ENVIRONMENTAL &
SOCIO-ECONOMIC

DATABASES

Methodology Report

Biodiversity Plan for the South East of South Australia

GIS Application Methodology

April 1999

Government of South Australia

Biodiversity Plan for the South East of South Australia

GIS Application Methodology

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BIOLOGICAL SURVEY SOUTH AUSTRALIA

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ENVIRONMENTAL & SOCIO-ECONOMIC DATABASES

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SUMMARY

This document outlines the GIS process undertaken for the South East Regional Biodiversity Planning project. A summary of the process of GIS analyses of environmental data, and the final spatial data products available as part of the Biodiversity Planning project, are provided. A background to the mapping data sets and to some of the available biological data for the region is also outlined.

Key spatial data bases discussed include regional remnant floristic vegetation mapping, regional pre-European settlement floristic mapping, and vertebrate fauna survey data.

The aim of the GIS analysis and modelling was to incorporate relevant GIS data held in the State's Environmental Databases along with expert scientific knowledge to identify areas of high habitat value and therefore biodiversity in the South East Region.

A key aspect of the analysis included GIS modelling for significant fauna species to determine recorded, predicted and potential habitat. The ecological theory the habitat model has been based upon is briefly discussed.

The GIS analysis included:

- fauna species habitat modelling for 32 regionally significant species (27 of which were included in the final Biodiversity Plan);
- spatially determining regionally rare and threatened plant communities based on the remnant and pre-European extent.

The final biodiversity information determined for each individual vegetation block includes:

- identifying vegetation blocks containing rare and threatened plant communities;
- identifying vegetation blocks containing known populations of rare and threatened plant populations;
- identifying vegetation blocks containing wetlands plant communities;
- identifying vegetation blocks containing significant habitat (based on habitat modelling results);
- identifying blocks containing koala release sites

At a regional scale the following key biodiversity areas were determined and mapped:

- large remnant areas (based on habitat analysis);
- threatened habitat areas.

A final biodiversity GIS layer now exists which incorporates all of the above information.

The document *Biodiversity Plan for the South East of South Australia* (Croft, Carruthers, Possingham and Inns 1999), outlines the significant biological assets of the South East, important biodiversity management areas, threats to biodiversity conservation, and recommendations for strategic management. All the results presented in this technical background document are discussed in their regional context for biodiversity conservation in the above mentioned Biodiversity Plan.

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1. INTRODUCTION

The Biodiversity Plan for the South East of South Australia is a strategic document designed to provide a regional context for biodiversity conservation. Part of the plan's production involved the use of available biological information including vegetation mapping and individual species data, and the use of GIS analysis tools. This report outlines the data and GIS modelling and analyses undertaken to produce information for the *Biodiversity Plan for the South East of South Australia* (Croft, Carruthers, Possingham and Inns 1999).

The GIS aspects included:

- mapping and digitising of Pre-European vegetation;
- mapping and digitising of areas where koala relocation has occurred;
- developing a GIS model to determine recorded and predicted habitat for vertebrate species;
- spatial comparison of remnant and pre-European floristic vegetation mapping to determine regionally rare and threatened plant communities;
- identification of key biodiversity areas including: large remnant areas and threatened habitat areas;
- creation of a final GIS biodiversity layer.

It is anticipated that the South East Biodiversity Plan will provide the framework for biodiversity planning for other regions in the State.

1.1 Geographic Information System (GIS)

A substantial amount of environmental GIS information exists for the South East region of the State and this has been used for the South East biodiversity plan. The GIS used is ESRI's (Environmental Systems Research Institute) ARC/INFO. The use of a GIS over traditional paper methods of landscape ecology assessment provides the opportunity to perform complex environmental analyses not previously possible. A GIS allows many layers of information to be added together and then re-grouped or categorised to provide a new perspective for interpretation. Using the raster or cell based approach large amounts of data can be combined and processed within short time frames. Analyses can be adapted for specific requirements and can take into account different input parameters. A GIS allows the development of a standard methodology ensuring analyses can be repeated for a different spatial location, allowing comparisons to be made.

2. STUDY AREA

The South East Region of South Australia as determined for the Biodiversity Plan is identified as the area below the line of 36 degrees latitude south of the equator. Based on vegetation mapping (Figure 1) from 1987 aerial photography, native vegetation is estimated to cover thirteen percent of the area. Area estimates are given in Table 1. This region comprises many thousands of isolated patches of native vegetation, surrounded by agricultural land. 21 percent of this remnant native vegetation is conserved within 56 National Parks and Wildlife (NPWS) managed reserves, another 4% is represented within 46 Native Forest Reserves, in addition to 162 Heritage Agreement areas, which conserve another 14 percent (Figure 2). These represent areas on private land for which an agreement has been reached between the owner and the State Government to be managed for off park conservation. The remaining patches of remnant vegetation varying from natural to degraded condition exist on both private and government owned land. An even smaller amount of this exists as remnants occurring along roadsides and stream corridors or as scattered trees on paddocks and some of these areas have not been mapped. The statistics showing remnant vegetation tenure are shown in Table 2.

Table 1: Landcover Area Statistics for the South East Region

AS2482 Code	Description	Estimated Area (Ha)	% of Total Area
1130	Built up area	2,678	<1%
44010, 44190	Perennial Lake/ Swamp	76,187	3.6%
44160	Salt Pan	271	<1%
51010	Sand Dune	11,827	<1%
51130	Rock – boulder	37	<1%
60010	**Native vegetation**	**276,742**	**13%**
65010, 61000, 65011, 65021	All plantation forestry (1997)	98,019	4.6%
065060	**Cleared land/crop**	**1,663,242**	**78%**
	Total	2,129,003	100

Source: Landcover mapping (GIS), 1987 aerial photography Planning SA; 1997 Forestry area mapping (GIS) Forestry SA.

Table 2: Native Vegetation Tenure in the South East Region

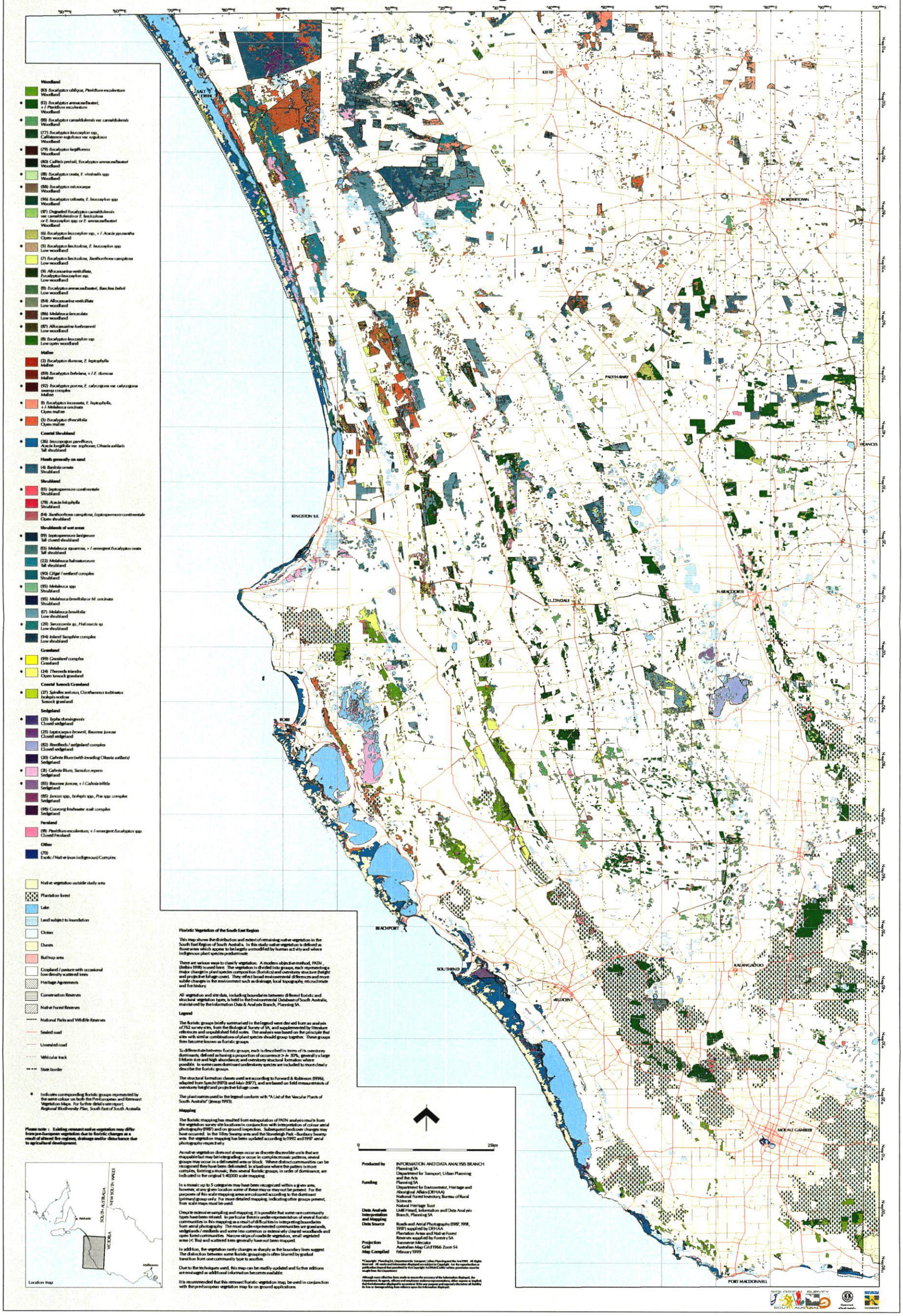
Native Vegetation	Number Existing	Estimated Area (hectares)	% of Total SE Vegetation
NPW Reserves	49	53,701	20%
NPW Conservation Reserves	7	4,215	1%
Native Forest Reserves	46	10,160	4%
Not formerly conserved		169,456	61%
Heritage Agreements	162	40,209	14%
Total		**276,742**	

Source: Landcover mapping (GIS), 1987 aerial photography Planning SA; 1997 Forestry area mapping and Native Forest Reserves(GIS) Forestry SA; Heritage Agreements (GIS) current to Jan 1998, DEHAA/Planning SA; NPWS Reserves including Conservation Reserves (GIS) current to Dec 1998 DEHAA.

Figure 1:

Floristic Vegetation Mapping of South Australia

South East Region



Floristic Vegetation of the South East Region

This map shows the distribution and extent of remaining native vegetation in the South East Region of South Australia. In this study native vegetation is defined as those areas which appear to be largely unmodified by human activity and where indigenous plant species predominate.

There are various ways to classify vegetation. A modern objective method, PATN, (Belbin 1998) is used here. The vegetation is divided into groups, each representing a major change in plant species composition (floristics) and overstorey structure (height and projective foliage cover). They reflect broad environmental differences and more subtle changes in the environment such as drainage, local topography, microclimate and fire history.

All vegetation and site data, including boundaries between different floristic and structural vegetation types, is held in the Environmental Database of South Australia, maintained by the Information Data & Analysis Branch, Planning SA.

Legend

The floristic groups briefly summarised in the legend were derived from an analysis of 762 survey sites, from the Biological Survey of SA, and supplemented by literature references and unpublished field notes. The analysis was based on the principle that sites with similar combinations of plant species should group together. These groups then become known as floristic groups.

To differentiate between floristic groups, each is described in terms of its overstorey dominants; defined as having a proportion of occurrence >= 50%, generally a large lifeform size and high abundance; and overstorey structural formation where possible. In some cases dominant understorey species are included to more closely describe the floristic groups.

The structural formation classes used are according to Forward & Robinson (1996), adapted from Specht (1970) and Muir (1977), and are based on field measurements of overstorey height and projective foliage cover.

The plant names used in the legend conform with "A List of the Vascular Plants of South Australia" (Jessop 1993).

Mapping

The floristic mapping has resulted from extrapolation of PATN analysis results from the vegetation survey site locations in conjunction with interpretation of colour aerial photography (1987) and on ground inspection. Subsequent landcover changes may have occurred. In the Tilley Swamp area and the Stoneleigh Park - Bunbury Swamp area the vegetation mapping has been updated according to 1992 and 1997 aerial photography respectively.

As native vegetation does not always occur as discrete discernible units that are mappable but may be intergrading or occur in complex mosaic patterns, several groups may occur in a delineated area or block. Where distinct communities can be recognised they have been delineated. In situations where the pattern is more complex, forming a mosaic, then several floristic groups, in order of dominance, are indicated in the original 1:40000 scale mapping.

In a mosaic up to 5 categories may have been recognized within a given area, however, at any given location some of these may or may not be present. For the purposes of this scale mapping areas are coloured according to the dominant (primary) group only. For more detailed mapping, indicating other groups present, finer scale maps must be used.

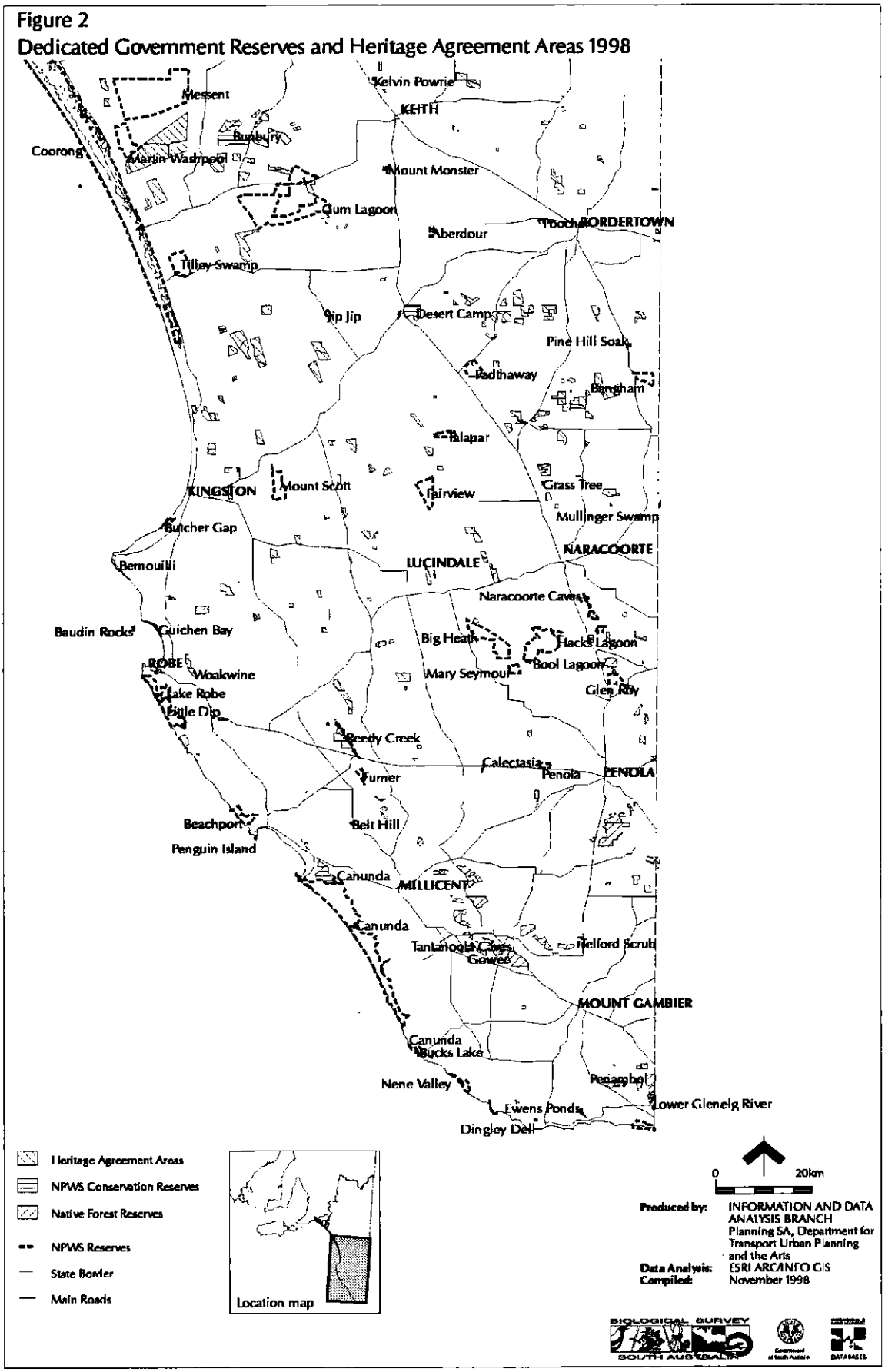
Despite extensive sampling and mapping, it is possible that some rare community types have been missed. In particular there is under-representation of several floristic communities in this mapping as a result of difficulties in interpreting boundaries from aerial photography. The most under-represented communities are grasslands, sedgelands / reedbeds and some less common or extensively cleared woodlands and open forest communities. Narrow strips of roadside vegetation, small vegetated areas (< 1ha) and scattered trees generally have not been mapped.

In addition, the vegetation rarely changes as sharply as the boundary lines suggest. The distinction between some floristic groupings is often blurred by gradual transition from one community type to another.

Due to the techniques used, this map can be readily updated and further editions are envisaged as additional information becomes available.

It is recommended that this remnant floristic vegetation map be used in conjunction with the pre-European vegetation map for on ground applications.

Figure 2
Dedicated Government Reserves and Heritage Agreement Areas 1998



3. LANDSCAPE ECOLOGY AND CONSERVATION OF BIODIVERSITY

3.1 Biodiversity

The term biodiversity describes the variety of all living things; the plants, animals and micro-organisms, the genetic information they contain and the ecosystems they form. It is considered at three interconnected levels: genetic diversity, species diversity and ecosytem diversity (Commonwealth Department of the Environment, Sport and Territories 1996).

Biodiversity by its very definition encompasses the variety of all living species and their interrelationships, and this makes it difficult to identify ways of measuring or defining it. In particular a biodiversity conservation plan needs to determine the current status of biodiversity, and by identifying threats and the role of their continued presence, make recommendations to prevent further decline.

The four principles of biodiversity conservation (Possingham 1996), adopted for the South East biodiversity approach were:

- A comprehensive and representative network of natural areas. This principle dictates that those habitat types which have been preferentially altered are the highest priority for restoration and revegetation;
- A focus on threatened species with highest priority on species of national, state and regional significance;
- A coordinated approach to the management of threatening processes;
- A strategic vision of subregions where diverse ecosystems can evolve and function in a relatively undisturbed fashion.

The SE project is based on an administrative regional scale approach, which aims to identify particular species' distributions at a scale that is significant and relevant for each. The ecological time frame includes the period from European settlement of the region to the present. The aim of biodiversity conservation is to prevent biodversity decline in the short to medium term of the next 50 to 150 years.

The following section is a brief attempt to summarise the most recently held scientific views, with regards to landscape ecology and the conservation of biodiversity of vertebrate fauna populations. The effects of fragmentation, a definition of habitat, and threats to conservation are outlined. This theory has formed the basis for attempting to model 'predicted' habitat.

3.2 Landscape Fragmentation

Broad scale vegetation clearance and the subsequent fragmentation of vegetation within the landscape has brought about the regional and local decline of faunal species. Fragmentation has resulted in the isolation of many populations of native species and an increasingly diminishing amount of available or suitable habitat for faunal species. The predominant strategy for conservation of biodiversity has been to protect larger patches and expand these where possible (such as the National Parks and Wildlife (NPWS) system of conservation and off park conservation through Heritage Agreements).

The other result of fragmentation relates in broad ecological terms to both the physical and biological effects that occur in the individual vegetation remnants it creates.

3.2.1 Effects

The physical effects of fragmentation are concerned with the alteration in microclimate at the boundary between remnant vegetation and other landscape elements. These include changes to the radiation, wind and water fluxes (Saunders, Hobbs and Margules 1991) whose effects are most pronounced at the edges of patches where the different landscape elements meet. These effects are often termed 'edge effects'. These physical effects in energy flows directly affect the physical environment of boundaries of patches and this in turn affects the community structure of the patch. Changes in radiation levels through increased sunlight affect plant species survival and soil moisture content. Wind regimes are altered at the boundaries of patches and this also decreases the soil moisture content. In addition to this changes in water fluxes are brought about by increased runoff at these boundaries.

This alteration of the microclimate at the edges of remnants brings about a change in the vegetation structure that can extend a large distance into the remnant. This alters the habitat of this area and its suitability for interior species. Species competition is increased at the remnant edge and typically outside species compete with resident species for nesting sites and food. There is also increased predation at the edges. The smaller the patch the greater the influence that the edge effect will have on the patch as a whole. Similarly, the shape of the patch will also determine the ratio of edge to interior and hence patch habitat integrity.

3.2.2 Fauna Populations

The most obvious biological effects of fragmentation are those caused by disturbance such as species invasion at the edges and changes in vegetation structure. The less obvious are those relating to changes in species population dynamics which have implications at both the local and regional level. Theories of species-area equation, species metapopulations and minimum viable populations attempt to explain these population dynamics.

Species Area Equation

According to the species-area equation there will be a certain number of species that can be maintained for a given area of habitat. If a habitat is destroyed the remaining part will initially contain more species than can be maintained at equilibrium and the time for the species number to become balanced is termed the relaxation rate (Diamond 1975). The rate of relaxation will be different among different taxa. In addition to this, one of the inevitable consequences of area reduction and isolation is that various local stochastic extinctions will result from physical and biotic changes in the ecosystem. Decreasing area results in a decreased population size and increasing isolation results in decreasing immigration from outside thereby increasing the risk of local extinction (Haila, Saunders and Hobbs 1993). Further extinctions may be caused through outside species moving in, and the loss of one species may then affect another.

Faunal responses to fragmentation are related to relative body size, dietary type, habitat specialisation and general rarity (Bennet 1990). Those species which are dependent upon native vegetation, have large territories, or which exist at low densities, will be most vulnerable to extinction (Saunders, Hobbs and Margules 1991).

