National Estate Values in the Southern Forest Region of South-West Western Australia

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- Volume Two -

Appendix 1

Assessment Methodology

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DRAFT REPORT

NATIONAL ESTATE VALUES IN THE SOUTHERN FOREST REGION, SOUTH-WEST WESTERN AUSTRALIA

APPENDIX 1

ASSESSMENT METHODOLOGY

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This document was prepared by the Australian Heritage Commission in co-operation with the Department of Conservation and Land Management.

1. INTRODUCTION

In 1991 the Australian Heritage Commission and the WA Department of Conservation and Land Management (CALM) jointly carried out a regional study in the Southern Forest Region of south-west Western Australia (see Figure 1). The study involved two main aspects: the assessment of places of national estate significance in the Region, and the development of guidelines for the regional protection of the places identified as being significant. The study is described in the draft report National Estate Values in the Southern Forest Region, south-west Western Australia ('the Report'). This appendix (Appendix 1 of the Report) details the methodology used by the Australian Heritage Commission for the assessment of places of national estate significance in the Southern Forest Region. The description of national estate values in the indicative places are described in Appendix 2 of the Report, and the protection of values are described in appendices 3, 4 and 5 of the Report.

The assessment methodology is that of the Australian Heritage Commission, and builds on previous assessment work of the Commission (AHC 1990a, 1990b). In applying the methodology in the Southern Forest Region, the Commission worked in close consultation with CALM.

The assessment objective of the regional study was to delineate those areas in the Southern Forest Region which should be listed in the Register of the National Estate. This requires an analysis of relevant attributes against the Commission's criteria for significance (Table 1), and involves two steps: the compilation of information on attributes relevant to the criteria, followed by an assessment of national estate value.

Table 1. Criteria for the Register of the National Estate

CRITERION A: Importance in the course, or pattern, of Australia's natural or cultural history

A.1 Importance in the evolution of Australian flora, fauna, landscapes or climate.

A.2 Importance in maintaining existing processes or natural systems at the regional or national scale.

A.3 Importance in exhibiting unusual richness or diversity of flora, fauna, landscapes or cultural features.

A.4 Importance for association with events, developments or cultural phases which have had a significant role in the human occupation and evolution of the nation, State, region or community.

CRITERION B: Possession of uncommon, rare or endangered aspects of Australia's natural or cultural history

B.1 Importance for rare, endangered or uncommon flora, fauna, communities, ecosystems, natural landscapes or phenomena, or as wilderness.

B.2 Importance in demonstrating a distinctive way of life, custom, process, land use, function or design no longer practised, in danger of being lost, or of exceptional interest.

CRITERION C: Potential to yield information that will contribute to an understanding of Australia's natural or cultural history

C.1 Importance for information contributing to a wider understanding of Australian natural history, by virtue of its use as a research site, teaching site, type locality, reference or benchmark site.

C.2 Importance for information contributing to a wider understanding of the history of human occupation of Australia.

Table 1 contd

CRITERION D: Importance in demonstrating the principal characteristics of: (i) a class of Australia's natural or cultural places; or (ii) a class of Australia's natural or cultural environments

D.1 Importance in demonstrating the principal characteristics of the range of landscapes, environments or ecosystems, the attributes of which identify them as being characteristic of their class.

D.2 Importance in demonstrating the principal characteristics of the range of human activities in the Australian environment (including way of life, custom, process, land use, function, design or technique).

CRITERION E: Importance in exhibiting particular aesthetic characteristics valued by a community or cultural group

E.1 Importance for a community for aesthetic characteristics held in high esteem or otherwise valued by the community.

CRITERION F: Importance in demonstrating a high degree of creative or technical achievement at a particular period

F.1 Importance for its technical, creative, design or artistic excellence, innovation or achievement.

CRITERION G: Strong or special association with a particular community or cultural group for social, cultural or spiritual reasons

G.1 Importance as a place highly valued by a community for reasons of religious, spiritual, symbolic, cultural, educational, or social associations.

CRITERION H: Special association with the life or works of a person, or group of persons, of importance in Australia's natural or cultural history.

H.1 Importance for close associations with individuals whose activities have been significant within the history of the nation, state or region.

All available sources of data were sought for the study. This included information stored in geographic information systems (GISs), published information, and unpublished data. Where no published or GIS data was available, expert opinion was sought from scientists in a range of disciplines, particularly those who had relevant field experience in the Region (Table 2). General types of data sources interrogated, and those used in compiling data for the assessment of value, are summarised in section 2 of this Appendix.

Table 2. List of experts contacted concerning natural environment values in the Southern Forest Region

Name	Position	Expertise
Allen, T	Curator, WA Museum	Fresh water fish
Beard, J	Independent researcher	Vegetation
Briggs, J	Research scientist, CSIRO	Rare or threatened flora
Brown, D & M	Independent researchers	Faunal ecology of karri forest (birds); White-breasted Robin ecology
Christensen, P	Research scientist, CALM	Flora, fauna, general ecology
Churchward, M	Principal Research Scientist, CSIRO	Soils, landforms

Table 2 contd

Davis, J	Lecturer, Murdoch University	Wetland and stream ecology
Dell, J	Research scientist, WA Museum	Fauna, south coast region
Edwards, D	Lecturer, University of Western Australia	Fresh water invertebrates
Growns, I	Research scientist, Murdoch University	Stream ecology
Hagan R	Operations officer, CALM	Forest assessment data for Reserve values
Hilliard, R	Research scientist, Murdoch University	Ecology and biology of the Lamprey
Hilton, R	Lecturer, University of Western Australia	Fungal ecology, south-west Western Australia
Hopper, S	Research scientist, CALM	Rare or threatened flora
How, R	Research scientist, WA Museum	Fauna, south coast region
Inions, G	Research scientist, CALM	Karri vegetation
Jackson, B	Private researcher	Floristics of karri in Walpole Region; orchids of karri forest
Jones, P	Project officer, CALM	FMIS data; fire ecology
Knot, B	Lecturer, University of Western Australia	Relic freshwater invertebrates
Main A.R & B.	Independent researchers	Gondwanic fauna
Majer, J	Lecturer, Curtin University	Invertebrate and ant ecology
McArthur, B	Private consultant	Soils
Meeny, C	Private consultant	Karri forest floristics; biology of rushes & sedges
Neville, S	Private consultant	Karri ecology
O'Brian, B	Research scientist, University of Western Australia	Faunal ecology (Marron and *Cherrex* sp.)
Pate, J	Professor of Botany, University of Western Australia.	Plant physiology of southern forest species; karri ecology
Penn, L	Research scientist, Murdoch University	Fish ecology
Potter, I	Professor, Murdoch University	Ecology and biology of the Lamprey
Pusey, B	Research scientist, formerly University of Western Australia	Salamander fish; acid peat flats
Roberts, D	Senior lecturer, University of Western Australia	Faunal ecology of karri forest (reptiles, frogs)
Robinson, C	Private consultant	Floristics, rare flora
Rowley, I	Research scientist, CSIRO	Faunal ecology of karri forest (birds); Fairy Wren biology
Sandro, P	Professor of Biology, University of Rome	Karri forest floristics
Taylor, J	Private consultant	Karri forest invertebrates
Walker, A	Project officer, CALM	FMIS data; landscape, wilderness
Wardell-Johnson, G	Research scientist, CALM	Flora, fauna, general ecology
Weston, A	Senior Botanist, Dames & Moore	Karri vegetation
Wooler, R	Lecturer, Murdoch University	Faunal ecology (Honey Possum; birds)

A single type of attribute may be relevant to a number of national estate criteria, and must be assessed in a manner appropriate to each criterion. A decision on whether there was sufficient information available in an appropriate form to allow a regional assessment was made on an attribute-by-attribute basis. Where insufficient data was available, no regional assessment was carried out. The assessment of national estate value in the Region, for those attributes with a sufficient level of information currently available, is detailed in section 3 of this Appendix.

After the above two steps had been carried out, places meeting the criteria for significance above a threshold level were delineated. All areas delineated for each attribute under each criterion were then overlaid to determine the overall areas of significance, and boundaries determined which appropriately reflected the value or range of values present. This is described in section 4 of this Appendix.

A summary of this methodology is shown diagrammatically in Figure 2.

