# TOWARDS A NATIONAL SYSTEM

# OF FOREST RESERVES

A Discussion Paper

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Department of the Arts, Sport, the Environment and Territories

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# EXECUTIVE SUMMARY.

1. The National Forest Policy Statement of December 1992 included the objective of the development and completion of a comprehensive, adequate and representative network of nature conservation reserves, explicitly including wilderness and old-growth forests.

2. There is broad agreement that the existing conservation reserve system is unrepresentative and insufficient to maintain current levels of biological diversity.

3. Selection procedures and goals differ between the States and Territories, and the extent and nomenclature of forest reservation varies substantially.

4. Improvements to the comprehensiveness of the reserve system will require national coordination, most readily achieved through (i) regionalisation, (ii) standardisation and integration of data sets, (iii) the establishment and use of nationally consistent reserve selection criteria and standards, and (iv) use of an appropriate reserve selection mechanism(s). Substantial progress has been made during the last decade towards these objectives.

5. A limited knowledge base creates profound difficulties in the assessment of the adequacy, representativeness and comprehensiveness of reserves and reserve systems, and in the establishment of criteria for reserve selection.

6. This Discussion Paper examines ecological criteria for use in the assessment of conservation values and the identification and selection of reserves. Major issues include (i) is the current definition of "forest" adopted by the NFPS appropriate?; (ii) what regions and land tenures should form the basis of the forest reserve selection process?; (iii) what environmental units should be used to assess comprehensiveness?; (iv) do these provide surrogates for the distributions of species?; (v) what is the appropriate scale for analysis and decision-making?; (vi) how should the distributions of species and communities be documented and accommodated?; (vii) which species should be considered?; (viii) how should old-growth forests be defined and conserved?; (ix) do rainforests require separate selection methods?; (x) what, if any, guidelines are required for determining the size and spatial arrangements of reserves?; and (xi) what proportion of each environment is needed for adequate reservation?

Reserve selection methods must also include recognition of Wilderness and other non-ecological criteria.

7. A one-day seminar attended by over 60 technical experts was conducted to address the major issues raised in point 6 above, and to identify the technical steps and options for implementing the forest reserve selction process in a systematic manner consistent with the target dates specified in the NFPS.

The following general areas of agreement emerged from the seminar:

* that the definition of forest needs modification, as a number of important forest communities (e.g. tall eucalypt open forest with canopy cover <30%, brigalow) are not currently included.

* that the main options for regionalisation are the use of: (i) existing administrative and other regions employed in the States and Territories; (ii) environmental domains based on continental, sub-continental through regional analyses; and (iii) a combination of (i) and (ii) where the environmental domain approach is used to complement and help resolve inconsistencies arising from (i). The adoption of the existing regions employed by the States and Territories with some modifications would ensure that the forest reserve selection process was not delayed.

* that all land tenures should be included from the outset in the forest reserve selection process. Constraints and priorities may be added later in the implementation phase of the process where tenure and other non-biological considerations become important.

* that the methodology employed for the delineation of old-growth forest attributes through the use of remotely-sensed and other data in eastern Victoria by the Victorian Department of Conservation and Natural Resources should be adopted (or form the basis of a generic methodology) throughout the remaining forest estate as soon as possible.

* that an operational threshold for defining old growth forest should be finalised.

* that explicit procedures for achieving representativeness and comprehensiveness of old-growth forest and wilderness areas should be established.

* that the methodology employed to identify wilderness and old growth forest should be validated in the field.

* that systematic biological surveys are integral to the entire forest reserve selection process and should precede regional incvestigations and reserve design wherever necessary and possible. Biological surveys may be required in identified notional reserves before those areas become gazetted.

* that it is undesirable to set a minimum level for the resolution of scale to be employed for the use of various data sources in reserve selection, although the preferred minimum scale of resolution is considered to be 1:250,000 or 1:100,000 or finer, wherever available.

* that estimates of forest coverage and species distributions prior to European settlement should, wherever possible, be used as the baseline for establishing the proportion of each environmental class or community to be reserved.

* that three general options exist as to the issue of what proportion of each environment is required to achieve adequate reservation: (i) the IUCN recommendation of 10% of the (pre-European) area of all environments as an absolute minimum; (ii) specified minimum representation of 90% of the remaining area/populations of nationally endangered species and communities, 60% of the remaining area/populations of communities drastically reduced by clearing and/or vulnerable, and 30% of the area of all other native species and communities; and (iii) set no minimum level but aim to reserve as much as is needed in each region to ensure that the NFPS goals are achieved.

* that guidelines for the spatial configuration of reserves are desirable but difficult to set explicitly because of limited knowledge and the attendant uncertainty, and the regionally idiosyncratic spatial arrangement of forest remnants and their landscape context.

* that setting a minimum size for reserves is inappropriate, particularly as even very small remnants may be important for the persistence of invertebrates or localised plants.

* that for a limited number and range of forest species the use of population viability analysis (PVA) can help inform decisions about reserve placement and spatial features. For most species, however, the use of PVA is not an option because of limited data. In these cases it is suggested that operational guidelines based on ecological theory and empirical studies need to be derived for identifying viable populations.

* that losses and degradation of forest ecosystems outside the reserve system will diminish chances for conserving existing biodiversity and achieving NFPS conservation reserve system goals. Strong protective measures and land acquisition will be required in some instances to prevent biodiversity loss.

* that uncertainties remain about the efficacy of corridors. It is suggested that guidelines framed as testable (working) hypotheses are required as a basis to direct off-reserve management and that these would be modified as new information becomes available. Such hypotheses and associated protective measures could be developed as part of a complementary research programme.

* that iterative computer-based procedures such as Conservation Options for Decosion Analysis (CODA) should eventually form the basis of reserve selection and re-evaluation in each region. In the short term, a combination of iterative and alternative techniques will need to be used for reserve selection as a means of rationalising and incorporating the disparate recent and existing State/Territory and Federal reserve selection processes.

* that it is considered desirable to undertake further comparative studies on the performance of different techniques for reserve selection at the regional level.

* that other land uses will need to be considered once the preferred notional conservation reserve network in each region has been designed. Several computer-based techniques can be used to modify, substitute and evaluate changes in reserve placement in order to resolve demands from a range of competing land uses.

* that wilderness and old growth forests should be considered first in the reserve selection process to achieve the aims of the NFPS. Biological diversity and other conservation goals can then be accommodated in the design of a notional ideal reserve sysem at the regional level.

* that the implementation of the forest reserve selection process requires the establishment of regional committees to advise on reserve selection, and a co-ordinating group(s) at a State/Territory and Federal level to help ensure the systematic and effective use of existing programs, consistency between regions, and that target dates are met. It is expected that the regional committees would comprise a panel of conservation design experts and other expertise where relevant. The framework, goals, objectives and criteria will need to be determined at the State/Territory and Federal level <u>prior</u> to reserve selection at the regional level.

* that a number of existing government programs be incorporated into the national forest reserve selection process to ensure the tight target dates are met and to minimise disruption and duplication.

* that a series of research activities must be considered to support the identification of conservation values and the selection of reserves.

8. The NFPS and other recent government initiatives set target dates for various stages in the development of the forest reserve estate. These include (i) wilderness data base to be completed by the end of 1993, (ii) adequate, representative and comprehensive system of conservation reserves for wilderness be established by 1995, (iii) adequate, representative and comprehensive system of conservation reserves for old-growth forests be established by 1995. In addition, the establishment of a national comprehensive reserve system for all ecosystems by 2000 was considered by HORSCERA. Priorities for actions to meet the NFPS targets are identified, and achievable targets for the essential intermediate steps are here set.

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# CONTENTS

**Towards designing an appropriate reserve system**

*List of Tables*

*List of Figures*

# LIST OF ABBREVIATIONS USED.

| | |
|---|---|
| ABARE | Australian Bureau of Agriculture and Resource Economics |
| ACF | Australian Conservation Foundation |
| AEGIS | Australian Environmental Geographic Information System. |
| AFC | Australian Forestry Council |
| AHC | Australian Heritage Commission |
| ALTERM | Australia's Long-term Ecological Research and Monitoring Program |
| ANPWS | Australian National Parks and Wildlife Service |
| ANZECC | Australian and New Zealand Environment and Conservation Council |
| AUSLIG | Australian Surveying and Land Information Group |
| BDAC | Biological Diversity Advisory Committee |
| CALM | WA Department of Conservation and Land Management |
| CCNT | Conservation Commission of the Northern Territory |
| CODA | Conservation Options for Decision Analysis |
| CONCOM | Council of Nature Conservation Ministers (now ANZECC) |
| CRES | Centre for Resource and Environmental Studies (Australian National University) |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| CYPLUS | Cape York Peninsula Land Use Study |
| DASET | Department of the Arts, Sport, the Environment and Territories |
| DCE | Victorian Department of Conservation and Environment (now Conservation and Natural Resources) |
| EIS | Environment Impact Statement |
| ERIN | Environmental Resource Information Network |
| ESAC | Endangered Species Advisory Committee |
| ESD | Ecologically Sustainable Development |
| ESU | Endangered Species Unit (of ANPWS) |
| FRS | Forest Resource Survey (for RAC) |
| GCM | Global circulation model |
| GIS | Geographic Information System |
| HORSCERA | House of Representatives Standing Committee on Environment, Recreation and the Arts |
| IGAE | Intergovernmental Agreement on the Environment |
| IUCN | International Union for the Conservation of Nature and Natural Resources |
| LCC | Land Conservation Council (Victoria) |
| LUPIS | Land Use Planning Information System |
| MOU | Memorandum of understanding |
| NAFI | National Association of Forest Industries Ltd. |
| NFI | National Forest Inventory |
| NFPS | National Forest Policy Statement |
| NIE | National Index of Ecosystems |
| NRIC | National Resource Information Centre |
| NWI | National Wilderness Inventory |

| | |
|---|---|
| PVA | Population viability analysis |
| QNPWS | Queensland National Parks and Wildlife Service |
| RAC | Resource Assessment Commission |
| ROTAP | Rare or Threatened Australian Plants |
| WWF | World Wide Fund for Nature |

# GLOSSARY

**Adequacy** - one of three essential principles of the reserve selection process as defined by the NFPS; vis. that the reserve system be 'adequate' to maintain the ecological viability and integrity of populations, species and communities.

**CODA** - an acronym for Conservation Options and Decision Analysis, which is a computer-based iterative procedure developed for the analysis of options for reserve identification.

**Complimentarity** - one of three identified features of reserve selection procedures; vis. reserves should complement one another in terms of the attributes they contain.

**Comprehensiveness** - one of three essential principles of the reserve selection process as defined by the NFPS; vis. that the reserve system be 'comprehensive' so as to include the full range of forest communities recognised by an agreed national scientific classification at appropriate hierarchial levels.

**Ecological Criteria** - criteria based on ecological/biological data or theory (e.g. presence of rare species; abundance and form of standing dead trees or stags) which are used to inform the reserve selection process.

**Environmental Classification** - is the procedure of grouping spatial units or objects into groups based on the association of environmental attributes recorded for these objects. This may lead to a Regionalisation - see below.

**Environmental Domain** - used in this paper: (i) to refer to the 'domain' or niche of a species/assemblage of species, as defined by specified environmental attributes; and (ii) as a synonym for environmental region. In the latter case, the environmental classification may be based solely on physical data or on a combination of physical and biological data.

**Environmental Domain Analysis** - a computer-based, explicit and repeatable procedure to delineate environmental domains for a specified part of the landscape (e.g. water catchment, continent).

**Flexibility** - one of three identified features of reserve selection procedures; vis. planning should be able to assess the costs involved in shuffling between sets of possible reserve configurations.

**Forest** - an area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding 5 metres, and with existing or potential projective cover of overstorey strata about equal to or greater than 30 per cent. This definition includes Australia's diverse native forests and plantations, regardless of age. It is also sufficiently broad to encompass areas of trees that are sometimes described as woodlands, although the focus of the NFPS excludes woodlands.

**Irreplaceability** - one of three identified features of reserve selection procedures; vis. some sites are essential and non-negotiable, mostly because they contain attributes not present elsewhere in the forest estate.

**Mobile Species** - typically used for faunal species which have large home ranges or forage over large areas of forest (e.g. large forest owls, quolls).

**Nature Conservation Reserve** - an area of publicly owned land, including forested land, managed primarily for nature conservation and providing multiple benefits and uses, such as recreation and water catchment but excluding wood production. This statement asserts that the nature conservation reserve system will be developed on the basis of three principles: comprehensiveness, adequacy and representativeness.

**Native Forest** - any local indigenous community the dominant species of which are trees - *see* Forest - and containing throughout its growth the complement of native species and habitats normally associated with that forest type or having the potential to develop those characteristics. It includes forests with these characteristics that have been regenerated with human assistance following disturbance. It excludes plantations of native species and previously logged native forest that has been regenerated with non-endemic native species.

**Non-ecological criteria** - criteria of a non-ecological/ biological nature such as wilderness which need to be considered in the reserve selection process.

**Old Growth Forest** - defined by the NFPS as forest that is ecologically mature and has been subjected to negligible unnatural disturbance such as logging, roading and clearing. The definition focuses on forest in which the upper stratum or overstorey is in the late mature to overmature growth phases.

**Precautionary Principle** - is embedded within the NFPS and is an important component of its implementation phase. The IGAE definition reads "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. In the application of the precautionary principle, public and private decisions should be guided by : (i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and (ii) an assessment of the risk-weighted consequences of various options."

**Predictive Models/Modelling** - used typically in this paper to refer to computer-based quantitative and qualitative models aimed at the systematic survey of biota and/or predicting the distribution, abundance and other attributes of organisms in space (within the forest estate) and time.

**PVA** - the acronym for Population Viability Analysis which is normally undertaken with computer-based mathematical/simulation models using biological and environmental data. The models attempt to assess the likelihood (probability) of the extinction of a population, meta-population or species over a specified time frame under different management scenarios.

**Regional Conservation Assessment** - a general term for the conduct of the reserve selection process in an agreed way at the region level.

**Regionalisation** - the outcome of the process of delineating regions as a basis, in this case, for conducting a Regional Conservation Assessment. Each region represents sites that are more related in terms of their ecological, biological and other attributes (e.g. administration), at a defined level compared to those sites forming other regions. It should be noted that most regionalisations can only provide a generalised picture of the area of interest and do not account for the inherent fine scale spatial and temporal dynamics of biota.

**Representativeness** - one of three essential principles of the reserve selection process as defined by the NFPS; vis. that those samples of the forest that are selected for inclusion in reserves should reasonably reflect the biotic diversity of the communities.

**Reserve** - see Nature Conservation Reserve.

**Risk** - is the chance of some event occurring, say with positive or negative impacts for biodiversity conservation, where the probability of the event is believed to be known.

**Uncertainty** - arises from lack of knowledge and takes three forms: removable uncertainty (i.e. where extra research will provide an answer and remove uncertainty); generated uncertainty (arises from contradictory or inadequate management); residual uncertainty (can not be removed within the timelines of policy formulation and decision making).

**Wilderness** - 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.

# 1. Introduction.

## 1.(i). Aim of discussion paper.

This discussion paper presents background information and a set of approaches towards (i) identifying criteria, (ii) developing a mechanism and (iii) establishing priorities for achieving the conservation reserve objectives and principles outlined in the National Forest Policy Statement (NFPS) of December 1992. It explicitly excludes detailed consideration of forest management practices and environmental standards, which will be dealt with elsewhere (a separate ANZECC/AFC technical working group).

This paper was prepared to provide a base for discussion among reserve design practitioners, and also to assemble information for members of the joint ANZECC/AFC sub-committee and working group on forest reserve systems. Where possible divergent views and approaches have been canvassed. This paper does not claim to be an exhaustive literature review.

A draft (22/1/93) was distributed among a group of land-use practitioners, and where possible their comments were included in this revised version. That version was further considered at a seminar attended by about 60 technical experts on 5 March 1993, and this discussion paper was further revised to incorporate comments from that meeting.

**1.(ii). National Forest Policy Statement: conservation reserve responsibilities, needs and limitations.**

The NFPS provided a set of goals for Australia's forests endorsed by Federal, State (other than Tasmania) and Territory governments. The conservation goals were defined as:

> *"to maintain an extensive and permanent native forest estate in Australia and to manage that estate in an ecologically sustainable manner so as to conserve the full suite of values that forests can provide for current and future generations. These values include biological diversity, and heritage, Aboriginal and other cultural values."*

A set of objectives towards these goals was identified, with the first objective being the development and completion of a comprehensive, adequate and representative network of nature conservation reserves, explicitly including wilderness areas and old-growth forests. Detailed extracts of relevant sections of the NFPS are presented in Appendix A.

To a large extent, the NFPS objectives have also been addressed in a series of recent government inquiries and protocols, most notably the:

. InterGovernmental Agreement on the Environment (IGAE, 1992);

. Ecologically Sustainable Development working group reports (most notably on forests, ESD 1991);

. Resource Assessment Commission Forest and Timber Inquiry (RAC 1992);

. The BDAC National Strategy for the Conservation of Australia's Biological Diversity (BDAC 1992);

. House of Representatives Standing Committee on Environment, Recreation and the Arts Inquiry into the Role of Protected Areas in the Maintenance of Biodiversity (HORSCERA 1993); and

. the National Strategy for the Conservation of Australian Species and Communities Threatened with Extinction (ESAC 1992).

Some of the relevant findings or objectives of these other reports are presented in Appendix B. Taken together, this series of inquiries and agreements demonstrate a clear purpose in aiming to protect biodiversity, in a large part through the development of a conservation reserve system which includes adequate representation of all environments. This is a concept which Australian conservationists and ecologists have been advocating for almost 30 years (Ride 1965; Australian Academy of Science 1968; Specht et al. 1974).

Not only is there general acceptance of the goal of improving the representativeness of the forest reserve system, but there is also a widely expressed recognition that this goal can only be achieved through a consistent national approach based on an accepted and transparent process. For example ESD (1991) stated:

> "*With the increased focus of the community on environmental matters, decisions on forest use have generally been taken in a climate of intense political pressure and public debate. Governments have sought to achieve consensual land-use decisions, notwithstanding that the differences in points of view may be based on irreconcilable value judgements. Approaches to resolving value conflicts through a range of mechanisms - such as judicial inquiries, scientific evalation,*

*environmental impact statements (EIS) and intergovernmental agreements, have tended to be* ***ad hoc*** *and address single point conflicts with short-term solutions, rather than develop broad regional forest-use strategies with ecologically sustainable development options. Accordingly, as processes to achieve sustainable forest use, they have been relatively unsuccessful*".

Outcomes from these recent series of inquiries have served to provide rational overviews of, and objectives for, the future of Australia's forests. One directly relevant comment was given by RAC who expressed the concern that a national forest policy statement "*may simply recommend mechanisms to deal with forest disputes when they arise. Such mechanisms should not be seen as alternatives to a more comprehensive forward-planning approach*".

The task now is to define and implement a procedure that will best permit these national objectives to be achieved. This will require a carefully considered mix of nationally accepted standards (in criteria, procedures and priorities) and sufficient flexibility to be able to meet regional (State/Territory) objectives and practices.

**1.(iii). Forest reserves within an overall reserve system.**

There is clearly some artificiality in considering a forest reserve strategy as separate from a strategy for the design of conservation reserves for all Australian habitats. It would be inappropriate, inefficient and potentially disharmonious to develop a protocol for forest reserves which is inapplicable or different to that for other habitats.

Of particular relevance are the findings of the House of Representatives Standing Committee on Environment, Recreation and the Arts inquiry into the role of protected areas in the maintenance of biodiversity (HORSCERA 1993). The deliberations of that Committee, and its recommendations for procedures to be adopted to attain an improved national system of conservation reserves, are largely consistent with and complementary to the isssues that this paper addresses. Submissions to that inquiry have provided a very valuable set of source documents for the issues here considered.

Of direct relevance also is recommendation 3.2.1 (Protected area establishment) proposed by BDAC (1992):

> "*Undertake a 10 year Commonwealth, State and Territory cooperative program, which includes the provision of adequate resources, to ensure that the terrestrial and marine protected area systems are comprehensive and ecologically viable. Particular attention should be paid to those components of biological diversity identified by action taken under 3.1.1 as requiring special conservation measures.*

*Take immediate action to identify those components of biological diversity which are known to be threatened and inadequately reserved, and to incoporate these within the protected area system. Action is also required to ensure that further areas of high wilderness quality are placed within the protected area system".*

The rationale of this document is that an established national procedure for forest reserves may provide a sensible base for that of all Australian environments. This is supported by the large amount of information now available for Australian forests relative to most other environments, the opportunity provided for the establishment of a reserve design mechanism following the detailed investigations of the Resource Assessment Commission, and the explicit guidelines set out in the NFPS.

Where do forests fit in any national priority for reserve selection? Using regionalisation based on 24 vegetation formations, ERIN indicated that the least represented (<10% of total area) included open herbfield, open tussock grasslands, low open shrublands, tall shrublands, low open woodlands, open woodlands and woodlands. The best represented (i.e. >20% of their total area) vegetation formations generally included the taller, denser growth forms and include open heathland, low closed forest, closed forest and tall open forest (ANPWS Submission to HORSCERA).

Woodland, shrubland and grassland floristic communities tend to be less well reserved (and often more alienated and cleared) than are forests (e.g. Specht et al. 1974; Benson 1991; Kirkpatrick 1991; Denney & Wilson 1991; Thackway & Cresswell in press). Relatively high rainfall coastal localities, especially of south-eastern, eastern and southwestern Australia, (i.e. where most of the forests are) have a higher proportion of lands reserved than do semi-arid and arid areas (Sattler 1986; Whitehead et al. 1992).

**1.(iv). Relevant NFPS definitions.**

The NFPS provides definitions for several terms used widely in this discussion paper. These definitions are accepted in this paper, though attention is drawn to alternative definitions, proposed modifications or concepts requiring more explicit definition, where appropriate.

NFPS definitions include:

***Forest***: an area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding 5 metres, and with existing or potential projective cover of overstorey strata about equal to or greater than 30 per cent. This definition includes Australia's diverse native forests and plantations, regardless of age. It is also sufficiently broad to encompass areas of trees that are sometimes described as woodlands. The focus of this Statement excludes woodlands.

***Native forest***: any local indigenous community the dominant species of which are trees - *see* Forest - and containing throughout its growth the complement of native species and habitats normally associated with that forest type or having the potential to develop those characteristics. It includes forests with these characteristics that have been regenerated with human assistance following disturbance. It excludes plantations of native species and previously logged native forest that has been regenerated with non-endemic native species.

***Nature conservation reserves***: areas of publicly owned land, including forested land, managed primarily for nature conservation and providing multiple benefits and uses, such as recreation and water catchment but excluding wood production. This statement asserts that the nature conservation reserve system will be developed on the basis of three principles: comprehensiveness, adequacy and representativeness. These terms are defined thus:

> *comprehensiveness* - includes the full range of forest communities recognised by an agreed national scientific classification at appropriate hierarchical levels,
>
> *adequacy* - the maintenance of the ecological viability and integrity of populations, species and communities,
>
> *representativeness* - those sample areas of the forest that are selected for inclusion in reserves should reasonably reflect the biotic diversity of the communities.

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

***Wilderness***: 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.

## 2. Background and overview of the current status of forests and forest reserves.

### 2.(i). The role of the conservation estate in protecting and maintaining forest values.

Designated conservation reserves are the cornerstone of attempts to maintain biological diversity. This maintenance is a specific aim of the management of conservation reserves and provides a contrast to that of other land tenures where management may allow activities detrimental to biological diversity. Many of the values provided by forests cannot be maintained without long term protection through adequate reservation.

A rational system of conservation reserves aims to represent all biological diversity across the landscape, with sufficient reservation to allow viable populations of species, comprehensive inclusion of genetic diversity within species, and adequate protection of all communities and environmental variation.

This role for reserves is widely accepted. For example the Royal Botanic Gardens Sydney submission to HORSCERA stated:

> *"we would whole-heartedly agree that reserves are the core of any biodiversity program ... and many more reserves are needed .. it cannot be over-emphasized that the acquisition of key lands (including rationalisation of present reserve boundaries) is critical to conserving species ... In many circumstances species loss can be minimised simply by acquiring land and managing it sympathetically."*

Indeed a representative national system of protected areas, combined with management of production systems in ways that minimise loss of biodiversity was regarded by CSIRO (in their submission to HORSCERA) as the key to Ecologically Sustainable Development.

There has been some query about whether the need to improve the functionality of the reserve network requires expansion of that network. For example CRA claimed (in their submission to HORSCERA):

> "*The IUCN recommended target figure of 5% of each major community to be reserved is based on the notion that reserving land is the best means of biological conservation. In the light of frequently inadequate resources being available for management of national parks and similar areas, together with demonstrated capable management of other areas, that notion is questioned*".

A similar concern was expressed by the National Association of Forest Industries (submission to HORSCERA):

> "*it is unacceptable to industry that further large tracts of land be set aside as 'preservation areas' in the name of maintaining biological diversity. This objective can often be met through appropriate multiple use management plans, and an integrated approach to resource management*".

These expressions suggest that it will become increasingly important to provide clear justifications based on objective criteria for reserve establishment. One such value may be in providing relative site security for long-term monitoring of environmental conditions. CSIRO and ANPWS have formulated such a monitoring program, "Australia's Long-Term Ecological Research and Monitoring Program" (ALTERM), in which protected areas play a key role in a national monitoring and research program.

## 2.(ii). The complementary role of off-reserve management.

It is now well recognised that any reserve system, in itself, will be insufficient to conserve all of the values that forests can provide for current and future generations (ESAC 1992; Global Biodiversity Strategy 1992; Commonwealth of Australia 1992b; Walker 1991; BDAC 1992). Many species occur only on private or unreserved lands and many species make landscape scale movements which take them from reserved lands to unreserved areas. The representation within a protected lands system of all species would probably demand the impossible requirement of virtually complete reservation of the whole continent (e.g. Adam 1992b).

The sustainable management of the whole forest estate, irrespective of land tenure and primary land-use is an integral part of conservation planning (Thackway & Stevenson 1989). Furthermore, given that much of the forest estate is now highly fragmented, it is important that all components of the landscape mosaic, including non-forested land, be used on a sustainable basis. The contribution of complementary management off-reserves will be determined by issues such as connectivity between formal reserves, buffer zones for reserves, and the appropriate mix of land-uses in areas adjacent to reserves.

General guidelines have been established for off-reserve forest management issues. A set of national principles of forest practices relating to wood production in native forests (Attachment A in the NFPS; Commonwealth of Australia 1992a) has been developed by the Australian Forestry Council and all governments signing the NFPS have agreed that these guidelines should be applied to all public and private native forests in Australia.

Regional forest estate management guidelines have been developed in many areas, for example the Otways Forest and Central regions in Victoria (DCE 1992ab), and provide context for the planning, function and spatial arrangement of conservation reserves. Specific off-reserve land-use options and operational forest management prescriptions will vary across regions and should be decided on the basis of regional level analysis. As the conservation reserve system is upgraded in any region, the current mix of primary land-uses in forest areas adjacent to reserves, and the codes of practice within these areas may need to be reconsidered.

A critical function of the regional level analyses will be to provide a dynamic landscape context for the assessment of various land-use options and on-site forestry prescriptions (Norton & Lindenmayer 1991). This ensures proper consideration of the major environmental and other factors operating at a larger scale that contribute to the present values of reserves (or areas identified for reservation), and the extent to which these factors may be compromised by different off-reserve management practices. A simple example of this is the potential detrimental 'downstream' impact on reserves (e.g. changes in water discharge) that might result from inappropriate land practices higher in the same water catchment.

In all jurisdictions legislative restraints and conservation objectives and managements vary between alienated lands and other (public) lands outside the reserve network. Consideration of both land categories may be critical in local and regional conservation planning and objectives. Many States have introduced legislation to help implement the protection and/or assist funding for the maintenance of conservation values on private lands (e.g. Land for Wildlife scheme in South Australia, Flora and Fauna Guarantee in Victoria, land clearing regulations in most States and Territories). BDAC (1992) also includes a section on Incentives for Conservation on private lands, aiming to provide financial assistance, other incentives and technical advice to landholders, especially to areas important for migratory species, threatened species, vegetation remnants and wetlands.

**2.(iii). The existing approaches and principles to reserve selection by the States and Territories.**

"*Unlike New Zealand or the United States, Australia has never had a national system of protected areas. Its 'national' parks, with only a few notable exceptions, are managed by State and Territory governments.*" (Robertson et al. 1992). The States have primary role in reserve selection and in the control of crown lands within their borders. This has led to some divergence in the development of reserve selection and purposes, and some loss of perspective for national conservation goals.

The States and Territories have differed in their stated philosophies for reserve selection and/or in the procedures adopted to achieve reservation. This historical disparity is highlighted in a recent comparative review (Canisius 1991) of reserve methodology and objectives prepared for the WWF (summarised here in Appendix C). With the development of the IGAE, there is now general agreement that consistency across States and Territories in reserve selection procedures and objectives is desirable and obtainable (e.g. HORSCERA 1993).

The States and Territories now also recognise that co-ordination in reserve selection between adjacent States and Territories will greatly benefit regional conservation aims. Historically, with few exceptions, the planning of the conservation reserve system within a State has shown little regard to that in adjacent areas of neighbouring States. The most notable exceptions have been in the Alpine Parks of Victoria, New South Wales and the ACT, the Nullabor region of South Australia and Western Australia, and more recently, in the Border Ranges/Lamington Plateau area of SE Queensland and NE New South Wales.

There have been substantial increases in the reserve network in all States and Territories over the last 20 years (Whitehouse 1990; Westcott 1991), and in all jurisdictions this expansion has involved an attempt to increase the comprehensiveness of the reserve network. The previous reliance upon largely ad-hoc selection criteria has been increasingly replaced by more rational methodologies, and several States have now experimented with sophisticated iterative algorithms to determine land-use allocation.

While it may be desirable to seek consistency or comparability between the States and Territories in the methodologies of survey and selection, and that these processes should aim to be the most efficient and flexible possible, it will clearly be impractical and undesirable to impose a nationally uniform protocol immediately. Approaches to improving and standardising procedures may have to be implemented gradually, possibly through some duplication and comparison of old and new methodologies applied to the same regional studies.

The baseline data required for rational biological planning of the conservation reserve estate vary in quality, accessibility and complementarity between States (NFI 1990; Canisius 1991). As an example, vegetation or land system maps for the States show little congruency across borders (Austin & Margules 1986). Recent initiatives, coordinated by the NFI and ERIN (including the National Index of Ecosystems) have greatly increased the consistency and integration of data collection methodologies and storage (Thackway 1989; NFI 1990). This is a valuable and essential advance towards achieving a national assessment of reservation status, and hence planning for protected area systems.

There is also confusing and chaotic variation between States in reserve category designation and in activities permitted within the range of conservation reserves (Mobbs 1989). This results in substantial difficulties in the comparison of reserved areas, and in the interpretation of national reservation status. Some calibration of the more than 40 terrestrial reserve categories across the States and Territories with categories recognised by IUCN is provided in Hooy & Shaughnessy (1992), and HORSCERA (1993) has recommended that consistent nomenclature and classification for Australia's protected areas be established.

## 2.(iv). Federal involvement in reserve selection.

The Federal Government has a number of responsibilities related to conservation reserve networks, due to its ratification or signing of International treaties. Most recently this has included the Convention on Biological Diversity, which requires Australia *inter alia* to:

> "*have in place all of the policies and necessary legislation which would be necessary to enable us to fulfil our obligations under the Convention ... (Article 8) also imposes an obligation (qualified by the words "as far as possible and as appropriate") on Parties to establish a system of protected areas or other areas (such as corridors) where special measures need to be taken to conserve biological diversity ... the article then requires Parties to develop guidelines for the selection, establishment and management of protected areas or areas where special measures need to be taken, etc. Parties are also to take appropriate action in areas adjacent to protected areas to ensure further protection of those areas*" (Department of Foreign Affairs and Trade submission to HORSCERA, 1992).

Australia has also ratified the Convention on Conservation of Nature in the South Pacific (Apia Convention) under which Parties shall "*encourage the creation of protected areas which together with existing protected areas will safeguard representative samples of the natural ecosystems occurring therein*".

The IGAE defined roles for the Federal and State Governments relevant to a national conservation reserve system. Commonwealth involvement includes the facilitation of consistency in relevant data collection and its integration, assistance in the development of coordinated standards of park management and selection mechanisms, cooperation in conservation actions affecting rare species, and conservation areas which cross State borders. Extracts from the Agreement are listed in Appendix B.

The Commonwealth's objectives and roles were further articulated in the Statement on the Environment by the Prime Minister in December 1992:

> *"The Commonwealth is committed to the development of a national comprehensive system of parks and reserves. This will be achieved in cooperation with the States and Territories. The Government has adopted a policy that all major ecosystems be surveyed and that a comprehensive, adequate and representative system of reserves be established progressively by the year 2000. In line with the National Forest Policy Statement, public old growth forests and wilderness surveys and reservation are to be completed by 1995. Accordingly the Government will provide $16.85 million over the next 4 years:*
>
> *. to continue and expand existing Commonwealth/State programs for the development and implementation of a bio-regional approach to the identification of protected areas;*
> *. to complete the National Wilderness Inventory by 1993 and to ensure its maintenance as one of several key indicators in the development of the reserve system;*
> *. to promote and encourage State and Territory cooperation in surveying and protecting publicly owned old growth forests and wilderness by 1995. Such forests on private land should be reserved by 1998 ...*
> *. to provide incentives for State and Territory cooperation in progressively developing a comprehensive system of protected areas, to be completed no later than 2000;*
> *. to develop and apply nationally consistent principles for the management of reserves in accordance with internationally accepted classifications and standards."*

The Commonwealth instigated the development of the National Strategy for the Conservation of Australia's Biological Diversity, in which improvement and coordination of Australia's conservation reserve system is embedded. The draft of this Strategy has been revised by BDAC in light of public comment, with consultation continuing with State and Territory Governments, via an ANZECC Task Force, and other Commonwealth agencies with a view to early finalisation and endorsement.

