NATIONAL FOREST CONSERVATION RESERVES

COMMONWEALTH PROPOSED CRITERIA

A Discussion Paper

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PROPOSED CRITERIA FOR THE DEVELOPMENT OF A NATIONAL FOREST RESERVE SYSTEM

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CRITERIA FOR THE DEVELOPMENT OF A NATIONAL FOREST RESERVE SYSTEM

1. INTRODUCTION

1.1 The National Forest Policy Statement (NFPS) 1992

The NFPS outlines an agreement by Commonwealth, State and Territory Governments on broad goals for the management of Australia's forests. The goals embrace the concept of ecologically sustainable development. Accordingly, governments aim to manage Australia's forests so as to conserve biological diversity, heritage, Aboriginal and other cultural values for current and future generations and at the same time develop a dynamic, internationally competitive forest products industry that can operate on a sustained yield basis, maximise efficient use of resources and develop value adding industries. The Commonwealth shares responsibility for the implementation of the NFPS with co-signatory State and Territory Governments and is guided by the NFPS in exercising its responsibilities for forests.

1.2 Regional Forest Agreements

Under the NFPS, governments agreed to a framework and process for comprehensive regional assessments of forests. The Regional Forest Agreement process offers a mechanism for governments to cooperatively assess the full range of forest attributes and values in a region and develop a conservation reserve system in the context of broader integrated forest planning and management. This process will provide an important mechanism for the interests of all potential users to be taken into account before considering changes to forest tenures.

The Commonwealth has outlined its requirements and preferred approach to achieving regional forest agreements in a recent position paper (Regional Forest Agreements: the Commonwealth Position, February 1995). The Commonwealth considers that intergovernmental accord on forest land use allocation and management will be best served by the implementation of a national framework of soundly-based regional forest agreements.

The One Nation Statement includes a commitment for the Commonwealth to implement procedures for the assessment of economic values of areas proposed for new parks and reserves. The Comprehensive Regional Assessment process, where all values are assessed in an integrated manner reflects the commitment of the One Nation Statement.

1.3 Development of National Reserve Criteria

The commitment of the NFPS to develop a comprehensive, adequate and representative (CAR) reserve system is a critical component in a balanced national policy approach for forests. Such a reserve system is one important means of achieving conservation goals in combination with off-reserve strategies aimed at ecologically sustainable management of forests and other ecosystems on public and private lands. Under the NFPS, governments agreed to develop broad national criteria to guide the assessment of the existing forest reserve system and to determine any further action that may be required to complete the system's development.

In the NFPS, governments agreed to a strategy to conserve and manage old growth forests and wilderness as part of the conservation reserve system. The strategy involved interim protection for areas of old growth forest and wilderness likely to have high conservation value until assessments of these areas are completed and the high value areas incorporated in the reserve system.

Conditional to agreement on reserve criteria, governments agreed to establish a comprehensive, adequate and representative (CAR) reserve system protecting old growth and wilderness attributes on public land by the end of 1995, and on any required private land by 1998.

An intergovernmental Technical Working Group on Reserve Criteria was established in 1993 to draft the national criteria required by the NFPS, under the Joint Australian and New Zealand Environment and Conservation Council (ANZECC)/Ministerial Council on Forestry, Fisheries and Aquaculture (MCFFA) NFPS Implementation Sub-committee (JANIS). The Technical Working Group comprised representatives from state forestry and conservation agencies, and from CSIRO. The Department of the Environment, Sport and Territories provided secretariat services to the Working Group.

In August 1994, the Working Group produced a draft report containing a set of proposed criteria. The report was submitted to JANIS and Ministers for endorsement as a public discussion paper. Ministers have not yet endorsed the paper for release as a public document.

The Commonwealth has now considered the report of the Technical Working Group on Reserve Criteria and this paper presents the Commonwealth's views on acceptable criteria for the development of a CAR reserve system. In preparation of this paper the Commonwealth has been advised by an eminent group of scientists chaired by the Chief Scientist, Professor Michael Pitman. The group consulted with selected experts from the scientific community in developing their advice on some of the scientific theory and information relevant to criteria for a national conservation reserve system for forests. Appendix A1 outlines some of the issues considered by the Scientific Group and summarises their views.

1.4 Purpose of the paper

Agreed criteria are required to progress the development of the CAR forest reserve system in joint assessment and planning processes with State and Territory Governments. Specifically, agreed reserve criteria are needed for:

- assessments of the adequacy of the existing forest reserve systems, as provided by the NFPS, including possible Commonwealth support for the assessment process and the establishment of new reserves, on a case by case basis;

- the 'regional forest agreement' process, to allow governments to cooperatively assess the full range of forest values in a region and develop a CAR reserve system in the context of broader integrated forest planning and management;

- the approach to the 1996 licence renewal process that is based on a preliminary analysis of the likely location of future reserves rather than the coupe-by-coupe approach used for the 1995 licence renewals;

- the implementation of reserve system assessment and establishment commitments contained in the Intergovernmental Agreement on the Environment, the National Strategy for Ecologically Sustainable Development (Commonwealth of Australia 1992), the Draft National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia 1994), the *Draft Strategy for the Conservation of Endangered Species (1991)* and the Commonwealth's National Reserves System Cooperative Program.

In this paper the Commonwealth proposes criteria for the development of a CAR reserve system for forests to provide an objective basis for consolidating the current reserve system and ensuring the representation of biological diversity and protection of other values. The Commonwealth invites discussion over the next six weeks on the proposed criteria in order to arrive at national agreed criteria.

2. PRINCIPLES FOR RESERVE SELECTION

2.1 Conservation goals

The conservation objectives of the NFPS are the maintenance of an extensive and permanent native forest estate in Australia and the protection of conservation values in forests. Under the NFPS, signatory governments agreed to manage for the conservation of all species of Australia's indigenous forest flora and fauna throughout those species ranges by means of three major strategies:

- establishing a dedicated conservation reserve system to protect native forest communities based on the principles of comprehensiveness, adequacy and representativeness;

- complementary management outside reserves in public native forests managed for wood production and other commercial uses and in forests on unallocated or leased Crown land;

- promoting the management of private forests in sympathy with biodiversity conservation (*NFPS pp 8,9*).

Therefore the development of the CAR reserve system sits in the context of the overall strategy for biodiversity conservation in the Australian forest estate. Dedicated CAR reserves contribute to the biodiversity conservation aims for forests, which are:

- to maintain viable populations of known native forest species throughout their natural ranges in Australia;

- to maintain the known genetic diversity of native forest species in Australia;

- to maintain viable examples of recognised forest types/communities throughout their natural ranges in Australia; and

- to maximise the chances of maintaining unknown elements of native biological diversity in Australia.

The NFPS recognises the particular needs of endangered and vulnerable species and communities. Adopting the precautionary principle, these species and communities require greater attention to reducing threatening processes and may require higher levels of reservation, where necessary to ensure protection, than would apply in the case of more common forest attributes because of the increased risk of loss, either through extinction of species or degradation of communities.

The NFPS specifically mentions the need for the conservation system to also protect old growth forest and forested wilderness. This commitment reflects the comparative rarity of old growth and forested wilderness and "*the significance of these areas to the Australian community because of their very high aesthetic, cultural and nature conservation values and their freedom from disturbance*" (NFPS, p11).

A CAR reserve system has conservation as its primary aim and can allow other uses such as recreation and water catchment, but excludes wood production. In addition to reserves in dedicated conservation tenures, there are areas set aside for biodiversity conservation and environmental protection purposes in public forests managed for wood production. The classification of reserve protection is outlined in Appendix A2.

A conservation reserve system needs to cater for many other attributes. Many attributes may be better maintained in reserves than in wood production forests. Such attributes include water catchment and spiritual values, including those associated with sacred sites and aesthetically pleasing landscapes. Many of these attributes will be included in a forest reserve system developed to protect biodiversity, old growth and wilderness. The Commonwealth also has statutory obligations to identify national estate values and to protect places on the Register of the National Estate. These national estate values include biodiversity, old growth and wilderness, the non-economic values listed above and others such as those listed in Appendix A3.

Some attributes may be best maintained though protection in the reserve system, others can be maintained by complementary off-reserve management. The comprehensive regional assessment process aims to identify the values held by the community for forest attributes and also assesses the ways in which these attributes may be best protected and maintained.

2.2 Principles of comprehensiveness, adequacy and representativeness

In the NFPS, the governments acknowledge that the forest conservation reserve system should be based on the principles of comprehensiveness, adequacy and representativeness (CAR).

This paper adopts the NFPS definitions of the CAR principles:

Comprehensiveness

> *the reserve system includes the full range of forest communities recognised by an agreed national scientific classification at appropriate hierarchical levels (NFPS, p49).*

The principle of comprehensiveness requires that the reserve system samples the full range of native forest biodiversity that is, community, species and genetic variation. Using the information on known species distributions and genetic variation, the reserve system can be specifically designed to include the representation of these species and/or genotypes.

However, the extent of biodiversity in forests is not completely known and unknown elements of biodiversity cannot be directly catered for in reserve selection. In practice, surrogate measures of biodiversity are often used (see Appendix A1). Forest vegetation communities or forest types are commonly used as surrogates for forest diversity. Forest types are commonly described by the main tree species and forest structure. Environmental domains, which describe units of land on the basis of similarity among such attributes as soil types, climate and topography, can also used as units for assessing the comprehensiveness of a reserve system.

Many species, particularly animals, have distributions that are not easily predicted by forest types or environmental domains. Another surrogate for unknown elements of forest biodiversity could be those species whose habitat requirements would incorporate the ranges of many other species. Using the distributions of such species together with other measures of forest biodiversity can increase confidence that the forest reserve system does comprehensively cover the full range of forest biodiversity (see Appendix A1). Using the distributions of such species alone will not guarantee the inclusion of all known elements of biodiversity. However, their initial inclusion might make more efficient the search for a reserve system that represents all known forest biodiversity.

Adequacy

> *the maintenance of the ecological viability and integrity of populations, species and communities (NFPS p 49)*

Adequacy addresses the difficult question of extent: what is the level of reservation that will ensure species remain viable, that is, what is the level of reservation that will ensure that species have a very high chance of survival over many centuries. To achieve the goal of viability, reserves need to be of suitable size, number and arrangement, and all elements of forest biodiversity (or at least those that are dependent on reserves for protection) should be present in areas, numbers and spatial arrangements that give a high chance of survival in the long term.

There are many approaches to identifying the level of reservation needed to ensure the viability of particular species or communities, ranging from best estimates for unknown ecosystems, to calculations for endangered species or even specific populations of animals and plants.

The general rule is that chances of long term survival increase with greater proportions of populations/areas reserved, from zero if no area is reserved, to the maximum possible if all remaining forest is managed for conservation. The degree of risk varies with different species (or suites of species) and with the degree of modification of the contiguous native forest beyond reserves. Most estimates show that the risk of loss is highest where only a small percentage of the distribution of the community or species is in conservation reserves (see Appendix A1).

