Narrawallee Nature Reserve

Vegetation Survey and Mapping 2004

prepared by

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June 2004

APPENDICES

1 INTRODUCTION

This report describes the methodology, results and conclusions of the vegetation survey and mapping of forest ecosystems of Narrawallee Creek Nature Reserve, in the Ulladulla Area of the South Coast Region. The report has been prepared by **ngh**environmental under contract for the NSW NPWS South Coast Region (Ulladulla Office). The project has also covered Conjola National Park and the adjoining extensions of Morton National Park to the north, which are documented in a separate report. A report on the establishment of fire response monitoring plots in both Narrawallee and Conjola/Morton has also been prepared, based on work undertaken during this project.

1.1 Background

During the Southern Comprehensive Regional Assessment (Southern CRA) in the late 1990s, a major project was undertaken to map vegetation types using full floristic site data, aerial photographic interpretation and modelling using climatic and physical environmental data. The project covered a large area within the Southern Directorate, part of which is the South Coast Region, covering all land tenure types. Methodology was previously developed for the Eden CRA and documented in a systematic review of forest ecosystem types, extent and conservation significance by Keith and Bedward (1999). A new classification and modelling methodology was developed for the Southern CRA and documented by Thomas, Gellie and Harrison (2000), which was heavily based on mapping by air photo interpretation.

Validating and where necessary re-mapping modelled forest ecosystems is necessary for conservation management of land within the National Parks Estate. This achieves a greater degree of detail and reliability that is necessary to support aspects such as pest and fire management, threatened species management and ecologically sustainable forest management. Methodology for this validation process was developed in 1999 by Nicholas Graham Higgs Pty Ltd (now **ngh**environmental) and has been applied in stages for the whole of the NPWS Estate in the Merimbula and Bombala areas together with Kooraban and Gulaga National Parks of the Far South Coast Region. Within the South Coast Region, a similar project was undertaken in 2001-2002 for the Ulladulla Office of NPWS covering Murramarang National Park and related offshore islands, Meroo National Park and Barnunj State Recreation Area.

This report is the result of the adaptation and application of previously used methodologies for the sampling and re-mapping of forest ecosystems in the Ulladulla Area. The project has involved field mapping, database entry of field data, air photo interpretation and GIS mapping as means of validating the modelled map by Thomas, Gellie and Harrison (2000) and preparing a revised map based on these findings.

1.2 Objectives

The aims as specified in the project brief are to:

- Carry out plot-based, full-floristic field surveys in Narrawallee Creek Nature Reserve, Cudmirrah and Conjola National Parks and the Morton National Park eastern additions;
- Prepare a field validated vegetation map for the study area identifying the dominant canopy and understorey vegetation associations and;
- Establish fire response monitoring plots to compliment and enhance existing operational sites for incorporation into the Vegetation Response to Fire Monitoring Project and state-wide database at sites selected as being appropriate.

The overall objective of the work is to provide a vegetation data set which includes floristic site data and updated vegetation maps of Conjola National Park, the eastern extension of Morton National Park and Narrawallee Creek Nature Reserve, with special reference to forest ecosystems of conservation management significance, supported by documentation of the methodology used and results obtained.

Specific objectives in the work were:

- to identify sites for floristic surveys to complement existing CRA data and to provide a basis for ongoing fire response monitoring;
- to sample important ecosystems that are vulnerable, rare, under-represented in the reserve system or fire sensitive;
- to undertake full-floristic plot sampling and provide an inventory of vascular flora from each of the plots and other environmental data as specified, including additional data for those sites established for fire monitoring purposes;
- to provide revised vegetation maps of the study area according to project specifications;
- to provide two reports on the vegetation mapping work, one for Narrawallee Creek Nature Reserve and one for Conjola and Morton National Parks, with recommendations for managing rare or fire-sensitive vegetation associations and
- to provide a report on the fire response monitoring sites.

1.3 Project Requirements

The following requirements were specified in the project brief.

Standard floristic survey sites:

- In conjunction with NPWS staff and using a gap analysis method, identify 15 sites to undertake plot-based, full-floristic surveys to complement existing CRA site data.
- Undertake full-floristic plot-based sampling using the standardised botanical plot sampling methodology such as that used during the CRA including permanent plot and photo-point establishment at each site.
- Provide an inventory of vascular flora and relevant environmental data from each of the plots, ensuring that the full range of important ecosystems or vegetation associations that are vulnerable, rare, under-represented in the reserve system or fire sensitive are sampled. Detailed notes made of fuel loadings and unusual, unique or interesting features found on or near plots are also required.

Fire response monitoring sites:

- In conjunction with NPWS staff, select at least 12 fire response monitoring sites (in both burnt and unburnt areas) in a range of vegetation types, where possible selecting sites with rare or threatened plant (ROTAP) species and/ or areas of highest fire risk potential. These sites may overlap with the full-floristic sites established to validate the CRA forest ecosystem mapping or be sites where full-floristic plots were measured during the CRA;
- Undertake full-floristic plot based sampling as per methodology described in Section 5: Methodology – Systematic Survey.
- Establish photo points at each monitoring site; and,
- Provide a stand-alone report of the work outlining the basis for selection of monitoring sites, description of location and fire history of each site including map, photographs of each site and full floristic or plant species fire response and fire fuel sampling sheet(s) for each site. The report is to be a stand-alone document containing a full set of maps, tables, appendices and photographs.

Mapping:

- Using the Southern CRA forest ecosystems classification and existing forest ecosystem mapping as a basis and guide, and other Southern CRA ecosystem-related datasets provided by NPWS, prepare a validated hard copy and digital vegetation map at a scale of 1:25,000 for each reserve. This is to include floristic data collected from the 20 (approx) existing sites created from the CRA and data collected from the 40 canopy plots set up by

the CSIRO and associated Kevin Mills and Associates Pty Ltd survey (The Vegetation of Cudmirrah National Park, Conjola National Park, Cudmirrah Nature Reserve). This information will also be provided by NPWS.

- A revised and reliable extant forest ecosystems map is to be prepared for the study area utilising pre-existing information as specified above and information collected in the field surveys component of this project.
- The contractor is expected to have available and utilise a sophisticated level of GIS capability and that is ESRI ArcView compatible.

Reports:

- Prepare two project reports, one for Narrawallee Creek Nature Reserve and another for the Conjola/Cudmirrah and Morton National Park (eastern addition) including recommendations for managing rare, vulnerable or fire-sensitive vegetation associations. The reports are to be stand-alone documents containing a full set of maps, tables, appendices and photographs.

1.4 The Study Area

The study area lies north of the town of Ulladulla and east of Milton on the NSW South Coast. It extends inland from the coastline for up to five kilometres to meet rural land on the coastal lowlands spanning the Princes Highway. Further to the west lies the cliff-lined plateau escarpment of the large Morton National Park. Narrawallee Creek Nature Reserve and Conjola National Park to the north, surround much of the large Conjola Lake and several smaller lakes and lagoons, extensive coastal forests and portions of the coastline. The small villages of Narrawallee to the south and Conjola Lake to the north, together with associated coastline, are excluded from the nature reserve.

Narrawallee Creek Nature Reserve has existed since 1986 as a relatively small coastal nature reserve. As an outcome of the Southern Regional Forest Agreement, the reserve was expanded in 2001 to include land to the north west and some smaller portions along Narrawallee Creek in the south west and south. The area of the reserve is 875 ha.

Conjola National Park and the adjoining eastern extensions of Morton National Park lie to the north of Lake Conjola and the vegetation survey for these areas is documented in a separate report. The study area referred to in the remainder of this report, therefore, refers to the Narrawallee portion only.

The study area is underlain by sedimentary rocks of varying ages. The Sydney Basin sediments occupy most of the reserve, with smaller areas of Quaternary or Tertiary sediments occupying low lying areas associated with estuarine environments or freshwater swamps.