Federal Government agencies have already provided support towards establishing a coherent national reserve network. Relevant examples include:

. compilation of lists of all conservation reserves across States (e.g. Mobbs 1989; Hooy & Shaughnessy 1992), with attempts to relate idiosyncratic reserve designations to internationally accepted (IUCN) park nomenclature (IUCN et al. 1991).

. investigation of sites for National Estate values, and compilation of sites meeting these established standards (AHC).

. development of a national listing of ecosystems (NIE).

. involvement and assistance with the integrated management of conservation reserves which cross State borders, notably Alpine areas in south-eastern Australia, mallee areas (in the Murray-Darling Basin); and some World Heritage areas (Great Barrier Reef, Wet Tropics).

. development of coordinated and consistent procedures and methodology for recording environmental attributes, and national integration of State-based data sources (NFI, NRIC, ERIN).

. development of national regionalisations based on climatic and physical characteristics, and the investigation of use of these analyses and maps for nationally coherent reserve design (ERIN).

. development of a methodology to evaluate wilderness, and the national survey of wilderness areas, in cooperation with the States (NWI).

. integration of information on rare plants and animals (ROTAP, ESU).

Essentially, the role of the Commonwealth is seen as providing a guide for consistency and a central bank for information, and as facilitator and coordinator of the selection process, with a special role in reserves which cross political boundaries (Walton et al. 1992*a*). Arising from the IGAE, the Commonwealth may also be invited by the States and Territories to participate in regional studies.

There have been calls for increased Federal environmental powers, or at least a greater national perspective from State institutions, for example Recher & Lim (1990) stated:

> "*Australia is not a set of political or economic land units but is a whole functional ecosystem ... Land management and the conservation of wildlife must be extended to include and involve all lands, irrespective of tenure. There must be national priorities which transcend political boundaries and the limits imposed by the Constitution on National and State responsibilities*".

Indeed, the *Commonwealth National Parks and Wildlife Conservation Act* (no. 12 of 1975) makes provision for the Commonwealth to acquire land within the States to establish parks and reserves "having regard to its status as a national government". However this power has never been exercised and is not consistent with the IGAE.

**2.(v). The existing and Pre-European forest estate in the States and Territories.**

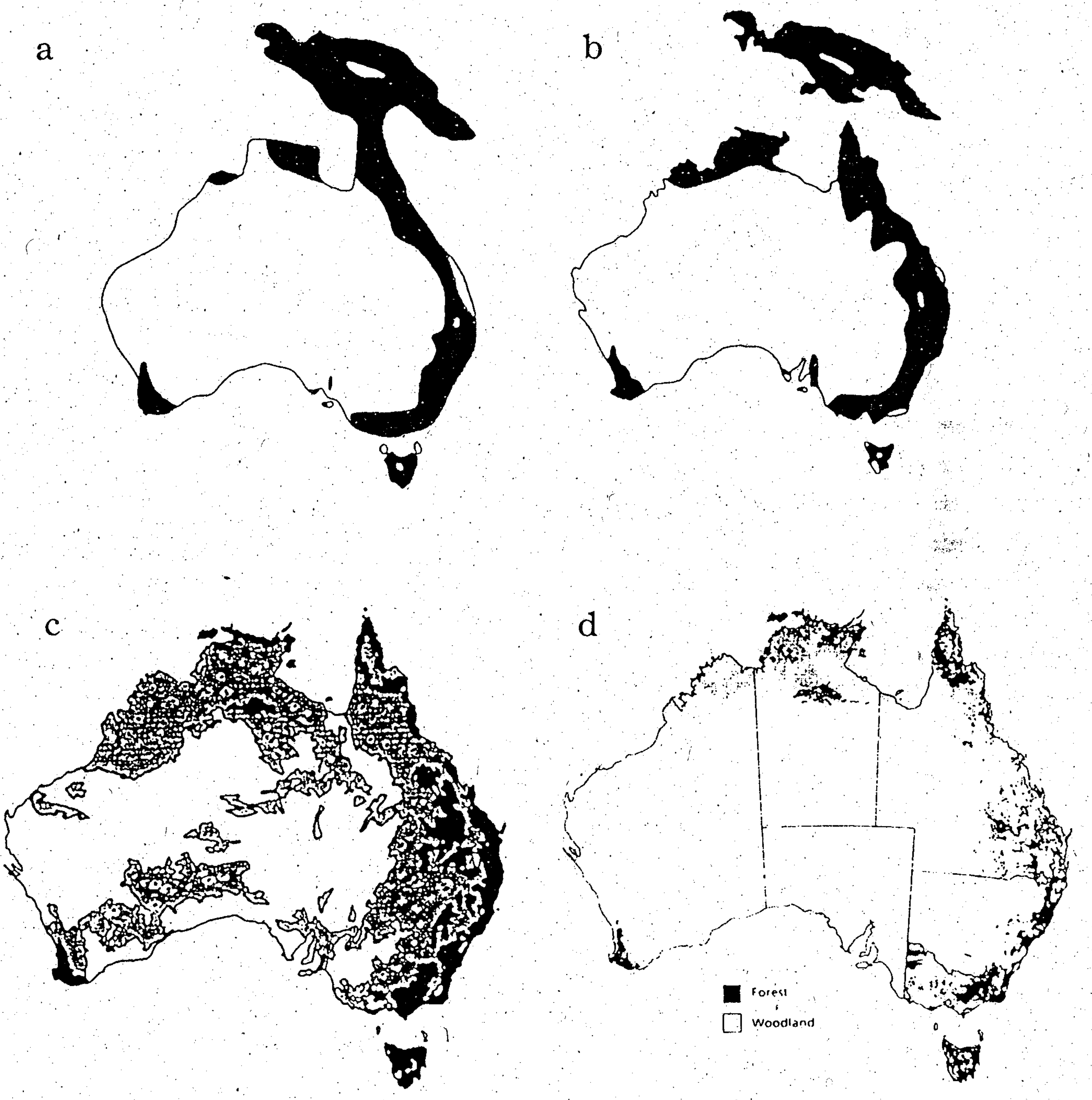
Australian forests have long been confined to the relatively high rainfall areas of the periphery of the continent. Estimates of broad forest distribution since the last glacial and at the time of European settlement are indicated in Figure 1 (a-c).

Warming from the most recent glacial occurred between 15,000 and 9,000 years ago (Chappell and Grindrod 1983) and the current tree lines were probably attained about 9,000 years before present (Kershaw 1981). In northern Queensland, rainforest expanded to replace woodlands as precipitation increased (de Deckker et al. 1988).

Since European settlement approximately half of Australia's forests have been cleared or severely modified (Fig. 1d; RAC 1992). Patterns of forest clearance and modification have not been consistent across forest ecosystems but have typically been heavily biased to relatively more accessible sites (often lowlands) of higher productivity (often underlain by good soils). Consequently, relatively large areas of some forest types have been destroyed or significantly modified while other forest ecosystems have suffered less impact from human exploitation (e.g. Braithwaite et al. in press).

The RAC documented the estimated rate of deforestation since 1788. In New South Wales extraordinarily high levels of deforestation occurred between 1892 and 1921, largely because of the rapid expansion of the wheat and sheep industries (Kestel Research and DCE 1990). Data on clearing licences issued by the New South Wales Forestry Commission and Western Lands Commission suggest that deforestation rates since 1986 have been about 20,000 hectares per year in the Eastern and Central Divisions of New

Figure 1. Estimated broad-scale changes in forest cover in Australia: a. generalised extent of cover approximately 9 000 years BP; b. cover at about 4 000 years BP; c. extent of forest (dark) and woodland (stippled) at time of European settlement; d. forest (dark) and woodland (grey) cover as of 1990. Note that scale varies. Adapted from the RAC Forest and Timber Inquiry (1991; 1992), original data sources vary.



South Wales and about 80,000 hectares per year in the Western Division (Kestel Research & DCE 1990).

In Victoria the recent (1972-87) rate of deforestation is only about 10 per cent of the long-term average rate but in other states the rate appears to be increasing. In Tasmania about 17,000 hectares of natural vegetation, mostly forest, were cleared each year between 1972 and 1980: 8,000 hectares per year for pasture, 3,000 hectares per year for pine plantations, and 6,000 hectares per year for hydro-electricity dams (Kirkpatrick & Dickinson 1982). This rate of clearing is well above the long-term average deforestation rate of 11,000 hectares per year.

The limited data suggest significant differences between deforestation rates on privately and publicly owned land. Between 1972 and 1987 in Victoria the rate of reforestation with native species (2,000 hectares per year) almost matched the rate of clearing (2,300 hectares per year) on publicly owned land, but on private land the rate of reforestation (2,300 hectares per year) was less than 20 per cent of the rate of clearing (12,100 hectares per year) (Woodgate & Black 1988). In Tasmania, woodchip operations on privately owned land are commonly used to clear forest for pasture establishment (Kirkpatrick & Dickinson 1982, Kestel Research & DCE 1990; RAC 1992).

The current rate of deforestation continues to be very high in many forested regions. The current national rate of 0.22 - 0.27 per cent a year, for example, implies the removal of Australia's forests within less than 250 years if such patterns were to persist (RAC 1992).

A recent estimate of the extent of remaining forest cover in Australia was obtained by the RAC through a Forest Resource Survey (FRS) with the assistance of the State and Territory forest management agencies (Table 1). Despite the diligence of this assessment, RAC concluded that "there is an urgent need for analysis of the forest estate throughout Australia, at a greater level of detail than was possible during this Inquiry, and for the appraisal and decisive redefinition of the present conservation reserve system", and Thackway (1990) listed a long series of limitations on the interpretation of these forest estimates due to problems with data sources.

The major forest groups identified by the FRS are listed in Table 2. The extent of these forests by State and Territory is given in Table 3. In comments on the earlier draft of this paper, both P. Sattler and H. Nix noted that it was unfortunate that this survey excluded low open-forest and forest/scrublands dominated by *Acacia* species in south-central Queensland (e.g. Brigalow, Gidgee), presumably omitted from the RAC report because of their structure and non-commercial nature of their dominant tree species. The conservation status of some of these communities is parlous, with massive clearing over this century reducing their former extensive cover to very small fragments (e.g. Bailey 1984).

The FRS identified about 1.43 million ha of northern rainforest and about 1 million ha of southern rainforest, putting the total estimated area of rainforest on the continent at around 2.5 million ha. The RAC (1991) noted that this estimate was approximately 25% above a previous independent estimate of rainforest cover made by ABARE (1990).

The RAC forest categories were very broad and represented an amalgam of many idiosyncratic State forest units. Most of these were based on dominant tree species, crown cover and tree height.

More detailed analyses of forest vegetation, including the description of vegetation communities, were prepared for all of Australia by Specht et al. (1974). Specht (1993) documented some problems in this process: the definition of major plant communities proved to be an insoluble problem as *"plant ecological surveys in Australia have been made haphazardly across the continent, often with markedly different degrees of resolution ... there was little attempt to co-ordinate the ecological studies on a national basis, even to rationalise the plant communities defined on either side of State/Territory borders. Some of the units recognised were very broad in concept, others were sub-divisions of larger units. The broadly-defined plant communities were often only recognised by the dominant tree or shrub species of the overstorey, with little consideration of the contribution made by the many associated understorey species."*

In an attempt to overcome some of these problems, Specht et al. (in prep, a) analysed species lists from almost 4,000 plant communities identified in over 1,500 ecological surveys across Australia, to derive almost 400 floristic groups at a comparable level of resolution across the nation. These include 59 closed forest, 25 semi-deciduous closed-forest and 190 open-forest and woodland groups, with "*perhaps another 40 floristic groups ... for the rainforest remnants of the Northern Territory, south-east Queensland and northern and central Queensland.*"

On a far finer scale, descriptions, maps and/or distributions of floristic communities within forests are available for many States and Territories, and/or regions or major environments within them (e.g. Benson 1989; Wilson et al. 1990; Kirkpatrick 1991; a series of Land Conservation Council reports in Victoria, e.g. LCC 1987). These usually show less emphasis on commercial tree species, and may provide very different environmental patterns to that derived from simple forest type. The NFI has sought integration of community descriptions and methodologies between States (NFI 1990).

**Table 1.** Extent of native forest in Australia, adapted from RAC (1992). Numbers represent thousands of hectares.

| | |
|---|---|
| Tall closed forest (>30 m high; >70% cover) | 2109 |
| Tall open forest (>30 m high; 30-70% cover) | 7764 |
| Tall woodland (>30 m high; 10-30% cover) | 220 |
| Closed forest (10-30 m high; >70% cover) | 3895 |
| Open forest (10-30 m high; 30-70% cover | 20004 |
| Low closed forest (<10 m high; >70% cover) | 101 |
| Low open forest (<10 m high; 30-70% cover) | 144 |
| Total forest | 26 010 |

**Table 2.** Major forest groups identified by RAC (1992).

**Northern rainforest:** All tropical, sub-tropical, gallery and monsoonal rainforest types of northern and N.E. Australia. *Eucalyptus* species are generally absent.
**Swamp forest:** Distributed in the coastal flood plains of northern Australia and along coastal dunes and river flood plains of eastern Australia. Two subgroups are recognised: the paperbark forests and woodlands dominated by *Melaleuca* spp.; and the *Eucalyptus* swamp forests and woodlands.
**South-western forest:** Confined to the high rainfall region of south-western Australia. Four subgroups are recognised: the coastal tuart (*E. gomphocephala*) forests; the wandoo woodlands (*E. rudis, E.wandoo*); the karri (*E. diversicolor*) forests; and the jarrah-marri (*E. marginata, E. calophylla*) forests.
**SE dry eucalypt forest:** Forests and woodlands spanning the western slopes of southern Queensland and New South Wales and parts of Victoria and Tasmania. Dominants include *E. albens, E. macroryhncha,* and *E. melliodora*. Native pines (*Callitris endlicheri* and *C. columellaris*) co-occur with eucalyptus.
**SE wet eucalypt forest:** Forests distributed over the high rainfall regions of New South Wales, Victoria and Tasmania with elements in South Australia and Queensland. Dominant tree species include *E. delegatensis, E. globulus, E. regnans, E. obliqua,* and *E. viminalis*. The western limit occurs in south-eastern South Australia (*E. baxteri, E. obliqua*). Subalpine forests (*E. pauciflora*) form a distinct subgroup. A Tasmanian element containing *E. gunnii* forms a distinct subgroup. Southern rainforest species co-occur with eucalypts.
**SE coastal forest:** Forests confined to the coastal lowlands of southern New South Wales and Victoria. The northern limit includes *Angophora costata* and *E. gummifera*, and to the south *E. botryoides, E. globoidea* and *E. sieberi* are widespread. Southern rainforest species co-occur with eucalypts.
**Central coastal eucalypt forest:** Forests confined to the coastal lowlands extending from central New South Wales into southern Queensland. Dominant tree species include *E. grandis, E. microcorys, E. pilularis, E. propinqua, E. umbra* and *Lophostemon confertus* (brushbox).
**NE coastal eucalypt forest:** Forests and woodlands of the coastal lowlands from northern New South Wales to Cape York Peninsula. Dominant trees include *E. intermedia, E. tessellaris, E. tereticornis* and *Lophostemon confertus*.
**NE eucalypt forest:** A widespread group extending from the coastal forests of Queensland to the semi-arid woodlands of western and northern Queensland. Dominant tree species include two widespread species, *E. crebra* and *E.*

*tereticornis*, along with *E. citriodora*, *E. maculata*, *E. trachyphloia* and *E. drepanophylla*. Woodland dominants include *E. alba*, *E. crebra*, and *E. moluccana*.

**River red gum forest:** A widespread group with strong affinities to the swamp eucalyptus forest subgroup, but characterised by the dominance of *E. camaldulensis*.

**Table 3.** Extent of native forest groups in Australia adapted from RAC (1992). Numbers indicate thousands of ha.

| | NSW | Vic | Qld | WA | SA | Tas | NT | ACT |
|---|---|---|---|---|---|---|---|---|
| Nth. rainforest | 64 | - | 1222 | - | - | - | 146 | - |
| Sth. rainforest | 233 | 11 | 3 | - | - | 754 | - | - |
| Mangrove forest | 0.44 | - | 27 | - | - | - | 145 | - |
| Swamp forest | 12 | 2 | 131 | - | - | - | 915 | - |
| SW forest | - | - | - | 2405 | - | - | - | - |
| SE dry eucalypt forest | 4329 | 10 | 21 | - | - | - | - | - |
| SE wet eucalypt forest | 3489 | 3880 | 20 | - | 27 | 2128 | - | 81 |
| SE coastal eucalypt forest | 222 | 422 | 87 | - | - | - | - | - |
| Central coastal eucalypt forest | 3457 | - | 565 | - | - | - | - | - |
| NE coastal eucalypt forest | 8 | - | 1062 | - | - | - | - | - |
| NE eucalypt forest | 645 | - | 3413 | - | - | - | 40 | - |
| River red gum forest | 42 | 35 | 6 | - | - | - | - | - |

**2.(vi). The existing forest reserves in the States and Territories.**

Conservation reserves in forests are managed primarily to protect and conserve the biological, ecological, geological, cultural, aesthetic, recreational and other values provided by forests. According to Hooy & Shaughnessy (1992), Australia had an estimated 50.1 million hectares, or about 6.4 per cent of the total land surface of the continent, reserved for conservation purposes as of 30 June 1991.

A large number of reserve classifications is used by the States and Territories in setting aside areas for conservation purposes and this creates difficulties for assessing the true protection status of many forest values. Thirty four different categories of terrestrial reserves were identified by Mobbs (1989) as having been established under various government legislative schemes in Australia. Few of these conservation tenures* are managed solely for conservation. Different types of reserves, for example, have different levels of protection and security of tenure. National Parks and flora and fauna reserves are protected legislatively whereby the primary objective is conservation. However, even these parks may be zoned for various uses and people are rarely excluded. Recreation parks may afford low protection for many biota because conservation is not one of the highest priority of uses. Within state forests, designated Flora and Fauna reserves are normally small and relatively insecure compared to National Parks.

The extent of forest conservation reserves in each State and Territory was estimated by RAC (1991). Approximately 8.8 million ha of forested land occurs in conservation reserves, although not all of this land has remained unlogged since European settlement (Table 4). About 58% of all forests found in conservation reserves have never been logged (RAC 1991).

Overall, the Forest Resource Survey undertaken by the RAC (1992) reported that a total of 16.25 million hectares of unlogged forest and woodland exists in the Australian Forestry Council regions of Australia, although in excess of 11 million hectares of this are of minor importance to timber production (i.e. encompass mangrove and swamp forest and rainforest). Roughly five million hectares of eucalypt forest was estimated to be unlogged by the RAC (1992), of which some 48% is in conservation reserves, 43% is designated state forest and 8% is other crown land. Notably, the extent of unlogged forest on private land could not be estimated (RAC 1992).

An assessment of the representation of different forest groups in conservation reserves in Australia, based on the Forest Resource Survey, is shown in Table 5. Thackway (1990) described how imprecision in the available data should qualify these estimates. Many forest groups are poorly represented within reserves in the States and Territories. For example, combined, the south-eastern dry eucalypt forest, central coastal eucalypt forest and north-eastern eucalypt forest occupy about 12.5 million hectares and have a combined representation of about 10% (1.32 million hectares) in conservation reserves. Compared to other forest groups, the RAC (1992) considered these forests to be under-represented in conservation reserves. Although some 70% of northern rainforest is in conservation reserves, less than one-quarter of this area has never been logged. The opposite is observed for the southern rainforests, of which 38% are in conservation reserves and 74% of this area remains unlogged (RAC 1991).

Of the south-eastern dry eucalypt forests found on the western slopes and tablelands of southern Queensland and New South Wales, some 1.748 million ha of these forests are privately owned while almost 2 million ha are in other crown lands (RAC 1992). The central coastal eucalypt forests occupy the coastal lowlands from Sydney through southern Queensland and their management is controversial. Some 1.438 million ha are privately owned and a further 1.459 million ha are designated as State Forest (RAC 1992). Based on the Forest Resource Survey, three eucalypt forest groups located in the south-western, north-east coastal and central coastal AFC regions have less than 50% unlogged forest in conservation reserves. The central coastal eucalypt forest is particularly poorly represented in conservation reserves (13% of total area), leading the RAC (1992) to note concern for its long-term conservation status.

It is important to note that the percentages given above are based on **existing** forest cover rather than **pre-European** forest cover. J. Kirkpatrick noted in comment on an earlier draft "if the original area is not used as a base, proportionate forest reservation can be improved by further clearance". Thackway (1990) presented changes in extent of various forest and woodland types from "natural" to present.

RAC requested qualitative evaluation from each State and Territory as to the representativeness of their existing forest reserves. This evaluation was as follows:

**New South Wales**

"The New South Wales Government submitted that the present system of conservation reserves in New South Wales does not provide an adequate sample of forest ecosystems and should be expanded to include, for example more old-growth forests, forests on high nutrition soils, and forests of the western slopes and plains."

**Victoria**

"According to Frood and Calder (1987), the conservation reserve system in Victoria does not include adequate samples of all ecosystem types (cited in Victorian Government, Submission 167, p. 10). Forest ecosystems requiring further representation include wet sclerophyll and closed forests, grassy candlebark, peppermint and messmate forests, box/ironbark forests and riverine forests (LCC 1988)."

**Queensland**

"Queensland's reserve system is representative of only about 58 per cent of the major vegetation types in the state (Queensland Government, Submission 217, p.79). At least seven 'commercial' forest types are unrepresented in National Parks. A program is under way to increase the area in National Parks to 4 per cent of the area of the state in the next three years as a major step towards achieving a fully representative reserve system (Queensland Government, Submission 217, p.86)." About 750 ecosystem types have been identified across each bioregion, with about 60% of these currently included within reserves of over 1000 ha (Queensland Department of Environment and Heritage supplementary submission to HORSCERA).

**South Australia**

"The extent of native forests is limited in South Australia. The Inquiry has not yet been able to ascertain the representativeness of the reserve system for such forests. Clearing of native vegetation is strictly controlled in South Australia. Approximately 16 per cent of the land in the state is currently reserved for conservation (SA Department of the Premier and Cabinet, Submission 156, p.52)."

**Western Australia**

"The Western Australian Government submitted that 'all major forest types' in the state are represented in 'secure conservation reserves' (Submission 194, p.30). However, it has also been claimed that 'the status and extent of reserves remains a matter for concern from both tourist and conservation angles' (Mr T

Brittain, Chairman, Independent Committee of Inquiry into Forest Resources and Values, Submission 86, p.2 of covering letter). The Inquiry has been unable to assess the extent to which the present reserve system in Western Australia is representative."

**Tasmania**

"The recent recommendations of the Working Group for Forest Conservation established by the Tasmanian Government identified additional areas of forest types for reservation (called Recommended Areas for Protection - RAPs). These additional areas represent a total of 3 per cent of the area of the state and 7 per cent of its forested areas; it was considered that their inclusion in the reserve system would improve its representativeness. However, further assessment and reservation will be required for some areas (for example, the Midlands) to obtain a fully representative reserve system (Tasmanian Department of the Premier and Cabinet, Submission 183, p.18)."
ESD (1991) stated "Many of the major forest ecosystem types are inadequately represented in reserves ... studies on dry sclerophyll forests, wet sclerophyll forests and rainforest which laid the basis for ... RAPS identified that a number of major forest ecosystem types are inadequately protected in reserves"

**Northern Territory**

"The extent to which the present reserve system is representative of all the forest and woodland vegetation communities of the Northern Territory is apparently unknown at present. Survey work to describe the vegetation is 'almost complete' (Conservation Commission of the Northern Territory, Submission 51, p.9). Despite this lack of knowledge, though, there is a perceived need for further reservation of certain forest and woodland communities, including lancewood and gutta percha communities (Environment Centre of the NT, Submission 26, p.2)."

**Australian Capital Territory**

"Much of the remnant native forest land of the Australian Capital Territory is reserved for its environmental and recreational values (ACT Government, Submission 196, summary). The extent to which representative samples of all forest communities in the Territory are protected in the reserve system does not appear to have been quantified."

More detailed analysis of forest floristic communities is available for some States and Territories. In the Northern Territory, Wilson et al. (1990) defined 7 floristic communities, of which one (*Acacia shirleyi* open forest) was entirely unreserved, and three were represented in only one reserve (Denney & Wilson 1991). In Tasmania, Kirkpatrick (1991) listed 136 forest plant communities, of which 17 were unreserved and 29 were poorly reserved. In New South Wales, Benson (1991) listed 241 plant associations (forested), of which 30 were "not conserved or, if so, to a very minor degree" and 101 were "inadequately conserved (small areas conserved or geographical range poorly conserved)". In Victoria, Frood & Calder (1987) listed "*open forests, woodlands and grassland communities of lower altitude snowplains and cold montane plateaux*" in "Category 1: conservation measures urgently required, particularly in refugia sites"; "*wet sclerophyll forest - cool temperate rainforest*" and "*riverine forests*" in "Category 2: further conservation measures in high need"; and "*warm temperate rainforest*" and "*forests and heathy woodlands of the ranges and coastal areas*" in "Category 3: conservation measures required". In Queensland, Sattler (pers.comm.) noted that 70% of that State's 186 forest ecosystems were represented in conservation reserves, although many of the conserved ecosystems were "poorly represented" in reserves.

**Table 4.** Extent (in thousands of hectares) of conservation reserve tenures in each State and Territory as identified by the RAC (1991). The percentage of unlogged forests in reserves is also shown.

| | Total | Percentage unlogged |
|---|---|---|
| New South Wales | 2 091 | 50 |
| Victoria | 1 345 | 54 |
| Queensland | 2 175 | 31 |
| Western Australia | 455 | 36 |
| Tasmania | 732 | 70 |
| Northern Territory | 1 882 | 100 |
| ACT | 42 | 93 |
| Australia | 8 774 | 58 |

**Table 5.** Representation of native forest groups in conservation reserves, as adapted from RAC (1992). Areas represent thousands of hectares.

| Forest group | Conservation reserves | Total area | % Reserved |
|---|---|---|---|
| Northern rainforest | 1 011 | 1 432 | 71 |
| Southern rainforest | 384 | 1 001 | 38 |
| Total | 1 395 | 2 433 | 57 |
| Swamp forest | 918 | 1 061 | 87 |
| South-western forest | 455 | 2 405 | 19 |
| SE dry euc. forest | 356 | 4 381 | 8 |
| SE wet euc. forest | 2 209 | 9 624 | 23 |
| SE coastal eucalypt forest | 454 | 730 | 62 |
| Central coastal eucalypt forest | 506 | 4 023 | 13 |
| NE coastal eucalypt forest | 417 | 1 071 | 39 |
| NE eucalypt forest | 456 | 4 098 | 11 |
| River red gum forest | 83 | 83 | 100 |
| Total | 4 936 | 26 415 | 19 |

**2.(vii). How well does the existing system measure up to an integrated and sufficient reserve system?**

The extent to which the current forest reserve network is sufficient for conservation goals depends upon how those goals are specified (and whether they allow any measured assessment). What then should a reserve network be?

In their submission to HORSCERA, WWF defined what a "representative protected areas network" had to attain:

> (a) sample all biogeographic regions of Australia; (b) sample all biological diversity of a region; (c) contain multiple representations of each species and system to guard against catastrophic events; and (d) incorporate 'viable' numbers and areas of each species and system, to provide optimal chances for long-term retention of biological diversity.

This definition was regarded as "an excellent starting point" and thought to "encapsulate the fundamental aspects of a national system of protected areas" by ANPWS (Submission to HORSCERA).

The problem is that most of the criteria are essentially unmeasurable or indefinite; or there is insufficient information to measure them. For example, there is no fixed number of biogeographic regions in Australia: one can define as many or few as convenient. It would be impossible to include all biological diversity within a region without representing virtually the entire region within a reserve. Detailed knowledge of genetic variability, and its spatial context, is unknown for most species. For most species, we know so little of distributional patterns that it is not possible to state whether they occur within any reserve, let alone enumerate how many reserves they occur in. The number of individuals needed to constitute a viable population is unknown for almost all species, and the minimum area required is similarly unknown. Some of these uncertainties are dealt with in more detail in Section 3 of this paper, but raised here as they dictate the extent to which the current system can be assessed. Although there are definitional and assessment problems, these criteria do represent some standards to aim for, and can be crudely estimated in some circumstances.

Another set of goals and operational procedures was specified by Richards et al. (1990):

> ". *A conservation strategy should reserve a representative sample of all environmental domains and their dependent plants and animals.*
>
> . *An optimal national strategy should provide for a small number of large reserves, a network of medium-sized regional reserves, and a large number of small local reserves.*
>
> . *A reserve system should maintain continuity of habitats along environmental gradients.*
>
> . *Design of the reserve system should take advantage of opportunities to locate reserves within a matrix of managed forest. Such reserves will be more resilient and persistent than those isolated within areas of unsympathetic land use.*
>
> . *Reserves should be circular rather than linear, except when the target area is favourable linear habitat and the surrounding land use practices do not jeopardise conservation values*".

These criteria basically enshrine also the principles specified by NFPS as the basis for the development of a nature conservation reserve system: comprehensiveness, adequacy and representativeness. The detailed assessment of the current reserve system according to these criteria will require much more definition of how these are evaluated and also much more information on what is present within conservation reserves.

A somewhat more specific version of these objectives was provided by the ACF/WWF submission to HORSCERA:

> "*an immediate and substantial expansion of the nature reserve system for genotypes, species, communities and environmental types that are already known to occur solely or largely outside reserves. The reserve system should capture all existing populations of rare and threatened species ... and it should encompass large populations of all other species across their geographic range. Where populations are sufficiently large, the reserve system should aim to encompass at least 10,000 individuals of each species in several spatially separate populations*".

One of the most honest approaches to the problem of vagaries of definition and evaluation of to what extent objectives are being realised is that of ESD (1991), which stated that "*there are no firmly established guidelines for assessing whether adequate conservation of the biodiversity of a region has been achieved ... and there are no scientifically established estimates of what constitutes an adequate amount of conserved habitat*".

Some general observations and preliminary assessments are nonetheless valid. Regarding the Australian forest estate, *in toto*, the RAC (1992) reported that:

> "*there are serious deficiencies in the current state of knowledge about the distribution, ecology and abundance of many species of plants and animals (ACF, Submission 322, p.30). Despite these deficiencies, it is clear, both from aggregating assessments of representativeness at regional and*

*State and Territory levels and from the few studies that have been undertaken at a national scale, that the present system of reserves is not fully representative of forest and woodland ecosystems across the continent. The Australian National Parks and Wildlife Service described the coverage of the national reserve system as 'not uniform or representative because it results from a generally opportunistic approach to acquisition in individual States and Territories*" (Submission 308, p.6); and "*The regional studies of which the Inquiry is aware have concluded that the reserve system is not fully representative of the diversity of forest ecosystems, flora and fauna that occur in the regions studied. The Inquiry has concluded that, in order to achieve the most efficient system possible to conserve Australia's flora and fauna, the representativeness of the reserve system should be assessed in a national context, rather than in the regional, state or territory context, as has often been the case in the past.*" (RAC 1991, pp. 151-54).

The deficiencies are biased. Braithwaite et al. (in press) in southeastern New South Wales found that the extent to which forest communities were reserved was closely related to the site productivity and accessibility. Associations on fertile and accessible lands were mostly alienated and mostly cleared. Unproductive remote forest associations were far better represented in the reservation network. This illustrates a national trend (CSIRO submission to HORSCERA, 1992; a comparable example is in mallee areas of Victoria: Blakers & Macmillan 1988), and suggests that reservation proposals should give priority to communities growing on these most productive and (perhaps less so) accessible lands. This bias was also described by Benson (1991):

"*communities on higher-nutrient soils such as tall open forest, box woodlands or inland floodplains are poorly represented. Only 5-19% of tall forests remain unlogged in NSW and most of the box woodlands in coastal valleys and on*

> *the western slopes have been cleared for cropping and grazing. Over 40% of the forest types in the north eastern corner of NSW have only a miniscule or no representation in protected areas".*

The national representation of *species* within the existing forest reserves is nowhere compiled. However, some indicative data are available. Briggs & Leigh (1988) found that 47% of rare and threatened higher plant species have not been recorded from conservation reserves in Australia. Woinarski (1992) calculated that about 25% of the species of mammals, birds and reptiles of northwestern Australia were not known from conservation reserves. By itself, representation may give a misleadingly optimistic assessment, for many of the reserved species may not have viable populations within reserves. Far less is known of the reservation status of invertebrates, and of their requirements (e.g. Greenslade & New 1990).

It is also clear that there are substantial disparities in the representation of environmental domains or regions within the reserved forest estate, with some domains and regions being effectively unrepresented (e.g. Thackway 1992). RAC concluded that:

> *"with the possible exception of the Australian Capital Territory, there is a need for further reservation of areas in all states and territories to achieve a fully representative reserve system".*

# 3. Towards designing an appropriate reserve system.

## 3.(i). Regionalisation and regional conservation assessment.

### (a). Regionalisation

Australia is too large an entity to attempt any fine-scale detailed set of proposals for allocation of land to conservation reserves simultaneously across the continent. Therefore there is a practical requirement to consider smaller parcels of land as the focus for land-use studies. This regionalisation also recognises that land-use considerations and conservation problems show substantial variation across Australia and hence may most efficiently be addressed within relatively homogeneous regions.

Division into regions has several useful functions. One is to provide the basis for sensibly defining portions of the nation in which intensive examination of land-use options may be most efficiently addressed. Another is the complement of the first, allowing a national perspective with which to compare and integrate conservation requirements and status between regions. Hence regions can be processed in a manner reflecting conservation priorities, with regions in most need of conservation actions or improvement in their protected area network being investigated first.