Replication across the range of geographic, environmental and biotic domains improves the adequacy of reserves. Replication is essentially "insurance" to maintain viability in the event of unforeseen loss of one or more reserves and to accommodate stochastic (foreseen but unpredictable) events. The possible impact of climate change means that reserves may need to replicate samples of forest communities along environmental gradients.

In general, comprehensive reserve areas based on natural landscape features, in which biodiversity, old growth (and a range of other age classes) and wilderness are conserved, and which are integrated with existing reserves and off-reserve areas are most likely to achieve viability of component species.

Representativeness

> *those sample areas of the forest that are selected for inclusion in reserves should reasonably reflect the biotic diversity of the communities (NFPS p49)*

The principle of representativeness needs to be adopted largely because of the limits to our knowledge of forest communities and species and particularly the genetic variation within species. Theoretically, comprehensiveness refers to the full range of biodiversity but, in practice, biodiversity is often defined in terms of broad scale forest communities/forest types (see above discussion). Hence, representativeness relates to the diversity within the forest communities recognised in comprehensiveness (their internal heterogeneity including genetic variability and different age classes) and to the sampling of this heterogeneity by the reserve network. The species composition of broadly defined forest communities can vary along environmental gradients, in relation to micro environments within that communities' distribution and in relation to the age of the forest community. This variation needs to be represented in the reserve system. Representing several samples of forest communities in a reserve system can increase the chances of including the range of biodiversity present particularly if the samples are chosen from across the range of environmental variation. Environmental domain analysis may assist in sampling broad forest communities.

2.3 Old growth forest attributes

In the NFPS (p 49) old growth forest is defined as

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

Definitions of old growth have two aspects - the presence of mature and over mature trees and the level of post 1788 disturbance. The methodology recently developed for old growth mapping in East Gippsland (Woodgate *et al*, 1994) has refined the definition, describing a range of old growth categories according to the degree of dominance of mature, senescent and regrowth elements, and categorising disturbance levels by the *effect* of the disturbance on the forest structure and floristics rather than the disturbance history. The East Gippsland study has developed a useful approach to assessing old growth that can be applied to similar forests outside East Gippsland and may well be adaptable to assessing old growth in other forests such as rainforest and dry forests.

Old growth is a relatively distinct successional stage in some forest types, usually the wetter forests, but is difficult to distinguish in other forest types which are characterised by trees of a mix of ages. The biodiversity attributes attributed to old growth stem from the fact that some plants and animals are restricted to the old growth stage or are dependent on old growth for some of their habitat requirements.

There are other species that only occur in younger forest or that need access to younger forest for some of their requirements and it is important for representativeness reasons that younger forest be included. Nevertheless, old growth stages may warrant particular attention for biodiversity reasons because of the time taken to replenish lost old growth. Once destroyed, old growth and the habitat for the other species that it creates, cannot be re-created in less time than it takes for the longest lived trees to reach maturity.

Old growth often has significant economic and cultural attributes. For example, old growth forests have high timber values and significant economic value as water supply catchments. Some of the cultural values attributed to old growth, such as its pristine nature, cannot be replaced when old growth is destroyed by human activities.

2.4 Wilderness attributes

The NFPS defines wilderness as

> *land that, together with its plant and animal communities, is in a state that has not been substantially modified by, and is remote from, the influences of European settlement or is capable of being restored to such a state; is of sufficient size to make its maintenance in such a state feasible; and is capable of providing opportunities for solitude and self reliant recreation* (NFPS p50).

Wilderness encompasses large areas of essentially undisturbed country. Wilderness has many attributes: aesthetic, spiritual, scientific, heritage. Wilderness areas are not determined on the principles of comprehensiveness, adequacy and representativeness for biodiversity conservation. Nevertheless, wilderness reservation has some direct benefits for biodiversity. The size of wilderness areas can allow the continuation of dynamic natural processes without human manipulation. Also, the remoteness from exotic plants and animals can reduce the conservation management effort (Kirkpatrick 1994) although this very remoteness can make control of feral animals and weeds difficult in some forests.

One important purpose of wilderness is as a recreational resource. Reserve systems based on landscape features (such as catchment boundaries) may achieve many wilderness objectives, such as having only undisturbed areas in a person's field of view.

3. RESERVE SELECTION CRITERIA

The criteria outlined in this section propose national benchmarks for the conservation of biodiversity, old growth and wilderness. These attributes of the forest have both ecological and social dimensions, hence the criteria encompass guidelines for reservation on ecological grounds and approaches for meeting the social objectives of the conservation reserve system.

The criteria have been developed bearing in mind the uncertainties regarding forest values and their conservation status, the differences among regions in the nature of their forests and different levels of data availability in States and Territories. The criteria describe a national approach to reservation that recognises the differences among States, Territories and regions but has the potential for a consistent approach across Australia.

The criteria outlined below are contingent on the management of the whole forest estate in accord with nature conservation goals, as stated in the conservation goals of the National Forest Policy Statement (see Section 2.1).

3.1 Criteria to protect biodiversity attributes

The Convention on Biological Diversity and the draft National Strategy for the Conservation of Australia's Biological Diversity consider biodiversity at three levels; genetic, species and ecosystem. While there is considerable information on the spatial patterning of biodiversity at the community and species levels, the information on genetic variation is limited. It is possible and desirable to use this limited genetic information in planning a reserve network, but the criteria outlined below relate primarily to the biodiversity represented by species and ecosystems, as indicated by forest communities or forest types.

(1) The approach should be regional

The broad variation in forested ecosystems across the continent and the large gaps between forested regions makes continental scale consideration of a CAR reserve system difficult, hence smaller and more manageable regional units are necessary.

There has been considerable development of bioregional frameworks by each of the States and the Northern Territory as a basis for conservation planning. These bioregional frameworks have been incorporated in the development of an agreed interim national bioregional framework (see Appendix A4). Such bioregions may reflect common land use and management characteristics that may assist implementation of regional biodiversity conservation and forest harvesting strategies.

However, assessments will be carried out in a number of instances within administrative regions due to the manner in which data has been collected and is managed. Administrative regions can encompass some bioregions in their entirety but only part of others. The contextual data from the bioregions and the country as a whole are important for an adequate assessment and will need to be incorporated in the analyses for the Regional Forest Agreement process (see Commonwealth of Australia 1995, *Regional forest agreements—the Commonwealth position).*
In brief, the regions chosen for assessment should be based on practicality (data availability and ease of management) but should relate assessments to the broader context wherever possible.

(2) The assessment should cover all forest tenures in a region

Consistent with the NFPS and the statutory obligations of the Commonwealth, the application of the criteria to identify reserve options should cover all tenures, including private lands, to provide an adequate context for reserve planning.

In some States, a substantial proportion of the forest estate is in private ownership or held under leasehold. In some cases it may not be practicable to rely entirely on public lands for effective conservation of all forest types, particularly in attempting to satisfy representativeness criteria. As an alternative to acquisition, cooperative arrangements with landholders through regional conservation strategies and conservation agreements may be necessary to complement the formal reserve network.

Although, initially reserves on public land will be considered, reserve options may need to include private land where this appears to be a more efficient way of meeting biodiversity criteria.

(3) Appropriate broad categories of forest biodiversity should be identified at a scale of 1:100,000

Information on forest communities or forest types has been collected under several classification systems and at several scales across Australia. The forest mapping units need to be indicative of the variation in forest communities at an ecologically meaningful level. Communities recognisable and mapped at 1:100,000 are considered to be at an appropriate scale for planning a nationwide forest reserve system (see Appendix A4). At scales smaller than 1:100,000 categories of forest types would be too broad to be useful indicators of forest biodiversity. Although there is no national classification of forest communities at the 1:100,000 scale, there are mapped data sets available that could provide consistency across the continent. Examples of this scale of ecosystem recognition include that of Kirkpatrick and Brown (1991) for Tasmania and the Victorian 'ecological vegetation classes' (Woodgate *et al*, 1992).

Further discrimination of forest communities can be achieved by combining biological domains (zoogeographic or floristic regions) with environmental domains (climatic, geomorphic and geographic regions) which can be derived using explicit numerical analyses of primary data.

Some data sets at the appropriate level of discrimination will only be available over the next five years hence lower quality data, such as environmental domains, should be used for the development of the reserve system on an interim basis.

No particular techniques are prescribed, recognising the variation in data availability and approaches to ecological classification. If the same scale is used (1:100,000) the different classifications among regions can be calibrated as the maximum number of mappable units derivable from interpretation of aerial photographs and environmental correlation. If environmental domain analysis is used as a surrogate for forest community information, the level of division used should be calibrated with the variability of the forest by comparison with other regions where better data are available.

(4) As a broad benchmark, 15 per cent of the pre-1788 distribution of each forest community should be represented in statutory conservation reserves. Thus the proportion of the *existing* distributions of forest communities in reserves would vary according to depletion from past clearing. The proportion should be varied further according to natural rarity of the forest community and the level of threats to its existence.

The international target of 10 per cent reservation is often quoted as an appropriate benchmark for reservation planning. However this figure has no particular scientific basis. The Caracas Action Plan developed by the IUCN Commission for National Parks and Protected Areas (1992) identified '10 per cent of the remaining distribution of each biome' as a minimum target for reservation. However, this figure was derived through negotiation among Commission members. It was considered to be a politically realistic figure recognising that in some countries higher targets may be set or this level may already be exceeded while in others it may not be achievable because the fraction of land remaining in an appropriate condition is already lower than 10 per cent (see Appendix A1). The Commission also recognised that, for effective conservation of biodiversity, a key factor is the condition and management of the adjoining areas outside the reserves: these areas should be managed in an ecologically sustainable manner.

Any recommendation for minimum reservation percentages is, to a degree, arbitrary. At low levels of reservation, marked biodiversity losses would be expected; at higher levels there are diminishing returns. Although no *precise* basis exists to specify areas to ensure the adequacy of a reserve network there is scientific theory and information that can assist a decision on an adequate level of reservation (see Appendix A1).

Studies of species loss through habitat removal or modification and research on biodiversity levels in different sizes of habitat fragments show that risk of extinction increases as habitat is lost or modified with these risks increasing as the habitat approaches low proportions of the species' original distribution (see discussion Appendix A1). The change in risk varies considerably among species depending on factors such as the degree of specialisation of habitat requirements.

An important consideration in assessing risk of biodiversity loss is the significance internationally of Australia's forests. Australia is one of the few developed countries with a high level of biodiversity. Australian forests contain many species that only occur in these forests and the forests are limited in their natural extent.

In consideration of this evidence, and bearing in mind the NFPS objectives to manage the whole of the existing forest estate in a manner consistent with conservation goals, the balance of scientific opinion suggests to the Commonwealth that reservation of 15 per cent of the estimated pre-1788 forest community distributions is an acceptable level of reservation (see Appendix A1). It is important to stress that the nature of forest management in forest areas outside reserves is critical to the extent of reservation needed. In this respect it will be necessary to ensure that the conservation measures being developed by the JANIS Technical Working Group on Forest Use and Management are adopted. Less conservative forest management outside reserves would mean that greater proportions of forest communities should be reserved.