The coastline is predominantly fringed by beaches and dunes, broken by the central rocky headland of Buckleys Point. Narrawallee Inlet in the south is a tidal estuary, extending inland for approximately three kilometres where Narrawallee and Croobyar Creeks enter. Pattimores Lagoon in the north is connected to Lake Conjola. Swamps are numerous, both along Narrawallee Creek and Pattimores Lagoon and in flat areas with poor drainage.

Narrawallee Creek Nature Reserve protects large areas of diverse coastal landform, plant communities and animal habitat including coastline, extensive dunal systems, estuaries and important bird breeding and feeding areas at Pattimores Lagoon. The vegetation ranges from dry forests on the ridges and flatter elevated areas, moist forests some of the wetter gullies, to the non-forest communities of the estuarine wetlands, lagoon foreshores, dunes and rocky headland. The rare plant *Pultenaea villifera* has been recorded in the reserve.

The study area has been disturbanced in the past by logging and quarrying but is not dissected to the same degree by roads and powerlines as the neighbouring Conjola National Park. Wildfires have been a major environmental factor influencing the vegetation in the Shoalhaven region and consequently a key factor in conservation and fire management of the parks and reserves, prompting the need for ongoing fire response monitoring of the vegetation. However, NPWS records indicate that extensive wildfires in 1968-69, 1991-92 and the Hylands fire in December 2001, did not enter the majority of the

reserve. This makes Narrawallee Creek Nature Reserve important as a reference area compared to more recently burned areas in Conjola and Morton National Parks.

1.5 Previous Studies

The review of previous vegetation studies documented by Thomas, Gellie and Harrison (2000) lists no studies relating specifically to the vegetation of the study area and no reports directly applicable to Narrawallee Creek Nature Reserve were found during the literature review for this project. The report on the vegetation of the former Cudmirrah National Park and Nature Reserve and Conjola National Park, all now included in the current enlarged Conjola National Park (K. Mills & Associates, 1995) was the closest area studied. This report is of relevance, as the two reserved areas share many vegetation communities, and was used as a source of information on vegetation communities present, their conservation significance and the conservation significance of particular plant species in the region. Mills described and mapped the location of 18 communities including 12 eucalypt forests or woodlands, with the latter including 5 heathy communities (characterised by an open tree cover and understorey dominated by sclerophyll shrubs), and 6 wetland or littoral non-eucalypt communities. A comparison of the Mills' vegetation communities with the forest ecosystem types by Thomas, Gellie and Harrison (2000) is contained in the report on Conjola and Morton (eastern extensions) National Parks.

Conacher Travers (2003) have undertaken flora and fauna impact assessment for development of an area about 1.5 km south of the Reserve, which also provided information about plant communities of significance in the region. They document the presence of the listed Endangered Ecological Community Sydney Coastal Estuary Swamp Forest Complex of the Sydney Basin Bioregion, listed under the *Threatened Species Conservation Act*. This community was also found in the Reserve.

Other vegetation studies which were consulted cover much broader areas, such as the CSIRO canopy survey in the 1990s and the surveys which formed part of the Southern CRA. Floristics data arising from these have been incorporated in the NPWS floristic survey sites database which was used during the present study. The database contains two canopy only sites by CSIRO. A further two partial floristics sites within the study area have been surveyed by Kevin Mills (consultant). The remaining site was part of the Southern CRA floristic surveys and was a full floristic survey.

Comprehensive mapping of the South Coast portion of the Southern CRA study area is documented in the Southern Region CRAFTI report (RACD, DUAP, 2000). This study, which was based on API assessment of forested lands, resulted in structural-based mapping related to growth stage, which was assigned broad floristic type classes This mapping provided a basis for assessing regional conservation status of vegetation communities, identification of old growth, fauna modelling, wilderness assessment and forest ecosystems modelling.

Using the CRAFTI API vegetation mapping as a basis, and drawing on methodology developed during the Eden CRA (Keith and Bedward, 1995, 1998,1999) for forest ecosystem modelling, new methodology was developed and applied to the Southern CRA area to produce a modelled layer of forest ecosystems. The methodology and a summary of vegetation profiles for each forest ecosystem are documented in the report by Thomas, Gellie and Harrison (2000). This modelling has been used as the basis for validation and re-mapping of vegetation in the Ulladulla Area, the Conjola-Morton section of which is the subject of this report.

The results of these CRA projects were used in the process of assessing the representativeness of vegetation types in the reserve system and the adequacy of existing reserves in conserving a range of vegetation types. The CRA provided the scientific basis on which the State and Commonwealth Governments could develop a Regional Forest Agreement (RFA) for the Southern Region of New South Wales. This agreement determined the future of these forests, providing a balance between conservation and ecologically sustainable use of forest resources. The process ultimately led to additions to the NPWS Estate including extensions to Narrawallee Creek Nature Reserve in 2001.

1.6 Forest Ecosystems in the Study Area

Forest ecosystems as modelled by Thomas, Gellie and Harrison (2000), which are represented within the study area, are listed in Table 1.1 below.

Table 1.1: Forest Ecosystems in Narrawallee Creek Nature Reserve

FE Code	Forest Ecosystem Type (Thomas, Gellie & Harrison, 2000)
20	Coastal Hinterland Gully Rainforest
21	Northern Coastal Hinterland Moist Shrub Forest - *C. maculata/E. pilularis*
22/23	Combined Southern Coastal Hind Dune/Headland Scrub and Southern Coastal Dune Scrub Complex
23/26	Combined Southern Coastal Dune Scrub Complex and Coastal Dune Herb/Swamp Complex
24	Coastal Tall Wet Heath Swamp Forest - *Casuarina glauca/Melaleuca ericifolia*
25	South Coast Swamp Forest - *Casuarina glauca*
28	Coastal Sands Shrub/Fern Forest - *E. botryoides/Banksia serrata*
29	Northern Coastal Sands Shrub/Fern Forest - *E. pilularis/Banksia serrata*
186	Mudflats/Saltmarshes
187	Coastal Headland Heathlands

These forest ecosystem (FE) types, based on descriptions by Thomas, Gellie & Harrison (2000), are outlined below.

Eucalypt dry forest types

- Coastal Sands Shrub/Fern Forest – *E. botryoides/Banksia serrata* (FE28), which is largely confined to sand deposits adjoining beaches and coastal lakes. Bangalay (*E. botryoides*) is often the sole canopy species. *Banksia serrata* forms a sub-canopy layer, or shares the canopy with bangalay in low wind-pruned stands. Typical shrubs are *Acacia longifolia, Breynia oblongifolia, Monotoca elliptica* and *Hibbertia obtusifolia*. Burrawangs may be present, and in long unburnt stands a mesophyll element of shrubs and small trees often develops, including *Pittosporum undulatum, Notelaea longifolia, Synoum glandulosum* and vines such as *Hibbertia scandens* and *Cissus hypoglauca*.
- Northern Coastal Sands Shrub/Fern Forest – *E. pilularis/Banksia serrata* (FE29), generally occurs on low foothills below 100m elevation, on Permian mudstones or on deep sand deposits slightly further from the coast than FE28. Blackbutt (*E. pilularis*) is the dominant tree, but it may be joined by many other species (*C. gummifera, Syncarpia glomerulifera, E. botryoides, E. piperita, E. sclerophylla*). *Banksia serrata, Acacia longifolia* and *Allocasuarina littoralis* commonly occur in the understorey, along with tussock plants such as *Lomandra longifolia* and *Lepidosperma laterale*. This type was modelled as occurring extensively in the northern and central parts of the reserve.