Minimum Viable Populations

Along with this, it is possible that populations remaining after isolation may be too small to be viable but these may persist for long periods of time due to the longevity of individuals (Saunders, Hobbs and Margules 1991). An example of this is the low extinction rate of birds in Australia in comparison with that of small mammals. What is predicted however, is the mass loss of bird species during the next century that has been based on a continent wide pattern of regional decline in abundance and local extinction (Recher 1993).

In reality there is no such thing as a definable minimum viable population (Lindemayer, Clark, Lacy and Thomas 1993), however it is understood that populations become increasingly vulnerable to extinction the smaller they are (Shafer 1991). In designing reserves for particular species and determining the status of populations, the important factors include: edge habitat and area requirements; the spatial and temporal availability of suitable habitat and; the effectiveness of remaining habitats in contributing to minimum critical areas (including the presence of wildlife corridors) (Lindenmayer et al 1993).

Metapopulation Theory

At the level of the regional perspective each patch may contain a local population which may become extinct and thereby cause a vacancy within that patch. The regional population, termed the metapopulation, consists of the sum of the local populations that are interacting. The regional population is persistent even though the local populations are ephemeral (Fahrig and Merriam 1994). While the metapopulation is an untested hypothesis replacing island biogeography theory (Simberloff et al 1992), it is useful in trying to explain the effects of fragmentation of species population dynamics. Local extinctions of fragmented populations are common and recolonisation is critical for regional survival.

The source-sink model (Pulliam 1988 in Fahrig and Merriam 1994) maintains that some patch populations will act as sources of colonists for other patches that depend on these sources for persistence. The probability of recolonisation will be dependent upon the spatial relationships among the landscape elements and the dispersal characteristics of individual species (Fahrig and Merriam 1994). The lower the migration rate for a species the longer will be the time from local extinction to recolonisation and the higher the probability of overall extinction (Burkey 1989).

The persistence of the regional or metapopulation of species is thought to be dependent upon the persistence of local populations which are in some way connected for the purposes of facilitating dispersal movement of individuals from one patch to another. These smaller patches which connect the larger remnants are sometimes referred to as corridors.

According to Simberloff et al (1992) the rationale of movement corridors is to (1) lower the extinction rate in the sense of the equilibrium theory, (2) lesson demographic stochasticity, (3) stem inbreeding depression and (4) fulfil an inherent need for movement. In the case of small population extinction Simberloff et al (1992) claim that numerous endemic species of small islands are endangered primarily by either habitat destruction or introduced species rather than through genetic inbreeding or stochastic extinction.

In summary the result of fragmentation for individual patches will depend upon the time since isolation, the distance from other remnants and the degree of connectivity between remnants (Saunders, Hobbs and Margules 1991).

3.3 Habitat

In order to determine the significance of individual remnants and their relationship to one another, it is important to identify those remnant habitat patches within the landscape that are most likely to maintain local populations. In broad terms there are 2 main factors which determine whether a remnant represents a habitat patch capable of sustaining viable local species populations, or not. These relate to the size and condition or disturbance of the remnant.

3.3.1 Area

There will be a minimum habitat area required by a species' population to survive within a remnant, regardless of whether this minimum area is a result of behavioural, such as home range areas, or practical reasons, such as availability of food and nesting sites. There will also be a minimum area for which population numbers are considered large enough for long term conservation.

Recent research by the CSIRO is looking into the patterns of fragment sizes, and field surveys are currently under way in NSW to study bird numbers in different size fragments. These have been divided into <20ha; 20-50ha; 50-100ha; 100-500ha; 500-2000ha; 2000-5000ha; 5000-20,000ha; >20,000ha (pers com. Julian Reid, CSIRO).

Appropriate patch sizes have not been generalised for the SE as habitat has been modelled with species' specific criteria, one of which has been minimum area required for a breeding pair.

3.3.2 Vegetation Condition

The condition of a habitat patch relates to the degree to which it is representative of its original state, prior to detrimental impacts. In many cases the degree of disturbance such as grazing will have a severe impact on vegetation condition. Grazing compacts soils, changes soil moisture structure and changes the soil faunal activity, along with decreasing the amount of ground litter and causing elevated soil nutrient levels (Scougall, Mayer and Hobbs 1991). In broad terms the vegetation structure is changed which equates to removing habitat, and regeneration of plants is prevented. Grazed patches provide minimal cover for small mammals and ground dwelling birds along with decreased food availability. Where vegetation structure has been altered, in particular where there has been loss of ground and lower storey cover, patches will provide inadequate habitat for many native species.

Weeds can also greatly affect the condition of remnant vegetation by replacing native species and altering plant community dynamics.

3.4 Threats

There are many direct threats to native plant communities and their fauna. Plant communities are threatened by degradation from effects such as grazing, dieback, disease, weeds, wildfire, clearance and changing soil salinity. Fauna populations are in danger through loss of habitat by fire, clearance, destruction of habitat by stock grazing and rabbits, predation by foxes and feral cats, and displacement by exploiter species.

3.5 Biodiversity Plan

Two types of key biodiversity significant areas were identified. Large remnant areas and threatened habitat areas. The large remnant areas were identified as areas containing large remnants of native vegetation that usually contain plant communities that are better conserved than others, and are considered to provide sufficient habitat for the long term sustainable populations of many vertebrate fauna species. The threatened habitat areas were identified as areas containing rare and threatened habitat that is very small in size and under threat.

The large remnant areas identified in the Biodiversity Plan are partly based on the results of the GIS analysis. The focus of the GIS analysis is the remnant native vegetation of the region, using it as the underlying factor upon which biodiversity can be evaluated. The conservation of biodiversity aims to prevent further decline of species that were more abundant prior to European settlement. The remnant native vegetation is therefore seen as the closest representative of the pre-European status of terrestrial biodiversity. Native vegetation has the additional advantage of being able to be divided and mapped in terms of discrete plant communities, which indicate suites of plant species that often occur together.

There are factors that occur within plant communities, at the borders or ecotones of plant communities, and at the edges and in the cores of blocks of remnant vegetation, which provide the conditions necessary for individual vertebrate species to survive and reproduce. As fauna species, particularly vertebrate fauna, rely on certain plant communities for survival they can be identified in many cases, though not all, via plant community mapping. To predict a vertebrate species' likely habitat however requires additional information to simply knowing the plant communities upon which it relies. Information such as plant species required for nesting, feeding, and cover; minimum area required for a breeding pair; and an understanding of species' particular habits such as willingness to leave the protection of remnants in search of new habitat, or whether species are ground frequenting or are sedentary. This information is only available by accessing the expert knowledge of field biologists.

The biodiversity plan uses significant vertebrate species for the region as indicators of important biological areas. The GIS analysis uses target vertebrate species to determine ecosystem function and ecosystem or remnant vegetation value with regards to vertebrate fauna biodiversity. Species may be significant because: they now exist in small numbers, they may represent a population of a nationally threatened species, they may represent a large population which have a stronghold in the region despite poor population numbers in other States or regions of the State. Some species indicate the typical overlap of species between the drier mallee areas and the wetter South Eastern area ie Shy Heath-wren versus

the Chestnut-rumped Heath-wren The conservation status for each species is outlined. Species can be rated Extinct (X), Endangered (E), Vulnerable (V), Rare (R), or Uncommon (U). Conservation rating provides an indication of how threatened a particular species survival is at either a regional, state or national level.

Thirty two species have been used in the biodversity analysis with 27 included in the final Biodiversity Plan. This list is by no means exhaustive. Some species are harder to define such as those that roam widely and are not intricately tied with native vegetation, these include birds of prey or wetland and wader birds. The species chosen have been used as a guide to determining highly significant areas of native vegetation in the region and therefore significant areas requiring management for the conservation of biodiversity.

4. VEGETATION MAPPING

The current floristic vegetation mapping, was the key information on which the habitat modelling was based. Without this detailed regional scale mapping the predictive modelling would have been impossible to do with any degree of accuracy. The vegetation mapping is explained in some detail here. In addition to this the pre-European vegetation was mapped as part of the project. This provides the unique opportunity to compare the pre-European extent of plant communities with their remaining extent, and hence determine their true conservation status, with some degree of spatial accuracy.

4.1 Floristic Vegetation Mapping

The regional floristic vegetation mapping (Figure 1) was mapped in 1994 from 1987 1:40,000 colour stereo pair aerial photography. Areas 1 hectare or larger are mapped. Some roadside vegetation is not included in the mapping due to its narrow linear nature. The mapping is based on site based vegetation survey data, which is statistically analysed to determine species' composition of, and similarities between, sites. The plant communities are defined according to the results of the statistical analysis and then mapped from aerial photograph interpretation and from ground truthing. Plant communities are mapped using dominant overstorey species to represent the particular suite of species likely to be found within that community. Table 3 lists the floristic plant communities mapped.

A vegetation condition code has been placed on the mapping for each discrete area of plant community mapped. This is an indication only of the likely condition or status of the vegetation patch in question. Those with a code of unknown may potentially have little native understorey, be weed infested and/or heavily grazed. This condition code is based on ground truthing and/or on aerial photo interpretation. While it is an indication of understorey condition and has therefore been used in the habitat modelling, it is not suggested that this is completely accurate. The condition coding has not been based on a standard assessment procedure. Some blocks identified as in good condition may actually be in poor condition and vice versa.

Changes may have occurred to the actual cover of vegetation since 1987 and these are not reflected in the mapping and therefore in the habitat analysis. Mosaiced plant communities (communities which intergrade with a more spatially dominant community and which are difficult to map) are not spatially identified within discrete plant community boundaries and these are not included in the habitat analysis.

Table 3: South East Region Floristic Plant Communities Mapped

Woodland
Eucalyptus obliqua, Pteridium esculentum Woodland (10)
Eucalyptus arenacea/baxteri, +/- Pteridium esculentum Woodland (12)
Eucalyptus camaldulensis var. camaldulensis Woodland (18)
Eucalyptus leucoxylon ssp., Callistemon rugulosus var. rugulosus Woodland *(77)*
Eucalyptus largiflorens Woodland over Grassland / Herbland (79)
Callitris preissii, Eucalyptus arenacea/baxteri Woodland (80)
Eucalyptus ovata, E. viminalis spp. Woodland (wetland complex) (81)
Eucalyptus microcarpa Woodland (88)
Eucalyptus odorata, E. leucoxylon spp. Woodland (96)
Degraded *Eucalyptus camaldulensis var. camaldulensis* or *E. fasciculosa* or *E. leucoxylon* spp. or *E. arenacea/baxteri* Woodland (understorey would differ between rise and flats) (97)
Eucalyptus leucoxylon ssp., +/- Acacia pycnantha Open woodland (6)
Eucalyptus fasciculosa , E. leucoxylon spp. Low woodland (5)
Eucalyptus fasciculosa , Xanthorrhoea caespitosa Low woodland (7)
Allocasuarina verticillata , Eucalyptus leucoxylon ssp. Low woodland (9)
Eucalyptus arenacea/baxteri , Baeckea behrii Low woodland (11)
Allocasuarina verticillata Low woodland (84)
Melaleuca lanceolata Low woodland (86)
Eucalyptus leucoxylon ssp. Low open woodland (8)
Allocasuarina luehmannii Low woodland (87)

Mallee
Eucalyptus dumosa , E. leptophylla Mallee (2)
Eucalyptus behriana, +/- E. dumosa, Melaleuca wilsonii, M. uncinata Mallee (89)
[Other Emergents could be *+/- E. odorata, +/- E. leucoxylon* spp.]
Eucalyptus porosa, E. calycogona var. calycogona swamp complex Mallee (UpperSE) (92)
Eucalyptus incrassata , E. leptophylla, +/- Melaleuca uncinata Open mallee (1)
Eucalyptus diversifolia Open Mallee (3)

Coastal Shrubland
Leucopogon parviflorus , Acacia longifolia var. sophorae , Olearia axillaris Tall shrubland (26)

Heath generally on sand
Banksia ornata Shrubland (4)

Shrubland
Leptospermum continentale Shrubland (15)
Xanthorrhoea caespitosa , Leptospermum continentale Open shrubland (14)
Acacia leiophylla Shrubland (ie. Rocky Reserve NFR) (78)

Shrublands of wet areas
Leptospermum lanigerum Tall closed shrubland (19)
Melaleuca squarrosa, +/- emergent *Eucalyptus ovata* Tall shrubland (13)
Melaleuca halmaturorum Tall shrubland (22)
Gilgai / wetland complex Shrubland (90)
Melaleuca spp. Shrubland (possibly *M. brevifolia* or *M. uncinata* in damp swales / flats +/- some emergent large *Eucalyptus* spp.) (93)
Melaleuca brevifolia or M. uncinata Shrubland
[Damp swales/ depressions north-east of Keith] (95)
Melaleuca brevifolia Low shrubland (17)
Sarcocornia sp. , *Halosarcia sp.* Low shrubland (29)
Inland Samphire complex Low shrubland (94)

Grasslands
Grassland complex Grassland (99)
Themeda triandra pen tussock grassland (24)

Coastal Tussock Grassland
Spinifex sericeus , Ozothamnus turbinatus, Isolepis nodosa Tussock grassland (27)

Sedgeland
Typha domingensis Closed sedgeland (23)
Leptocarpus brownii , Baumea juncea Closed sedgeland (25)
Reedbeds / sedgeland complex Closed sedgeland (82)

Gahnia filum (with invading *Olearia axillaris*) Sedgeland (20)
Gahnia filum , *Samolus repens* Sedgeland (21)
Baumea juncea +/- *Gahnia trifida* Sedgeland (83)
Juncus spp., Isolepis spp., Poa spp., complex Sedgeland
[Reedbeds - Interdune Tussock Grassland / Sedgeland] (85)
Coorong freshwater soak complex Sedgeland (98)

Fernland
Pteridium esculentum, +/- emergent *Eucalyptus* spp. Closed fernland (91)

Note: () refers to numbers shown on map legend
Source: Heard and Goodwins (in prep)

4.2 Pre-European Vegetation Mapping

The Pre-European vegetation was mapped as part of SE regional biodiversity planning project at 1:50,000 scale using 1981 or 1979 black and white mosaic aerial photography (Figure 3). The fundamental basis of the mapping however was based on a variety of sources. This included: 1945 1:20,000 B&W RAAF aerial photography; 1969 and 1981 1:50,000 B&W aerial photograph mosaics; 1981, 1982, 1987 and 1998 1:40,000 colour aerial photographs; accounts of early travellers and residents and landholders of the region; land surveys for Hundreds, general literature research and the CSR's 1940's and 1950's agricultural assessment potential report surveys; remnant regional floristic mapping (Planning SA); Forestry SA information; Biological Survey plant records; and 12 years of extensive ground truthing.

The plant communities identified and mapped are listed in Table 4.

The pre-European vegetation mapping presents some differences to the current vegetation mapping. Some of this is due to interpretation of the aerial photography. Other differences are due to the extensive changes that have occurred in the South East region. These changes relate to alterations in ground water flow, or in differences brought about by changes in fire regimes or clearance methods. One example that illustrates this is the alteration of large areas of predominantly a *Eucalyptus arenacea/baxteri* Woodland with a *Banksia ornata* heath understorey to a *Banksia ornata* Shrubland. This was most likely brought about by the chaining of these areas and removal of the Stringybark overstorey . Based on the area figures in Table 5, the original extent of *Banksia ornata* Shrubland is estimated at approx 9,000 hectares, with the current extent estimated at approx 34,500 hectares.

Table 4: South East Region Pre-European Floristic Plant Communities Mapped

Forest

Eucalyptus arenacea/baxteri, +/-E. obliqua, +/-E. fasciculosa +/- E. viminalis ssp. cygnetensis Open forest to Woodland
Eucalyptus willisii ssp. willisii Open forest to Woodland

Woodland

Eucalyptus camaldulensis var. camaldulensis Woodland
Eucalyptus leucoxylon, +/- E. fasciculosa Woodland
Eucalyptus largiflorens Woodland
Eucalyptus microcarpa Woodland
Eucalyptus ovata Woodland
Eucalyptus porosa Woodland
Eucalyptus viminalis ssp. cygnetensis Woodland
Allocasuarina *luehmannii* Woodland
Allocasuarina verticillata Woodland
Banksia marginata Low woodland
Melaleuca lanceolata, Allocasuarina verticillata Low woodland

Mallee

Eucalyptus behriana, +/-E. dumosa, +/- Melaleuca wilsonii, +/- M. uncinata, or E. incrassata, +/- E. leptophylla Mallee
Eucalyptus diversifolia Mallee
Eucalyptus odorata Mallee
Eucalyptus rugosa Mallee

Coastal Shrubland

Acacia longifolia var. longifolia Tall closed shrubland
Olearia axillaris, Leucopogon parviflorus Shrubland

Heath generally on sand

Banksia ornata Shrubland

Shrubland

Leptospermum continentale Shrubland
Melaleuca gibbosa, Hakea rugosa Shrubland
Muehlenbeckia florulenta Shrubland

Shrublands of wet areas

Leptospermum lanigerum Tall closed shrubland
Melaleuca halmaturorum ssp. halmaturorum or *M. brevifolia* Low open forest to Shrubland
Halosarcia spp Low shrubland

Grassland

Poa spp., Stipa stipoides Tussock grassland
Themeda triandra, Stipa spp Tussock grassland

Coastal Tussock Grassland

Spinifex sericeus, Isolepis nodosa Tussock grassland

Sedgeland

Baumea juncea, Chorizandra enodis Sedgeland
Gahnia filum Sedgeland
Gahnia trifida Sedgeland
Phragmites australis, Typha domingensis Sedgeland

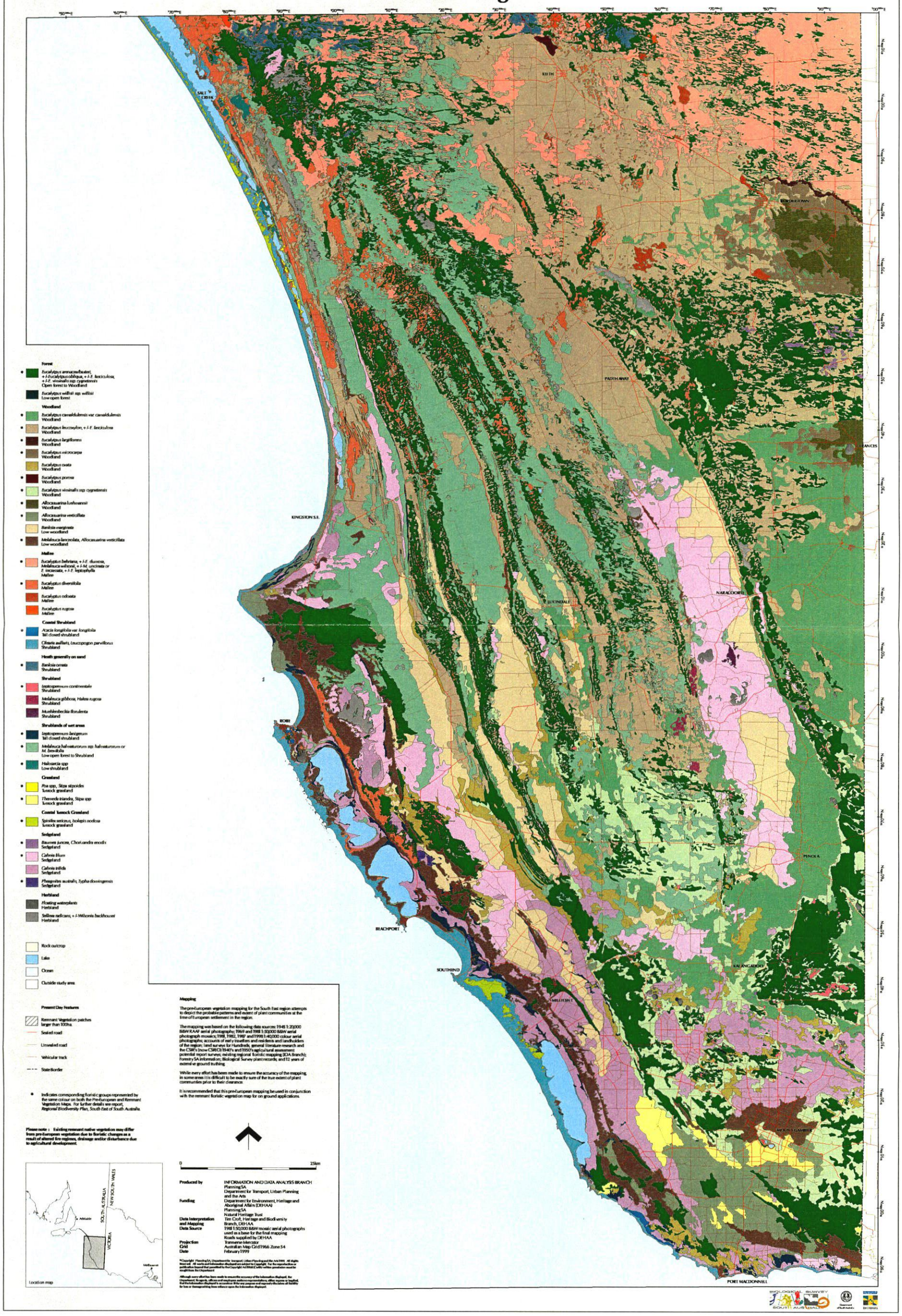
Herbland

Floating waterplants Herbland
Selliera radicans +/- Wilsonia backhousei Herbland

Figure 3:

Pre-European Settlement Floristic Vegetation Mapping

South East Region



4.3 Identifying Regionally Threatened Plant Communities

To determine the actual conservation status of plant communities the pre-European and the remnant regional vegetation map have been spatially compared. The resulting statistics from this spatial comparison provide a clear indication of the plant communities that have been heavily cleared. In order to compare these 2 separate maps some of the plant communities from the existing mapping were amalgamated to form more general groupings that better corresponded with the pre-European mapping groups. For example five plant communities from the current mapping were grouped in order to be statistically compared with the group *Eucalyptus arenacea/baxteri, +/- E. obliqua, +/- E. fasciculosa +/- E. viminalis ssp. cygnetensis* Open forest to Woodland from the Pre-European mapping (see Table 5).