The benchmark of 15 per cent of pre-1788 distributions could be modified for particular circumstances. Some forest types are expanding (since the last glacial period). Others are contracting and only exist today as relict communities. For extensive, little-cleared forest communities there may be no need to reserve as large an area as the 15 per cent benchmark would dictate. On the other hand, relict, naturally rare communities would warrant much higher levels of reservation than 15 per cent of their pre-1788 distributions. Also, forest types that are particularly vulnerable to further loss would warrant high levels of reservation. For example, *Athrotaxis selaginoides* rainforests are very vulnerable to further destruction by fire and have limited ability to invade burned areas (Brown, 1988). Although 60 per cent of the pre-1788 distribution of this community remains, its vulnerability warrants almost total reservation.

Nevertheless, the 15 per cent benchmark can provide a useful 'rule of thumb' for assessing the reservation needs of forest communities (see Table 3.1). Forest clearing over the past 200 years has reduced some forest communities to a much greater extent than others hence the pre-1788 distributions provide a more representative baseline than existing distributions. If reservation proportions were based on existing distributions then the most severely depleted forest types would be under represented.

Table 3.1

Indicative reservation proportions estimated from extent of depletion

extent of clearing	reservation of remaining distributions
no clearing	15%
20% cleared	18%
40% cleared	25%
50% cleared	30%
75% cleared	60%
>85% cleared	100%

In some regions, the extent of clearing of some ecosystem types, for example the lowland tropical rainforests of Queensland, will mean that even if all this forest type were reserved the level would be considerably below 15 per cent of its pre-1788 distribution.

Applying the 15 per cent benchmark in practice would require the use of the broad estimates of pre-1788 vegetation classes (AUSLIG 1990) where no better estimates exist. Within a region, the benchmark for individual forest communities would be varied from the regional average according to the forest communities' level of depletion, rarity and threats to existence, with the aim of achieving a total reservation area consistent with the regional percentage target. Given the difficulty in determining the pre-1788 distributions and the significant error margin , even at a regional level, many of the estimations will need to be made on the best local knowledge available.

It is important, however, not to become too pre-occupied with the precision of 15% as both the reconstruction of the extent of pre-1788 forest communities, in particular, and even the measurement of the extant forest community inevitably involve some error of estimate. In any event, the process for determining appropriate proportional levels of reservation for each forest community should be transparent (ie made public) and well documented.

(5) All known elements of biodiversity should be represented in reserves

Although not all biodiversity is known, there is good distributional data for a large number of forest species, genotypes and communities. Reserve selection methods such as described in Kirkpatrick (1983), Margules *et al* (1988) and Pressy and Nicholls (1989) can be used to ensure that all species whose distributions are relatively well known are viably represented in the reserve system. Common species well represented in reserves elsewhere in Australia need not be included, except where the occurrence in the region has high conservation significance.

Furthermore, it is not necessary to ensure that every element of biodiversity that occurs within a forest community is reserved within that community. Many species may be well reserved in one forest community in a region and infrequent in another. It does not seem necessary to contort reservation decisions to ensure that they are represented in the second community. The important thing is that all known communities, species and genotypes have their viability ensured by adequate reservation, not that they are reserved in every forest community in which they have been recorded. This process will need to include the 'target species' identified in the UNEP International Convention on Biological Diversity, ratified by Australia in June 1993.

The application of this criterion will need to ensure the representation of those species whose distributions and habitat requirements are not well correlated with any particular forest community.

(6) In applying criterion (4) the areas of reserved forest communities should include a range of successional stages and a range of the environmental variation typical of the communities' distribution, wherever possible.

Many of the wetter forest communities have distinct successional stages that are initiated by major natural disturbances such as fire and cyclones. These stages are often characterised by different suites of plant and animal species. Forests used for wood production can contribute to the maintenance of species dependent on habitat provided by different aged forests, with the exception of those species dependent on forest ages greater that the rotational age. However, it is important for representativeness reasons, that the conservation reserve system include samples of successional stages arising from *natural* disturbance. Given the relative under-representation of old growth stages in forests used for wood production, the inclusion of 'old growth' in reserves should be maximised except where this would result in under representation of earlier successional stages.

Forest communities identified at the 1:100,000 scale are often distributed over a variety of physical environments. The species composition of the broadly defined forest communities can vary along environmental gradients and in relation to micro environments within that communities' distribution. To increase the chances of including the range of biodiversity present in a forest community, sample areas should be selected from as many different physical environments as possible.

(7) The habitat requirements for vulnerable and endangered forest species should be identified and the reserve system modified where necessary

Priority in reserve and management planning will need to be given to vulnerable and endangered elements of biodiversity as proposed by Kirkpatrick and Brown (1991) and reflected in the *Commonwealth Endangered*

Species Protection Act 1992 and similar State and Territory legislation. The reserve system may need to be modified to incorporate the habitat requirements of these species, along with management of threatening processes.

(8) Reserve design should, where possible, incorporate ecologically meaningful boundaries

Where possible, reserves should be set in a landscape context having strong ecological integrity, such as catchment boundaries. Boundary area ratios should be minimised and linear areas should be avoided where possible except for riverine systems and corridors identified as having significant value for nature conservation. Reserves should be developed across the major environmental gradients if feasible, but only if these gradients incorporate key conservation attributes or contribute to the CAR system.

(9) The conservation reserve system should integrate with off reserve forest management

Management of the whole forest estate in a manner consistent with nature conservation goals is critical to the adequacy of the dedicated reserve system. Areas adjoining reserves have a special role as buffer zones. Beyond the reserve system, off-reserve management, and whole landscape planning approaches will be required to conserve many species that are mobile across tenures and biomes, or otherwise dependent on unreserved environments. Certain animal species, which are primarily forest-based, have a habitat mosaic requirement that includes the need for access to resources in non-forest areas (for example, heathland). Reserves may need to include non-forest areas to ensure the protection of these species. Complementary management is also important for species needing particular conjunctions of different forest or other biomes and species that use forest in particular successional conditions.

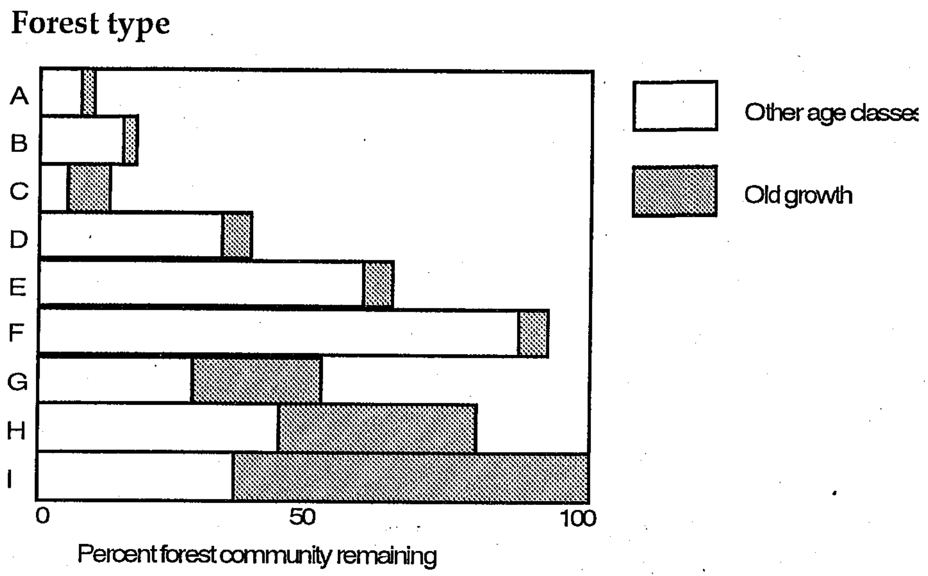
Where reservation for particular species is not considered adequate, management plans may need to be developed that aim to maintain viable populations across the forest estate through other means.

3.2 Criteria to protect old growth forest attributes

The precautionary principle applies particularly to old growth, given the long time taken for old growth to re-establish and the high value that the community attaches to old growth.

Old growth can have a high value for biodiversity and hence a substantial proportion of the remaining old growth will be incorporated by applying the CAR criteria for biodiversity (see Section 3.1). The actual amount of old growth incorporated under these criteria depends on the remaining extent in each forest type and its contribution to biodiversity goals. The following diagram (Fig 3.1) describes schematically the range of clearing extent and old growth depletion that exists for different forest types.

Figure 3.1 Schematic representation of a range of forest types differing in level of depletion and amount of old growth remaining



Forest types A,B,C have been extensively cleared for agriculture or urban development to levels of 15 per cent or less of their pre-1788 distributions. Forest types D,E,F have been less cleared but past logging or the fire regime in that forest type has resulted in only small areas of old growth now present. For these types, the development of a reserve on CAR principles for biodiversity in line with the nine criteria listed in Section 3.1 should include most or all of the remaining old growth of these types. The depletion of old growth in some forest types can only be addressed in the longer term through appropriate management and rehabilitation of areas that have not been too severely modified.

Forest types G,H, I have been little cleared and still include a reasonable proportion of old growth. The extent of old growth in such forest types is known only for a few areas. For example, in East Gippsland, about 38 per cent of the Shining Gum/Mountain Ash tall forests and 33 per cent of Alpine Ash is classified as old growth (Woodgate et al 1994). A reserve system developed on CAR principles for biodiversity is unlikely therefore to incorporate all the old growth in these forest types. While this may be acceptable in terms of preserving biodiversity attributes, it may not be acceptable when considering the other attributes of old growth forests, including the values attached to these forests by the community.

Where the reservation of old growth for biodiversity criteria is not sufficient to fully meet the needs of, for example, water catchment, tourism and preservation of particular cultural attributes, the decisions on additional reservation will need to vary from region to region. The additional area of old growth required, beyond that reserved for biodiversity reasons, depends on the balancing of industry needs/demands and other community needs/demands. These decisions should be made in the integrated planning context of the Regional Forest Agreements.

Bearing in mind that few Regional Forest Agreements are likely to be finalised within the next 12 months, the Commonwealth proposes the following interim arrangements for setting aside old growth on public land.