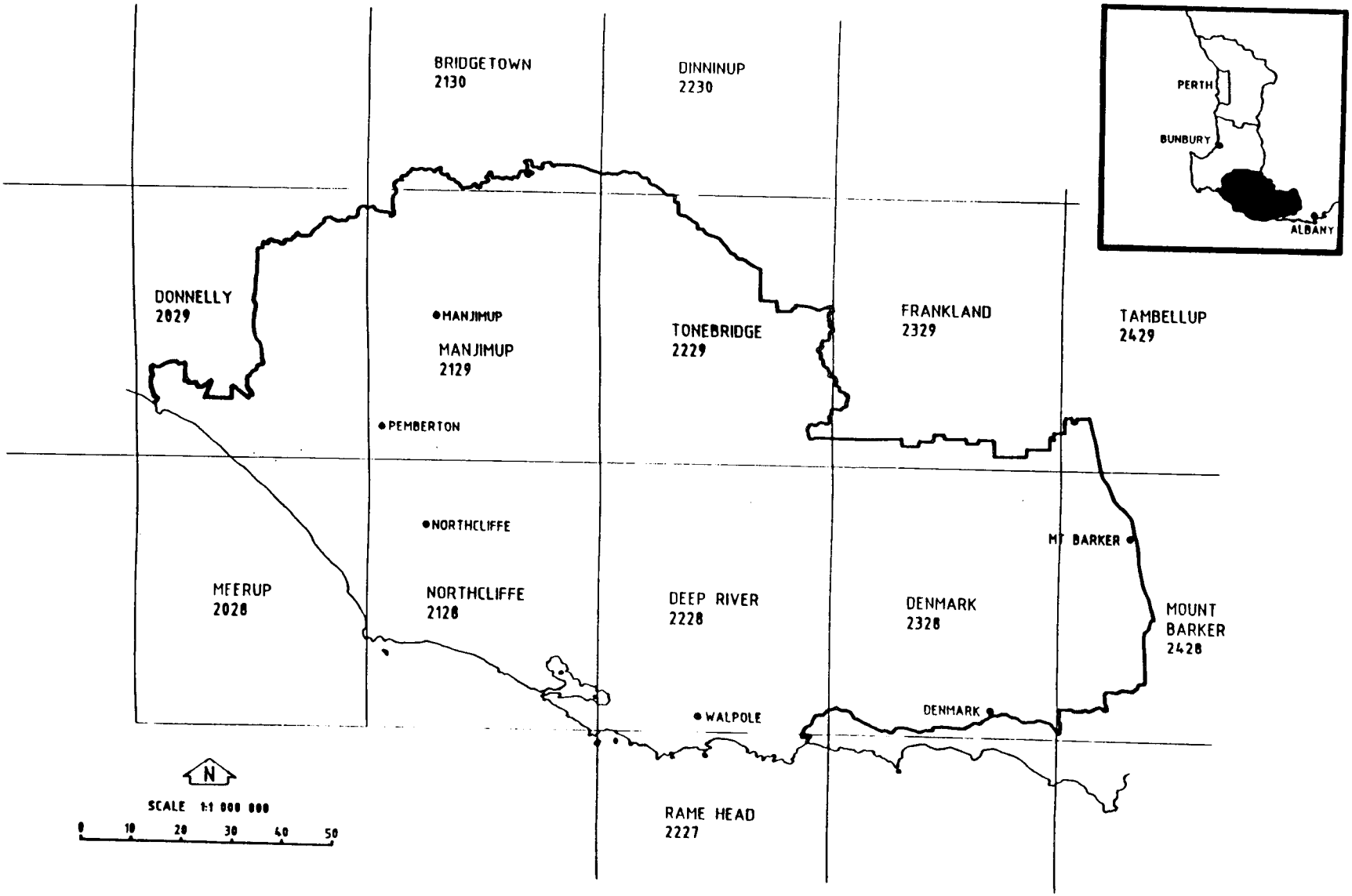

Figure 1. 1:100,000 Topographic Maps (names & numbers) covering the Southern Forest Region, and the Location of Southern Forest Region.
(Grid based on 1:100,000 map coverage)

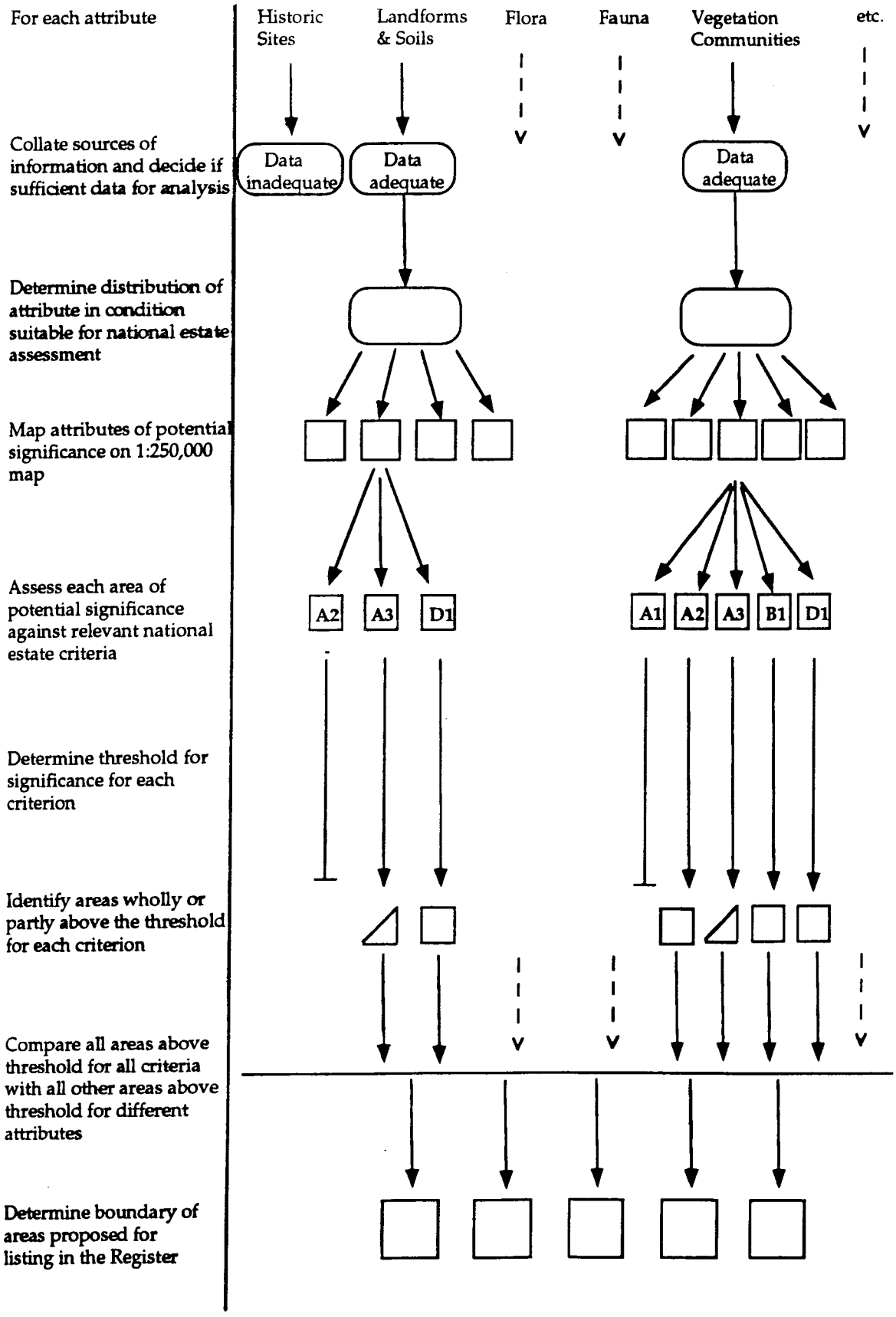

Figure 2. Flow diagram showing main steps in assessment methodology. (ovals represent steps not tied to individual places; squares represent individual places identified during the process; diagonal half squares represent part of an area above threshold; truncated lines represent areas below threshold).

2. COMPILATION OF DATA ON RELEVANT ATTRIBUTES

The objective of the data compilation step is to delineate areas which are potentially of national estate significance, i.e. areas where particular attributes are known to occur and which require an assessment of value to determine whether they meet the threshold level of national estate significance or not. These areas of potential significance were termed 'potential areas'.

Because data was available for the Southern Forest Region at a variety of scales and in a range of formats, a uniform scale and format was required to allow efficient compilation of information prior to the regional assessment of value. Data for each attribute was analysed at scales of 1:50 000, 1:100 000 or 1:250 000, depending on the type of attribute and the manner in which the data had been collected, stored and/or displayed/mapped. The results of these analyses were then compiled as a series of overlays at a scale of 1:250 000 to provide a spatial representation of each attribute in the Region. The potential areas determined for each attribute were represented by 'polygons' (i.e. discrete areas of any shape or size) on the 1:250 000 overlays.

The scale of 1:250 000 for the overlays was chosen as being appropriate for the analysis of 'extensive' values in the Region (i.e. values based on attributes which are widespread in the landscape), as it enabled a regional overview without sacrificing detail or understanding of the biophysical environment. For site specific or localised attributes, data was collated at 1:250 000 for the determination of potential areas, but the detailed site information (at a larger scale) was retained for reference.

Attributes which were considered relevant to the criteria, and the general sources of information interrogated, are outlined in the following sections.

2.1 Cultural data

2.1.1 Aboriginal archaeological sites

Information on Aboriginal archaeological sites was obtained from records held in the WA Museum and from published reports. It was evident that insufficient data was available for systematic regional assessment. A few individual sites were assessed for significance but have not been included in this analysis. Ongoing joint work has identified the need for further work in this area, so the information gained as part of this study will be incorporated into the future assessment activity.