In some cases the same groups from the existing mapping have had to be included in more than one of the pre-European mapping groups for statistical comparison. For example the plant community *Eucalyptus fasciculosa , Xanthorrhoea caespitosa* Low woodland (7) from the current mapping, has been included in both the *Eucalyptus arenacea/baxteri, +/-E. obliqua, +/-E. fasciculosa +/-E. viminalis ssp cygnetensis* Open forest to Woodland and the *Eucalyptus leucoxylon, E. fasciculosa* Woodland, Pre-European groups for statistical comparison. This is because this mapping group identified in the current mapping is spatially found to occur in both of these Pre-European mapped groups. It therefore couldn't be separated into either one or the other, but is probably a representative of both, when interpretation differences between map authors is taken into account. For this reason the statistics are still best estimates only. The groups amalgamated for comparison are shown in Table 5.

The estimates in Table 5 provide these statistics for the South East region vegetation communities. Also included in Table 5 are the statistics for the amount of each plant community conserved within the States' formal reserve system. While in South Australia plant communities may still remain in an adequate amount, in most cases the amount conserved formally is less than the minimum 10% recommendation. The formal reserve systems includes NPWSA managed reserves (including Conservation Reserves), Heritage Agreements and Native Forest Reserves.

Table 5: Comparison of SE Region Plant Community mapping extents: Pre-European vs Remnant

Plant Communities Pre-European mapping	Plant Communities Current mapping	% remaining of original amount	Area in formal Reserve System	% left in formal Reserve System
WOODLANDS				
#*Eucalyptus arenacea/baxteri, +/-E. obliqua, +/-E. fasciculosa +/- E. viminalis ssp cygnetensis* Open forest to Woodland **Estimated Original Area 384,704 ha** (a significant portion of this community now represented as *Banksia ornata* Shrubland)	*Eucalyptus arenacea/baxteri, +/-E. obliqua, +/- E. fasciculosa* Low woodland (7,10,11,12,91) **Estimated Current Area 73,485 ha**	19.1%	25,088	6.5%
#*Banksia ornata* Shrubland **Estimated Original Area 8,803 ha**	*Banksia ornata* Shrubland *(4)* **Estimated Current Area 34,586 ha**	100%	19,244	
Eucalyptus willisii ssp. willisii Open forest to Woodland **Estimated Original Area 231 ha**	Not mapped **Estimated Current Area 91 ha**	17.3	39	16.9
Eucalyptus camaldulensis var. camaldulensis Woodland **Estimated Original Area 171,844 ha**	*Eucalyptus camaldulensis var. camaldulensis* Woodland (18) **Estimated Current Area 16,742 ha**	9.7%	659	0.4%
Eucalyptus leucoxylon, +/- E. fasciculose Woodland **Estimated Original Area 409,408 ha**	*Eucalyptus leucoxylon spp., +/- E. fasciculosa* Woodlands (5,6,7,8,9,77,96,97) **Estimated Current Area 31,921 ha**	7.8%	6,538	1.6%
Eucalyptus largiflorens Woodland **Estimated Original Area 1,163 ha**	*Eucalyptus largiflorens* Woodland (79) **Estimated Current Area 74 ha**	6.4%	9	
Eucalyptus microcarpa Woodland **Estimated Original Area 20,538 ha**	*Eucalyptus microcarpa* Woodland (88) **Estimated Current Area 492 ha**	2.4%	0	0
Eucalyptus ovata Woodland (39,195 ha) or *Eucalyptus viminalis ssp. cygnetensis* Woodland (98,639 ha) **Estimated Original Area 137,834**	*Eucalyptus ovata E. viminalis* Woodland and Melaleuca squarrosa, +/- E. ovata Tall shrubland (81,13) **Estimated Current Area 2,492 ha**	1.8%	1229	0.9
Eucalyptus porosa Woodland **Estimated Original Area 773 ha**	*Eucalyptus porosa, E. calycogona var. calycogona* swamp complex Mallee (92) **Estimated Current Area 89 ha**	11.5%	0	0
Allocas*uarina luehmannii* Woodland **Estimated Original Area 18,389**	Allocas*uarina luehmannii* Woodland (87) **Estimated Current Area 530 ha**	2.9%	3	0
Allocasuarina verticillata Woodland **Estimated Original Area 39,957 ha**	*Allocasuarina verticillata* Woodland *(84,9)* **Estimated Current Area 347 ha**	0.9%	163	0.4%
Banksia marginata Low woodland **Estimated Original Area 100,960 ha**	Not mapped **Estimated Current Area 334 ha**	0.3%	9	0
Melaleuca lanceolata, Allocasuarina verticillata Low woodland **Estimated Original Area 67,083 ha**	*Melaleuca lanceolata* Low woodland *(86)* **Estimated Current Area 815 ha**	1.2%	162	0.2%
MALLEE				
Eucalyptus behriana, +/-E. dumosa, +/- Melaleuca wilsonii, +/- M. uncinata or +/- E. incrassata, +/- E. leptophylla Mallee **Estimated Original Area 141,083 ha**	*Eucalyptus behriana, +/-E. dumosa, +/- E. incrassata, +/- E. leptophylla* Mallee *(1,2,89)* **Estimated Current Area 6,680 ha**	4.7%	1,656	1.2%
Eucalyptus diversifolia Mallee **Estimated Original Area 60,139 ha**	*Eucalyptus diversifolia* Open Mallee (3) **Estimated Current Area 29,851 ha**	49.6%	11,640	19.4%
Eucalyptus odorata Mallee **Estimated Original Area 3,119 ha**	*Eucalyptus odorata, E. leucoxylon spp.* Woodland *(96)* **Estimated Current Area 81 ha**	2.6%	17	0.5%
Eucalyptus rugosa Mallee **Estimated Original Area 1,594 ha**	Not mapped **Estimated Current Area 97 ha**		49	
COASTAL SHRUBLAND				
#*Acacia longifolia var. longifolia* Tall closed shrubland (911 ha) or #*Olearia axillaris, Leucopogon parviflorus* Shrubland	*Leucopogon parviflorus, Acacia longifolia var. longifolia, Olearia axillaris* Tall shrubland *(26)*			

Plant Communities Pre-European mapping	Plant Communities Current mapping	% remaining of original amount	Area in formal Reserve System	% left in formal Reserve System
(28,359 ha) **Estimated Original Area 29,269 ha**	**Estimated Current Area 19,458 ha**	**66.5%**	**11,154**	**38.1%**
SHRUBLAND				
#Leptospermum continentale Shrubland **Estimated Original Area 2,660 ha**	*Leptospermum continentale* Shrubland (15) **Estimated Current Area 885 ha**	**33.3%**	**324**	**12.2%**
Melaleuca gibbosa, Hakea rugosa Shrubland **Estimated Original Area 1,296 ha**	Cleared **Estimated Current Area 0 ha**	**0**	**0**	**0**
Muehlenbeckia florulenta Shrubland **Estimated Original Area 454 ha**	Cleared **Estimated Current Area 0 ha**	**0**	**0**	**0**
SHRUBLANDS OF WET AREAS				
#Leptospermum lanigerum Tall closed shrubland **Estimated Original Area 10,742 ha**	*Leptospermum lanigerum* Tall shrubland *(19)* **Estimated Current Area 1,023 ha**	**9.5%**	**352**	**3.3%**
Melaleuca halmaturorum ssp. halmaturorum or *M. brevifolia* Low open forest to Shrubland **Estimated Original Area 250,971 ha**	*Melaleuca halmaturorum ssp. halmaturorum* or *M. brevifolia* Low open forest to Shrubland *(17,93,95,22)* **Estimated Current Area 50,298 ha**	**20%**	**19,774**	**7.9%**
#Halosarcia spp Low shrubland **Estimated Original Area 2,373 ha**	All samphires *(29,94)* **Estimated Current Area 3,868 ha**	**100%**	**1812**	**76.4**
GRASSLAND				
#Poa spp., Stipa stipoides Tussock grassland **Estimated Original Area 821 ha**	Grassland complex (99) **Estimated Current Area 281 ha**	**34.2%**	**202**	**24.6%**
Themeda triandra, Stipa spp Tussock grassland **Estimated Original Area 12,679 ha**	Cleared **Estimated Current Area 0 ha**	**0**		
COASTAL TUSSOCK GRASSLAND				
Spinifex senceus, Isolepis nodosa Tussock grassland **Estimated Original Area 4,172 ha**	Reedbeds to Grassland (85,27) **Estimated Current Area 880 ha**	**21.1%**	**482**	**11.6%**
SEDGELAND				
#Baumea juncea, Chorizandra enodis Sedgeland **Estimated Original Area 1,859 ha**	Cleared **Estimated Current Area 0 ha**	**0**		
#Gahnia filum Sedgeland (104,964 ha) or *#Gahnia trifida* Sedgeland (96,675 ha) **Estimated Original Area 201,639 ha**	*Gahnia filum, Samolus repens* Sedgeland or *Baumea juncea, Gahnia trifida* Sedgeland (20,21,82,83) **Estimated Current Area 16,556 ha**	**8.2%**	**4773**	**2.4%**
Phragmites australis, Typha domingensis Sedgeland **Estimated Original Area 762 ha**	*Typha domingensis* Closed sedgeland (23) **Estimated Current Area 248 ha**	**32.5%**	**64**	**8.4%**
HERBLAND				
Floating waterplants Herbland **Estimated Original Area 2,845 ha**	Not mapped	**n/a**	**n/a**	**n/a**
#Selliera radicans +/- Wilsonia backhousei Herbland **Estimated Original Area 16,939 ha**	Cleared/Altered **Estimated Current Area 0 ha**	**0**		

#indicates plant communities that have been significantly altered in the region since European settlement

Formal reserve system includes: NPWS Reserves (1999), Conservation Reserves (1999), Heritage Agreements (Jan 1998), Native Forest Reserves (1998).

Source: Floristic Vegetation Mapping (GIS), Planning SA; Pre-European Settlement Floristic Vegetation Mapping (GIS), DEHAA/Planning SA; NPWS Reserves (GIS), DEHAA; Heritage Agreements (GIS), DEHAA/Planning SA.

4.3.1 Regionally Rare and Threatened Plant Communities

Conservation status can be determined for major plant communities by comparing the pre-European and remnant vegetation mapping. A method for assigning conservation status for major plant communities of the region is outlined in Croft and Carpenter (in prep) and this is based on the Commonwealth Endangered Species Act, 1992. A threatened plant community is one that is considered to be endangered or vulnerable.

Croft and Carpenter (1998) define the plant communities as:

- Endangered if the plant community is less than 3% of its original area, and poorly represented in reserves;
- Vulnerable if the plant community is less than 10% of its original area;
- Rare if the plant community had a limited distribution at the time of European settlement comprising an estimated less than 1% of the region (<20,000ha);

Based on the GIS comparison of remnant and pre-European plant communities, of the 46 pre-European plant communities identified and mapped:

- 14 are Endangered;
- 8 are Vulnerable;
- 6 are Rare at the regional level.

These are listed in Table 6.

Table 6: Regionally Rare and Threatened Plant Communities of the South East Region

Woodlands	**Conservation Status**	**% of original amount in formal reserve system**
Eucalyptus viminalis ssp. cygnetensis Woodland (81)	Endangered	0.9%
Eucalyptus ovata (Swamp Gum) Woodland (81,13)	Endangered	0.9%
Allocasuarina verticillata (Drooping Sheoak) Woodland (84,9)	Endangered	0.4%
**Banksia marginata* (Honeysuckle banksia) Low woodland	Endangered	0%
Melaleuca lanceolata (Dryland teatree), *Allocasuarina verticillata* (Drooping Sheoak) Low woodland (86)	Endangered	0.4%
Eucalyptus microcarpa (Grey box)Woodland (88)	Endangered	0%
Allocasuarina *luehmannii* (Buloke) Woodland (87)	Endangered	0%
Eucalyptus camaldulensis var. camaldulensis (River Red gum) Woodland (18)	Vulnerable	0.4%
Eucalyptus leucoxylon (Blue Gum), *+/-E. fasciculosa* (Pink gum) Woodlands (5,6,7,8,9,77,96,97)	Vulnerable	1.6%
Eucalyptus largiflorens (River Box) Woodland (79)	Vulnerable	0%
*Eucalyptus willisii ssp. willisii (Willis' peppermint) Open forest to Woodland	Rare	16.9%
Eucalyptus porosa Woodland (92)	Rare	0%
Mallees		
Eucalyptus odorata Mallee (96)	Endangered	0.5%
**Eucalyptus rugosa* Mallee	Endangered	0%
Eucalyptus behriana, +/-E. dumosa, +/- Melaleuca wilsonii, +/- M. uncinata or E. incrassata, +/- E. leptophylla Mallee (1,2)	Vulnerable	1.2%
Shrublands		
***Melaleuca gibbosa, Hakea rugosa* Shrubland	Endangered	0%
***Muehlenbeckia florulenta* Shrubland	Endangered	0%
***Themeda triandra, Stipa spp* Tussock grassland	Endangered	0%
Leptospermum lanigerum (Silky teatree) Tall closed shrubland (19)	Vulnerable	3.3%
Leptospermum continentale Shrubland (15)	Rare	2.1%
Grasslands		
Poa spp., Stipa stipoides Tussock grassland (99)	Rare	24.6%
Spinifex sericeus, Isolepis nodosa Tussock grassland (85,27)	Rare	11.6%
Sedgelands and Herblands		
***Baumea juncea, Chorizandra enodis* Sedgeland	Endangered	0%
***Selliera radicans +/- Wilsonia backhousei* Herbland	Endangered	0%
Phragmites australis, Typha domingensis Sedgeland (23)	Rare	8.4%
Gahnia filum Sedgeland (20,21,82,83)	Vulnerable	2.4%
Gahnia trifida Sedgeland (20,21,82,83)	Vulnerable	2.4%

** Mapping indicates these communities have been completely cleared
* not mapped in Remnant Floristic Map
() indicates the corresponding remnant vegetation plant community which these broader pre-European plant communities include (refer to Remnant Floristic Vegetation map and Table 3).

Mapping indicates that 5 plant communities have been almost completely cleared, with very small remnants left in road reserves. These include:

Melaleuca gibbosa, Hakea rugosa Shrubland
Muehlenbeckia florulenta Shrubland
Themeda triandra, Stipa spp Tussock grassland
Baumea juncea, Chorizandra enodis Sedgeland
Selliera radicans +/- Wilsonia backhousei Herbland

With regards to amounts conserved within the formal reserve system the plant communities with none formally conserved (ie. less than 1%) include the following:

Eucalyptus microcarpa Woodland (88)
Eucalyptus porosa Woodland (92)
Allocasuarina *luehmannii* Woodland (87)
Eucalyptus largiflorens (River Box) Woodland (79)
Banksia marginata Low woodland
Eucalyptus ovata Woodland (81, 13)
Eucalyptus viminalis ssp. cygnetensis Woodland (81)
Melaleuca lanceolata (Dryland teatree), *Allocasuarina verticillata* (Drooping Sheoak) Low woodland (86)
Melaleuca lanceolata (Dryland teatree), *Allocasuarina verticillata* (Drooping Sheoak) Low woodland (86)
Eucalyptus odorata Mallee (96)
Eucalyptus rugosa Mallee

5. KEY GIS DATA LAYERS AND LIMITATIONS

5.1 Data Layers

The GIS Environmental database for the State contains a large amount of baseline environmental information. The polygon (ie area) data layers used in this model were landcover, regional floristic vegetation, and the 1997 Forestry SA pine plantation areas. Point data layers of Biological Survey, Opportunistic Sightings database, and the SA Museum records were also used. Related species data from each database was also used. A summary of each layer and its relative information is shown in Table 7.

Other data layers used to produce the final biodiversity layer included: polygon layers of Pre-European vegetation and Koala release blocks; along with point data layers including: Rare and Threatened Plant Population database; RAOU Bird Atlas records; and nesting locations of both the Red-tailed (pers. com. Richard Hill, Birds Australia and Grahem Carpenter DEHAA), and Yellow-tailed Black Cockatoos (pers com Graham Carpenter). Much of the information on significant fauna species of the region was based on Croft and Carpenter (1998).

The landcover layer was used in order to define native vegetation according to condition, which is classified as either natural or condition unknown where a preliminary assessment of vegetation condition had been made during mapping.

Landcover elements such as swamps, lakes, sand and rock outcrops are also identified. The 1997 pine plantation layer from Forestry SA was used to identify current pine plantation areas in the region.

5.2 Point Source Record Databases

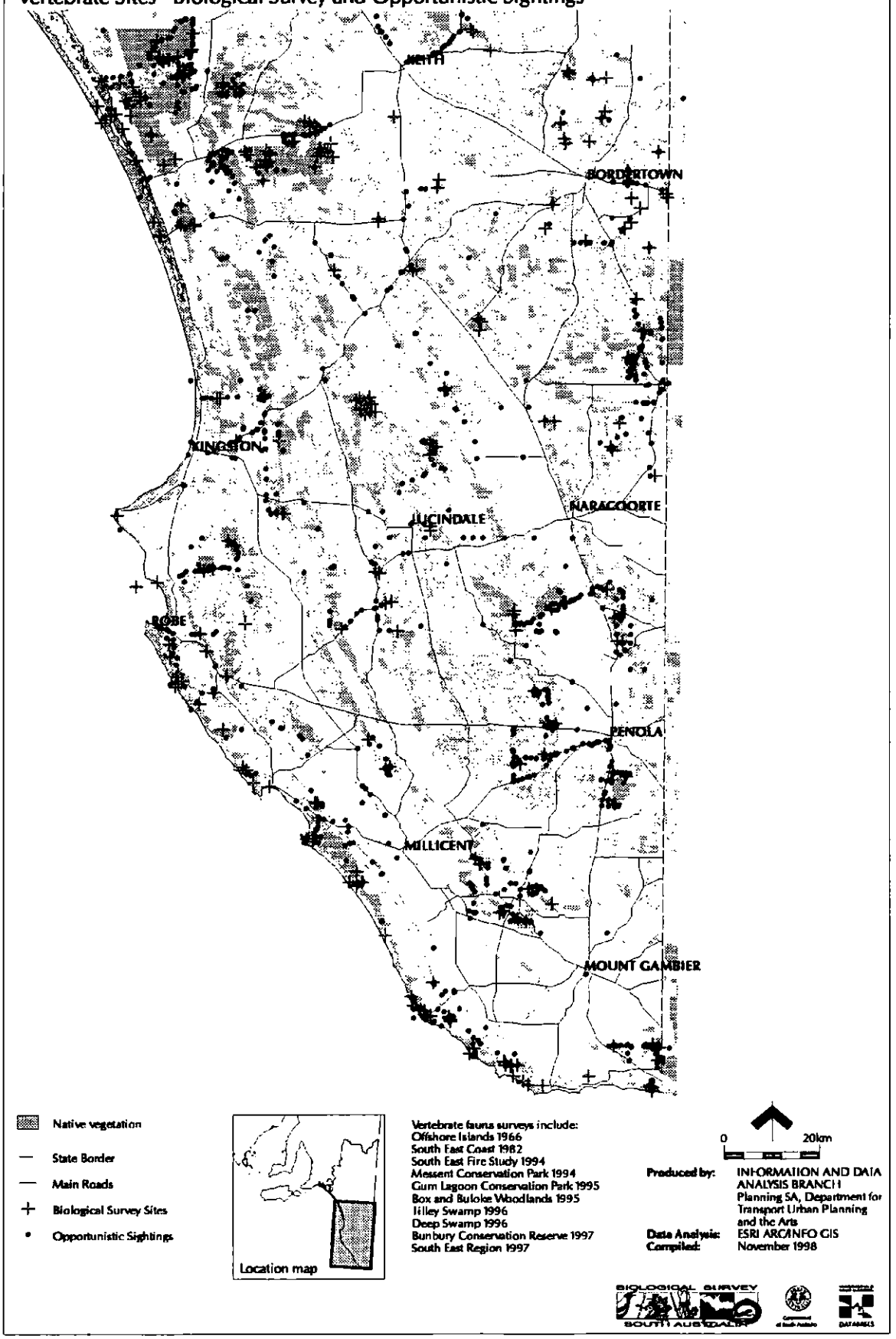
Several databases containing vertebrate species information are managed by State Government agencies. All of these databases indicate species' presence only. That is, they indicate the presence of species' at a particular timed location not their absence from elsewhere.

All vertebrate data is managed from a central taxonomic database. That is to say that all species listed in the following vertebrate data sets have been given a unique species code with which species information in the separate databases can be easily compared. This code is referred to as the NSXCODE in the DEHAA maintained databases. A species may have more than one NSXCODE but no two species have the same NSXCODE. For example the species *Leipoa ocellata* (Malleefowl) has the NSXCODE of Z00007, and the species *Calyptorhynchus banksii graptogyne* (Red-tailed Black Cockatoo) has an NSXCODE of A00264 and Y09312. Individual species are identified for the model via their appropriate NSXCODE(s).

