Biodiversity Indicators:

Key Habitats and Conservation Status of Vegetation in the Southern Tablelands, NSW and ACT.

A report prepared by the NSW National Parks and Wildlife Service

Southern Directorate

February 2003

CONTENTS

FIGURES

MAPS

APPENDICES

1. INTRODUCTION

This report is designed to assist in planning for the conservation of biodiversity in the Southern Tablelands and ACT (Figure 1) by providing information on the conservation priorities in this region.

The objectives of the biodiversity indicators project are to:

- Assist Local Councils in land use planning for development by providing additional information on areas of predicted conservation importance, and amending the ecological planning settings presented in the Planning Framework.

- Inform conservation investment strategies such as restoration of degraded native vegetation or replanting by assessing natural values in terms of set conservation targets, consistent with the recommendations of draft Catchment Blueprints for this area.

- Identify areas likely to be important for multiple threatened species and which are potentially high in biodiversity;

- Undertake a pilot project to test the utility of NPWS computer-based tools in informing regional biodiversity protection programs.

This project provides information that will assist the NPWS in achieving its biodiversity conservation goal for this region (see section 2.1 below)

Information in this report can be used to assist in regional planning by local councils and should be considered in the context of the following Planning Framework:

> Fallding, M., (2002), Planning Framework for Natural Ecosystems – NSW Southern Tablelands and ACT. Natural Heritage Trust, Land and Environment Planning and NSW National Parks and Wildlife Service, Sydney.

The Planning Framework provides a decision-making framework and includes points for consideration in landuse planning and information on the conservation values of the region. The Framework provides a map of areas of known and likely conservation value in the Southern Tablelands and ACT which are classed into "ecological planning settings", (Part 4 of the Planning Framework). The ecological planning settings have been developed to assist in land-use planning at a regional scale. The Planning Framework also provides profiles on ecological sub-units of the study area termed landscape management units. These units have been delineated on the basis of broad vegetation, geological and topological characteristics. Landscape management units have been developed to assist land-use assessment, design and management decisions at a sub-regional scale.

The Biodiversity Indicators project complements the Planning Framework by providing additional information on the natural values of this region. The Biodiversity Indicators project includes a map which replaces the ecological planning settings (Map number P3) in the Planning Framework. The replacement map incorporates additional information on areas of predicted conservation importance. The Biodiversity Indicators project provides additional information on the conservation values of landscape management units which may be used to assist land-use planning decisions at a region-wide this scale.

The Biodiversity Indicators project provides information relevant to Catchment Management Boards and may be used to assist in the implementation of Catchment Blueprints. The study area used in this project covers parts of the Southern, Murrumbidgee, Lachlan and Warragamba catchments as defined in the draft Catchment Blueprints for these areas. The blueprints define a set of conservation targets and regional priorities for each catchment. The study area for the Biodiversity Indicators project does not encompass any one catchment boundary in its entirety, therefore the patterns of conservation significance identified in this study will not be identical to those within the catchments. However, the information on landscape management units may be of assistance in catchment management as they form logical planning units for conservation actions, including many of those identified in the draft Catchment Blueprints.

The Biodiversity Indicators project has used a range of computer software tools developed by NPWS that are designed to be used in combination with a Geographical Information System software package. This project can be viewed as a pilot project to test the suitability of these tools for informing regional scale land use planning. The NPWS seeks to use the Biodiversity Indicators project to generate public awareness of this approach and to encourage discussion on its usefulness in informing catchment management and other regional conservation assessment projects. The methods used by the Biodiversity Indicators project could potentially be applied to whole catchment areas.

2. BACKGROUND

2.1 Biodiversity Conservation Goal for the Southern Tablelands, NSW and ACT.

The NPWS biodiversity conservation goal for the ACT and Southern Tablelands is to improve the viability of threatened and rare flora and fauna, and rare and endangered ecological communities by allowing existing genetic interchange to continue, and improving connectivity in the landscape to potentially increase this interchange.

This project provides a number of measures of habitat fragmentation and identifies regional fragmentation patterns in order to inform conservation priorities. Increasingly, landscape conservation assessments have focused not only on habitat presence and absence, but also on the spatial arrangement of this habitat. Fragmentation of native vegetation may have the following effects:

- Habitat removal maybe so extensive that sufficient resources to sustain viable fauna populations are no longer present.
- Some fauna species may not be able to access critical resources in fragmented and isolated habitats due to an inability to cross large areas of non-habitat.
- Genetic exchange may be inhibited between individuals of the same species occupying isolated patches.
- Dispersal of new individuals into unoccupied patches may be inhibited which may, over time, cause a reduction in a species range and population decline.
- Smaller patches, having a greater boundary in proportion to their area, may be subject to more disturbance per area than larger patches.
- Ecosystem processes in the landscape such as water and nutrient cycles may be altered over time.

The NPWS considers that, in order to meet this conservation goal in the Southern Tablelands, a minimum of 30% of the original native vegetation cover should be managed for biodiversity protection (IUCN reserve categories I to IV (IUCN 1994)), with an additional 40% retained in the landscape. In order to meet conservation objectives, the remaining 40% of native vegetation would require management that is sympathetic to the persistence of biodiversity, such as retention for salinity or water quality management (IUCN category VI (IUCN 1994)). Sympathetic management may not be inconsistent with low to moderate intensity agricultural or natural resource exploitation such as grazing at low stocking rates or selective logging. This target sets the acceptable limit on development to 30% of the region. This native vegetation retention target has been adopted by NPWS for Western NSW.