2.1.2 Historic sites

Preliminary discussions with CALM suggested that there were numerous sites of possible historic interest in the Region, linked to the timber industry and early agricultural development. However, no systematic work had been carried out to document these sites. Although some information on historic sites was available in unpublished records, published reports, and personal knowledge of CALM officers, it was evident that insufficient data was available for a systematic regional assessment. This issue is also to be considered within the context of future joint work.

2.2 Natural data

A range of attributes were considered relevant to the assessment of natural environment values. A major source of information used was data held in CALM's Forest Management Information System (FMIS). Data in the FMIS is taken up at a scale of 1:25 000 or 1:50 000 based on 2 ha units. Although the FMIS had been compiled for the purposes of forest management, largely for silvicultural and inventory purposes, it contained a range of data on attributes relevant to the assessment of national estate value.

The general types of natural environment attributes considered in the study and major data sources interrogated are outlined below. Details of all sources of data are provided in Appendix 2 of the Report.

2.2.1 Catchments, rivers, wetlands

Information on catchments and rivers was relevant to the assessment of national estate value against criterion A.2 (ecosystem processes), while information on wetlands was relevant to criteria A.1 (biogeographic value), A.2 (natural processes), A.3 (diversity) and D.1 (representativeness). Major sources of information for all three attributes were FMIS, personal knowledge of CALM officers, and 1:250 000 and 1:50 000 topographic maps of the Region. Additional information on wetlands was also obtained from published and unpublished reports, including those of Churchward *et al.* (1988) and Churchward (1990). The spatial representation of these attributes was used in conjunction with the vegetation and disturbance overlays to determine potential areas, particularly under criteria A.2 (natural processes) and A.3 (diversity).

2.2.2 Landform, geomorphology, soil

The main sources of information on landforms and soils were the 1:100 000 maps of Churchward *et al.* (1988) and Churchward (1990), while additional information on coastal geomorphology and landform features such as monadnocks was obtained from published reports, 1989 Landsat images, and published 1:50 000 topographic maps.

The landform/soil data was mainly used for an analysis under criterion A.3 (diversity). The 1:100 000 maps were qualitatively analysed to determine potential areas with a high diversity of mapped units. Diversity was assessed at a scale of one order of magnitude greater than the average size of the mapped units, i.e. this defined the standardised sample size. Polygons where the number of mapped units per standardised sample size exceeded the expected average number of units were determined and recorded as potential areas on a 1:250 000 overlay.

Using the maps of Churchward *et al.* (1988) and Churchward (1990), the Region was also divided into broad sub-regions based on dominant landform/soil types. Areas of landform and soil transition were then delineated by examining the patterns of distribution of mapped units, and highlighting areas where three or more major landform/soil groups intersected. These transitional areas were also marked as potential areas on the above 1:250 000 overlay.

Due to the lack of systematic information on the general distribution of geomorphological features, it was not possible to carry out a regional assessment on most landform types. However, as a specific and well mapped landform type, an assessment of granite rock outcrops (monadnocks), was possible. Information about the location and characteristics of monadnocks was used to inform the assessment of potential areas under criteria B.1 (rarity) and D.1 (representativeness).

Coastal landforms were assessed separately under criteria A.1 (for landscape evolution), A.2 (for natural geomorphological processes) and D.1 (representativeness). All areas of undisturbed dunefields were marked as potential areas on a 1:250 000 overlay, and relevant published information used to inform the assessment of value.

2.2.3 Fauna

After initial discussions with ecologists in CALM, it was evident that no systematic faunal surveys had been implemented in the Region, although intensive survey/research had been carried out at some sites for which published and unpublished data were available. The expert opinion of relevant scientists who had worked on fauna in the Region was thus also sought to determine the extent to which assessment of places for faunal value would be possible. This included commissioning a report on Gondwanic fauna, which include species of insects, arachnids and other invertebrates, amphibia, and fish (Main & Main 1991).

Information on fauna from published and unpublished sources and expert opinion was collated. Where there was an adequate level of information about fauna/faunal habitats for individual places (e.g. Tone-Perup area), these were marked as potential areas on the 1:250 000 overlays. Other collated information was retained for use in informing the description of national estate value, under criteria A.1, A.2 and B.1, of potential areas selected using other attributes (especially

vegetation and disturbance). The status of species for criterion B.1 (rarity) was determined from the CALM 1990 schedule of rare species (CALM 1990).

2.2.4 Vegetation

Several complementary sources of data were interrogated to compile information on vegetation, as follows:

- FMIS forest type data: provides information on dominant and co-dominant species, based on air photo interpretation compiled between 1950 and 1965, but does not contain structural or understorey information. The data was plotted as maps with a minimum grid cell size of 2 ha. The various categories of forest type stored in FMIS are listed in Table 3, which also shows the classification of these types used in the regional assessment. The distribution of a number of dominant canopy species using the classification shown in Table 3 was plotted at 1:100 000, i.e. a single 1:100 000 map showed the distribution of Pure Karri, Mixed Karri, Pure Marri, Mixed Marri etc. Plots at 1:250 000 were produced for individual dominant species classifications, i.e. a single 1:250 000 map would contain a plot of Pure Marri, or of Mixed Karri etc.

- mapped vegetation types of Smith (1972): map is 1:250 000 scale and is primarily based on vegetation structure, with some limited floristic data.

- mapped vegetation types of Beard (1979): map is 1:250 000 scale and contain structural information, but was of limited use due to the coarse nature of the mapping.

Table 3. Forest type data in CALM Forest Management Information System

FMIS Forest type	Classification used for regional analyses
Pure karri	Pure Karri
Karri	Pure Karri
Karri-Marri	Mixed Karri
Marri-Karri	Mixed Marri
Marri-Karri-Jarrah, Karri-Marri-Jarrah, Jarrah-Marri-Karri	Mixed Karri
Marri	Pure Marri
Marri-Jarrah	Mixed Marri
Jarrah-Marri	Mixed Jarrah
Jarrah	Jarrah
Jarrah-Yellow Tingle, Yellow Tingle-Jarrah	Tingle
Jarrah-Red Tingle, Red Tingle-Jarrah	Tingle
Karri, Yellow Tingle, Yellow Tingle-Karri	Tingle
Karri, Red Tingle, Red Tingle-Karri	Tingle
Karri, Rates Tingle	Tingle
Wandoo	Wandoo
Yate	Yate
Bullich	Bullich
Warren River Cedar	Warren River Cedar
Blackbutt	Blackbutt
Lakes, Water	Lakes, Water
Sand	Non forest
Low Jarrah	Low Jarrah
Non forest, scrub, flat, Cedar	Scrub
Peppermint, dune vegetation	Dune vegetation

The data from FMIS, Smith and Beard indicates dominant species, but does not capture the variation of understorey in the vegetation. After considerable discussion, it was decided that the landform/soil maps of Churchward *et al.* (1988) and Churchward (1990) provide an indirect

measure of community variation at the understorey level because of the broad correlation across the Region between the understorey types and landforms/soils.

Information on vegetation types was compiled at 1:250 000 for regional assessment under criteria A.3 (diversity) and D.1 (representativeness), and was also used as the basis for the analysis of undisturbed vegetation under criterion B.1 (rarity) and rare dominant canopy species (criterion B.1).

(a) Vegetation diversity. In compiling data for vegetation diversity, the FMIS, Smith, and Churchward maps were qualitatively analysed to determine potential areas with a high diversity of mapped units. The Beard maps was not used due to the broad nature of mapping compared with that of Smith.

For each of the three mapped data sources (FMIS, Smith, Churchward), diversity was assessed qualitatively at a scale of one order of magnitude greater than the average size of the mapped units, i.e. this defined the standardised sample size. Polygons where the number of mapped units per standardised sample size exceeded the expected average number of units were determined and recorded as potential areas on 1:250 000 overlays. The three types of potential areas were recorded separately on the overlays. The disturbance overlay (see section 2.2.7 below) was used to delineate those potential areas/parts of potential areas where the communities were undisturbed.

(b) Representative vegetation types. The information on representative vegetation types was derived from Smith/Beard and Churchward as the mapped units represented most closely the original vegetation types presumed to occur in the Region at the time of European settlement.

The Smith and Beard maps were used in the one analysis to provide coverage across the whole region. It was recognised that the differences in data scale between Smith and Beard would result in different levels of detail between the western two-thirds of the area (Smith map) and the eastern third (Beard map). It was also recognised that the vegetation structure shown in the mapped units (especially for 'forest' and 'woodland') would not necessarily be identical for the Smith and Beard maps. However, it was considered that these differences did not preclude an acceptable analysis across the Region for vegetation diversity.

A table of derived vegetation types was prepared from the Churchward map legends by CALM officers. Each landform/soil type was classified according to a characteristic vegetation community known to occur on it. These categories were not necessarily uniquely correlated, with some soil types supporting a number of different communities, and some communities occurring on more than one soil type. However, it was strongly felt that for the major forest types at least, there was a strong correlation between landform and soil types and dominant understorey communities. This correlation had been demonstrated for a sub-region within the Southern Forest Region by Wardell-Johnson *et al.* (1989) who developed a floristic classification of the Walpole-Nornalup National Park based on clustering and ordination techniques associated with the landform/soil units of Churchward *et al.* (1988).

