since the time of European settlement: from an informal concept in the 19th century through several definitions in the 20th century; and from discursive description of species under headings of structure, to quantitative definition of only those forests potentially commercially harvestable; and now to biologically based scientific definitions.

These changes in definition have been in part paralleled by ever broadening opportunities for inventory arising from major technological developments in remote sensing, mapping and databases. The major definitions of the 20th century were those of the Forest and Wood-Based Industries Conference, Specht, the National Forest Inventory (first published in the Resource Assessment Commission's Forest and Timber Inquiry), the National Forest Policy Statement, and the current National Forest Inventory definition. In broad terms, during the 20th century, it was always recognised that the total forest cover of Australia exceeded 100 million ha. However, the narrow, use-specific definition of FORWOOD and its predecessors was commonly used to indicate the totality of forests, relegating woodland forests to a separate category called woodlands. Later scientific work clearly demonstrated that the oldest views were correct: woodlands and commercial forests were not separate entities. The confusion this caused has begun to dissipate with the development of a scientifically robust and nationally agreed National Forest Inventory definition of forest based on the National Forest Policy Statement. This definition is the basis of extensive inventory work by the States and Territories and the National Forest Inventory, including areas covered by Regional Forest Agreements. It also aligns with Australia's primary international forest reporting requirements.

Australia is now well served by a definition of forest that adequately encompasses the diversity of its tree-dominated vegetation, irrespective of its many actual or potential values or uses.

*Keywords:* forest resources; forest inventories; vegetation types; forest policy; forest definition; Australia

### Introduction

Forests are among Australia's major natural resources. Determining their locations, extent and qualities has been a major activity for the past 150 y. Fundamental to such determinations is a definition of forest itself. Changing the definition of forest can result in changes to the basic understanding of what forest resources are. Changes in technology — in our ability to map or record forest resources — can also result in changes in the understanding of those resources.

This paper documents the chronological sequence of changes to both the concept and the formal definition of forest and how these have affected our knowledge of forest resources in Australia.

### The changing concept of forest

From the beginning of European settlement of Australia through to the early 20th century, scientific writings about the vegetation of Australia do not appear to have used formal definitions of vegetation units, including forests. Instead, there appeared to be an implicit assumption that classification units such as rainforest, savannah woodland, mallee scrub and grassland were understood by the readership (Diels 1906). During these early years, Australian forests were primarily described as tree-dominated vegetation with individual forest components being considered in terms of the species that yielded dominant uses such as timber, posts or oils.

A non-scientific use of the term 'forest' in parts of eastern Australia until at least 1868 was 'a tract of open, well-grassed land with occasional trees or stands of trees' (Ramson 1988). The focus of the user was on the presence of either grass for grazing animals or land that would suit agricultural cultivation. Nevertheless, in each instance, it appears that it was the presence of trees that stimulated the naming of the land as 'forest', despite the primary interest in grass and rich soils. This usage should not be taken to indicate that 'forest' was a term that meant 'land with grass or good soil' but rather was a shorthand way of describing, in context, land with tree cover that also had a grassy understorey or soil capable of growing desirable plants.

Australia had several definitions of forests during the 20th century. Most of them focused on forests with potential to produce commercial timber. Some definitions were biologically or scientifically focused, but they came many decades after the former.

By 1920, all States had set up public agencies to manage public forested lands excluded from clearing (Dargavel 1995). The focus of these agencies was the protection of forests in perpetuity, and their usage for economic gain, for recreation and for the protection of water catchments.

To manage the forest it was important to know how much of it there was, its qualities and where it occurred. The first attempts to gather this information were made in the 19th century. Although the results were often very wide of the mark, they were made in the absence of technologies such as remote sensing and with very limited overland access in often-rugged and remote landscapes. The focus on commercial uses of the forests eventually led to a formal definition of forest, as early as 1911, that excluded tree-dominated vegetation of relatively low wood yield. Tree height greater than 20 m was the primary factor used to determine whether a forest could be used for the economic production of timber. Common usage of this value-specific definition was such that the term ‘forest’ came to mean only highly productive forests that were potentially commercially exploitable (whether or not they occurred on State Forest or conservation land). In parallel, the term ‘woodland’ came into wide use for all the rest of the tree-dominated vegetation. The association of woodlands with agricultural lands also created the common perception that woodlands occurred only in regions dominated by extensive agriculture and pastoralism.