The NPWS position is consistent with the draft Murrumbidgee and Southern Catchment Blueprints, which have adopted a recommendation that a minimum 30% of the landscape be managed primarily for biodiversity conservation and/or landscape conservation purposes.

Ideally, vegetation should be retained at the target level consistently across the bioregion to ensure connectivity between remnant vegetation is maintained, and to ensure biodiversity is adequately sampled across changing environments (NPWS 1999a). However, there is currently 53% of the original vegetation cover left in the study area. Some landscape management units within the study area have high native vegetation cover (over 90%) while others have a native vegetation cover of less than 30%; well below the NPWS retention target. In order to meet the NPWS target, the revegetation of almost 300,000 ha would be required. Constraints on meeting this goal include the cost of revegetation works, existing landuse practices and zonings, tenure and development pressure. Cost effectiveness of revegetation works would vary between localities depending on factors such as the condition of the environment and threatening processes. It is likely that in areas that have been extensively cleared, substantial biodiversity loss may have occurred. These areas may be less of a priority for conservation actions than areas with higher current biodiversity values.

The biodiversity indicators project provides information on the conservation status of vegetation and on key habitats which will help in the allocation of resources across the study area to regions where they are most likely to be effective. Once the priority areas have been identified, further action in these areas can be planned in the context of existing landuse zonings, development pressures and current levels of vegetation and biodiversity protection and vegetation condition.

2.2 Objectives of the Biodiversity Indicators Project

The objectives of the biodiversity indicators project (as stated in the Introduction) are to:

- Assist Local Councils in land use planning for development by providing additional information on areas of predicted conservation importance, and amending the ecological planning settings presented in the Planning Framework.

- Inform conservation investment strategies such as restoration of degraded native vegetation or replanting by assessing natural values in terms of set conservation targets, consistent with the recommendations of draft Catchment Blueprints for this area.

- Identify areas likely to be important for multiple threatened species and which are potentially high in biodiversity;

- Undertake a pilot project to test the utility of NPWS computer-based tools in informing regional biodiversity protection programs.

3. BIODIVERSITY INDICATORS ASSESSMENT METHODOLOGY

3.1 Justification of the Methodology

The analysis has four main components: vegetation analysis, fauna habitat analysis, linkages analysis and synthesis of data into ecological planning settings. Figure 2 provides a flow chart of the steps involved in the Biodiversity Indicators analysis.

This project relies on four surrogates for measuring biodiversity; vegetation (forest ecosystems), predictive models of fauna habitat, wetlands and old growth forest.

The vegetation analysis is predominantly based on forest ecosystems mapping. Forest ecosystems mapping classifies vegetation communities on the basis of associations between flora species. This project assumes that variations between forest ecosystems reflect variations in the species composition of other flora and fauna species that make up these communities. The assumption is that by conserving samples of each vegetation system, the suite of biodiversity (species, ecosystem and genetic diversity) is also conserved. The term “comprehensiveness” is used in this project to describe the state where examples of forest ecosystems are protected.

The adequacy of forest ecosystems as a surrogate for biodiversity has not been analysed for all fauna and flora groups in Southern NSW, however they have been found to be a poor surrogate for invertebrates (Australian Museum 2000). In order to improve the usefulness of Forest Ecosystems as a surrogate the Biodiversity Indicators project combines this data with other surrogates.

The fauna analysis uses predictive habitat models as indicators of threatened species habitat. Consistent information on the presence or absence of fauna species across the landscape is often lacking, and predictive models of species occurrence have been developed as an alternative to species records.

The approach used in this project assumes that habitat value is a function of the resources available for a species at any given point in the landscape and the ability of a species to access those resources. For example, an area that is remote from other habitat and difficult to access for a given species would be ranked lower than another habitat patch with the same resources but which is well connected. Habitat quality may also be affected by habitat patch size, as small patches may not provide sufficient resources to sustain a resident individual and may be subject to greater disturbances, which in turn can lower habitat quality. Terms such as “accessible” and “small” are of course relative factors which will vary depending on what species is being considered.

This project has refined fauna habitat models by measuring habitat patch size and habitat connectivity at six different spatial scales, representing the way different fauna assemblages may be utilising the environment. The resulting layer essentially ranks habitat patches according to how well they are likely to function as effective habitat in the landscape context.

3.2 Study Area

The study area for this project includes the ACT and extends across the following seven LGAs surrounding the ACT: Mulwaree, Gunning, Yarrowlumla, Yass, Goulburn and

Cooma-Monaro (north) (17,000km^2). This study area was selected due to the wealth of biodiversity data available in this region, particularly on native grasslands and woodlands. The areas is one of high conservation importance and is experiencing relatively rapid population growth and associated development pressure.

The study area incorporates 18 landscape planning units. These subregions within the study area (Figure 1) have been delineated on the basis of broad vegetation, geological and topological characteristics. These form logical planning units for conservation actions. The units have overlapping characteristics and the boundaries reflect transitional zones rather than distinctive changes in ecological characteristics.

An overview of the natural ecosystems, trends in their use and pressures operating in this study area are provided in the Planning Framework.