Table 7: GIS Layers

Layer Name (Custodian)	Mapping Scale	Item	Description	Coding
		POLYGON LAYERS		
Landcover (Planning SA)	1:40,000 (derived from floristic mapping)	AS2482	Lakes	44010
			Swamp	44190
			Cleared land/ crop	65060
			Vegetation – natural	60010
		(Vegetation) Condition	Natural vegetation	1
		(Vegetation) Condition	Vegetation – modified or unknown	61
Pine Plantations 1997 (Forestry SA)	1:10,000 to 40,000		map of Forestry SA pine plantations	65010 65011
Floristic Vegetation (Planning SA)	1:40,000	GP1	Floristic community groups based on overstorey dominance	1 to 99
Pre-European Vegetation (DEHAA)	1:50,000	MU_250	Plant community groups based on overstorey dominance	1 to 34
Koala Release Blocks (DEHAA)	1:10,000		Patches of vegetation that koalas were released into in 1997-98 KI koala relocation program	
NPWS Reserves (DEHAA)	cadastre		reserve boundaries	
NPWS Conservation Reserves(DEHAA)	cadastre		reserve boundaries	s
Heritage Agreements (DEHAA)	cadastre		reserve boundaries	
Native Forest Reserves (Forestry SA)	cadastre		reserve boundaries	
		VEGETATION POINT RECORDS		
Rare & Threatened Plant Population Database (DEHAA)	1:50,000	POPNR	Location of State rare & threatened plant populations	
		VERTEBRATE SURVEY POINT RECORDS		
Biological Survey (DEHAA)	1:40,000	NSXCODE	Vertebrate survey records	
Opportunistic Database (DEHAA)	varied	NSXCODE	Opportunistically collected vertebrate field records	
SA Museum Database (SA MUSEUM)	varied	NSXCODE	Historical vertebrate records	
RAOU Bird Atlas (Birds Australia)	grid based	NSXCODE	Australia wide bird survey ranging from 1020's to 1978 – varied accuracy of identification and location	

Figure 4
Vertebrate Sites - Biological Survey and Opportunistic Sightings



5.2.1 Vertebrate Survey Records

Biological Survey Database

Biological Survey of South Australia Database (DEHAA) contains information gathered about vertebrate species on biological survey expeditions. It is the standard vertebrate survey database for the State. Each biological survey site represents a full compliment of species observed at the site including both pitfall trap identifications and bird observations and counts. The survey sites located in the South East are shown on Figure 4.

Opportunistic Species Database

The Opportunistic Species Database (DEHAA) contains opportunistic information gathered about vertebrate species by DEHAA scientific officers and others while in the field. Unlike the Biological survey sites the accuracy for the location of the opportunistic sites can vary from within 200m to greater than 1km. The location of these record sites are also shown on Figure 4.

SA Museum Database

The SA Museum has a vertebrate database for vouchered specimen records for the State. The South East region records were made available for this project. The site locations of the museum records are not shown in this report for data sensitivity reasons. At the time of data supply for this project the avifauna records were unavailable. Museum records for the following species were used: Swamp Skink, Striped Legless Lizard, Common Wombat, Red-necked Wallaby, Sugar Glider and the Swamp Antechinus.

RAOU Bird Atlas Records

The RAOU Bird Atlas database contains all SA grid reference information of recorded bird species. The uncertain spatial accuracy of the records meant that this database was used for validation for individual species' distributions across large areas only and was not used in the final GIS analysis for determining known habitat.

5.2.2 Plant Species Records

Rare and Threatened Plant Population Database

The rare and threatened plant population database holds information about the location of known plant populations of nationally and State rare or threatened plants. The information is currently restricted due to the significance of some plant populations and their susceptibility to interference. The plant population database contains point location references for records. It has been used in the South East biodiversity plan to identify vegetation blocks containing one or more known rare and threatened plant populations. The database is presence only and information is acquired and updated on an ad hoc basis.

6. GIS HABITAT MODEL

The model discussed here uses both raster and vector analysis of spatial data. The raster component used is GRID, part of ESRI's ARC/INFO GIS. The GIS input data layers used in the GRID model being presented here are stored in vector format. This information is stored in either polygon, line or point form. The data layers were converted to raster format in the form of 100 metre cells for analysis. The use of a raster or cell based analysis such as is possible with GRID, allows large amounts of information to be analysed and processed without losing spatial integrity of the data involved. The GRID environment allows cell values to be calculated based on the accumulated or individual values of other features at the individual cell level. The key data layers were converted to grids. The cell size of 100 metres was chosen for this model based on the size of the study area and the original 1:40,000 scale of the landcover and floristic mapping.

The habitat model is based on an earlier model designed to identify species' habitat and best placed corridors for movement using regional floristic vegetation mapping and expert knowledge (Carruthers and Smith 1996).

6.1 Significant Species Habitat

The data layers used for the habitat model included:

- Regional floristic vegetation mapping;
- Vegetation condition estimate value (recorded on regional floristic vegetation mapping);
- Fauna survey point location records including:
  Biological survey database, opportunistic sightings database, and SA museum records.

The RAOU Bird Atlas database was used initially as a guide for species' historical locations recorded across the region but was not used in the model.

The model relies heavily on expert and local knowledge for each species' particular habitat requirements and distribution. Several ecologists including two co-authors of this report, Tim Croft and Hugh Possingham, along with other ecologists from DEHAA (including Graham Carpenter) were involved in the determining and refining of individual species' habitat maps produced by the model. Each species was treated individually with regards to its preferred habitat including vegetation communities for foraging, nesting, feeding, type of vegetation condition required (ie understorey plants required), and species' known current distribution across the region. Each species model was refined several times to produce the best possible map, within the limitations of the data and the model.

Thirty two significant vertebrate species for the region were included in the analysis.

The model distinguishes between 3 main habitat types: recorded; predicted; potential.

In every instance final habitat type identifies the entire vegetation block and not the smaller plant community areas found within each block. That is, the species' habitat may not cover the entire vegetation block but the whole block is identified as containing habitat.

Recorded Habitat
Identifies those vegetation blocks for which the species has been officially recorded within either DEHAA's biological survey database or opportunisitic sightings databases, or within the SA Museum's database.

Recorded habitat was determined by selecting survey locations for which individual species had been recorded. These point locations were overlayed with the remnant vegetation mapping, and the remnant block within which they were recorded was then identified as recorded habitat for that species.

Predicted Habitat
Based on an extrapolation of expert and local knowledge of the plant communities a particular species is known to use as a feeding or breeding area along with a minimum required area suggested to be for a minimum of one breeding pair. Predicted habitat also takes into account whether a species is reliant on native vegetation in relatively undisturbed condition or not. The predicted habitat is restricted to the species' spatial extent as defined by expert knowledge of each species.

Predicted habitat was determined by:
1. selecting an initial grid of potential habitat patches that were of the specified size or larger and of good condition and then selecting from these patches, those that contained the appropriate floristic communities and removing those that did not;
2. measuring the total area of habitat (floristic groups) within each patch and removing individual patches if they did not contain the required total area of recommended habitat;
3. measuring the radius of these patches to determine if they were appropriately round and removing those that weren't;
4. using this final grid as the predicted habitat grid.

Potential Habitat
Based on the same criteria as predicted habitat but takes into account the vegetation blocks that have been identified as potentially having a significantly disturbed understorey and identifies these blocks as being potential habitat if fenced and allowed to regenerate. This is intended to show remnant areas which are large enough to support a particular species were they restored or fenced off and allowed to re-establish. This was determined on a species' specific basis. Some species were considered to be able to survive in disturbed vegetation and potential habitat is not identified for these species.

Potential habitat was determined using the same process as for predicted habitat, however the initial grid of potential habitat patches was chosen from the areas of remnant vegetation that were classified as condition unknown. This potential habitat shows those areas that

contain the correct floristic communities and area for breeding pairs but were vegetation patches of unknown rather than good condition.

An example of the information parameters used to run the model and the difference of the information required for individual species in shown in Table 8. All of the requirements listed in Table 9 are input as parameter variables prior to running the model. The 32 species of conservation significance chosen for the South East and their individual requirements are listed in Table 9. Table 10 lists the type of habitat that was modelled for each species ie recorded and/or predicted and/or potential.

Table 8: Species' Information Required for Model

Required for Model	Example 1	Example 2
Species	Malleefowl	Stone Curlew
NSXCODE (s)	Z00007	U00174
Floristic habitats	*1,3,4,11	8,88
Area of habitat required for one breeding pair	100ha	1ha
Separate Nesting habitat where applicable	1,3	n/a
Separate area of nesting habitat required for one breeding pair where applicable	10ha	n/a
Use officially recorded survey locations	yes	yes
Condition of vegetation cover required ie understorey relatively intact or not	good condition	any condition
Extent of Distribution in SE Region	N Kingston (and also an area W of Padthaway excluded through local knowledge of species extent)	N Penola E Padthaway

* numbers refer to individual floristic plant communities as listed in Table 3.

Narrow habitat blocks were excluded from predicted and potential habitat for the final species' habitat maps. This was based on measuring the 'roundness' of the vegetation patch and excluding those that were extremely narrow (ie less than two thirds the width of the optimum round patch dimensions) in relation to the amount of habitat area required by individual species.

Figure 5 illustrates the process for the habitat modelling.

Table 9: Bird, Reptile and Mammal Species of Conservation Significance in the South East Region

Bird Species	Scientific Name	Cons. Status in SA	Nesting Habitat	**Habitat	Min. Area of Habitat (Ha)	Distribution
Beautiful Firetail	*Stagonopleura bella*	R		5,7,12,22,21	50	SE
Black-chinned Honeyeater	*Melithreptus gularis*	R		5,6,8,18,88	50	10km S Bordertown E Desert Camp N Penola
Blue-Winged Parrot	*Neophema chrysostoma*	V	18	8,10,12,18, 26	50	SE
Brush Bronzewing	*Phaps elegans elegans*	U		5,6,7,3,22	50	SE
Chestnut-rump Heathwren	*Hylacola pyrrhopygia*	U		11,12	50	10km E Southport
Crested Shriketit	*Falcunculus frontatus frontatus*	V		6,8,10,12,13, 18	30	S bordertown
Diamond Firetail	*Stagonopleura guttata*			6,8,18,77,97	50	N Naracoorte
Little Lorikeet	*Glossopsitta pusilla*			5,6,7,8,18	1	SE
Malleefowl	*Leipoa ocellata*	E	1,3	1,3,4,11	50	N Kingston
Olive Whistler	*Pachycephala olivacea olivacea*	V		19,26	100	S Robe
Orange Bellied Parrot	*Neophema chrysogaster*	E		26,27,29	1	10km toward coast edge
Painted Button Quail	*Turnix varia varia*	V		3,5,6,7,8,11,1 2,18	100	SE
Purple-gaped Honeyeater	*Lichenostomus cratitia*	U		3,4	100	10km N Kingston
Red-tailed Black Cockatoo	*Calyptorhynchus banksii graptogyne*	E	5,6,8,9,1 1,12,18, 77,80,91, 96,97	11,12,80,87,9 1,97 (feeding)	50	E Keith S Bordertown
Rufous Bristlebird	*Dasyornis broadbenti*	V	26	26,17	100	Coastal Edge
Shy Heathwren	*Hylacola cauta*	V		1,3,4	50	N Kingston
Slender-billed Thornbill	*Acanthiza iredalei hedleyi*	V		4,17	100	N Big Heath
Southern Emu-wren	*Stipiturus malachurus*	V		4,15,17,20,21 , 26,93,95	(20 of gp1 =15) or 100	N Kalangadoo
Stone Curlew	*Burhinus*	E		6,88	1	N Penola

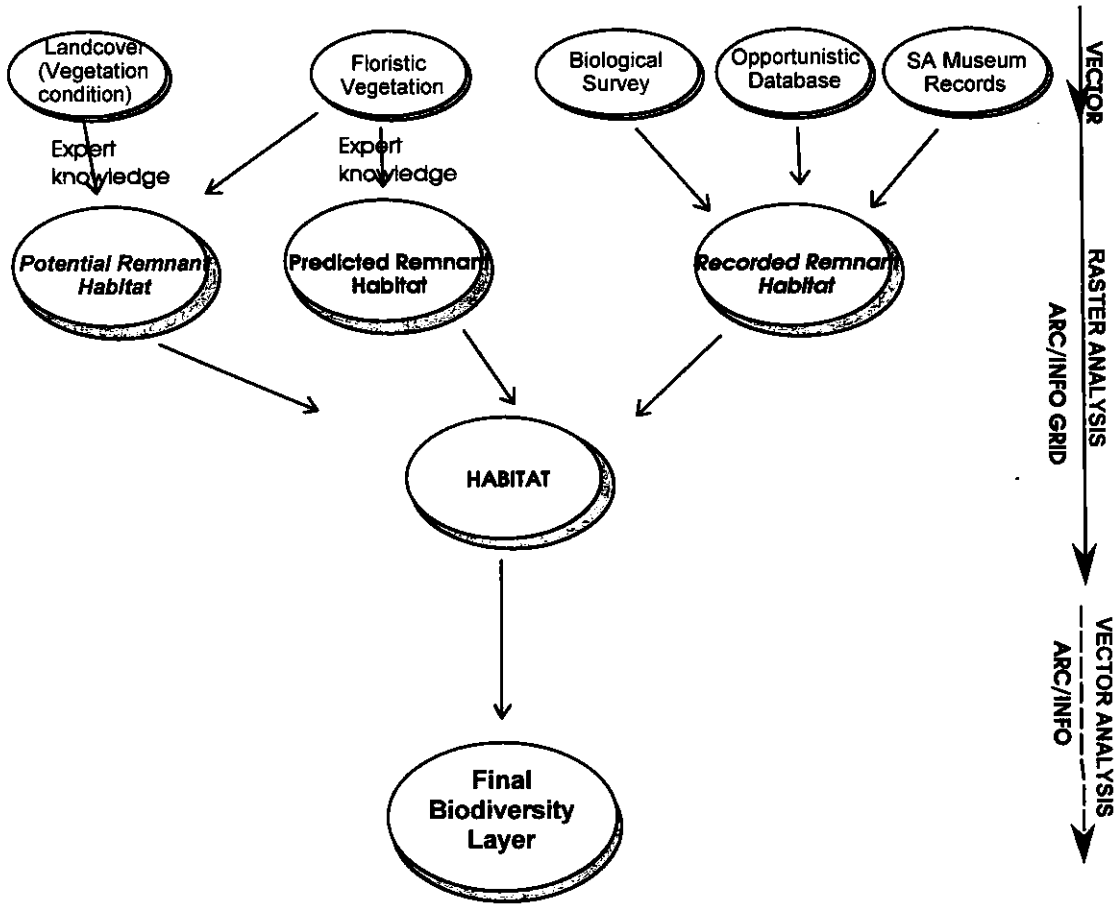
Bird Species	Scientific Name	Cons. Status in SA	Nesting Habitat	**Habitat	Min. Area of Habitat (Ha)	Distribution
	grallarius					E Padthaway
Western Calamanthus	*Calamanthus campestris campestris*	U		4,17,26	50	N Robe
Yellow-tailed Black Cockatoo	*Calyptorhyncus funereus*	V	5,6,8,18	5,6,18,97,4, Pine	1	S Bordertown
REPTILES						
Striped Legless Lizard	*Delmar impar*	V		5,6,8,9,77,96, 87,88	10	SE
Swamp Skink	*Egernia coventryi*	R		19,78	5	S Robe
MAMMALS						
Sugar Glider	*Petaurus breviceps*	E		6,8,9,10,13,7 7,81 E vim + blocks with sightings	50	E Lucindale
Yellow Bellied Glider	*Petaurus australis australis*	U		10,13,81,E vim + blocks with sightings		E Millicent S Kalangadoo
Common Wombat	*Vombatus ursinus*	V		blocks with sightings		SE
Red Necked Wallaby	*Macropus rufogriseus*	R		1,2,3,5,6,7,8, 9,10,11,12,18 ,70,77,79,81, 88,89,96,97 and Pine	50	SE
Southern Brown Bandicoot	*Isoodon obesulus*	U		11,10,12 + blocks with sightings	25	S Naracoorte
Swamp Antechinus	*Antechinus minimus*	R		19,78 + blocks with sightings	10	S Robe
Eastern Pygmy-possum	*Cercartetus nanus*			blocks with sightings		
Little Pygmy-possum	*Cercartetus concinnus*			blocks with sightings		
Western Pygmy-possum	*Cercartetus lepidus*			blocks with sightings		

** Numbers refer to floristic communities as shown in Figure 1.
E = endangered, R = rare, V = vulnerable, U = uncommon

Table 10: Type of habitat modelled for each species

Bird Species	Scientific Name	Recorded Habitat	Predicted Habitat	Potential Habitat (based on vegetation condition poor/unknown)
BIRDS				
Beautiful Firetail	*Stagonopleura bella*	yes	yes	yes
Black-chinned Honeyeater	*Melithreptus gularis*	yes	yes	yes
Blue-Winged Parrot	*Neophema chrysostoma*	yes	yes	yes
Brush Bronzewing	*Phaps elegans elegans*	yes	yes	-
Chestnut-rump Heathwren	*Hylacola pyrrhopygia*	yes	yes	yes
Crested Shriketit	*Falcunculus frontatus frontatus*	yes	yes	-
Diamond Firetail	*Stagonopleura guttata*	yes	yes	yes
Little Lorikeet	*Glossopsitta pusilla*	yes	yes	yes
Malleefowl	*Leipoa ocellata*	yes	yes	yes
Olive Whistler	*Pachycephala olivacea olivacea*	yes	yes	yes
Orange Bellied Parrot	*Neophema chrysogaster*	no	yes	yes
Painted Button Quail	*Turnix varia varia*	yes	yes	yes
Purple-gaped Honeyeater	*Lichenostomus cratitia*	yes	yes	yes
Red-tailed Black Cockatoo	*Calyptorhynchus banksii graptogyne*	yes	yes	-
Rufous Bristlebird	*Dasyornis broadbenti*	yes	yes	yes
Shy Heathwren	*Hylacola cauta*	yes	yes	yes
Slender-billed Thornbill	*Acanthiza iredalei hedleyi*	yes	yes	yes
Southern Emu-wren	*Stipiturus malachurus*	yes	yes	yes
Stone Curlew	*Burhinus grallarius*	yes	yes	-
Western Calamanthus	*Calamanthus campestris campestris*	yes	yes	-
Yellow-tailed black cockatoo	*Calyptorhyncus funereus*	yes	yes	-
REPTILES				
Striped Legless Lizard	*Delmar impar*	yes	no	
Swamp Skink	*Egernia coventryi*	yes	yes	-
MAMMALS				
Sugar Glider	*Petaurus breviceps*	yes	yes	-
Yellow Bellied Glider	*Petaurus australis australis*	yes	yes	-
Common Wombat	*Vombatus ursinus*	yes	no	-
Red Necked Wallaby	*Macropus rufogriseus*	yes	yes	-
Southern Brown Bandicoot	*Isoodon obesulus*	yes	yes	yes
Swamp Antichinus	*Anthechinus minimus*	yes	no	-
Eastern Pygmy-possum	*Cercartetus nanus*	yes	no	-
Little Pygmy-possum	*Cercartetus concinnus*	yes	no	-
Western Pygmy-possum	*Cercartetus lepidus*	yes	no	-

Figure 5: GIS Habitat Model



Not all of the species were modelled using the same sets of criteria. Some examples of the variation between species' habitat modelling are given below. All species' particular requirements were based on expert knowledge.

The habitat maps are considered to be the best estimate for each of the species they represent and in each case their purpose is to assist the conservation and management of the species at the regional level.

Some of the marsupials and reptiles have proved difficult to predict habitat for. One reason may be that they have already greatly declined in extent with isolated localised populations remaining. A number of reptiles are "generalists" and not restricted to a particular habitat and may take advantage of human constructed materials. Predicting habitat using the modelling process here is not successful for these species. In these cases habitat was determined on the basis of sighting records only.

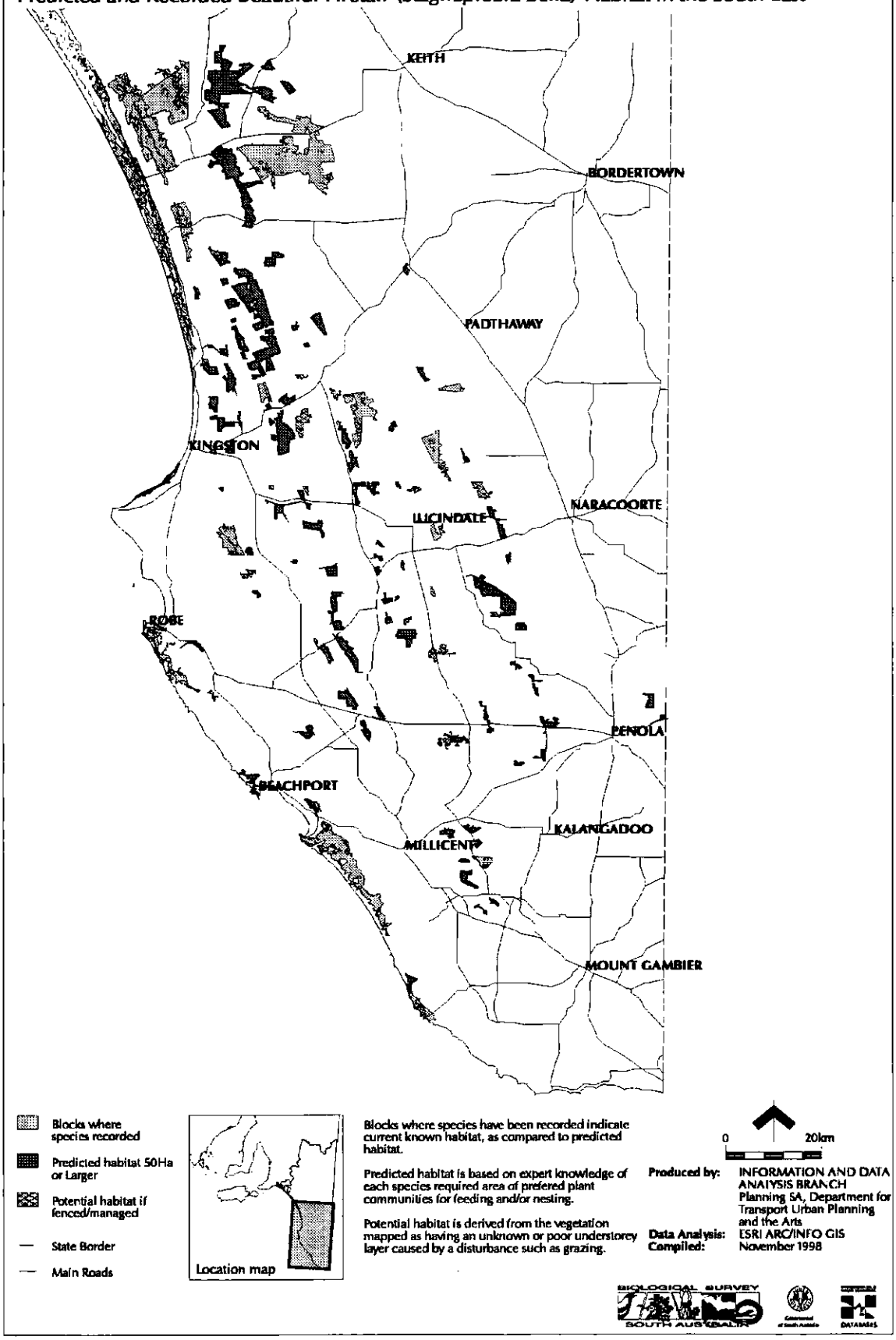
Example 1: Beautiful Firetail

The Beautiful Firetail uses the habitat provided by the following plant communities (numbers correspond to the coding in the GIS coverage, see Table 3)) *Eucalyptus fasciculosa , E. leucoxylon spp.* Low woodland (5), *Eucalyptus fasciculosa , Xanthorrhoea caespitosa* Low woodland (7), *Eucalyptus arenacea/baxteri +/- Pteridium esculentum* Woodland (12), *Melaleuca halmaturorum* Tall shrubland (22), *Gahnia filum , Samolus repens* Sedgeland (21). The area estimated to be required for at least one breeding pair is 50 hectares. Their distribution was identified as the whole SE with an area in the lower SE ruled out due to a lack of sightings in that area during the last 50 years (expert knowledge). Only vegetation blocks that were identified from the coding as having a condition of natural were used to determine habitat, as this species is considered to require an appropriate understorey layer for survival (Figure 6).