Scientific research during the 1950s through to the early 1970s resulted in definitions of forests that were based on the observable structural characteristics of canopy and height. The most significant of these definitions was that of Specht (Specht *et al.* 1974), which was extensively used in its original or slightly modified form by most agencies that mapped vegetation in Australia. Its most recent form can be found in Specht *et al.* (1995). In attempting to improve the quality of their work, agencies opted to use ‘scientific’ definitions of forest in preference to the older, narrowly focused commercial definitions, but most did not reassess the field situation to see if units already mapped actually matched the new definition. While the earlier ‘commercial’ definition of forest was conceptually different from the more recent ‘scientific’ definition, this significant difference was not apparent to many. Indeed, national statistics of ‘forest’ area continued to be reported — by agencies such as the Forestry and Timber Bureau, followed by Australian Bureau of Agricultural and Resource Economics (ABARE), and then the early National Forest Inventory (NFI) — according to the definition restricted to commercially productive forests.

The two major Australian forest inventories of the 1970s and 1980s (details later) used a restricted definition of forest which primarily focused on the commercially exploited forests within Australian Forestry Council Regions, and each inventory recognised that ‘forests’ were much more extensive both inside and outside these regions. Moreover, they also acknowledged that many commercial forests were situated within tree-dominated vegetation labelled ‘woodland’. This acknowledgement could have added confusion, but it seems that no one noticed it amongst the accompanying

text, as all attention appears to have been focussed on the tables and definitions.

In 1992 the NFI produced its first map of the forest cover of Australia, based largely on information provided by State and Territory agencies. That map highlighted the disparity between the scientific definition of forest and the forest-use definition, and also the variable rigour with which precise definitions of forest were applied in forest mapping. It also revealed the different approaches of different agencies. For example, Queensland reported all of its tree-dominated forests that were commercially utilised, whether they were more than 20 m high or not, whereas South Australia and New South Wales, for possibly different reasons, applied the definition precisely. Thus South Australia continued to report that it had ‘no native forests’, and New South Wales did not report the existence of nearly all of the extensive *Callitris* forest, which it used commercially. This first NFI map was used only for internal planning and was not released for general use.

As mapping of forests improved in quality and coverage, field workers in New South Wales, Victoria, Tasmania and Western Australia came to realise that, as they applied the new scientific definition of forest, what forest agencies had previously mapped and called uniform ‘tall open forests’, were in fact mixtures of tall open forest, woodland and other structural forms based on their overstorey strata. Thus, the jarrah–marri forest of the south-west, the mountain ash–swamp gum forests of the south-east, and the central east coast forests, were technically mixtures of so called ‘forest’ and ‘woodland’. Many of these tall forests also contained ‘closed’ mid-storey strata. Additionally, extensive areas of ‘forest’ were found in the agricultural zones where previously it was believed that only ‘woodland’ occurred.

The National Forest Policy Statement (NFPS), developed in 1992 (Commonwealth of Australia 1992), introduced a new biologically-based definition of forest that explicitly included what previously had been called forest and woodland into a single definition of ‘forest’. ‘Forest’ became the collective noun for tree-dominated vegetation. Unfortunately, the definition left room for ambiguity because it included a final comment to the effect that the Statement did not cover woodlands. Disentangling the clash between the application of a rigorous scientific definition and the deeply entrenched common usage of the concept and associated words is not easy. Applying the scientific criteria relating to height and cover included in the NFPS definition to areas of concern to the Statement, some ‘woodlands’ must be included and some forest must be excluded.