3.3 Vegetation Analysis: Conservation status of vegetation

3.3.1 Refinement of Vegetation Data

The data sets used to measure the conservation status of native vegetation are listed below. The data sets have been mapped for the whole of the study area unless otherwise specified.

a) Pre-1750 - Modeled Forest Ecosystems (NPWS CRA Project data, Thomas *et al* 2000)).
b) Extant Vegetation - Modeled Forest Ecosystems (NPWS CRA Project data, Thomas *et al* 2000) – extant vegetation.
c) Additional Woodlands and Grasslands Mapping - Satellite imagery-derived native grasslands and fragmented grassy woodlands mapping.
d) Mapping extent: Approximately 80% of the area. The extent of this mapping is shown in Figure 4.
e) (Data collected for NPWS Planning Framework project, ERIC 2001).
f) Landscape Management Units (Figure 1), (data collected for NPWS Planning Framework project, ERIC 2001).
g) Reservation status layer. This differentiated between reserved land (IUCN categories I to IV), unreserved native vegetation and cleared land. Areas included in the reserved category were State Forests of NSW FMZ 1 and 2, NSW NPWS estate, Environment ACT reserves and areas under voluntary conservation agreements.

Figure 2 gives an overview of the method of analysis used to assess the conservation status of vegetation.

The modeled forest ecosystems layer (described under b) above) excludes areas of woodlands with sparse (<30%) canopy cover, patches of woodland or forest under 10ha in size and native grasslands. The satellite image-derived data detected native vegetation of patches 1 ha or greater but did not provide floristic information. The areas of native vegetation mapped in the satellite image-derived data were allocated forest ecosystems using the pre-European forest ecosystems layer. This was combined with the extant vegetation forest ecosystems layer to form a revised extant vegetation layer.

A map of areas likely to be disturbed vegetation was also derived. Modeling information on pre-1750 vegetation predicted that, based on factors such as geology and topographic position, these areas were likely to have supported forest, whereas the satellite-derived data indicated these areas now support woodland or grassland. Two explanations are possible for this discrepancy in the data: either the pre-1750 modeling is inaccurate and the areas did not previously support forest, or what was once forest has now undergone substantial canopy disturbance, altering the structure to woodland or grassland. These areas were considered priorities for further investigation, as they are potentially suitable for natural forest regeneration and restoration programs. The data from these areas was therefore considered separately. This data set does not provide a comprehensive map of disturbed vegetation within the study area. The forest ecosystems that were included in the disturbed layer are listed in Appendix 1.

The pre-1750 forest ecosystems, revised extant forest ecosystems, disturbed vegetation and landscape management unit data were used to examine vegetation cover and fragmentation (section 3.3.2) and comprehensiveness (section 3.3.3).

Metadata statements regarding the above data layers are provided in Appendix 2.

3.3.2 Native vegetation cover and fragmentation

Comparisons were made between the original extent of native vegetation and extant vegetation. The aim of this analysis was to provide a regional overview of patterns of native vegetation cover and fragmentation. This analysis examined native vegetation as a whole and did not differentiate between different native vegetation communities. The extent of clearing and percentage of extent vegetation comprised of patches between 10-50 ha, under 10 ha and under 1 ha was calculated for the study area in total and for each landscape management unit.

3.3.3 Comprehensiveness

Conservation status of each forest ecosystem was measured by examining the extent to which each forest ecosystem had been cleared since European colonisation and by measuring each forest ecosystem against the two conservation targets outlined in section 2.1 above. These targets are: a biodiversity protection target of 30% of pre-1750 vegetation and a retention target of 70% of pre-1750 vegetation. The retention target was mapped over extant vegetation, disturbed vegetation and cleared land to provide information on the conservation value of existing vegetation and to assist in setting priorities for restoration and revegetation. NPWS software was used in combination with a Geographical Information System software package ArcView 3.2 (Environmental Systems Research Institute Inc.) to produce the indices and maps.

Further explanation of how these indices were derived is provided in Appendix 2

3.4 Key Fauna Habitats

3.4.1 Identifying key habitat from species models

Probability maps of species habitat were used to determine what areas in the landscape were most likely to be of importance for species that are sensitive to habitat fragmentation. Habitat maps were analysed and refined using NPWS software. The stages involved in developing this layer are shown in Figure 2 and outlined below.

a) Selection of species' habitat models

Species were selected to represent each of the major ecosystems in the study area and which were likely to be indicators for a greater number of species of conservation importance. This included threatened species (listed under the NSW *Threatened Species Conservation Act 1995*) and common species. The predictive habitat models are based on environmental data and what is known of species habitat requirements. Some of the more widespread, common species habitat models are confined to selected habitat components (such as nesting habitat or high quality foraging habitat) rather than all areas where this species may be found. Species models for 29 species were used. Appendix 3 lists the species models used in this project and the environmental parameters used to derive them.