Eucalypt wet forest types

- Northern Coastal Hinterland Moist Shrub Forest – *C. maculata/E. pilularis* (FE21), which is found on sheltered slopes and along drainage lines in coastal foothills on Permian mudstone or Ordovician metasediments. Blackbutt and spotted gum dominate the canopy, with a small tree layer including *Syncarpia glomerulifera* and *Acacia mabellae*. Mesic elements such as *Elaeocarpus reticulatus, Synoum glandulosum* and *Notelaea longifolia* occur alongside sclerophyll shrubs like *Persoonia linearis* and *Acacia longifolia*. Vines and ferns are common. It was modelled as occurring within the reserve as only as a sliver of a larger polygon on its western edge.

Rainforest

- Coastal Hinterland Ecotonal Gully Rainforest (FE20). Although widespread in the region, this vegetation type is naturally fragmented, occurring only in situations which are topographically protected from fire, such as sheltered gullies. It is also sensitive to frequent burning. It consists of a mixture of rainforest and wet sclerophyll elements including trees such as lillypilly (*Acmena smithii*), cabbage palm (*Livistona australis*), *Acacia mabellae, Callicoma serratifolia, Elaeocarpus reticulatus* and *Tristaniopsis collina*, and shrubs including *Notelaea venosa, Eupomatia laurina* and *Psychotria loniceroides*. Ferns and vines are a similar mixture of rainforest species, and those more usually found in moist eucalypt forests. Only one occurrence of this type was modelled as occurring within the reserve, in the north west.

Non-eucalypt forest types

- Coastal Wet Heath Swamp Forest – *Casuarina glauca/Melaleuca ericifolia* (FE24). This vegetation type generally occurs in a narrow band around the margins of saline coastal lakes, Diagnostic species are the canopy species *Casuarina glauca*, with an understorey of the smaller tree *Melaleuca ericifolia* and occasional *Myoporum acuminatum*. Groundcover can very from dense stands of sword-sedge (*Gahnia clarkei* or *G. sieberiana*) or other sedges and rushes such as *Baumea juncea* or *Juncus kraussii*, to bare ground. The rampant vine *Parsonsia straminea* may be present. The modelled locations are around Pattimores Lagoon and Narrawallee and Croobyar Creeks upstream of their junction.
- South Coast Swamp Forest Complex – *Casuarina glauca* (FE25). This vegetation type generally occurs in situations which are less saline, and more frequently inundated with fresh water than FE24. It is often a taller forest, with less groundcover of sedges than the preceding type. The vine *Parsonsia straminea* is often abundant. It was modelled as being more extensive than FE2, in the same and other locations.

Non-forest types

- Southern Coastal Hind Dune/Headland Scrub and Southern Coastal Dune Scrub Complex (FE22 and FE23). These two types have been mapped as a complex (coded 2223 in the GIS dataset), since they tend to occur in very small or narrow patches, and are almost always found together. FE23 occurs on the beach dunes and consists of *Spinifex sericeus* and coast wattle (*Acacia sophorae*), while FE22 occurs on the hind dune and consists of coast banksia (*Banksia integrifolia*) with the shrubs *Monotoca elliptica* and *Leucopogon parviflorus* over a groundcover of bracken and spiny matrush (*Lomandra longifolia*).
- Coastal Dune Herb/Swamp Complex (FE26). This type is described as a composite group of disturbed swampy areas within coastal dunes. It was poorly sampled. It has been mapped as occurring as a composite with FE23 (coded 2326 in the GIS dataset) along much of the coastline, extending at a broad band on the northern side of Narrawallee Inlet.
- Mudflats/Saltmarshes (FE186). These occur in the mid-tidal zone of coastal lakes, and are generally dominated by the succulent herb samphire (*Sarcocornia quinqueflora*), with a range of other salt-tolerant herbs, grasses and sedges. It was modelled as occurring in a large patch on the northern side of Narrawallee Inlet close to the mouth.
- Coastal Headland Heathlands (FE187). These are described as tall shrublands dominated by *Allocasuarina distyla* and a number of other shrubs which generally do not occur south of Jervis Bay. Despite this, the vegetation type is described as occurring on rocky headlands as far south as Narooma. The only modelled occurrence of this type in the study area is on Buckley's Point.

Not all of the above forest ecosystem types were found to be present in the study area and a number of additional types were identified which were described by Thomas, Gellie and Harrison (2000) but not predicted to occur in Narrawallee Creek NR. Details are contained in the tables in Appendix 1.

2 METHODOLOGY

2.1 Overview

The purpose of vegetation sampling for the Narrawallee study area was twofold:

- to determine the accuracy of the vegetation maps produced during the Southern CRA, particularly as they relate to vegetation types which are of regional conservation significance or of particular management concern and to make appropriate corrections to the maps based on field validation and air photo interpretation, and
- to collect baseline data from permanently marked quadrats which could be used in the future to assess the impacts of management activities such as deliberate use of fire for asset protection around the coastal villages.

Prior to commencement of the botanical work, the GIS data set for the study areas, supplied by NPWS, was reviewed and assembled to facilitate the selection of sampling sites and for field validation and mapping purposes. A set of field maps was prepared at 1:25,000 scale covering the project area (see section 2.4.1 below). These maps of the modelled forest ecosystems were overlayed with previous and proposed new survey sites, contours, drainage roads and an AMG grid. The new floristic sites were suggested by Mr Phil Craven (Project Officer (ESFM), NPWS, Nowra), based on a gap analysis, and provided a basis for refinement by the project team. A second set of field maps was also prepared using the Southern CRA API (CRAFTI) mapping on the same base as the FE maps. This mapping was also used in the validation process as explained below in sections 2.2 and 2.3.

A meeting of the project steering committee and consultant team was held in October 2003 to plan the approach to the project and to finalise the selection of floristic sampling sites. This process involved taking into account practicalities of access and time to make the field sampling as effective as possible and aimed to establish a permanent set of plots for future reference and monitoring. Approximately 30 full floristic survey sites were initially identified in the combined Conjola-Morton and Narrawallee study areas by reference to the existing vegetation mapping and locations of earlier floristic field survey sites. Of these, about one third were to be fire response monitoring sites. The sites were marked on the field maps which also showed previous (CRA and earlier) floristic survey sites.

Members of the project team, which included botanist (Ms Jackie Miles) together with NPWS Project Manager/Ranger (Ms Libby Shields), visited the project area over a number of days during two weeks in late October 2003. The work involved locating suitable sampling sites, establishing permanent markers, recording quadrat floristics and validating previously-mapped vegetation types. Vegetation sampling took the form of 20 x 20 metre quadrats, nested at one end of a 20 x 50m quadrat. The larger area was used for recording canopy species, although understorey was only recorded from the 20 x 20 quadrat. Quadrat data were recorded on data sheets and later transferred to digital format.

The field maps were used (in addition to the published topographic maps, aerial photos and GPS) for navigation and field orientation, recording of new sampling sites and noting of results of forest type validation. Opportunities were made to check the existing vegetation maps and make corrections when travelling to and from the sample sites. A further visit was made in December 2003 by Mr Phil Kendall to facilitate the re-mapping work, focussing on the coastal and estuarine areas.

For the purposes of classification and re-mapping, it was decided to use the CRA Forest Ecosystems as defined by Thomas, Gellie and Harrison (2000) with minor modifications, rather than adopt a substantially different classification. The existing FE classification appeared to work reasonably well for the vegetation in Conjola and Morton (East) National Parks. However, some of the diagnostic species lists provided by Thomas, Gellie and Harrison, 2000 had to be broadened somewhat to embrace different suites of canopy species. For example, blackbutt (*E. pilularis*) is not listed as occurring at all in Lowland Red Bloodwood-Turpentine Dry Shrub Forest (FE2), yet in the Ulladulla area it seems to be one of the most common trees in this vegetation type. Apart from this single difference the species assemblage of this forest type in the Ulladulla area is very similar to that listed for FE2 by Thomas, Gellie and Harrison. The revised profiles for each forest ecosystem encountered in the study area are included in Appendix 4.