Sattler (in HORSCERA 1993) gave an alternative set of purposes for a bioregional framework:

> *1. To develop a systematic basis for understanding and recognising inherent biodiversity in each region.*

*2.To enable environmental auditing of each region to determine the conservation status of biodiversity threatening processes, sustainability of landuse and socio-economic issues, so as to focus and prioritise conservation planning in this country.*

*3.To develop regional conservation strategies that integrate a representative reserve system with off reserve measures and ecologically sustainable development.*

Regionalisations allow a geographic hierarchical overview of conservation status. Obtaining a workable and optimum balance between national, State/Territory and regional concerns will very much dictate the feasibility and success of any protected areas system. Local input into decision making is vital, although there is a caveat:

> "*problems arise, however, when local concerns over-ride regional and national priorities*" (Royal Botanic Gardens Sydney submission to HORSCERA).

Recently, much research has been directed towards devising a regionalisation of Australia based on biophysical characteristics, and of such a scheme being used to assess conservation status and requirements across the nation, for example BDAC (1992) stated:

> "*Regional planning in which environmental characteristics are a major determinant of boundaries is considered to be of major importance for biological diversity conservation to succeed ... the regions must be based on ecological parameters, vegetation types, catchment areas, climatic factors, combined with community interest ... Recommended actions (are to) manage biological diversity on a regional basis using natural boundaries ... This will require:*
> *- the determination of a system of bioregional planning units, based on environmental parameters and community*

*identity, which emphasise regional environmental characteristics and need;*

*- the promotion of community participation;*

*- the identification of appropriate inter- and intragovernmental mechanisms to ensure cooperation and coordination in bioregional planning; and*

*- the preparation and implementation of bioregional plans*" (BDAC Recommended action 3.1.3),

and further proposed that:

"*National policies which integrate the conservation and ecologically sustainable use of biological diversity into relevant sectoral .. plans .. will be implemented on a bioregional basis*".

How should these regions be delineated? This question has been addressed by Commonwealth, State and Territory conservation and land management agencies in recent workshops and discussion papers (Thackway 1992; Thackway & Cresswell in press). Thackway (1992) recommended that regionalisation should be derived from an approach which (i) integrates "several environmental themes to form regions based on a number of interacting attributes" rather than on single thematic attributes (e.g. vegetation), and (ii) is supported by point based data rather than "pre-classified" data. The second of these principles allows ready numerical analysis to illustrate classes at any defined hierarchical level, and hence the number of regions (or, the scale of resolution) to vary according to the needs of the user.

Recently ERIN has produced a series of regionalisations of Australia based upon 12 environmental variables comprising temperature, precipitation, terrain and soil attributes (Thackway & Cresswell in press). The 20 and 30-group products of this regionalisation were considered by the States and Territories for their use in defining regions for conservation assessment. Note that although these units have been called "bioregions" (e.g. HORSCERA 1993), H. Nix (in comment on the previous draft of this paper) stated that this term is inappropriate as they do not incorporate biological data in the classification, and hence should more correctly be termed "environmental domains".

The Queensland Department of Environment & Heritage reported (Supplementary submission to HORSCERA) that most State agencies were reluctant to support the ERIN regions because they (i) showed little congruency with existing State or Territory based regions, and in many cases the existing within-State regions have become established for conservation administration and planning (e.g. Sattler 1986; in press) and (ii) showed little congruency with other biological classifications (e.g. the Mitchell grasslands were not isolated).

Specht et al. (in prep., b) have provided an alternative regionalisation, based on floristics. They tabulated all major plant communities foe every $1^{o}$ x $1^{o}$ cell throughout Australia to enable "biogeographic regions to be defined objectively, based on the total flora of the continent" (Specht 1993).

It is doubtful that any national regionalisation should be imposed upon the States and Territories in a way which will dictate their definition of regions for land-use study. A way needs to be found to allow the benefits of a national regionalisation to be at least partly retained within a system where the States and Territories still largely retain control of the delineation of regions within their jurisdictions. A national regionalisation based on biophysical criteria has these desirable qualities:

- the regions make biological sense, and hence they provide a valid context in which to consider the issues, and conservation requirements of species and communities;

- the conservation of environments which cross State/Territory boundaries is best achieved by assessment across those boundaries;

- national and biophysically based regionalisation identifies (and forces consideration of) all major environments - these may slip through the net in the case-by-case aggregation of irrationally defined regions.

- it provides a standardised measure of the extent of variability within a State or Territory, and hence can be used to guide how many regions may be most suitable to identify within a State or Territory.

These assets can be partly retained within State-defined regions where:

(i) these existing regions have some biophysical basis (as most indeed have - for example Queensland) or can be modified somewhat to better reflect environmental variation (and the ERIN maps may assist such refinement);

(ii) formal or informal links in conservation assessment are established between neighbouring States/Territories (this may take the form of joint cooperative assessment of clearly defined environments which cross borders, such as the Nullabor, Simpson Desert or Alpine areas, or less coordinated assessment in which one State/Territory considers the existing or proposed reserve placement and environmental representation in neighbouring areas of adjacent States/Territories); and

(iii) some overview of the reserve network is developed and maintained by the Commonwealth, State and Territory government agencies. This overview may include a requirement that the individual regional studies and reserve selections should knit together in such a way that all nationally defined environments (and species) are adequately represented.

The preferred size of study regions may also be a factor which should be considered. Clearly, finer resolution may be available in small regions, but at the cost of possibly substantially delaying a national completion of regional studies and selections and with the possibility that larger issues are lost in the detail of local concerns. Pragmatically, larger regions may be more desirable in areas where few data are available (e.g. in the Northern Territory). Larger regions may also be more suitable for areas with extensive relatively homogeneous landscapes.

ANPWS, in their submission to RAC, attempted to define the appropriate scale for a 'bioregion' as:

> "*an area of land of sufficient size to maintain the integrity of the region's biological communities, habitats and ecosystems; maintain important ecological processes; meet the habitat requirements of all species; and include the people and communities involved in the management, use and understanding of biological resources*".

However, it is unclear how this definition could practically delimit acceptable sizes for study regions.

Enthusiastic endorsement of regionalisation as being the foundation for a reserve network is not universal. J. Kirkpatrick, in comment on a previous draft, identified a series of problems with regionalisations and/or regarded it as a low priority. His comments follow:

> "*regions are a general classification of land with a contiguity constraint. Bioregions emphasize biological attributes in classification. The boundaries between such regions are essentially arbitrary, even with the application*

*of quantitative procedures for their determination. For example, if a 40 region solution was chosen for Australia instead of the 30 region solution depicted in HORSCERA (1993) almost all of the boundaries would be different. The largely continuous changeover of species that occurs along environmental gradients means that many species will have only a small part of their range within any bioregion, no matter how defined. This makes the ANPWS definition quoted ridiculous, unless all bioregions are islands.*

*The main virtue of a bioregional approach would be that it forces at least some replication of some elements of biodiversity within the reserve network. However, it may lead to a better conservation status for those entities with cross-boundary distributions than those confined to a region. National assessment is therefore a critical necessity.*

*A bioregional approach to conservation assessment, planning and implementation seems to have propagated its way through the various reports and policies without much thought being given to practicalities. With very few exceptions, a system of bioregions for Australia would not correspond to data collection catchments, planning areas or administrative units. It seems a poor use of scant funds to set up yet another set of administrative boundaries, seemingly unintegrated with any level of our three tier government system, and to reorganise the large amount of existing data to allow assessment within new boundaries.*

*I urge an incremental approach to bioregionalisation that recognises the desirability of congruence between administrative and assessment units. The Local Government Area or regional aggregations of such areas would seem to be a good starting point."*

Regionalisation was also not a high-order component of the current reserve design project of the Conservation Commission of the Northern Territory (e.g. N.T. Government submission to HORSCERA). For this project, data bases for the whole of the Northern Territory are being considered, with regionalisation being seen to impose an artificial barrier and further constraint to most efficient reserve placement. This eschewment of regionalisation may reflect the Territory's sparse data base but Territory-wide consistency in the main planning data base, a 1:1,000,000 vegetation map.

### *3.i.(b). Regional conservation assessment*

Assessments of conservation adequacy have been undertaken in many regions, and/or for many broad environmental types, in Australia in recent years. These assessments include the Nullabor region of South and Western Australia (McKenzie et al. 1989), the wet tropics of northeast Queensland (Mackey et al. 1988; 1989), Cape York Peninsula ("CYPLUS": see Holmes 1992) and the Mulga and Channel Country of Queensland (Sattler in press), the forests of south east New South Wales (Richards et al. 1990), Tasmania (Kirkpatrick and Brown 1991; Lewis et al. 1991), mallee areas of South Australia (Margules & Nicholls 1987; Margules 1989b), the Kimberley region of north-west Western Australia (Burbidge et al. 1991) and rainforests within that region (McKenzie and Belbin 1991), the Gulf region of the Northern Territory (NT Department of Lands & Housing 1991), the dry rainforests of eastern Australia (Nix et al. 1992), all Victorian regions (a series of Land Conservation Council reports) and national estate values of the southern forest region of south-west Western Australia (AHC/CALM 1992). The specific purpose of most of these studies has varied, as have the reserve selection criteria employed and conceptual approaches to landscape assessment.

Some examples of these approaches to regional studies and planning are described below. Note that not all examples examine forest environments, but this listing is mainly to indicate the variety of approaches to land-use assessment and reserve placement.

#### South-east forests of NSW

The Joint Scientific Committee's study of the South-east forests of New South Wales (Richards et al. 1990) was a response to a series of conflicts between forest use and conservation. It was a collaborative venture of the Commonwealth and State governments, and was undertaken by a "panel of experts" mostly with forestry experience. It set out to collate biological survey data mostly of National Estate areas, and to examine forestry options and reserve adequacy. Other land uses were not specifically considered. The region was defined by latitude and longitude (and coastline) and totalled about 12,000km$^2$. Some perspective on the study region was gained by considering also environments in adjacent areas. Reserve adequacy was assessed primarily through analysis of environmental domains, supplemented by data on the distributions of individual species (especially rare and unusual species and communities). The environmental domains (n=127) were shown to be tolerably well associated with the distributions of individual vertebrate species and with floristic associations. An unusually large amount of distributional data was available and assembled.

Indicative reserve proposals were largely based on representation of environmental domains, with some allowance made for species distributions. Representation was examined at several levels (5, 10 and 20% of the total area of each domain) with allowance also made for the fragmented or disturbed nature of domains. A series of notional reserves to meet the given criteria was depicted, although these notional reserves were not defined as necessarily the best solutions. Indeed, no clear selection mechanism was described, so the siting, extent and shape of the notional reserves cannot be justified from the information presented. The linear nature of many of the proposed reserves was criticised, and some of the solutions were regarded as being of low conservation value (e.g. cleared areas being chosen to represent domains).

The procedures adopted in this study were seen by their proponents as a good generic guide to other regional assessments:

> "*The Committee hopes that its study of the south-east forests might serve as a general guide, so that there need not be a fresh inquiry into the conservation value of every area of*

> *forest nominated for inclusion on the Register of the National Estate."*

However, the procedures of reserve selection and consequent findings of the Joint Scientific Committee were much disputed, in part reflecting the limited opening for public consultation and justification in the process. C.Margules in comments on a previous draft of this paper noted that this study demonstrated that reserve selection was dependent on two main components, assembling an adequate base and then using that data base in an explicit procedure. The limitations in the second component led to major shortcomings in the eventual solutions.

## RAC Tasmanian forestry consultancies

An assessment of regional conservation adequacy in Tasmanian forests was commissioned by RAC. It provides the best example of a comparison of an 'environmental domain approach' (Lewis et al. 1991) and a 'biologically-based approach' (Kirkpatrick and Brown 1991a). The following extract from the RAC (1992, p.205) summarises the major findings of the work:

> *Conservation adequacy was assessed in terms of representation of 5, 10, 20 and 30 per cent of forest communities or environmental domains in the current reserve system. In addition, a combination of 90, 60 and 30 per cent reservation was used by Kirkpatrick and Brown (1991a) for endangered species, vulnerable species and other species respectively.*
>
> *The consultants found deficiencies in the extent to which forest vegetation communities (Kirkpatrick & Brown 1991a) and environmental domains (Lewis et al. 1991, Kirkpatrick & Brown 1991a) are represented in reserves. For example, six of 39 forest vegetation communities were not reserved at all and,*

*of those reserved, four had less than 5 per cent of their area currently in reserves (Kirkpatrick & Brown 1991a).*

*Techniques to identify priorities for further reservation were based on iterative allocation methods (see Kirkpatrick 1983; Margules & Austin 1991) ... the general approach taken in the consultancies provides a useful structural basis for determining future reservation priorities. Both studies concluded that environmental domain analysis, mapping of environments and species distributions, and detailed field studies are complementary and that a combination of the approaches is the most desirable option for land inventory, land use planning and reserve design."* (RAC 1992, p.205).

## Nullabor

McKenzie et al. (1989) present an example of reserve allocation for a large (c.220,000km$^2$) area with a particularly sparse data base, the Nullabor region of South and Western Australia. Their reserve selection was based on a systematic sampling of plant, bird, mammal and reptile species, followed by classification of assemblages of species into "guilds that have similar geographic patterns" (Belbin in press), modelling the distributions of these assemblages and their richness, and then selecting areas likely to contain a diversity of assemblages and/or assemblages with restricted distributions.

## Kimberley rainforests

A related procedure was followed to propose reserve design for monsoon rainforests in the Kimberley, based on gradients of compositional richness for plant, bird and land snail assemblages (McKenzie & Belbin 1991). Monsoon rainforests occupy only a small area within this landscape, but this is divided into very many patches. Sampling at all patches was clearly impossible, so the study carefully stratified sampling and used sophisticated predictive modelling to derive distribution patterns across all patches. This methodology may provide a good model for reserve design in remanant forest patches in the much modified landscapes of temperate Australia.

In the Kimberley rainforests, snail distributions included many species which were particularly restricted, in many cases to only single patches, and the reserve design was moulded to incorporate such specific requirements. The consideration of a very diverse range of taxonomic groups (e.g. birds, plants, snails) for reserve design was considered to be a major advantage of this study (McKenzie & Belbin 1991).

Gulf Region of the N.T.

The land use study of the Gulf region of the Northern Territory (NT Department of Lands & Housing 1991) was the first intensive assessment of options for a large region in the Northern Territory. As with the Nullabor study, it's conservation evaluation was limited by a sparse data set, but unlike that study this data set was not treated in any synthetic manner. Instead land use recommendations were based largely on suitability to pastoralism, with secondary influences of tourism and mining. Conservation values were largely set by distribution records of putative rare species (based not on systematic sampling) and scenic attractions, and no selection procedure was defined for the allocation of lands to conservation purposes. The study was criticised for the influence of industry pressure groups and its failure to meet any of a wide range of evaluation criteria (Holmes 1992).

Southern forests of W.A.

A notable recent regional assessment was that jointly provided by the AHC and CALM, the Western Australian land management and conservation agency, in the Southern Forests region of south-west Western Australia (AHC/CALM 1992). While this study did not set out to assess the current reserve network nor to identify areas suitable for new reserves, these proved to be products of the central aim of the assessment of sites of National Estate value (partly in response to controversy about forest use). The methodology of this study was carefully and explicitly stated at its outset. The process had three main aspects: joint identification of all areas within the region which matched clearly defined national estate criteria, joint agreement for analysis of the extent to which identified national estate values in the region were currently protected within existing reserves, and discussion about management options in non-reserved areas. Areas requiring more data for adequate assessment were identified. The study was conducted across all land tenures and ignoring current national estate status. Four principles were considered to provide protection of defined sites: protection should be focussed on the regional occurrence of each value, rather than in isolation; for sensitive values, the highest level of protection is obtained through reservation; all sensitive national estate values should have adequate representation in conservation reserves; and management outside reserves should be aimed at minimising adverse impacts on those national estate values which may be sensitive to disturbance. Assessment was based on a very wide variety of data sources (these attributes included Aboriginal archaelogical sites, historic sites, catchment/rivers/wetlands, landform/geomorphology/soil, fauna, vegetation (including diversity, representative types,), flora, wilderness and disturbance) which were spatially collated and examined against the criteria defined for national estate acceptance. Note that, following initial investigation, data pertaining to cultural values were found unsuitable for incorporation into the regional assessment.

The procedure of this study was endorsed by RAC, who suggested that it should be extended to include government cooperative assessments of regions. An outline of such assessment was provided in the NFPS (1992):

> "*The Governments have identified a single, comprehensive regional assessment process whereby the States can invite the Commonwealth to participate in undertaking all assessments necessary to meet Commonwealth and State obligations for forested areas of a region.*
>
> *Comprehensive regional assessments will involve the collection and evaluation of information on environmental and heritage aspects of forests in the region. The Commonwealth will ensure that its evaluation of information is efficient, avoiding duplication and delays wherever possible and taking into account the analyses of other Commonwealth agencies where appropriate.*
>
> *These assessments will provide the basis for enabling the Commonwealth and the States to reach a single agreement relating to their obligations for forests in a region. Commonwealth obligations include assessment of national estate values, World Heritage values, Aboriginal heritage values, environmental impacts, and obligations relating to international conventions, including those for protecting endangered species and biological diversity*".

## Land Conservation Council studies

Regional studies undertaken by the Land Conservation Council have examined conservation (and other) values of all public lands in

Victoria sequentially since 1970. Descriptions of its process are provided in Frood & Calder (1987), LCC (1988) and Scott (1991). Membership of the LCC is established by legislation and includes the permanent heads of the main government agencies concerned with land management and representatives from conservation, farming and business interests. It has divided the State into 17 regions. For a particular region it first issues a report describing land characteristics and values (this typically includes good quality 1:250,000 maps of geology, vegetation and land systems, as well as summaries of distributional records for vertebrate species, and more detailed information for species of conservation concern). Public submissions on land use are then invited. The LCC then makes proposed recommendations for all public lands in the region, based on its initial report and public submissions. Public comment is then invited on the proposed recommendations. Final recommendations are then prepared and submitted to the appropriate Minister (with an overwhelming majority being then implemented). These recommendations cover not only conservation reserves but also areas proposed for intensive logging, recreation and other uses. Although allocation of sites to the protected area estate are influenced by factors such as representation, diversity, adequacy and naturalness, this allocation is not clearly explicit and enumerated. For example, the LCC apparently does not use the computer-based reserve selection mechanisms described elsewhere in this paper. Nonetheless the highly systematic and thorough cataloguing, assessment and recommendations of the LCC, and its relative longevity, have given the Victorian conservation estate unusally good comprehensiveness.

The extent to which any of these studies provides a sufficient model for regional conservation assessment aiming to provide a comprehensive, adequate and representative national system of reserves is arguable. Some generalities in what regional studies and assessment demands have been provided by Holmes (1992), who listed seven criteria for effective strategic land use planning: they must be well informed, dynamic and flexible, consultative and participatory, responsive and accountable, capable of resolving conflicts, coordinative, and influential.

BDAC (1992) also listed what it perceived as the major elements of a bioregional plan:

> *- identifying the biological diversity elements of national, regional and local significance, the extent to which they need to be protected, and the extent to which they already occur in protected areas;*
> *- identifying the major activities taking place within the region and in the adjoining regions, and analysing how these impact on the region's biological diversity and which of them are ecologically sustainable;*
> *- identifying any areas of importance for biological diversity conservation requiring repair or rehabilitation;*
> *- identifying priority areas for biological diversity conservation and for ecologically sustainable use."*

A review of all regional land assessments trialled in Australia is probably long overdue. Such a review would help define optimum or realistic methodologies, timeframes, requisite data bases, suitable sizes for regions, composition of decision-making bodies, public participation, and success at legislative implementation, amongst other characteristics.

### 3.(ii). Consideration of land tenure and uses.

Within a defined region, conservation planning can involve either all lands (i.e. including freehold and leasehold lands) or be restricted to lands over which the crown still maintains control. As noted in the previous sections, there have been Australian examples of both approaches.

Complete investigation of a region has the advantages of:

- allowing greater flexibility in reserve choice and spatial arrangements;

- deriving a biologically meaningful regional picture of the distribution and abundance of species and environments;

- increasing the possibility of detection of rare species or communities or environments (especially so as because of bias in alienation some environments and communities may now occur almost completely on alienated lands) and thereby avoiding the danger that irreplaceable components of the environment may be missed. For example almost all of the remaining drier forested parts of Queensland occur outside public lands (P. Sattler *pers.comm.*);

- providing an analysis of historic changes in ecological patterns;

- interpreting the context of proposed reserves, for example whether they will be surrounded by cleared lands or buffered by relatively unmodified vegetation;

- recognising that for some environmental classes and some species, public land will be unable to provide adequate, comprehensive or representative reservation.

Examination of all lands rather than of only public lands has the disadvantages of:

- potentially alarming local industries and residents;

- possibly greater difficulty of access for survey;

- potentially far higher costs for reserve procurement;

- perhaps less efficient use of time, as resources are spent examining greatly modified landscapes.

Flexibility in reserve categories, including concepts of sanctuaries and leaseback arrangements, may defuse some of the concerns of private landholders. In some cases, sufficient conservation safeguards for important sites on private lands will be possible through Landcare or other community-based conservation programmes (e.g. HORSCERA 1992). Such off-reserve conservation is recognised as an essential component of the maintenance of biodiversity (e.g. BDAC 1992).

One consideration in assessing private lands for their conservation values may be an initial sorting by vegetation clearing or modification: usually it will be wasteful of resources to include assessment of cleared lands in an investigation of forest values. In some cases, however, particular forest communities may survive only as vestiges on otherwise mostly cleared private land, and there may be some scope for rehabilitation, reclamation or expansion of these fragments.

It is impossible to assess the state of the national environment and regional components of it without considering all land tenures. In order to consider forest loss and reservation, RAC examined forests on public, freehold and leasehold lands (Thackway 1990). In order to examine the environmental patterning or regionalisation across the continent, all lands were considered (Thackway 1992; Thackway & Creswell in press). In order to map the distribution of rare species, records from public and private lands were aggregated (Briggs & Leigh 1988).

The NFPS implicitly endorses the examination of conservation values of private lands:

> "*the Governments agree that the representative areas for reservation will, in the first instance, be drawn from Crown lands. Purchase of private land for reservation purposes is appropriate in cases where high conservation values are inadequately represented on Crown land and where complementary management practices on those private lands are unlikely to adequately protect those conservation values or provide for public amenity*"

This hierarchical approach can be formalised in reserve selection algorithms, such that proposals for procuring private lands for conservation reserves are explicitly last-resort options.

Another consideration in regional conservation using transparent and objective criteria is that existing reserves may be shown to not satisfy those criteria, or that a more efficient matrix of reserves can be constructed without some or any established reserves. The posssibility of forcing scrutiny of existing reserves according to currently defined criteria was advocated in the CRA submission to HORSCERA: "*The present distribution and boundaries of protected areas need to be reviewed*" and in the NAFI submission:

*"the extent and management of Australia's existing forest reserves should be evaluated. Boundaries of reserved areas may be changed, only after regional assessments of the ecological, economic, social and cultural forest attributes have been undertaken ... There is actually scope for increasing the effectiveness of the reserve system without actually increasing the area in reserves. For example this can be achieved by ... changing boundaries to take in a more representative sample of forest. Based on the logic put forward by RAC, it should not be automatically assumed that the total area of forest in reserves needs to be increased to achieve adequate representation".*

The NFPS notes that the appropriate ANZECC/AFC working group will consider "such issues as the design and rationalisation of reserve boundaries". Clearly there would be difficulties in "rationalising" or degazetting existing reserves:

- there may be substantial public disquiet or concern about the diminution or removal of treasured National Parks;

- there may be substantial costs for removal of infrastructure and managers, and conservation agencies may have already invested substantial resources into the reserve;

- precedents will be established for weakening of the relative inviolability of conservation reserves, such that the reserve estate may become more vulnerable to non-conservation uses or encroachment;

- it creates uncertainty in regional planning (for example the parks may move again with further information).

There are precedents for recommending the removal of areas from the protected areas system, including cases where the proposed changes have been undertaken because areas long previously declared as National Parks no longer matched current National Park qualification standards. Lind National Park in Victoria was recommended for degazettal by the Land Conservation Council, although subsequent public concern led instead to it being included within a larger reserve. As rationalisation will be a highly sensitive issue, it is important that public participation in the process is sought and encouraged at an early stage.

Kirkpatrick commented on a draft of this paper that "*the critical scientific fact that is relevant to this point is the medium to long term irreversibility of changes due to exploitative land use. For example, the area excised from the Mt Field National Park for timber production has suffered accelerated erosion ... with a replacement time of many millenia. Even the re-establishment of the tall eucalypt forests with rainforest understories after logging will be a matter of several hundred years. In contrast, an area of forest held in reservation will always be available for logging if political circumstances permit*".

A variant on this theme was suggested by RAC, that reserve boundaries may need to be flexible, and "*changes ... may be required to accommodate the effects of fire, changes in the age structure of forests and shifts in management priorities. Changes in boundaries may be needed also to mitigate the impacts of global climate change on the representativeness and viability of the reserve system*".

## 3.(iii). Ecological criteria for selecting reserves.

*(a) Introduction*

All lands have some conservation values. This value can increase or decrease with different management. The conservation value of a given piece of land is relative rather than absolute, and must be determined in some landscape context: for example if it now represents the only surviving remnant of a much diminished habitat some of its values are greater than if the habitat has remained largely intact. How should lands be evaluated for their conservation worth, and how should this evaluation be translated into reserve design? Margules & Nicholls (in press) provide one solution:

> "*Reserve networks should encompass a complete sample of the regional biota and sustain that sample into the future ... (this) gives rise to a simple explicit working definition of conservation value ... of a site (which is) the contribution it makes to sampling and sustaining regional biological diversity*".

There is an increasing recognition of the inefficiency and inadequacy of ad-hoc selection of conservation reserves, and a willingness to look to scientific or at least more explicit criteria as means toward improving the selection process (Margules 1989a). Before expecting this apparent new recognition to be manifested in substantial change in land-use decision making, it is sobering to note that Ride stated in 1975 that "*the present climate ... values the use of scientific criteria as the basis for the selection of (reserve) areas*". Ride's perception of the legitimacy and acceptance of rationality has taken a long time to begin to filter through to the land-use decision-makers, and many putative objective criteria remain poorly defined or hypothetical.

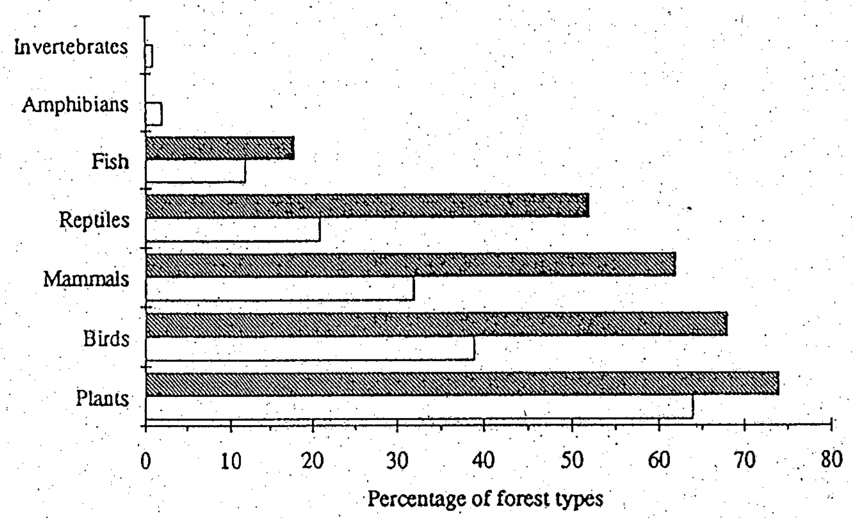
Nonetheless, it is critical to attempt to sharpen the scientific contribution, for Ride (1975) again points out that those making land-use decisions, and politicians answerable for them, can provide explicit values for many exploitable commodities of that land. Uncertainty about the basis of scientific criteria or the assessment of those criteria will lead to a reluctance to be perceived to be foregoing alternative and more tangible values. This point is apparent from the questioning by user-groups about the conservation (as opposed to exploitative) values of lands proposed for parks, for example CRA (Submission to HORSCERA 1992) noted:

> "*Since ... 1974, the increased emphasis on conserving representative ecosystems in national parks and reserves has been appropriate. However, not all land which has been put into such protected areas over the past fifteen years has been rigorously justified on any ecological basis. Despite this, there has been considerable weight given to the precise boundaries of parks and reserves, even where these are simply straight lines drawn on a map and without any ecological justification whatsoever*".

As noted by Gell & Mercer (1992), "*if the ... Ecologically Sustainable Development process has taught us nothing else, it has served to underscore the inescapable conclusion that in Australia we desperately need 'to get our science right'*". The NFPS offers conservation biologists an uncommonly explicit opportunity to define and apply their science for the substantial benefit of a nationally recognised goal.

One of the difficulties with assessing lands for conservation value and examining the extent to which a reserve network protects biodiversity is lack of information about biological diversity. This is conventionally defined at three levels: ecosystem, species and genetic (e.g. BDAC 1992). Sattler (in press) adds a higher level, that of landscape, which was formally recognised as a component level of biodiversity by the Queensland Nature Conservation Act 1992. Knowledge of each of these levels and their constituent components varies enormously. Generally, however, the availability of knowledge decreases from the ecosystem to the genetic level. Much more, for example, is known about the distribution of vegetation communities than the distribution and abundance of individual species or intra-specific genetic variability (Richardson 1983; Hopper & Coates 1990). Necessarily, species, assemblages of species and ecosystem types will be the major conservation 'units' for the immediate future although genetic and other relevant biological data should be factored into conservation considerations as they become available. Within species, more information is known about forest vertebrates than invertebrates and within these classifications, more is known about birds than reptiles or fish (Fig. 2).

Figure 2. The relative availability of species lists for different vertebrate taxa and invertebrates in forests (percentage of forest types), adapted from RAC (1992, p. 211).



### 3.iii.(b) *Environmental classes and classifications*

#### The role of environmental classification

Environmental classification and mapping serves two main roles in reserve selection: it acts as a code describing the distribution of individual species, and it enables a ready assessment of the extent to which environmental variability is captured in a selected reserve network.

Although there is widespread agreement that the species is the fundamental unit of biodiversity, that it is a (mostly) distinct and indisputable entity, and that capture of all species in the reserve network should be a fundamental goal of reserve design (Kirkpatrick & Brown 1991a), in most cases there is insufficient knowledge available to use the distribution of species as the foundation of a reserve assessment. Species distributions are usually extremely laborious to map, and it is impractical to map the distributions of all species. This lack of information has led to the widespread use of environmental classifications acting as surrogates for the distribution of animal and plant species. The extent to which they fulfill this role is a key measure of the value of different environmental classifications in reserve design. Unfortunately, there have been few examinations of the association of species with environmental classifications (Pressey in press), and until such relationships have been described, the interpretation of representativeness will continue to suffer major contextual problems (Mackey et al. 1989).

Explicit prioritisation for conserving environmental classes ahead of species has been used as another argument for classification forming a base for reserve design (e.g. Bowman & Whitehead 1993; Specht 1993), for example Specht (1993) noted:

*"A network of reserves, based on all distinctive ecosystems, would conserve a large proportion of the plant and animal species recorded in Australia ... In effect, this approach would channel limited manpower and resources into those conservation areas likely to achieve the greatest lng-term benefit, rather than dissipate these energies on the emotional issues of conserving a single 'rare and endangered' species".*

Arguments for the importance of including rare and endangered species as a major foundation for reserve design and conservation action have been widely presented (e.g. Kennedy 1990; Woinarski in press), and reserve design should clearly consider both representation of ecosystems and distributions of species (and perhaps especially rare and threatened species), as is stated in the NFPS.

The Australian environment is infinitely more complex than our descriptive ability. Nonetheless we can attempt to portray environmental spatial variability by using classification and mapping to simplify or provide shorthand descriptions of this environmental complexity. These classificatory schemes can form foundations for the allocation of reserves, as they permit relatively easy determination of the extent to which the environmental classes that they describe are included within a proposed reserve network. This utility is substantially improved if the information represented by the map is derived from retained point-based data and if these data are digitised in a manner suitable for GIS. Such quantitative data will also permit re-analysis of the classification to alter the number of classes, and hence change the mapping scale resolution. The reliability and utility of the data base is also clearly dependant on the density and dispersion of sampling points.

In terms of a national assessment of the reservation status of our environments, the data on which environmental classifications and descriptions are based must be collected in a consistent manner across jurisdictions. NFI and ERIN are attempting to coordinate and integrate collection of such data (NFI 1990; Bolton 1992), but this process has only recently begun, such that there are not yet any substantial point-based digitised data sets across Australian states which map or classify biological elements of the environment. NFI and ERIN (including the National Index of Ecosystems) have also considerably advanced the usefulness of classification schemes by providing a national overview and integrating the classificatory schemes previously used by individual States and Territories (e.g. Thackway 1989; NFI 1990; Kestel Research 1991; Bolton 1992)

Environmental classes (of whatever type) are elements of biodiversity (or influences upon biodiversity) which merit reservation in their own right. As such measures of their inclusion within reserves provide one assessment of how comprehensive a protected area network is, although this assessment may be heavily influenced by the choice of scale.

## Scale

Largely because environmental variation is continuous, any classification system adopted can be tuned for scale and resolution. The number of classes that are presented in a classification matches the perspective and needs of the analyst. Particular elements within the environments may be of more interest and hence subdivided in greater detail than for those elements of less interest. Flexibility in dealing with and portraying scale is important in considering reserve design and the concept of representativeness. Flexibility is substantially increased where point-based plots sample an environment intensively and systematically, and where hierarchical classification methods are employed.

It is trivial to say that forests, wetlands, woodlands and heaths are each represented in the national reserve network. These classes each include such extreme variation that one reserve would be incapable of representing the range of heterogeneity subsumed under that class. The problem to be faced is what is the optimum or appropriate resolution to consider the representation of environmental variation within a region?