Habitats suitable for wetland dependent birds were not considered in this section of the analysis but were considered separately (see section 3.4.2).

b) Building Species Assemblages

Models were grouped into species assemblages (groups of species) according to geographical overlap of distribution using the NPWS software PatnMap. Six assemblage maps (grids) were derived and each assemblage grid was graded from high value habitat (those areas likely to support most of the species from a single assemblage) to lower value habitat (likely to support only a small proportion of the species from a single assemblage).

c) Determining optimal spatial configuration of habitat

The assemblages were further refined to take into account species requirements for habitat patch size and proximity to other habitat patches. The NPWS software uses a "neighbourhood analysis" to look at the context of each habitat patch in relation to other habitat patches. The neighbourhood analysis examines small regions within the assemblage grid and allocates new values to that region based on the average of the values of the component cells. The effect is that where core habitat is within small, isolated patches the relative value of that area will be lower than core habitat in larger, well connected patches. Whether or not a patch of habitat is considered isolated or well connected depends on the parameters used in the neighbourhood analysis. To reflect the different spatial scales with which species utlise the landscape, a different set of parameters was selected for each assemblage. For instance, small grassland-dependent reptiles are likely to move only short distances between habitat (<1km) but are able to utlise small patches (<1ha), whereas a species such as the heath monitor is much more mobile but requires very large (>500ha) habitat patches. Accordingly, different parameters were set for the neighbourhood analysis on each assemblage. These parameters are listed in Figure 7. The resulting grids were essentially refined habitat grids that represented not only the resources likely to be available to species but the ability of a species to access those resources.

Core habitat within the final assemblage grids was defined as areas where the majority of species of that assemblage were predicted as likely to occur. This was determined using by overlaying the original species habitat models over the modified assemblage grids and checking the results against expert opinion regarding likely species occurrence.

d) Defining Core Habitat

In the final stage the modified assemblage grids were combined to form a single layer of optimal spatial arrangement of habitat. The combined assemblage map was formed by retaining the maximum values from each assemblage grid. For example, if a given location was ranked as low value in the grasslands assemblage grid and of intermediate value in the woodlands assemblage grid, the intermediate value would be retained. Consequently, if an area was predicted to be core habitat for any assemble this information is retained in the combined assemblage map. The resulting map does not differentiate between areas that are predicted to be core habitat for multiple assemblages and those that are predicted core habitat for only one assemblage. Core habitat is defined as those areas which are predicted to contain most species from at least one assemblage.

3.4.2 Additional Key Habitats: Wetlands and Old Growth

Certain wetlands in the study area were identified as core habitat because of their known value for wetland bird species. Mapping sources for wetlands were NPWS 1993 and Environment Australia 2001. NPWS data records of wetland birds of conservation significance were obtained from NPWS Wildlife Atlas and Southern NSW CRA data.

Old growth forest is defined here as forest which is ecologically mature and where the effects of disturbances are now negligible. The candidate old growth forest was sourced from the Broad Old Growth Mapping project (BOGMP) (NPWS unpublished CRA data). The BOGMP in Southern NSW involved rapid aerial photograph interpretation (API) of growth stage and disturbance characteristics over forested land, and ground truthing. The methodology was the same as that applied in the BOGMP in northern NSW (NPWS 1999b). This layer was identified using aerial mapping interpretation and covers NSW but excludes the ACT.

3.5 Incorporating Biodiversity Indicators Data into Planning Settings

Map P3 in the Planning Framework divides the study area into four ecological planning settings (described in section 4.3 of the planning framework). The four categories reflect differing regional conservation values, and were based on information on known and likely presence of threatened species and endangered ecological communities.

Planning setting A: areas of known conservation importance,
Planning setting B: areas predicted to contain endangered ecological communities and threatened species habitat (for those species identified as having the highest priority in the context of the planning framework);
Planning setting C: areas containing forest ecosystems that may contain threatened species habitat and or minor areas of endangered ecological communities.
Planning setting D: Areas known or predicted to have relatively limited natural habitat values.

Additional areas of predicted threatened species habitat were derived during the biodiversity indicators project. These were combined with the data on predicted areas of conservation importance in the Planning Framework (planning setting B), and a new planning setting B was derived. The revised planning setting was used to derive an amended ecological planning settings map.

4. RESULTS

4.1 Vegetation Analysis: Conservation status of vegetation

4.1.1 Native vegetation cover and fragmentation

The landscape management units and extent of vegetation cover is shown in Figure 1.

Figure 3 shows the percentage of each landscape management unit comprised of mapped native vegetation and the proportion of this vegetation that occurs in small (10ha and 1ha) patches. Figure 4 maps vegetation cover across the study area, with pie charts illustrating the percentage of vegetation that occurs in patches <10ha, 10-50ha and over 50ha. The relative size of the pie charts represents the percentage of native vegetation cover in each landscape management unit, from the smallest (Yass) with less than 20% vegetation cover, to the largest (Taleganda) with greater than 90% vegetation cover.

4.1.2 Comprehensiveness

The results of the comprehensiveness analysis are presented in Figure 5 and the Map series FE 1 –FE 5. Figure 5 can be used in combination with the FE map series to yield information on each forest ecosystem and the extent to which these have been cleared or have met the conservation targets.

As described in Section 3.3.3, different measures are used to represent the vegetation data. One is an absolute measure of clearing extent of each forest ecosystem (Clearing Extent). The remaining four measures are indices of the conservation status of each forest ecosystem in terms of the NPWS vegetation targets (a biodiversity protection target of 30% of pre-1750 vegetation and a retention target of 70% of pre-1750 vegetation). A graphical explanation of how the indices relate to vegetation cover is presented in Figure 6.

Clearing Extent: (Percentage of each forest ecosystem that has been cleared since 1750). The percentage values reflect the extent to which the original extent of each forest ecosystem has been cleared, with a score of 90% indicating 90% of that forest ecosystem has been cleared, (Map FE1).