On the basis of the findings of the field work, re-mapping of the forest ecosystems of the study area was undertaken using GIS methodology by Mr Phil Kendall, involving adaptation of the existing mapping, re-mapping some of the area by air photo interpretation, digital capture and processing of

linework and vegetation coding and preparation of new maps for checking and refinement by the project team. This work was done in parallel with preparation of the draft report and in consultation with Ms Jackie Miles.

2.2 Vegetation Sampling Methodology

2.2.1 Floristic Site selection

Ten full floristics quadrats were located in Narrawallee Creek NR. Two of these also double as fire monitoring quadrats, although only one, NARJM04F, was placed in vegetation which had been burnt. The distinction between the two types of quadrat is trivial in quadrats which have not burnt, as the fire monitoring quadrats are full floristics quadrats for which additional information on fire recovery mechanisms is collected. For unburnt quadrats, obviously this cannot be done but information about presence of seedlings, flowering and seed production is also collected, which is omitted from full floristics quadrats. However, the one can readily be converted into the other if the need arises, that is, if the area is burnt. The only difference on the ground is that fire quadrats (distinguished by an F at the end of the site name) are marked by a centrally located permanent steel marker post, while for full floristics quadrats the post was positioned, as requested, in the north-east corner of the plot. This difference could be remedied to make the plots consistent if it is subsequently decided to turn the full floristics plots into fire monitoring plots.

The placement of quadrats was broadly determined by negotiation with NPWS staff prior to commencing work, but some modifications were made during field work to include significant vegetation associations which were discovered to be present, though not mapped. One proposed fire monitoring quadrat requested in coastal heath at Buckleys Point was moved north to a point about 1 km south of Lake Conjola township, as the target vegetation type (heath) was found not to occur on the site, and it was judged that the coastal headland scrub on the site would be unlikely to burn, making a fire monitoring quadrat somewhat redundant. This quadrat (NARJM09F) was shifted into FE29, dune forest dominated by blackbutt (*E. pilularis*), as it was judged that this area was likely to require relatively frequent hazard reduction burning, for which some monitoring of impacts would be valuable.

An additional quadrat (NARJM06) was placed in unusual grassy forest dominated by forest red gum (*E. tereticornis*) south-west of Lake Conjola township in order to document its presence in the Reserve. Another quadrat requested in an area likely to be FE29 was shifted to sample FE175, Northern Coastal Lowlands Swamp Forest - *E. robusta*, since it was considered that this vegetation type was of greater conservation significance and probably under-sampled in the area.

A description of all the quadrats is provided in Appendix 3.

2.2.2 Quadrat survey method

A steel post was driven either centrally (for fire monitoring quadrats) or in the north-east corner of the plot and a metal tag with the name of the plot attached. The posts have a yellow plastic top to assist with relocating them. A GPS reading was taken at the marker post to enable relocation of the plot, using the Australian Geodetic Datum (1966) and UTM projection (Australian Map Grid) in Zone 56. One plot (NARJM08) was not marked with a post. It was only done in order to assist with map validation (the area had been mapped as wetland but was eucalypt forest) and insufficient posts had been carried in to mark it. A conspicuous tree stump was used as the south-east corner of this plot.

20m tapes were run out from the post either to the south and west (on full floristics plots) or for 10m either side of the post on fire quadrats. In the latter case tapes were either parallel and perpendicular to the adjacent access track, or where the track was out of sight tapes were laid N-S and E-W. Site data relating to physical features and disturbance history were recorded, all plants on the quadrat were recorded and assigned a cover abundance score (modified Braun-blanquet score from 1 to 6). An additional 20 x 30m area was checked for the presence of any extra canopy species not recorded in the 20 x 20m quadrat. This methodology is consistent with that employed for Southern CRA surveys.

For fire quadrats additional information was collected on recovery mechanisms of each plant species recorded after fire. The fire response mechanisms were based on those developed by Gill and

Bradstock (1992) and were the same as those used in 28 fire monitoring quadrats established in the Nowra area in 2002 (EcoGIS, 2002). They are outlined in Appendix 5. Where the site had been only partially burnt (NARJM04F) such information was recorded only for those species affected by fire. Information on which species had seedlings present, which were flowering and seeding, were collected on both burnt and unburnt fire monitoring quadrats. Proportion of plants flowering or seeding and numbers of seedlings present were recorded in broad abundance categories

Similar field data sheets to those used for the Southern CRA were used in this survey. The Braun-Blanquet cover abundance scoring system was used to assess the representation of each species in the quadrat. In addition to floristics, data about vegetation structure and age classes present were recorded, as well as physical data of topography, aspect, elevation and geology. A modified and extended version was used for fire response monitoring sites .Blank data sheets are reproduced in Appendix 2.

2.2.3 Photography

Digital photographs were taken of all quadrats. The sign proposed to be used in each photograph to identify the sites was too small to be legible in the photos and was not used. Instead each photo file has been named with the quadrat name and the bearing to the quadrat centre at which it was taken.

For full floristics quadrats three photos were taken, from 1-2m back from the corner peg. One was taken diagonally across the quadrat and one along each tape. The tapes are visible in the photo and generally the tape running south is white and the one running west is yellow. However this may not have been done invariably and if this information conflicts with the photo name then it is the name which is correct.

For fire monitoring quadrats one or two photos were taken. The location from which they were taken was documented on the field recording sheet. It varied depending on the sun angle at the time of day the plot was done and the degree to which vegetation obscured the rest of the plot from each corner. The corner chosen was that which gave the most open view of the plot. In some cases a photo was taken from the end of one of the tapes, not from a corner.

Photos have been provided as .jpg files on the data CD accompanying this report.

2.2.4 Forest Ecosystem Type Validation

Using the plot records, vegetation was assessed as either conforming to the expected species composition for the type mapped in the vicinity, or not doing so. If the vegetation did not appear to be as mapped, then an attempt was made to determine to which type (as defined by Thomas, Gellie and Harrison, 2000) it belonged. However, in some instances vegetation did not fall neatly into any of the defined types, sometimes being transitional between two or more types and occasionally not conforming to any of the types described previously.

Where additional data were considered necessary to correct the vegetation map, this was collected in the form of a species list from an area of roughly 20 x 20m, with the same Braun-Blanquet cover abundance scoring system. However, less attention was paid to recording every species present. Only enough data was gathered from these sites to determine the vegetation type. These sites were used during the vegetation analysis and re-mapping work and were not recorded on the standard survey forms and have not been entered into the database.

Species lists with cover abundance scores were available from earlier sampling used in the CRA, and these were also consulted to help confirm or refute the vegetation types mapped as occurring at the locations where these samples were taken. Some additional canopy only sites were recorded by CSIRO. The locations and site numbers of these earlier floristic survey sites were printed on the field map and floristic information was retrieved using the CRA access database - GM-Naomi.

Separate field maps of Forest Ecosystems and Southern CRAFTI API mapping derived during the Southern CRA were printed for use during field work. At the same time as the vegetation was validated in the field against the modelled forest ecosystems maps, the corresponding API maps were also consulted to determine if they provided a better fit to the observed vegetation types and boundaries. Equivalent FE types for many of the API types had previously been determined and printed on the API maps and these were checked and changed where necessary. This process is explained in more detail in section 2.3.

Any additional information about vegetation types observed during travelling through the parks and between survey sites was recorded in the form of annotations on either of the field maps, field data sheets or additional notes on the sampling plot sites.

Data obtained for the full floristics quadrats, the incidental partial floristics lists, earlier site records and annotations made during field work, were later used as the basis of a comparison between the two map versions and were used to assist with validation of the FE map. Within the budget and time constraints of this project, and given the lack of roads in some areas, it was not possible to visit all parts of the parks to check the accuracy of every mapped ecosystem. Where the FE map was found to be wrong in a particular location and the API map could not clarify the true nature of the vegetation type over the whole of the area where it was mapped, then air photos were re-examined and the existing API mapping was confirmed or changed. The API methodology is documented in Section 2.3 below.