### The processes for reporting forest area

Since the beginning of the 20th century, a number of processes have been used in Australia to provide statistics on forest areas, ownership and use. Initially, national-level planning and coordination of Australian forestry took place at a series of ten conferences held between 1911 and 1959. During this time the interstate conferences made a number of estimates of forest area, using the best available data describing Australia’s forests that possessed harvestable timber. These early data indicated that Australia had somewhere between 10 and 15 million ha of forest with harvestable timber.

These conferences were followed by two significant attempts to quantify Australia's forest resources: the Forest and Wood-Based Industries Conference (FORWOOD) (FORWOOD 1974), and the Resource Assessment Commission's Forest and Timber Inquiry (Resource Assessment Commission 1992). Additionally, State, Territory and national statistics, based on State and Territory data on forest areas with timber suitable for harvesting, appeared in Annual Reports of the Forestry and Timber Bureau.

During the 1990s, with the development of the NFPS, significant work was undertaken by the NFI to develop a comprehensive forest definition that was relevant to a wide range of forest values beyond the simple commercial productive value of forest. The NFI now provides forest resource data annually, through the ABARE publication *Australian Forest and Wood Products Statistics*, and to other national statistical reporting agencies including the Australian Bureau of Statistics.

### FORWOOD Conference

The FORWOOD Conference was the first attempt at producing a consistent, national-scale map of Australia's forests. Data were compiled from a variety of sources using a consistent classification scheme, resulting in a 1-to-1 000 000 scale map. The Forest Resource Panel, which compiled this map, defined forest as:

native forest with an existing or potential stand height of 20 metres or more, or cypress pine forest currently in commercial use, regardless of stand height.

The FORWOOD inventory had a definite commercial focus. The classification scheme was made up of six primary classes:

1. Rainforest
2. Eucalypt Productivity Class 1
3. Eucalypt Productivity Class 2
4. Eucalypt Productivity Class 3
5. Tropical Eucalypt and Paperbark
6. Cypress Pine Forest.

The inventory was restricted to the Australian Forestry Council Regions, which included all of Queensland, New South Wales, Victoria, Tasmania and Australian Capital Territory, but only small parts of Western Australia, the Northern Territory and South Australia. The technology at the time significantly limited the sizes of forest patches that could be mapped at the chosen scale. As a consequence, only the larger, more commercially important and thus well-known forest areas were mapped, and thus the FORWOOD inventory was not a complete inventory of forested land in Australia.

The FORWOOD conference recognised that Australia was covered by about 140 million ha of tree-dominated vegetation, which included woodland, but was interested only in the inventory of a subset called 'productive or potentially productive forest'.

The FORWOOD inventory revealed that Australia had some 42 million ha of forest including 35.8 million ha of eucalypt (productivity class 1, 2 or 3); 4.36 million ha of cypress pine and 1.86 million ha of rainforest. The study found that about 27% (11.363 million ha) of forest was within dedicated timber reserves; a further 47% (19.906 million ha) was in other crown lands including

leasehold land, and only 4% (1.82 million ha) was in dedicated parks and reserves (Table 1).

### Forestry and Timber Bureau and ABARE reports

From the FORWOOD conference until the arrival of the State of the Forests Report (National Forest Inventory 1998), the same statistics were published annually in the Forestry and Timber Bureau *Annual Reports* (1966–1976), then in sequence by ABARE's *Australian Forest Resources* (1977–1991), *Quarterly Forest Products Statistics* (1992–1995), *Australian Forest Statistics* (March 1996) and *Australian Forest Products Statistics* (1997–2001). From 2001, these reports have been produced every six months as *Australian Forest and Wood Products Statistics*. Until 1996, annual surveys were completed by State forest agencies using the definition of forests, forest types and productivity classes used by the FORWOOD conference. As can be seen from Table 1, the area of potentially commercially harvestable forest reported in these statistics declined by 19% between 1974 and 1996.