Example 2: Malleefowl

The Malleefowl was slightly different to the Beautiful Firetail in that it had separate nesting and feeding habitat requirements. The Malleefowl required habitat of *Eucalyptus incrassata , E. leptophylla, +/- Melaleuca uncinata* Open mallee (1), *Eucalyptus dumosa, E. leptophylla* Mallee (2), or *Eucalyptus diversifolia* Open Mallee (3) of an estimated 10ha for nesting. It then also required that this 10ha of nesting habitat be found within a much larger block of 100ha or larger which contained a more general habitat of either the above mentioned plant communities or *Eucalyptus arenacea/baxteri , Baeckea behrii* Low woodland (11). Their distribution was identified as North of Kingston with an area to the West of Padthaway excluded (expert knowledge) in the modelling process as this was considered to have never been part of the species' range (Figure 7).

Figure 6
Predicted and Recorded Beautiful Firetail *(Stagnopleura bella)* Habitat in the South East



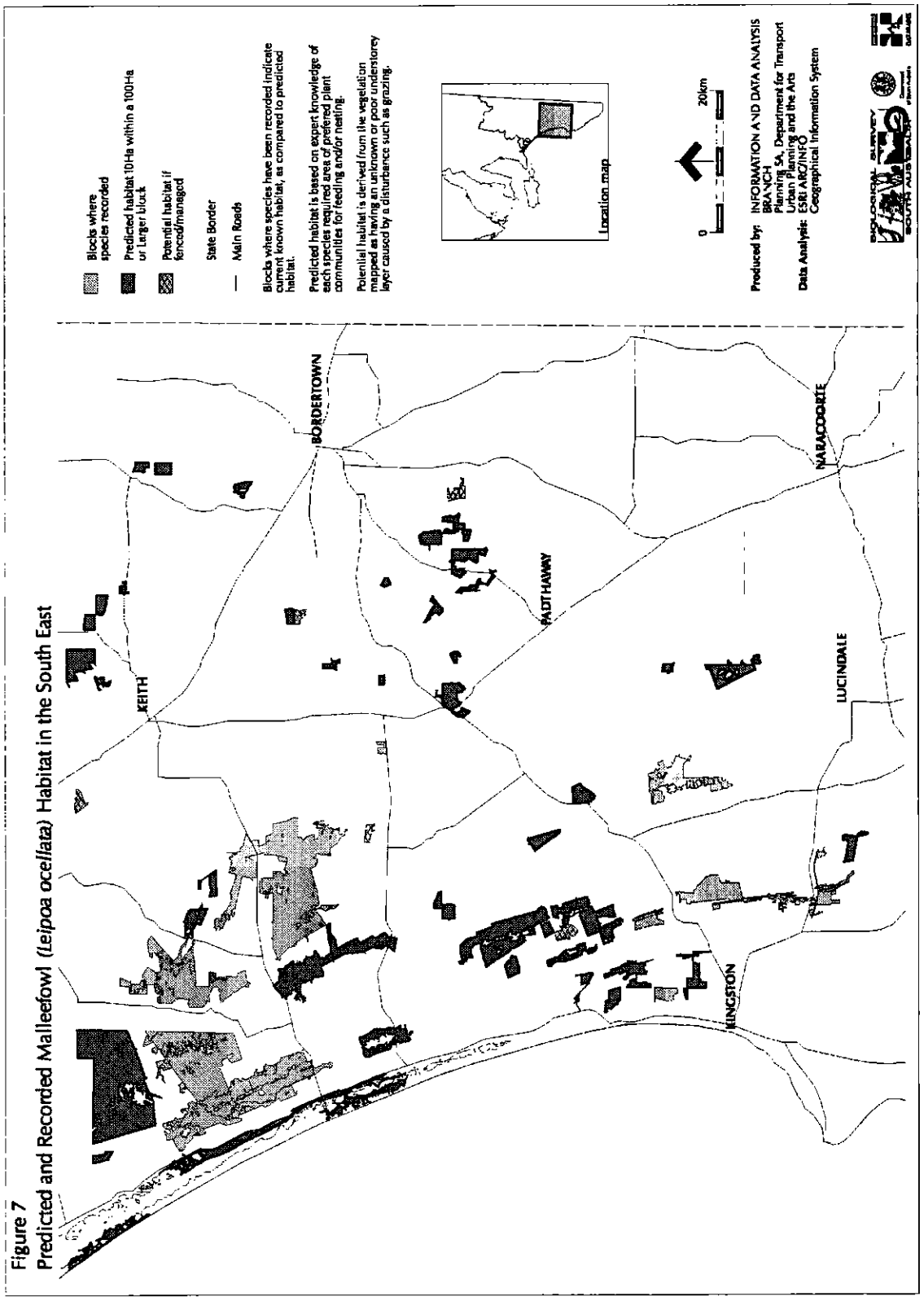


Figure 7
Predicted and Recorded Malleefowl (*Leipoa ocellata*) Habitat in the South East

Example 3: Red-tailed Black Cockatoo

The Red-tailed Black Cockatoo requires hollows for nesting and as such it had both nesting and feeding habitat requirements. Its potential nesting area was identified as including *Eucalyptus fasciculosa , E. leucoxylon spp.* Low woodland (5), *Eucalyptus leucoxylon ssp. +/- Acacia pycnantha* Open woodland (6), *Eucalyptus leucoxylon ssp.* Low open-woodland (8), *Allocasuarina verticillata, Eucalyptus leucoxylon ssp.* Low woodland (9), *Eucalyptus arenacea/baxteri , Baeckea behrii* Low woodland (11), *Eucalyptus arenacea/baxteri +/- Pteridium esculentum* Woodland (12), *Eucalyptus camaldulensis var. camaldulensis* Woodland (18), *Eucalyptus leucoxylon ssp., Callistemon rugulosus var. rugulosus* Woodland *(77), Callitris preissii, Eucalyptus arenacea/baxteri* Woodland (80), *Pteridium esculentum +/-* emergent Eucalyptus spp. Closed fernland (91), *Eucalyptus odorata, E. leucoxylon spp.* Woodland (96), Degraded *E. camaldulensis var. camaldulensis* or *E. fasciculosa* or *E. leucoxylon* spp. or *E. arenacea/baxteri* Woodland (97). In addition to this the breeding locations of the birds for the 1997 breeding seasons were included as point locations and these were buffered by 12km to indicate the known breeding locations of the birds and their expected feeding range while nursing young. Breeding locations were obtained from DEHAA ecologists (pers com Graham Carpenter) and were also provided by Birds Australia (pers. com. Richard Hill) (Figure 8).

The cockatoos feeding area was identified as *Eucalyptus arenacea/baxteri , Baeckea behrii* Low woodland (11), *Eucalyptus arenacea/baxteri, +/- Pteridium esculentum* Woodland (12), *), Callitris preissii, Eucalyptus arenacea/baxteri* Woodland (80), *Allocasuarina luehmannii* Woodland (87), *Pteridium esculentum +/-* emergent Eucalyptus spp. Closed fernland (91) and Degraded *E. camaldulensis var. camaldulensis* or *E. fasciculosa* or *E. leucoxylon* spp. or *E. arenacea/baxteri* Woodland (97).

The required area was minimised to 1 hectare as the birds are not restricted in terms of utilising individual trees for feeding or nesting. The habitat of the Red-tailed Black Cockatoos is related to nesting sites, abundance of feeding habitat near these sites, and amount of habitat for feeding and roaming for the non-breeding and juvenile birds, rather than a set patch of vegetation of a given size. The distribution of the species was identified as East of Keith and South of Bordertown.

Example 4: Common Wombat

The Common Wombat habitat was derived through identification of vegetation blocks where it had been recorded. In general wombats are associated with sandy areas suitable for warrens and are not tied to a particular vegetation type because of this. Using the recorded locations therefore was considered the most accurate way of determining the main habitat areas of the species. Discrete vegetation blocks that contained a recorded sighting(s) of this species were identified as habitat (Figure 9).

Example 5. Yellow-bellied Glider

The current status of the Yellow-bellied Glider is not certain within the South East region of SA. According to the survey records it has been recorded within one block in the lower South East. Its extinction from most or all the region is due to habitat loss and a variety of other combined factors including predation, competition for hollows, etc. The habitat map derived from the model shows predicted habitat for the species were it introduced back into the area based on expert knowledge of its habitat requirements. This is the only species map of the 32 to illustrate known areas, from which the species is no longer thought to occur, as habitat.

Its habitat was identified as *Eucalyptus obliqua var., Pteridium esculentum* Woodland (10), *Melaleuca squarrosa +/-* emergent *E. ovata* Tall shrubland (13), *Eucalyptus ovata, E. viminalis spp.* Woodland (81). The minimum area required was estimated at 20 hectares. The distribution was restricted to East of Millicent and South of Kalangadoo (Figure 10).

Example 6: Striped Legless Lizard and Swamp Antechinus
These 2 species proved difficult to predict habitat for using the model. For both of these species the predicted habitat while fitting initial predictions of ecologists seeking to find the species, their habitat determined via the model appeared to be incorrect from current known populations. For both species the predicted habitat determined via the model, had in most cases been areas where either extensive trapping or searches for the species had occurred with no results. It is not clear whether these species have a more limited distribution than initially suspected, whether they have disappeared from certain habitat areas and not re-established or whether they have specific habitat requirements linked more definitely to topographic or water conditions, which cannot be determined from the floristic mapping alone. Habitat was determined from known records only (Figures 11 and 12).

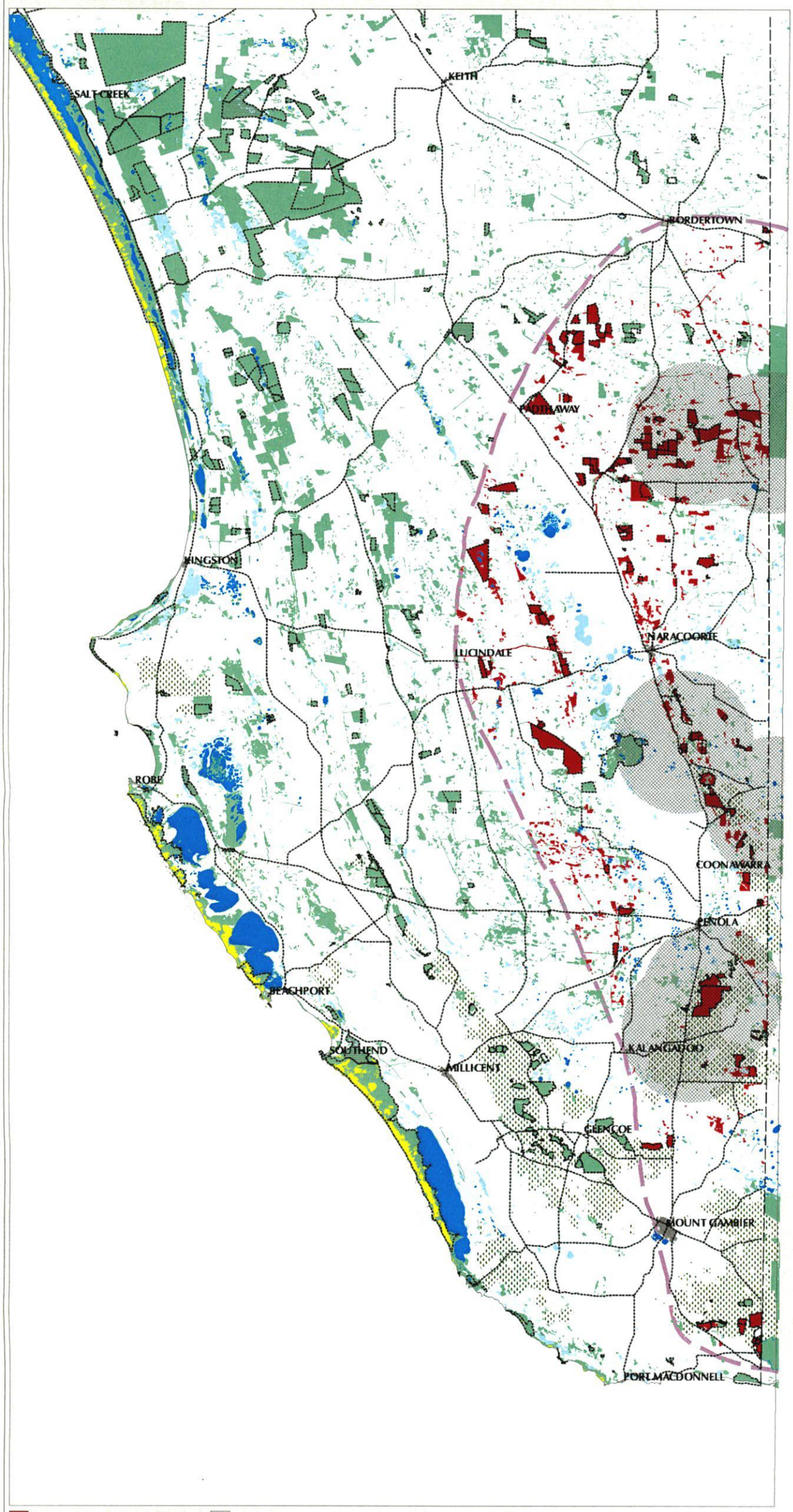
Example 7: Pygmy Possums
For other mammal species including the 3 Pygmy Possum species ie Eastern, Western and the Little Pygmy Possum, recorded habitat was the only habitat determined by the model. Unlike the Swamp Antechinus however, predicted habitat was not possible as not enough was known about the species to make a definitive statement about their habitat requirements for prediction purposes (Figures 13,14 and 15).

Habitat maps for 28 of the 32 species modelled can be found in the *Biodiversity Plan, South East of South Australia.*

6.2 Significant Overall Habitat

Combining the species' habitat information, habitat has been grouped to identify blocks containing 1/3 or more of the 32 significant species for which habitat across the SE region has been identified. Only those blocks that represent recorded or predicted habitat are included in this category. The potential habitat was considered to be habitat pending rehabilitation only and was not considered in this grouping. The results are shown in Figure 16.

Figure 8 Red-tailed Black Cockatoo: South East Region Interim Management Plan



The South-Eastern Red-tailed Black Cockatoo *Calyptorhynchus banksii graptogyne* is listed as Endangered under the Commonwealth Endangered Species Protection Act. This means that the species is likely to become extinct unless the threats to its abundance and survival cease to operate.

The total population of this species in 1998 is estimated at between 500 and 800 birds. The species is restricted to western Victoria and the eastern portion of the South East of South Australia.

Red-tailed Black Cockatoos are large seed-eating birds which roam over their habitat range during the non-breeding season. During the breeding season, which lasts about 6 months from September to March, the breeding birds nest in hollow-bearing trees which have a suitable area of feeding habitat within 12 km.

The species is under threat from the historical loss of its feeding and breeding habitat by vegetation clearance, and by the continued clearance of scattered trees which are either current nest trees or may be nest trees in the future.

A Recovery Plan for the Red-tailed Black Cockatoo has been prepared which identifies the actions required for the species' continued survival and recovery. Implementation of this Recovery Plan is being coordinated by Birds Australia in conjunction with other stakeholders including the SA Department of Environment, Heritage and Aboriginal Affairs (DEHAA).

This document has been prepared as part of DEHAA's South East Regional Biodiversity Plan to help develop an interim management strategy for the species in South Australia.

This map shows the 2 main habitat requirements of the Red-tailed Black Cockatoo in the South East region of South Australia.

Nesting

Nest trees are a key to the continued survival of this endangered species.

Red-tailed Black Cockatoos nest in large old eucalypts with suitably sized hollow limbs (i.e. with entrances greater than 15 cm in width). All mature Red Gums *(Eucalyptus camaldulensis)*, Blue Gums *(E. leucoxylon)*, Manna Gums *(E. viminalis)*, Swamp Gums *(E. ovata)* and Stringybarks *(E. arenacea/baxteri)* in the region represent potential nesting sites for this species.

During the breeding season the adult nesting birds are restricted to a feeding range of about 12km from the nest. If there is insufficient feeding habitat within this area then the energy the birds need to expend in search of food may reduce their ability to successfully raise young.

This map shows 12 km grey zones around nesting locations recorded in South Australia in the last 10 years. These grey zones are currently considered key areas for Red-tailed Black Cockatoos in South Australia, based upon current information and understanding of their ecology. All eucalypts of the above species within these zones are important as they may be nesting trees or future nesting trees for the species.

Where scattered mature eucalypts are present in the grey zones, clearance of these trees represents a threat to the survival of the Red-tailed Black Cockatoo and is not recommended.

Feeding

The cockatoos feed in woodlands of Stringybark and Buloke *(Allocasuarina luehmanii)*. Vegetation blocks that contain these plant communities are shown on the map in red.

Buloke woodlands were subjected to heavy clearance during early agricultural development and are now considered a threatened plant community. Remnants are small and scattered, and most are degraded and subject to grazing pressure.

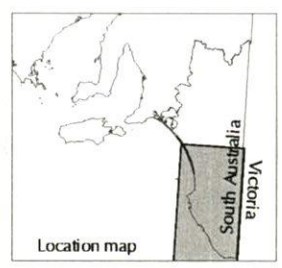
Where possible Buloke and Stringybark woodlands should be protected from grazing and regeneration should be encouraged.

This interim management plan is endorsed by the Red-tailed Black Cockatoo Recovery Team and by Birds Australia.