(1) Wherever practicable, *all* old growth of the following categories of forest types/communities should be included in the CAR reserve system

Forest types that have been extensively cleared (85 per cent cleared or more);

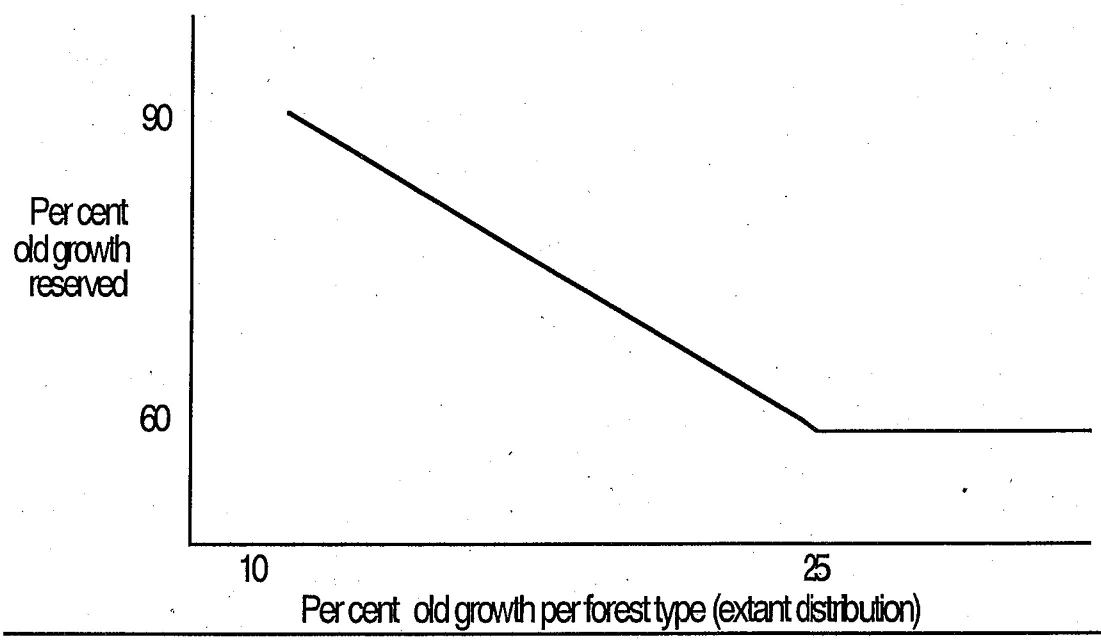
Forest types with little remaining old growth (less than 10%);

Forest types that represent refugia;

Forest types vulnerable to further loss (eg fire sensitive with limited recolonising ability).

(2) For forest types with 10 to 25 per cent old growth, (see Figure 3.2) varying proportions of old growth should be protected in reserves, varying inversely from 90 per cent to 60 per cent according to the proportions of old growth in the extant distribution. At least 40 per cent of the protected old growth should be in dedicated conservation reserves.

Figure 3.2 Old growth reservation for forest types with 10 to 25 per cent old growth in the extant distribution



(3) For forest types with more than 25 per cent old growth in extant distributions, 60% of that old growth be protected in reserves, with at least 40 per cent in dedicated conservation reserves.

For decision rules **(2)** and **(3)** in assessing whether existing reserve levels are adequate, regard will be had to the States commitment to the forest protection strategy. If the States agree formally to the interim arrangements to protect the old growth areas in State Forest Tenures pending decisions during the Regional Forest

Agreement process, then reserves would include conservation reserves and protected areas in State Forest tenures. If the States refuse to agree to the proposed interim arrangements then the old growth will need to be protected in conservation reserves alone.

(4) The extent of old growth identified depends critically on the scale of mapping and the definition used. The scale at which old growth is mapped should be complementary to the 1:100,000 map scale at which the diversity of forest ecosystems are recognised. The methodology recently developed for old growth identification and mapping East Gippsland (Woodgate *et al*, 1994) forms a basis for the delineation of old growth. The methodology is based on the age of the forest and its disturbance history to identify and assess old growth attributes, and uses remotely sensed and other data (Appendix A4). The approach will need to be extended to cover rainforest communities.

3.3 Criteria to protect wilderness attributes

A consistent nationwide approach for identifying wilderness quality would be to apply the results of the National Wilderness Inventory (NWI) (Lesslie, Taylor and Maslen 1993) through a co-operative process agreed to by the Commonwealth, States and Territories. The Australian Heritage Commission, in cooperation with state governments, has successfully applied the NWI in a number of states as part of national estate assessments. In these studies a sophisticated approach to establishing a suitable regional threshold was developed.

The NWI measures wilderness quality on a class scale by adding scores derived from four standard indicators:

- remoteness from settlement
- remoteness from access
- apparent naturalness
- biophysical naturalness

Areas of forest suitable for wilderness reservation are those with wilderness quality in the core of at least 12 on the NWI scale and with at least part of the core more than 5 km from mechanised access or major human disturbance. Non-forest vegetation types may need to be included to maintain a largely forested wilderness area. The core wilderness needs to be surrounded by a buffer zone in order to maintain the remoteness of the cores from mechanised access and major human disturbance.

Wilderness reservation should form a sequential overlay criterion in the selection process for a forest reserve system that meets both the objectives of protecting biodiversity and wilderness attributes. It is not envisaged that wilderness attributes will be protected on a representative basis for each forest type. A sequential process is required to avoid a situation where protection of biodiversity and of wilderness become competitive issues that could result in a skewed conservation reserve system that does not adequately protect all levels of biodiversity. In any event, a CAR reserve system based on landscape features (such as catchment boundaries) is likely to achieve many wilderness objectives.

Decisions on the reservation of wilderness areas will be made on a regional basis in the development of Regional Forest Agreements. In this process consideration may need to be given to natural forest areas of lower wilderness quality than 12 (smaller size and less remote) where options for wilderness are few.

Bearing in mind that few Regional Forest Agreements are likely to be finalised within the next 12 months, the Commonwealth proposes the following interim arrangements for wilderness reservation.

(1) 90 per cent, or more wherever practicable, of the areas of high quality wilderness (NWI equal to or greater than 12) that meet minimum area requirements be protected in reserves, and no activity undertaken that would reduce the NWI rating of the wilderness areas.

Under the interim arrangements, formal State agreement will be sought to protect the reserves in State forest tenures pending decisions during the Regional Forest Agreement process.

4. APPLICATION OF THE CRITERIA

The purpose of agreed reserve criteria is to progress key NFPS and related initiatives, primarily the 'Comprehensive Regional Assessment' and 'Regional Forest Agreement' process where governments will cooperatively assess the full range of forest attributes in a region and develop a CAR reserve system in the context of broader integrated forest planning and management.

4.1 A pragmatic approach

One of the first steps in the development of Regional Forest Agreements is to review the comprehensiveness, adequacy and representativeness of the existing forest reserve system and assess what additional areas need to be included in the reserve system to meet the agreed reserve criteria. This task needs to be undertaken urgently to enable governments to meet their NFPS commitments.

The urgency of the task dictates a pragmatic approach to the development of a CAR reserve system for forests. The criteria outlined in Section 3 are designed to ensure a consistent approach across regions in the development of a forest reserve system but the criteria are broad enough for the best available data to be used in each forest region and for the regions to be selected on a practical basis. In most instances, local expertise and knowledge will need to be used to extend the broadly held data. In regions where the data is too limited for adequate assessment then additional data should be obtained initially to allow resolution of contested areas.

In some circumstances, it may be necessary to set aside some areas until further assessments are completed, so as not to foreclose reserve or other land use options. A staged process may be appropriate also to ensure that priority areas are reserved in the short term with complementary protection afforded to other candidate areas for reservation until sufficient resources are available to place them in the permanent reserve system. This process is important particularly where private land is a potential candidate for a reserve system.

The Commonwealth objectives through the Regional Forest Agreements is to secure a level of assurance on reserves consistent with a requirement that they only be reduced after consultation with the Commonwealth and the community through a prescribed statutory process. Pending completion of Regional Forest Agreements, if a state is prepared to provide an undertaking to provide protection to existing administrative reserves or other deferred forest areas pending their assessment for inclusion in the reserve system, then those administratively protected reserves may be taken into account in reserve adequacy.

4.2 Integration of reserve criteria

The integration of environmental, economic and social data in the analytical process needs to be transparent, explicit and repeatable.

The assessment process should be formal involving stakeholders including individuals, community groups, and the forest dependent industries. Information should be freely available to stakeholders throughout the process.

Conservation assessments can be undertaken through a sequential, staged approach can be adopted where data are evaluated, enhanced and analysed and finally a range of possible conservation options are included in the integrated planning process. Alternatively, some of the issues of value to community stakeholders could be identified early in the process and help guide the development of conservation options. The contentious issues identified by the stakeholders can help determine the type and extent of information needed to resolve the land allocation and management issues that are central to the Regional Forest Agreements.

The use of iterative algorithms for reserve selection and multi-criteria algorithms for land allocation can facilitate the analysis. Recent developments in linking reserve selection and multi-criteria algorithms in a single integrated analytical procedure allow comparisons of the economic efficiency and social costs and benefits of different configurations of reserve options in an interactive manner (see Appendix A4).

To be functional, application of the criteria for reserve selection must be flexible. There are many possible configurations of a CAR conservation reserve system in a forested region. For example some forest communities may be sampled equally well at a number of alternative locations. Thus there is considerable scope for negotiation with all land-users in resolving conflicts of interest. Flexibility in the system will similarly assist land-use decision-makers.

4.3 Reserve design

Given any particular set of reserve selection criteria there are several factors that need to be considered in designing the CAR forest reserve system. These factors cannot be applied as criteria as many are contradictory and are all highly contingent. These factors will need to be borne in mind by the expert teams in formulating the reserve options during the Regional Forest Agreement process.

The design factors identified below principally relate to achieving conservation adequacy objectives, but many factors have other benefits also such as more ease and lower costs of managing reserves and maintaining attributes such as wilderness and old growth.

- Boundaries should be set in a landscape context with strong ecological integrity, such as catchments.
- Size - large areas are preferable to small areas, other factors being equal.
- Boundary-area ratios should be minimised and linear areas should be avoided where possible except for riverine systems and corridors identified as having significant value for nature conservation.
- Reserves should be developed across the major environmental gradients if feasible, but only if these gradients incorporate key conservation attributes or contribute to the CAR system.
- Reserves should maximise efficiency by each reserve contributing to as great a number of reserve criteria as possible.
- Where information is limiting, the precautionary principle should be applied in the form of conservative land use decisions.
- Where refugia (both glacial and inter-glacial) are known to exist these should be incorporated in the reserve system.

4.4 Comprehensive, adequate and representative (CAR) reserve management

Achievement of the biodiversity goals of conservation reserves is contingent to a large degree on management. Management is needed to minimise the impact of human activities allowed in the reserves. Active management is needed to ameliorate threatening processes and ensure that the reserve system retains the biodiversity for which it was initially set aside. Such management may involve use of specific fire sequences and even managed disturbance or selectively reducing certain populations.

Maintaining reserves will require establishment costs, management costs and the cost of acquisition of information.

4.5 Complementary conservation management

The complementary conservation strategies adopted by the NFPS, for State Forest, Crown lands and for private forest, aim to achieve integrated conservation goals for the whole landscape.