Two factors are relevant. The first is that some States had neither remapped nor comprehensively updated information collected since the FORWOOD conference. Where quantitative measurements were not available, many States relied on estimates made by professional officers to increase or decrease the reported forest areas according to known regional activity. The second factor is the use of the commercially-based definition of forest. After the 1970s, the total area of commercially exploitable, or potentially exploitable, forest in Australia did not change significantly, and significant clearing of the non-commercial forests for agriculture was not recorded in these statistics. The reported area of commercially harvestable forest declined only 19% between 1974 and 1996 compared with the large decline when the forest definition was rigorously implemented and reported in 1998 (Table 1).

### Resource Assessment Commission, Forest and Timber Inquiry

The Resource Assessment Commission's Forest and Timber Inquiry commenced in November 1989 and was published in March 1992 (Resource Assessment Commission 1992). As part of the Inquiry, a Forest Resource Survey was conducted to provide a national summary of the extent, uses and values of Australia's forests.

The Forest Resource Survey was conducted using Australian Forestry Council regions, as the FORWOOD inventory had done. It was recognised during the Inquiry that extensive areas of forest and woodland lay outside these regions. Nevertheless, they were not considered significant in terms of wood production and were therefore not included in the Forest Resource Survey. However, to suit local interests, each State and Territory used different criteria to define forest, such as the inclusion or not of *Callitris* forests. The Inquiry also included the cautionary note in volume one paragraph 3.04, 'that forest management agencies did not consistently distinguish "woodland", as defined, in their estimations of the extent of forest resource. This affects the estimations presented in the relevant tables throughout the report.'

**Table 1.** A comparison of published statistics of forest area ('000 000 ha) over time

Classification	FORWOOD 1974 <sup>a</sup>	RAC 1992 <sup>b</sup>	ABARE 1996 <sup>c</sup>	SOFR 1998 <sup>d</sup>	MIG 2001 <sup>e</sup>
Total forest area	140	135	105	156	164
Potentially commercially harvestable forest area	40.68	33.24	32.9	13.30	11.84
<i>Forest type</i>					
Eucalypt woodland area	97.50		63	84.20	88.76 (98.66) <sup>f</sup>
Eucalypt closed and open forest area	35.80	25	34.26	28.60	29.28
Mallee area	n/a	n/a	n/a	11.76	15.36 (5.41) <sup>f</sup>
<i>Callitris</i> area	4.36	4	4.17	0.87	0.95
<i>Acacia</i> area	n/a	n/a	n/a	12.30	16.60
<i>Melaleuca</i> area	n/a	n/a	n/a	4.09	4.09
Rainforest area	1.86	2.5	2.29	3.58	4.33
Mangrove area	n/a	n/a	n/a	1.05	0.80
<i>Casuarina</i> area	n/a	n/a	n/a	1.05	0.98
Other area	n/a	n/a	n/a	8.44	3.26
<i>Tenure</i>					
Public multiple-use forest area	11.73	11.5	12.12	13.35	11.82
Public multiple-use forest as fraction of total forest (%)	27	26	29	9	7
Conservation reserve area	1.83	9.76	6.61	17.58	20.51(26.77) <sup>f</sup>
Conservation reserves as fraction of total forest (%)	4	22	16	11	12 (16) <sup>f</sup>
Crown + leasehold forest area	19.90	10.60	10.71	81.70	92.12
Crown + leasehold forest as fraction of total forest (%)	47	24	26	52	56
Private forest area	9.0	11.34	11.27	42.02	37.30
Private forest as fraction of total forest (%)	21	26	27	27	23
Plantation area	0.50	1	1.12	1.04	1.48
Plantations as fraction of total forest (%)	1	2	3	0.7	1

n/a = not reported

<sup>a</sup>FORWOOD (1974)

<sup>b</sup>Resource Assessment Commission (1992)

<sup>c</sup>ABARE (1996) — data as at 1993

<sup>d</sup>*State of the Forests Report*. National Forest Inventory (1998)

<sup>e</sup>Montreal Process Implementation Group for Australia (2001)

<sup>f</sup>The un-bracketed figure refers only to forest areas in formal nature conservation reserves (e.g. national parks). The bracketed figures refer to forest areas in formal nature conservation reserves *plus* areas that are formally protected through other legal or institutional procedures on multiple-use forests tenures.