Red-tailed Black Cockatoos

0 40km

- Predicted feeding habitat
- Recent Nesting Zone
- Native vegetation
- Pine plantation
- Land subject to inundation
- lake
- Ocean
- Exposed dunes
- Built-up area
- Cropland / pasture with occasional low density scattered trees
- Conservation reserves
- Sealed road
- Unsealed road
- Vehicular track
- Railway
- Non-access linear features drains, powerlines, pipelines
- State border
- NPWS Reserve/Heritage agreement/ Native Forest Reserve
- Species' distribution limit (approx)



Produced By : INFORMATION AND DATA ANALYSIS BRANCH
Planning SA,
Department for Transport, Urban Planning and the Arts
Data Analysis : ESRI ARC/INFO
Geographic Information System
Data Source : Landcover and Vegetation mapped from 1:40,000 colour aerial photography, 1987 by IDA Branch. Subsequent landcover changes may have occurred. Roads and coastline supplied by DEHAA. 1997 Pine plantation and Native Forest Reserve data supplied by Forestry SA.
Date Compiled: September 1998

BIOLOGICAL SURVEY SOUTH AUSTRALIA
Government of South Australia
ENVIRONMENTAL & SOCIO-ECONOMIC DATABASES

Figure 9

Recorded Common Wombat *(Vombatus ursinus)* Habitat in the South East

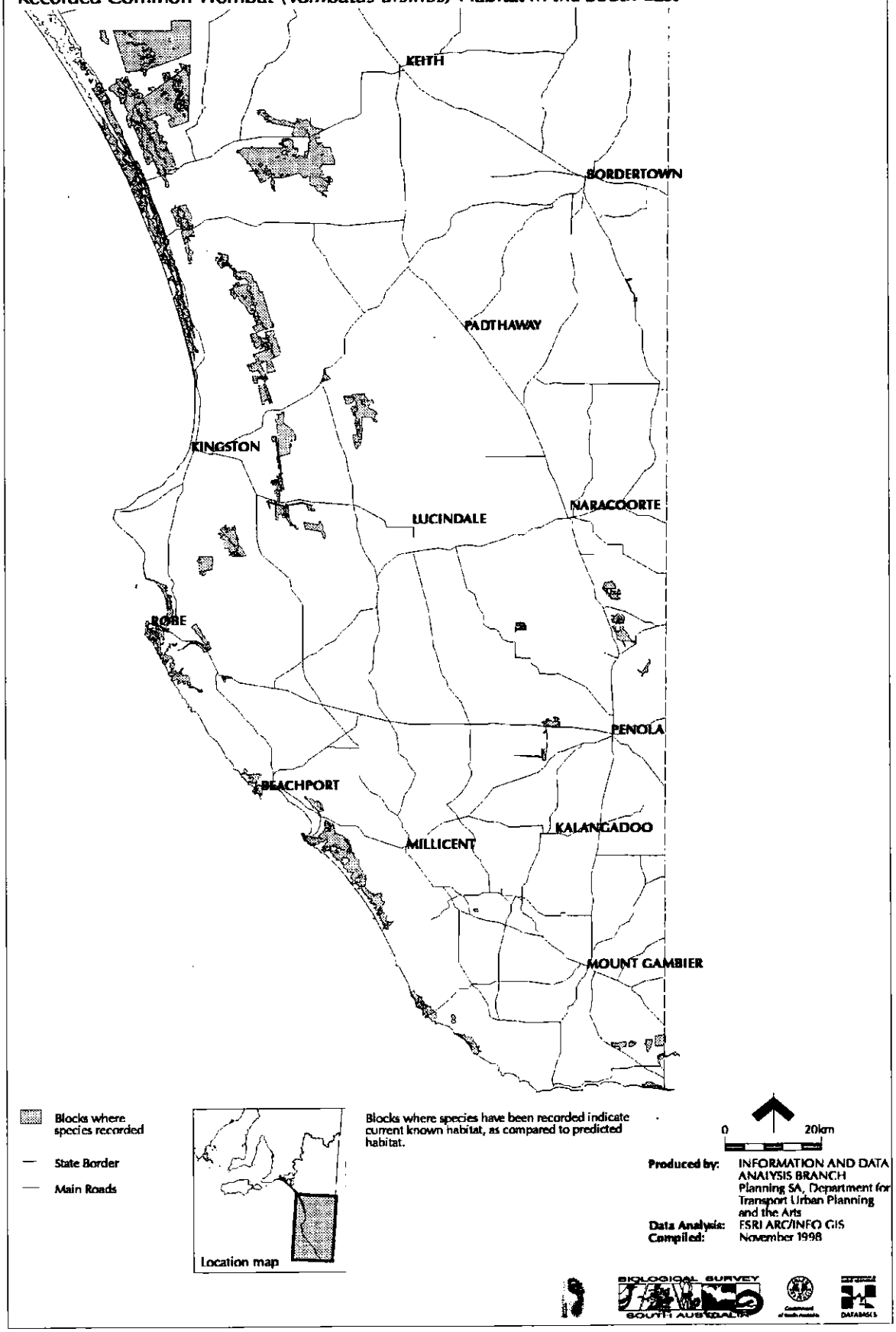


Figure 10
Predicted and Recorded Yellow-bellied Glider *(Petaurus australis australis)* Habitat in the South East

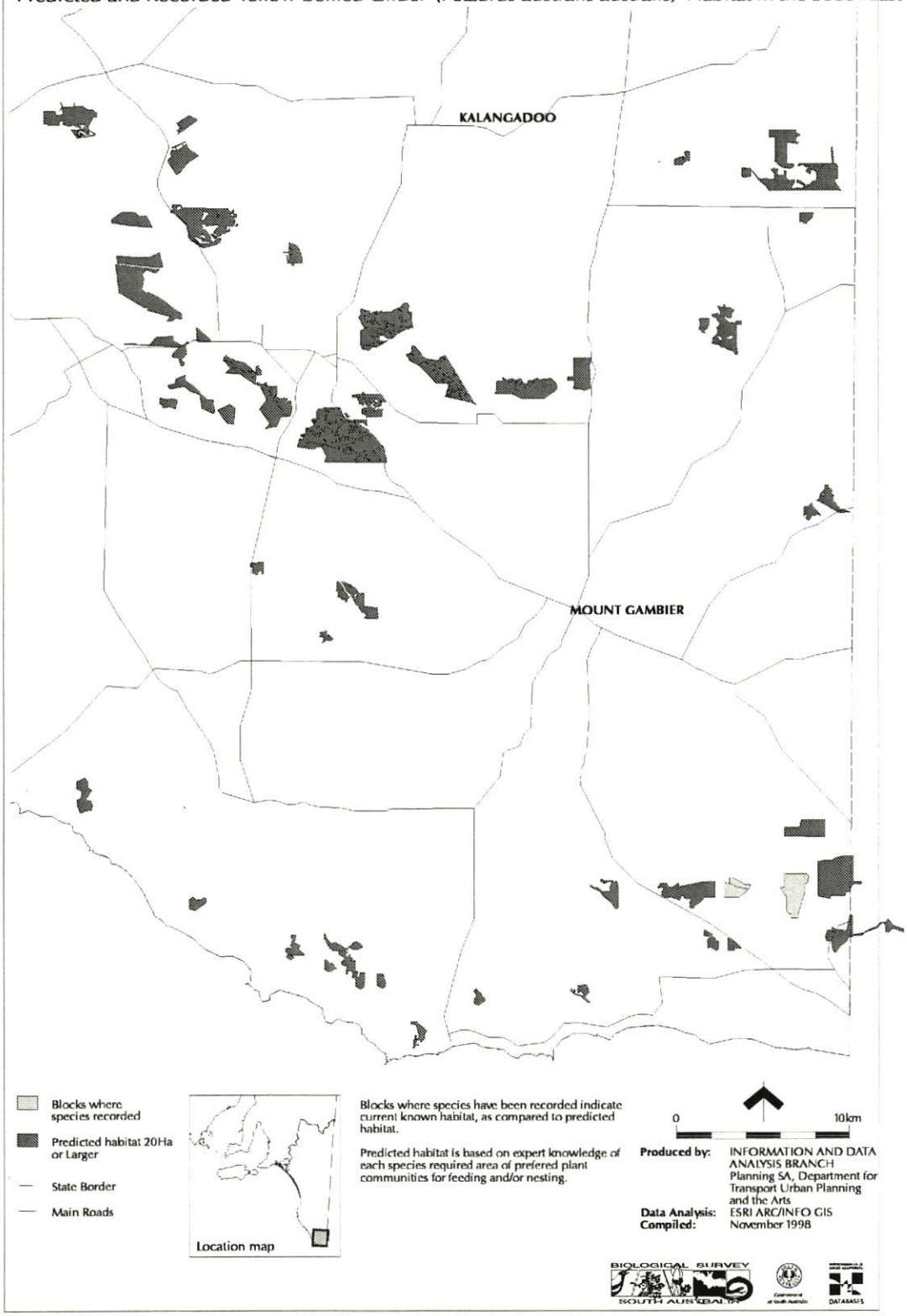


Figure 11
Recorded Striped Snake-lizard *(Delmar impar)* Habitat in the South East

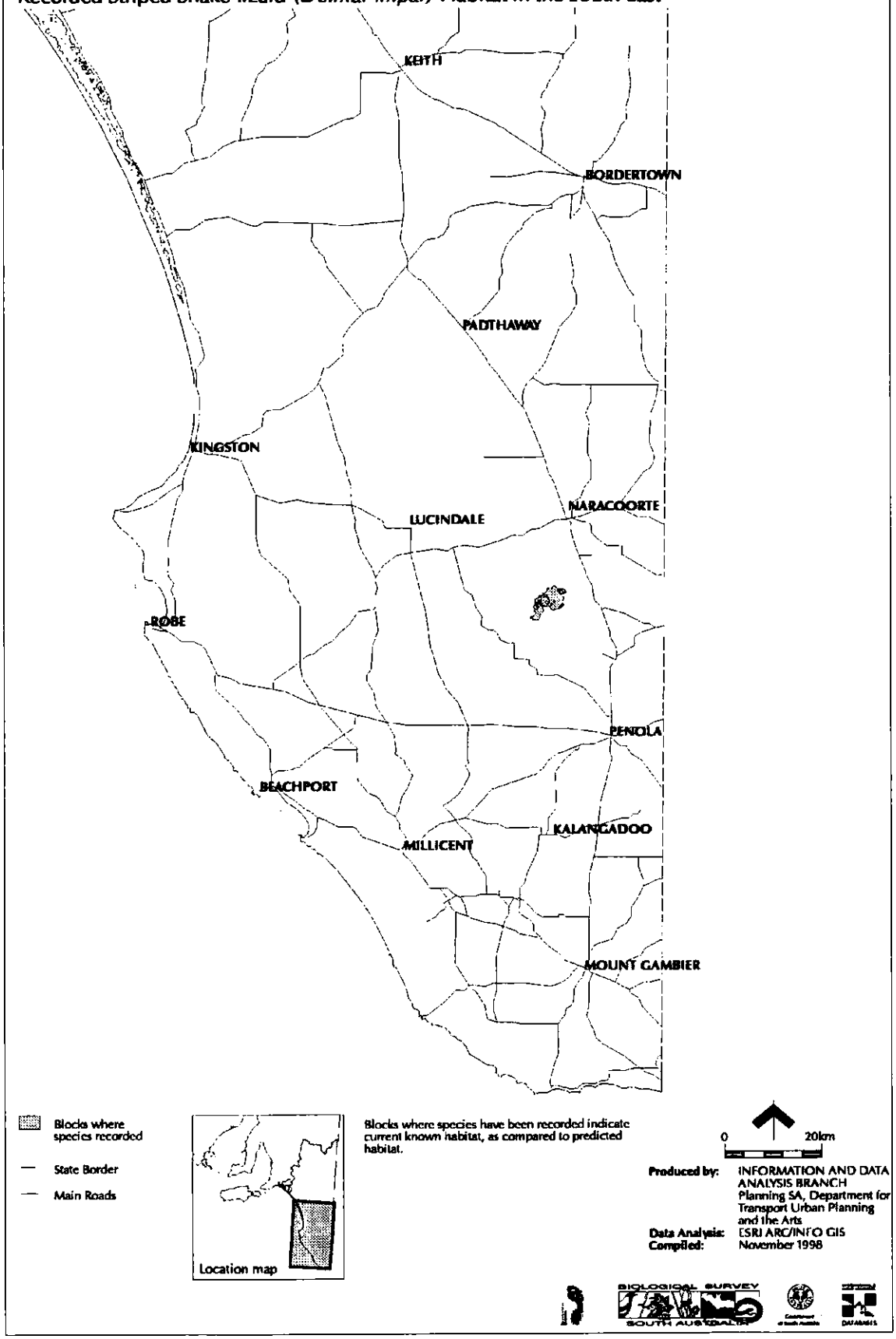


Figure 12
Predicted and Recorded Swamp Skink *(Egernia coventryi)* Habitat in the South East

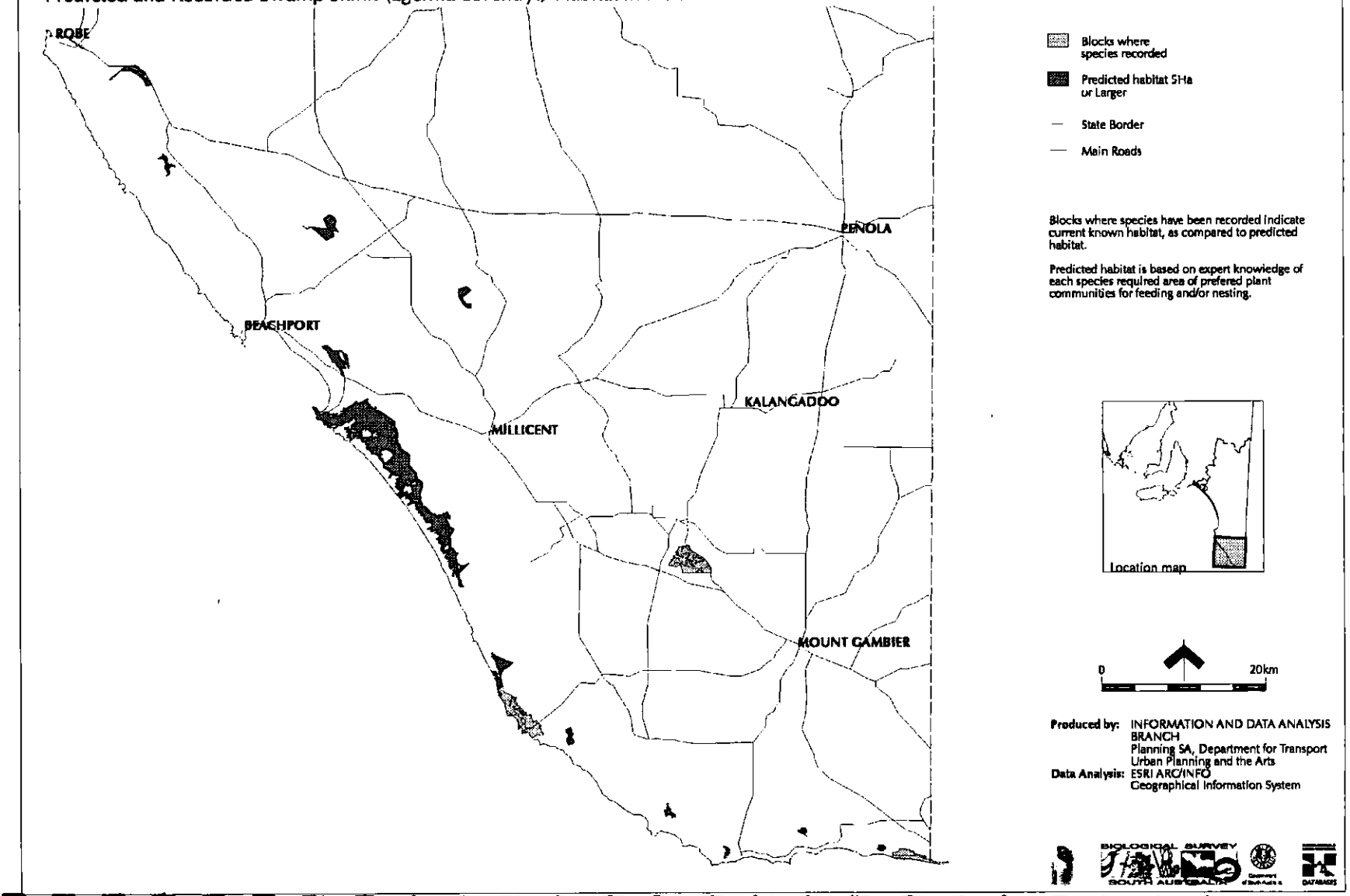


Figure 13

Recorded Eastern Pygmy-possum *(Cercartetus nanus)* Habitat in the South East

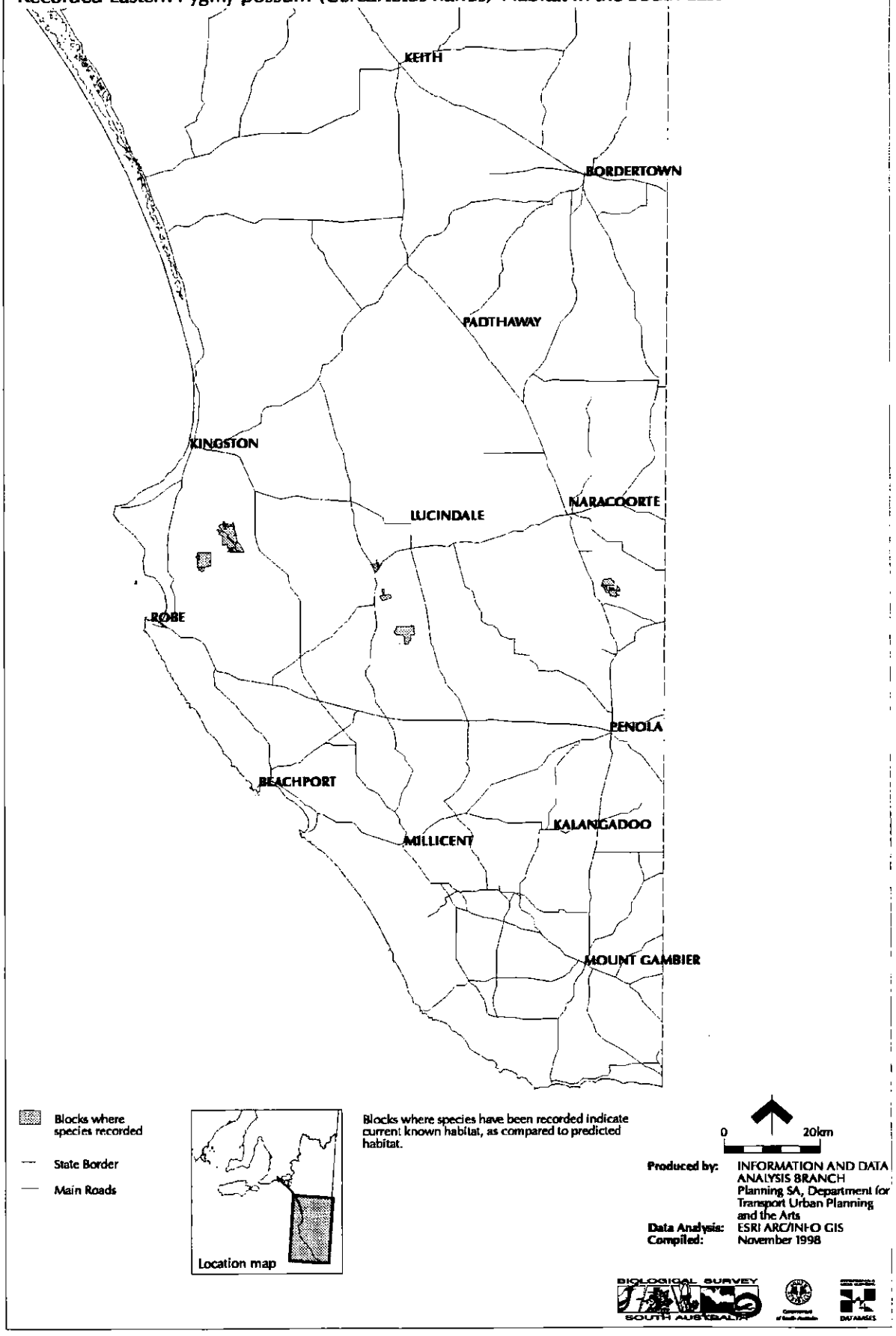


Figure 14
Recorded Little Pygmy-possum *(Cercartetus lepidus)* Habitat in the South East

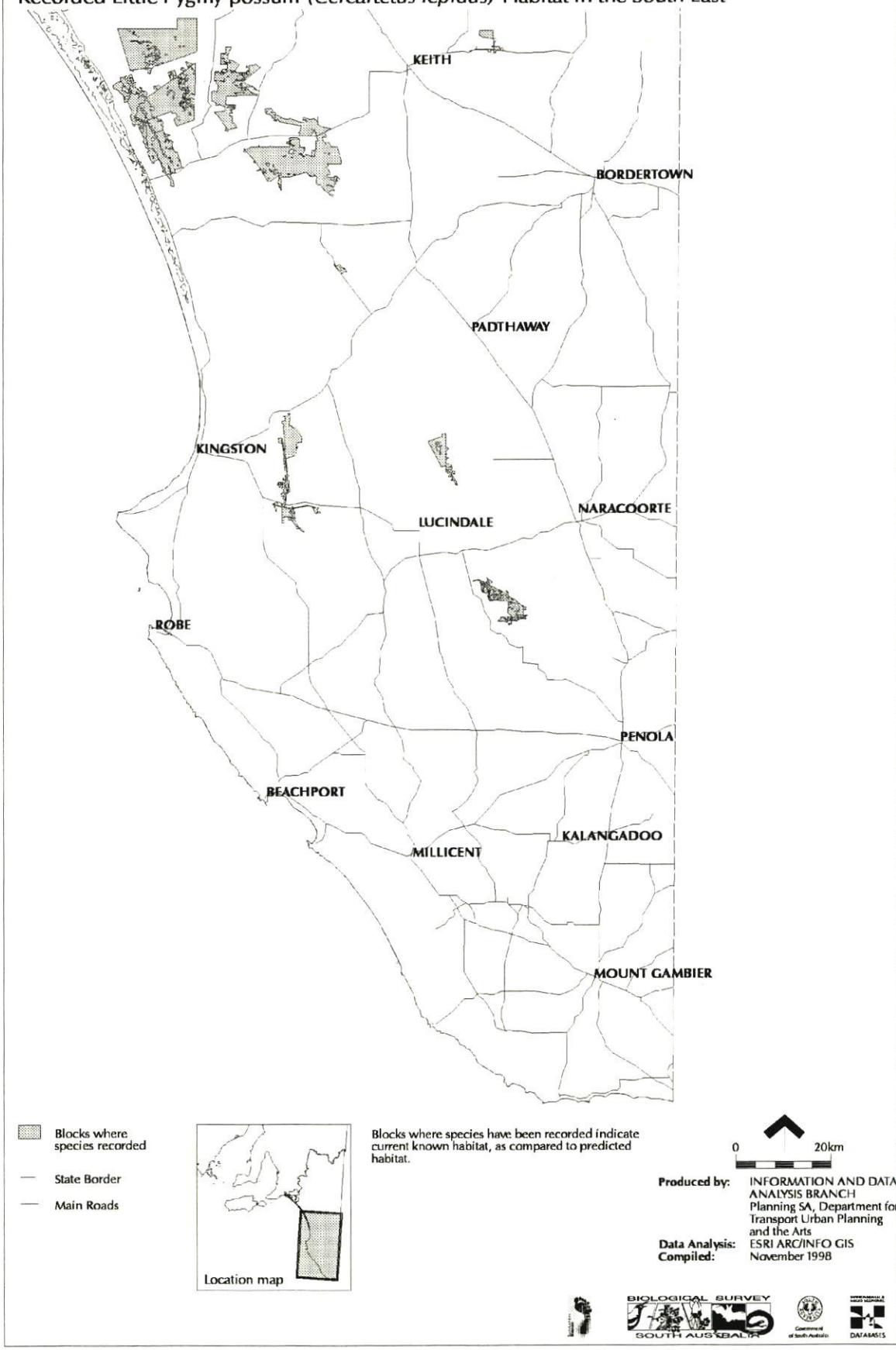


Figure 15
Recorded Western Pygmy-possum *(Cercartetus concinnus)* Habitat in the South East