2.3 API Methodology

Two API methodologies were employed during this study:

- Adaptation of CRA API mapping with translation of API to FE types.
- Preparation of new API linework and coding for areas that required re-mapping, mostly along the coastline, around the estuaries and coastal lakes and in cleared areas, road corridors and powerline easements.

2.3.1 Translation of CRA API Mapping to Forest Ecosystem Types

It was found during previous studies in the Far South Coast and South Coast Regions, that many of the forest ecosystem photo patterns were very similar to the boundaries mapped during the CRA API projects, despite fundamentally different classifications being used. Often, the patterns recognised on the air photos were a much more realistic representation of forest ecosystem types, than those in the forest ecosystems modelled layer. Consequently, methodology has been developed to utilise and adapt selected components of the API maps rather than re-map forest ecosystem types by undertaking entirely new API work.

It was not always easy to find equivalent API categories for all forest types. Because the FE types are based on full floristics, they are divided more finely than the API categories. There can be several FE types which consist of various combinations of the species for an API type. On a regional basis, it is therefore impossible to devise a list of direct equivalents between FE and API types. However, on a reserve by reserve basis, given a knowledge of the main vegetation types present in the area, it is possible to produce a rough correlation between the two classifications. The corresponding types also had to be established separately for different parts within each reserved area in some instances, because of local variations in geology or terrain.

During the Southern CRA, Forest Ecosystem types were assigned to API polygons by Nic Gellie and botanists Phil Gilmour and Michael Doherty. However, this process did not include all API types and a significant proportion of API polygons were not assigned to FE types. To assist in the interpretation of the API mapping for this present project, a table of the FE to CRAFTI API code correspondence was assembled by cross tabulation of the API codes and assigned FE types. In general there was agreement with our field observations, although the omission of the *E. pilularis* dominated FE29, which should correspond in some circumstances with the API code E0601, was puzzling.

Differences in classifications between the forest ecosystems modelling and API mapping projects required a close comparison based on predominant indicator species types and to a lesser extent on understorey structure and floristics. This process was validated where possible during the field work and using data from previous surveys. While it is possible to develop conversion code tables, as was the case for the Conjola-Morton (East) study area, as a means of automatically assigning FE types to API codes, the small size of the Narrawallee study area made this unnecessary and FE codes were assigned manually for each polygon. A manual process was also more appropriate, since a substantial proportion of the reserve was re-mapped by new API work. FE codes were assigned on the basis of field evidence or where not field checked, the CRA API code, location, ecological characteristics and air photo pattern were assessed. There were many cases where the a particular API type translated

to different FE types depending on location. This was notably the case for separating Hinterland Heath Shrub Dry Forest (FE2) and Northern Coastal Hinterland Moist Shrub Forest (FE21) which are difficult to separate by API. These types had to be split based on field checking and general trends thought to be determined primarily by terrain and aspect such that FE21 is confined to the lower valley slopes of the larger drainage lines while FE2 occurs on the mid to upper slopes above.

It was found that the translation of API to FE codes worked best for predominantly forested areas. Since the API mapping tended to represent the vegetation boundaries more accurately than the FE model, it was used as the preferred mapping source. However, substantial inaccuracies in both the FE and API mapping for coastal areas made it necessary to carry out new API work in these areas. Since very little of the FE model was found to contain accurate boundaries, all of the modelled map was replaced by converted API polygons or new API boundaries.

2.3.2 Re-mapping of Coastal and Estuarine Vegetation Types

Neither of the CRA vegetation maps was found to be sufficiently accurate for the areas along the coastline and around the estuaries and coastal lakes. The lack of locational accuracy relative to water bodies and unvegetated sand and rock areas made it difficult to validate and adjust the forest ecosystem types. The API mapping, while generally more accurate than the forest ecosystems model, did not delineate some of the known FE types and so a straight translation would not represent the true situation.

It was, therefore, decided to re-map all of the coastline and lake foreshores within the reserve by API, focussing on the non-forest ecosystems such as dune scrub and estuarine wetland types. Because this new API work was undertaken as part of the GIS work by Phil Kendall, it was possible to capture and at the same time match these new boundaries into the converted API mapping immediately inland.

The re-mapping included delineating new boundaries for vegetation types which were not adequately represented in either of the existing maps as well as replacing the boundaries of API polygons on their seaward edges and along lake shorelines. In the latter case, the edge of vegetated areas was mapped rather than the actual high tide line, thereby excluding unvegetated rock and beach areas. It was found that most vegetation boundaries could be relatively easily recognised in digital orthophotos and mapped directly rather than having to use a standard API process of marking up acetate overlays, scanning, rectifying and digitising. However, stereo pairs of air photos were used in many instances to interpret vegetation types and to guide the digitising of boundaries from the orthophotos. The 1991 Ulladulla aerial photography (at an approximate scale of 1:25,000) provided by the NPWS, was used for this work.

The coding of new polygons was guided by the results of the field work, interpretation of previous survey sites, reference to the API maps and interpretation using stereo pairs. Field checking was carried out for some of the coastline to confirm the coding and to investigate instances of uncertainty in areas which were not readily apparent in the orthophotos, such as regenerating scrub or ecotonal situations.

To enable a more consistent coverage of the new mapping so that whole polygons could be included rather than being clipped at park boundaries, the mapping was extended beyond the study area in some instances. In particular, the whole of Conjola Lake and its southern foreshores were included in the re-mapping. This also had the benefit of providing a seamless coverage of new mapping with that in the Conjola – Morton (East) study area. The API mapping was in fact carried out initially for the combined study areas and separated at a later stage into the individual parks and the nature reserve.

2.3.3 Re-mapping of cleared areas and corridors

Within the inland parts of the reserve, the linework on the CRA API map was often found to be inaccurate in delineating cleared land (usually former agricultural areas or quarries) and representing cleared road corridors. Re-mapping of boundaries was carried out using the digital orthophotos, with new polygons added and boundaries of existing ones changed. These polygons were allocated to a ‘cleared’ category in the legend for the new maps and polygons which were incorrectly included in the API maps as excluded (i.e. cleared) but in fact contain vegetation, were re-coded to their most probable type, usually that of the surrounding vegetation. This re-mapping of cleared areas was carried out as part of the GIS work and relates particularly to the definition of the study area boundary which is discussed in more detail in Section 2.4.2.

2.4 GIS Methodology

2.4.1 Field Map Preparation

A single field map was prepared on A3 size sheets at 1:25,000 scale, for field and API work, covering Narrawallee Creek NR and surrounding areas. By developing a new map, it was possible to improve the clarity of the vegetation colour coding and show all relevant background details.

The study area falls within UTM Zone 56 and all data sets supplied by NPWS used this projection. The GIS information was compiled in Zone 56 coordinates, using the Australian Geodetic Datum (1966) and the appropriate Australian Map Grid for this zone was shown on the field maps.

The source forest ecosystems layer used was the extant forest ecosystems grid model prepared during the Southern CRA. This was converted from a grid to a polygon layer and from a version in which the boundaries had been smoothed, the relevant study area portion was clipped and attributes added for FE type and descriptive labels. Details of the map preparation using ArcView GIS software are as follows.

- Those FE polygons appearing on the map sheet were selected and a summary procedure used to produce a table of the unique codes. This was used to manually trim the FE legend so that only those FE types seen on the map sheet were included in the legend.
- The colour coding for Forest Ecosystem (FE) types was developed for the range of type encountered in the study areas to provide a sufficiently wide range of colours to minimise confusion.
- Access roads and trails were classified according to classes based on surface type and function. A legend was developed to reflect this classification.
- Other background layers included were 100 metre and 10 metre contours generated from the digital terrain model (DTM), drainage from the 1:25,000 map sheets, air photo centroid points, previous and proposed vegetation survey sites and NPWS estate boundaries.
- The AMG 1 km grid (zone 56) was overlayed on the map for easy reference in the field and API work.