The Forest Resource Survey was sent to all state forest and conservation agencies with a responsibility to manage forests. Only existing information was used and, in many cases, professional estimates were again used where data did not exist. Furthermore, extensive areas of forests within some regions were not included because information on them was inadequate or they were not of commercial concern. These factors are often overlooked when the Resource Assessment Commission data are cited as comprehensive forest statistics. Thus the Resource Assessment Commission's Forest Resource Survey, as acknowledged in the report, was not a complete inventory of Australia's forests.

The definition of forest used by the Resource Assessment Commission was that of the NFI at the time:

woody vegetation, usually with a single stem, having a mature or potentially mature stand height exceeding 5 metres, with existing or potential projective foliage cover of overstorey strata about equal to or greater than 30%.

When surveys were conducted, however, some States also recorded woodland communities. The definition of woodlands used by the Resource Assessment Commission was:

woody vegetation, usually with a single stem, having a mature or potentially mature stand height exceeding 5 metres, with existing or potential projective foliage cover of overstorey strata of between 10 and 30%.

Following the compilation of the Forest Resource Survey, the analysis and interpretation of results were constrained by a number of factors.

1. No two State agencies used the same method for classifying forest, and as a consequence, aggregation at the State and national level was made very difficult. This included cross-border problems where one State described a community as a forest and the adjacent State described it as woodland.
2. A number of Forest Resource Survey questions were not completed, resulting in a highly variable response rate. This was most notable with regard to forests on private land.

3. Although reporting was undertaken at the state forest or national park level within a region, the minimum size of the unit reported varied considerably between regions and between States. Conservation agencies also had the option to report only on forested reserves greater than 500 ha; in Victoria this threshold was raised to 1000 ha. This option resulted in extensive areas of forest being excluded from the final figures.

### National Forest Inventory

The NFI was initiated in 1988 as a collaborative partnership between the Commonwealth and State and Territory governments to collect and report information on Australia's forests. The NFI used the definition of forest as reported in ABARE publications to create its first forest map. Following the development of the NFPS (Commonwealth of Australia 1992) the NFI adopted the NFPS definition of forest, rewording it slightly to remove uncertainty regarding crown cover<sup>1</sup> and height criteria in forest mapping. This definition, the basis of the 1998 State of the Forests Report, is:

An area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding 2 metres and with existing or potential crown cover of overstorey strata about equal to or greater than 20%. This definition includes Australia's diverse native forests and plantations, regardless of age. It is also sufficiently broad to encompass areas of trees that are sometimes described as woodlands.

This definition differed from those previously widely used in Australia and had major implications for the understanding and reporting of forest in this country. Firstly, the primary method of reporting on density was changed from projective foliage cover (Specht *et al.* 1974), to crown cover (McDonald *et al.* 1990), and the minimum potential crown cover was reduced to 20% (equivalent to a projective foliage cover of 10%). The reason for changing to crown cover was because it provided the most consistent means of mapping forest density using aerial photography, which at the time was the primary source of information for the NFI, and because major Landsat<sup>TM</sup>-based landcover mapping programs in the southern States (Ritman 1995) had also demonstrated the ability to reliably map crown cover down to 20%. It was recognised, however, that satellite-based mapping of crown cover is often unreliable in Australia's northern forests (SLATS 2000) where projective foliage cover provides a more reliable and repeatable measure of canopy density. The *operational* definition is therefore 'greater than 20% crown cover or 10% projective foliage cover'. This definition allows the explicit inclusion of 'woodland' within the definition of 'forest'. As of 2003, the NFI reports 'woodland' as occupying nearly 106 million ha. This definition of forest is also closer to the definition used by the Food and Agriculture Organization of the United Nations (FAO).