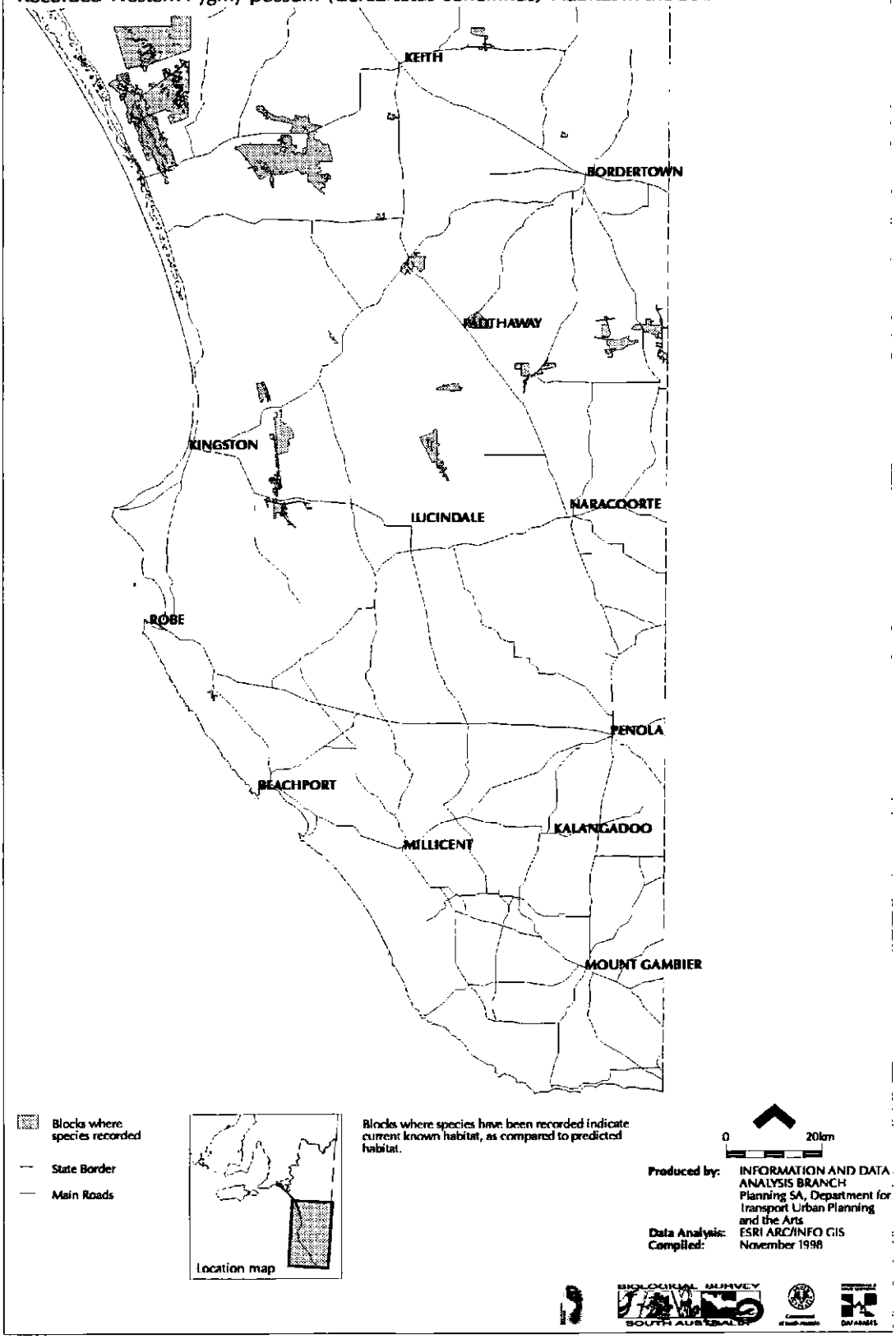


Figure 16
Vegetation Blocks Representing Habitat for More Than One Third of Species Modelled

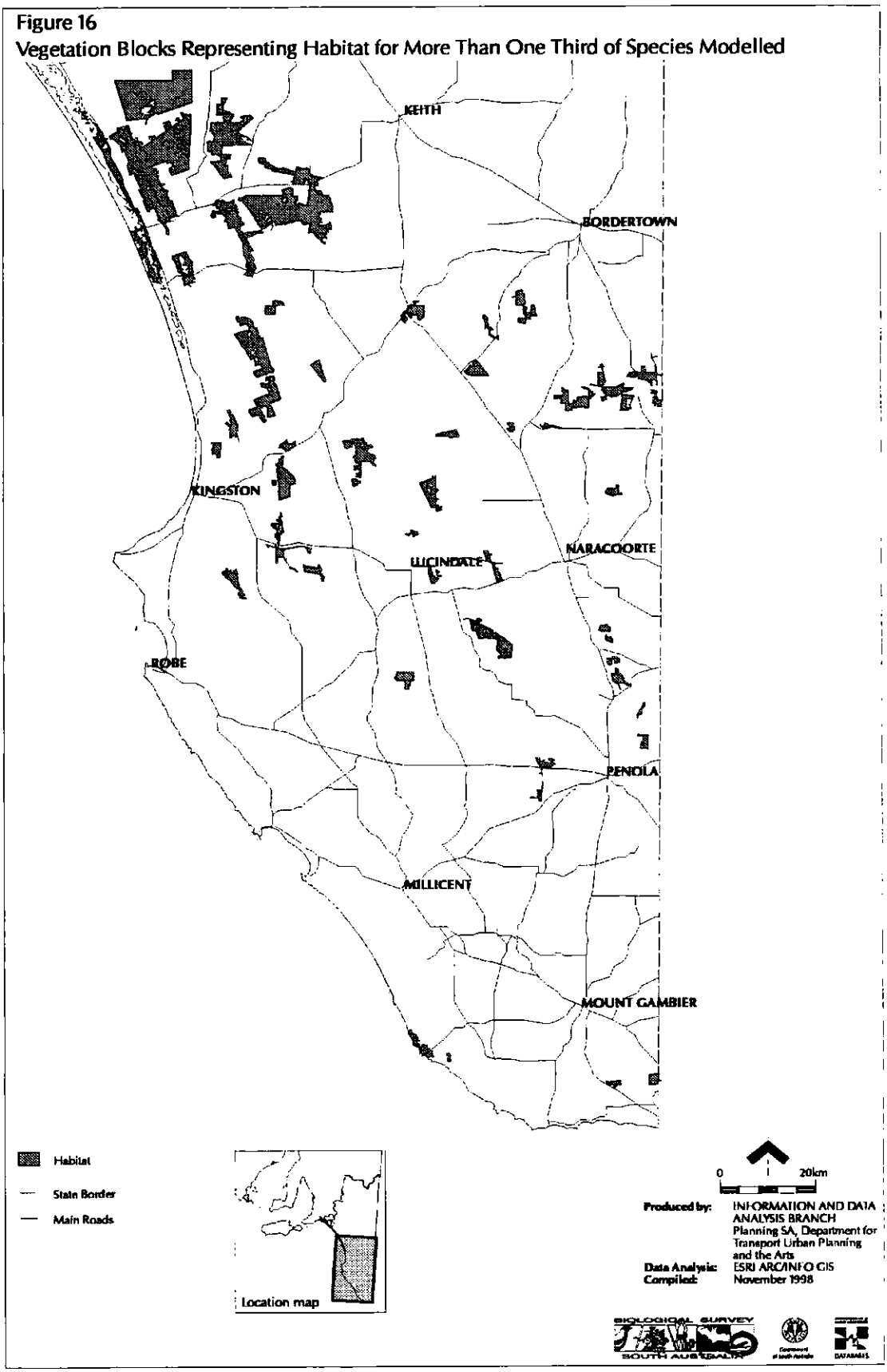
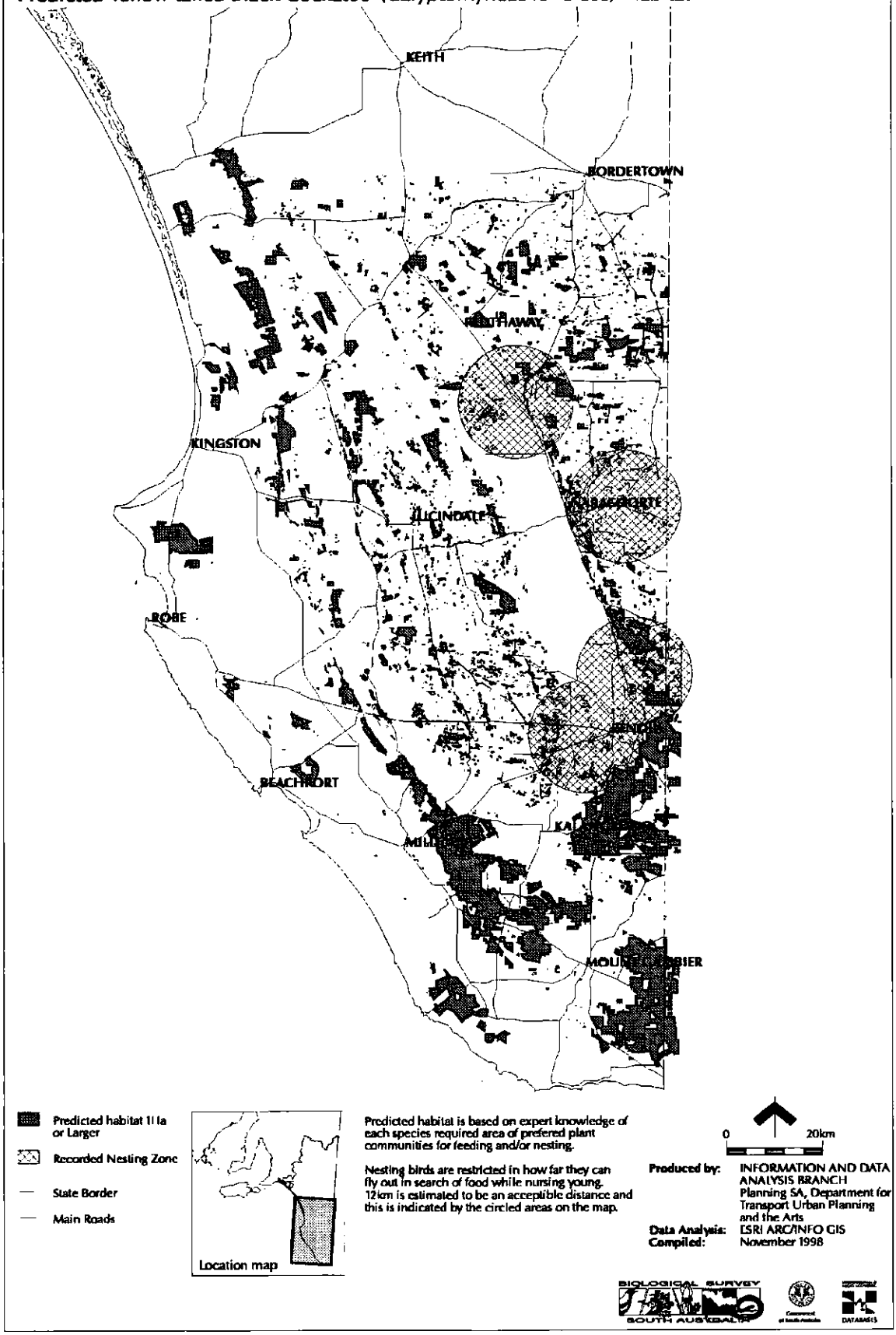


Figure 17
Predicted Yellow-tailed Black Cockatoo *(Calyptorhyncus funereus)* Habitat in the South East



6.3 Nesting Zones

6.3.1 Red-tailed Black Cockatoo and Yellow-tailed Black Cockatoo Nesting Zones

Known nesting sites in South Australia for the Red-tailed Black Cockatoos and for the Yellow-tailed Black Cockatoos from recent years, were buffered by 12km. The purpose of this is to indicate critical feeding zones for the Cockatoos while breeding. These zones are considered to be areas where scattered tree clearance is not recommended, as the hollows they contain may represent current or potential nesting trees. The nesting zones for each species are shown in Figures 8 and 17 respectively.

6.4 Further Limitations of the Habitat Model

Wetland Birds

Wetland bird species in general were not considered. These birds are not necessarily tied to plant communities but to wetlands and wetland conditions. For this reason and because wetland vegetation is poorly managed in general in the SE region, wetland plant communities have been identified and recognised as significant. A more detailed examination of individual wetland areas would contribute to a better understanding of the level of management required for the conservation of biodiversity in these areas. This detailed examination was not possible within the scope of this project.

Scale

At a local scale some smaller areas of vegetation may not be mapped and would therefore not have been used in the analysis. This is significant when they are overlooked at the local level when implementing measures to manage or improve the conservation of biodiversity. At a regional scale of analysis small pockets of vegetation (ie < 1ha) and roadside vegetation are overlooked, in order to gain a larger picture of regional patterns, in order to implement plans at the local scale.

7. RESULTS

7.1 Significant Biodiversity Factors

All native vegetation is important. The biodiversity plan aims to identify some of the main reasons why.

No specific ranking system has been applied. Blocks identified with any of the following criteria have a significant biodiversity, and therefore conservation value. Blocks identified with more than one of the outline criteria are therefore significant for more than one reason, not necessarily more significant in an overall sense.

Results of the SE regional biodiversity project will be used to determine where there are significant areas of vegetation are that are not conserved within the reserve or heritage agreement system.

Two types of key biodiversity significant areas were identified. Large remnant areas and threatened habitat areas.

7.1.1 Key Biodiversity Areas

Large Remnant Areas
The Biodiversity Plan identifies five distinct areas of the region (see Figure 18) which are considered highly important because they contain:

- high habitat value (based on GIS modelling results)
- blocks of remnant vegetation > 1000 ha.;
- supporting blocks of remnant vegetation > 200 ha.;
- high species diversity;
- are estimated to have good population sizes for fauna species within these areas;
- species of high conservation significance

Although large areas usually contain plant communities that are better conserved, these areas are also considered to provide sufficient habitat for the long term sustainable populations of many vertebrate fauna species. These areas are based on the results of the habitat analysis (Figure 16) and from subjective interpretation based on expert knowledge.

Key management options for these areas include:
linking existing blocks
fox control
weed control
fencing

Threatened Habitat Areas

There are five distinct areas (Figure 19) that are considered to contain concentrations of threatened habitats considered highly important as they contain:

- selectively cleared and modified habitats
- low habitat remnancy (< 10%)
- plant communities poorly conserved in government reserves
- small vegetation blocks (< 50 ha.);
- regionally and/or State threatened plant communities;
- species of high conservation significance (often at the national level).

These areas are considered to contain species populations and ecosystems at threat from extinction in the longer term (> 50 years).

Key management guidelines for these areas include:
buffering existing remnants
fencing
weed control

7.2 Final Biodiversity Layer

The complete GIS modelling process has been summarised and illustrated in Figure 20.

All information has been translated back to each particular discrete vegetation block found in the South East region. Where individual plant communities were used to identify habitat, in the final identification of habitat these have been presented at the whole block level.

The reasons for this were:

- Mapping of plant communities has an element of interpretation as to where actual boundary lines between different plant communities occur.
- To only choose the identified plant community of concern and not the remainder of the continuous block of which it is a part, represents a loss of information.
- A whole block and not just the plant communities of concern may be playing a significant role in regard to the use of the block by the fauna species.
- A whole block is effectively a buffer or protection zone around each plant community of concern.