Kirkpatrick et al. (1988) present one example of scale effects: for wet *Eucalyptus* forests in Tasmania, both classes defined at the first cut level of a classification of all sites are included in reserves, but if these classes are further subdivided the reservation status of the defined classes appears substantially worse (e.g. by the sixth level of the hierarchy (i.e. 22 classes) 23% of classes are unrepresented). In a more detailed analysis Pressey & Bedward (1991) concluded that:

1. the homogeneity of vegetation map units and the percentages of species represented by reserving them both increase as map scales become finer, at first rapidly and then more slowly;

2. the costs of mapping and of reservation to sample all the map units also rise with finer scales, but at a constant rate or more rapidly at fine scales;

3. cost-effectiveness of mapping, in terms of homogeneity and species reserved per unit cost, and of reservation, in terms of species reserved per unit area, is high at coarse scales and low at fine scales;

4. if cost-effectiveness were to determine the appropriate scale of vegetation mapping for map production and reserve selection, then:

- map units would be relatively heterogeneous floristically,
- many species would probably be absent from the reserve system;

5. representation of all species by reserving vegetation types requires:
   - reserve selection at a scale of mapping probably finer than that which could feasibly be produced,
   - a reserve area probably much greater than that which could feasibly be dedicated;

6. approaches to reservation of map units which maximise the likelihood of all species being reserved should be developed; some possible approaches are:
   - complementing reservation of map units with specific reservation of species which have restricted distributions, i.e. those least likely to be adequately protected by reserves selected only on the basis of map units,
   - identification of other indices of distribution of species, within and between mapping units, which influence the likelihood of their reservation,
   - relating reserved area per mapping unit to the heterogeneity of units,
   - basing maps on classifications which reflect species diversity or rarity.

Scales used may be determined pragmatically by (i) the size and environmental variability of the region being considered, (ii) the time allowed for assessment and (iii) the resolution and extent of baseline data. The scale chosen may be a case of the cloth cut to suite a series of resource demands or limitations.

The spatial resolution of biological and environmental data sets varies across the forest estate. Nix (1992) listed a series of gridded environmental data available at relatively high resolution, for various regions:

Australia-bioclimatic regions (3' resolution);
North Australia, north of 20 degrees S (7.5' resolution);
N.E. Queensland (12" resolution);
S.E. Australia (90" resolution);
S.E. Forests (9" resolution);
Tasmania (9" resolution);
Northern Territory (90" resolution); and
Queensland (90" resolution).

Scales of 1:100,000 or 1:250,000 have been found to be convenient and adequate for consideration of vegetation, land systems, etc. in regional studies (Queensland Department of Environment and heritage submission to HORSCERA).

Note that to some extent the difference between comprehensiveness and representiveness as defined in the NFPS is a scale question. As resolution is made finer (i.e. large scale maps) the variability within a community (i.e. that sampled by representativeness) can become explicitly recognised as distinct associations (and hence require inclusion under the criterion of comprehensiveness).

## Environmental domains

In part as a response to the shortfall in, and resources required to obtain, consistent biological data, there have been a series of environmental classifications of Australia, or parts thereof, based upon climatic and physical characteristics (e.g. Laut et al. 1975; Richards et al 1990; Nix et al. 1992). These schemes also have the proclaimed advantage of addressing process rather than of simply describing pattern (Nix et al. 1988) or recognising and delineating pattern in the environmental factors first and then relating this to the distribution of plant communities (Richards et al. 1990). A mapping of environmental domains, produced by CRES and ERIN, has been considered recently for devising a regionalisation for Australia (Thackway 1992; Thackway & Creswell in press).

One of the most established of environmental mapping schemes is AEGIS (Australian Environmental Geographic Information System), developed by Nix and colleagues at CRES. Richards et al. (1990) describe it thus:

> "*AEGIS is based on the concept that it is possible to define a minimum data set that will satisfy the needs of most land users. This minimum data set is based on those relatively stable and time invariant components of the environment that underpin key physical processes and biological responses. These are as follows:*
>
> *. climatic attributes (e.g. solar radiation, temperature, precipitation, evaporation);*
>
> *. terrain attributes (e.g., elevation, slope, aspect, relief, landscape position);*
>
> *. substrate attributes (e.g. geology, regolith, soil).*
>
> *Primary attribute data relating to these three components provide a basis for modelling light, temperature, water and nutrient regimes at landscape scales and through a more generic and process-based approach to predicting the distribution and abundance of plants and animals*".

This classification also has the flexibility (?arbitrariness) of being capable of further manipulation by possible weightings of the importance of any of the contributing attributes. H.Nix noted that for any environmental domain classification of Australia with fewer than 100 classes, that classification was dominated by climatic factors; when about 200 classes were defined terrain parameters became influential, and when more than 200 classes were defined substrate parameters became important.

The extent to which this combination of characters relates to the distribution of individual species has not yet been widely tested, however the arrangement of some of these characters in BIOCLIM (Busby 1991) has been shown to provide good models for the distribution of many elapid snake (Longmore 1986) and rainforest vertebrates (Nix & Switzer 1991), as well as for individual species of some conservation interest (e.g. Busby 1984; Lindenmayer et al. 1990). Both M. Brown and H. Nix (during the seminar discussing this paper) noted that surficial geology could not yet be satisfactorily included in environmental domain analysis, a problem given the good relationship reported between surficial geology and the distributions of many plant and animal species and communities (e.g. Woinarski & Gambold 1992).

Environmental domains have been used for modelling distributions and for designing and allocating reserve systems in several regions in Australia, including northern Australia (Nix et al. 1988), SE Forests of NSW (Richards et al. 1990) and Tasmania (Williams 1989; Lewis et al. 1991; Nix et al. 1992). Richards et al. (1990) recommended that "environmental domain analysis should be the primary guide to identify additional areas for reserves".

Kirkpatrick & Brown (1991a) examined the representation of forest types and higher plant species in a reserve network based on environmental domains for Tasmania, and found that: (a) domain analysis was more successful at capturing biodiversity when the size of the selected reserves was increased, (b) species with restricted distributions were poorly represented, and (c) some forest types and some species in high rainfall environments were over-represented. Kirkpatrick further commented on a previous draft of this paper: "*work done on predicting the distribution of rare species in Tasmania suggests that some types of distributions are not easily predictable using this technique. On theoretical grounds it could be expected that species with distributions that are largely a response to the continued availability of rare disturbance regimes, or are the product of migration history, would not be amenable to this type of analysis*". In their submission to HORSCERA, the ACF and WWF claimed that "*the poor representation of rare species is a critical failing of a physical domain approach to conservation planning (as) rare species are often more vulnerable to extinction*".

## Land systems

Land system mapping, a technique developed by CSIRO in the 1950s incorporates a range of topographic, vegetation and soil variables (e.g. Christian & Stewart 1968), essentially incorporating some biological characters into environmental domain analysis. This breadth of contributing factors gives the scheme potentially a reasonable likelihood of providing a good association with the distributions of individual species. However, land system classifications remain extremely subjective, and there has been little research on their ability to describe the distributions of plant or animal species (e.g. Pressey in press). Although very many regional land system surveys have been undertaken (e.g. Blain et al. 1985), these show substantial variation in scale, and many geographic gaps remain.

There have been a number of studies which have used land system mapping as the base for reserve selection procedures (e.g. Purdie 1985; Pressey & Nicholls 1989*a*; Pressey in press). Laut et al.

(1975; 1980) presented a basic land system description of all catchments in Australia. These were initially used as the basis for the National Index of Ecosystems (Thackway 1989), but have now largely been superceded by more advanced systems, such as AEGIS.

## Vegetation classification and mapping

Australia-wide vegetation maps exist (Carnahan 1976; AUSLIG 1990; NFI 1991), although these are of limited use as templates for reserve design because of their scale and lack of point-based digitised underlying data. However within the States and Territories, and for local regions within the states, more detailed vegetation maps have formed a pivot for reserve design (e.g. NT Government submission to HORSCERA; Pressey 1990; Kirkpatrick & Brown 1991a; Land Conservation Council Reports in Victoria (Frood & Calder 1987; Scott 1991)), and their overt representation of a tangible environmental feature has in some cases favoured their use ahead of synthetic climate/physical classifications. Further, the relationship of the distributions (and diversity) of many mammal and bird species with vegetation structure and floristics has been a touchstone of the description and definition of habitat, not least in Australia (e.g. Recher 1971; Newsome 1973). Specht (1993) provides an example of this argument: "*As most animals depend on particular plant communities for food, shelter, and nest-sites and since plant communities can be relatively easily studied and should be conserved for their own sake, one can readily substitute major plant community for major ecosystem*". Nonetheless, there have been remarkably few tests of the extent to which vegetation classification and mapping is useful for describing the distributions of animal species (e.g. Fox & Fox 1981; Woinarski & Tidemann 1990; Woinarski & Braithwaite in press).

Vegetation classification and mapping is itself a complex task, and a series of shortcuts has achieved widespread use. Interpretation of aerial photography or satellite imagery can provide a quickly derived estimate of canopy cover, tree height and dominant tree species. As this information is also directly related to commercial timber value, mapping of forest types has wide currency. While the simplicity of this approach and the sparseness of data required allow the rapid production of maps, these also represent serious disadvantages when assessing the value of forest typology as a surrogate for the distribution of individual species.

Much more intensive field work is required to complete full inventories of plant species at a sufficiently intricate network of sites to produce a floristic classification and map of plant communities. For a number of reasons (Kirkpatrick & Brown 1991a), a mapping of these floristic communities may bear little relationship to that of forest types. Vegetation community description and mapping has several distinct advantages over forest typology:

- it offers more detailed information on differences in diversity within and between units;
- its resolution can be manipulated to any specified level;
- it provides information on the distribution of individual species; and
- it allows the detection of rare or restricted plant communities.

Other than its laboriousness, vegetation community classification and mapping suffers the same disadvantages as that of other environmental classifications: the units described are somewhat artificial constructs representing or distorting an underlying continuum, and they generally provide only an instantaneous description, hence failing to portray possible successional dynamism. They also provide little structural information, yet vegetation structure, and the availability of hollows, is an important determinant of habitat for many forest animals (e.g. Smith & Hume 1984; Lunney 1991). P. Sattler also noted in comments on a previous draft of this issues paper that a given floristic community may occur across a range of geology or soil types, and that this environmental variation should be properly considered in reserve design.

### Integration of plot-based environmental data

Recently, NFI and ERIN have coordinated the disparate environmental pro-forma used in different States, and established substantial common ground in the selection of what environmental attributes to measure, how to measure and code them, plot size, and classificatory techniques (NFI 1990; Bolton 1992; Dyne 1992). The attributes include many of direct importance to animals (e.g. hollows, water sources), such that the resulting environmental descriptions may be expected to have substantial power to predict animal distributions. Such an integrated scheme should substantially improve the value of environmental classification and mapping.

Note that in some cases mapping of environmental variation may not be mandatory for conservation assessment and reserve design: the analysis and classification of systematically and intensively collected data may provide sufficient information.

### Choice of templates

No classification will provide the ideal template for species distributions. As a simple example, within one study area the distributions of birds and mammals could be relatively well described by vegetation characteristics, but that of reptiles was far better explained by substrate conditions (Woinarski et al. 1992a; Woinarski & Gambold 1992). Likewise patterns in the distribution of snails in Kimberley rainforests varied appreciably from those of vertebrates (McKenzie & Belbin 1991). Individual species have idiosyncratic distributions.

The task then of choosing what scheme to use for a particular area is at least partly pragmatic, determined by what schemes are available (and at what scale) and what resources are available for increasing the resolution of existing schemes or in undertaking the fieldwork required to prepare new schemes. The problem with such pragmatism is that variation between regions in the environmental classification used as the reserve template will result in severe problems in attempting to compare conservation status between regions and in deriving national overviews.

Of course, representation of environmental variation within a selected reserve network is improved where several environmental classification schemes can be combined, either simultaneously (by layering to form a new set of classes as the product of the constituent classifications) or in series (by examining the representation of the classes of scheme B in a set of proposed reserves chosen on the basis of scheme A). Preference for one scheme over another can be accommodated easily by weighting the required minimum representation thresholds.

Choice may not be critical if a range of classification schemes largely tell the same story. In some cases good agreement has been demonstrated between various schemes, for example Richards et al. (1990) reported that a forest type classification in the South-east forests was tolerably congruent with a floristic community scheme, and that both showed clear similarities with an environmental domain scheme. Kirkpatrick & Brown (1991a) reported less good matching between environmental domains and floristic communities in Tasmania. Kirkpatrick also noted in comments on a previous draft, that "*vegetation mapping units are also likely to* *be better predictors than environmental domains, because they classify on biological grounds, not on the grounds of more remote factors. They are also likely to be better predictors than land systems, the units of which are geomorphically based, and contain catenas of vegetation types"*.

What proportion of each environment should be reserved?

The principles of comprehensiveness, adequacy and representativeness as currently defined do not inform the specific issue of 'what proportion of each identified environment should be reserved?'. The RAC addressed the issue of minimum reservation. Various submissions were made to the Inquiry about possible minimum threshold levels.

The ACF suggested that reservation targets for Australia should be set at 30% for disturbance-resilient communities and for species in general, 60% for communities and species that are rare or vulnerable to disturbance, and 90% for communities and species that are endangered by current disturbance regimes or climatic change.

The IUCN specifies minimum levels of representation in reserves that are used widely by land management agencies in many countries to assess reserve 'adequacy'. The IUCN guidelines set representation at 5% of the existing area but recent recommendations have proposed that this reservation target should be increased to 10% for the 'main ecological regions of a country' and that the new target should be achieved by 2000 AD (IUCN et al. 1991, p. 179).

In the ANPWS submission to RAC it was stated that no clear and easy rules for defining adequate representation exist. Rather, in some instances adequacy might require the reservation of all examples of an ecosystem whereas in other circumstances only relatively small levels of representation might be adequate to meet conservation objectives.

Overall, the RAC Inquiry was unable to define criteria for what constitutes adequate reservation. The Inquiry recognised the need for such rules of thumb in the absence of alternative approaches, and it recommends that more attention be given to the question, concluding:

> "*representation thresholds should be established on the basis of a flexible approach that takes into account knowledge of the range of factors relevant to the conservation of species and ecosystems, including rare and endangered status, the extent of loss or modification since pre-European times, present distribution and location, surroundimg land uses and proximity to high-use areas, vulnerability to disturbance and population viability.*" (RAC 1992; p. 199).

This flexible approach should not be seen as complete *laissez-faire*: some criteria need to be established, even if those levels vary between different communities or species. Selection programs such as CODA need levels to operate on. Also, if conservation biologists aren't forthcoming in setting thresholds for adequacy, then thresholds are inevitably established anyway, either by default or by the proponents of alternative land-uses.

Richards et al. (1990) provided one example of explicit but flexible adequacy thresholds:

> "*a more flexible method than the specified minimum proportion ... whereby a higher proportion of small and more unusual domains and of domains where significant disturbance has taken place, would be conserved. To achieve this objective, it adopted the principle that not less than 5% and up to 100% of each domain be reserved but with a minimum reserve area of*

*$10km^2$. For this **rule a)** to apply, the domain would be largely intact and fully forested. If the vegetation on a domain is fragmented by clearing or partial clearing, **rule b)** would apply so that a larger minimum area of the domain should be conserved where possible, and the Committee suggests this be $20km^2$ ... some extensively cleared domains would need to be partially reforested to achieve the desired minimum level of reservation".*

Another issue, although defining comprehensiveness more than adequacy, is whether aiming to include all environmental classes within reserves is realistic. Based on submissions from the Queensland Department of Environment and Heritage and Sattler (in press), HORSCERA (1993) recommended that a protected area system should set a minimum target of at least 80% of bioregional ecosystems (with the conservation requirements of the remaining 20% being met by off-reserve measures). A problem with this threshold is that the unreserved residue probably consists of those classes in most parlous conservation status, being "difficult" to include in a reserve system because they are the most economically valuable, already much modified or fragmented or mostly on alienated lands. As noted previously a range of inquiries and processes, including the NFPS, has endorsed the concept of comprehensiveness as a central theme of reserve design: this implies that a sufficient reserve system must contain all environmental classes defined.

### *3.iii.(c). Cases apart?: old growth forest and rainforests*

Old growth forests

The conservation adequacy and management of old growth forests has been controversial - the community is concerned that these ecosystems are adequately protected and conserved in perpetuity. As well as supporting a diversity of species often largely or totally dependent on these forest ecosystems for habitat, old growth forests provide a range of 'essential life-support' services to humanity including non biological and ecological values. Many of these values are intangible and stem from personal experiences such as beauty, wilderness or spirituality.

Old growth forest ecosystems have particular value under the following Criteria for the Register of the National Estate:

- A.2 Importance in maintaining existing processes or natural systems at the regional or national scale.
- B.1 Importance for rare, endangered or uncommon flora, fauna, communities, ecosystems, natural landscapes or phenomena, or as wilderness.
- C.1 Importance for information contributing to wider understanding of Australian natural history, by virtue of their use as research sites, type localities, reference or benchmark sites.
- D.1 Importance in demonstrating the principle characteristics of the range of landscapes, environments or ecosystems, the attributes of which identify them as being characteristic of their class.

Note however, that unlike wilderness which is explicitly recognised in National Estate criteria, old-growth forest is not specifically identified within this framework.

Various definitions of old growth forest ecosystems have been proposed (Table 6). RAC (1992) found that "*the concept of 'old growth forest' encompasses a complex mixture of the measurable biological attributes of forest ecosystems and a range of intangible personal values associated with experience (direct or indirect) of the forest environment. It is this combination of the measurable and the immeasurable that creates the difficulty in defining and estimating the extent of old-growth forest ecosystems.*"

Most definitions of old growth forest typically include some or all of three criteria: the absence of disturbance associated with European activity; the presence of old trees that are sometimes described as 'over-mature' or 'senescent'; and high structural diversity (that is, many different growth forms). The concept of old growth has been used to refer to the oldest forest that has remained relatively free of European disturbance within a region. But it can be difficult to unambiguously identify such forests. Consequently, the RAC (1992) called these forests 'unlogged'- which could include areas "*lightly logged before logging activity was recorded as well as relatively young regrowth forests, previously undisturbed by European activity, that have resulted from natural disturbances such as wildfires.*" There was however disagreement in the community as to the approach of the RAC on this matter.

The RAC (1992) found that the term 'old growth' had been used to emphasise the ecological qualities of stands of trees approaching the limit of their life span. The Inquiry nominated to call such forests 'ecologically mature'. These forests are often not, or only slowly, increasing in biomass and they may support a relatively high diversity of species.

The RAC limited its use of the term 'old growth forest' to those forests that are both negligibly disturbed and ecologically mature and have high conservation and intangible values. It recommended that use of the term old growth be used only in relation to those forests meeting this definition.

A national workshop sponsored by NFI was recently held to consider definitions and attributes of old-growth forests (Dyne 1992). Relevant attributes and characteristics of old-growth forest were identified, and are generally consistent with those presented in Table 7.

The representation of old growth forest is a simplification of ecological reality since many native forests cannot be easily positioned along an age gradient. Similarly, the gradient of decreasing disturbance is more complex than the representation suggests because disturbances can be 'natural' or the result of human intervention. Both of these factors complicate the identification and appropriate reservation of old-growth forest.

According to the RAC (1992), "*the occurrence of fires, either deliberately or accidentally lit by humans, does not necessarily reduce the old-growth characteristics of a forest. Intense wildfires may kill most trees and thus severely modify any characteristics associated with maturity, but mild fires, including occasional prescribed burning, may have little impact on these same characteristics.*"

The Victorian Department of Conservation and Natural Resources is undertaking a survey of old-growth forests in East Gippsland. P.Woodgate provided a rationale for definitions used in that study:

> "*The study team considered that, for a given forested vegetation community, the most significant old-growth*

*characteristics were represented by stands that comprised the oldest possible growth stage and least disturbed forest for that community. These stands constitute old-growth forests. The study team further considered that old-growth characteristics, in a continuum of diminishing presence, were also to be found in younger stands, or more disturbed stands. The point at which a particular stand no longer constitutes an old-growth forest is most subjective and likely to be delineated only through arbitrary and dual assignment of a growth stage threshold and a disturbance level threshold.*

*A whole suite of characteristics has been identified as belonging to the broad perceptions of what constitutes old-growth forests. Only a small number of these can be used in practice to delineate these forests. In our study they comprised: growth stage, crown density, floristic community and type of disturbance (human induced; including clearfelling/selective logging, fuel reduction burning, agricultural clearing, mining and grazing, and naturally induced, with wild-fire being the only example).*

*The growth stages were described by some quite precise morphological characteristics developed by Jacobs in 1955 for* ***Eucalyptus pilularis*** *(Blackbutt). These were readily detected on aerial photographs and could be applied with confidence to most eucalypt dominated communities. However, non-eucalypt communities such as Banksia Woodland required their own suite of morphologically defined characteristics in order to recognise 'old-growth'.*

*It was this requirement which drove the need to identify floristic communities.*

*Forest was defined as all woody vegetation greater than 10% crown cover and 2m tall to include the broadest spectrum of woody vegetation types. This definition opens up the* *possibility of including mallee, brigalow anmd other woodland communities in the consideration of old-growth forest.*

*Consequently, the study team has recommended a definition that specifies old-growth as negligiblly disturbed forest dominated by its oldest growth stage. A fuller and more descriptive definition will be included in the report of this work which is due to be published within a few months.*

*The definition developed for the East Gippsland study clearly has practical application. It may well be able to form the basis of a nationally applicable definition. In view of the number of studies that are just about to commence around Australia it is important that the issue of the definition be dealt with as soon as possible. Perhaps the best way to resolve this question is to convene a technical sub-commitee out of the joint ANZECC/AFC process, with ERIN, the NFI and other key parties involved."*

An operational procedure for determining the extent of old growth forest was outlined in a recent national workshop and the NFI was proposed as the survey coordinator (Dyne 1992). The true extent of old growth forests in Australia is unknown - the situation being summarised well by the Australian Heritage Commission submission (Submission 85c, p. 30) to the RAC Forest and Timber Inquiry:

*"There is a lack of detailed information about the types, extent and location of the old growth forests remaining in Australia. Thus it is not possible, at present, to say exactly how many types of old growth forest exist, or how rare various types may be."*

In the absence of comprehensive and reliable estimates of the extent of remaining old-growth, the RAC Forest and Timber Inquiry used unlogged forest as a surrogate for these ecosystems. At the same time, the Inquiry explicitly stated that unlogged forest is not equivalent to old-growth forest. Rather, the RAC considered old-growth forest to be an ecological subset of unlogged forest. On the basis of this limited approach, the RAC (1992) reported the following:

- Approximately 22 per cent of state forest is unlogged.

- Approximately 64 per cent of conservation reserves is unlogged.

- Approximately 38 per cent of all remaining rainforest is unlogged.

- Approximately 18 per cent of all remaining eucalypt forest is unlogged.

- Approximately half of all remaining eucalypt forest in conservation reserves is unlogged.

- For three eucalypt forest groups, south-eastern dry forest and woodland, north-eastern coastal eucalypt forest, and river red gum forest, less than 10 per cent of the total remaining forest is unlogged.

The RAC (1992) also estimated how much of the forest estate is unlogged and currently represented in the conservation reserve system:

- Approximately 14 per cent of all remaining unlogged forest and woodland is in conservation reserves.

- Approximately 9 per cent of all remaining unlogged eucalypt forest is in conservation reserves.

- Apart from the mangrove and swamp forest group, no forest groups have more than 27 per cent of their remaining unlogged area in conservation reserves.

- Six forest groups have less than 10 per cent of their remaining unlogged area in conservation reserves.

Even given the gross inadequacies of using 'unlogged' forest as a surrogate for estimating the extent of the remaining old growth forest ecosystems in Australia, the limited inclusion of old growth forests in conservation reserves is strongly evident.

A further complication with providing adequate reservation for old-growth forests is that they derive from younger-growth forests. Reserved old-growth forests may gradually (or precipitously) decline in area because of natural disturbance events, most notably fire. Without long-term planning through protection of forests of younger ages, old-growth forests will disappear from the landscape.

P. Woodgate provided further comment on reservation of old-growth forests:

> "*There are 3 considerations in designing reserves for old-growth forest:*
>
> *(i) representation of old-growth within each floristic community*
>
> *(ii) representation of younger forest which is currently negligibly disturbed (this is future old-growth)*
>
> *(iii) ensuring that negligibly disturbed non forest communities, present in the overall mosaic of forest communities, are used to maximise the contextual characteristics (naturalness) of old-growth stands.*

*(note: where I use the word representative I also intend to invoke the concepts of adequacy and comprehensiveness).*

*As with all forest, there are dynamic and cyclic properties to old-growth forest. A rigid reserve system based on todays 'old-growth' stands that fails to recognise these properties strongly runs the risk of becoming irrelevant at some future time. Moreover the small suite of mappable characteristics that scientists will use over the next few years to delineate old-growth provide no certain measure of the many secondary characteristics (such as faunal attributes, functional process and intangible values) that may well warrant equal consideration. It is these factors that underline the need to have a responsive approach to the long-term delineation and management of these forests".*

**Table 6.** Some definitions of 'old growth' given to the RAC Forest and Timber Inquiry (1992, p. 138):

*"The New South Wales Government submitted that old-growth forest is an area of natural forest*

*1. showing relatively few or no signs of direct disturbance by human activity;*

*2. with, in its upper storey, many specimens of trees which:*
   *a) are overmature or senescent, and*
   *b) appear to be in the upper limits for the expected longevity of the trees for their site and species, and*
   *c) carry frequent crown and stem hollows suitable as nesting or roosting sites for birds, bats and arboreal mammals; and*

*3. with the stems of dead trees standing or present on the forest floor. (Submission 200, Forestry Commission of NSW section, app.14, p.2).*

*The Victorian Government submitted,*

> *Old growth, or ecologically mature forest (defined here as those areas least disturbed by past logging) is recognised as having habitat characteristics that are not found in younger forest. These characteristics derive from generally high structural diversity and relate to a high availability of nest and den sites and foraging substrates. These habitat characteristics make old growth forests critical for some species including hollow dependent species, some insectivorous birds and certain lizards. (Victorian Government Submission 167, p.10).*

*The Australian Conservation Foundation defined old-growth forest as, 'forest that has not been, or has been minimally, affected by timber harvesting and other exploitative activities by Australia's European colonisers' (Submission 322, p.45). The Foundation commented further,*

> *The old growth refers to the fact that the current forest has not had a history of recent disturbance by human intervention, but has been regenerated and maintained by natural processes. Many of these forests are indeed old in age, and this is why the phrase old growth came to be used. A more appropriate term is 'undisturbed forests' as they may indeed be naturally multi-aged or even young regrowth, providing the regrowth was initiated by a natural event. (Submission 322, p.45)*

*The Australian Heritage Commission discussed in detail the concept and values of old growth forests:*

> *Old growth forests are communities which are the older developmental stages of the forests, and characterised, at least in part, by low growth rates of trees in the tallest*

> *stratum; low to zero biomass production of trees in the tallest stratum; trees in the tallest stratum are mature to senescent; trees in the tallest stratum have very high biomass and are usually more than c.100 years old. (Submission 85c, p.28)*

*The Western Australian Government submitted, 'old growth forest is synonymous with virgin forest -- ie, forest which has been largely unmodified by timber cutting or agricultural clearing since the time of European settlement' (Submission 194, p.37).*

*Writing in response to the Forest and Timber Inquiry's draft report discussion of old growth, the Western Australian Department of Conservation and Land Management commented,*

> *This definition [that is, the one used by the Inquiry] is in fact that of virgin forest which may consist of forest of any age and which may or may not have old growth characteristics ... The emphasis on the absence of signs of European activity, rather than the actual old growth characteristics themselves is inappropriate. The absence or otherwise of European activity per se has no meaning in ecological terms. How old growth characteristics were developed is much less important than the fact that they exist. (Submission 451, p.3)".*

---

**Table 7.** Some attributes of old-growth forest ecosystems, including characteristics that may alter old-growth status and characteristics relevant to policy and management; adapted from the RAC (1992).

Characteristics indicative of ecological maturity

- structural and compositional properties
  - relatively large trees and other plants for the area
  - relatively old vegetation in terms of developmental stage
  - presence of large crown gaps (in some forest types)
  - characteristic biotic composition
  - presence of tree hollows (in some forest types) or fallen logs
  - presence of indicator species
  - presence of certain growth forms (for example, epiphytes in some forest types)
- functional properties
  - characteristic levels of gross and net productivity
  - stable nutrient cycles, high litter levels (in some forest types)
  - low or negative changes to standing biomass
  - low turnover of species, forest structure and ecosystem functioning

Characteristics that alter old-growth status

- physical alteration or disturbance
- biological disturbance

Characteristics relevant to policy and management consideration

- aesthetic considerations
- wilderness quality
- size of the forest stand
- spatial context of the forest
- public perception and opinion
- ease of long-term maintenance
- ownership

## Rainforests

Rainforests differ from many *Eucalyptus* forests in now being characteristically patchily distributed, to the extent that much of the rainforest estate is too small to be mappable at most scales (e.g. Russell-Smith & Dunlop 1987; Kimber et al. 1991). This patchiness may create special conservation problems (Winter 1991; McKenzie & Belbin 1991; Russell-Smith et al. 1992; House & Moritz 1992):

- single patches chosen as representative of a rainforest community are unlikely to contain a high proportion of the species of that community (Russell-Smith & Bowman 1992).

- rainforests often contain a high proportion of endemic and specialised species (Adam 1992).

- many rainforest plant and animal species occur in only a small number of patches, and the distribution patterns across patches of such rare species tend to be specifically idiosyncratic (Solem & McKenzie 1992; Duff et al. 1992; Russell-Smith & Lee in press).

- vertebrate (and invertebrate) vectors are often important in permitting dispersal of plant species between patches and maintaining the genetic diversity of species within patches (Jones & Crome 1990; Woinarski et al. 1992b). In turn, these animal species may persist only if floristic diversity is maintained within patches and the number and size of patches is maintained in the landscape (Crome & Moore 1990; Russell-Smith et al. 1992).

Rainforests may also be more vulnerable to disturbance than are neighbouring forests, and this may especially threaten small rainforest patches (Russell-Smith & Bowman 1992). Russell-Smith et al. (1992) and Russell-Smith & Bowman (1992) have argued that active local management may be required to maintain individual rainforest isolates, and the sustainability of gene flow between patches will require the protection of diffuse connections (e.g. riparian corridors) and careful thought about the spatial arrangement of patches chosen to be retained.

In part because of their general relative susceptibility to disturbance, the dynamic relationship between rainforests and *Eucalyptus* forests can be heavily influenced by management practices. The fluidity of this relationship, and the sometimes slow pace of succession from *Eucalyptus* forest to rainforest has led to definitional disputes and failures to include incipient rainforests or "mixed forests" within rainforest reserve systems (Cameron 1992; Kirkpatrick 1992).

In designing forest reserve networks, rainforests may need to be accorded some special recognition. This is written into legislation in several States (e.g. Victoria, New South Wales).

### 3.iii.(d). *Species.*

Fitting individual species in

Reservation based on procuring representative areas of all environmental classes will not ensure that all species will be included, or will persist, within the reserve system (Pressey in press).

Some species will be omitted because:

- their distribution is not associated with the environmental classification used;

- their distribution may be associated with the environmental classification, but they occur patchily or rarely within a given class and those limited occurrences may not have been included within that area chosen to represent the preferred environmental class.

Other species initially may be included within a chosen reserve network, but will not persist because:

- their habitat may require a combination of environmental classes not realised in the reserve network (e.g. edge species, Regent Parrot: Burbidge 1985);

- their use of the landscape undergoes substantial spatial changes, with season or with rainfall events (e.g. mobile and migratory species: Ride 1975; Woinarski et al. 1992b);

- they depend upon a particular successional stage of the environmental class (e.g. MalleeFowl, which is largely

dependant on mallee which hasn't been burnt for at least 30 years: Benshemesh 1990);
- their population size and/or required area of suitable habitat within the chosen reserve network is too small;

- deleterious processes not necessarily connected with reserve actions may be leading to population decline (e.g. foxes [Kinnear et al. 1988]; parasites [Tidemann et al. 1992]).

As recognised in BDAC and ESAC (refer to Appendix B) this group of species merits special consideration in reserve design, and there is wide acceptance that reserve design based upon representing environmental variation must be complemented by an examination of the needs of this group of species (ESAC 1992). Meeting these needs may require carefully considered design of the representative reserves and/or specific reserve allocation. The latter may be most appropriate for extremely localised species, or for species in which a large proportion of the population breeds (or roosts) in only a small number of colonies.

While special attention for these species is appropriate, this may present formidable difficulties. It is by no means always apparent which of these difficult species occur in a region nor into which of the above categories they fit. There may also be only limited capacity for a reserve system to meet all of their idiosyncratic individual requirements.

Pressey (in press) present some approaches to addressing these problems. Steps towards a solution include:

**- rigorous investigations into the relationships between land classes and the distribution of species;**

**- focussing attention on rare and threatened species;**

- **identifying discrete areas or dispersed features which provide critical resources for individual species;**

One ingredient of this process is the identification within the landscape of "hot-spots" or localised sites with high diversity (e.g. Dwyer 1972). One problem with the identification of such sites is that they are rarely coincident for different taxa, for example in the United Kingdom animal and plant hotspots do not coincide (Georgiades & Balmford 1992), and in the Kakadu Conservation Zone areas with high diversity for birds, mammals and reptiles were in different locations (Woinarski & Braithwaite 1990). Hotspots also tend not to include rare species (Georgiades & Balmford 1992).