Due to the scale of the mapped data and the complexity of the patterns of mapped units, both spatially and according to classification, it was not possible to compile information on individual community types. Instead, groups of communities were used for determining potential areas. Due to inconsistencies in the data between the published Churchward *et al.* (1988) maps and the Churchward (1990) maps, separate classifications were undertaken for the two data sets. The derived groups ('derived vegetation types') used to compile information from each map set are summarised in Tables 4 and 5.

Where the derived vegetation groups were classified as some type of tingle, the Churchward data was cross-referenced with the FMIS data and unpublished CALM maps of tingle distributions to resolve community classes. Non-forest communities were identified and mapped, but not assessed further due to the complexity of the classifications of these types and the lack of data necessary to resolve this complexity.

The disturbance overlay (see section 2.2.7 below) was used in conjunction with the Smith/Beard and Churchward maps to delineate, for a range of vegetation types, areas of undisturbed communities, which were then marked as potential areas on 1:250 000 overlays. Only areas above a minimum size were included as potential areas; this size ranged from 50-200 ha depending on the natural scale of distribution of the species characterising the derived vegetation types. All mapped occurrences of pure Marri were marked as potential areas on the overlays, as pure Marri occurs naturally in areas which rarely exceed c. 50 ha. All known occurrences of tingles were also mapped as these species are rare.

Table 4. Derived vegetation types - Churchward *et al.* (1988)

Community type from map legend	Derived vegetation type
Karri/Karri-Marri/Karri-Marri-Jarrah Tall Open Forest	Karri-Marri Tall Open Forest
Jarrah/Jarrah-Marri Open Forest	Jarrah-Marri Open Forest
Jarrah/Jarrah-Allocasuarina/Bullich and Jarrah/Blackbutt and Albany Blackbutt Woodland	Mixed Jarrah Woodland
Red Tingle/Rates Tingle, Karri-Yellow Tingle Tall Open Forest	Karri-Marri/Red Tingle Tall Open Forest
Yellow Tingle/Jarrah/Karri/Marri Open Forest	Jarrah-Marri/Yellow Tingle Open Forest
Rates Tingle/Red Tingle-Marri Open Forest	Jarrah-Marri/Yellow Tingle Open Forest; or Karri-Marri/Red Tingle Tall Open Forest
Yate Open Forest	Not assessed
Wandoo Woodland	Not assessed
Woodland (chiefly Peppermint)	Not assessed
Shrubland/Teatree	Partial assessment
Heathland	Partial assessment
Granite Outcrop	Not assessed
Sand	Not assessed
Melaleuca Woodland	Partial assessment
Sedgeland	Partial assessment
Banksia Woodland	Partial assessment

Table 5. Derived vegetation types - Churchward (1990)

Community type from map legend	Derived vegetation type
Karri/Karri-Marri/Karri-Marri-Jarrah Tall Open Forest	Karri-Marri Tall Open Forest
Jarrah/Jarrah-Marri Open Forest	Jarrah-Marri Open Forest
Jarrah/Jarrah-Allocasuarina/Bullich and Jarrah/Blackbutt and Albany Blackbutt Woodland	Mixed Jarrah Woodland
Yate Open Forest	Not assessed
Wandoo Woodland	Not assessed
Woodland (chiefly Peppermint)	Not assessed
Shrubland/Teatree	Partial assessment
Heathland	Partial assessment
Granite Outcrop	Not assessed
Sand	Not assessed
Melaleuca Woodland	Partial assessment
Sedgeland	Partial assessment
Banksia Woodland	Partial assessment

(c) Representative vegetation assemblages. Within the Southern Forest Region, different vegetation types occur in distinct patterns related to climatic factors and position in the landscape. These patterns vary across the Region. The Smith and Beard maps were used to determine areas which contained typical assemblages of communities. The minimum size for the potential areas was 2000 ha. This was determined from the scale and distribution of the community patterns as mapped, and the preferred minimum area determined for the individual communities (see section 3.2.5 and section 3.2.6.2 (i)).

2.2.5 Flora

Information on individual flora species is relevant to criteria A.1 (e.g. restricted endemics, limits of distribution, refugial species) and B.1 (rare species and rare communities). Systematic information on the distribution of rare species within the Region was available only for dominant tree species (e.g. Red Tingle - *Eucalyptus jacksonii*; Red Flowering Gum - *E. ficifolia*). Information on other rare species was obtained from published reports, unpublished CALM data and from scientific experts. This information was collated on 1:250 000 overlays. Rare flora species were determined from CALM (1991) and from Briggs & Leigh (1988). As rare species are usually restricted in distribution, the information on these species was generally used to inform the description of significance of Indicative Areas determined for extensive attributes. However, where rare species occurred in isolation from any other attribute of national estate significance, these were designated 'Sites of Significance' (see section 4).

2.2.6 Wilderness

Potential areas with wilderness characteristics were identified by CALM, using the Lesslie indicators of wilderness quality, i.e. biophysical naturalness, remoteness from access, remoteness from settlement and aesthetic naturalness (Lesslie *et al.* 1987). These indicators are used by the Commission to identify areas with wilderness characteristics, and the Lesslie methodology is accepted as the basis of the National Wilderness Inventory project, which is sponsored by the Commonwealth Government.

Areas with wilderness characteristics were determined manually by examining published 1:50 000 topographic maps annotated to provide up-to-date information on tracks, roads, past logging, past grazing etc, and each area assigned a qualitative level of wilderness quality, i.e. moderate, high and very high. All areas which met one or more of these three levels were marked as potential areas on a 1:250 000 overlay.

2.2.7 Disturbance

In general, for values related to biological attributes, highest national estate value is assigned to places which are the most "natural", i.e. have been the least affected by human disturbance. This is a widely accepted principle in nature conservation disciplines. For rare biological attributes, disturbed areas may have a high level of significance if no undisturbed areas remain. For physical ecosystem attributes such as surface geomorphological features (sand dunes, lakes etc), the highest level of significance is usually also assigned to the least disturbed areas. However, for attributes such as landforms/soils, the level of significance is frequently independent of the associated biological features, irrespective of their condition.

Disturbance history is thus critical for determining potential areas for many natural environment attributes. CALM's FMIS, which contains detailed information on logging history in the Southern Forest Region, was used to generate an overlay at 1:250 000 showing disturbance from logging. This overlay showed various classes of disturbance across the Region (see Table 6), and was used to inform both the selection of potential areas as well as the assessment of value. Landsat images of the Region taken in 1989 and printed at 1:250 000 were also used for this purpose, as was the local knowledge of CALM officers. Forms of disturbance considered in determining potential areas and carrying out the assessment of significance included logging, roading, grazing, and incidence of dieback (*Phytophthora*).

Table 6. Logging history disturbance classes

Undisturbed
Clear-felled before 1967
Clear-felled after 1966
Selection cut before 1940
Selection cut between 1940-1970
Selection cut after 1970

3. ASSESSMENT OF NATIONAL ESTATE VALUE FOR NATURAL ATTRIBUTES

Each occurrence of an attribute relevant to a national estate criterion can be assigned a level of significance. For each attribute, only those occurrences with a higher level of significance are listed in the Register, i.e for each attribute under each criterion, a "threshold" level of significance must be determined above which places are considered of sufficient value to warrant listing.

Any comparative analysis of levels of significance and determination of thresholds of significance must be within an appropriate context, i.e. must be in reference to a particular "type" of place. Ideally a "type" represents a relatively homogeneous class of place which, for the natural environment, must also be ecologically sensible (AHC 1990b). Definition of the type must thus take into account the natural scale and pattern of distribution, and natural abundance, of the attribute. Definition of type must also take account of the nature of data available for attributes relevant to the type: the less detailed the information available, the more general will be the type of place defined. The significance assessment is thus to some extent a function of the levels of current knowledge.

In determining areas whose attributes meet a threshold of significance against the criteria, all potential areas delineated on the overlays described in section 2 were assessed against the appropriate "type" and a threshold of significance determined for each attribute for relevant criteria.

The method of assessment of national estate value for a range of natural environment attributes is outlined in the following sections.

3.1 Assessment of site specific/localised values

Most site specific/localised values related to populations of flora species, restricted faunal habitats, specific landform features etc. For attributes which are rare or uncommon (criterion B.1), in general, all occurrences of the attribute, provided they were in good condition relative to the type, were considered significant. For some of these values, it was not appropriate to attempt to assign a a qualititative level of significance (such as Very High, High etc.) as the information required to support that level of assessment (such as detailed habitat knowledge and an ecological understanding of the various species) is not currently available. In these instances, the expressions were all rated as highly significant, in recognition of the national estate significance of the value regionally and the fact that each expression had been identified as above the threshold for significance. For features under other criteria (e.g. A.1, C.1, D.1, E.1), the assessment of whether such features were significant or not was based on published or unpublished expert opinion.