Biodiversity Protection Index: (Percentage of the 30% target that has been met). An index showing how well each forest ecosystem is conserved, as measured against a 30% target for protection for biodiversity conservation purposes. A score of 100% indicates 30% of the original extent of that forest ecosystem falls within formal reserves and the target has been met. A score of 0% indicates none of that forest ecosystem is reserved. For example, if 500 ha of a forest type existed within the study area in 1750 the target area for biodiversity protection would be 30% of this area, or 150ha. If 75 ha of this forest ecosystem was currently reserved, the biodiversity protection index would show that 50% of the target has been met (Map FE2).

Vegetation Retention Index: (Percentage of the 70% target that has been met). An index showing how well each forest ecosystem meets the target of 70% retention of pre-1750 distribution across the landscape. This index gives an indication of clearing extent (similar to the Clearing Extent shown in map FE1) but measures clearing against a target rather than providing a figure of total clearing extent. A score of 100% indicates that the target has been met and 70% of that forest ecosystem is retained in the landscape. A score of 1% indicates the forest ecosystem has been almost entirely cleared, and only 1% of the target remains. As this index is mapped over extent vegetation only, forest ecosystems that have been completely cleared are not shown (Map FE3).

Retention Index (Disturbed Vegetation): (Percentage of the 70% target that has been met, mapped on areas which are likely to have undergone substantial canopy disturbance). As for the vegetation retention index, this gives an indication of how well each forest ecosystems meets the 70% target, however the results are mapped only on areas that have undergone substantial canopy disturbance, (Map FE4). (See Section 3.3.1 for a description of the disturbed vegetation data set).

Revegetation Index: (The percentage of the 70% target that requires revegetation if the target is to be met. The index is displayed on areas which are currently mapped as being cleared or comprised of exotic vegetation). This index is a reversal of the retention index: it indicates how much is required to meet the target vegetation level rather than how far each forest ecosystem falls undertarget. The higher the percentage in the revegetation index, the greater the revegetation required to meet the target. For example if the original extent of a forest ecosystem was 100 ha the target area to be retained would be 70ha. If only 7 ha of this forest ecosystem remained, this forest ecosystem would score 90% on the revegetation index, as 90% of the target would require replanting. Conversely, where a score of 0% is mapped, this indicates that the forest ecosystems that were once present are well retained elsewhere (with over 70% of the original extent remaining in the study area). This index can be used to identify parts of the landscape which were once occupied by forest ecosystems which are now extensive cleared and to inform decisions about where revegetation might be a priority, (Map FE5).

4.2 Key Fauna Habitats

[The current key habitat map requires refinement using an expert panel prior to being released.]

4.2.1 Spatial configuration

Optimal spatial configuration is presented in Map KH1. Habitat is differentiated into:

- Predicted threatened species habitat: These areas are likely to contain habitat for at least one threatened species;
- Predicted core habitat for threatened species: These areas are likely to contain the majority of species from at least one of the fauna assemblages listed in Figure 7. Core habitat is likely to be sufficiently well connected to provide habitat resources and be of a sufficient size to support these species. These core habitat areas have a high likelihood of containing significant biodiversity value.

Maps showing the habitat for each of the 6 fauna assemblages are presented in maps KH2 to KH7.

4.2.2 Additional Key Habitats: Wetlands and Old Growth

Wetlands are presented in Map KH1. Wetland-dependent threatened bird species recorded on or within 1 km of these wetlands are: Freckled Duck, Australasian Bittern, Black-necked Stork, Magpie Goose and Blue-billed Duck. Other regionally significant species have recorded in these areas including those listed on the China - Australia Migratory Birds Agreement: Sharp-tailed Sandpiper, Marsh Sandpiper and White-bellied Sea Eagle (NPWS Wildlife Atlas and Southern CRA unpublished data).

The candidate old growth forest layer is shown in Map KH1.

4.3 Incorporating Biodiversity Indicators Data into Planning Settings

A revised layer for planning setting B has been used to produce Map P3A in this report and should be used to replace Map P3 in the Planning Framework.

5. DISCUSSION

The information presented in this report is intended to assist in biodiversity conservation and land use planning in the Southern Tablelands and ACT by providing information on the conservation values and priorities in this region.

Map FE1 shows the extent of clearing of forest ecosystems in the study area and is likely to be the most useful vegetation map for local councils. These maps, in conjunction with Figure 5 allow a comparison between the conservation status of forest ecosystems in the different landscape management units and can inform landuse planning at a regional level.

Maps FE2 to FE4 show the degree to which extant vegetation meet targets for biodiversity protection and vegetation retention. The indices are mapped on extant vegetation, disturbed vegetation and on cleared land. These maps may be of most use to those preparing and implementing natural resource management plans such as Catchment Blueprints. The maps may be used to guide priority setting for projects which focus on voluntary environmental protection, enhancement or restoration on private and public land. Relevant programs include education and extension schemes such as Farming for the Future, protection mechanisms such as Land for Wildlife, Voluntary Conservation Agreements, Property Agreements, Wildlife Refuges and restoration programs conducted under Bushcare and Landcare.