A parallel map showing Southern CRA API (CRAFTI) floristics polygons was prepared to allow checking in the field and comparison of the two maps in order to derive classification conversion codes. This was prepared on the same base map with polygons labelled with the relevant API code. Additional codes for the FE types assigned by Gellie, et al. (see section 2.3 above) were also printed on the map.

The maps were prepared using the NPWS supplied vegetation layers derived from the CRA mapping, clipped to the park boundaries. It was apparent from mismatches between the roads, drainage and vegetation layers that there were substantial inaccuracies in the previous mapping which required attention during the re-mapping process.

2.4.2 Study Area Definition

In preparing and using a study area boundary based on NPWS Estate boundaries, a number of problems were encountered which made substantial editing of the boundary necessary and subsequent editing of the CRA API layer which was used as the basis for re-mapping.

The main problems apparent were as follows.

- Generally, park boundaries are defined using cadastral or other previously mapped boundaries which are rarely accurate and do not match well with real boundaries as seen in air photos and orthophotos, such as the coastline, edges of tidal lakes or roads. When used as a clipping boundary they often miss slivers of land between these boundaries and the true boundary and include other slivers which should be excluded.
- Some park boundaries follow exclusion corridors such as along roads and powerlines and the omission of these corridors from the vegetation map results in gaps in the mapping which create problems where the corridors are inaccurate in the NPWS Estate mapping.

- The clipping of the vegetation maps with the external park boundary results in fragmentation of many polygons which extend beyond park boundaries, effectively splitting vegetation or natural features such as the coastline or lake margins, causing confusion and detracting from the cartographic quality of mapping using the new the vegetation map.
- Inaccuracies in the Southern CRA forest ecosystems modelling has resulted in many instances of polygons extending over or falling short of lake/estuary waters, beaches, cliffs, rock platforms, etc.

NPWS Estate boundaries are often complex polygons which exclude land parcels (private in-holdings) and corridors along non-park roads and stock routes. As such the park areas can be somewhat fragmented. The boundaries are usually mapped by interpretation of gazettal details using available topographic and cadastral maps which have inaccuracies Consequently, the boundaries do not match well with the true positions of natural features such as water bodies and coastal features or built features such as roads, infrastructure and fenced property boundaries. Corridors are usually created as fixed distance buffers either side of roads or powerlines, and do not follow actual cleared boundaries along these easements. This problem is compounded when the roads and powerlines used for buffer creation were mapped incorrectly.

Both the external and internal boundaries of Narrawallee Creek NR were found to be inaccurate when overlayed on the digital orthophotos. Inaccuracies of over 50 metres were not uncommon, consequently many roads did not actually fit within the exclusion corridors through the parks. On examination of the supplied layer of the CRA API map, which had been clipped to the park boundaries, many gaps were apparent where exclusion corridors had resulted in information loss from the vegetation map. Areas which carry forest had been clipped out while slivers of cleared land in the easements had been left adjacent to the corridors. This problem was further compounded where the CRA API mapping had attempted to capture these easements (often inaccurately). The resulting map was confusing and very difficult to re-code and use.

The correction of NPWS Estate boundary mapping was clearly beyond the scope of this project. However, boundary definition problems needed to be resolved for the purposes of vegetation re-mapping. Consequently a new study area boundary was created by editing the NPWS Estate boundaries to remove internal boundaries for road and powerline corridors and around small in-holdings and to minimise polygon splitting around the periphery of the study area. Rather than clipping out parts of polygons along the coastline, estuaries and around lakes in the vegetation maps and leaving slivers behind or including unwanted slivers, the study area has been enlarged to include all such polygons wherever possible. These boundaries could then be split or re-shaped to map an accurate edge between vegetated areas and non-vegetated areas such as rock, beach or water. New polygon topology was created in pc Arc/Info and the boundary was then used for clipping the vegetation layers. Further editing of the API layer was carried out during the re-mapping work to correct previous inaccuracies such as boundaries between cleared and forested land, as explained in section 2.4.3 below.

The resultant study area is larger than the actual reserved area but the inclusion of portions of non-park areas within the study area has considerable benefits for vegetation re-mapping purposes. Perhaps most importantly it avoided the loss of information along park boundaries and along the coastline resulting from inaccuracies in previous mapping. The cleaning up of the boundary also enhances the final mapping product. Should the new FE layer of the study area need to be analysed to extract statistical data for areas specifically within the park (e.g. percentage areas of each FE type in the park), it is a simple process to clip it with the mapped (but inaccurate) park boundaries.

2.4.3 Preparation of GIS Layers for Re-mapping

The study area portion of the Southern CRAFTI map was extracted using the boundary extent derived from the new study area boundary as outlined above. The map used was a modified version of the original CRAFTI map which contained updates by Nic Gellie (EcoGIS) to 2001, re-named fields and an additional descriptive field for the corresponding forest ecosystem type. A clipped version of this map using NPWS Estate boundaries supplied as part of the source data by NPWS was used. A considerable amount of manual editing was carried out to rectify problems along road corridors to match them to the vegetation boundaries along these easements as they appeared in the digital orthophotos, to remove numerous slivers and re-code the easements as ‘cleared’ rather than excluded.

2.4.4 Data Capture and Processing

In summary, new API line work along the coast and around Conjola Lakes and Narrawallee Inlet, was interpreted and captured by digitising boundaries directly off the digital orthophotos during the GIS data capture and coding processes. This included digitising the boundaries of water bodies, cleared and urban areas. The new linework was incorporated directly into the CRA API linework and coded with the forest ecosystem types. The old and new API polygons were merged to create a new composite API map for the study area, coded according to FE types. This involved both digitising new polygons, splitting and re-shaping the boundaries of existing ones and making appropriate changes to the attribute tables. Editing was carried out primarily using ARCGIS 8.3 in ARCVIEW shapefile format. Additional polygon processing and re-building was carried out using pc ARC/INFO. The final layers are compatible with ARCVIEW 3.x and have been developed using AMG Zone 56 coordinates.

More specifically, there were three aspects to the re-mapping of vegetation in coastal areas.

- Vegetation types which were not accurately delineated in either of the two CRA vegetation maps were re-captured by identifying the patterns and digitising directly from the digital orthophotos. This process was assisted in some cases by first identifying boundaries and types from air photographs using stereo pairs. It was found that most vegetation boundaries in coastal areas could be relatively easily recognised in digital orthophotos and mapped directly rather than having to use a standard API process of marking up acetate overlays, scanning, rectifying and digitising.
- Boundaries of polygons which had a frontage to coastal lakes and estuaries or a seaward edge along beaches or rocky headlands were re-mapped by API so that the incorrect edges of these polygons could be replaced, while the landward edges could be retained. The edge of vegetated areas was mapped rather than the actual high tide line, thereby excluding unvegetated rock and beach areas. Boundaries of cleared areas were also captured.
- Further polygons in the existing maps were checked as necessary by overlaying the boundaries in outline on the orthophotos and adjusting or splitting without requiring full replacement of boundaries.

The procedure for polygon processing was as follows.