Secondly, the reduction of height to 2 m and reference to 'trees usually having a single stem' allowed the explicit inclusion of 11.8 million ha of forest-forming mallees. Without the height amendment, the distinctive mallee forest associations would be arbitrarily split into forest and non-forest. The reference to 'stand height exceeding 2 metres' also allowed most mangroves to be included, as existing information on mangrove distribution did not distinguish sub-units based on height or cover. A situation similar to that of mallee forest will exist when detailed mapping of mangrove vegetation is carried out. A standard that is both ecologically sensible and nationally consistent with respect to height is still required for mapping mangroves.

Finally, the definition was biologically based rather than focused on a particular use of the forest. Previous non-scientific definitions were designed to capture only those forests that were potentially commercially productive. Current interest in forests at the local, regional and national levels is much broader than commercial production alone, thus requiring a general, biologically-based definition suitable for all users. Each interest group can now identify its particular subset of forest within the overall context of the continent's forests. Hierarchically structured subdivisions of the over-riding highest category of 'forest' are of course regularly reported on, depending on the needs of each user (see Table 1 for an example of reporting at the national level).

The result of this new definition, which was nationally adopted by the Ministerial Councils for both Forestry and Environment in 1998, was forest statistics dramatically different from those of past inventories. It also provided a consistent and scientifically robust definition of a forest: a requirement for monitoring and reporting on the state of Australia's forests. Using this new definition, the NFI produced the *State of the Forests Report* in 1998 (National Forest Inventory 1998) which set a benchmark for domestic State of the Forests and State of the Environment reports, and international sustainable forest management reporting to which Australia is committed.

There was significantly improved and new forest mapping during the Comprehensive Regional Assessment component of the Regional Forest Agreement process between 1996 and 2000. After that, the 1998 *State of the Forests Report's* inventory was updated in 2000–2001. The results of this new inventory were reported in the *Australian Montreal Process Category A Report to the Standing Committee on Forests* (Montreal Process Implementation Group for Australia 2001).

### International forest definitions

The Australian forest definition is now more closely aligned with international forest definitions, including the FAO definition (also known as the United Nations Economic Commission for Europe/ Food and Agriculture Organization of the United Nations (UN-ECE/FAO 2000) definition):

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

<sup>1</sup>For any particular patch of forest, crown cover is greater than or equal to projective foliage cover. Crown cover is the fraction of an area that is covered by the vertical projection of the circumference of the crown onto the ground, with the area within the circumference being treated as having 100% cover. Projective foliage cover is the fraction of an area that is covered by the vertical projection of the foliage and branches onto the ground.

**Table 2.** Comparisons between Australian (Aust.) and FAO definitions of forest and ‘other wooded land’ (OWL)

Criterion	Crown cover		
	5–10%	10–20%	>20%
Height <2 m		FAO OWL	
Height 2–5 m	Aust. OWL	FAO OWL Aust. OWL	Aust. forest
Height >5 m	FAO OWL Aust. OWL	FAO forest Aust. OWL	Aust. forest FAO forest

Young natural stands and all plantations established for forestry purposes which have yet to reach a crown density of 10 per cent or tree height of 5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention or natural causes but which are expected to revert to forest.

The FAO definition includes a sparser cover of trees, with a lower threshold of 10% crown cover, compared with Australia’s lower threshold of 20%. As such, the FAO definition includes what has been called open woodland in Australia. Differences between the definitions result in an overlap of forest cover classes between the FAO forest class, the NFI forest class and the FAO ‘other wooded land’ class (Table 2). The ‘other wooded land’ class is essentially equivalent to Australia’s open woodland and tall shrubland vegetation; it is not mapped as forest in Australia.

The FAO requirement for a height of 5 m excludes some areas of tree-forming mallee and mangrove, which, under Australia’s requirement for a minimum height of 2 m, are included as part of the forest. There is no natural boundary or discontinuity in the heights of woody plants that can be applied rigorously and still have ecological meaning for *all* vegetation. Common sense combined with expert opinion is needed to identify which areas to include and which not — a definition provides guidance. The FAO has suggested that its needs could be met if Australia were able in future to report forest height classes of 2–5 m and 6–10 m, but this information is not currently available.