For arid Australia, Morton (1990) argued that the persistence of species within a region depended upon their access to, and the continued health of, limited but particularly fertile (drought-resistant) sectors. More recently, this "refugia" concept has been extended to seepage areas within tropical *Eucalyptus* forests (Braithwaite 1990; Williams et al. in press). Caves suitable for the roosting and breeding of bats provide another example of localised sites which require retention for the conservation of part of the forest fauna. On a broader scale, Nix (in press) identified mid-central Queensland as providing a critical wintering area for migratory bird species from south-eastern Australia. The management and conservation of some species retreating because of climate change may also require the anticipatory identification and reservation of particular topographic/vegetation combinations which can serve as refugia.

- **autecological research on species which require several environmental classes;**

- **analysis of the life history traits of the species present in order to provide an informed assessment of**

**which species may require more detailed surveillance** (the "elimination planning" of Kirkpatrick & Brown 1991);

**- predictive modelling for the distributions of particular species.**

The establishment of relationships between environmental variation and the distribution and abundance of individual species or groups of species is a cornerstone of ecology. Where these relationships are satisfactorily demonstrated and where the environmental factors concerned can be mapped, it is possible to predict distributions of individual species. This provides a powerful tool for considering conservation planning. Examples of its application for reserve selection include birds in the South-east forests (Braithwaite et al. 1989), Leadbeater's Possum (Lindenmayer et al. 1990) and *Eucalyptus* species in northeastern and southeastern New South Wales (Austin et al. 1984, 1990; Austin 1987; Margules et al. 1987). Recent reviews have been published by Ferrier (1991) and Neave & Norton (1991).

## Distributional data

Accurate and comprehensive distributional data are available for only a small proportion of species. Best information is available for conspicuous vertebrates (e.g. national atlas for birds (Blakers et al. 1984), state atlasses for mammals and reptiles (e.g. for Victoria and Western Australia)) and for rare species (e.g. ROTAP).

Maintaining and regularly updating national geographic data bases on rare species is a key component of accomodating rare species into the selected reserve network within a region. This procedure is endorsed by ESAC and BDAC, and is already undertaken nationally for plants ("ROTAP": Briggs & Leigh 1988) and on a State or region basis for many taxa (e.g. Pressey et al. 1991). There does not appear to be any immediate intention for a central compilation of detailed distributional data for endangered vertebrate species (J.Hicks [ESU] pers. comm.), a surprising neglect given the endorsement of this procedure by ESAC and BDAC, and the critical importance of consolidated distributional/abundance data about endangered species for the process of reserve selection.

McIntyre (1992) has cautioned that biases in listings of rare species (e.g. widespread species that are insidiously declining tend not to be represented) lead to taxa at risk not being properly considered in regional land-use planning.

In comments on a previous draft, Kirkpatrick noted:

> *"we do have good distributional information for a very substantial number of species (e.g. birds, many other vertebrates, large numbers of higher plants, including most of the rare and threatened species). Limited biological distributional information is likely to provide a better predictor for conservation of biodiversity than environmental data because: some of the biodiversity is directly included within the analysis; non-included elements of biodiversity are likely to be functionally related to those included; the most endangered elements of biodiversity are likely to be included disproportionately in the data set; many endangered elements of biodiversity do not have distributions that can be predicted from environment, rather having distributions that are largely a function of disturbance regimes, successional stage and migration history."*

Data on both the distribution and abundance of species is preferred for conservation evaluation. Abundance data are important as they provide a basis for assessing the relative importance of various habitats for species, as opposed to simply knowing that the species is present or absent at a particular site.

Most of the biological data currently available for conservation assessment is restricted to presence/absence from various sources including specimen-backed observations from herbaria and museums, opportunistic sightings (e.g. road kills) and field survey. The age and reliability (in terms of the species actually observed and its precise location or geocode), of these records varies greatly, as does their ease of accessibility for analysis. In terms of the latter, much of the specimen-backed data held for invertebrates is yet to be transferred to computer. Imprecision of location (e.g. Richards et al. 1990; Nix and Switzer 1991; Chapman 1992) and other factors may limit the conservation utility of biological data, particularly in regard to spatial modelling (Austin 1991; see below). Most of these difficulties have been well known for some time and numerous attempts have been made to rectify the situation. More recently, considerable emphasis has been given to standardising the types of data collected (e.g. minimum data sets) and the way this is done (e.g. data quality and precision), and improving survey design (e.g. Austin & Heyligers 1989; Margules & Austin 1991). For data standardisation and collation, ERIN and the NFI have conducted workshops on key attributes and guidelines for assessing biota (eg. Bolton 1992; Dyne 1992), and establishing MOUs for the sharing of data (AustFor 1992). Similar efforts have been made by the AHC regarding national estate values, which include biological values. Even so, much more work remains to be done in this area - thus the assessment of conservation adequacy must be seen as an on-going and iterative process.

Some ingenious quantitative methods have been developed to use very limited biological data to aid understanding of the distribution of species. One example is BIOCLIM (Nix 1986; Busby 1991), which can be used to generate useful predictions based simply on species' presence data. Another more powerful example is statistical modelling, such as GLIM (e.g. Nicholls 1991), where data are available for both presence and absence. However, efforts to enhance the use of existing data can only go so far.

Even where species' observations can be precisely located in the landscape, information on a range of site attributes, that cannot be estimated remotely, may be required to achieve the maximum information from point-based observations. This and other considerations mean that field surveys will be required in many instances to assess the actual complement of species present within sites identified as options for reservation.

Distributional data, even where precise and comprehensive, are not sufficient ends. Knowledge of the autecology of species (such as habitat preference, population dynamics, breeding requirements, movements, etc.) are necessary to determine management requirements within reserves, and to better inform reserve selection (e.g. Laurance 1990) and off-reserve management.

## Role of predictive modelling

The predictive modelling of biological data has several important roles for supporting the design, management and monitoring of a forest reserve system. These roles include to:

- predict spatially the likely occurrence of species and assemblages of species in areas that have not been sampled (e.g. Braithwaite et al. 1989; Margules & Stein 1989; Austin et al. 1990; contributions in Margules & Austin 1991; Yee & Mitchell 1991). Note that some probability level may need to be set in order to presume from predictive modelling the presence of a given species within a reserve (e.g. M. Brown (*pers.comm.*) is using a threshold of 80%);

- predict the minimum areas of habitat required by species to maximise the probability of their persistence in the long term (e.g. Possingham & Noble 1991; Lindenmayer et al. 1991; Boyce 1992);

- predict and/or mitigate the likely impacts of various threatening processes on biota (e.g. Norton & Possingham 1991; Austin 1992; Burgman & Lamont 1993);

- assess the extent to which certain areas may be more or less exposed to climate change and other global changes, and local changes (e.g. 'downstream effects' within common water catchments) (e.g. Moore & Gallant 1992; Austin 1992);

- design cost-effective field surveys for a more complete assessment of forests which are identified as candidates for reservation (e.g. Austin & Heyligers 1989; Margules & Austin 1992);

- locate reserve 'buffers' and 'corridors' for enhancing the connectivity between reserves within complex landscapes (eg. contributions in Saunders & Hobbs 1991; Shepherd et al. 1992);
- differentiate between "source" (resilient) and "sink" (marginal) habitats (e.g. Pulliam 1989); and

- identify key species for monitoring or to identify the key processes influencing the likelihood of persistence of species of concern to management such as rare and endangered plants and animals (e.g. Possingham et al. 1993).

One technique that could play an increasing role in reserve design and management is population viability analysis (PVA). This technique was supported by the ESD Working Group on Forest Use (ESD 1991) and the RAC (1992), and has been recommended for use in regional case studies supported by the National Forest Inventory (AustFor 1992). The RAC (1992) recommended that PVA techniques "be applied to land use decision-making processes for forested land."

PVA is an explicit, quantitative technique for modelling the population dynamics of a target species based on its ecological response (Possingham & Noble 1991; Boyce 1992). Although relatively new in Australia (Clark et al. 1991), the technique has been used under a range of conditions overseas (e.g. Thomas et al. 1990; Dennis et al. 1991). PVA is used to provide information about the relationship between population size and the probabilities of extinction under different management scenarios. As such, it permits the critical issue of extinction across the entire landscape to be addressed, taking into account conservation reserves and off-reserve management (Possingham et al. 1991). The technique provides an explicit basis for deciding the minimum area of individual reserves and the optimum spatial arrangement of a reserve network within the landscape (see Thomas et al. 1990).

Detailed knowledge of the population biology (e.g. rates of fecundity, mortality and dispersal for different cohorts; major forcing environmental variables) of the target species is preferred to use population viability analysis techniques. However, recent models allow sensitivity analyses to be undertaken on various life history parameters quickly (Possingham et al. 1991), thereby providing a means to isolate the critical processes influencing the likelihood of a species' persistence or variables for which more information is required before a reliable analysis can be performed (Possingham et al. 1993). PVA can also be used to identify ways of eliminating unwanted species such as exotic plants and animals.

Important questions follow from the use of PVA for informing decision on the appropriate size and spatial arrangement of reserves:

- what is the lowest level of probability of extinction acceptable for species, should this vary for species with different conservation status (eg. endangered, rare, vulnerable to extinction, keystone species), and can these levels be identified?

In comments on an earlier draft of this issues paper, H. Possingham noted that "*probably the best handle we can get on the adequacy of a nature conservation program is via PVA, however initially at least, PVA should only be used to aid reserve design under special circumstances and on smaller sub-regional scales where a particular species is important*".

## Ecological processes and functionality

Ecosystems and the distribution and abundance of taxa are dynamic in space and time. Understanding the major ecological processes affecting these dynamics and the functional role of various species within ecosystems will be essential to adequately protect and manage reserves and their constituent biota in the long term (BDAC 1992; Bridgewater et al. 1992; Walton et al. 1992a, b). The use of carefully selected keystone and indicator species to provide a "shorthand" description of the health and status of whole ecosystems has been advocated by some scientists (eg. Soule & Kohm 1989; Walker 1991) and conservationists, especially in areas where poorly known but complex systems are being rapidly destroyed (Gilbert 1980).

Currently, empirical scientific data in support of the concept of keystone, indicator species and functional groups of taxa are limited, although in some situations there is no doubt that such species and groups exist. Indicator species such as aquatic invertebrates (water quality) and lichens and bryophytes (air quality, acid rain) have been used in environmental monitoring for some time (Common & Norton 1992). Bridgewater et al. (1992) suggested that thermophilous (warmth loving) insects such as some Lepidoptera and Odonata may be useful 'markers' for early changes in climate. Animals involved in pollination and seed dispersal, for example the Cassowary (Crome & Moore 1990) and flying foxes

(Cox et al. 1991), have been classified as keystone species and may be useful candidates for ecosystem monitoring (Soule & Kohm 1990).

Enhanced study of ecological processes and key species and groups as potential functional representatives of ecosystem viability has been advocated in the global change research strategy for Australia (1992-1996) (Australian Academy of Science 1992) and as part of the Global Change and Terrestrial Ecosystems initiative of IGBP (Steffen et al. 1992).

The identification of key species and groups could also be used in conjunction with PVA to address the issue of reserve size and spatial arrangement.

### Taxonomic similarity and the notion of redundancy

The conservation of all existing biodiversity will be an almost impossible task. In an attempt to assign priorities for which taxa to spend the most resources upon, two sorting approaches have been considered recently.

Taxa can be assessed on the basis of their genetic (taxonomic) distinctiveness. The argument for this was summarised in the ANPWS's submission to HORSCERA:

> *"The question needs to be asked whether all species should be given equal weighting ... given, for example, two threatened taxa, one a species not closely related to other living species and the other a subspecies of an otherwise widespread and common species, it seems reasonable to give priority to the taxonomically distinct form ... what is needed is some form of weighting to individual species that includes such characteristics as genetic uniqueness, rarity, etc".*

Faith (1992) presents a method of enumerating this taxonomic distinctiveness ("Phylogenetic Diversity"), and provides illustrations of its use in reserve selection. A related procedure has been described by Humphries et al. (1991).

Taxa can also be assessed on their contribution to the functioning of ecosystem processes. Walker (1992) suggested that some species are ecologically redundant, that is that they could be removed from the environment without any negative effect on other species or processes. Walker (1992) argued that such species, if identified, would be given low priority in reserve assessment. Such species are effectively the opposite of "keystone" species, which structure and maintain ecological communities and processes. The categorisation of redundant species could never be an easy process, as the determination of functional roles may need very intensive investigation, and because some species may be of little functional importance for long periods but then assume major roles during some periods of environmental fluctuations. Blake (1993) has further criticised the concept, including on the grounds that all species have largely exclusive roles.

## What is adequate representation for species?

In contrast to environmental classes where most commentators have chosen to recommend a minimum proportion of a given class required to fulfil a conservation threshold, discussion about adequate representation of species usually concerns absolute minimum numbers. For example, for rare plant species, Benson (1989, 1991) considers a threshold for adequate reservation is 1000 individuals being present in reserves.

This distinction is not absolute as some studies have recommended minimum areas for rare environmental units (e.g. Richards et al. 1990) and other studies have recommended proportions for species (e.g. Kirkpatrick & Brown (1991a), or the presence of species in at least *n* conservation reserves of size greater than, say, 1000ha.

Minimum numbers reserved may need to consider ecological and reproductive traits, and vulnerability to disturbance or climate change. For example, Kirkpatrick & Brown (1991a) used a combination of 90%, 60% and 30% of total distributions (?numbers) for endangered species, vulnerable species and other species, respectively, in their assessment of the adequacy of existing reserves in Tasmania.

The ACF/WWF submission to HORSCERA noted that "*the reserve system should capture all existing populations of rare and threatened species*".

One concern is that populations included within reserves should be large enough to persist with reasonable probability over a long time period. Where adequate knowledge is available, PVA can provide predictions for survival probabilities given various population levels of a particular taxon. These probabilities can then be used to guide consideration of adequate numbers of individuals (or reproductive units) reserved, and hence reserve sizes and boundaries.

Adequacy for the reservation of a specified taxon may also be related to the genetic heterogeneity within that taxon, with a higher proportion of individuals needed to sample genetic variability for those taxa which are genetically relatively more heterogeneous.

A clear problem in determining adequacy of the conservation estate in terms of its protection for individual species is that there is insufficient knowledge about the distribution of species within the regional environment and within reserves. There is no national overview of the reservation status of even most vertebrates, let alone invertebrates.

As with reservation of environmental classes, it may be necessary to ask which species do we seek to reserve? Specht et al. (1974) noted that:

> *"all species should be conserved ... however, the conservation of every known species may be a utopian dream. it may be better to aim for the conservation in their natural habitat of "particularly interesting species" ... (although any such list) would be a subjective and far from complete attempt by very few botanists. Many species would be omitted from the list because of lack of knowledge".*

Ecological redundancy and functionality and taxonomic distinctiveness are further attempts to set priorities for choosing which species to conserve first.

The whole approach of attempting to assign priorities for species to be reserved was questioned by Kirkpatrick in comments on a previous draft:

> *"It should not be necessary in Australian forests, or in Australia as a whole, to allocate elements of biodiversity to the notional redundancy scrap heap, or to spend money searching for elusive keystone species."*

### *3.iii.(e) Size and spatial arrangements of reserves and related considerations*

Size

The simple question of how large should a conservation reserve be has spawned an enormous literature from which generalisations (other than the trite) are almost impossible. Part of the problem is that the question is not that simple. Reserve size is a concept usually linked with reserve adequacy, or the proportion of an environment which is included within a reserve system. Large reserves tend to represent a high proportion of the environment, whereas small reserves contribute little area (which usually means a low proportion) to representation. We consider the issue of what proportion to reserve elsewhere.

Given a selection choice from an extensive and uniform landscape and the criterion of, say, 10% of the environment to allocate to reserves, the decision-maker can spend that proportion in an infinite number of ways, with the two extremes being a single large reserve or many small ones.

As a general rule the small reserves will be more susceptible to disturbance because they contain higher edge:interior ratios and for agents of disturbance (e.g. weeds, fire, feral species, agricultural chemicals) edges tend to be an open gate. Hence the small reserves will tend to be degraded quickly while the large reserve will be somewhat more resilient (e.g. Janzen 1983). Examination of the distribution patterns of individual species suggests that some species actively avoid edges, or are selected against around edges (e.g. Numbat survival is lower close to edges because of differential fox abundance: Friend 1990). Such species will disappear rapidly from small forest fragments.

The other ecological argument in favour of large reserves is that they retain their inhabitants for longer than do small reserves. This concept has received much theoretical support, and some credible observational evidence, from studies examining the number of species on islands versus island size and age. It has since been further supported by PVA. Larger samples will initially contain more individuals of a given species than do small samples. The small populations in the small samples will be more susceptible to inbreeding (especially if the population size is very small) and to stochastic (and some deterministic) population changes leading to extinction. Hence species will be lost more rapidly from small reserves, and the eventual (equilibrium or stable) number of species retained will be lower.

The maintenance of ecological processes has been advocated as one of the main conservation advantages of wilderness areas, large reserves, entire catchments or other areas in which disturbance by humanity (and its agents) is minimised, and consequently such areas may be key elements in the protected lands network.

But in this model system, several small reserves also have some advantages over one or few large reserves. Replication of reserves provides some safeguard mechanism in the event of catastrophic population loss from one reserve. Replication may also sample genetically distinct populations and/or the separation of small populations may increase genetic diversity within a taxon. A number of small reserves may also initially include more species than one large reserve of the same total area as species are not distributed uniformly in the landscape and the geographic range covered by the small reserves will be greater than for a single reserve (Higgs & Usher 1980; Jarvinen 1982; Simberloff & Gotelli 1984).

Before leaving the model system, there are some non-ecological advantages of the single large reserve, most notably in the greater efficiency with which one large reserve (rather than many small reserves) can be managed. A large reserve chosen for ecological criteria may also satisfy wilderness criteria, and allow scope for zoning for a range of activities within the reserve.

The real world is much more complex, and the somewhat arguable advantage of a single large reserve is accordingly harder to apply. Rarely is such an explicit option offered or available, and the choices will almost always be coloured by the juxtapositions of a range of environmental classes. In the real world, the spatial arrangements of remnants (or the land uses in areas between reserves) influence or control genetic interchange between sites. Although species may occur patchily across the landscape the dispersal of some individuals may link these units as a "meta-population". Additionally, in many relatively modified areas of Australia, there may be no effective size choice, with improvements to representativeness of forest reserves having to come about only through the reservation of a large proportion of the available (small) remnants.

Minimum size for reserves to protect species and ecosystems is an individualistic question. As a crude approximation for species, it is a product of the effective population size and the home range/territory size of an individual. Main & Yadav (1971) used this rationale, based on data from the persistence of species on Western Australian islands, to estimate minimum viable population sizes (and thence minimum reserve size) for several macropod species. More recent estimates (Short & Turner 1991) were of a minimum viable population size for Euros of 1800 individuals. Based on data from mammals in southwestern U.S., Belovsky (1987) suggested that a rabbit-sized mammal requires a population size of tens of thousands to have a 95% chance of persisting over 1,000 years. As estimates of minimum viable population sizes vary between species, and average home range size also varies between species, different species will require very different minimum reserve sizes. Hence when considering how big any reserve must be, the question must be qualified by for what species. It may be appropriate to devise a minimum reserve size based upon the largest of minimum sizes required for those individual species (or communities) for which that reserve is important. In many cases, those species will be top order carnivores (e.g. quolls, owls), large species, or species which otherwise occur only at low population densities. On the other hand, even very small reserves (20-100ha) may be important for restricted invertebrate species, very localised plant species or restricted breeding or roosting sites, and "may be the only practicable way of preserving something of a threatened ecosystem" (Key 1977). Briggs & Leigh (1988) stated that reserves under 10ha in area were inadequate to protect the flora within them.

There has been a burgeoning literature on the occurrence of species in forest and woodland fragments, most notably in the much-cleared wheatbelt and pastoral areas of south-western Australia (e.g. Saunders et al 1990), with other good examples being for mammals in the western district of Victoria (Bennett 1987) and birds in the Mt Lofty Ranges (Ford & Howe 1980). This knowledge base is providing critical information on the persistence of species in different sized remnants, and hence can provide guidelines for minimum conservation reserve size for a wide range of species. For example, Kitchener et al. (1980) claimed that a minimum reserve area of "*about 40,000 ha is required to conserve (a significant) part of the regional assemblage of mammals in southern and western Australia likely to persist in the face of moderate disturbances by man and his agencies*".

It is apparent that some groups of species are especially vulnerable to habitat fragmentation and/or poorly adapted to persist in small fragmented populations (e.g. Laurance 1990). The definition of characteristics of such species may help predict the conservation problems and remedies for particular areas and species.

Note however, that the applicability of these remnant size relationships to minimum reserve size is confounded by what goes on in surrounding lands (Janzen 1983). In most of the examples given above, the fragments studied were surrounded by cleared agricultural lands in which retention of conservation values was not a management concern. It would not be valid to use remnants in such a landscape as models for designing reserves in a landscape in which lands outside reserves were still managed with some sympathy to conservation goals.

A wider (and somewhat concerning) perspective on reserve size was offered by Westcott (1991), who demonstrated that National Parks and conservation reserves tend to be much smaller in Australia (a total reserved area of $20.2 \times 10^6$ ha divided amongst 530 National Parks) than their counterparts in the USA ($21.2 \times 10^6$ ha from 50 National Parks) and Canada ($18.2 \times 10^6$ ha from 34 National Parks). The ANPWS submission to RAC claimed that no Australian reserves were sufficiently large to be independent of surrounding land uses.

Another perspective on minimum size of reserves was provided by Hopkins & Saunders (1987), based on the presumption that the level of management required in small reserves will be greater than that in large reserves. They suggested that biodiversity in reserves smaller than about 500,000ha may not be sustained in the long term without active (interventionist) management.

Given the practical and theoretical problems, the need for case-by-case answers (dependent largely on the shape, size and positioning of land units available for allocation, and perhaps also on the productivity of the particular environment), and the range of other compromises involved, pragmatic solutions rather than fixed quantitative rules may have to be applied. A generally accepted compromise (e.g. ESD 1991) "involves a small number of very large areas, a moderate number of medium-sized areas, and small areas where they contribute to the long-term protection of plant and animal species and vegetation types". A general consensus at the seminar discussing this paper was that, in general, reserves should be as large as possible but that no universal minimum size could be established.

## Buffers around conservation reserves

In principle, many options are available for providing buffers around formal conservation reserves. The biosphere reserve concept was developed by the UNESCO Man and the Biosphere program as an ideal model for ecologically sustainable development and is one example of how to 'buffer' formal reserves or protected areas. The core of the biosphere reserve is a protected area (IUCN category I or II) which is devoted to the preservation of biological diversity and ecological processes. Surrounding the core of the reserve is a buffer zone devoted to the amelioration of human impact on the core, research in conservation biology, public education and recreation. An outer ring, termed the transition zone, is an area of controlled human impact with emphasis placed on the involvement of the local community in the care, maintenance and management of the zone. All three zones are subject to the implementation of management plans and long-term monitoring to assess and protect the biological diversity of the region. An example of this approach in operation in Australia is the Fitzgerald River Biosphere Reserve in Western Australia (UNESCO submission to HORSCERA).

The buffer zone concept can also be applied less formally through, for example, the retention of an additional portion of forest around reserves to minimise the likelihood of outside impacts such as changes in local climate resulting from forest clearance, and the incursion of exotic predators from nearby roaded areas.

A set of guiding principles for the design and use of reserve buffers across the conservation reserve network within forests is required. As with the codes of forest practice outlined in the NFPS, this set of principles could then provide a basis for developing specific prescriptions within target regions. Presently, however, no widely-agreed approach has been adopted by government on this matter. The biosphere model approach is favoured by ANPWS (e.g. submission to HORSCERA). However, the ACF has suggested that the biosphere concept will serve to compromise the meaning of conservation reserves to the advantage of those seeking economic gain through resource exploitation.

## Connectivity between conservation reserves

The maintenance of gene flow between small fragmented populations serves to greatly increase the probability of persistence in those populations (e.g. Stacey & Taper 1992), with the geographically separated units functioning as a "meta-population". Small isolated populations may also be extremely vulnerable in the short-term to stochastic processes (e.g. random population fluctuations) and catastrophic loss (e.g. through bushfire), and movements between populations help maintain the demographic structure and stability of population fragments and help restore populations following loss through catastrophe.

The Global Biodiversity Strategy (1992) recognised the need for connectivity between formal reserves or protected areas so as to facilitate the movement of organisms and gene flow within and between populations and enhance the likely persistence of at least some biological values in reserves during global climate change. Similar sentiments have been indicated by various government documents in Australia. For example, the RAC (1992) outlined a strategy for the conservation of the forest estate which involved, as high priority, the improvement of the "structure and connectivity of the reserve system". The National Greenhouse Response Strategy identifies a number of adaptive response actions, including "*In developing conservation reserve systems and forest management approaches, Governments will seek to provide corridor systems that link reserves and refuges with a relatively large altitudinal and other geographical variation, to take into account climate change impacts.*" (Commonwealth of Australia 1992c, p. 34). Similarly, BDAC (1992) recommended that contingency arrangements be established to "*investigate the capacity of protected areas to sustain their biological diversity in the event of climate change and where appropriate ensure that altitudinal and latitudinal buffer zones or corridors exist to allow for the potential movements of organisms in the event of shifts in climatic zones.*" Similar comments have been made by the Endangered Species Advisory Committee (ESAC 1992).

The submission of the Queensland Department of Environment and Heritage to HORSCERA considered that wildlife corridors linking protected areas were necessary for biodiversity conservation:

> "*....because of their size, many of the existing National Parks and other reserved protected areas might not be viable in the long-term without some form of active intervention. Such intervention includes the establishment of corridors linking protected areas with each other and habitat remnants and lands that are sympathetically managed.*"

The NFPS also commits governments to the maintenance of connectivity between conservation reserves. For example, as well as repeating the commitment outlined in the Greenhouse Response Strategy, it is stated that:

> "*The reserve system will safeguard endangered and vulnerable species and communities. Other areas of forest will also be protected to safeguard special areas and to provide links where possible between reserves or other protected areas.*" and

> *"in developing the nature conservation system and forest management approaches in other public native forests, each government will, where possible, ensure that effective corridor systems link reserves, refuges and areas with a relatively large range of altitudinal and other geographic variation so as to take into account the possible impacts of climate change".*

Much has been written about reserve connectivity and corridors in the scientific literature. Corridors are relatively linear landscape features that are highlighted as a means of facilitating the movement of biota and, as can be seen from the above statements, are commonly seen as important to ensuring landscape connectivity. However, the scientific data supporting the concept of corridors are remarkably limited (Hobbs 1992) and are largely confined to observations on birds (e.g. Saunders & de Rebeira 1991) and some small mammals (e.g. Bennett 1987). Currently, there is little empirical evidence that other vertebrates, invertebrates or plants use corridors as a means of disseminating across the landscape although it must be recognised that these sorts of data are difficult to obtain. Lindenmayer & Nix (in press) suggested that "some species may be poorly conserved by a network of wildlife corridors....". Simberloff et al. (1992) regarded corridors as highly dubious investments in the maintenance of biodiversity.

In one of the few available quantitative studies, Lindenmayer et al. (in press) reported the results of surveys of arboreal marsupials in 49 linear strips of retained vegetation within Mountain Ash *Eucalyptus regnans* and Alpine Ash *E. delegatensis* forests used for timber production in the Central Highlands of Victoria. The value of retained strips as habitat for animals was investigated as opposed to their more commonly perceived role in facilitating the movement of individuals between disjunct areas of habitat. A number of species of arboreal marsupial were found to be present within the retained linear strips but their total abundance was significantly lower than predicted from measures of habitat suitability (Lindenmayer et al. in press). Furthermore, colonial and social species that consume widely dispersed foods were uncommon; a pattern predicted by central place theory (see Recher et al. 1987).

The strategy of retaining areas of habitat for wildlife conservation at various spatial scales in rural, agricultural and forested landscapes in Australia has been reviewed recently by Bennett (1990), Norton (1990), Taylor (1990), Saunders & Hobbs (1991), and Hobbs (1992), among others. Systems of retained habitat are considered important for fauna such as arboreal marsupials, owls, cockatoos and bats which require relatively large areas for foraging, and some migratory birds. Few studies have quantitatively investigated the efficacy of various options for enhancing connectivity between reserves.

In a recent desktop study, the New South Wales National Parks and Wildlife Service developed a management strategy for the Nalbaugh Special Prescription Area (NSPA), an area of State Forest located between the proposed Genoa and Coolangubra National Parks (Shepherd et al. 1992). The NSPA was established to provide a connecting link between the parks but is also subject to some integrated forestry harvesting and associated activities such as prescribed burning. The intention of the management strategy was to attempt to ensure that the 'connectivity' role of the NSPA was not undermined while at the same time minimising the impact on wood supply to industry. The strategy developed by Shepherd et al. (1992) included or relied upon:

- scientifically-based guidelines for the allocation and management of native forests at a regional and catchment scale;

- a systematic and reproducible methodology for assigning potential wildlife habitat values to forests in the absence of detailed site-based data;

- a retained habitat system linking the proposed parks;

- estimates of the relative habitat values of logging compartments in the NSPA; and

- management prescriptions for both retained and logging areas.

Eight management guidelines were suggested by Shepherd et al. (1992): (i) management to maintain forest conservation values at a local level must be placed within a regional context and this can only be achieved through field survey and by the establishment of regional databases of major forest attributes; (ii) until such time as regional databases are sufficiently developed, a conservative approach to the use of forest resources should be adopted; (iii) further forest fragmentation and degradation should be minimised and every effort must be made to sustain forest connectivity and the linkages between important forest habitats by ensuring that areas of retained forest are as large, intact and interconnected as possible and that planning consider such linkages at all scales from the local to the catchment, sub-regional and regional; (iv) conservation planning should occur prior to the construction of roads; (v) particular emphasis should be placed on the conservation of old growth forests because logging will destroy their unique attributes and values, they are becoming increasingly rare and fragmented, are poorly represented in reserves, and contain old-growth dependant threatened fauna; (vi) special management prescriptions should be applied in forests with high conservation values; (vii) conservation reserves must be designed so that they can maintain viable populations of fauna and this can only be achieved by ensuring that reserves are as large, contiguous, representative of the local range of habitats, well connected and with a low edge to area ratio as possible; and (viii) ecological uncertainties necessitate that a precautionary principle must be observed in forest management if options are to remain open for the future (RAC, 1992).

On the basis of the above ecological guidelines, Shepherd et al. (1992) proposed the creation of Population Assisting Links (PALs) - relatively linear areas of retained forest of high habitat quality which are large enough to allow for the dispersal of species between fragments, to support resident populations of key fauna over the long term, and adequately buffered against edge effects. The authors suggested that PALs would also be appropriate in other forest areas with very high conservation values particularly where they may act as links between reserved forests.

Some further ecological principles for the design of wildlife corridors are presented by Lindenmayer and Nix (in press). Government agencies responsible for forestry activities on public lands usually employ retained areas (e.g. 'corridors') for connectivity as part of their on-site prescriptions but the extent to which these achieve their aims is poorly known. As an example of corridor planning, Queensland is setting up a riparian corridor network backed by legislation defining minimum corridor widths according to stream order (P. Sattler *pers.comm.*).

## Replication

Any given community will show some spatial variation in species composition across the landscape. Any given species will show spatial variation in genetic composition across the landscape. To retain the components of this variation (and hence to maintain biological diversity over several scales) the unit (community or species) should be conserved at several sites across its geographic range. This argument provides one basis for replication of reserves, and is measured by the extent to which the reserve system is **representative** of biological diversity.

The extent to which intraspecific genetic diversity varies geographically may be related to the fragmentation of the species range. For example, in the widespread *Eucalyptus saligna*, genetic variation is relatively high within localities and low between localities, whereas the very disjunct populations of *E.caesia* show marked genetic divergence (Moran & Hopper 1987; Hopper & Coates 1990). At present there are no rapid and cheap methods for examining genetic variation across the range of a species, so it is apparent that such investigations cannot be undertaken for all species before land-use decisions are made. Pragmatic approaches to incorporate some genetic information into a regional reserve assessment could include:

- examination of genetic variability in targetted rare or particularly disjunct species;

- seeking patterns in environmental, ecological or taxonomic characteristics of species which have been shown to have pronounced genetic variability between locations;

- aiming to reserve populations of a species across the extent of its geographic and environmental range;

- aiming to reserve the largest populations.

Australian examples of planning to protect intraspecific genetic variation include the work of Potts (1989) and Leeton & Fripp (1991) on rare plants. Hopper & Coates (1990) present some more general approaches.

As noted above (section on size), including species or communities in more than one reserve also guards against catastrophic loss of the entire population.

Belbin (1992; in press) describes a method which aims explicitly to identify sites which are most "typical" of a given environmental class and which can compare the naturally occurring variability within this class with the variability sampled by a reserve system aiming to provide representation of that class. Sites to be included within reserves are added until the variability included within the reserve system matches that naturally occurring.

## Borders and boundaries

Areas which meet criteria for inclusion in the conservation reserve network can be identified in a general way, but rarely is the fine resolution available to accurately delineate the borders of suitability. In part this is a result of imprecision in data (or the lack of its fine-scale resolution) and it is in part because conservation values tend not to undergo steep changes across a landscape (sharp borders of uncleared forests with agricultural areas may be an exception). What criteria should be used for the definition of boundaries?

In many cases, cadastral boundaries impose fairly inflexible reserve borders. However in some cases, a sensible reserve design may require some rationalisation or swap of crown and private lands.

The Royal Botanic Gardens Sydney, in their submission to HORSCERA stated: "*another principle that should be enshrined in reserve design is the protection of whole catchments where possible*". Keith et al. (1991) proposed reserves with catchment boundaries

*. minimise the inclusion of inlying areas below threshold levels of ignificance, particularly where such areas may give rise to conflict;*

*. encompass those contiguous areas which reach the registration threshold level;*

*. include areas at or near the threshold level of significance if such areas contribute to the appropriateness of the boundary as a whole;*

*. exclude all areas at the perimeter which do not reach the threshold".*

for the SE forests of NSW, which they claimed gave superior protection to reserves than the non-watershed boundaries adopted by Richards et al. (1990).