3.2 Assessment of extensive values

It was recognised that broad N-S and E-W environmental/ecological gradients occur across the Southern Forest Region which determine or influence the expression of many types in the region. The analysis of levels of significance and thresholds of significance for each type thus required an appropriate environmental/ecological context within the Region.

Sub-regional classifications were developed for this purpose, recognising that the sub-regions most appropriate for the analysis of significance would vary with the nature of the attributes defining the type. Thus for some values, e.g. natural processes (criterion A.2), it was felt that the Region itself provided the most appropriate context. However, for others values, e.g. characteristic vegetation communities (criterion D.1), it was recognised that some form of sub-regional context was necessary for proper evaluation.

The assignment of a qualititative level of significance, such as Very High or High, was not possible for all types of values, even within the framework of a regional analysis. The Commission considered that it was not possible to qualitatively distinguish, for example, between two areas of significance as representative vegetation communities (Criterion D.1) where both were above the size threshold for ecological viability. The other types of values falling into this

category were: representative vegetation assemblages (Criterion D.1) and diverse landforms/soils (Criterion A.3). In these instances, the Commission rated each expression as highly significant, in recognition of the national estate significance of the value regionally and the fact that each expression had been identified as above the threshold for significance.

The following subregions were used during various assessments of value.

(a) Land systems and rainfall (Finkl & Churchward 1973). A combination of rainfall patterns and etched land surfaces, based on the work of Finkl and Churchward (1973), was considered the most appropriate sub-regional context to account for the major biogeographical variations within vegetation communities across the Region. The sub-regions so determined are shown in Figure 3.

(b) Vegetation systems (Beard 1980, 1981 and *pers. comm.*). When assessing the significance of vegetation assemblages (i.e. patterns of the major vegetation types) across the Region, the appropriate context was considered to be the vegetation systems of Beard (1980, 1981). This was preferred to other sub-regional classifications as the systems themselves are based on the major patterns of vegetation in the south-west region of the state. While the integrity of the Beard system boundaries was maintained, a number of the systems were divided into sub-regions. This was done where it was apparent that major variations in vegetation patterns (at the scale of the analysis) occurred within the individual systems and was confirmed with Beard as an appropriate further classification (Beard *pers comm.)*. The various systems and sub-regions based on Beard are shown in Figure 4.

(c) Coastal and non-coastal. For a number of attributes, the Region was subdivided broadly into coastal and non-coastal sub-regions. This method was used for those values, e.g. wilderness characteristics (B.1), and ecosystem processes (A.2), where there was insufficient information generally to support an analysis on a more detailed sub-regional basis. The coastal sub-region was generally determined from the landform/soil maps of Churchward *et al.* (1988) and Churchward (1990).

The sub-regional classification used in analysis of significance is indicated for each criterion in the following sections.

3.2.1 Evolution of the Australian biota or landscape (criterion A.1)

For most attributes relevant to this criterion, a uniform level of information across the Region was not available, and thus a systematic regional assessment was not possible. The significance of individual areas for which information was available was assessed using published and/or unpublished expert opinion. The areas included those significant for Gondwanic fauna, acid peatlands, wetlands, habitats of endemic biota etc. References to all sources of information used for these assessments are provided in Appendix 2 of the Report.

3.2.2 Maintenance of natural ecosystem processes (criterion A.2)

The basic principle underlying this assessment is that for the attributes assessed, highest national estate value was afforded those areas least disturbed by humans.

The assessment involved analysis of potential areas for two types of process, the first related to physical, abiotic processes, the second to biological ecosystem processes. Assessment for the first type of process was taken to include consideration of potential areas for maintaining broad physical processes, such as geomorphological processes, hydrological cycles, nutrient cycles etc. The context used for this analysis was a simple classification of coastal and non-coastal areas.

All potential areas were also assessed for biological ecosystem processes throughout the Region. It was recognised that ecological gradients from east to west and north to south throughout different land systems probably influence biological processes in the Region. However, because of the general lack of detailed, systematic information about the mechanisms and functions of biological ecosystem processes within the Region, it was decided that the analysis could be carried out only

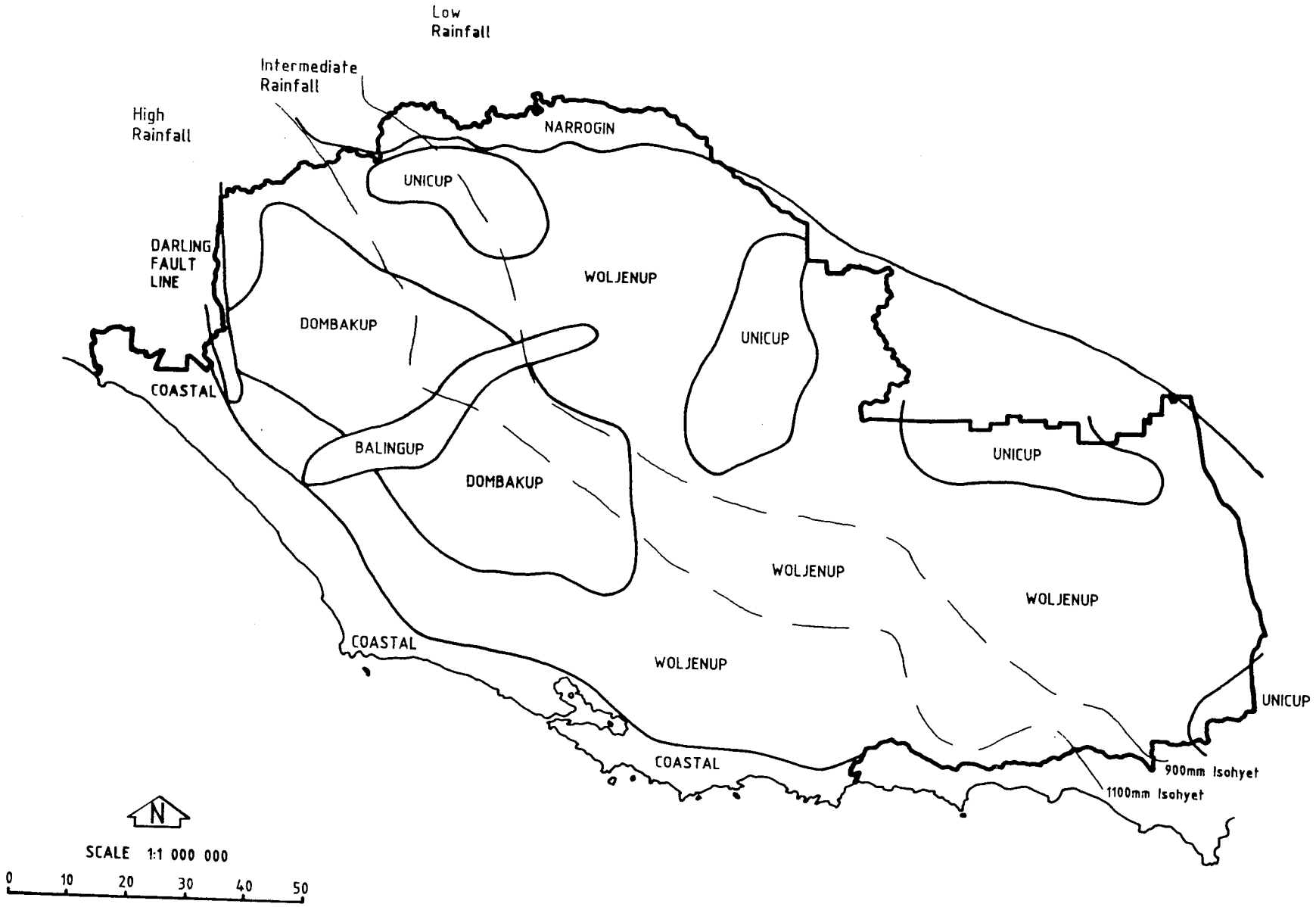

Figure 3. Sub-regions based on land systems and rainfall (after Finkl & Churchward 1973).