- Relevant portions of the study area boundary (which is discussed above) or portions of the CRAFTI map which were immediately outside the study area, were used in the API vegetation layer to enable polygon closure along the boundary. In some instances, polygons were allowed to extend beyond this boundary rather than being split.
- Where further processing of polygons was required in the ARCEDIT module of pc ARC/INFO, the clean command was used to build polygons with nodes automatically snapped within a set tolerance of less than 1 metre and dangling arcs removed using a 2 metre tolerance. Relatively few points had to be manually edited to close polygons and remove overshoots. This reflects the greater accuracy and automated error correction capability of on-screen digitising techniques relative to traditional digitising direct from hard copy maps.
- The polygon layer was coded in ARCGIS according to the map codes marked on the field maps or for codes to be assigned from the coastal re-mapping work. Codes were added to two new fields in the attribute table. These fields contained the new FE code and status fields for recording details update status of each polygon linework and coding. Details of the attribute table are included in Appendix 6. The polygon layer was checked against the aerial photographs, field maps or other notes, for completeness.

The resultant polygon layer represents all new polygons derived from the API work, within and adjacent to the study area and provides the basis for the new forest ecosystems map. The final map was prepared by dissolving the boundaries between polygons of the same type so as to create a neater map for presentation purposes. However, since this process results in loss of most of the attribute fields, the original re-coded API maps were retained with full attribute details for the purposes of analysis and any further re-mapping.

2.4.5 Accuracy Level

The API mapping carried out during the CRA was generally regarded as being reasonably accurate although some vegetation types are difficult to distinguish by API and some significant ecotonal boundaries between forest types have been missed because of indistinguishable photo patterns.

Although generally accurate to around 25 metres or better, there are instances, however, of errors of greater than 50 metres. These may relate to inaccuracies in the 1:25,000 base mapping to which the CRA API linework was rectified, or to errors in raster to vector conversion from scanned overlays.

Although this API linework was theoretically utilised in the CRA forest ecosystems modelling project, during the present project, many instances of wrongly placed boundaries in the FE model were detected which do not reflect the accuracy of the underlying API linework. Either the API linework was not fully utilised or inaccuracies were introduced during the modelling. The FE modelling does not conform well to the topographic patterns in many instances. This is compounded by the inherent inaccuracy and grid patterns along polygon edges, caused by grid data modelling. Because of the inaccuracies apparent in the FE modelled boundaries, these boundaries were not used in the new mapping. This does not imply however, that the FE model was ignored, since it was field validated and the modelled polygons were considered in the re-coding of polygons derived from API mapping.

It has already been noted that significant mis-matches between the NPWS Estate boundaries and other GIS data layers were frequently apparent. While the park boundaries are clearly defined in words by gazettal notices, the interpretation of these boundaries using available mapping has resulted in many inaccuracies. Consequently, for the purposes of this project, it was often meaningless to adopt mapped park boundaries for defining the study area.

The digitising of linework for polygons mapped from orthophotos was carried out in a manner which minimised inaccuracies. The resulting linework is generally accurate to well within 25 metres of true positions on the ground and probably in most cases to within 10 metres. This is closely dependent on the accuracy of the digital orthophotos which is likely to vary slightly as a result of the rectification process in converting the air photos to orthophotos. This accuracy level does not necessarily relate to topographic and cadastral mapping inaccuracies.

Despite some minor discrepancies between the mapping and GPS records for field survey sites, it is considered that the GIS methodology for capturing the new API work, combined with field checking using GPS readings, achieves accuracy levels which exceed those of the Southern CRA mapping.

Clipping of the new vegetation layer with the park boundary polygons may be necessary in some instances (for example, to calculate percentages of each vegetation type within the park), however, it should be realised that this will split many vegetation polygons around the periphery of the mapping and create numerous slivers.

2.4.6 Polygon Attribute Coding

Coding of the new mapping, which was based on the Southern CRAFTI layer with additions and modifications resulting from the API work, was guided by the findings of the field surveys and interpretation of the existing vegetation maps, air photos and some field checking of the API work. Coding was an iterative process of validating the coding of polygons against the many sources of information and involving several levels of subsequent checking as outlined in section 2.4.8. Comments in the attribute tables were constantly updated to reflect the information on which code allocations were based. Re-coding of the new API layer was carried out using ArcGIS 8.3. However, for compatibility with the NPWS database, legends for forest ecosystem types were developed using ArcView 3.x.

Attributes were retained from the original CRA API layer, including all original ID fields. This made it possible to link the new layer back to the original ones if required for cross-checking purposes and importing additional attributes. Attributes added or re-named by EcoGIS were also retained. The coding process was as follows.

- The API map attribute table was extended with new fields as indicated in Appendix 6 included some additional fields relating to conversion codes and notes on this process, field survey site numbers (if present), polygon and code update status (i.e changed or unchanged) and final allocated new FE type and descriptive labels.
- The new FE type was firstly coded according to the findings of the field work, using annotations on the field maps and the FE types assigned to each floristics survey site and any comments relating to this were added to the notes field. During this process several additional FE types were added to the list occurring in the study area.
- The new API work was carried out and coded based on interpretation of the orthophotos, air photos and any other available information. During this process, many polygons were split to

better represent the patterns evident from the field or API work and given appropriate revised codes.

- FE codes which translated from API codes were assigned as outlined in section 2.3.1. During this stage, many sliver polygons from the original API mapping were rationalised and re-coded. In most cases slivers were retained and re-coded. Very small slivers were deleted in some cases around the external study area boundary and along internal corridors and the boundary was corrected to match the air photos as necessary.
- Further confirmation or amendment of the mapping was carried out by selective checking using stereo pairs of air photos.
- The mapping was checked by the project team and the coding was further refined.

The final forest ecosystems map was prepared as a dissolved version of the modified CRAFTI maps and contains only the new FE codes and labels, together with polygon perimeter and area calculations.

A full list of attribute codes is contained in Appendix 6. Along with a description of all of the GIS layers supplied on the data CD.

2.4.7 Survey Site Mapping

The brief required field data sheets to be presented in electronic format as well as the original hard copies. The field sheets for standard floritic survey sites were initially transferred to the MS Access Database developed by NPWS staff Michael Bedward and Murray Ellis. This allowed maximum automation of data entry and provided a suitable means of analysing and re-formatting the data. The fire response monitoring site data were entered into an Excel spreadsheet database, designed by Nic Gellie (EcoGIS) for fire response monitoring in the Nowra area.

To enable the floristics data to be used in the GIS in conjunction with the forest ecosystems and other GIS layers, they were translated to a number of DBase files which could be loaded into ArcView GIS. The tables which were converted included the site details (including AMG eastings and northings), the floristics records for each site and the master table of species names and reference numbers.

The sites table was converted to a GIS point feature layer so it could be displayed and labelled for mapping purposes. Additional fields were added to the feature attribute table for old and new FE types, drawn from the field data sheets and botanical notes.

After initial removal of unnecessary fields, the floristics and species tables were permanently joined so that species reference numbers were followed by several columns of relevant species information including family, scientific and common names. The resulting floristics table can be dynamically linked to the point feature layer using the common site number field so that a listing of species recorded for each site can be readily obtained.

The sites and floristics tables were used in checking the new forest ecosystems map coding and in helping to identify and resolve anomalies. This process was greatly assisted by having easy access to the records of FE types found at each new survey site. The GIS version of the database was also used in compiling the forest ecosystem profiles.

2.4.8 Checking of Information

As noted above, several levels of checking were made during the process of conversion coding of the API polygons and during the new API work along the coast, to rationalise the coding of FE types and to ensure consistency between the new mapping, the site survey database and the information in this report. This process was assisted through the recording of notes in the various GIS layer attribute tables and in the conversion code tables. The compilation of the results section in the draft report was undertaken concurrently with the API and GIS work to ensure consistency of the information presented, with anomalies and queries resolved as a team effort. The GIS layers were checked at several points to ensure that coding had been correctly maintained during editing and polygon processing.

Some inconsistencies were detected between the mapped types and the types recorded for the corresponding field data records. In some cases this was a result of difficulties in delineating the field assessed types by API. In the majority of instances, the problems related to the placement of field survey points close to vegetation boundaries, so that they appeared either on the boundary or just

outside it in a neighbouring polygon. Although the GIS mapping was accurate to around 10 metres, this level of inaccuracy may have been sufficient in some cases to cause misplacement of the boundary relative to survey site points. In a few instances, survey site map references were found to be incorrect and point locations had to be manually adjusted. GPS errors or transcription of coordinates to the field sheets may have been responsible for some mismatches of information.