Australia has been reporting forest-related activities to the FAO since its establishment in 1945. In 1998–1999, Australia responded to the UN-ECE/FAO Temperate and Boreal Forest Resource Assessment 2000 Enquiry (UN-ECE/FAO 2000). The request focused on statistics relating to both forests and ‘other wooded land’ (Table 2). The data supplied by the NFI was fed into the FAO Global Forest Resource Assessment (FRA) (FAO 2001a) and reported in the subsequent *State of the World’s Forests 2001* report (FAO 2001b) and Global Forest Resources Assessment 2000.

## Case studies of comparisons between Australian systems

### Cypress pine

The NFI statistics in Table 1 show an apparent reduction in the area of *Callitris* (cypress) forest from over 4 million ha (ABARE 1996) to less than 1 million ha (Montreal Process Implementation

Group for Australia 2001). This is not because the forests were cleared, but rather because forest areas were assigned to different classification units through the more rigorous application of the rules of classifying forest according to structural criteria rather than primary uses. While there are ‘pure’ *Callitris* forests, most of the forest communities in which *Callitris* occur are mixed, usually dominated by a range of *Eucalyptus*, with *Callitris* being less abundant than the *Eucalyptus*. The commercial focus of ABARE and the State Forest agencies reporting the figures meant that the *Eucalyptus* species that occur in these communities were ignored because of their lesser commercial value. These forests are now correctly classified as *Eucalyptus*-dominated forests.

In the *State of the Forests Report* (National Forest Inventory 1998), although *Callitris*-dominated communities were reported as about 870 000 ha (rising to 948 000 ha in 2001), a further 6.5 million ha of forest were identified as having *Callitris* species occurring as sub-dominants. This is an actual increase of forests with significant *Callitris* cover of over 3 million ha or nearly 80% of that reported in ABARE’s Quarterly Forest Products Statistics. These changed numbers are primarily due to improvements in assessment techniques and coverage but they may also include some unspecified natural increase.

### Mallees

The question of how to treat mallees has been a long-standing issue in the classification of vegetation in Australia. Some vegetation scientists have treated all mallees as shrubs or scrubs (Specht *et al.* 1974; Carnahan 1976). Others recognised that while some mallees are clearly shrub-forming, some grow as perfectly good trees (Muir 1977). Some individual plants, or even groups of individuals covering extensive areas, may begin life as single-stemmed plants and mature into trees that are considered typical. Then, in response to fire or drought that kills only the part of the tree above ground, these trees may regenerate with multiple stems from the latent lignotubers and then again mature, but this time into a classical mallee with tree-size stems. It is appropriate to treat as trees those plants that produce trunks clearly of tree size irrespective of how many trunks arise at or near ground level. The Resource Assessment Commission, NFI and NFPS definitions of forest clearly allow for this by implication when they use the phrase ‘trees having usually a single stem’. Australia is not unique in its inclusion of multi-stemmed trees in its forest inventory. FAO allows coppice forest to be recorded in its forest area statistics.

## Discussion

Understanding of Australian forests has evolved over the last 150–200 y. Both the concept of forest and the knowledge of its location and extent have changed dramatically from a time when it was not necessary to *define* forest, to a time when a scientifically rigorous, structural definition of forest was accepted as the norm.

The collision of different ideas about forest, which made sense in isolated contexts but which clashed when changing times forced them to interact with each other, demanded a nationally comprehensive resolution. A significant step was the definition of forest in the glossary of the NFPS (Commonwealth of Australia 1992), where a scientifically rigorous concept of forest, enunciated

some decades earlier, was given national credence. The word forest was presented as a high-level collective noun that explicitly included concepts such as woodland. The inclusion of 'usually' in the phrase 'having usually a single stem' in the NFPS definition (and concurrently in the then NFI definition) clearly implied that trees with multiple stems, such as mallee formations, were to be included.

The NFI took up the challenge of producing a spatial inventory of Australia's forests based on the new NFPS definition. It was found necessary to interpret two aspects of the new definition before the mapping program could be fully operational.