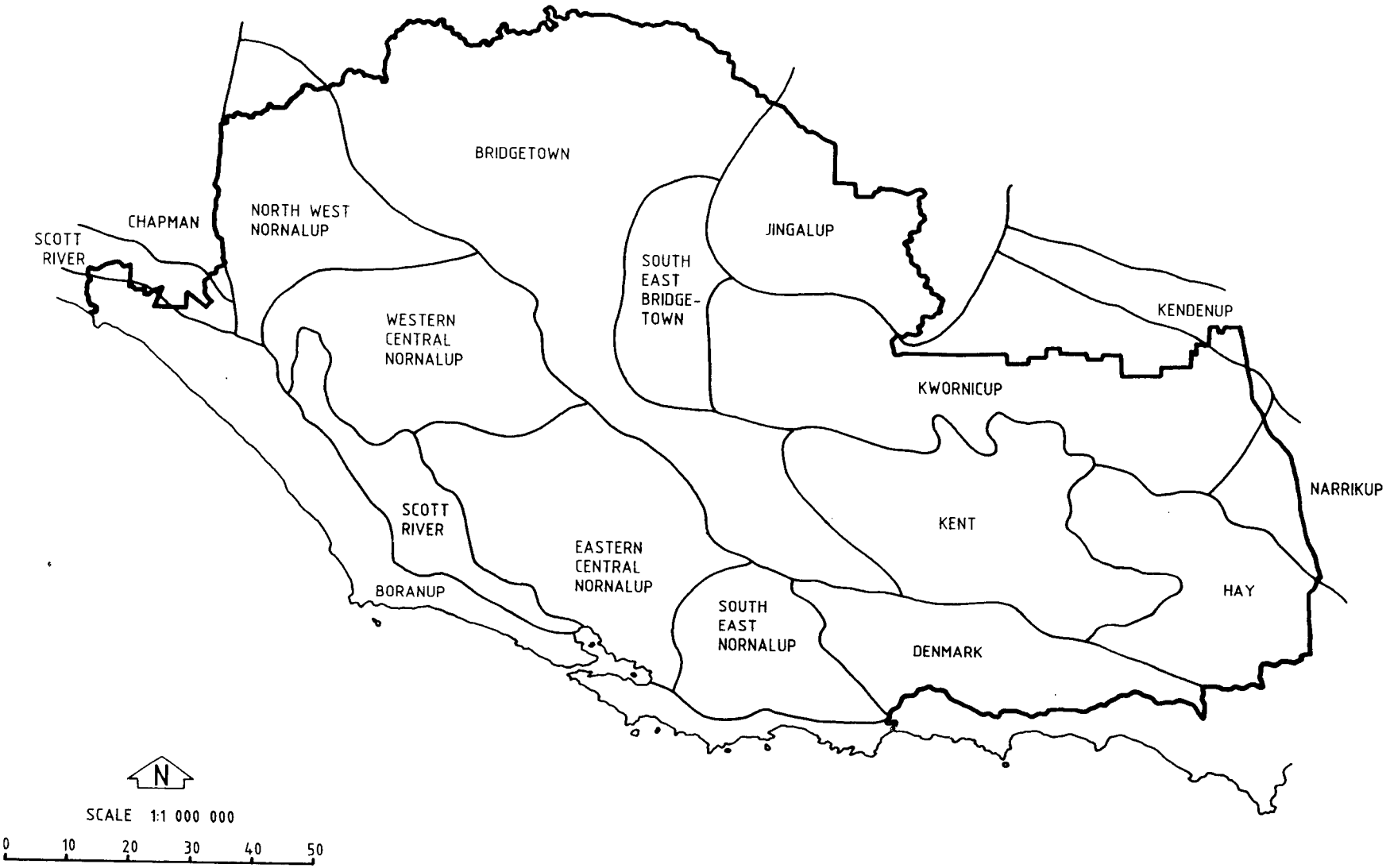

Figure 4. Sub-regions based on vegetation systems of Beard (1980, 1981 and pers. comm.).

at a very general level of classification, viz forests, woodlands and wetlands, within the context of coastal and non-coastal sub-regions. An assessment was also carried out for some fauna species in the Region, particularly mammals, because of the relatively good level of knowledge of their habitat requirements.

Although the two types of assessment are of necessity very general, it was considered that they were an appropriate means of addressing criterion A.2 on current levels of knowledge.

Factors which influenced or determined the threshold limit included size, shape and disturbance. For both types of process, data used to inform the assessment included the CALM map of potential wilderness quality, FMIS map of logging history, FMIS map of catchments and stream orders, and topography data. Sub-catchments of third order streams, derived from the stream order maps, were used as basic units for assessment of values and delineation of boundaries.

Only areas above a minimum size, with a shape appropriate for long-term viability of the area, for maintenance of the value, and a low level of disturbance, were considered significant. It was recognised that the minimum area will vary with the biophysical characteristics of ecosystems, e.g. natural size of catchments and sub-catchments. After discussion, however, it was agreed that 2000 ha would be used as an appropriate minimum size for ecosystems in the Southern Forest Region.

All areas/sub-areas reaching the threshold of significance were qualitatively assigned a relative level of significance, based on the following factors:

- position of area/sub-area in a catchment (compared with other areas);
- size and spatial configuration of area/sub-area (compared with other areas);
- level of significance (including degree of disturbance), size and configuration of adjacent areas/sub-areas;
- coincidence of areas significant for abiotic and biotic processes.

Generally, larger unfragmented areas with circular boundaries were rated of greater significance than large areas with a high boundary:area ratio, or small areas. Size was thus integral to the value of each area. The larger unfragmented areas were considered to have a potentially higher ecological viability than the other areas.

3.2.3 Diversity (criterion A.3)

Three types of diversity were assessed: landform/soil diversity, vegetation diversity and faunal diversity. In general, highest value was afforded areas of least human disturbance for vegetation diversity, but disturbance of the "biological cover" was not considered relevant to the assessment of landform/soil diversity.

3.2.3.1 Landform and soils diversity

The Churchward maps of landforms and soils (Churchward *et al.* 1973 & Churchward 1988) were used to classify the Region into very broad landform and soils 'types'. The characteristics and overall patterns of the mapped units were then examined within the context of this broad classification to identify potential areas of high diversity. Potential areas were then compared with each other to determine those containing the highest diversity of different map units. The minimum size of polygons was set by the minimum area necessary to represent the full range of mapped landform/soil variation in the immediate area, as determined approximately by the standardised sample size.

3.2.3.2 Vegetation diversity

Potential areas based on the data of FMIS, Smith, and Churchward were assessed for vegetation diversity. The Finkl & Churchward (1973) land system/rainfall sub-regions were used as the context for assessment for the Smith, Churchward and FMIS plots.

The size of an area was not considered to be of great importance as a threshold limit for potential areas, as a smaller area may express a greater diversity of vegetation communities per unit area than a larger area. All potential areas for vegetation diversity with undisturbed communities and no smaller than the standardised sample size were therefore considered to be significant.

In sub-regions with no undisturbed potential areas meeting the minimum size, disturbed potential areas were examined. Factors which were considered relevant to the determination of the threshold for these potential areas included the degree and nature of disturbance, assessed from Landsat, CALM logging and grazing history, and the FMIS logging history map. This was in recognition that different types of management practices vary in their impact on forest structure. For example, selective logging in Jarrah communities has less of an impact on structure than clearfelling in Karri communities. After considerable discussion, it was decided that there was insufficient knowledge about the impact of disturbance on community structure and floristics to determine a threshold for disturbed potential areas. It was agreed that this be the subject of future research.

Undisturbed areas determined to be above the threshold were qualitatively assigned a relative level of significance based on the natural structural diversity present, the natural abundance/rarity of the communities, nature of the communities and the total number of communities per unit area. The types of communities occurring within each area were determined and the degree of commonality in community types between areas assessed. For areas containing a similar mix of communities, those areas with the higher number of communities per unit area were assigned a higher level of significance. Where the mapped community composition within areas was dissimilar, the significance rating took account of the 'rarity' of communities present: areas including rare or uncommon community types were rated more highly than areas containing only 'common' communities. Similarly for areas with a low degree of commonality, areas containing community types with a high floristic diversity (e.g. heathlands) were rated more highly than areas lacking these community types.

3.2.3.3 Faunal diversity

No data was available to address faunal diversity or faunal habitat diversity systematically across the Region. The extent to which the areas of high vegetation diversity also reflect areas of high faunal/faunal habitat diversity is not known, although it is common for mapped vegetation diversity to be used as a surrogate for faunal habitat diversity. For areas where considerable scientific research had been carried out on the habitat requirements of rare mammal species, expert opinion was sought on the overall level of significance of such areas in the Region. The assessment of significance was largely based on known occurrences of the species within the Region in viable populations in areas with suitable habitat.

3.2.4 Wilderness (criterion B.1)

Potential areas with wilderness characteristics within the Southern Forest Region are small and fragmented. While the assessment of wilderness quality was carried out just on the potential areas, it was noted that options exist for enhancement of wilderness in the Region through appropriate management, if desired.

Potential areas for places with wilderness characteristics were assessed within the general context of coastal and non-coastal sub-regions. The non-coastal areas were classified at a general level as predominantly forest or predominantly woodland, while the coastal areas were predominantly tree-less. A separate assessment of wilderness significance was carried out for the three wilderness types.

Factors which influenced or determined the threshold limit for each wilderness type included:

- the areal extent: only potential areas with high and very high ratings were included (minimum size threshold was approximately 700 ha);
- physical configuration: compact areas were assessed as having higher significance than linear areas.

Large compact areas were thus assessed as having a higher level of significance for wilderness characteristics than smaller and/or less compact areas. It was noted that the minimum size threshold was very small compared with wilderness areas in other parts of Australia. However, the potential areas represent the only remaining areas in the Southern Forest Region with wilderness characteristics. It was thus considered valid to include a wilderness assessment despite the small minimum size.