The spatial arrangements, relative to a proposed reserve, of other reserves and unreserved lands capable of acting as dispersal routes or buffers may provide the best general guide to the actual demarcation of reserve boundaries. To an extent these considerations (e.g. perimeter minimisation and connectivity) can now be incorporated within reserve selection algorithms (e.g. Lewis et al. 1991).

Of some relevance are the specifications given by AHC (1990) in defining boundaries for National Estate sites:

> *"All boundaries involve a level of generalisation, whether it be generalisation about the limits of a plant community or the extent of a particular value or the extent of the area which meets the threshold level of significance for registration.*
>
> *In most cases it is impossible to delineate a boundary which exactly corresponds to the area which reaches the threshold level of significance and which excludes all areas which do not meet the threshold. Drawing a boundary almost always involves some 'give and take'. The objectives, in priority order, are:*
>
> *. define a boundary to the place which is appropriate to its value, e.g. (one or more of) landscape, ecological, geological values, etc;*
>
> *. include all areas which are critical to the significance of the place;*

*3.iii.(f). Climate and global change*

Human-induced climate change is likely to have serious implications for biodiversity conservation (e.g. Norton 1990). Current scenarios of climate change are primarily limited to the outputs of global circulation models (GCM). The spatial resolution of GCMs is too coarse to inform management at a regional scale, although work on limited area models is proceeding to overcome such constraints. BDAC (1992) recommended action 5.5.1 offers further support for directed research into the predicted effects of climate change:

> "*Support research into the potential impacts of climate change and of secondary effects such as altered fire regimes on vulnerable species and areas important for their biological diversity*".

Necessarily, attempts to mitigate the effects of climate change at a regional and landscape level will need to be based largely on general biogeographic and ecological principles. Commonly quoted options for conserving biological diversity in the face of a changing climate range from the use of a national network of corridors linking reserves (e.g. Hobbs & Hopkins 1992; Bridgewater 1992) to the reservation of large and heterogenous areas of forest which preferably encompass a range of climatic types (e.g. Braithwaite & Werner 1987). BDAC (1992) recommendation 5.5.2 is typical of such approaches:

"*Investigate the capacity of protected areas to sustain their biological diversity in the event of climate change and where appropriate ensure that altitudinal and latitudinal buffer zones or corridors exist to allow for the potential movement of organisms in the event of shifts in climatic zones*".

The ACF/WWF submission to HORSCERA also suggested that planning for climate change should encompass the placement of reserves in areas which will function as "refugia", or in areas which will provide pathways to refugia. This may be especially important for localised and threatened species (e.g. Long-footed Potoroo, Mountain Pygmy Possum). However, the identification of such areas may be difficult or illusory. Kirkpatrick, in comments on a previous draft, noted that "climatic modelling and the BIOCLIM facility combined with fossil data, such as pollen, can give us a good idea of the major glacial refugia. We can identify some current refugia from the coincident ranges of local endemics (Kirkpatrick & Brown 1984)". However uncertainties of climate models, idiosyncratic responses and interrelationships of different species, and complicated shufflings of associated and independent disturbance regimes will limit the predictability of "refugia".

In reality, it is recognised by many parties (eg. RAC 1992) that the approach will involve a combination of options given the existing extent of modification and fragmentation of the forest estate. Some of the environmental data sets (eg. climate, hydrologic) discussed earlier could assist in regional planning (Hobbs & Hopkins 1992; Norton & Nix 1991).

Given climate and other global changes, an important technical issue is how best to enhance reserve connectivity and reserve viability through time? More specific guidelines than those currently stated are required as a basis for meeting particular needs and circumstances within regions. These guidelines will also need to accommodate reserve connectivity between regions and across State and Territory borders. Explicitness should not be confused with inflexibility. H. Nix commented on the previous draft:

> "*The need to consider climate and global change emphasizes the role of uncertainty and risk and thus a need for an*

*ongoing, flexible process of reserve selection as part of a wider system of land use. Static land allocation procedures should be avoided at all costs".*

## 3.iv. Operating with imperfect knowledge: dealing with risk and uncertainty

### *(a). Uncertainty and risk*

A central component of ecologically sustainable management is making wise decisions in light of considerable risk and uncertainty. Risk is the chance of some event occurring, say with positive or negative impacts for biodiversity conservation, where the probability of the event is believed to be known. In contrast, uncertainty arises from lack of knowledge and takes three forms: removable uncertainty - for example, where extra research will provide an answer and remove any uncertainty; generated uncertainty - which arises from contradictory or inadequate management; and residual uncertainty - which is irremovable over the period within which policies must be formulated and decisions made (Dovers & Handmer 1992).

Uncertainties and risks affect planning for the protection of biological diversity within forests (Norton & Williams 1992). Forest ecosystems are complex and knowledge of their biological composition, dynamics and functioning is rudimentary. The human infrastructures that are designed to protect and conserve these ecosystems are variable in quality and prone to failure. Because of this, it is inevitable that some poor decisions will be made, management systems will fail at different times and unpredictable chance events (e.g. drought, wildfire, disease) will occur that will have detrimental impacts on forest values. These considerations must be factored into the planning and management processes established for reserve selection and on- and off-reserve management (Thomas et al. 1990; Murphy & Noon 1991).

Uncertainties arise in reserve selection because of major inadequacies in biological data, particularly with regard to invertebrate taxa and genetic diversity. Further, a number of geographic regions are poorly surveyed and their biological complement is largely unknown. Uncertainties result also, for example, from limited knowledge of: ecosystem dynamics, the niche requirements and habitat relationships between species, movement and dispersal patterns of species, the use of corridors by species, the response of species to climate change and other global changes.

These levels of ignorance, in our requisite data and in the understanding of processes involved in persistence or extinction of species or communities in an environment, are alarming. In some ways conservation biology is dressed in the Emperor's New Clothes. This provides a very tentative basis for establishing firm and inflexible settings for defining conservation requirements, especially so when conservation decisions may have to be defended against much more certainly defined economic values for exploitable resources that they contain. Sensitivity about the science is beginning to be addressed (e.g. Murphy 1990; Wilcove & Murphy 1991), forced, at least in part, by the exposure of conservation recommendations to detailed public scrutiny.

One argument used to accommodate imprecision is that the bounds of uncertainty (e.g. is 10 or 30% of a vegetation type included within reserves enough?) lie well beyond what exists now, so that even setting the lower bound provides a target not yet reached. J. Kirkpatrick, in comment on the previous draft, noted "*the lack of firmly established guidelines ... is misleading to some extent as there is consensus about a large number of gaps, and probably scientific consensus about an indisputably safe level of reservation for organisms. The area of uncertainty is well beyond the present reserve network, allowing action to improve reservation that is beyond scientific dispute*".

Another argument to accommodate such risks and uncertainty, invokes the precautionary principle. The precautionary principle has been embedded within the NFPS and is an important component of its implementation phase. The definition of the principle reads:

> - "*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. In the application of the precautionary principle, public and private decisions should be guided by: (i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and (ii) an assessment of the risk-weighted consequences of various options.*" (IGAE)

Rather than delay action, the precautionary principle aims to allow decision-making to proceed, but with some safety margins for mistakes. Bridgewater et al. (1992) summarise the need such:

> "*Can we afford to wait until we have all the information before the management begins? Obviously, we cannot. Management must begin based upon what we know and research efforts balanced with management. Pursuit of scientific truth is fascinating, but it is an unaffordable luxury when species and communities are vanishing and when the truth arrives only in time to be included in a eulogy*".

The Northern Territory Government specifically addressed the question of how uncertainty affects reserve selection (perhaps reflecting the extreme dearth of biological knowledge in that jurisdiction):

> "*decisions will inevitably be made on the basis of imperfect biological information. It follows that the chosen configurations will also be imperfect in a*

*conservation sense, despite efforts to minimise error. At least three distinct responses to this difficulty are available. The most obvious is rejected: that is, to await better information before acting to develop comprehensive conservation strategies. Another possibility is to implement a static but imperfect design and seek to offset deficiencies, as they become apparent, by complementary off-reserve conservation strategies. Thirdly, a protected lands network might be viewed as an evolving construct with sites changing in status as knowledge improves and better configurations become apparent".*

This may provide a base for approaching the problem more widely.

The influence of uncertainty in conservation of forests values in general was considered by BDAC (1992):

*Improve the knowledge base underpinnning forestry in a coordinated way by:*

*- ensuring that the relevant State and Territory agencies undertake surveys of forests for old-growth values and of forested and other lands for wilderness values;*

*- asking State and Territory agencies to undertake a comprehensive assessment of both unlogged and ecologically mature forests to identify their value for the conservation of biological diversity;*

*- ensuring accessibility and improved compatability between data bases and, where necessary, standardising data sets between local government, regional, State and Commonwealth agencies.*

It is clear that priorities must be set about what data sets are inadequate (and hence defining which areas require further research or survey) and how much conservatism must be built into the reserve estate in order to incorporate uncertain outcomes. This conservatism may be manifest in the setting of criteria for reserve adequacy and representation. For example, it is not known whether reservation of 5%, 10%, 30% or 90% of the distribution of a vegetation community (or genetic variability within a species) is sufficient to provide acceptable security. Similarly, for most species it is not known whether a reserve must be at least 1, 10, 100 or 100km$^2$. In such cases, to err on the side of caution would be the wisest option.

*3.iv.(b). Minimum data set.*

To succeed in its aims, reserve selection must be based on accurate and sufficient data. This has been clearly stated by Margules & Nicholls (in press):

> "*If reserve networks are to be positioned so that they sample, and have some chance of sustaining, regional biodiversity, then two requirements have to be met. There must be an adequate data base and there must be an accepted procedure for using that data base.*"

and by Richards et al. (1990):

> "*Adequate information about ecological processes, and the plant and animal communities dependent on them, is ... required in order to provide a rational basis for the resolution of land use allocation and management disputes*".

What is an adequate data base for regional conservation assessment? This question does not seem to have been explicitly addressed for land evaluation and selection of reserves (although an indicative listing for regional integrated assessment is in preparation within DASET). There are two alternatives:

. a minimum amount of information is needed to provide the base for a sensible reserve system, and that this minimum type and amount of information should be consistent across regions studied;

. regions will vary so much in the amount and type of information that whatever data are available should be used, and hence flexibility in data requirements should be stressed. Further, conservation needs may be so urgent that it is imprudent to delay actions further while waiting for minimum data sets to be achieved.

Several commentators on the previous draft of this paper thought that there should not be any defined minimum data set. For example, Kirkpatrick noted:

> "*A minimum data set to do something for conservation of biodiversity within a region would be the locality of a population of a rare and threatened species. It is possible to reserve all known biological entities within a region without a knowledge of the complete distributions of all of them, the various parameters of the physical environment and the distribution of other values. A distinction needs to be made between an ideal data set and a minimum one.*"

Likewise the AHC noted that pragmatism was needed about the types of information required, that assessors should take whatever information they could get, even if this was only available by talking with "experts" or locals.

In contrast, L.W.Braithwaite (at the seminar) argued that there were dangers in using only opportunistic or unsystematic records, and that at least some data bases derived from directed surveys were necessary in order to provide some evenness of coverage from which to adjudge conservation values and reserve placement within a region. J.Kirkpatrick also noted that reliance on only a limited number of data bases, such as environmental domains, would inevitably lead to poor representation of some species (notably those showing little relationship to such classifications) in resultant reserve proposals.

Recent progress in centralising and creating consistency in biological data sets (e.g. ERIN, NFI) means that it is now, or will soon be, possible to have somewhat standardised data sets for distributions of species and some environmental classes available for all regions (although of course the amount of information available may vary greatly between different regions). Environmental domains can also be determined and mapped for any region, due to the continent-wide accumulation of physical information (e.g. by CRES and ERIN). There are also centralised data bases for rare and threatened plants, and many State-wide distributional/status data bases for plants, vertebrates and particularly rare and endangered taxa. Wilderness values are now also available for many regions and the completion of the NWI will mean that comparable information will be accessible for any region in Australia. Other physical features, such as geology and soil type, have also been mapped across Australia, and in detail for many regions.

A minimum data set for regional conservation assessment could include:

. **physical classification (environmental domains)**, which are available, or could readily be derived, for any region in Australia.

. **floristic classification**, which is available for many regions (though at variable scale) and which may be regarded as the fundamental biological description of regional environments, and a good template for predicting distributions of many animal and plant species. Its inclusion as an essential data base is implicit in the NFPS definition of comprehensiveness, which measures the inclusion of communities within a reserve system. Note that in many cases, a floristic classification will also provide some assessment of clearing and disturbance.

. **current land tenure**, which may dictate conservation options and is already available for all Australian regions.

. **wilderness values**, which are explicitly regarded by the NFPS as a high priority and which must be considered in reserve design. (Note however that wilderness itself is not a primary data set, but derives from information about road placements, past and present uses, etc.).

. **old-growth forest values**, as for wilderness above.

. **distribution of endangered/vulnerable taxa**. The inclusion of these species (and communities) is widely regarded as a major priority in reserve design and placement. The distributions of these species are often poorly predicted by environmental classifications, so specific information is required. Centralised and regional data bases are available for many taxa already.

Other important data bases include social and economic values, distribution/abundance data for all taxa, regional climate change scenarios, and assessments of environmental modification.

Systematic survey, possibly including rapid appraisal for particularly poorly known groups (such as invertebrates: e.g. BDAC 1992) will undoubtedly increase the knowledge base underpinning reserve design, and hence its efficacy and efficiency in achieving its conservation goals. But, for any given region, it is probably not feasible to determine how much, if any, further survey work is required. The amount of information accessible and fed into the regional study and conservation assessment may largely be dictated by the timeframe imposed in agendas such as that of the NFPS. This implies that it may be unrealistic to set national standards for minimum amounts of biological information required for regional assessment.

## 3.v. Non-ecological criteria for the selection of conservation reserves.

*(a) Introduction.*

In common with practice elsewhere, Australian reserves and National Parks have served and been nominated for many functions other than or additional to the maintenance of biodiversity (Ride 1975; Whitehouse 1990). Pluralism of uses has been both beneficial and harmful to conservation goals. For example, the wide acceptance that parks are for the recreation of people has ensured community support for, at least some, reservation proposals, but has brought environmental costs in the form of tourist impacts and management driven more by catering for visitors than for maintaining conservation values. This perception and treatment of parks as recreational facilities has been one of the main factors in the imbalanced environmental representation of the existing reserve network, this being most evident in the many very small reserves based around waterfalls and scenic points in Queensland (Mobbs 1989). More recently, conservation reserves and National Parks have been especially targetted for Aboriginal land claims.

There have been attempts to rationalise the diverse roles expected of parks and reserves, most obviously by varying designations and permitted land uses across the park. This approach has its problems, as is evident from attempts to compare conservation reserve categories between the States (Mobbs 1989; Westcott 1991; Hooy & Shaughnessy 1992). The proliferation of reserve designations and functions substantially complicates any assessment of the sufficiency of any given reserve network. For example, there has been prolonged debate about whether "reserves" in which exploitative industries are permitted should be included in calculations of adequacy and representativeness (e.g. Kirkpatrick et al. 1988).

*3.v.(b) Wilderness*

Introduction

In 1979 the Big Desert Wilderness was proclaimed, the first area set aside for this land category in Australia. Information and recognition of wilderness has increased dramatically since then. Reflecting this contemporary prominence, wilderness is given detailed and explicit treatment in the NFPS:

> "*The Governments have agreed to a strategy designed to conserve and manage areas of old-growth forests and wilderness as part of the reserve system. The strategy acknowledges 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 ... The Governments' agreed approach to conserving and managing old-growth forests and forested wilderness has five basic elements:*
>
> . *First, agreed criteria for old-growth forests and wilderness will be determined through the working group process already described.*
>
> . *Second, using these criteria, the relevant State agencies will, as a matter of high priority, undertake assessment of forests for conservation values, including old-growth values, and of forested land for wilderness values.*
>
> . *Third, until the assessments are completed, forest management agencies will avoid activities that may significantly affect those areas of old-growth forest or wilderness that are likely to have high conservation value.*

*. Fourth, forested wilderness areas will be protected by means of reserves developed in the broader context of protecting the wilderness values of all lands. For old-growth forest, the nature conservation reserve systems will be the primary means of protection, supported by complementary management outside reserves. The Governments agree that, conditional on satisfactory agreement on criteria by the Commonwealth and the States, comprehensive, adequate and representative reservation system to protect old-growth forest and wilderness values will be in place by the end of 1995 ...*

*. Fifth, the relevant management agencies will develop management plans to appropriately protect old-growth forest and wilderness values."*

## Definition

There have been many attempts to define and evaluate wilderness (e.g. Lesslie et al. 1988; Preece 1990; LCC 1990; Lesslie 1990; Robertson et al. 1992). A recent widely-used definition is that given in Robertson et al. (1992) as "*an area that is or can be restored to be: of sufficient size to enable the long-term protection of its natural systems and biological diversity; substantially undisturbed by colonial and modern technological society; and remote at its core from points of mechanised access and other evidence of colonial and modern technological society*". Relatively objective and quantitative procedures for its assessment are illustrated in Lesslie et al. (1988) and LCC (1990). However, the identification of areas meeting these specifications within a region "remains an area of uncertainty" (R. Lesslie *pers.comm.*).

R. Lesslie further noted in comments on a previous draft:

> *"It is fair to say that there is now general agreement as to the environmental attributes which comprise wilderness quality and that there is a generally accepted means of measuring and assessing these attributes in the landscape in the form of the National Wilderness Inventory (NWI). The NWI process does not, however, result in the production of a catalogue of wilderness areas. The NWI process is designed to measure variation in wilderness quality across the landscape using objectively measurable indicators. The result is a database providing information concerning variation in levels of remoteness and disturbance (wilderness quality) across natural lands. There still remains the problem of establishing the degree of remoteness and naturalness that is sufficient for a location to be regarded as a wilderness area".*

This problem was addressed also by J. Kirkpatrick, in comments on a previous draft of this paper:

> *"The technique of Lesslie et al. (1988) adds a primitiveness score to a remoteness score in order to gain a wilderness score. This is a methodologically unsound procedure as wilderness is defined by the combination of primitiveness and remoteness (Kirkpatrick & Haney 1980). Remote altered areas and roaded primitive areas are not wilderness. For this reason the national data compiled by Lesslie will have to be reassessed to ensure that primitive, non-remote areas and remote non-primitive areas are excluded from the core wilderness areas. These cores will then only exist because of their distance from mechanised access. The buffer or remoting zone between the mechanised access and the core must be protected if the core is to survive as wilderness. Thus the boundary of wilderness areas must include the minimum area that has to remain disturbance-free if the core is to survive. Lesslie*

*has grades of wilderness quality. I suggest that all grades be included as long as the areas concurrently satisfy both criteria. I also suggest that the type of investigation into improvement of wilderness quality and expansion of wilderness area by closing of selected roads that has taken place for the Tasmanian Wilderness World Heritage Area Management Plan be adopted as part of the final mapping process".*

Lesslie, in comments on the previous draft, provided some operational or pragmatic procedures for wilderness definition:

*"Determining (recognition of wilderness) involves assessing the relative importance of the wilderness quality (as well as weighing up the worth of competing landuse claims). This can be achieved by the use of explicit evaluation and decision making criteria and applying these to the NWI database. The AHC is at present undertaking work in this area. In practice, agencies which have been using NWI data to assess and select areas as wilderness have relied on it principally to ensure that a comprehensive review of wilderness resources takes place and to assist in their assessment and evaluation processes. The final identification of and determination of wilderness areas has generally been pragmatic, with area selection based on certain simple decision rules, often with adjustments to account for local circumstances."*

Assessing adequacy, comprehensiveness and representativeness

Given the hope of defining wilderness, what wilderness areas should be included within the protected areas estate, and can these be assessed according to the criteria of adequacy, comprehensiveness and representativeness?

Considering the question of which of the areas deemed to have wilderness value should be formally reserved as such, Robertson et al. (1992) suggest that "arguably, all of Australia's wilderness is now of high value". They also consider a possible selection process based on representativeness or significance, but the process is not elaborated. Instead they suggest:

> "*the community interest may best be served by ensuring that the process for deciding which wilderness areas are to be protected, which is essentially a political process, is at least simple and clear, with ample opportunity for community input*".

The NFPS states that the ANZECC/AFC working group will consider "*how the principles of comprehensiveness, adequacy and representativeness relate to protect wilderness areas, their definition and criteria based on those principles*". These three principles can clearly be related to the extent to which ecological processes and biodiversity can be maintained, but their use may be inappropriate for defining wilderness or in determining which of several possible areas should be chosen for wilderness designation.

Lesslie noted in comment on a previous draft of this paper that:

> "*The relationship between wilderness and the principles of comprehensiveness and representativeness is clear when the importance of environmental context in wilderness identification is considered.*
>
> *Highly remote and natural lands are valuable for conservation simply by virtue of these attributes alone, but there are many areas of lesser wilderness quality that are also important as wilderness because of environmental context. In environments that are rare or unusual, or have*

*been subject to intensive development, even the low levels of wilderness quality that remain may be regarded as important. For instance, it is not valid to equate similar levels of wilderness quality in Australia's alpine environments and in arid areas such as the Great Victoria Desert.*

*Wilderness criteria therefore vary from region to region with the significance of any given level of remoteness and naturalness very much dependent on environmental setting. There is a tendency for wilderness criteria to be set in a way that ensures that the most remote and natural remaining examples of environments are selected, subject to minimum requirements. The setting of differing selection rules or wilderness criteria (whether explicitly or pragmatically) for coastal, alpine, arid, semi-arid and different types of forested wilderness in recent wilderness assessment and identification procedures in South Australia and Victoria is evidence of this.*

*Given these considerations, it is appropriate that the principles of comprehensivenes and representativeness are taken into account in the design of wilderness reserves, and that some form of explicit regionalisation play a central role in wilderness reserve design.*

*The principles of representativeness, comprehensiveness and adequacy should apply in wilderness reserve design, although there will not necessarily be a complete match with the design principles of a reserve network intended to optimise biological conservation.*

*Regionalisation will be important in this regard, enabling the identification of areas that represent the most remote and relatively undisturbed examples of selected environmental types (subject to a minimum standard). An* *adequate reserve system for forested wilderness should be representative to the extent that it includes at least the most remote and undisturbed examples of all major forest types*".

Environmental regions, communities or forest assemblages may also influence the recreational amenity and diversity of recreational experiences provided by the wilderness area, which may provide another means to assess representativeness. As demonstrated in previous sections of this report it is difficult to establish and defend levels of representation of all environmental units for nature conservation goals: it may be far harder to rationally determine how much (or what proportion) of all forested environmental classes need to be represented in a wilderness system which aspires to sample all of this variation.

Adequacy may infer that at least one forest wilderness area should be gazetted per region (though more may be required to meet the principles of representativeness and comprehensiveness). In some regions this may be an impossible goal, as no lands may remain which statisfy wilderness criteria.

## Relationship of wilderness to conservation of biodiversity

The relationship of wilderness to conservation is somewhat tangled. Certainly some potential wilderness areas can be assessed for their contribution to conservation values (for example representativeness), but assessment on such criteria should not be confused with selecting between areas on any of the attributes which define wilderness.

Large areas in relatively natural condition with little human activity are important conservation sites, and may be particularly so for some species. The absence of roads and other disturbances reduces the spread to these areas of weeds and pest species. For example, roads are important access routes for foxes and feral cats and dogs into otherwise remote areas (e.g. Pyke & O'Connor 1990). At least the core of large natural areas is also relatively buffered from the influence of damaging practices operating outside their boundaries, and large natural areas serve as important scientific benchmarks (LCC 1990). J. Kirkpatrick further notes, in comments on a previous draft of this paper that:

> "*The critical point relating wilderness preservation and nature conservation is that, all else being equal, a large area without roads, and in a primitive condition, will be easier to manage for long term nature conservation and the continuity of evolutionary processes than small areas covering the same range of biodiversity*".

BDAC (1992) has specifically addressed the relationship of wilderness to the conservation reserve network:

> "*Within the protected area system, land designated as wilderness can be of particular importance for biological diversity conservation. Areas designated as wilderness must be large and relatively undisturbed, with core areas remote from mechanical access. The absence of artificial barriers to the movement of native species and the absence of artificial channels (such as roads and power line easements) which permit the movement of exotic species are directly beneficial to biological diversity conservation. They also benefit from the "distance-decay" effect which reduces the impact of deleterious disturbances such as human-induced fire, pollution and exotic disseminule drift, and alterations to drainage and water quality*".

But the conservation value of such sites is not enhanced by labelling such areas wilderness as opposed to conservation reserve. How such areas maintain their biodiversity is dependant upon operational management rather than nomenclature. In some cases the restrictions associated with wilderness designation may provide the type of management needed to conserve the biological diversity values of those remote and little disturbed areas, but they may also impose conservation costs (for example by effectively prohibiting intensive survey or by reducing the options for manipulation of fire regimes).

Wilderness **per se** is not an essential ingredient of a reserve network designed to optimise conservation of biological diversity. However it can make an important **de facto** contribution to that estate, or may be regarded as a complementary and sympathetic land use to a reserve system aimed explicitly and primarily at the conservation of biological diversity.

Lesslie, in comments on a previous draft, further elaborates the relationship of wilderness to conservation:

> *"The relationship between wilderness and conservation may seem confused at least in part because the wilderness concept can be appropriated for a wide variety of conservation purposes, in fact any conservation purpose which depends on relatively remote and ecologically intact lands. Recreationists have seen wilderness as beneficial in providing opportunities for unconfined and self-reliant recreation. Ecologists regard wilderness as capable of providing certain important conservation functions.*
>
> *Wilderness is characterised by relatively high levels of remoteness, and minimal ecological disturbance. While there are some major conceptual difficulties in applying the notion of naturalness to Australian ecosystems, relative freedom from disturbance by European influences and substantial remoteness from access and settlement (large size) are both fundamental characteristics.*

*If a reserve system is designed in a way that successfully incorporates ecological requirements for the maintenance of integrity then, the conservation benefits of high levels of remoteness (size) and naturalness to ecological integrity may be redundant. However, the practical and theoretical difficulties of determining and applying appropriate reserve design principles to ensure the security of individual species and ecosystems will often be extreme. Given these difficulties, together with the risks and uncertainties of operating with imperfect knowledge, levels of remoteness and naturalness associated with wilderness quality will often be a useful proxy for more theoretically explicit means of establishing reserve integrity.*

*Although there is a substantial complementarity between wilderness protection needs and the conservation of biodiversity and ecological processes, this issue should not dominate wilderness conservation considerations. It is important not to lose sight of wilderness as a conservation goal in its own right, as is very clearly established in the NFPS. Remote and relatively undisturbed areas of forest are increasingly scarce and areas that retain these values have an important place in nature conservation because they are rare and essentially irreplaceable natural assets. For that reason alone they are an essential ingredient of any reserve system designed to optimise nature conservation".*

In comments on the previous draft of this issues paper, the AHC noted that "*wilderness can be used as a surrogate for reserve selection and design, particularly with reference to the individual components for the identification of wilderness (e.g. biophysical naturalness, remoteness from access)*".

### Defining the selection order

Given the need and desire to include allocation of lands to wilderness as part of regional assessment, where should wilderness selection fit in the priorities of designing a sufficient reserve network?

There are three possibilities:

- wilderness areas may be identified initially and then these areas immediately earmarked for reserve (depending on the number of wildernesses required). This will ensure that the best (or all) wildernesses are guaranteed inclusion, but may markedly increase the inefficiency of meeting requirements for inclusion of all biological diversity units into a reserve network;

- wilderness and biodiversity conservation can be assessed simultaneously, with options then arranged to identify an optimum combination of wilderness and other reserve needs;

- the optimum solution for inclusion of all biological diversity units will be derived first, and then the elements of this solution would then be examined for their suitability as wilderness (or additional areas outside this solution could be added specifically for wilderness). This would maximise the efficiency of the biological conservation solution, but could limit the possibility of incorporating some wilderness areas.

J. Kirkpatrick noted in comments on a previous draft of this issues paper:

> "*The NFPS reads that all areas of wilderness should be conserved. So the appropriate policy for nature conservation is to determine which elements of forest*

*biodiversity need to be conserved outside wilderness, and, indeed, outside the equally secured old growth forest".*

Lesslie, in comments on a previous draft stated similarly:

> *"An appropriate model for wilderness reserve selection should firstly make provision for the inclusion of all areas that are* ***prima facie*** *wilderness".*

Alternatively, Sattler stated (in comments on the previous draft) that:

> *"The maintenance of wilderness is an important consideration in the management of lands for conservation purposes. Care must be taken that it is not confused with primary selection criteria for the protection of biodiversity. Rather, it should be considered as an important management objective that may be subsequently overlaid on a reserve system that in the first instance seeks to preserve biodiversity".*

Most selection procedures (such as CODA: Bedward et al. 1992) offer the possibility of choosing special cases first and guaranteeing that these will appear in the ultimate reserve design solution. In regions where several areas match wilderness criteria, the selection amongst these areas may be based on their relative contributions to representing restricted environmental classes or on the occurrence of rare species.

*3.v.(c) Other criteria (cultural, geological, etc.) for reserve selection*

Reserves in Australia (as elsewhere) serve a large variety of functions and have been declared for many purposes (e.g. Ride 1975; ANPWS submission to HORSCERA). There has been a strong association of National Parks with recreational use, and scenic and agreeable locations form a large proportion of the park estate. Recreational use will continue to be a major determinant of reserve allocation, and indeed of public support for the protected areas network. This recreational use is being increasingly coupled with educational uses, through interpretative facilities offered in many reserves. There exist some relatively objective methodologies for estimating tourist potential for various areas and hence selecting reserved sites for their recreational values (e.g. Wood 1990). Additionally, evaluation of scenery can be achieved in a formalised manner.

Many reserves have been declared primarily for the protection of water qualities, especially in catchments supplying drinking water to major towns. Such reserves are often managed in an especially protective manner, and hence provide valuable components of the conservation reserve network.

Unusual physical (geological or geomporphological) features may require protection through special reservation. Again, AHC has developed methodologies for evaluating the significance of such features.

Sites important for cultural reasons may also merit consideration for placement in reserves, and several existing conservation reserves have been established for this purpose (e.g. Alice Springs Telegraph Station reserve). Aboriginal cultural sites may also be protected within the reserve network, however the protective mechanism varies greatly between the States and Territories. Established AHC criteria can be used to evaluate the significance of such sites.

Reserves can also function, or be designed, to protect important fossil sites, and locations where type specimens were collected. The recent dedication of the Riversleigh area, based largely on its value for the interpretation of Australia's evolutionary history, is a good example of reserve selection being based not primarily on its value for protecting (existing) biodiversity, but which nonetheless may contribute to this function.

These disparate values and rationales for reservation sometimes can be accommodated readily within reserves selected for their contribution to maintaining biodiversity. For large reserves, specific recognition can be granted through park zoning. Alternatively, specific reserves may need to be created to meet the requirements of these criteria. In many cases such reserves may contribute little to biodiversity goals, and this may be best admitted by designating such sites outside the formal reserve network, or by using a distinct reserve category for such sites.

## 3.vi. Reserve selection procedures - the mechanism.

Until recently, for most States and Territories conservation reserves and National Parks have been selected mostly without any explicitly defined methodology (the Victorian example spanning 20 years of the Land Conservation Council is probably the most notable exception: e.g. LCC 1988). Although many important conservation reserves have been selected and their constituent biota accordingly protected, the overall selection process has resulted in a legacy of an unrepresentative reserve network, inefficiency and redundancy. All State/Territory conservation and land management agencies now recognise the need for selection procedures which improve the representativeness of their protected areas network.

As this will involve the establishment of further conservation reserves, the selection procedures will require the capacity to choose as efficiently as possible. The complexity of conservation evaluation, the number of permutations of considered land units, and the requirements to be economical and to recognise competing land uses means that the process of land selection generally requires use of GIS and specific algorithms to optimise consideration of possibilities.

This argument is not universally accepted. For example, Weatherley (1993) has presented a case that opportunistic reserve acquisition has been, and remains, important, and that attempts to define the most efficient combinations of land units needed to assemble a comprehensive and adequate reserve system are benighted. In a somewhat related argument, AHC (in comments on a previous draft of this paper) stated that land evaluation should include all available relevant information and not be restricted to data amenable to computer manipulation.

Increasingly sophisticated procedures are now available for the assessment, according to defined criteria, and consequent selection of land units for inclusion in a reserve system. Methodologies and algorithms developed in Australia over the last decade (Kirkpatrick 1983) have considerably advanced the power and applicability of these approaches (Margules 1989a,b).

There have been few detailed comparisons between alternative reserve selection procedures (Pressey & Nicholls 1989b; Bedward et al 1991; Canisius 1991), and the pace of improvements to existing algorithms or the develoment of new ones renders these comparisons of little currency, other than confirming the general advantage of computer-based iterative methods. The evaluation of alternative procedures requires a comparison of at least these measures:

- ability to incorporate diverse sets of data (e.g. land classification and tenure, presence of rare species),
- their base on a set of clearly specified rules,
- flexibility,
- efficiency in minimising costs in the attainment of a specified reserve goal,
- ability to present alternative solutions,
- ability to incorporate spatial relationships (e.g. linkages, juxtaposition or adjacency of chosen reserves) into solutions,
- ability to handle large data sets,
- ability to incorporate new information and hence update solutions,
- operating costs and user-friendliness.

The CSIRO submission to HORSCERA defined three features of reserve selection procedures: **complementarity** - reserves should complement one another in terms of the attributes they contain; **flexibility** - planning should be able to assess the costs involved in shuffling between sets of possible reserve configurations; **irreplacability** - some sites are essential and non-negotiable, mostly because they contain attributes not available elsewhere.

Iterative methods consider the changing context of environments (or species) requiring further conservation during the cumulative selection of land units. They produce a constellation of land units (either in order of selection or without priority) necessary to fulfil the conservation requirements within a region. If requested this can be done in the way which most efficiently (as measured for example by total area) meets these goals, i.e. a minimum set.