Ideally, all species should be sampled in the reserve system. However, the area required to achieve this for the last few per cent of species may reach a point of diminishing returns. In this situation, biodiversity conservation objectives may be more efficiently and effectively achieved through complementary management 'off reserves'. Off reserve management applies particularly to the protection of migratory and mobile species, and of patchy or linear ecosystems. The management zoning system used in State Forests in most states for multiple-use forests reflect the special conservation attributes of particular areas through various administrative reserves. The environmental management guidelines being developed by the JANIS Technical Working Group on Forest Use and Management have as their aim the maintenance of ecosystem process and hence forest productivity and biodiversity. The application of these guidelines will be essential to the achieving the conservation goals of the National Forest Policy Statement

Particular attention should be paid to the management of areas directly adjacent to reserves to minimise the abruptness of the transition from areas of high protection to more intensively used landscapes. The activities allowable in these adjacent areas should be specifically defined.

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APPENDIX A1 REPORT OF THE SCIENTIFIC ADVISORY GROUP

Background

The Commonwealth sought assistance from the scientific community in the development of a Reserve Criteria Discussion Paper for release as a public document. An *ad hoc* Scientific Advisory Group was appointed for the four week period that the Discussion Paper was developed.

The Scientific Advisory Group was asked to advise the Commonwealth on the scientific basis for a whole of government position on criteria to assist in establishing a comprehensive, adequate and representative national nature conservation reserve system and the manner in which these national criteria might be best used in:

- developing agreed criteria with state and territory agencies;
- facilitating the Comprehensive Regional Assessment and Regional Forest Agreement process.

In undertaking this task the Scientific Advisory Group was asked to consider the documents produced by the JANIS Technical Working Group and the options papers from the Commonwealth Environment and Primary Industries and Energy portfolios. The Scientific Advisory Group consulted with selected experts from the Australian and international scientific community in developing their advice on a scientifically based set of criteria for a CAR reserve system for forests.

Membership

Dr Keith Boardman, FRS, FAA, FTS
former Chief Executive of CSIRO

Professor Jamie Kirkpatrick, Head, Department of Geography and Environmental Studies, University of Tasmania.

Dr Ian Noble, Group Leader, Ecosystem Dynamics
Research School of Biological Sciences, Australian National University
former Commissioner on the Resource Assessment Commission Forest and Timber Inquiry

Professor Ralph Slatyer, FRS, FAA, FTS
Chairman of the Cooperative Research Centre for Tropical Rainforest and Ecology and Management
former Chief Scientist

The group was chaired by the Chief Scientist, **Professor Michael Pitman, FAA.**

Scientific theory and information relevant to reservation adequacy

This appendix elaborates the logic and scientific justification of the key features of the criteria that are presented in the Discussion Paper.

A comprehensive, adequate and representative (CAR) forest reserve system for biodiversity requires criteria that address the requirements of both those elements of biological diversity that are formally defined and have well known distributions and those that exist but are yet to be described and/or whose distributions are poorly known. It seems likely that this latter class forms the larger part of the native biodiversity of Australian forests, as, despite some recent conservation-related genetic research (e.g. Shapcott 1995; Robinson 1995), our knowledge of genetic variation in forest species is limited, large numbers of invertebrate species are reasonably presumed to be undiscovered and/or undescribed, our knowledge of microbial biodiversity is fragmentary and floristic communities have only been described from a portion of our forest estate. The knowledge of the distributions of known elements of biodiversity also varies markedly between the bioregions and administrative divisions of Australia.

Viable representation of known elements of biodiversity

CAR criteria aim to ensure that all known elements of native forest biodiversity are represented viably within reserves in each region, except where no viable populations exist or where a species needs to be managed off-reserve as well as on-reserve. In the latter case an integrated management plan needs to be implemented. The normal situation in which management would be required as well as reservation would be for taxa that have large ranges across the semi natural and natural landscapes. These are often organisms at the higher trophic levels, such as raptors and other carnivorous vertebrates, or nomadic organisms that follow seasonal flowering patterns.

In many regions, most known elements will be found in viable numbers/areas and spatial arrangements in the existing forest reserve system (see for example, Kirkpatrick and Brown, 1992, AHC 1994). Species and communities with inadequate representation in the reserve system should be targeted for reservation at viable levels. In practice, viability thresholds for species and communities will need to be determined by the experts for particular species and species groups. Each species has a specific requirement for habitat, including features of the physical environment and the presence of other species. As the area of suitable habitat is reduced so the average population size supported by the habitat falls and the chance of extinction increases. The chance of extinction may increase rapidly once the area of habitat falls below a critical level (Shaffer 1981).

Threshold requirements for habitat vary considerably between different species and communities, and be highly contingent on local circumstances. In some cases, population viability analyses (Boyce 1992) may be a useful way to determine appropriate population sizes and habitat requirements. Population viability analyses are a way of considering all the complex factors that affect the probabilities of species extinction, including demographic, genetic and environmental stochasticity, and life history and ecological characteristics (Gilpin and Soule 1986; Ruggiero *et al.* 1994). They are most appropriately used for taxa that require management off-reserves, those that are critical for the survival of other taxa (i.e. keystone species), or those that are in danger of short-term extinction. They do not eliminate all uncertainty, but, as in the case of Leadbeaters possum (*Gymnobelideus leadbeateri*) (Lindenmayer *et al.*, 1993), do give otherwise unavailable insights to the better overall reservation and management strategies to ensure survival.

The most important elements of biodiversity to place in the reserve system, and manage intensively, are those threatened with extinction by on-going processes, such as land clearance and the effects of exotic competitors and predators. Some threatened species may only survive if all their range is reserved and appropriately managed. Such management may not necessarily benefit many of the more common species (e.g. Kirkpatrick and Gilfedder, 1995).

In applying the criterion to viably represent all known elements of biodiversity best use should be made of available data. All defined elements of biodiversity that have reasonable spatial data coverage within a region should be used in the design the CAR reserve system. For example, the use of mappable forest communities should not preclude the inclusion of floristically defined forest communities, such as those of Kirkpatrick *et al.* (1991) for Tasmanian wet eucalypt forest, or communities based on physiognomy and dominance, such as the Tasmanian rainforest communities of Jarman *et al.* (1984, 1991). Similarly, genetically-based morphological variation within species should be covered in the reservation system as well as the results of DNA or allozyme analyses, even if they cover the same taxon, as there is no necessary covariance between these different attributes (e.g. Leeton and Fripp 1991).

Conserving unknown elements of biodiversity

Reserving viable populations of species, and genetic variants, unknown to science, or known to science and with poorly-known distributions, is obviously more difficult than representing well-known elements of biodiversity in the reserve system. Surrogate approaches are needed. Environmental domains, vegetation types and particular species may be good predictors of the presence of many elements of biodiversity, but the few studies that have tested these relationships (e.g. Kirkpatrick and Brown 1994; Whinam *et al.* 1989) indicate that the prediction is imperfect. Thus, the precautionary principle would suggest that it is appropriate to maximise the chances of including unknown elements of biodiversity within reserves by using several surrogate approaches, ensuring replication in the system and having relatively high targets for reservation.

The surrogates incorporated in the criteria are forest types/communities and known biodiversity. It is axiomatic that reserving known vegetation communities and areas necessary for the maintenance of known species will also incorporate many unknown elements of biodiversity at the species and genetic variation levels. The issue is the uncertainty about how well the surrogate measures can represent unknown biodiversity.

Forest types, if defined by their biological characteristics, are elements of biodiversity in themselves. If defined partially or wholly by environmental attributes they are still moderately good predictors of biodiversity. However, some rare and threatened elements of biodiversity are poorly selected by reserves based purely on environmental domains (Kirkpatrick and Brown 1994), emphasising the importance of also basing reserve design on the inclusion of known elements of biodiversity. The use of biologically-based forest types alone is also an imperfect strategy. Vegetation types based on structure and dominance do not necessarily reflect floristic variation (e.g. Rice and Westoby 1985), especially when they have to be mappable units (see discussion in Kirkpatrick and Dickinson 1986).

Forest types/communities are not particularly good surrogates for many animals. Animals often have habitat requirements that relate more to such things as forest structure, forest nutrient distribution, specific micro environments, seasonal events and juxtaposition of different types of vegetation than to floristically defined forest communities. Maintaining these species often requires management over different tenures including reservation of specific habitat. The known habitat requirements of 'demanding' species, that is, those with the most specific requirements, those requiring the largest areas and so on, can be used as surrogates to provide protection for the lesser known and/or less habitat demanding species. Arboreal mammals, insectivorous and nectivorous birds are some of the groups that are relatively well known and could be appropriate surrogates.

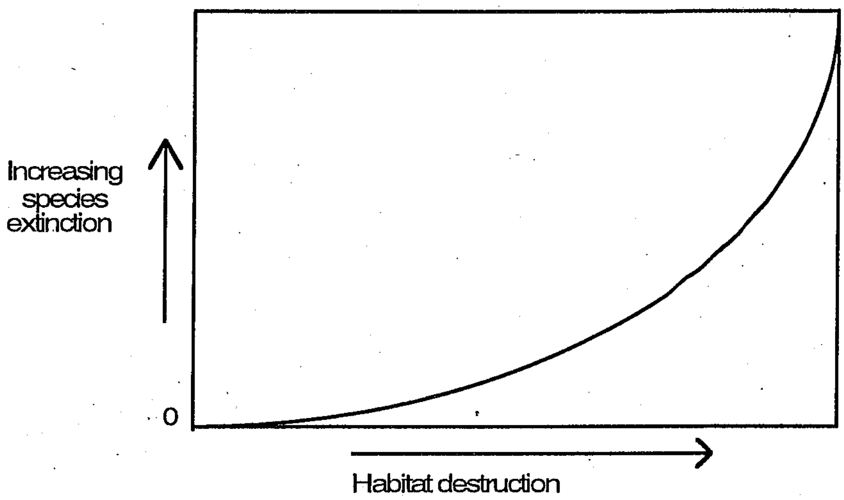
Minimising risk of biodiversity loss

Even if 100 per cent of the remaining native forest was conserved and actively managed for conservation unknown elements of biodiversity may be lost as a result of past reduction and fragmentation (see, for example, Koopowitz *et al.* 1994), as would many presently threatened *known* elements without adequately resourced recovery processes. This is because the populations of some species are already so low, particularly in fragmented or remnant areas of natural habitat, that local extinction will occur at some stage. That stage may be some generations away but is inevitable unless the extinction/colonisation balance is redressed.

However, given that 100 per cent reservation for nature conservation is not in accordance with the National Forest Policy Statement (NFPS) minimising biodiversity loss becomes a matter of risk assessment.

Habitat destruction is held to be the major cause of species extinction (Wilson, 1988). However there is considerable uncertainty within the scientific community concerning the relationship between the degree of habitat destruction or modification and the loss of biodiversity (eg Whitmore and Sayer, 1994). It is common for a substantial amount of habitat modification to occur with concomittent small losses in biodiversity, followed by a steep losses of biodiversity with small additional reductions in habitat (Kareiva and Wennergren 1995). Even the most initially abundant species can be at risk since these species tend to be good competitors but poor colonisers of modified habitat, making them particularly vulnerable (Tillman et al 1994). The long time lags between habitat modification and species loss means that species can be 'committed to extinction' long before before they disappear (Tillman et al 1994). The figure below desribes a generalised relationship between habitat loss and modification and plant species extinction adapted from Koopowitz *et al.* 1994. The spatial and temporal scales at which these losses would be readily detected are usually well beyond the scales at which research has been funded and undertaken.