The key habitats map KH1 identifies areas likely to provide threatened species habitat and may be a useful indicator of areas of high biodiversity. The key habitats map combines data from each of the 6 fauna assemblage maps (Maps KH 2 to 7). Key habitats are areas of predicted conservation importance and are consistent with planning setting B in the Planning Framework. While all areas mapped are likely to be of significance to threatened species, those areas mapped as core should be considered as highly significant and of primary importance for biodiversity protection

5.1 Conservation status of vegetation

5.1.1 Limitations of the vegetation data

It is important to note that the assessment of likely conservation values presented in this report have been made independent of information on the condition of these remnants. Site condition factors such as degree of disturbance and presence or absence of many key habitat resources (such as hollow bearing tress or understorey) was not available for the study area. An assessment of vegetation condition is required to confirm the suitability of areas for conservation programs.

The forest ecosystems layer has been mapped using a combination of field sampling and ecological modelling and as such represents a likelihood or probability that forest ecosystems occur at the specified locations. Consistent with ecological planning setting B in the Planning Framework, field checking is required to determine whether a site contains the forest ecosystem predicted in this report.

The effectiveness of Forest Ecosystems as a surrogate for biodiversity is likely to be improved if conservation efforts aim to preserve examples of forest ecosystems across their geographic range (Australian Museum 2000).

Woodlands with sparse (<30%) canopy cover, patches of woodland or forest under 10ha in size and native grasslands have been mapped for the central section of the study area but have not been mapped for the far western and far eastern section of the study area. The area outside the refined woodland and grasslands mapping region is illustrated in Figure 4. Information on vegetation and habitat values provided in this report is less accurate for areas outside of the additional grassland and woodlands mapping. The landscape management units Taralga, Yass and Marulan are most affected, and to a lesser degree the High Country and Wee Jasper units.

Vulnerability of remnant vegetation to threatening processes has not been considered in this report. When setting the priorities for conservation actions, it will be necessary to consider conservation values in the context of the threatening processes operating within the study area. For example, areas of high conservation value that have little likelihood of being disturbed are likely to be a lower priority for formal protection than areas where competing land use pressures exist. Some information on land use pressures in the study area are provided in the Planning Framework.

5.1.2 Native vegetation cover and fragmentation

Figure 3 and 4 illustrate regional differences in clearing patterns over the Southern Tablelands. These analyses look only at native vegetation cover independent of floristic data, but provide a useful overview of patterns of fragmentation within this region. The analysis examined the proportion of remaining vegetation occurring in patches of 1ha, 10ha, 10-50ha and over 50ha. Patches of differing sizes were analysed because of the likely effect of patch size on habitat quality. For example, patches under 10 ha have been found to be more likely to be simplified in habitat structure (lacking key habitat elements such as ground logs and shrubby understorey) and have been found to support few woodland birds in the Canberra region (Seddon *et al* 2001, Freudeburger 1999). Patches of 1 ha or less were consider in this study to be likely to be highly vulnerable to disturbance and potentially unviable as fauna habitat without active management.

Of the 17 000 km^2 study area approximately 47% of the study area has been cleared of native vegetation, leaving over 893 000 ha (53%) of native vegetation remaining. Only 4 of the landscape management units have met the retention target of 70% native vegetation cover. These are Tallganda, Tindery and the High Country (all of which contain substantial National Parks and State Forests) and Captains Flat (Figure 3).

Landscape Management Units for which estimated vegetation cover falls between 30-70% are Bungandore, Tharwa, Royalla, Wee Jasper, Marulan, Michelago and Lake George Range.

Those land units where cover of native vegetation has been reduced below 70% are likely to be the most sensitive to biodiversity loss. Ecosystem processes such as pollination and nutrient and water cycles may be at risk of alteration. The persistence of threatened species currently present may be jeopardised if habitat loss and fragmentation continues.

As stated in section 5.1.1 above, native grasslands were not mapped consistently for all landscape management units, resulting in an underestimate of overall vegetation in Marulan, Yass, Taralga, Wee Jasper and High Country landscape management units. Even once this factor is taken into account, the Yass and Taralga landscape management units are likely to fall amongst those units with the lowest proportion of native vegetation cover, with current estimates showing native vegetation cover as 19% and 24% of the original extent respectively. Vegetation cover in the Canberra-Queanbeyan and the Goulburn landscape management units also falls below 30% (Figure 3). These areas also have a higher proportion of the remaining vegetation occurring in patches less than 10 ha when compared to landscape management units with greater vegetation cover (Figure 4). It is likely that the landscape management units that contain less than 30% of their original vegetation cover have suffered substantial biodiversity loss. There are limited opportunities for biodiversity protection in these areas and the conservation objective of 70% vegetation cover is unlikely to be achieved.

5.1.3 Comprehensiveness: Forest Ecosystems

Map FE1 shows the extent of clearing of each forest ecosystem within the study area. Of a total of 106 forest ecosystems remaining in the study area, 16 have had greater than 70% of their original distribution cleared (Figure 5). These ecosystems occupy approximately 107,000 ha (12% of extant vegetation). Not surprisingly, the most under represented ecosystems are grasslands and woodlands occurring on the lower more fertile volcanic soils and flatter areas in the north and north west and follow these landscape features south along the east and west of Lake George Range to Michelago.

Forest ecosystems that have undergone the greatest level of clearing (>90% of their original extent) are concentrated in the north and north west of the study area in Yass, Cullerin and Gunning landscape management units. These forest ecosystems are woodlands dominated by *Eucalyptus pauciflora, E. blakelyi* or *E. melliodora* (Forest ecosystem types 116, 159, 160 and 161). These forest ecosystems fall within the definition of the endangered ecological community White Box/ Yellow Box /Blakely's Red Gum Woodland under the *Threatened Species Conservation Act 1995*.