Iterative selection procedures were developed by Kirkpatrick (1983; also Kirkpatrick & Harwood 1983), initially based on an algorithm that first selected the richest sites, then the site which added the most number of additional species (or environments). Research since (e.g. Margules et al. 1988; Pressey & Nicholls 1989*a*,*b*; Nicholls in press; Nicholls & Margules in press) has developed a more efficient procedure, based on the selection first of sites that have unique occurrences of species (or environments). Where species lists aren't available for many sites, predicted distributions can provide a substitute (e.g. Austin et al 1984, 1990; Margules & Nicholls 1987; Margules & Stein 1989).

The efficiency of iterative procedures relative to more traditional reserve selection procedures was illustrated by Pressey & Nicholls (1989*a*) who ranked pastoral leases in the Western Division of NSW according to scores from 12 conservation value indices (including rarity, diversity, representativeness, etc.), and then recorded how many properties it was necessary to select before all attributes (land systems) were represented. The iterative selection procedure used required 5.7% of properties, compared to between 45 and 98% for other sampling procedures.

A recent example of the algorithm used in minimum set analysis is given in Table 8 [from Margules & Nicholls (in press)], and describes representation of tree communities and environments in a set of grid cells.

Minimum set algorithms for reserve selection have been greatly advanced and developed by teams at CSIRO Wildlife Research in Canberra and, jointly and separately, by teams at NSW NPWS. The mechanism which probably now best meets the criteria given above is CODA (Bedward et al. 1992), which is based on iterative minimum set algorithms but includes also flexible consideration of reserve design and land suitability criteria.

Canisius (1991) presented a detailed comparison of a range of reserve selection methods, including minimum set analyses, for consideration within the preparation of a strategic plan for QNPWS. Brief descriptions of recent techniques follow.

The **Rapid Appraisal Approach** has been used widely in Queensland, and was developed by Stanton & Morgan (1977). Its most recent version is given in Morgan & Terrey (1990). Procedure involves the delineation of "provinces" (essentially representing suites of similar land systems), the determination of major ecosystems within provinces (mostly through land system maps, or surrogates), and then the delineation of key conservation areas based on capture of representatives of all major ecosystems. This last is achieved through scan of Landsat images to reveal areas greater than 1000ha. For these large areas, component major ecosystems are determined and areas are given a higher priority if they contain ecosystems representative of the province and not represented within existing reserves. Priority is also given to areas capturing the greatest number of representative ecosystems, and rarity can also be accommodated. Canisius listed some limitations including inconsistent land units, reliance on intuition and manual analysis, inefficiency, potentially inconsistent solutions, subjectivity and some terminological problems with "ecosystems", "provinces", "land units", "land zones", etc. In comments on a previous draft of this issues paper, P.Sattler noted that notwithstanding these limitations, this method had proven extremely valuable especially where inconsistent data bases exist and in the absence of thematic mapping for vegetation or land systems and "*will continue to be the best available semi-quantitative technique available*".

The **Bolton/Specht** analysis (Bolton & Specht 1983; Purdie 1987) has also been widely used in Queensland, most notably in resource assessment of Mulga lands (Purdie 1985) and the Channel Country. This method uses regular units, e.g. grid cells. Within the study region, resource (e.g. land system) maps are digitised, and cells with similar resources are grouped into broad landscape types, such that the conservation value of units is calculated relative to the landscape type in which they occur. Three indices are then calculated, based on the %area of all resource types in each cell. These indices rate cells according to high diversity and more representative mapped systems (Priority Diversity Index), high diversity and amount of rarer mapped systems (Rarity Diversity Index) and number of mapped systems within a cell (Diversity). Focal (and subfocal) cells are then designated on the strength of their scores, or nominated on the basis of knowledge of the distribution of rare species. Land tenure is then overlaid on a display of focal and subfoacl cells, and a tentative reserve network delineated on the basis of clusters of focal and subfocal cells. This is then assessed to ensure that complete representation of mapped systems has been achieved, and the percentages of systems represented in the putative reserves are calculated, in order to prioritise the reserves. Canisius listed the advantages of this method as providing objectivity and rigor of a standard calculation applied over regular grid cells, but with also a (desirable) high degree of manual input in the definition of final reserve boundaries. Deficiencies included inefficiency (through repeating the application of a single formula rather than iteration), complicated translation of grid cells to acquisition units, lack of definition of the optimal grid cell size, and potential inconsistency between operators.

**Linear Programming** was implemented by Cocks & Baird (1989) in identifying potential reserve areas on Eyre Peninsula, and achieved comparable efficiency there to a minimum set analysis. Linear programming can concurrently address any number of selection guidelines. It first identifies whether any feasible reserve network exists, and then searches for an optimum solution which satisfies all selection criteria. It is highly flexible, but computationally intensive and complex for the layperson, and Canisius considered it insufficiently tested to be adopted for immediate use by QNPWS.

H. Possingham (in comments on the previous draft of this paper) has advocated greater consideration of mathematical programming as a procedure for most efficiently designing reserve networks, stating that "*they are guaranteed to be superior to rule-based iterative methods - especially for big data sets, complex constraints and complex cost functions ... the methods are not difficult to implement and with the recent rapid advances in workstation computing power large problems can be solved*". Possingham is currently comparing mathematical programming solutions to those derived by iterative minimum-set algorithms (data from Pressey in N.S.W.). Mathematical programming can also incorporate connectivity principles, redundancy, risk and uncertainty, and has the flexibility to produce and compare alternative solutions.

**LUPIS** (Cocks & Ive 1988; Ive & Cocks 1988; Ive et al. 1989) was developed from linear programming, and was regarded by Canisius as extremely flexible and user-friendly. It is a spatial decision support system package, and can accommodate requirements to simultaneously plan for both reserve selection and selection for other land uses. It can incorporate variable selection units (e.g. vegetation communities, grid cells, land tenure). It first identifies commitment guidelines (for which an area is immediately included), exclusion guidelines (for which an area is immediately deleted from further consideration), preference guidelines (not absolute rules, such as 'as far as possible choose areas adjacent to existing reserves') and avoidance guidelines (not absolute rules such as 'as far as possible avoid areas which are degraded'). Preference and avoidance rules are tallied for every map unit to determine a suitability score to evaluate its ranking for reserve (or other land use). A reserve network is then proposed based on these relative scores, and can be varied by further weightings of rules. The efficiency of LUPIS can be increased by inclusion of minimum set algorithms (CSIRO submission to HORSCERA).

Belbin (1992, in press) has developed a further approach to examining the representativeness of reserve networks (**"Environmental Representativeness"**). This procedure first develops an environmental classification, then identifies the centroids of the resultant classes, and then determines the distance of every land unit from its relevant centroid. Sites closest to the centroid are regarded as the most representative. Sites relatively distant (in multivariate space) define the variability within that class and/or form the nucleus of a (newly-defined) distinct environmental class. Belbin (in press) summarised aspects of the procedure:

> "*The use of a consistent method for creating environmental partitions and defining degrees of representativeness is explicit. Complementarity is automatically addressed by classification. Representativeness is defined as a continuous function; the distance in multivariate space of each sample from its cluster centroid. The number and size of reserves is not directly addressed. Environmental Representativeness does, however provide information that should assist in addressing these issues*".

It remains to be resolved whether all State and Territory agencies will converge in their use of one or several of these alternative selection mechanisms. Much could be gained by comparing selection techniques across the same region.

A basic consideration in reserve selection methodology is the preferred spatial unit for analysis (e.g. grid cells, catchments, properties). Grid cells have the advantage of (more or less) equal size, and hence simpler calculations of relative diversity and interpretation of the significance of species inventories, but they may provide some translation problems from a chosen reserve network to units of acquisition. Catchments may provide the best conservation reserves, but may show enormous variation in area which could confound some selection methods. Properties may be the easiest units to work with for reserve acquisition purposes, though they too vary in area, and may not be the dominant land tenure in many areas.

A more profound decision about selection mechanism is whether the selection process is explicitly limited (at least initially) to conservation assessment, or whether it includes simultaneously other land-use considerations and options (integrated assessment). The approach taken will determine the composition of the assessment panel and the mechanism with which decisions are made. This issue is further addresssed in section 3.viii.

It is also worth noting that reserve solutions derived from any mechanism must be adequately ground-truthed before their nomination or acquisition. This stage should include fine-tuning and iterative consideration of desk-derived "notional" reserves.

**Table 8**. An example of the algorithm used in minimum set analysis from Margules & Nicholls (in press), which describes representation of tree communities and environments in a set of grid cells.

STEP 1. An optional step at which some sites can be included before the selection procedure begins. Examples might be existing reserves or sites with known rare species.

STEP 2. Select all grid cells with unique occurrences of environments.

STEP 3. Find the next rarest environment and select the grid cell that, when added to those already selected, will represent that environment, plus the greatest number of other environments, at or above 10%.

STEP 4. If there is a choice, select the grid cell nearest to one already selected.

STEP 5. If there is still a choice, select the grid cell that also contributes the largest number of environments not yet represented at the 10% level.

STEP 6. If there is still a choice, select the grid cell that will enable the 10% level to be achieved for the rarest group of environments remaining under or unrepresented.

STEP 7. If there is still a choice, select the grid cell that will contribute most to achieving the 10% level of representation of the rarest group of environments remaining under- or unrepresented.

STEP 8. If there is still a choice, select the grid cell which either (a) contains the smallest percentage area necessary to achieve the 10% level of representation, or (b) contributes the largest percentage area of that environment if no one grid cell can enable the 10% level of representation to be achieved.

STEP 9. If there is still a choice, select the smallest (as all sites, being grid cells are equal in size, this step was not used).

STEP 10. If there is still a choice, select the first one on the list.

**Table 9.** The pathway used by CODA for reserve selection (from Bedward et al. 1992).

*Preprocessing*

STEP 1. Exclude inappropriate conservation features (e.g. marginal environments).

STEP 2. Allocate conservation features and units of cost to selection units.

STEP 3. Allocate land suitability classes to selection units and, optionally, exclude unsuitable units.

STEP 4. Define the representation target for each feature.

STEP 5. Identify focal selection units (either existing reserves, or irreplacable sites which must be included within the reserve network) which provide the "nuclei about which the expanded reserve network will be constructed".

*Preliminary selection of new reserves*

STEP 6. Apply the reserve selection algorithm (e.g.iterative or linear programming). This will produce a (displayed) array of notionally reserved units.

*Modification of the network*

STEP 7. Replace unsuitable selection units. (Features now falling below target representation are displayed, and land units capable of meeting targets are listed).

STEP 8. Check for any unnecessary increase in the cost of the network (e.g. redundant selection units).

STEP 9. Rationalise reserve boundaries.

### 3.vii. Reserve designation and management.

Variation in the designation and management of reserves within the protected areas network allows flexibility in purpose and selection criteria (and hence management), and may allow the provision of some pragmatic solutions in otherwise seemingly impossible or irreconcilable land use conflicts.

The downside of this variation is that the plethora of existing reserve designations and management regimes makes it very difficult to determine overall reservation status, and the extent to which a given reserve actually functions to protect biodiversity. This is especially so when States and Territories are compared, for example in some States and Territories extractive industries such as mining are permitted within (some) National Parks.

There have been many calls for a standard nomenclature for conservation reserves across States and Territories, with this standard calibrated to that adopted by IUCN (see Table 10). For example, the ACF/WWF submission to HORSCERA stated:

> *"the enlarged conservation estate should comprise reserves in categories I, II, and IV of the IUCN Classification. These reserves should have consistent nomenclature."*

That submission actually listed five classes of reserves:

1. National Parks: relatively large areas which contain representative, and wherever possible, ecologically integral samples of native vegetation. Managed for controlled recreation, educational and tourist activity.

2. Wilderness areas: natural areas of sufficient size to protect the pristine natural environment which serves physical and

spiritual well-being ... they are to be maintained largely free of human intervention.

3. Scientific reserves. reference areas for monitoring and ecological research ... often closed to the public.

4. Habitat and wildlife management areas maintained for specific conservation ends, and ... will require intensive management (e.g. critical breeding areas).

5. Local conservation areas, to protect small areas of native habitat ... administered through local government.

In 1985 CONCOM reviewed the classification of Australian National Parks and conservation reserves, and found that their divergent nomenclature and management regulations were a reasonable response to local needs, but some simplification could be warranted (ANPWS submission to HORSCERA). ANPWS and State agencies have recently completed a listing of all parks with categorisation according to the five IUCN criteria, which provides a useful context and base for comparison (Hooy & Shaughnessy 1992). ANPWS (in their submission to HORSCERA) were of the view that "the different categories for protected areas and differing management regimes (are) not likely to change for a considerable period of time".

Recommendation 3.2.2 (Protected area management) of BDAC (1992) also addresses management considerations:

> "*Undertake a 10 year Commonwealth, State and Territory cooperative program to:*
>
> *. develop management plans for all protected areas. These plans should ensure that genotypes, species or communities that depend on a particular protected area for their security are given the highest priority in management. Management plans should normally be developed within five*

*years of proclamation of protected areas, and should include provision for monitoring, and review of management objectives;*

*. evaluate boundaries of existing protected areas as part of the management planning process to identify whether alterations will provide for better long-term biological diversity conservation;*

*. ensure public participation in the development and implementation of management plans ...;*

*. provide and maintain sufficient resources, including trained staff, to implement management plans, and*

*. ensure that the range of protected area types has transparent nomenclature and associated management requirements, preferably relating to the IUCN classification of protected areas."*

In selecting lands for addition to the reserve network, it is important to tailor their reason for inclusion with an appropriate reserve designation and management regime. Some vulnerable species or environments may demand explicit management protocols, possibly including exclusion of recreational or commercial activities. Other areas may be chosen to sample environments which are resilient to disturbance and hence they may be managed to cater for a wide diversity of uses. In some locations, choices available for reservation may be limited to very small remnants. These patches may be sufficient to provide adequate representation of restricted plants or invertebrates. Although this is a valid and specific conservation function, these reserves may not match other criteria (e.g. size) for National Park status.

In general, "*the protected areas that are most important for the future of biological diversity are those that have nature* *conservation as their primary goal of management and which exclude all conflicting uses (eg IUCN Category 1 reserves). Nevertheless all classes of protected area, including those which allow activities such as the controlled extraction of minerals or the grazing of stock, are significant for biological diversity conservation*" (BDAC 1992).

Where a reserve network is explicitly constructed, every reserve has a clear reason for inclusion, and this rationale should be capable of determining the appropriate reserve designation and management. The detailed justification and explicit purpose of reserve proposals is now widely demanded (e.g. CRA submission to HORSCERA: "*the objectives of such protected areas need to be clear*").

Nomenclature conveys a general intention, but the effectiveness of the conservation function of protected areas is entirely reliant not on name but on on-ground management. This is especially the case for vulnerable species and communities which may demand research and regular active management (e.g. control of foxes, implementation of appropriate burning regimes) for their persistence within the reserve. In some cases, the type of management required may determine the reserve designation.

The critical role of management was emphasised in the National Association of Forest Industries (NAFI) submission to HORSCERA:

> "*there is growing evidence that the existing protected areas may be counter productive for biodiversity because of inadequate management practices*".

In one of the few available examinations of how well conservation reserves fulfil their purpose, Russell-Smith & Bowman (1992) found that monsoon rainforest patches suffered substantial degradation more or less equally across three land tenures: conservation reserves, Aboriginal Land and pastoral properties.

In general, Westcott (1991) concluded that the Australian National Park system "*was grossly under-resourced if judged by international standards*".

As an overriding principle, acquisition of lands for conservation purposes must be accompanied by the provision of sufficient resources to manage that land appropriately. In addition, sufficient knowledge of the reserve must be acquired to allow the development and implementation of an informed management plan, which charts the procedures for ensuring that conservation values are maintained.

**Table 10.** IUCN Protected Areas Management Categories.

**Strictly protected areas.**

I. *Strict Nature Reserves.* Generally smaller areas where the preservation of important natural values with minimum human disturbance is emphasized.

II. *National Parks.* Generally larger areas with a range of outstanding features and ecosystems that people may visit for education, recreation and inspiration as long as they don't threaten the area's values.

III. *Natural Monuments.* Similar to National Parks, but usually smaller areas protecting a single spectacular natural feature or historic site.

**Extractive Protected Areas.**

IV. *Habitat and Wildlife Management Areas.* Areas managed to protect and utilise wildlife species.

V. *Protected Landscapes.* Areas consisting of publicly or privately owned lands that may be subject to resource extraction and their associated human settlements, where the objective is to maintain the quality of the overall landscape, harmonious human interaction with it, and the biological diversity it contains.

**3.viii. Who decides: the role of Commonwealth and State agencies, experts, industry and public participation.**

ESD (1991) recognised that "*land use decision-making procedures are of paramount importance in avoiding or minimising conflict over forest use*" but were unable to give an explicit mechanism or protocol for such procedure. They did note several important stages: assessment of all forest values; wide community consultation; and involvement of Commonwealth and State Governments in cooperative assessment and determination of options. They also encouraged the development and use of integrated planning and decision support systems.

There are a number of models for the deliberation of regional land-use (including reserve selection) decisions. In Victoria (Land Conservation Council) and Western Australia (Conservation through Reserves Committee) explicitly-defined authorities have been established to consider allocations of public lands. These committees represent a range of primary industries, recreational groups, conservation organisations and relevant state government departments. In special cases (usually provoked by heated public controversy) land-use decisions have been decided in a judicial or quasi-judicial manner (e.g. Helsham Inquiry, DASETT 1988). In most other cases of reserve selection, prospective areas have been chosen by government (or occasionally non-government) conservation agencies, and these proposals have then been subjected to the scrutiny of other government agencies and/or the public, and then accepted, altered or rejected. Generally, selection criteria have not been explicit or, if so, then this explicitness is not based on any scientific grounds. Partly because of this lack of explicit criteria, there has been little attempt or ability to demonstrate the costs imposed by deviations from the optimum reserve network.

A protocol for implementing a representative, adequate and comprehensive reserve network across Australia's forests would aim to avoid such subjectivism and inefficiency.

It would require:

- a consistent and objectively-defined set of reserve selection criteria, established and accepted by Commonwealth, State and Territory governments,

- the application of these criteria by State and Territory conservation authorities to regions within their jurisdictions, to derive an optimum reserve network,

- the assessment of this optimum network by the Commonwealth, by other State and Territory agencies and by the public,

- refinement of the optimum network in light of input from these other sources, including an assessment of the cost of such changes.

With respect to this process, RAC noted that:

> "*the most effective way in which the states can demonstrate that their reserve systems are satisfactory would be to show that they conform with carefully drawn national criteria.*"

The Commonwealth's role (implemented through ANZECC and the AFC) may include:

. to provide assistance in the establishment of criteria;

. to ensure that the State's information base is adequate;

. to help liaison between neighbouring States where adjacent regions were being assessed;

. to assist where called upon in regional land-use assessment; and

. to provide possible support for acquisition or management of proposed reserves.

HORSCERA (1993) provides a similar set of roles for all reserve systems, including the provision of funds for acquisition and management of reserves which were nominated on the basis of their demonstrated contribution to the maintenance of biodiversity. This proposal was expanded by Kirkpatrick, in comments on the previous draft of this paper:

> "*The criteria for funding priorities in relation to forests could be recommended by this workshop. I recommend that the highest priority proposals should be those that demonstrably increase the number of species, communities and genotypes in viable numbers or areas within the reserve system, with weightings being given to ANZECC declared threatened species and communities. For the purpose of defining viability I suggest taking safe numbers or areas (e.g. 10,000 individuals in at least four spatially separate populations for higher plants; at least 2,000ha for floristic communities, the 30/60/90% rule for mappable entities).*
>
> *Bioregionalisation could continue as a parallel process, based on the aggregation of existing administrative/data collection units for the assessment of regional conservation adequacy.*
>
> *In another parallel process reserve patterns could be optimised within States and Territories on non-private land*

*using all available biological data and vegetation maps. Environmental data should only be used* ***in extremis****. The reserve selection techniques developed by Pressey and his associates provide the best option for optimisation after the elimination analysis described by Kirkpatrick and Brown (1991b). The parametres should be defined to select in the following sequence: 1) wilderness; 2) old growth (=unlogged forest); logged public forest; logged private forest. The targets should be: (90%/60%/30% as elaborated elsewhere). In all cases, if populations/areas do not reach minimum viability targets (see above) these should take precedence.*

*ANZECC is the appropriate overseeing body, with ANPWS providing the national and bioregional overview and advice on funding for land purchase/management."*

Variations on this theme were proposed by the Northern Territory Government and WWF in their submissions to HORSCERA, and other general protocols (for "Protected Area Systems Plans") have been developed for the IUCN (McNeely & Thorsell 1991). The WWF procedure is for a Protected Areas Network Strategy (PANS), which should be developed and implemented in the context of the framework National Strategy for the Conservation of Biological Diversity. In this proposal, the Federal Environment Minister would establish an expert sub-committee of the Federal Biological Diversity Advisory Committee to draft a Protected Areas Network Strategy for Australia. The sub-committee should consist of experts in the field of protected areas and include representation from the States and Territories and the Aboriginal community. They also recommended that the committee should have an independent chair.

RAC proposed that:

*"the choice of actual areas for further reservation is best left to 'balanced panels of experts' reviewing current land*

*uses within a bioregional context. The 'balanced panel of experts' concept endorsed by the Inquiry is similar to that used by the Forests and Forest Industry Council of Tasmania in developing the Forests and Forest Industry Strategy for that state."*

In comments on the earlier draft of this issues paper, ANPWS noted that:

> *"It is essential ... to distinguish between two separate stages in the process of reserve establishment: identification and selection.* ***Identification*** *involves the application of more-or-less scientific procedures to identify which areas of forests should be included in the system of reserves. It requires technical expertise in nature conservation and therefore is the prerogative of ANZECC.* ***Selection*** *is the political process by which decisions are made as to the actual areas to be reserved. This is a State-level responsibility, and involves trade-offs relating to other priorities such as agriculture, mining, forestry, etc. Industry groups have a role to play in the selection process, but* ***not*** *in the identification process".*

This general point is probably valid, although the distinction is softer than that claimed. The development of a comprehensive reserve system involves the steps of measuring the conservation values of all units of land considered, arranging these units in a way which best meets conservation (and other) criteria, and then assessing the loss (or alternative solutions) if the preferred solution is not obtainable. These are all stages in which conservation biology is an essential ingredient.

The NT Government submission to HORSCERA presented an explicit procedure for reserve selection. This procedure included:

1. The Commonwealth to develop a biogeographic regionalisation of Australia at an appropriate scale;

2. that regionalisation to be submitted to the States and Territories for agreement and amendment as necessary;

3. that then be adopted by ANZECC;

4. ANZECC should determine criteria for establishment of a national protected lands network taking account of the endorsed biogeographic regionalisation; important criteria will include (i) specification of the number, extent, and optimal configuration of sites to be included in each biogeographic zone and (ii) a timetable with milestones;

5. Each State/Territory develop reserve proposals that (i) satisfies State objectives in regard to representativeness, scale and configuration, (ii) is integrated with off-reserve measures, (iii) derives from extensive public consultation, (iv) minimises conflict with other land uses, (v) appears achievable financially and likely to attract community support, (vi) identifies options for variation of configurations to accomodate new information, (vii) takes account of and as far as possible complements proposed configurations in States sharing the same biogeographic zones; and (viii) in combination with neighbouring States incorporates reserves within each of the biogeographic zones recognised in the national regionalisation;

6. ANZECC to appoint a Task Force, including representatives of industry and other resource users, to review and integrate State proposals to satisfy criteria for the national network.

The duration of the assessment and selection process should be carefully set to ensure that reservation proposals are brought to fruition while they still retain the values that they were selected for. It is sobering to note Ride's (1975) lament that "*during the period of operation of the Reserves Advisory Council, even knowledge that the mineral potential of a recommended area was unknown was enough to cause the indefinite deferment of allocation*". Some groups propose that the economic value or potential of all proposed reserves be fully investigated before any reserve declaration, although the potential delay in reserve dedication because of this process was clearly illustrated in CRA's submission to HORSCERA, that "*the discovery of the world-class Century zinc deposit in an already well-explored area ... demonstrates that it is dangerous ever to write-off land as 'unprospective'*".

Public participation must be clearly defined in the reserve selection process. The LCC in Victoria provides an example where explicit opportunities are provided for public input, following the release of the background information report, and again following initial recommendations. It is important for the acceptance and support of reserve design proposals that the goals and methodology of regional study and land-use decisions are clearly explained to locals and other interested parties. Local input should be sought at the information-gathering stage, and during the process of reserve design and modification.

## 3.x. Limitations, priorities and timetable.

It has been argued (e.g. Adam 1992b) that all biological diversity cannot be captured within a reserve system. To do so might well require the inclusion of virtually all individuals (to incorporate the range of genetic variation) of all species (including the myriad invertebrate species, most of which are currently undescribed and for which information on distribution is essentially non-existent), with sampled areas being large enough to include viable populations of species, room for the required movements of mobile species, and the need for a range of management actions to serve the requirements of species for a diverse range of successional ages or disturbance regimes. Application of the precautionary principle may further expand the proportion of land area required to meet the above demands. Recher (1992) used the obverse of this argument to suggest that disturbance to any, even limited, area would probably result in the extinction of at least one species.

Even where tightly defined objectives and efficient selection procedures are used, reserve solutions may demand a politically unacceptable proportion of land. For example, Margules et al. (1988; 1991) demonstrated that even with minimum set algorithms 44.9% of total wetland areas were needed for single representation of all plant species (in the Macleay Valley floodplain), increasing to 75.3% of total area if all wetland types were also to be included. The inclusion of multiple representation substantially increased even this proportion.

It may be pragmatic for reserve selection practitioners to prioritise objectives, rather than to be forced to accept the cuts imposed less objectively by advocates of other land uses.

### 3.ix. Review period.

No reserve design will be perfect. Imperfections may come to light following designation, with the accumulation of more data. Areas deemed unsuitable at the time of assessment may be restored or otherwise gain suitability at a later date. The reserve estate should contain enough flexibility to allow for modifications in the light of increased knowledge or regional environmental change (Bridgewater et al. 1992). Perhaps the best way of factoring this in to the process is to ensure that a review period is explicit, such that assessment is repeated at a designated interval. In Victoria, a review process is adopted by the Land Conservation Council. Flexibility was also suggested by the Northern Territory and by the National Association of Forest Industries in their submissions to HORSCERA:

> "*Decisions on resource use cannot be delayed until we have perfect knowledge. Social and economic imperatives set a timetable for decisions which cannot be avoided. However, provision should be made for incorporation of additional information*".

To meet the timetables set in the NFPS and other recent initiatives, first-cut solutions for all regions may need to be made in the absence of the optimum detailed biological data. These solutions should not foreclose better design based on subsequently collected information or changes in the status of species or communities, and the system may have to be seen as one under continual refinement and improvement.

The cost of this flexibility is that there will be less stably defined boundaries for user-groups such as exploitative industries (i.e. less chance of "resource security").

The argument that adequate reservation of all species and communities may be unachievable was opposed by both C. Margules and J. Kirkpatrick in their comments on a previous draft of this paper. Kirkpatrick argued:

> "*The various strategies and policies relevant to the present exercise define biodiversity to be communities of species, species and the genetic variability of species. The hypothesis is unlikely to be correct for any of the components, or all of them together, if, as is implied by these documents and the general tenor of discussion in the issues paper, conservation requires only global survival of all the elements of forest biological diversity.*
>
> *Forests almost certainly cover a substantially greater area today than at the height of the Last Glacial in Australia, despite recent anthropogenic depletion (Hope & Kirkpatrick 1988). This implies that the present forest biodiversity survived many thousands of years in a smaller area than it occupies at present. A large proportion of the forest species in Australia have suffered little or no diminution in their extent as a result of land clearance and logging activities. For example there has been little or no clearing or logging in temperate rainforest and the eucalypt forests of the wet/dry tropics. Other forest species, especially those confined to the highly productive eucalypt forests in the temperate zone and the tropical rainforest on the most productive sites, may have suffered a greater disaster than the Last Glacial and therefore require protection within the remainder of their range, and, in many cases, rehabilitation. Nevertheless, our knowledge of vegetation history makes it seem unlikely that all Australian forests would need to be placed in Protected Areas to ensure the survival of native forest biodiversity, especially as extensive slash and burn silviculture seems likely to allow the survival of most native plant species.*

*The example used to bolster the case for full forest protection, and therefore the abandonment of biodiversity maintenance as a practical goal, is the study of Margules and his coworkers (1988, 1991) on the wetlands of the Macleay Valley flood plain. This cannot be fairly extrapolated to biodiversity maintenance in Australia as a whole, as the elements of biodiversity covered by their study are widespread throughout eastern Australia. It may well have been that all of them were well-reserved, by the most risk-averse criteria, elsewhere. If they were not so well reserved, the proportion of the total area of Australian wetlands that would be necessary to satisfy the criteria used within the Macleay flood plain would be infinitesimal compared to the results of the study.*

*It is worth noting in the above context that the reservation analysis of Kirkpatrick & Brown (1991a) in Tasmania that extended the present reserve network to encompass, where it was not already the case, 30-90% of the area/occurrences of forest mapping units, higher plant species and floristic communities selected little more than 40% of the extant forest estate. This included enormous over-representation of some non-commercial western Tasmanian forest types and species in the existing large Tasmanian reserve system. Given that higher plant species and floristic plant communities are likely to be good predictors of the unknown portion of our forest biodiversity, it seems reasonable to predict that, in Australia as a whole, 40% of the extant forest estate within protected areas would be a reasonable and prudent target for biodiversity maintenance, if the larger portion of this area were selected for biological representativeness. The figure of 40% for Australia as a whole is suggested because Tasmania has lost relatively little of its original forest compared to most States. If* *other States and Territories had similar depletion of forests, a smaller percentage would have been appropriate, as Tasmania's forests stand in the same relationship to Australia's forests as the Macleay River flood plain wetlands stand to the wetlands of New South Wales.".*

However, priorities may need to be applied, as some species, environmental classes or regional ecosystems are in immediate danger of complete elimination. The target dates established in recent reports and initiatives can probably only be met through a considered order of actions and attention.

The NFPS places explicit target dates for reserve improvement, most notably:

*"The Governments agree that, conditional on satisfactory agreement on criteria by the Commonwealth and the States, comprehensive, adequate and representative reservation system to protect old-growth forest and wilderness values will be in place by the end of 1995 ... The Governments have agreed that their objective is to complete, to the extent feasible, the inclusion of any private forested land in the reservation network by 1998."*

A range of other processes and government initiatives bear upon the pace and order of procedures for forest reserve selection and consolidation. These include:

(a) BDAC (1992), which includes recommendations (3.2.1) to:

*"undertake a 10 year Commonwealth, State and Territory cooperative program, which includes the provision of adequate resources, to ensure that the terrestrial and marine protected area systems are comprehensive and ecologically viable ... take immediate action to identify those components of biological diversity which are known to*

*be threatened and inadequately reserved, and to incorporate these within the protected area system. Action is also required to ensure that further areas of high wilderness quality are placed within the protected area system*", and

"*Undertake a 10 year Commonwealth, State and Territory cooperative program to develop management plans for all protected areas ...(and) ... provide and maintain sufficient resources including trained staff, to implement management plans*" (Recommendation 3.2.2).

Consolidation of information bases are also included within set timetables, for example the NFPS (1992) included these commitments:

"*Over the next four years, the NFI will:*

*. develop further regional data sets for priority areas and purposes;*

*. establish a directory of datasets relevant to government forest planning and decision-making, within the National Directory of Australian Resources;*

*. adopt a standardised format for the classification and collation of all existing and new information on major forest attributes, both wood and non-wood;*

*. co-ordinate NFI information with natural resource, environmental and other complementary database systems to maximise efficient data use*".

The Statement on the Environment by the Prime Minister in December 1992 also included the following timetables:

> "*The Government has adopted a policy that all major ecosystems be surveyed and that a comprehensive, adequate and representative system of reserves be established progressively by the year 2000 ... Accordingly the Government will provide $16.85 million over the next 4 years:*
>
> *. to continue and expand existing Commonwealth/State programs for the development and implementation of a bio-regional approach to the identification of protected areas;*
> *. to complete the National Wilderness Inventory by 1993 and to ensure its maintenance as one of several key indicators in the development of the reserve system;*
> *. to promote and encourage State and Territory cooperation in surveying and protecting publicly owned old growth forests and wilderness by 1995. Such forests on private land should be reserved by 1998 ...*
> *. to provide incentives for State and Territory cooperation in progressively developing a comprehensive system of protected areas, to be completed no later than 2000;*
> *. to develop and apply nationally consistent principles for the management of reserves in accordance with internationally accepted classifications and standards.*"

The most commonly used prioritisation involves taking account of likelihood of extinction. For example, Floyd (1990) provides one attempt at establishing priorities:

> "*Ideally, all rare or threatened species should be conserved over their full geographic, edaphic and altitudinal range, preferably by several reserves including each factor. All species are important and represent*

*unique genetic material. As a guide, the first priority is that all species should be conserved in at least one site. Next, additional sites throughout their ranges should be secured. Finally, replication of key sites should be attempted in case one site is destroyed by catastrophe."*

Similarly arguments for initial attention to threatened species and communities were given by the ANPWS (in their submission to HORSCERA):

"*immediate action is required to identify and incorporate within the protected area system those components of biological diversity which are known to be threatened and inadequately reserved*"

and by Kirkpatrick & Brown (1991b), that conservation strategy should concentrate on poorly-reserved, rare and endangered species. This approach was also supported by ESD (1991).

Attention should be directed to how priorities can be defined for:

regions,
ecosystems,
communities,
species,
processes,
baseline data,
establishment of criteria,
development of modelling,
methodology for national and regional assessment, and
planning for climate change,

amongst other issues.