Firstly, the NFPS definition referred to '30% projective cover'. In order to make the statement about percentage cover consistent with the explicit intent that forest should include those areas sometimes called woodlands, the NFI chose to use a lower limit of 20% (which is about equal to 10% projective foliage cover). The 20% figure also made it possible to use satellite imagery to map the lower boundary of forest by using methods that had been extensively tested for satellite vegetation mapping for the Murray-Darling Basin Commission (Ritman 1995). The phrase 'projective cover' was ambiguous, as it did not align with commonly used terms of crown cover or projective foliage cover. As aerial photo mapping was the primary method of data collection of the day, the NFI chose to use crown cover as the primary method of defining and mapping forest density, but also used data based on projective foliage cover, particularly in relation to satellite-based mapping. To ensure that both methods could be used 'seamlessly' the NFI also adopted methods for assessing canopy types (McDonald *et al.* 1990) that enabled data to be transformed from one measure to another without information loss.

Secondly, to make the mapping of forest types operative under the new definition, the NFI adopted a small change in the tree height used to define mallee vegetation classified as forest. Applying the NFPS 5 m height limit would have divided an otherwise homogeneous mallee community into two groups without ecological meaning. State agencies, therefore, recommended that a minimum height of 2 m should be used for mapping mallee forest vegetation. In practice, a minimum height limit of 5 m is still used when mapping non-mallee forest vegetation. A situation similar to that of mallee forest will occur when detailed mapping of mangrove vegetation is carried out. A standard for mapping mangrove is still required, with respect to height, which is both ecologically sensible and nationally consistent.

During the 1990s there was intensive activity to fill gaps in knowledge of the distribution and location of Australia's forests. This work has profoundly changed understanding of the extent and diversity of forests in this country. As shown in this paper, there have been major changes to the statistics on forest area. Forest mapping that took place after 1996 was deliberately not included in the statistics in the *State of the Forests Report* (1998) in order to allow the full impact of the Regional Forest Agreement processes on forest area statistics to be evident in subsequent inventory work and reports. That effect has now been reported by the NFI (Montreal Process Implementation Group for Australia 2001). As anticipated, reports including data from the Regional Forest Agreement work reveal that forest area statistics have

changed yet again, demonstrating some of the outcomes from major forest policy and inventory initiatives. The significantly upgraded and improved forest data in the NFI are being incorporated in the 2003 State of the Forests Report, and, through the work of the National Land and Water Resources Audit (National Land and Water Resources Audit 2000), into a larger, more comprehensive set of data for the entire continent of Australia. Although these changes are unsettling to some, they represent significant improvements in knowledge, especially through improved forest assessment techniques and mapping technologies. As human beings continue to intensify their management of natural resources in Australia, it is vital that the extent and location of those resources are as well known as is possible.

## Conclusion

After more than a century with diverse and sometimes conflicting definitions of 'forest', Australia now has a definition of forest that adequately encompasses the diversity of its tree-dominated vegetation, irrespective of the many actual or potential values or uses that can be made of it. This new definition, used by States and Territories and reported in the 1998 *State of the Forests Report*, is derived from the NFPS and approved by the NFI. It also has the imprimatur of the Ministerial Councils for Forestry and for Environment.

Australia is able to report with high levels of confidence, within the capabilities of current technologies, on the kinds, amounts and geographic distribution of its forest resources. However, there are still some issues to resolve at the international level concerning the interpretation and use of boundaries between classes of forest to ensure that those accepted make scientific and ecological sense, as well as adhering as closely as possible to international standards. There are also issues about boundaries and mapping of forest and 'other wooded land' that still need attention.

To date, sequential reports of forest area have been complicated by inadequate resources to regularly inventory the entire estate, as well as by major changes in knowledge coming from technological changes that make the inventory of extensive areas economically feasible. Thus statistics of forest area have been unsatisfactory as a measure of forest sustainability. In future, it will be possible to determine some indicators of forest sustainability that do not rely directly on forest area (such as biomass increase with time and forest condition) using a proposed monitoring framework being developed by the NFI.

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