3.2.5 Undisturbed forest/woodland as a rare phenomenon (criterion B.1)

The assessment of value for undisturbed forest and woodland communities required consideration of two aspects: the natural distribution of these vegetation communities throughout the Region, and the extent to which existing undisturbed communities were remnant areas reflecting past land use practices. Because of the way in which data on vegetation communities in the area had been compiled on FMIS, and by Smith and Beard, information on the natural distribution of vegetation communities was available only at a general level of community classification (i.e. little data was available to determine the natural rarity of some communities, e.g. pure Karri).

Although the distinction between forests and woodlands would be internally consistent within the three data sources used, i.e. FMIS, Smith and Beard, it was noted that there may be some inconsistency in definitions between the three sources. While these possible inconsistencies may affect the description of value within Indicative Areas, it was considered they would not affect the location of the areas.

In some parts of the Southern Forest Region, undisturbed forests and woodlands are relatively abundant. However within the Region as a whole, it was considered that undisturbed forests and woodlands are a rare phenomenon. The threshold for significance of these communities thus was determined at the regional level, although an assessment was also carried out at a sub-regional level in recognition of ecological gradients across the Region.

The level of data available on vegetation communities allowed an assessment only at the broad level of classification into forests and woodlands, i.e. on current information, it was not possible to consider 'undisturbed Karri forest' as the type, only 'undisturbed forest'. For the sub-regional analysis, two classifications were considered, viz. the Beard sub-regions and the Finkl/Churchward sub-regions. After considerable discussion, it was agreed that the Finkl/Churchward sub-regions, which provided a better understanding of the environment, were most appropriate for the analysis, as the type under consideration was undisturbed forest and not specific vegetation communities.

The threshold for significance for Indicative Areas of both forest and woodland was based on size, and set at 2 000 ha unless the communities were rare within a sub-region. If the sub-regional analysis showed a lack of undisturbed areas larger than 2 000 ha, a sub-regional size threshold of 200 ha was set. These size thresholds were considered appropriate, given the abundance and distribution of the types in the Region/sub-regions.

3.2.6 Representative ecosystems (criterion D.1)

The data available allowed a regional assessment only of vegetation and monadnocks under this criterion. For other attributes, e.g. lakes, published or unpublished expert opinion was used to determine the significance of individual features.

3.2.6.1 Landforms: monadnocks

For the assessment of monadnocks, the coastal and non-coastal sub-regions were used. Although monadnocks are a specific landform in the Region and their landform value can be assessed, monadnocks are also known to support a diversity of flora and fauna taxa, and thus have biological value related to the habitat associated with the landform.

The threshold of significance for monadnocks was based on the areal extent and character of the outcrops, and the type and level of disturbance in the immediately surrounding area, in recognition

of the habitat values associated with the outcrops. Although most land uses would not be expected to impact on the physical features of the landform, the habitat features may be adversely affected. Thus in assessing condition in relation to habitat, timber harvesting operations were generally not seen as having a negative impact, while the impact of grazing was seen to be negative.

3.2.6.2 Vegetation

Based on the available data, several separate analyses were carried out, viz. two on individual vegetation communities using the Smith/Beard data and Churchward data (Churchward *et al.* 1988; Churchward 1990), and one on vegetation assemblages. Due to the intrinsic lack of structural information in the FMIS data, it was not used for an analysis of representativeness. The AHC and CALM recognised that these analyses are inherently biased towards forest, or tree dominant, communities. However, it was noted that information is not currently available to identify, or understand, the full range of non-forest/woodland communities. It was thus agreed that part of the joint ongoing research program should include survey work on these communities.

(i) Vegetation communities - Smith/Beard data

Because of the data available, a very broad level of structural classification was used for the analysis, viz forest, woodland, other. Forest and woodland communities were also classified at the general floristic level of dominant species. It was agreed that a sub-regional analysis would be necessary to determine good expressions of different vegetation communities sensitive to the ecological gradient of the Region. The Finkl/Churchward sub-regions were considered appropriate for this analysis.

The determination of threshold limits for this category was based largely on consideration of minimum size and condition. All potential areas above a minimum size threshold for each community type were considered as good examples of that type. It was recognised that the minimum size needed to be appropriate to the characteristics of each type, including both the natural scale and pattern of distribution in the Region/sub-region, and the current scale and pattern of distribution resulting from past land use.

It was noted that a preliminary size threshold had been applied at a regional level in determining potential areas to be considered for assessment of value (see section 2.2.4(b)). After detailed discussion, it was agreed that two size thresholds would be applied for each sub-regional analysis. The first ('preferred threshold') applied to sub-regions where the community type was relatively common; the second ('fallback threshold') applied only in sub-regions where the community type was uncommon, i.e. where no potential areas reached the first threshold. The two thresholds agreed for community types in the region are shown in Table 7. Where the second threshold was used, it was agreed that lightly disturbed areas which could still be considered good examples of the community type, would also be assessed.

Table 7. Size thresholds for community types based on Smith (1972) and Beard (1979).

Vegetation type	Preferred Threshold	Fallback Threshold
Karri forest	2,000 ha	200 ha
Jarrah forest	2,000 ha	200 ha
Jarrah woodland	2,000 ha	200 ha
Jarrah/banksia etc	2,000 ha	200 ha
Paperbark etc	500 ha *	200 ha
Peppermint	2,000 ha	200 ha
Sedges	500 ha	200 ha
Jacksonia herblands	500 ha*	200 ha
Marri, pure	all expressions	n/a
Tingles	200 ha	n/a
Wandoo	500 ha*	200 ha

* it was noted that linear configurations appropriately reflected the occurrence of this type within the landscape

Issues relevant to the determination of thresholds for particular community types are summarised below.

Marri: it was agreed that Marri forest is a recognised community which occurs naturally in small clumps rarely larger than c. 50 ha. It was agreed that each mapped potential area is significant.

Tingle: It was agreed that all three types of tingle should be assessed separately, noting that although in the past Rates Tingle has generally been mapped as Karri, accurate data (Wardell-Johnson, unpublished data) was now available on its distribution. It was agreed that 200 ha should be the threshold for all tingles to 'capture' the best examples of the extant populations. However, it was noted that all potential areas of tingle should be assessed under criterion B.1 (rarity). It was agreed that the 200 ha threshold is appropriately different from that used for pure marri, because of the differences in the natural scale of distribution, with the tingles generally occurring in larger clumps than Marri.

Other 'small' communities: communities such as Bullich, Yate, and Warren River Cedar have a natural small scale of occurrence, and often occur in linear patterns (e.g. because they are riparian communities). These particular habitat features mean the communities probably occur in larger potential areas although their presence has not been mapped. It was also noted that 'pure' expressions of these communities have not been mapped and/or are not picked up at the scale at which the data has been compiled.

Wandoo: it was agreed that, due to the extensive disturbance of Wandoo, the lightly disturbed areas should be assessed in conjunction with the small areas of remaining undisturbed forest/woodland. It was also noted that due to the history of CALM's API priorities, Wandoo in the region was mapped on FMIS only as woodland where it was the dominant canopy species. Wandoo occurrence is, however, generally shown on 1:50 000 topographic maps.

For areas above the threshold, no assessment of relative significance was carried out on the intrinsic quality of the communities themselves. It is the Commission's view that an adequate framework for determining relative significance in the context of this criteria does not exist. It was therefore determined that all places should be rated as highly significant.

(ii) Vegetation communities - Churchward data

The potential areas for derived vegetation types based on the Churchward data were assessed in a manner similar to that for potential areas based on the Smith/Beard data. It was considered that the Finkl/Churchward sub-regions provided an appropriate classification for sub-regional analyses which take into account variation in the vegetation communities throughout the Region.

It was agreed that the basic thresholds of size and condition set for the Smith/Beard assessment (see 3.2.6.2(i)) were also appropriate for the Churchward derived vegetation types. The size thresholds are outlined in Table 8.

Table 8. Size thresholds for derived community types based on Churchward *et al.* (1988) and Churchward (1990)

Derived vegetation type	Preferred Threshold	Fallback Threshold
Karri-Marri Tall Open Forest	2,000 ha	200 ha
Jarrah-Marri Open Forest	2,000 ha	200 ha
Mixed Jarrah Woodland	2,000 ha	200 ha
Karri-Marri/Red Tingle Tall Open Forest	2,000 ha	200 ha
Jarrah-Marri/Yellow Tingle Open Forest	500 ha	200 ha
Shrubland/Teatree	500 ha	200 ha
Heathland	500 ha	200 ha
Melaleuca Woodland	500 ha	200 ha
Sedgeland	500 ha	200 ha
Banksia Woodland	500 ha	200 ha

For areas above the threshold, no assessment of relative significance was carried out on the intrinsic quality of the derived communities themselves, as no data is currently available to do this. However, an assessment of relative significance was carried out similar to that used for the Smith/Beard analyses, with larger areas being assessed more highly than smaller areas solely on the basis that the large areas are more viable in the long-term than small areas.

(iii) Vegetation assemblages

The assessment of vegetation assemblages (i.e patterns of major vegetation types) across the Region was carried out using the sub-regional classification based on Beard (1980, 1981), as the vegetation systems mapped by Beard are based on major patterns of vegetation in the south-west of WA.