On a national basis, it may be critical to examine what regions (however defined) are most in need of urgent assessment, and to begin assessment on these. Such priority areas may be those known to be presently poorly reserved (e.g. Thackway 1990, 1992) or those in which ecosystems are known to be immediately threatened (e.g. Brigalow country in Queensland). At the same time it may be possible to identify the regions for which data are particularly sparse, and then to target these immediately for further systematic survey.

This approach will either attempt to heal the most serious problems or provide a band-aid solution which may in fact impair the provision of long-term more appropriate solutions. H. Possingham, in comments on the previous draft of this paper, warns about this latter possibility:

> "*In designing a reserve system it is tempting to place certain criteria above representativeness eg. first acquire reserves that contain endangered or vulnerable species, keep existing reserves, etc. Although these can make the overall task much simpler they set dangerous tacit priorities that need to be carefully thought through before being enacted. In the long term a representative reserve system based on an environmental classification will probably be the best strategy. Endangered species may become extinct despite our best efforts, functioning ecosystems are the cornerstone of long-term nature conservation" and the philosophy of patching up obvious "holes" in the reserve network (as recommended by HORSCERA 1993 for example) "will further constrain future options. It would be best if we carried out the whole task of setting up a representative reserve system for each region as soon as possible. Until that is achieved there should be a moratorium on vegetation clearance*".

Within regions, the target dates already defined suggest that first emphasis must be given to considering old-growth forests and wilderness. Indeed, the target date of 1995 for the establishment of a comprehensive, adequate and representative reservation system to protect old-growth forest and wilderness values is such that it is unlikely that other values within regions can be thoroughly examined and satisfactorily incorporated into reserve design.

Following attention to old-growth and wilderness, the definition of the status and distributions of rare or endangered taxa or environmental classes may be the next level of priority within regions. Again however, the argument presented by Possingham should be considered, and reserve design may be poorly served by immediate attention to rare species at the possible expense of the consideration of comprehensiveness.

The amount to be considered and the timetable for its consideration means that as far as possible, much of the evaluation process needs to be done in parallel rather than sequentially. As an example, there probably isn't time to delay assessment until regions are defined based on adding biological data to environmental domain information. Kirkpatrick's model (presented in section 3.viii. above) describes a process whereby the goals of a protected area network can be approached very quickly. Note that to meet the explicit dates for the development of the reserve system envisioned in the NFPS, then a series of other steps (e.g. for data acquisition) will have to be tightly slotted in, with their own deadlines. We identify, and present an estimate of the deadlines required for, these steps in the following section.

## 4. Options for achieving the goals outlined in the National Forest Policy Statement.

### 4. (i). Introduction

Sections 1 - 3 of this Discussion Paper provide background and consider the major issues associated with the task of creating a continental forest reserve system based on the principles of comprehensiveness, adequacy and representativeness. This section considers approaches and, where necessary, the options available for achieving the National Forest Policy Statement goals within the identified timeframes. The approaches and options presented are based on a combination of the large body of research summarised earlier in this paper and outcomes emerging from a technical seminar held in Canberra on 5th March 1993 involving over 60 representatives from State, Territory and Federal government agencies.

A consensus emerged from the technical seminar as to the overall framework and steps required to achieve the NFPS goals. It was agreed that the overall framework should be based on a co-operative and collaborative approach between the Federal, State and Territory governments. The goals of the NFPS will be met largely through technical and other deliberations undertaken at a regional level with co-ordination at a State/Territory and national level so as to ensure consistency across the forest estate. The framework, goals, objectives and criteria will need to be determined at the State/Territory and Federal level <u>prior</u> to reserve selection at the regional level.

The major steps involved in the process were identified as:

* to identify the regions and land tenures that will form the basis for the reserve selection deliberations

* to identify the data required to meet the goals

* to establish criteria for reserve selection

* to establish guidelines for the configuration of reserves (including the enhancement of reserve connectivity within the landscape) and off-reserve management

* to identify the most appropriate procedure(s) to select reserves

* to suggest a process(es) for decision-making at the regional level which can be embedded in the co-ordinated State/Territory and Federal process

* to ensure that existing government processes are properly incorporated into the NFPS forest reservation process

* to identify priorities and timelines for the implementation of the NFPS forest reservation process.

These eight steps are addressed below (Sections 4.(ii) to 4.(ix)).

*(a). The NFPS definition of forest*

Difficulties associated with the current definition of "forest" adopted by the NFPS have been identified in various comments on an earlier draft of this paper (see Section 3) and were raised repeatedly during the technical seminar.

It is apparent that the current definition of forest needs modification as a number of important forest communities (e.g. tall open eucalypt forest with canopy cover of less than 30%, brigalow) are not covered by the current definition.

**4. (ii). Regions and land tenures which will form the basis for the forest reserve selection deliberations.**

There exists broad consensus that the use of regions can facilitate the achievement of the NFPS goals. However, such "regionalisations" are simply tools or a means to an end that provide a focus for forest reserve assessment. Therefore, the adoption of a regional approach should be done in a manner which maintains flexibility while enhancing consistency across regions. Necessarily, the implementation of the reserve selection process within any nominal region is likely to require the consideration of relevant factors in adjacent areas/regions as well. The latter already occurs as part of the current Regional Assessment process undertaken by the Australian Heritage Commission and a previous example was the consideration of physical heterogeneity in neighbouring East Gippsland, Victoria that was undertaken by the Joint Scientific Committee in their deliberations on the south east forests of New South Wales.

*(a). Regionalisation issues*

In terms of regionalisation, three main questions arise and were addressed at the technical seminar: (1) how should the regions be defined?; (2) should size criteria be set for these regions?; and (3) how should the reserve selection process be managed if regions transcend State and Territory borders?

In defining regions, the main options are approaches based primarily on the use of:

(1) existing administrative and other regions employed in the States and Territories;

(2) environmental domains based on continental, sub-continental through regional analyses; and

(3) a combination of 1 and 2 where the environmental domain approach is used to complement and help resolve inconsistencies arising from 1.

Both the existing administrative and other regions employed in the States and Territories and the environmental domain modelling approach undertaken by ERIN and CRES can be used in a complementary manner. The adoption of the existing regions employed by the State and Territories with some modifications would ensure that the forest reserve selection process proceeded without delay and, thus, was more likely to meet the timeframes agreed in the NFPS. The physical data on which the current continental-scale environmental domains are based are the only continuous data sets available and provide a means to explicitly evaluate consistency in approaches to regionalisation.

It is considered inappropriate to establish specific size criteria for regions. The level of biophysical heterogeneity will vary considerably between different parts of the forest estate. Therefore, it appears more appropriate to provide flexibility in the size of regions and to let resource availability and needs, and administrative support and considerations primarily determine size. The management of regions that transcend borders was not considered to be a significant difficulty given a co-operative and collaborative approach was adopted by all concerned governments; working models are already in operation for such circumstances (e.g. Murray Darling Basin Commission, National Forest Inventory studies in north east NSW and south east Queensland).

*(b). Land tenure*

Widely-based agreement exists that all land tenures should be included from the outset in the forest reserve selection process. Clearly, however, constraints and priorities may be added later in the implementation phase of the process where tenure and other non-biological considerations become important. The latter is already explicitly recognised in the NFPS regarding the chronological achievement of a comprehensive, adequate and representative reserve system on public and private lands.

**4. (iii). Data requirements and related considerations to meet the NFPS goals**

Data of sufficient coverage, resolution and reliability are required to ensure that the nature conservation, old growth forest conservation and wilderness conservation goals of the NFPS are met. Given the short timelines for achieving the NFPS goals three significant matters are identified:

(1) that, because of time and data constraints, the forest reserve system arising from the immediate NFPS reserve selection process would be a "first cut" and it is essential that the emerging reserve system be re-evaluated as new information comes to hand;

(2) that, because of limited data, the data set used for forest reserve selection should be ALL relevant data that are currently available - furthermore, ecological theory and quantitative techniques such as predictive modelling and computer simulations (e.g. population viability analysis) should be exploited wherever possible. However some participants in the seminar warned that reliance only upon opportunistic data could be dangerous, and result in substantial distortions in conservation assessment and reserve placement; and

(3) that a research programme be designed and implemented to ensure the availability of data to re-evaluate and enhance the reserve system beyond the immediate timelines outlined in the NFPS.

*(a). Priorities for old-growth forest and wilderness*

Four priorities are identified to permit the reservation of old growth forest and wilderness in accordance with the principles outlined in the NFPS:

(1) the methodology employed for the delineation of old growth forest attributes through the use of remotely-sensed and other data in eastern Victoria by the Victorian Department of Conservation and Natural Resources (P. Woodgate et al.) should be adopted throughout the remaining forest estate as soon as possible;

(2) an operational threshold for defining old growth forest from the methodology employed in 1 should be finalised;

(3) explicit procedures for achieving representativeness and comprehensiveness of old growth forest and wilderness areas should be established; and

(4) the methodology employed to identify wilderness and old growth forest should be validated in the field.

*(b). Continued occurrence of old growth forest*

The definition of old growth forest adopted in the NFPS is similar to that used by the RAC Forest and Timber Inquiry. Both definitions, however, are limited to the extent that young successional stages of old growth forest may not be adequately considered and accommodated within any regional reserve system. Means to address this limitation are required and appear best implemented at the regional level provided that consistency across regions is ensured.

*(c). Biological surveys*

Biological surveys are integral to the entire forest reserve selection process. Systematic biological survey should precede regional investigations and reserve design wherever necessary and possible. Biological surveys may be required in identified notional reserves before they become formalised.

*(d). Scale*

It is undesirable to set a minimum level for the resolution of scale to be employed for the use of various data sources (eg. environmental domains, vegetation mapping, predictive modelling of fauna distributions) in reserve selection. It is essential to recognise the constraints and potential for errors that the use of "coarse" data may involve, while at the same time appreciating that where urgent decisions need to be made there may be no other option. Nonetheless, the **preferred minimum scale of resolution** for data is considered to be 1:250,000 - 1:100,000 or finer, wherever available.

To an extent, dealing with scale can be quite flexible. Timelines may dictate the level of detail used and achievable. Mapping scales may provide the resolution which determines the level of hierarchy at which vegetation communities are defined, and hence the placement and amount of reserves necessary to achieve the goals of comprehensiveness. If the scale is coarse, there will be substantial variation within the defined communities. This should be captured under the criterion of representativeness.

## 4. (iv). Criteria for forest reserve selection

Four key reserve selection criteria are addressed: (1) should pre-European settlement be the baseline for deciding on adequacy for reservation?; (2) what proportion of each environmental class should be reserved?; (3) should guidelines for reserve size and spatial arrangement be set?; and (4) how should the reservation of viable populations of taxa be dealt with?

*(a). Pre-European baseline?*

A consensus emerged from the technical seminar that estimates of forest coverage and species distributions prior to European settlement should, wherever possible, be used as the baseline for establishing the proportion of each environmental class or community to be reserved on a regional basis. This is considered feasible for most broad forest types but pre-European distributional data of sufficient precision are unlikely to be available for most species.

*(b). What proportion?*

Three general options were identified but no consensus was reached at the technical seminar as to which option or combination should be adopted:

(1) The IUCN recommendation of 10% of the (pre-European) area of all environments as an absolute minimum.

It should be noted, however, that this level of representation may be unlikely to conserve a number of biological communities.

(2) Specified minimum representation of 90% of the remaining area/populations of nationally endangered species and communities, 60% of the remaining area/population of communities substantially reduced by clearing and/or vulnerable, and 30% of the area of remaining native species and communities.

It should be noted that some flexibility would have to be adopted in the implementation of options 1 and 2 to accommodate exceptional situations and needs. This may be best left discretionary, on the basis of each regional context.

(3) Set no minimum level but aim to reserve as much as is needed in each region to ensure that the NFPS goals are achieved. Necessarily, decisions on the level of reservation would be made at the regional level.

*(c). Reserve size and spatial arrangement*

Guidelines for the spatial configuration of reserves are desirable but difficult to set explicitly because, primarily, of limited knowledge and the attendant uncertainty, and the idiosyncratic spatial arrangements of forests in different regions. This area is a priority for research.

The option of setting a minimum size for reserves is inappropriate - particularly as it is clear that many very small remnants may be critical for the persistence of invertebrates and plant species with limited ranges. The preferred size and spatial arrangement of reserves will vary regionally depending on context and, to a large extent, such matters appear best decided within the regional process.

Off-reserve management will have a critical influence on the long term viability of any reserve system.

*(d). How should the reservation of viable populations of taxa be dealt with?*

A goal of the NFPS is to ensure the reservation of 'viable' populations of species. For a limited number and range of forest species the use of population viability analysis can help inform decisions on this goal. For most species, however, the use of PVA is not an option because of limited data. In these cases it is suggested that operational guidelines based on ecological theory and empirical studies need to be derived for identifying viable populations.

**4. (v). Guidelines for the configuration of reserves and off-reserve management**

Every attempt should be made to avoid the loss and degradation of forest ecosystems outside the reserve system. Strong protective measures and land acquisition will be required in some instances to prevent biodiversity loss. The management of the landscape *in toto* is seen as essential since the reserve system is only one component of attempting to maintain biodiversity and other forest values at the landscape level. Decisions over reserve configuration, off-reserve protective measures and related matters will vary with regional setting and are considered best dealt with at the regional level.

Uncertainties remain over the efficacy of corridors and other retained areas to facilitate the maintenance of biodiversity and other forest values outside reserves and under human-induced climate change. It is suggested that guidelines framed as testable (working) hypotheses are required as a basis to direct off-reserve management and that these would be modified as new information becomes available. Such hypotheses and associated protective measures could be developed as part of a complementary research programme.

## 4. (vi). Procedures to select forest reserves

Four issues are addressed: (a) reserve selection procedures; (b) procedures to consider alternative land-uses; (c) the role of public participation; and (d) the order in which wilderness, old growth forest and other forest values would be considered in reserve selection at the regional level.

*(a). Reserve selection procedures*

The longer term aim is that iterative computer-based procedures such as CODA - which is quantitative, explicit and repeatable - will form the basis of reserve selection and re-evaluation in each region. In the short term, a combination of iterative and alternative techniques will need to be used for reserve selection as a means of rationalising recent and existing State/Territory and Federal reserve selection processes.

It is desirable to undertake further comparative studies on the performance of different techniques for reserve selection at the regional level, as initiated by the RAC Forest and Timber Inquiry in Tasmania. A comparative study of the AHC Regional Assessment approach versus CODA or other techniques is desirable. It must be stressed however, that these proposed comparative studies represent means to complement and improve on existing mechanisms and procedures, NOT a reason to slow down the reserve selection process.

*(b). Consideration of alternative land-uses*

The technical seminar considered that, initially, it is critical that the preferred notional reserve system should be based on environmental data. Alternative land-uses will need to be considered once the preferred notional reserve network has been designed. Various options exists to use quantitative computer-based techniques to consider alternative land-uses at this stage. Models such as LUPIS or CODA are potential candidates for use as they have demonstrated capability to include consideration of substitutability and flexibility.

*(c) Public participation*

It was widely agreed that public involvement should be an explicit component in many stages of reserve design, such as collection of information, reserve proposals and consideration of other land uses. More effort should be expended on explanation of methodologies and goals.

*(d). Selection order of forest values*

On the basis of earlier submissions and deliberations at the technical seminar it is apparent that wilderness and old growth forests should be considered first in the reserve selection process to achieve the aims of the NFPS. Biological diversity and other conservation goals can then be accommodated in the design of a notional ideal reserve system at the regional level.

**4. (vii). Who decides?**

The implementation of the forest reserve selection process requires the establishment of regional committees to advise on reserve selection and a co-ordinating group(s) at a State/Territory and Federal level to help ensure the systematic and effective use of existing processes, consistency between regions, and that timelines are met. It is expected that the regional committees would be comprised of a panel of conservation design experts and other expertise as relevant.

**4. (viii). Ensuring that existing government programs are properly incorporated into the NFPS forest reservation process**

The timelines indicated in the NFPS for upgrading the forest reserve system are only realistic if a number of exisiting government programs are incorporated into the national forest reserve selection process, and the possibility of duplication is minimised. These programs include the NFPS Comprehensive Integrated Regional Assessment process, the AHC Regional Assessments, the old growth studies of the Victorian Department of Conservation and Natural Resources and the NFI, the National Wilderness Inventory, CYPLUS (ERIN), the Development of a National System of Reserves, and the States' and Territories' reserve allocation and evaluation programmes. The incorporation of these programs in a systematic manner will require co-ordination at a national level.

**4. (ix). Priorities and timelines for the implementation of the NFPS forest reservation process**

The NFPS, and other recent Federal initiatives, have placed explicit target dates for various stages of the development of a national reserve system. These are indicated by asterisks in the following list. There are a number of steps needed to meet these targets, and probable intermediate targets are set for these steps in the following list. Wherever possible actions to meet these nominated targets should begin immediately (if they are not already currently underway) and operate in parallel.

The following actions were considered to be high priority and the targets achievable.

*Identification & research*

* (a) Data base for wilderness to be completed by end of 1993.

(b) Criteria for assessment, reserve selection and Commonwealth/State process (including for wilderness and old-growth forest) to be determined by end of 1993.

(c) Regions to be used for regional investigations to be defined by end of 1993.

(d) The most poorly-known regions to be identified and systematic survey commenced by end of 1993.

(e) The most "vulnerable" (or least reserved) regions to be identified by end of 1993, and regional investigation/reserve selection process commenced immediately for these regions.

(f) Compilation of reservation status for at least all vertebrate and vascular plant species, vegetation types, etc prepared by end of 1994.

(g) Population size, distribution and environmental requirements for all rare/endangered species and communities to be collated by end of 1994, including PVA for a systematic representation of these.

(h) All old-growth forest areas to be identified by end of 1995.

(i) Research on relationships between species distributions and environmental classification and predictive modelling be systematically addressed by end of 1995.

(j) Survey for the most poorly-known (and/or "vulnerable") regions to be concluded by end of 1995.

(k) Survey for all other regions to be completed by 1998.

*Allocation & implementation*

(l) Reservation requirements for endangered species and communities to be met by end of 1995.

* (m) Adequate, representative and comprehensive system of conservation reserves established for wilderness by 1995.

* (n) Adequate, representative and comprehensive system of conservation reserves established for old-growth forest by 1995.

* (o) Regional investigation/reserve design for all regions to be completed by 2000. Note this target date is from the broader National System of Reserves policy, not the NFPS.

(p) Design to be implemented and management plans prepared by 2002.

**4. (x). Some research needs**

As a result of discussions at the technical seminar, several areas of research are evident and could be conducted in parallel with other activities in the forest reserve selection process, where other immediate needs do not take priority:

* further biological survey - especially to fill in gaps of poorly known regions and poorly known biota (e.g. non-vascular plants, invertebrates, mobile species)

* further development and testing of reserve selection procedures

* comparative studies of reserve selection procedures using common data bases in the same region

* compilation of a database/atlas of the distribution of endangered species

* development of testable (working) hypotheses and protective measures for guiding off-reserve management

* development of guidelines for the reservation of viable populations

* further development and testing of environmental domain methodologies, predictive modelling and computer simulation techniques (e.g. PVA) for modelling components of biodiversity in space and time.

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APPENDIX A: Extracts from the National Forests Policy Statement, December 1992.

*"The nature conservation objectives are being pursued in three ways. First, parts of the public native forest estate will continue to be set aside in dedicated nature conservation reserve systems to protect native forest communities, based on the principles of comprehensiveness, adequacy and representativeness. The reserve system will safeguard endangered and vulnerable species and communities. Other areas of forest will also be protected to safeguard special areas and to provide links where possible between reserves or other protected areas. Nature conservation reserves will be managed so as to protect their values. Second, there will be complementary management outside reserves, in public native forests that are available for wood production and other commercial uses, and in forests on unallocated or leased Crown land. Third, the management of private forests in sympathy with nature conservation goals will be promoted ... In developing the nature conservation reserve system ... each Government will, where possible, ensure that effective corridor systems link reserves, refuges and areas with a relatively large range of altitudinal and other geographic variation so as to take into account the possible impacts of climate change .... The Governments agree that the representative areas for reservation will, in the first instance, be drawn from Crown lands."*

*"It is important that Australia has a comprehensive, adequate and representative network of dedicated and secure nature conservation reserves for forests and reserves for protecting wilderness ... The Governments agree to review the appropriateness of the existing reserve system to determine any further action that may be required to complete its development. They agree that the system of reserves should be reviewed and its development completed as a matter of priority. Accordingly, the Governments will establish a working group of technical experts under a Steering Committee of ANZECC and the AFC ... to make recommendations to the Government on broad criteria on which to base reserve systems to protect the nature conservation values of forests. The criteria will be based on the principles of comprehensiveness, adequacy and representativeness. Within these principles, the working group will consider such issues as the design and rationalisation of reserve boundaries, the area required to maintain viable populations and genetic diversity, the need for replication of protected communities, and the protection of rare, vulnerable and endangered species ... The working group will also consider how the principles of comprehensivenss, adequacy and representativeness relate to reserves to protect wilderness areas, their definition and criteria based on those principles."*

*"In progressively developing the nature conservation reserve system and reserves to protect wilderness areas, the Governments will give priority to those forested areas that best meet the*

*criteria adopted jointly by the ministerial councils and endorsed by the Governments. In situations where the Comonwealth has been invited by the States to assist in assessing the adequacy of the existing reserve systems, the Commonwealth will, when requested, consider support for the assessment process and the establishment of new reserves ... The Governments will provide adequate resources for managing their respective nature conservation reserve systems ... The Governments will ensure that unique features and heritage values of conservation significance are protected as part of the overall reservation systems. ANZECC and the AFC will report regularly to the Governments on progress in establishing the reserve systems."*

*"The Governments have agreed to a strategy designed to conserve and manage areas of old-growth forests and wilderness as part of the reserve system ... The Governments' agreed approach to conserving and managing old-growth forests and forested wilderness has five basic elements: first, agreed criteria for old-growth forests and wilderness will be determined through the working group process already described. Second, using these criteria, the relevant State agencies will, as a matter of high priority, undertake assessment of forests for conservation values, including old-growth values, and of forested land for wilderness values. Third, until the assessments are completed, forest management agencies will avoid activities that may significantly affect those areas of old-growth forest or wilderness that are likely to have conservation value. Fourth, forested wilderness areas will be protected by means of reserves developed in the broader context of protecting the wilderness values of all lands. For old-growth forest, the nature conservation systems will be the primary means of protection ... The Governments agree that, conditional on satisfactory agreement on criteria by the Commonwealth and the States, comprehensive, adequate and representative reservation to protect old-growth forests and wilderness values will be in place by the end of 1995 ... Fifth, the relevant management agencies will develop management plans to appropriately protect old-growth forest and wilderness values."*

APPENDIX B: Synopsis of some relevant findings of recent Inquiries and agreements.

(i) Protection of biodiversity

IGAE (3.5.3): *conservation of biological diversity and ecological integrity should be a fundamental concern.*

ESAC: *The overall aims defined in the strategy are:*

- *to ensure that endangered and vulnerable species and ecological communities can survive and flourish;*
- *to ensure that endangered and vulnerable species and ecological communities retain their genetic diversity and potential for evolutionary development in their natural habitat; and*
- *to prevent further species and ecological communities from becoming endangered.*

BDAC: *The strategy recognises that: the maintenance of biological diversity and ecological processes and systems is one of the core objectives of ecologically sustainable development.*

BDAC: *The conservation of biological diversity is an activity essential for the maintenance of the quality of life for both present and future generations of Australians and we all bear responsibility for it.*

(ii) Requirement for an improved reserve system.

IGAE (Schedule 9.13-14) *The parties agree that a representative system of protected areas encompassing terrestrial, freshwater, estuarine and marine environments is a significant component in maintaining ecological processes and systems. It also provides a valuable basis for environmental education and environmental monitoring. Such a system will be enhanced by the development and application where appropriate of nationally consistent principles for management of reserves. The parties agree that the national approach to the conservation, protection and management of native species and habitats may include the addition of new areas to reserve systems and protected areas*

BDAC: *The implementation of the Strategy will require actions affecting virtually all of Australia's land and sea, most of which will continue to be subject to a multiplicity of uses, either in parallel or in sequence. It will also involve the establishment of a comprehensive and ecologically viable system of protected areas. ... Biological diversity is best protected in-situ.*

BDAC: *Recommended actions. Undertake a 10 year Commonwealth, State and Territory cooperative program, which includes the provision of adequate resources, to ensure that the terrestrial and marine protected area systems are comprehensive and ecologically viable. Particular attention should be paid to those components of biological diversity ... requiring special conservation measures ... take immediate action to identify those components of biological diversity which are known to be threatened and inadequately reserved, and to incorporate these within the protected area system. Action is also required to ensure that further areas of high wilderness quality are placed within the protected area system.*

(iii) Complementary need for better management off-reserves.

IGAE (Schedule 9.15): *The parties further recognise that the establishment and management of a reserve system is not in itself sufficient to ensure the protection of Australia's flora and fauna. Off-reserve protection and management, particularly of remannat vegetation, are also required. The parties recognise the need for national co-operation to ensure that remnants that are ecologically significant on a national scale are identified; management and protection arrangements are consistent across borders; research initiatives are co-ordinated and not duplicated; and that off-reserve protection activities complement the reserve system.*

ESAC: *National parks and other conservation reserves ... cannot alone ensure the survival of species and ecological communities. It is crucial that lands outside the reserve network be managed in ways that allow native species, including endangered and vulnerable species, to flourish over as much as possible of the ange they inhabited before European settlement.*

BDAC: *Australia's biological diversity and the threats to it cross tenure and admininistrative boundaries ... the conservation of biological diversity ... requires consistent approaches across freehold, leasehold and crown lands.*

(iv) Requirement for better baseline data, and more coordination of data sets.

IGAE (Schedule 1:2-5): *The development of consistent standards for the description and exchange of all land-related information will be co-ordinated and fostered by the Australian Land Information Council in conjunction with Standards Australia and specialist groups where needed. The collection of data on natural resources should, where possible, be integrated from the outset, in order to avoid the difficulties inherent in collating data collected with different methodologies and in different conditions. ALIC, (through NRIC and ERIN) will consult with the relevant national co-ordination bodies and, through its members,* *with Commonwealth and State jurisdictions, to ensure the development and maintenance of comprehensive directories of natural resource and environmental spatial datasets and to develop and maintain national resource data standards.*

BDAC: *The conservation, restoration and sustainable use of biological diversity requires adequate knowledge of that diversity, of ecological processes and systems over time, and of the costs and benefits to society of particular policy choices for implementing the Strategy. However, lack of full knowledge should not be an excuse for postponing cost effective measures.*

BDAC: *In recognition of the difficulties and uncertainties involved in conservation and sustainable use of biological diversity, it is best to deal cautiously with al aspects of risk.*

(v) Role of governments.

IGAE (Schedule 2:6,8): *To ensure that State land and resource use planning processes properly address matters of Commonwealth interest, a State may refer its land and resource use planning system ... to the Commonwealth for a preliminary view, as to whether its system or process can be accredited as accommodating Commonwealth interests. In the event that the Commonwealth is of the view that the processes are inadequate to accomodate the Commonwealth interest, then the State will consider whether it wishes to review and modify the systems and processes and will consult with the Commonwealth on terms of reference for such a review. Where the Commonwealth has accredited a system or process within a State, the Commonwealth will give full faith and credit to the results of that system or process when exercising Commonwealth responsibilities.*

IGAE (Schedule 7.2) *The parties ... acknowledge that primary responsibility for land use and resource planning decisions rests with States.* (Schedule 9.2) *The parties recognise that the States have primary responsibility in the general area of nature conservation.* (Schedule 9.3) *The Commonwealth also has a particular interest in facilitating the effective and efficient co-ordination of nature conservation across all jurisdictions.*

IGAE (Schedule 9.1) *The parties recognise that each level of Government has responsibilities for the protection of flora and fauna and should use their best endeavours to ensure the survival of species and ecological communities, both terrestrial and aquatic, that make up Australia's biota. The parties recognise that the protection and sound management of natural habitats is of fundamental importance to this aim and that all levels of Government should use their best endeavours to conserve areas critical to the protection of Australia's flora and fauna and the maintenance of ecological processes.*

IGAE (Schedule 4:1): *The Commonwealth and States acknowledge that there is benefit to the people of Australia in establishing* *national environmental protection standards, guidelines, goals and associated protocols.*

IGAE (Schedule 9.4) *The parties agree that a national approach should be taken to rare, vulnerable and endangered species.*

IGAE (Schedule 9.5,6) *The parties agree that environmental management and resource use decisions taken by all levels of Government should have regard to the national distribution of species and other agreed nature conservation considerations. The Commonwealth and the States agree to cooperate in the conservation, protection and management of native species and habitats that occur in more than one jurisdiction.*

BDAC: *Since all levels of government have responsibility for the management of living resources, a co-operative national approach will be required in order to implement policies, programs and practices for the conservation and sustainable use of biological diversity.*

BDAC: *One of the major determinants of the success of bioregional planning will be the extent to which all levels of government cooperate and coordinate their activities.*

APPENDIX C: Summary of reserve selection procedures, goals and base data sets for all States and Territories (mostly following Canisius 1991), with updates [...] from ANPWS submission to HORSCERA.

## Queensland

Selection process. Reserve selection is regionally (N=13) based, and follows methodology developed by Bolton & Specht (1983) and/or a manual Rapid Appraisal Approach.

Goals. At least 5% of the State protected in National Parks. [Doubling the National Park estate to achieve maximum representation of the State's biodiversity within the park system].

Data sets. The largest scale available for consistent vegetation mapping is 1:5,000,000. No consistent state-wide land system mapping, but 1:250,000 vegetation and/or land system maps are available for specific regions under study.

Note. More detailed investigation (including finer scale distributional data) is being undertaken by CYPLUS for Cape York, and other regions (e.g. Channel Country: Sattler 1986).

## New South Wales

Selection process. Selection is primarily achieved manually, and is not based on a biogeographic region approach. Priority is given to proposed reserves which contain vegetation associations known to be poorly represented in NSW, or which support endangered species. A computer-based selection procedure, CODA, has been developed and tested in some areas.

Goals. No formal policy to achieve a more representative conservation reserve network, but a new corporate plan for a 'Park and reserve system 20% more representative of keystone and endangered species and communities per annum'. [to work towards the development of a reserve system which samples the complete range of natural and cultural environments of the State].

Data sets. The largest scale available for consistent vegetation mapping is 1:5,000,000. No consistent state-wide land system mapping.

Note. Systematic reserve design/land use studies have been undertaken for some regions within NSW, most notably the SE forests (e.g. Richards et al. 1990) and the western region (pressey & Nicholls 1989a).

## Victoria

Selection process. Selection is assessed within 17 LCC study areas, with land-use allocation determined manually on such criteria as diversity, representation, adequacy, rarity/uniqueness and naturalness.

Goals. To achieve "representative and ecologically viable examples of all land systems, native vegetation types and native animal communities in the conservation reserve system".

Data sets. Vegetation mapping over the state at 1:250,000. Land systems at 1:250,000.

## Australian Capital Territory

Selection process. Selection procedure is manual and relatively ad-hoc, though currently poorly-reserved habitats are targetted for investigation, and some consideration is given to spatial arrangements, size and special features.

Goals. No relevant formal policy.

Data sets. 1:25,000 vegetation map. No consistent land system mapping.

## Tasmania

Selection process. Systematically, through Recommended Areas for Protection (RAPS) process, and through vegetation survey and public nominations. On a regional (N=11) basis, vegetation classification, geology, topography, and special feature maps are overlaid and reserves selected manually to best represent all realised combinations. Other factors considered include disturbance, shape, naturalness, diversity, tenure, fire barriers, spatial relationship to other reserves, and predictive modelling of rare species and communities.

Goals. "adequate representation of communities and species in its park estate", and more specifically for RAPS to reserve 30% of rainforest and 5% of eucalypt forest in conservation reserves.

Data sets. Vegetation maps and land system maps at 1:100,000.

## South Australia

Selection process. Areas of high diversity, representativeness or naturalness are nominated within about 30 regions.

Goals. No specific policy about improving representation of the conservation reserve system. Systematic biogeographic surveys are now being undertaken.

Data sets. State-wide vegetation map at 1:5,000,000. State-wide mapping of environmental associations at 1:250,000 (agricultural regions) and 1:1,000,000 (other) and vegetation communities are being mapped at 1:50,000 (agricultural regions). No other consistent land system maps.

Note. Several regions have been subject to investigation of iterative reserve selection projects (e.g. Margules & Nicholls 1987; Margules 1989; Cocks & Baird 1989) or selection based on modelling of species and community distributions (McKenzie et al 1989).

## Western Australia

Selection process. On a regional (N=24 according to Canisius, N=12 according to Ride (1975)) basis, reserves are selected manually, based on representation of all land units, replication and land condition and availability. In a few areeas studied in more detail, the distributions of species and assemblages are modelled to manually derive biological diversity in a minimum area and number of reserves (McKenzie et al 1989).

Goals. To "prevent further decline in species and genetic diversity" and "to adequately protect and manage representative areas" with recognition of "the need to preserve representative samples of all the State's major ecosystems".

Data sets. Vegetation mapping at 1:1,000,000 (although this is not digitised).

Note. Iterative procedures have been investigated for monsoon rainforest reserve selection in the Kimberley (McKenzie & Belbin 1991). Detailed assessment of environmental values for land-use decisions has also been recently completed for the Karri forests (AHC/CALM 1992).

**Northern Territory**

Selection process. The selection procedure has been substantially updated since Canisius (1991). Minimum set algorithms are being used to derive a reserve network representative of all 112 vegetation types. The process will also consider distributions of rare species, representation of vegetation types in at least two reserves, representation of land systems, and more intensive capture of rainforest and wetland vegetations types (NT Government submission to HORSCERA).

Goals. To reserve "at least two representations of all vegetation types in all biogeographic realms".

Data sets. 1:1,000,000 vegetation map. Land systems maps covering much of the NT.