Figure 18
Large Remnant Areas of the South East Region

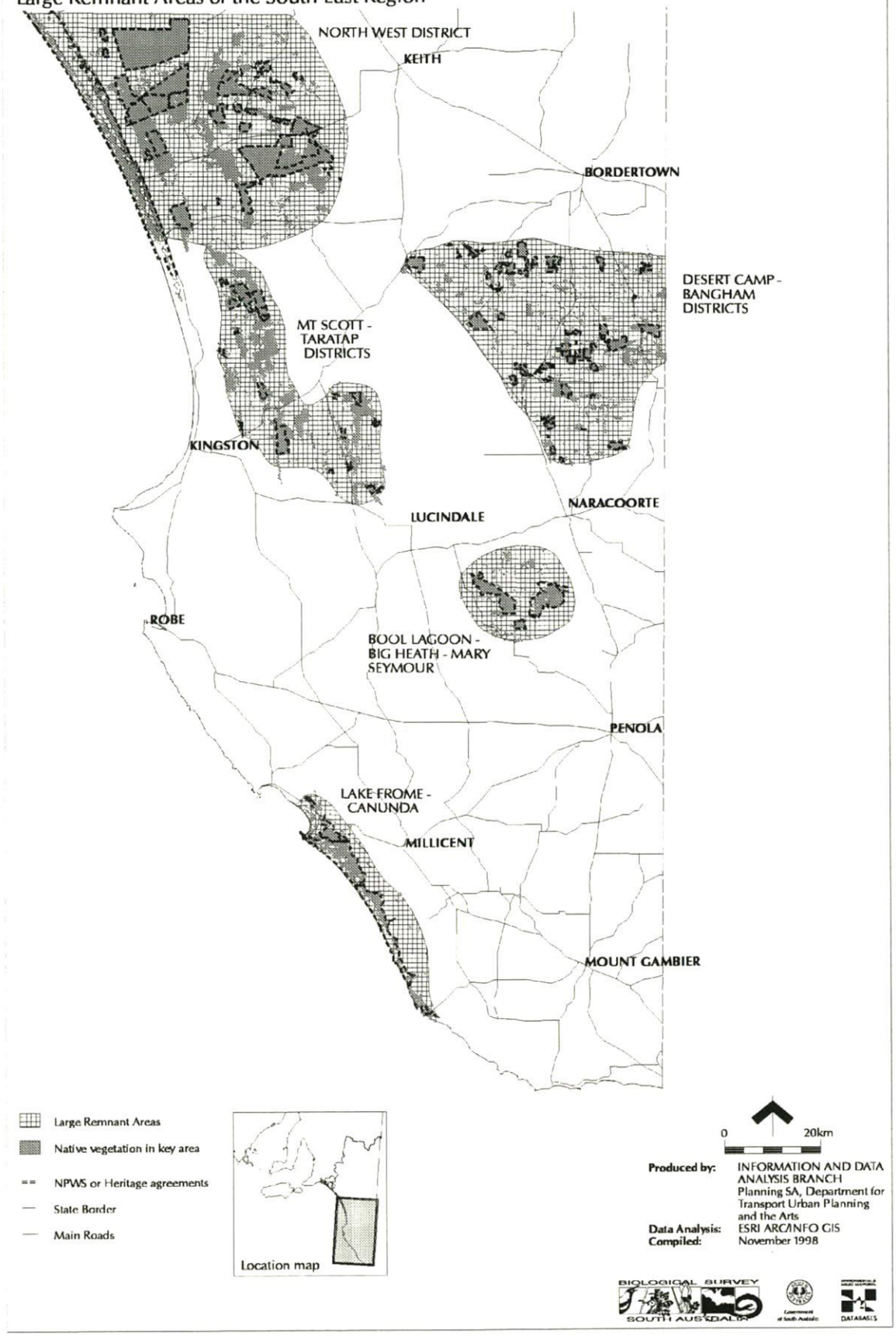


Figure 19
Threatened Habitat Areas of the South East Region

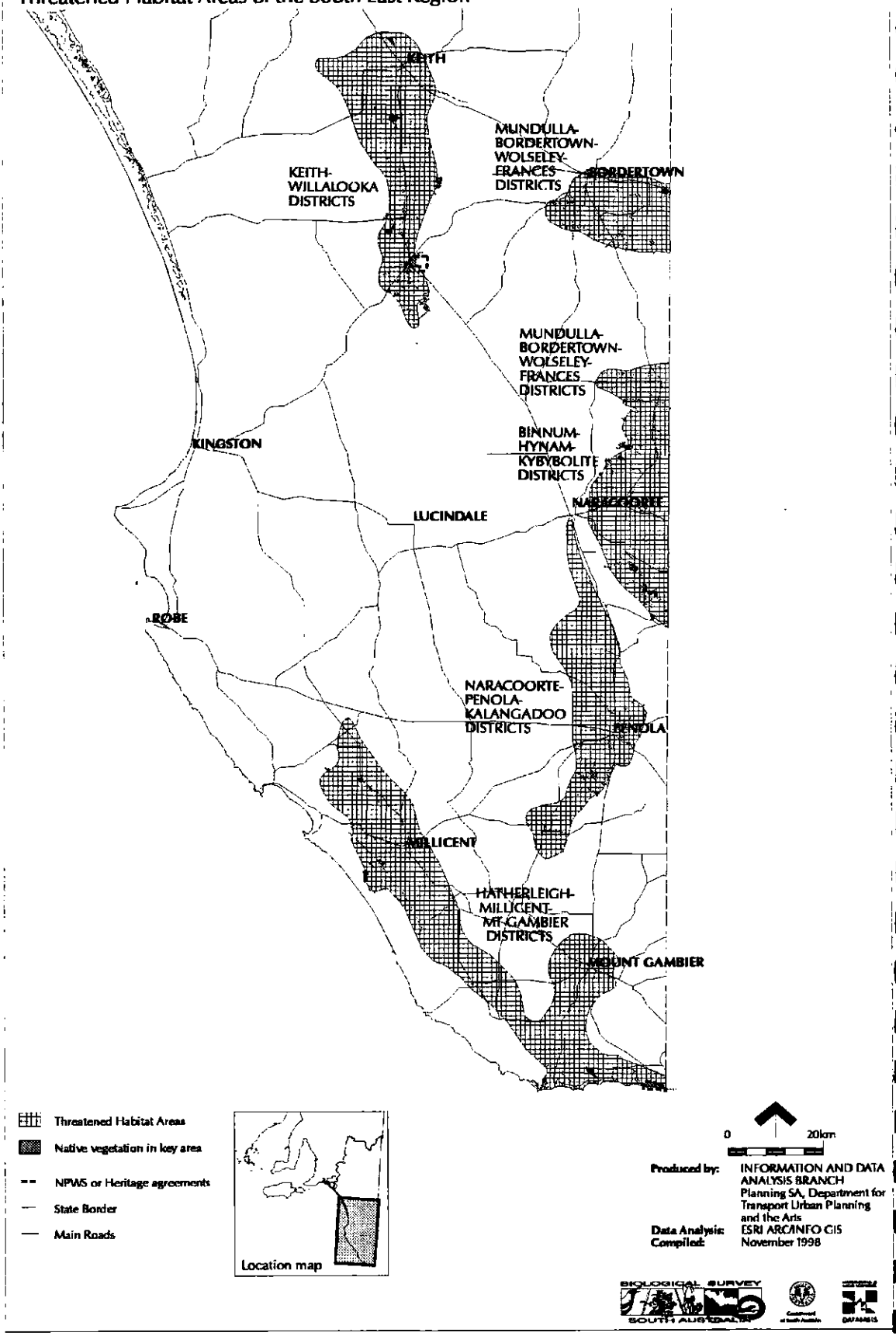
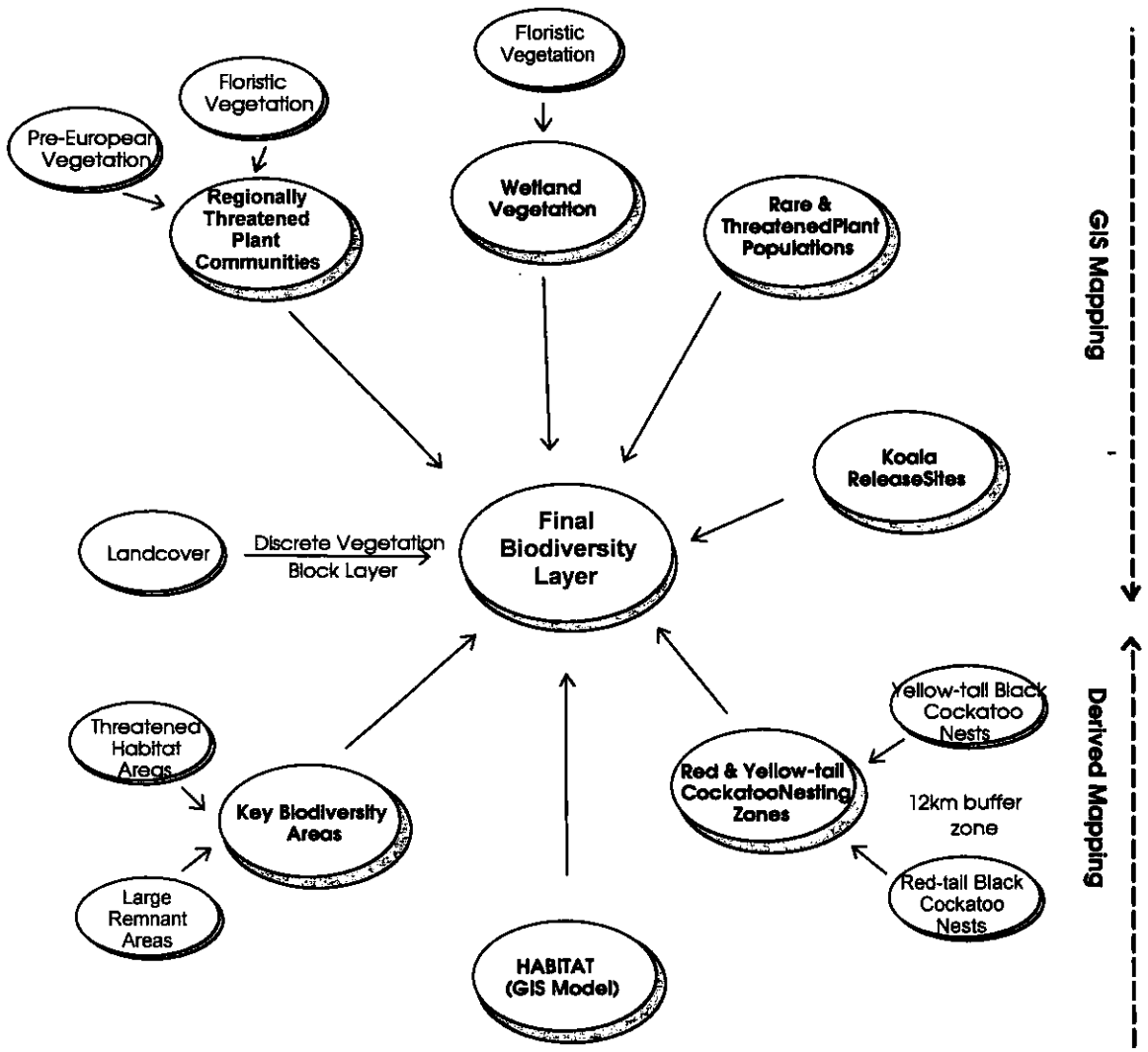


Figure 20: Biodiversity GIS Model



7.2.1 Individual Vegetation Block Level

At the individual vegetation block level the following information has been determined and recorded against each block in the final biodiversity layer:

- Regionally Rare and Regionally Threatened Plant Communities;
- Rare and Threatened Plant Populations;
- Significant Sized Blocks;
- Koala release Sites;
- Wetland Plant Communities.

Rare or Regionally Threatened Plant Communities
Where vegetation blocks contain a regionally rare or threatened plant community the whole block is identified in the final biodiversity layer. These are based on a comparison of Remnant vegetation mapping and Pre-European vegetation mapping (see Section 4, Table 5).

Rare and Threatened Plant Populations
Blocks greater than 20 hectares that contain one or more plant population from the Rare and Threatened Plant Population Database (refer to Section 5.2.2) have been identified in the final biodiversity layer. Twenty hectares was chosen as the smallest size due to the sensitivity of information contained within this database. The information is based on presence only data.

Significant Sized Blocks
Blocks of native vegetation of between 200 and 1000ha and larger than 1000 ha or larger (including areas identified as being of unknown condition).
Blocks have been identified as belonging to one of the following size groups:
<20ha 20-50ha; 50-100ha; 100-500ha; 500-2000ha; 2000-5000ha; 5000-20,000ha; >20,000ha.

Koala release Sites
Patches of vegetation in the SE that koalas were released into during the 1997-98 Kangaroo Island Koala relocation program have been mapped and digitised into the GIS. This mapping is stored within the State Government's Environmental database. The patches of *Eucalyptus viminalis* ssp. (Manna gum) or *E. ovata* (Swamp gum) were individually mapped at 1:10,000 from colour aerial photography. The final biodiversity layer identifies the vegetation blocks that contain these release areas (Figure 21).

Wetland Plant Communities
Blocks containing wetland plant communities, which are considered significant for conservation, are identified in the final biodiversity layer. Wetland plant communities require management, particularly in relation to water salinity and quality, and are significant from a regional perspective. Wetland plant communities identified from the regional floristic mapping are listed in Table 11.

Figure 21: South East Region Koala Release Sites

Koalas relocated from Kangaroo Island

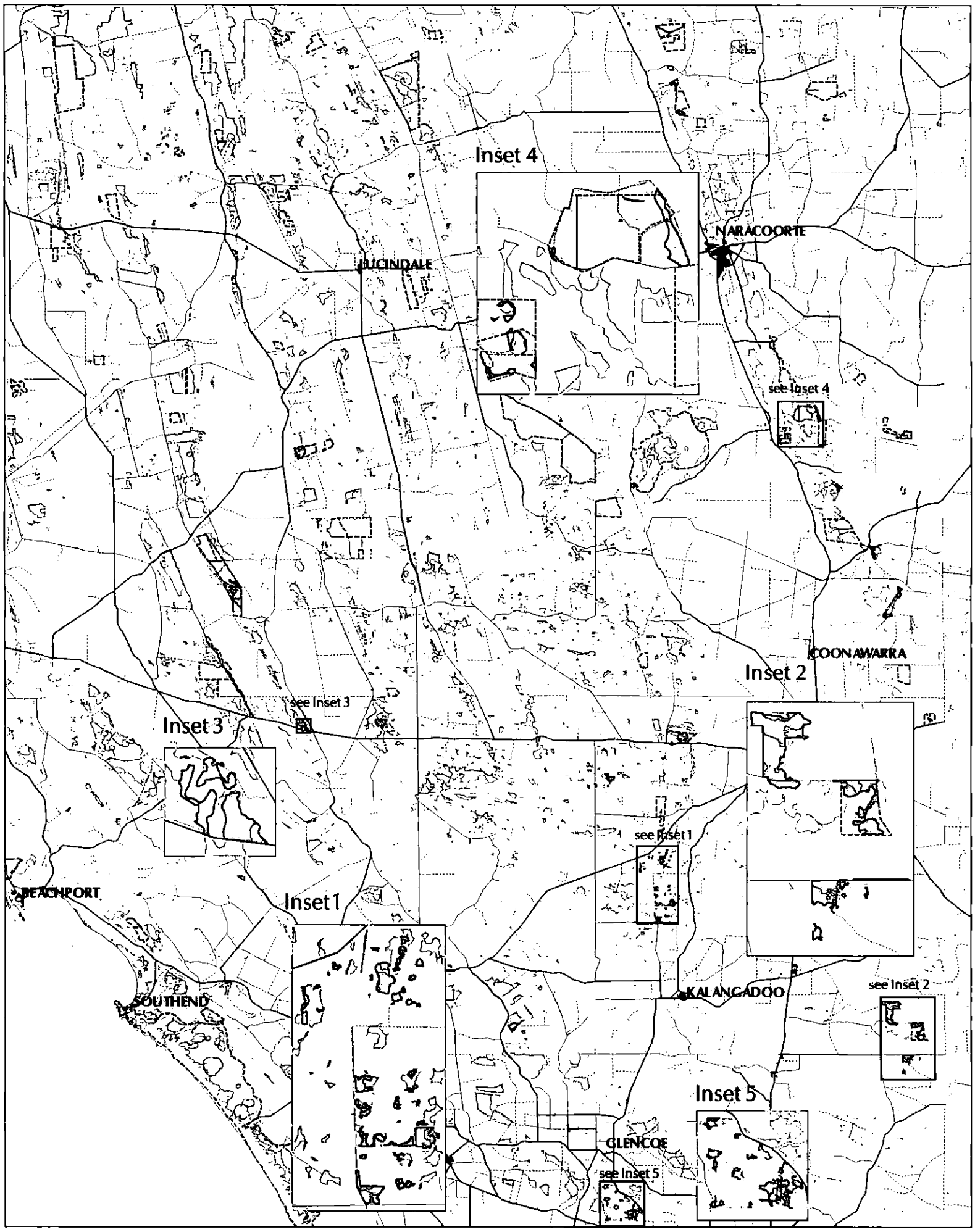


Table 11: Wetland Plant Communities mapped

Woodland
Eucalyptus camaldulensis var. camaldulensis Woodland (18)
Eucalyptus ovata, E. viminalis spp. Woodland (wetland complex) (81)
Shrublands of wet areas
Melaleuca squarrosa +/- E. ovata Tall shrubland (13)
Melaleuca brevifolia Low shrubland (17)
Leptospermum lanigerum Tall shrubland (19)
Melaleuca halmaturorum Tall shrubland (22)
Sarcocornia spp. , Halosarcia spp. Low shrubland (29)
Gilgai / wetland complex Shrubland (90)
Melaleuca spp. Shrubland (possibly *M. brevifolia* or *M. uncinata* in damp swales / flats +/- some emergent large *Eucalyptus* spp.) (93)
Melaleuca brevifolia or M. uncinata Shrubland [Damp swales/ depressions north-east of Keith] (95)
Inland Samphire complex Low shrubland (94)
Sedgeland
Gahnia filum Sedgeland (20)
Gahnia filum , Samolus repens Sedgeland (21)
Typha domingensis Closed sedgeland (23)
Leptocarpus brownii , Baumea juncea Closed sedgeland (25)
Reedbeds / sedgeland complex Closed sedgeland (82)
Baumea juncea +/- Gahnia trifida Sedgeland (83)
Juncus spp., Isolepis spp., Poa spp., complex Sedgeland [Reedbeds - Interdune Tussock Grassland / Sedgeland] (85)
Coorong freshwater soak complex Sedgeland (98)

() Refers to numbers shown in Remnant Floristic Vegetation Map Table 3.
Source: Remnant Floristic Vegetation Map, South East Region of SA.

7.2.2 GIS Layer Items

All species' habitats have been amalgamated to be accessible via the biodiversity layer. This is done using a corresponding data file with a one to many relate to the biodiversity layer. While all habitat analysis has been done in grid, the grid data layer results have been related back to the original landcover layer. This has prevented a loss of information and data quality from the translation of vector (GIS) into raster data (cell based) and then back to vector.

Items on the final biodiversity layer are listed in Table 12. Items on the related species' habitat file are listed in Table 13.

Table 12: Items on final biodiversity layer

ITEM NAME	WIDTH	OUTPUT	TYPE	N.DEC
AS2482	5	5	I	-
LANDCOVER	25	25	C	-
CONDITION	2	2	I	-
VEG_CONDITION	20	20	c	-
BIONO	4	5	B	-
BLOCK_SIZE	35	35	C	-
HABITAT	70	70	C	-
REMNANT_AREA	47	47	C	-
THREAT_HABITAT	47	47	C	-
YTAIL	45	45	C	-
RTAIL	45	45	C	-
WET_PLANT_COM	40	40	C	-
RARE_PLANT_COM	50	50	C	-
RARE_PLANT_POP	47	47	C	-
KOALAHAB	20	20	C	-

where:
As2482 – refers to the Australian Standard feature identification code
LANDCOVER – refers to the landcover description eg swamp, vegetation etc
CONDITION – refers to the native vegetation condition code
VEG_CONDITION – refers to the condition description ie natural or modified/unknown
BIONO – each unique vegetation blocks identification number
BLOCK_SIZE – refers to the signficant sized block description
HABITAT – refers to blocks of significant habitat
REMNANT_AREA – refers to key remnant area
THREAT_HABITAT – refers to threatened habitat area
YTAIL – refers to Yellow-tailed Black Cockatoo Nesting Zone
RTAIL - refers to Red-tailed Black Cockatoo Nesting Zone
WET_PLANT_COM – refers to wetland plant communities
RARE_PLANT_COM – refers to rare plant communities
RARE_PLANT_POP – refers to rare and threatened plant populations
KOALAHAB – refers to blocks containing koala release areas

A list of possible examples of information contained within each item follows:

AS2482		**LANDCOVER**
AS2482 = 1130	&	LANDCOVER = built up area
AS2482 = 44010	&	LANDCOVER = Perennial Lake
AS2482 = 44190	&	LANDCOVER = Swamp
AS2482 = 44160	&	LANDCOVER = Salt Pan
AS2482 = 51010	&	LANDCOVER = Sand dune
AS2482 = 51130	&	LANDCOVER = rock = boulder
AS2482 = 60010	&	LANDCOVER = Native vegetation
AS2482 = 65101	&	LANDCOVER = Softwood plantation
AS2482 = 61000	&	LANDCOVER = Native/ pine mix
AS2482 = 65021	&	LANDCOVER = Olive plantation
AS2482 = 65011	&	LANDCOVER = Hardwood plantation
AS2482 = 65060	&	LANDCOVER = Cleared land/crop

CONDITION		**VEG_CONDITION**
CONDITION = 1	&	VEG_CONDITION = natural
CONDITON = 61	&	VEG_CONDITION = unknown/modified

BLOCK_SIZE
BLOCK_SIZE = block size <20ha
BLOCK_SIZE = block size >20ha and <50h
BLOCK_SIZE = block size >50ha and <100ha
BLOCK_SIZE = block size >100ha and <500ha
BLOCK_SIZE = block size >500ha and <2,000ha
BLOCK_SIZE = block size >2000ha and <5,000ha
BLOCK_SIZE = block size >5,000ha and <20,000ha

HABITAT
HABITAT = habitat for 1/3 or more of species modelled

REMNANT_ AREA
REMNANT_AREA = key remnant area

THREAT_HABITAT
THREAT_HABITAT = key threatened habitat area

YTAIL
YTAIL =Yellow-tailed Black Cockatoo Nesting Area

RTAIL
RTAIL = Red-tailed Black Cockatoo Nesting Area

WET_PLANT_COM
WET_PLANT_COM = contains a wetland plant community

RARE_PLANT_COM
RARE_PLANT_COM = contains regionally rare/threatened plant community(s)

RARE_PLANT_POP
RARE_PLANT_POP =contains threatened plant species population(s)

Table 13: Items on the related file

ITEM NAME	WIDTH	OUTPUT	TYPE	N.DEC
BIONO	4	5	B	-
LATIN	80	80	C	
COMMON	70	70	C	-
HABTYPE	2	2	I	-
HABITAT_TYPE	10	10	C	-
SPABR	10	10	C	-

where:
- **BIONO** – refers to the unique identifier number of each vegetation polygon in the final biodiversity layer;
- **LATIN** – refers to the species' latin name;
- **COMMON** – species common name;
- **HABTYPE** – refers to whether the habitat is 1 (predicted), 2 (recorded) or 3 (potential);
- **HABITAT_TYPE** - habitat type in words
- **SPABR** - the species abreviated name input as the variable name for identification in the modelling process.

Example of information in the habitat INFO! relate file

BIONO	=	13
LATIN	=	Hylacola cauta
COMMON	=	Shy Heathwren
HABTYPE	=	1
HABITAT_TYPE	=	Predicted
SPABR	=	shyla
BIONO	=	13
LATIN	=	Acanthiza iredalei hedleyi
COMMON	=	Slender-billed Thornbill
HABTYPE	=	1
HABITAT_TYPE	=	Predicted
SPABR	=	thorn
BIONO	=	13
LATIN	=	Stipiturus malachurus
COMMON	=	Southern Emu-wren
HABTYPE	=	1
HABITAT_TYPE	=	Predicted
SPABR	=	semu

Where BIONO = 13 relates to an individual vegetation block (or GIS polygon) on the final biodiversity layer. Many species have been identified as using the same block as habitat, hence the need for a one to many related data file.

9. REFERENCES

Bennett, A.F. 1990. Habitat corridors and the conservation of small mammals in a fragmented forest environment. *Landscape Ecology* 4(2/3):109-122.

Burkey T.V. 1989. Extinction in nature reserves: the effect of fragmentation and the importance of migration between reserve fragments. *OIKOS*, 55: 75-81.

Carrruthers S. and Smith K. 1996. *Identification of Strategic Linklands for Conservation. A GIS Approach*. Information and Data Analysis Branch, Department of Housing and Urban Development.

Croft, T. and Carpenter, G. (1998). *The Biological Resources of the South East of South Australia. (DRAFT).* Internal Report, Department of Environment Heritage and Aboriginal Affairs.

Croft, T. Carruthers, S. Possingham H. and Inns, B. 1999. *Biodiversity Plan South East of South Australia.* Department of Environment Heritage and Aboriginal Affairs.

Diamond, J.M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. *Biological Conservation*, 7: 129-146.

Fahrig L. and Merriam G. 1994. Conservation of fragmented populations?. *Conservation Biology* 8(1):50-59.

Haila Y. Saunders D. A. and Hobbs R.J. 1993. What do we presently understand about ecosystem fragmentation? in Denis A. Saunders, Richard J. Hobbs and Paul R. Ehrlich (eds) *Nature Conservation 3: The Reconstruction of Fragmented Ecosystems* p 45-55. Surrey Beatty & Sons Pty Ltd.

Heard L.M.B. and Goodwins D.R. (in prep). *A Remnant Vegetation Survey, Floristic Analysis and Mapping for the South East Region of South Australia.* Geographic Analysis and Research Unit, Dept of Housing and Urban Development.

Lindenmayer D.B., Clark T.W., Lacy R.C. and Thomas V. 1993. Population Viability Analysis as a Tool in Wildlife Conservation Policy: With Reference to Australia. *Environmental Management* 17 (6): p745-758.

Possingham H. P.1996. *Regional Biodiversity Plans: a technical template.* Report to Department of Environmental Science. The University of Adelaide. Roseworthy Campus, Roseworthy.

Recher H.F. 1993. The loss of biodiversity and landscape restoration in Denis A. Saunders, Richard J. Hobbs and Paul R. Ehrlich (eds) *Nature Conservation 3: The Reconstruction of Fragmented Ecosystem* p 141-51. Surrey Beatty & Sons Pty Ltd.

Saunders, D.A, Hobbs, R.J. and Margules, C.R. 1991. Biological Consequences of Ecosystem Fragmentation: A Review. *Conservation Biology*, 5 (1): 18-31.

Scougall S.A., Majer J.D. and Hobbs R.J. 1993. Edge effects in grazed and ungrazed Western Australian wheatbelt remnants in relation to ecosystem reconstruction in Denis A. Saunders, Richard J. Hobbs and Paul R. Ehrlich (eds) *Nature Conservation 3: The Reconstruction of Fragmented Ecosystems* p 163-78. Surrey Beatty & Sons Pty Ltd.

Shafer, C L 1991. *Nature Reserves. Island biogeography and conservation practice.* Smithsonian Institution Press, Washington, DC.

Simberloff D, Farr J A , Cox J, Mehlman D.W. 1992. Movement Corridors: Conservation Bargains or Poor Investments? *Conservation Biology* 6 (4): 493-504.