The threshold for vegetation assemblages was based on minimum size and condition, with a minimum area of 2000 ha being set as the threshold for all assemblages. This was considered to be an absolute minimum area, as the value is based on the overall expression and inter-relationships between community types across the broad landscape regions.

3.2.7 Landscape/aesthetic values (criterion E.1)

A uniform level of information on landscape/aesthetic attributes was not available for the Region, and thus a systematic regional assessment was not possible. Individual areas for which information was available were assessed using published or unpublished expert opinion. Some areas which CALM staff considered had a high landscape/aesthetic value were included in the assessment, although the landscape/aesthetic characteristics of these areas are not formally documented anywhere.

4. FINAL ASSESSMENT AND BOUNDARY DELINEATION

The assessment of significance described in section 3 above resulted in a series of overlay maps at 1:250 000 on which individual areas which met the threshold for significance against the various criteria had been marked. The information from each overlay will be stored in CALM's GIS to provide a permanent record of areas found to be significant and, where appropriate, their relative levels of significance, which can be easily accessed for management purposes.

The delineation of Indicative Areas proposed for listing in the Register of the National Estate was carried out by combining the information for all 1:250 000 overlays resulting from the assessment of significance. Where an area of significance did not overlap with any other area, the boundary of the area of significance became the boundary of the indicative national estate area. In those instances where the significance of these areas related solely to the presence of rare or endemic species, these places were designated as 'sites of significance' to distinguish their very limited size.

However, where two or more areas of significance overlapped in any way, a final boundary of the indicative national estate area was delineated by drawing a boundary which encompassed all the overlapping areas (see Figure 5). In many instances, small areas with site specific values were located within larger areas of significance. In finalising the boundary for overlapping areas, the significance of the place resulting from the coincidence of individual values was also taken into account.

After the boundaries of the indicative national estate areas had been finalised at the 1:250 000 scale, the boundaries were then translated to 1:50 000 scale maps for detailed boundary description. This could be carried out accurately because the minimum data plot size of many of the extensive attributes was 2 ha. In finalising the boundaries at 1:50 000, easily distinguished features, such as roads, tracks, creeks, tenure boundaries etc, were used where ever possible, provided the boundary so determined closely approximated the national estate values identified for each area.

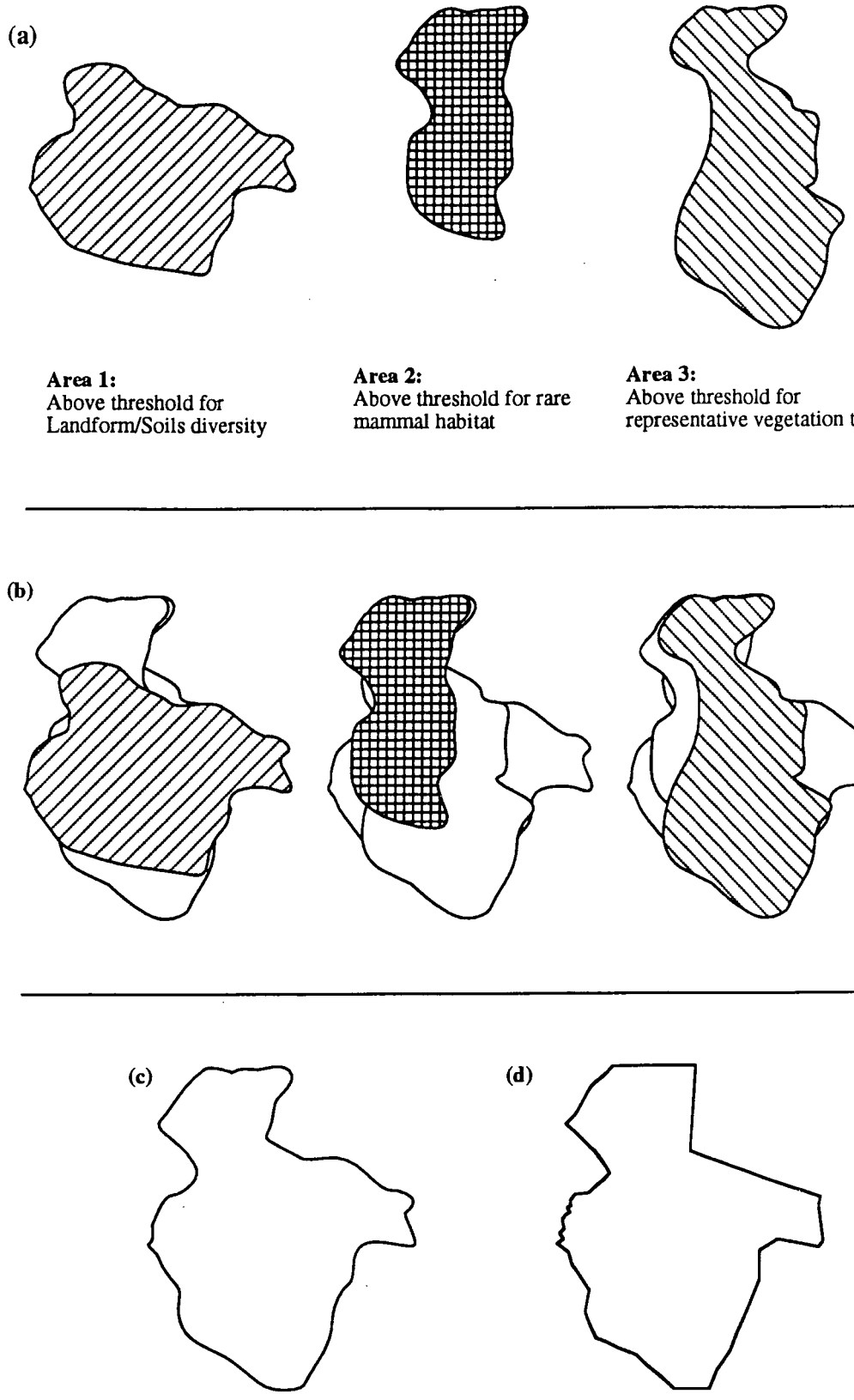

Figure 5. Determination of indicative area boundary.
(a) represents three individual areas above the threshold of significance; (b) shows the composite area formed by overlaying the three individual areas, and the location of each value in the composite area; (c) shows the resulting boundary of the indicative area; (d) shows the final boundary proposed for listing, based on easily distinguished features.

Detailed maps showing Indicative Areas proposed for listing in the Register, and tables outlining the identified national estate values for each Indicative Area, and Site of Significance, are provided in Appendix 2 of the Report. (There are no location maps for the Sites of Significance in order to ensure the protection of these sensitive sites.)

5. REFERENCES

AHC (1990a) *What do we want to pass on to future generations? – An overview of criteria and assessment procedures for the Register of the National Estate.* Australian Heritage Commission.

AHC (1990b) *Future directions in assessment of national estate significance.* Australian Heritage Commission.

Beard J.H. (1979). *The vegetation of the Albany & Mt Barker areas, Western Australia. Map and explanatory memoir. 1:250 000 series.* Vegmap Publication, Perth.

Beard J.H. (1980). *1:1 000 000 SWAN - Vegetation Series Sheet 7.* University of Western Australia Press, Nedlands.

Beard J.H. (1981). *Vegetation survey of Western Australia. SWAN. 1:1 000 000 Vegetation Series, Explanatory notes to Sheet 7.* University of Western Australia Press, Nedlands.

Briggs J.D. and Leigh J.H. (1988). *Rare or threatened Australian plants.* Australian National Parks & Wildlife Service Special Publication 14.

CALM (1990). Wildlife Conservation Act 1950. [Fauna]. Government Gazette, WA, 16 November 1990, pp 5696 - 5697.

CALM (1991). Wildlife Conservation Act 1950. Wildlife Conservation (Rare flora) Notice. Government Gazette, WA, 17 May 1991, pp 2468-2470.

Churchward H.M. (1990). Soils and Landforms of the Manjimup Area, Western Australia. Draft manuscript and 1:100 000 maps. WA Dept Agriculture.

Churchward H.M., McArthur W.M, Sewell P.L. and Bartle G.A. (1988). *Landforms and soils of the south coast and hinterland, Western Australia. Northcliffe to Manypeaks.* CSIRO Div. Water Resources Divisional report 88/1.

Finkl C.W. and Churchward H.M. (1973). The etched land surfaces of south western Australia. *J. Geol. Soc. Aust.* 20(3), 295-307.

Lesslie R.G., Mackey B.G. and Schulmeister J. (1987). *National Wilderness Inventory - A computer based methodology for the survey of wilderness in Australia.* A report to the Australian Heritage Commission.

Main A.R. and Barbara York Main (1991). *Report on the Southern Forest Region of Western Australia.* Unpublished report to the Australian Heritage Commission.

Smith F.G. (1972). *Vegetation survey of Western Australia: Vegetation map of Pemberton and Irwin Inlet.* WA Dept Agriculture.

Wardell-Johnson G., Inions G. and Annels A. (1989). A floristic classification of the Walpole-Nornalup National Park, WA. *For. Ecol. Manage.* 28, 254-279.