Figure 1 Schematic diagram of the relationship between habitat destruction and species extinction.



Although the general statement can be made that with increasing habitat destruction or modification there is an increase in species extinctions, the form of the relationship is complex and the relationship varies from species to species and for any one species it is influenced by a variety of biological and environmental factors. The relationship is further complicated by the fact that loss or modification of one habitat may be an opportunity for other forms of biodiversity to become established in the modified habitat. The theoretical bases for such species area curves has some shortcomings. These relationships were developed originally to show the relationship between the number of species (of a given set of taxa) and the area of 'habitat islands'. These curves have been applied by analogy to questions about loss of habitat. However the analogy is weak: the processes describing long term gain/loss/evolution of island biotas is different to that describing species loss from an area being converted from suitable to unsuitable habitat. Predictions of species loss as a function of habitat modification have also been made using extensions of metapopulation models (Tillman *et al*, 1994) and stochastic models for plant species extinctions (Koopowitz *et al*, 1994). There have been some empirical studies aimed at providing data to assess the relevance of these theoretical projections to the actual effects of habitat loss and fragmentation (eg Lovejoy et al, 1986, Margules, 1992) but it is still not possible to predict the relationship between extent of habitat loss and species loss.

Most models of species/area relationships and of the effects of habitat loss assume that the replacement habitat is unsuited to all of the target biota and that the habitat fragments (reserves) are surrounded by a sea of unsuitable habitats and will remain so. Neither of these assumptions apply to forest that is managed in an ecologically sustainable manner for wood production and harvesting. The NFPS requires native wood production forests to be managed in a manner that is sympathetic to biodiversity conservation. Silvicultural treatments vary considerably on their impact on biodiversity (e.g. Hickey 1994). Native forest that is not cleared for agriculture or tree plantations, has considerable value for nature conservation, if not the security that is necessary for viability of all species.

There are also historical ecological reasons to believe that, for many forest types that have not been severely depleted by clearing, a relatively small proportion of their eighteenth century area might, given proper attention to refugia and to off-reserve management, ensure a high level of biodiversity conservation. Pollen and macrofossil data from tropical Queensland and south eastern Australia (see for example Kershaw *et al.* 1986; Hopkins *et al.* 1993) indicates that forests were much more restricted at the height of the Last Glacial than today. Thus, the forest biodiversity of Australia passed through a narrow areal bottleneck only 18,000-22,000 years ago. Some elements of the forest biodiversity may well have been lost during the Last Glacial but the species and genotypes present in the forest today are the survivors of that bottleneck, and possibly earlier bottlenecks, hence they may well be able to survive similar contractions in area. However, it is important to be aware that the analogy of the retraction of forest communities to refugia over the thousands of years before the Last Glacial is not necessarily appropriate to the current situation where substantial habitat loss and fragmentation have been imposed over a period of only decades. Of course, many forest species occur today in other native vegetation types and may have done so in the past, perhaps surviving solely within their bounds. Thus, a high level of reservation for non-forest communities may be a necessary corollary of a reserve system forforests.

In Australia, pre-1788 distributions of forest types are the logical baseline for reservation benchmarks. Forest clearing over the past 200 years has reduced some forest types to a much greater extent than others, hence basing the benchmark on the pre-1788 distributions skews the reservation of existing distributions so that the most depleted communities are those with the highest reservation levels. Expressing targets as proportions of the pre-1788 area is also more consistent with the scientific logic of species depletion/area depletion curves, such as that of Koopowitz *et al.* (1994). However, the uncertainties in estimating pre-1788 vegetation distributions mean that in practice these distributions can only be used as an approximate baseline.

The foregoing discussion has highlighted the difficulties of providing a simple scientifically defensible percentage figure for the area of land that should be set aside in a reserve system to conserves biodiversity in Australian forests. Nevertheless the Scientific Advisory Group considered the following points can be defended.

In general with increasing habitat destruction or modification, there is an increase in species extinctions. The form of this relationship is complex; but it tends to be progressive; with each increment of modification there is a proportionally greater increment of extinction. The relationship varies from species to species and, for any one species, it is influenced by a variety of biological and environmental factors, and the nature of the habitat modification.

It follows that it is not possible to assign any specific fraction of a bioregion, or forest type to reserve and assume that all biodiversity will be conserved. What can be said is that the higher the fraction of a forest type that is conserved, the more secure the populations of its component species will be. Given the uncertainties of a baseline figure, and the certainties of extinctions, the precautionary principle would argue for the highest possible fraction. This applies particularly to old growth because, one destroyed, old growth and the habitat for the species it creates, cannot be re-created in less time than it takes for the longest-lived trees to reach their maximum age.
The only effective way to ensure that the maximum possible fraction of biodiversity is conserved, while retaining a production forestry industry, is to ensure that the entire forest estate remains in as natural condition as possible.

The best way to achieve this would be to:

- develop a reserve system based on CAR principles;
- embed the reserves in the off reserve areas represented by the broader forest estate; and
- ensure that all forestry operations are undertaken with conservation oriented ecologically sustainable management.

These measures have been agreed under the National Forest Policy Statement, hence the Scientific Advisory Group considers that a provisional figure for the establishment of the reserve network could be to assume that the reserves should occupy, on average, 15 per cent or more of the pre-1788 extent of each forest type. This benchmark equates to about 30 per cent of the remaining forest overall.

The Scientific Advisory Group was aware that the International Union of Nature Conservation (IUCN) has proposed a level of 10 per cent reservation of each biome on a global basis. However this figure has no specific scientific basis. It was proposed in the Caracas Action Plan developed by the IUCN Commission for National Parks and Protected Areas at a workshop in 1992 (IUCN, 1993). The Commission also recognised that, for effective conservation of biodiversity, a key factor is the condition and management of the adjoining areas outside the reserves and recommended that reserves should be surrounded by buffer zones which are managed in an ecologically sustainable manner. The specific figure of 10 per cent is a global figure, agreed to by the majority of Commission members based on their collective experience. When asked "how much is enough" workshop participants agreed that 10 per cent was a pragmatic political response in the light of the value of protected areas for enhancing sustainability and the quality of life. It was considered a realistic figure recognising that in some countries higher targets may be set or this level already exceeded; while in others it may not be achievable because the fraction of land remaining in an appropriate condition is already lower than 10 per cent.

The reservation proportions for broadly defined forest communities within regions, and the requirement to incorporate samples from the range of genetic and age variation within the broadly defined communities, aim to ensure replication of widespread elements of biodiversity, and make it more likely that variation in the unknown biodiversity of forest types is captured. The benchmark reservation proportions are necessary to ensure that sufficient land is included in reserves to ensure some chance of capture of the unknown biodiversity, as well as the known biodiversity, at viable levels.

Old Growth

Old growth is a relatively distinct successional stage in some forest types, usually the wetter forests, but is difficult to distinguish in other forest types which are characterised by trees of a mix of ages. Old growth has important biodiversity benefits. Older forests have elements of biodiversity that are absent from, or rare in, younger forests (e.g. papers in Norton and Dovers 1994), just as regrowth forest has its own characteristic biodiversity. The biodiversity values attributed to old growth stem from the fact that some plants and animals are restricted to the old growth stage or are dependent on old growth for some of their habitat requirements. There are other species that only occur in younger forest or that need access to younger forest for some of their requirements and it is important for representativeness reasons that younger forest be included. Nevertheless, old growth stages may warrant particular attention for biodiversity reasons because of the time taken to replenish lost old growth. Once destroyed, the habitat for other species that old growth creates, cannot be re-created in less time than it takes for the longest lived trees to reach maturity.

Old growth forest has been extensively lost to clearing, logging and wildfire, so is likely to be the primary target for CAR reservation for any forest type. However, the reserve system should include those regrowth forests that are necessary to ensure viable representation of their peculiar biodiversity, and sufficient area and developmental diversity to ensure that the eventual loss of any reserved old growth stand will be compensated for by the aging of a reserved regrowth stand.

Wilderness

Wilderness areas are not determined on the principles of comprehensiveness, adequacy and representativeness for biodiversity conservation. Nevertheless, wilderness reservation has some direct benefits for biodiversity.

Forests are highly dynamic ecosystems. The forest reserve system should allow this dynamism to be expressed. The size of wilderness areas can allow the continuation of dynamic natural processes without human manipulation.

Remoteness, in itself, has some direct benefits for biodiversity. These include the absence of artificial barriers to the movement of native organisms, the absence of artificial channels for the movement of exotic organisms and the distance decay effect noticeable with deleterious disturbances such as anthropogenic fire, fertiliser and pesticide drift, pollution drift, exotic disseminule drift and alterations to drainage and water quality. The benefits to be gained from the reduction in edge effects are greater for the first kilometre or so of remoteness, but less marked or negligible with increases in remoteness beyond this distance as most edge effects have a rapid reverse exponential decline with distance (Kirkpatrick 1994)

Primitive country is generally the cheapest to manage for biodiversity conservation, Thus the higher proportion of biodiversity reserves that are wilderness, the cheaper is the management (Kirkpatrick 1994).

Because the attributes of remoteness and primitivenes have survived in areas that have been of little use to agricultural and industrial people, the wilderness today contains only a subset of biodiversity. Thus, while wilderness preservation will greatly increase the chances for long term survival of a substantial part of our biota, it will not be enough in itself to ensure biodiversity maintenance in Australia. The priority areas for nature conservation lie in the fragmented natural landscapes of the most heavily modified parts of the continent and in improved control of exotic plants and animals (Kirkpatrick, 1994).

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APPENDIX A2 RESERVE CLASSIFICATION

The National Forest Policy Statement identifies that nature conservation objectives will be met by combining a dedicated nature conservation reserve system with off-reserve conservation initiatives.

A large number of dedicated nature conservation tenure exist under Commonwealth, State and Territory jurisdictions in Australia. The management regimes for the dedicated nature conservation reserve system should be equated to specific protected area management categories defined by the IUCN Commission for National Parks and Protected Areas (1994).

The IUCN Management Categories relevant to the National Forest Policy Statement for a nature conservation reserve system are Categories I, II and IV. These categories are defined as:

Category 1 Strict Nature Reserve/Wilderness Area: protected areas managed mainly for science or wilderness protection:

Areas of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.

Large areas of unmodified land, or slightly modified land, or land and water, retaining their natural character and influence, without permanent or significant habitation, which are protected and managed so as to preserve their natural condition.

Category II National Park: protected area managed mainly for ecosystem protection and recreation:

Natural area of land and/or sea, designated to

(a) protect the ecological integrity of one or more ecosystems for this and future generations,

(b) exclude exploitation of occupation inimical to the purposes of designation of the area and

(c) provide a foundation for spiritual, all of which must be environmentally and culturally compatible.