Forest ecosystems which have >70% of their original distribution cleared predominate in the following landscape management units: Yass, Gunning, Cullerin, Goulburn, Taralga, Bungendore, Canberra-Queanbeyan, Tharwa and Royalla (Map FE1). These areas may be at considerable risk of biodiversity loss in the long term. The majority of forest ecosystems that have undergone more than 70% clearing are grassy woodlands.

Sixteen forest ecosystems have between 30-70 % of their original extent cleared. These make up 376,800 ha and comprise 42% of extant vegetation and are most common in landscape management units Captains Flat, Lake George Range, Gunning, Marulan and Wee Jasper. The majority of forest ecosystems have undergone clearing levels of 30-70% of their original extent are dry forest ecosystems. Some of these have undergone extensive canopy disturbance and now form native grasslands, for example *Eucalptus dives /E. mannifera* dominated forest (Type 113) in the southern half of Marulan landscape management unit.

Seventy-two forest ecosystems have greater than 70% of the original extent remaining in the landscape and make up 46% of extant vegetation. These forest ecosystems predominate in the High Country, Taralga, Wee Jasper and Tinderry landscape management units. Forest ecosystems which have greater than 70% remaining are predominantly wet and dry forests including *E. pauciflora* dominated forests (Types 99 and 100) in the High Country, *E. dalrympleana / E. viminalis* dominated forest (Type 89) in Tallaganda and *E. seiberi/E. dives* dominated forest (Type 112) on ridges in northern Bungendore and central Goulburn landscape management units.

Map FE 2 show the priority areas for biodiversity protection actions, with the biodiversity protection index illustrating the degree to which forest ecosystems require protection in order to meet the 30% biodiversity protection target. The biodiversity protection index can be used to set priorities for voluntary conservation protection mechanisms over native vegetation on private land and for investigating opportunities for reservation of currently unreserved public land.

Over half of the forest ecosystems have met the biodiversity protection target (representing 53% of forest ecosystem types). Protection of forest ecosystems has favored those areas on steeper and less fertile regions and has been biased towards protecting some ecosystems well above 30% of their original distribution whilst many others remain unprotected; 17 forest ecosystems are not represented in reserves. Forest ecosystems that are well reserved typically fall within close proximity to or are within reserves. For example, Michelago landscape management unit is dominated by Tableland Acacia Moist Herb Forest (*Eucalyptus pauciflora/E. dalrypleana/Acacia dealbata*) which is well represented within Tinderry Nature Reserve and also present in Talleganda National Park.

Map FE3 shows the degree to which forest ecosystems meet the 70% retention target. A comparison between maps FE2 and FE3 shows the discrepancies between areas that are well retained within the landscape but which are poorly protected under biodiversity protection mechanisms. Such forest ecosystems may still be of high priority for protection when they occur in areas vulnerable to clearing. For example forest ecosystem 148 -Tableland Tussock Grassland /Sedgeland/ Woodland (*Poa labillardieri / Carex appressa*) occurs in Canberra-Queanbeyan and Bungendore landscape management units, both of which are under high development pressure (Planning Framework). This forest type has greater than 30% of the retention target met but is not represented in reserves.

The retention index (disturbed vegetation) and revegetation index are essentially the same data as that provided in the retention index but are mapped over disturbed vegetation and cleared land respectively. This index is mapped over areas likely to have once been forest and which have been structurally altered, creating woodland or grassland. This index is therefore useful to guide priority setting for restoration works such as fencing and natural regeneration, and for replanting works where the objective is to replace some of the original biota. The retention index (disturbed vegetation) indicates that disturbed forest ecosystems most under target occur in Cullerin landscape management unit, with Marulan, Michelago and Royalla showing 50% or more of the target met. Cleared areas that would contribute most to improving the retention target if revegetated fall within Yass, Taralga and Cullerin, followed by Canberra-Queanbeyan and Gunning landscape management units.

5.2 Key Fauna Habitats

5.2.1 Limitations of the key habitats data

Preliminary field testing indicates the key habitats map is accurate in differentiating between threatened species habitat of lower value (likely to support fewer threatened species) and higher value areas, particularly within the area where additional woodland and grassland mapping as been conducted. Again it must be stressed that that these habitat maps are modeled and only represent the likelihood of the habitat values existing in any point within the study area.

While many areas along roadsides and adjacent to population centres are likely to provide important habitat, these areas are also more vulnerable to disturbances which may reduce their habitat value. It is therefore important to interpret the key habitat data for roadsides and remnants in urban areas in particular with caution until the habitat value of these areas is validated in the field.

The extent of habitat and value of habitat outside of the additional woodlands and grassland mapping (Figure 4) is underestimated for species dependent on these habitats.

The candidate old growth forest layer is provided in map KH1. This data applies to forested landscapes in NSW only and does include information on native vegetation patches less than 10ha or with a canopy cover of less than 30%.

5.2.2 Key Fauna Habitats

[The current key habitat map requires refinement using an expert panel prior to being released.]