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

Area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.

Category VI 'Managed Resources Protected Area(s)

managed mainly for the sustainable use of natural ecosystems.

Security of tenure is an important consideration in the establishment of a dedicated nature conservation reserve system as well as in the establishment of appropriate reservation and management measures in other tenures.

Security of tenure can be demonstrated if Parliamentary action by Commonwealth, State or Territory Governments' is required for revocation of the reserve. Accordingly, forest reserves established for nature conservation in State Forest tenures in some States may meet the above standard in the development of a CAR nature conservation reserve system. Some examples of the various classifications of such reserves is given in Table 1.

Table 1 Examples of nature conservation protection zones in State Forest Tenures

State	**Classifications**	**Degree of protection**
Victoria	Special Protection Zone Special Management Zone General Management Zone	These zones are incorporated in forest managment plans, approved by the Secretary,Dept of Conserv. & Natural Resources and by the Minister. Changes to boundaries or conditions of managment require review, public comment and approval by Secretary and Minister
Western Australia	Riparian Zones Diverse Ecosystem Zones	These zones are incorporated in forest managment plans (10 yr duration) Changes to boundaries or conditions of managment require public review, public comment and Ministerial approval
NSW	Preferred Management Priority System (PMP) including flora reserves and forest preserves	Flora reserves can only be changed by an Act of Parliament Other areas under PMP can be changed by Forestry Commission staff

Tasmania	Native forest Protection Zone (include forest reserves, Recommended Areas for Protections) Deferred Zones	Incorporated into forest management plans (10 yrs duration), approved by Minister Changes to reduce boundaries or conditions of managment require public review, public comment and Ministerial approval Changes that enlage protected areas or improve management can be implemented immediately by Forestry Commission
Queensland	Scientific Areas Feature Protection Areas	Gazetted

APPENDIX A3 NATIONAL ESTATE VALUES ASSESSED IN THE CENTRAL HIGHLANDS JOINT PROJECT

	CRITERION	VALUE
	Fauna	
A1	Places Demonstrating Evidence of Past Processes	Endemic Species
A2.1	Places Demonstrating Existing Processes	Refuge from Drought and Frequent Fire
A2.2	Places Demonstrating Existing Processes	Key Habitats and Habitat Classes
A3	Places of Unusual Richness	Modelled and Observed Richness
B1.1	Places of Rare and Threatened Fauna	Immediate Habitats of Known Sites of Rare and Threatened Species
B1.2	Places of Rare and Uncommon Communities	Rare and Uncommon Habitat Classes
	Flora	
A1.1	Places Demonstrating Evidence of Past Processes	Endemic Species (areas identified as containing concentrations of species2))
A1.2	Places Demonstrating Evidence of Past Processes	Species on the Limit of their Range (areas identified as containing concentrations of species2))
A1.3	Places Demonstrating Evidence of Past Processes	Disjunct Species (areas identified as containing concentrations of species2))
A1.4	Places Demonstrating Evidence of Past Processes	Relictual Vegetation Classes Cool Temperate Rainforest[1] Wet Forest Subalpine complex Wet and Swamp Heathland
A1.5	Places Demonstrating Evidence of Past Processes	Refuges from Climatic Change
A2.1	Places Demonstrating Existing Natural Systems	Successional Stages
A2.2	Places Demonstrating Existing Natural Systems	Remnant Vegetation Classes Box Woodland Plains Grassy Woodland Floodplain Riparian Woodland[1] Plains Grassland
A3	Places of Unusual Richness	Modelled Flora Richness
B1.1	Places of Threatened Flora	Known Sites of Threatened Flora
B1.2	Rare Landscapes	Natural Landscapes

B1.3	Rare Ecosystems	Old-Growth Forest
		Montane Wet and Wet Forest
		Damp Forest
		Dry Forest EVCs
		Other Forest types
B1.4	Rare Landscapes	Remote and Natural Areas
B1.5	Nationally Rare EVCs	
D1	Places Demonstrating the Principal Characteristics of Vegetation Class	
		Box Woodland
		Cool Temperate Rainforest[1]
		Damp Forest
		Floodplain Riparian Woodland[1]
		Grassy Dry Forest
		Herb-rich Forest
		Heathy Dry Forest
		Heathy Foothill Forest
		Heathy Woodland
		Montane Dry Woodland
		Montane Damp Forest
		Montane Riparian Thicket[1]
		Montane Wet Forest
		Plains Grassy Woodland
		Riparian Forest[1]
		Riparian Thicket[1]
		Rocky-outcrop Scrub
D1	Places Demonstrating the Principal Characteristics of Vegetation Class (cont.)	
		Subalpine Dry Shrub, Wet/Damp Heath
		Subalpine Woodland
		Valley Forest
		Wet and Swamp Heathland
		Wet Forest

	Geology and Geomorphology	
A1, A2, A3, B1, D1	Geological and Geomorphological Sites	
	Natural and Cultural Values	
C1, C2	Type Localities and Research, Reference and Educational Areas	
	Cultural	
A3.1	Places Exhibiting Unusual Richness of Cultural Features	Historic
A3.2	Places Exhibiting Unusual Richness of Cultural Features	Contemporary Aboriginal Places Archaeological Aboriginal Places
A4.1	Places Associated with the Course and Pattern of Human History	Historic
A4.2	Places Associated with the Course and Pattern of Human History	Contemporary Aboriginal Places Archaeological Aboriginal Places
B2.1	Places that are Distinctive, Endangered or of Exceptional Integrity	Historic
B2.2	Places that are Distinctive, Endangered or of Exceptional Integrity	Contemporary Aboriginal Places Archaeological Aboriginal Places
D2.1	Places Demonstrating the Principal Characteristics of Human Activities	Historic
D2.2	Places Demonstrating the Principal Characteristics of Human Activities	Contemporary Aboriginal Places Archaeological Aboriginal Places
E	Places of Aesthetic Value	
F1.1	Places Demonstrating Creative or Technical Achievement	Historic
F1.2	Places Demonstrating Creative or Technical Achievement	Contemporary Aboriginal Places Archaeological Places
G1.1	Places Highly Valued for Social, Cultural or Spiritual Reasons	Non-Aboriginal
G1.2	Places Highly Valued for Social, Cultural or Spiritual Reasons	Aboriginal
H	Places Associated with People of Importance	

1 The mapping process used by the project tends to exaggerate the true extent of linear EVCs, sometimes by as much as an order of magnitude. Figures quoted should be taken only as indicative.
2 These values are potentially sensitive to timber harvesting, depending on the species.
3 The figure is only approximate: areas estimated from maps, not generated by the GIS.
4 The reservation analysis of these values has not been made because they represent a range of different habitats that were difficult to analyse separately and meaningless if analysed collectively.

APPENDIX A4 ASSESSMENT AND ANALYTICAL METHODS

The following notes provide some elaboration of methods of assessment and analysis referred to in the discussion paper 'National Forest Conservation Reserves, Commonwealth Proposed Criteria'. The intention is to clarify the purpose and outline the general approach rather than give any details of the procedures. These details can be found in the references. A loose grouping has been made into specific methods, general framework for application of methods, and general approaches to assessment.

SPECIFIC METHODS

Environmental Domain Analysis
Environmental domain analysis (EDA) uses existing data on environmental attributes (altitude, terrain, climate and geology, for example) together with classification techniques to identify and map the different types of environments that occur in a region; these types are called 'environmental domains'. Knowledge of the distribution of these environmental domains, together with some biological distribution data, may be used to predict the distribution of plants and animals in the region and to assess the design systems of nature reserves. For example consultants to the RAC's Forest & Timber Inquiry used EDA to assess the adequacy of the current conservation reserve system in Tasmania.

The main advantage of EDA analysis is that it can greatly reduce the need for costly direct surveying of plants and animals, especially for large scale analyses. The technique has the additional advantage of using data that are readily available and relatively constant over time. The principal disadvantage is that it can indicate only the potential for the occurrence of particular species or communities; there is no certainty that a community is present even if the physical and climatic conditions are appropriate.

RAC (1992) Methods for analysing development and conservation issues - the Resource Assessment Commission's experience. Research Paper no. 7.

Lewis, A, Stein, J L, Stein, J A, Nix, H A, Mackey, B G & Bowyer, J K (1991) An assessment of regional conservation adequacy Tasmania. RAC Forest & Timber Inquiry Consultancy series FTC 91/17.

Kirkpatrick, J B and Brown, M J (1991) Reservation Analysis of Tasmanian Forests, Forest and Timber Inquiry Consultancy Series No FTC91/16, Resource Assessment Commission, Canberra

Forest Mapping
A report (NFI Consultants, 1990) reviewed for the National Forest Inventory the various classification systems currently in use by land management agencies in Australia, and contained a synopsis of consultations held with these agencies regarding similarities and differences in their approaches to forest mapping. These consultations revealed few fundamental differences between the various classification systems in use. A workshop in 1989 assisted in the formulation of recommendations that a three-level hierachical classification system be adopted to provide national, regional and local forest classification (Chapter 6). Such a framework allows for maximum use of existing information at each level, but at the same time provides for the systematic and standardized collection of site attribute data. Among the report's conclusions were:

- the collection and measurement of both structural an floristic information is critical
- there is a need for collection of site attribute data
- ecological processes at work within each classification are important as is definition and measurement of fauna habitat
- development of classification systems should take advantage of modern technology and latest ecological theory
- the vegetation classification adopted needs to meet the needs of user-groups
- the choice of classication system should permit easy integration of additional attributes which may be of importance, such as cultural, wilderness etc. at the regional and local levels

Several classification systems were briefly reviewed in the report - those of Specht, Walker and Hopkins, Webb and Tracey (rainforest), Floyd (rainforest), Johnston and Lacey, forest 'type' mapping, and classification through collection of site attributes by quadrats. Brief reference was also made to classification systems used by FAO. An appendix summarizing issues raised and views of various land management agencies and research organizations gave valuable insight into diverse perceptions held of best approaches to forest mapping.

NFI Consultants (1990) National Forest Inventory - review of vegetation classification and mapping systems. Working Paper WP/4/90 Bureau of Rural Resources

Old Growth Assessment
The preferred Commonwealth model for the assessment of old growth values is contained in a AHC-DCNR study begun in 1990, the primary purpose of which was to describe the characteristics, attributes and values of the range of age classes for the forests of East Gippsland, Victoria, with a major focus on the older age classes. The signing of the National Forest Policy Statement in 1992 put renewed emphasis on old growth forest which the study was well placed to address. The concept of old growth is

embodied in the definition adopted for the study, viz.
Forest which contains significant amounts of its oldest growth stage in the upper stratum - usually senescing trees - and has been subject to any disturbance, the effect of which is now negligible.
This definition does not contradict the definition used by the NFPS, being seen as a refinement only.