Core habitats have been mapped within both well-connected larger vegetation patches and small fragmented areas. The presence of large, well connected habitat is essential for the persistence of many threatened fauna. Other threatened species are known to persist in small grassland and woodland patches but these patches are often subject to disturbances which may impact on the viability of these species in the long term.

Extensive areas of key habitat occur outside of conservation reserves on private land. Core habitat in reserves is highly skewed towards forest habitat in the High Country, Talaganda, Tinderry and escarpment areas in Marulan which are primarily forest and montane habitats, with the predicted habitat for Montane-dependent falling almost entirely within reserves.

The predicted core habitat for forest dependent species falls within existing reserves in the High Country, Tinderry, Tallegana and north and east Marulan landscape management units. Unprotected habitat occurs primarily within southern Marulan, Lake George Range and in scattered areas in Bungendore and Captains Flat. Map KH7 shows those forested habitats that are largest and best connected to other suitable habitats.

Land management units predicted to contain substantial areas of habitat for grassland dependent species are Canberra–Queanbeyan, Gundaroo, Yass, Goulburn and Marulan (map KH6). Some predicted grassland habitat is also present in Tharwa and Gunning. All of these landscape management units have less than 70% vegetation cover and predicted grassland habitat in Canberra-Queanbeyan, Yass and Goulburn landscape management units is particularly fragmented. Map KH1 indicates that predicted core habitat for this assemblage is almost entirely restricted to Canberra-Queanbeyan and Gundaroo landscape management units, however core habitat for grassland species is likely to be more widespread than indicated. (The grassland assemblage model was developed using only 3 species and the mapping of core habitat is consequently highly sensitive to any one species model). It is important to note that very little of the predicted grassland assemblage habitat falls within reserves.

Predicted core habitat for woodland species is partly protected in reserves in the landscape management units Tharwa, Canberra-Queanbeyan and Lake George Range (map KH5). These reserves cover only a small proportion of the predicted core habitat for the woodland-dependent fauna assemblage and often occur adjacent to built-up areas. Predicted core habitat primarily occurs within large, well connected patches of vegetation, often in woodlands which fringe large forested areas such as the Queanbeyan escarpment and Lake George Range.

Predicted grassland assemblage habitat and woodland assemblage habitat falls primarily within two forest ecosystems which have been heavily cleared, with clearing rates of 63% and 74% of original distribution cleared respectively. These forest ecosystems are Northern Slopes Dry Grass Woodland (Type 160, dominant species - *E. blakelii*/ *E. melliodora*/*Danthonia racemosa*/*Austrostipa scabra* spp *falcata*) and type 154 Tableland Dry Grassy Woodland (Type 154, dominant species *E. bridgesiana* and *Themeda australis*). While the forest ecosystems data describe the predicted core grassland-dependent species habitat as woodland, satellite data indicates that these areas are likely to contain both grasslands (areas with less than 10% tree cover) and woodlands (areas with 10% to 30% tree cover).

Predicted habitat for rocky outcrop and escarpment dependent species is well protected in Tharwa and the High Country landscape management units but poorly protected in the Yass and Wee Jasper units. Marulan also contains areas of unprotected habitat on the eastern boundary of the study area, however extensive areas of core habitat for this fauna assemblage occur beyond the study area boundary along the Great Dividing Range, much of which falls within reserve.

6. REFERENCES

Australian Museum, 2000. Evaluation of the effectiveness of derived forest ecosystems as surrogates for invertebrate biodiversity, and identification of hotspots of invertabrate endemism. A project undertaken as part of the NSW Comprehensive Regional Assessments. Australian Museum, Sydney.

Environment Australia, 2001. A Directory of Important Wetlands in Australia. Third Edition, Environment Australia, Canberra.

Fallding, M., 2002. Planning Framework for Natural Ecosystems – NSW Southern Tablelands and ACT. Natural Heritage Trust, Land and Environment Planning and NSW National Parks and Wildlife Service, Sydney.

Freudenberger, D., 1999. Guidelines for enhancing grassy woodlands for the Vegetation Investment Project. Unpublished report, CSIRO Wildlife and Ecology Canberra.

IUCN Commission on National Parks and Protected Areas, 1994. Guidelines for Protected Area Management Categories. IUCN, Gland, Switzerland.

NSW National Parks and Wildlife Service, 1999a. Derived Forest Ecosystems: an evaluation of surrogacy value and internal biological variation. A project undertaken as part of the NSW Comprehensive Regional Assessments. NSW National Parks and Wildlife Service, Sydney.

NSW National Parks and Wildlife Service, 1999b. Old-Growth Forest Related Projects - UNE / LNE CRA Regions. A project undertaken as part of the NSW Comprehensive Regional Assessments. NSW National Parks and Wildlife Service, Sydney.

NSW National Parks and Wildlife Service, 1993. Metadata Statement For The Wetlands Of The Murray-Darling Basin Series 2 Coverage. Unpublished report, NSW National Parks and Wildlife Service, Sydney.

Seddon, J., S. Briggs and S. Doyle, 2001. Birds in woodland remnants of the central wheat/sheep belt of New South Wales. Report to the Natural Heritage Trust. NSW National Parks and Wildlife Service, Sydney.

Thomas, V., N. Gellie and T. Harrison, 2000. Forest Ecosystem Classification and mapping for the Southern CRA region, Volume II. A report undertaken for the NSW CRA/RFA Steering Committee, NSW National Parks and Wildlife Service, Sydney.