Remote sensing and existing maps were used to identify areas of 'forest' (defined as all woody vegetation with a potential height greater than 5 metres and crown cover generally greater than 10% - thus including 'woodland'). Data existing or newly collected within these areas on growth stage, projected crown cover, forest type, ecological vegetation classes, disturbance influences (stratified according to their intensity and identified as 'natural' or 'unnatural') were combined in a geographic information system to identify and map OG forest.

The inclusion of vegetation classes allows consideration of environmental processes operating within old growth forests, providing a means of assessing the likely impacts of disturbance. Limited dendrochronological work provided some interesting insight into ages for senescing trees compared with trees in the mature growth stage but more detailed work is required to develop a comprehensive picture of the age ranges of trees within the study area for all forested vegetation classes. It is also recommended that more effort be put into consideration of the links between animal populations and the secondary attributes of old growth forest such as habitat, biodiversity, and biomasss. The method will need to be modified to include rainforest for regions where rainforest is not excluded from logging.

Woodgate, P W, Peel, W D, Ritman, K T, Coram, J E, Brady, A, Rule, A J, Banks, J C G (1994) A Study of the Old Growth Forests of East Gippsland. Department of Conservation and Natural Resources, Victoria.

Wilderness Assessment
The preferred model for assessing wilderness quality is described in the 'Handbook of principles, procedure and usage - National Wilderness Inventory' (Lesslie et al 1993). The Australian Heritage Commission is responsible for maintaining the database which is available through the Environmental Resource Information Network (ERIN). The program is supported by the Department of Geography, University of Adelaide.

The program is designed to measure variations in wilderness quality in the landscape using consistent and objectively measurable criteria. The database that is produced may then be used in an entirely flexible way to assist in determining which areas meet specified criteria for wilderness, which may be suitable for wilderness management and which should be considered for inclusion in a wilderness protection system.

Numeric values are attached to four wilderness quality indicators used to represent the two essential attributes of wilderness: remoteness and naturalness. The indicators are i) remoteness from settlement, ii) remoteness from access, iii) apparent naturalness (visual) and iv) biophysical naturalness (freedom from disturbances caused by modern society). These indicator values are combined to give a wilderness quality index. After setting minimum thresholds wilderness quality indices provide a picture of variation in wilderness quality across a surveyed region; they cannot be used on their own to identify areas worthy of designation as wilderness. This decision rests upon whether the remoteness and naturalness of an area is sufficiently valued by society. The focus of this program is expected to shift increasingly from inventory towards applying the wilderness database to conservation policy and land management.

Lesslie, R, Taylor, D., Maslen, M (1993) National Wilderness Inventory. Handbook of principles, procedures and usage. Commonwealth Government Printer, Canberra.

Selection methods to maximum biological diversity

The belief that biological diversity is taken care of with the dedication of one or a few well chosen reserves in an ecological domain is unfounded. The reality is that very large numbers of reserves seem necessary. Using explicit numerical procedures Margules et al (1988) showed that, for wetlands on the Macleay Valley floodplain in NSW, to represent every plant species at least once 4.6% of the total number of wetlands is required constituting 45% of the total wetland area. In order to represent all types of wetland, as well as all plant species, 75% of the total wetland area is required. In a similar analysis for remnant mallee patches in South Australia 12 patches out of 101 (12%) was the smallest number which would represent each of six plant communities at least once. To have a 95% chance of representing each plant community five times 45, or nearly half, the patches would be needed. *"If this result is found in many other situations, any hope of maintaining biological diversity in the face of competing land uses looks forlorn."*

Explicit **numerical analyses** such as these maximise the transparency and repeatability of assessments though in some circumstances numerical analyses may not be feasible.

Reserve adequacy may be checked by a method developed by Belbin (1992) whereby the distance, in multi-dimensional space, that new ecological data is from existing classified or unclassified numerically analysed data may be used to see whether the new data is significantly different. The distance is measured by Czekanowski resemblance coefficient as this has been found to provide the best estimate of ecological distance - far better than Euclidean distance. A threshold value for the resemblance coefficient based on either species overlap or other attributes of the data will determine significant difference. The method was used to test the adequacy of existing reserves to represent 876 vegetation sites on the south coast of New South Wales. Numerical analysis partitioned 265 sites sampled already in reserves into 14 groups but it was found that an additional nine (9) groups were 'seeded' by 160 sites outside the reserves found to be significantly different from those sites in reserves. This represents an additional 64% more groups. This relatively simple method is efficient and robust and is able to accommodate ecological data better than the traditional discriminant analysis.

Margules, C R, Nicholls, A O & Pressey, R L (1988) Selecting networks of reserves to maximize biological diversity. Biol. Conserv. 43, 63-76.

Belbin, L (1992) Comparing two sets of community data: a method for testing reserve adequacy. Aust. J. Ecol. 17, 255-262.

GENERAL APPROACHES

Biodiversity Assessment

The procedures outlined in the paper Guidelines for the Assessment of Biological Diversity (Commonwealth Environment Portfolio 1995) provides the framework for the identification and assessment of biodiversity values in the context of the comprehensive regional assessment process. Biodiversity assessment is carried out at the species population level since the fundamental goal of biodiversity conservation is to minimize loss of biodiversity by maintaining viable populations of species, the basic evolutionary units, and the ecological processes on which they depend. As knowledge of intraspecific variation and techniques for assessing this improve it will be necessary to revise strategies for preserving genetic variation. The other level at which assessment is carried out is at the ecosystem level. Ecosytem classes are used to define zones within which broadly similar management regimes and actions would be required to maintain biodiversity. Biogeographic regions and land systems are comprised of groupings of ecosytems.

The inventory component of biodiversity assessment consists of three parts, viz physical environment, biological and disturbance regimes. Assessments are carried out within a bioregional framework. Often, to speed up the assessment, surrogates of biodiversity are used, e.g. a land system. Predictive modeling is also used as a surrogate, extrapolating species, assemblages or ecosystem distribution from physical environment data. The outcome of analyses using surrogates will be uncertain given the large numbers of assumptions inherent in their application and the lack of sufficient validating studies. They are necessary where other biological data is poor or unavailable but should be viewed as preliminary assessments only. A simple model has been adopted by ANCA for formal disturbance analyses and is proposed for use in the biodiversity component of the CRA process. Analysis and mapping of all inventoried data are carried out using geographic information systems.

In the evaluation phase there are two main tasks to be addressed, viz. options for conservation, and viability of proposed management zones.

Concepts important for conservation options analysis are 'irreplaceability' (Pressey et al, in press) and 'complementarity' (Vane-Wright et al., 1992). These were developed for selecting representative reserve networks. The question of adequacy (viability) of management zones for maintaining species populations and ecological processes might be considered using three different methodologies: population viability analysis (Burgman et al., 1993); development of guidelines on size, shape and connectivity using principles from ecological theory; and integrated monitoring program concept (Karr, 1991). The review of monitoring strategies developed for the Wet Tropics Management Agency (Anon, 1993) is recommended for consideration for use in the CRA process. It is recommended that the precautionary principle be applied to partially counteract the risk and uncertainty in attempts to preserve biodiversity. The precautionary principle states '*where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.*'

Commonwealth Environment Portfolio (1995) Proposed guidelines for biological diversity assessment - a component of the regional forest agreement process.

Decision support systems

This is a computer utility for helping with management and planning decisions. The term has been coined to recognize that, whilst land managers are reluctant to accept computer systems which totally automate decision-making, they welcome systems which provide timely and relevant information to support or improve their decisions. CSIRO's LUPIS is a site or local scale program which identifies the preferred management strategy, e.g. a land use, having taken into account the exercise-specific guidelines proposed by the user in response to goals, the characteristics of the resource base, and the relative political importance attached to fulfilling the goals. A module of LUPIS has been developed to solve problems of designing a system of nature reserves. This module can identify substitutes for proposed protected areas that result in about the same total amount of represented biodiversity, but avoid conflict with the requirement of some areas for non- protection (or partial protection) land uses. Preliminary results of applying these methods illustrate how a biodiverse combination of areas may be found that avoids using areas suitable for forestry.

Another CSIRO support system, ARIS, is a spatial decision support system which stores a wide variety of natural and other resource information against administrative and grid cell units covering the whole of Australia..

Cocks K D (1989) Decision support systems for natural resource management. Biennial Report, CSIRO Division of Wildlife and Ecology 60-61.

Multi criteria analysis
Multi criteria analysis (MCA) may be viewed as a set of procedures designed to identify and organize information relevant to various steps in the decision-making process. It begins with the specification of options to be examined and the criteria that are deemed to be of importance in evaluating them. The advantages and disadvantages of each option are compared by using a 'table of effects'. Each effect is measured in a common unit across all options using quantitative or qualitative indicators. Weightings for each criterion may be introduced, indicating the relative importance attached to each effect by the analyst. All methods of analysis involve some subjectivity: MCA is no different, but it does make the assumptions transparent.

Multi criteria analysis was used by the Resource Assessment Commission's Forest & Timber Inquiry to evaluate broad-scale options for forest use at the national level. The analysis underlined the extreme sensitivity of forest use strategies to the weights that are attached to economic or ecological goals. It also highlighted the crucial importance of the nature of the options identified for analysis in the first place. It was the view of the Inquiry that MCA has significant potential to assist in the evaluation of alternative forest policy strategies and management plans at a regional scale.

RAC (1992) Methods for analysing development and conservation issues - the Resource Assessment Commission's experience. Research Paper no. 7.

BROAD FRAMEWORKS

Bioregional Framework
'Natural' regions have been delineated in each State and Territory based on biophysical, environmental and vegetation considerations . When the need was recognized for a national regionalization specifically for the National Reserve System Co-operative Program (administered by ANCA.) these regions were modified using a variety of attributes including climate, lithology, landform, vegetation, flora and fauna and landuse to allow cross border regionalization. The result is an Interim Biogeographic Regionalization for Australia (IBRA) . Data for IBRA were input to geographic information systems at a scale generally around 1:500 000 and, when synthesized, loaded onto the ERIN network for plotting at 1:3 million scale. Eighty (80) biogeographic regions have been identified under IBRA compared to a total of 128 previously in existence in all States and Territories.

IBRA will be useful for addressing the reserve selection criteria of *comprehensiveness* and *representativeness*, but given that *adequacy* requires variables which have not been included in the developement of IBRA, it cannot be used to address this criterion. It is important to remember that the main purpose of the regionalization is to assist in identifying major deficiencies in the national system of protected areas. .'*It is the topmost rung of an heirarchical classification scheme which should not be used for anything other than continental scale comparisons*'. Selection of land for reservation will occur at a much finer scale.

Thackway, R & Cresswell, I.D. (eds) (1994) Towards an Interim Biographic Regionalization for Australia. Proceedings of a technical meeting held at the South Australian Department of the Environment and Natural Resources, 7-11 February, 1994.

Geographic Information Systems
These are computer databases where digitized numerical, text or symbol data pertaining to land areas or points in space can be stored for manipulation, analysis and reproduction as tables, reports or maps.