As a result of the potential for mapping and field data inconsistencies, a technique for preparing the forest ecosystem profiles (contained in Appendix 4) was adopted where the field sites were only included in the species lists where they clearly fell within the mapped polygon of the same type. All other sites, including mismatching types and sites close to boundaries, where possible errors could occur, were listed as marginal sites and excluded from the consolidated species lists for that FE type.

All draft material was checked by the botanist (Jackie Miles) and further amended to remove inconsistencies between the field and API work and to check the validity of the GIS mapping.

3 RESULTS

3.1 General Findings

Based on the findings of the work, the vegetation of Narrawallee Creek Nature Reserve can be most simply described as follows.

Narrawallee Creek Nature Reserve carries two main forest types. On higher ridges and slopes dry forest dominated by red bloodwood (*Corymbia gummifera*) is found, with a sclerophyll shrub understorey. In more sheltered locations, such as north of Lake Conjola Entrance Road, there may be a dense understorey of tall shrubs and small trees such as wattles and blackbutt (*Eucalyptus pilularis*) tends to be the dominant tree. About half the reserve consists of extensive sand flats which have formed at the mouth of Narrawallee Creek. Dune scrub dominated by coast banksia (*Banksia integrifolia*) occurs along the immediate coastal strip. Behind this is a belt of dry bangalay (*E. botryoides*) forest with saw banksia (*Banksia serrata*) in the understorey. This in turn gives way to tall dry blackbutt forest, with wetter swamp mahogany (*E. robusta*) forest in low-lying areas. Along Narrawallee Creek, wherever sand or mud flats occur there are fringing strips of grey mangroves (*Avicennia marina*), saltmarsh, or occasionally swamp oak (*Casuarina glauca*).

The following trends were apparent from the field botanical survey work and the API work, relating to inconsistencies identified in the forest ecosystems modelling by Thomas, Gellie and Harrison (2000). The forest ecosystem (FE) type names have been shortened in most cases by excluding the species names which are typical of each type.

The forest ecosystem map was found not to be particularly accurate for Narrawallee. As in earlier CRA vegetation map validation work in Meroo National Park and Barnunj SRA, and also in the Conjola-Morton (East) study area, substantial mapping errors were found. These particularly related to mis-interpretation and over-mapping of non-eucalypt vegetation types, such as *Casuarina glauca* swamp forest types: Coastal Tall Wet Heath Swamp Forest (FE24) and South Coast Swamp Forest (FE25). These were again modelled as being very much more extensive than they really are. Mangroves and mudflats/saltmarsh, which are extensive along Narrawallee Creek, had been omitted and a large area north of the creek which is in fact eucalypt forest had been incorrectly modelled as Coastal Dune Scrub/Herb Swamp Complex (FE23/FE26) which is not fully described by Thomas, Gellie and Harrison (2000).

Eucalypt associations were also not very accurately modelled, with most of the eucalypt forest mapped as Northern Coastal Sands Shrub/Fern Forest (FE29), regardless of location, a community which principally occurs on flat sand deposits. Much of the eucalypt forest in the steeper northern parts of the Reserve was found to in fact be Hinterland Heath Shrub Dry Forest (FE2), with some Northern Coastal Hinterland Heath Shrub Dry Forest (FE139) and Northern Coastal Hinterland Moist Shrub Forest (FE21), and none of these had been modelled as occurring there. Two highly significant communities with restricted distributions had been overlooked, but these were also omitted from the CRAFTI API maps. These are Coastal Swamp Mahogany Forest (FE175), which is listed as an Endangered Ecological Community (as Sydney Coastal Estuary Swamp Forest Complex) in the region, and Coastal Red Gum Grassy Forest (FE171), which is naturally rare and greatly depleted by farming activities.

Not all the vegetation communities mapped as present in the Reserve were found to be there. Coastal Gully Rainforest (FE20) was only predicted as a single small sliver in a gully head in the north-west corner of the Reserve. It was not checked, but is possibly correct, based on the local topography (steep, south-facing) and the presence of this vegetation type in similar locations in other reserves in the region. However, the API map does not indicate any rainforest in the Reserve and it is not obvious in this location on the air photos.

Southern Coastal Dune Scrub complex/Coastal Dune Herb Swamp complex (FE23/26) was predicted to occur over large areas of the Reserve. The genuine existence of this vegetation type is quite doubtful. FE23 is the same as Beach Strand Grassland described for the Eden region (Keith and Bedward 1999) and consists of *Spinifex sericeus* and other coastal grasses and herbs which typically

only grow on beaches. Its occurrence over large patches of the landscape is very unlikely. FE26 as a discrete vegetation type does not stand up to close scrutiny when the list of characteristic species (Thomas, Gellie and Harrison, 2000) is examined. The areas mapped as this combined vegetation complex were all found to carry eucalypt forest of various types.

Coastal Headland Heathland (FE187) was not located in the Reserve. The small area of this mapped on Buckleys Point was found to be Headland Scrub dominated by *Allocasuarina verticillata*, which is included within the broad category of FE22 (Coastal Hind Dune/Headland Scrub).

Some of these findings are discussed in relation to rare and under-reserved vegetation types in more detail below.

3.2 Findings Related to Specific Vegetation Types

Discussion of the findings of the field and API work for those vegetation communities observed in Narrawallee Creek Nature Reserve is provided below. Full descriptions of these types as they relate to the study area, have been adapted from descriptions by Thomas, Gellie and Harrison (2000). They are tabulated in the form of Forest Ecosystem Profiles in Appendix 4. The list of communities present may be incomplete as not all parts of the Reserve were seen, although all tracks were traversed and some time was spent investigating vegetation at some distance from tracks.

In the descriptions below, the numbering system of the CRA classification (Thomas, Gellie and Harrison, 2000) has been retained but the community names have been simplified to make them more descriptive. While most of these types are directly equivalent to the Thomas, Gellie and Harrison types, some of the original names do not accurately reflect the types as represented in the study area. In some cases the dominant species may differ and therefore the original long names, which frequently contain a list of key species, may not be appropriate. One additional sub-type of a more common forest type has also been added. The corresponding original names are included along with the new names in the forest ecosystem profiles contained in Appendix 4.

3.2.1 Non-eucalypt communities

Saltmarsh (FE186)

Found within the tidal zone of Narrawallee Creek in small patches, this community has two discrete components, samphire (*Sarcocornia quinqueflora*) and sea rush (*Juncus kraussii*). Samphire occurs in the lower part of the saltmarsh, while sea rush generally forms a band along the upper edge, which is much less frequently inundated by salt water. The samphire belt typically occurs above a band of mangroves, which lines Narrawallee Creek in all areas where there are sloping rather than vertical banks. However, saltmarsh is restricted to situations where there is a wide, gently sloping sandy or muddy flat, such as on the inner face of bends in the creek and at the confluence of the two creek branches close to the western edge of the Reserve. Elsewhere mangroves generally form a one tree width belt adjacent to eucalypt forest on the upper bank. The quadrat NARJM02 was located within saltmarsh which is gradually being invaded by young grey mangrove (*Avicennia marina*) plants, currently under one metre in height. The movement of mangroves into areas of saltmarsh is a trend which has been documented throughout the NSW coastline. It may be a response to rising sea levels, or to increasing sedimentation of estuaries.

Mangrove Forest (FE185)

In all areas surveyed on Narrawallee Creek this community consisted solely of the small tree, grey mangrove (*Avicennia marina*). River mangrove also occurs commonly at the upper end of estuaries where the water is less salty. This zone of Narrawallee Creek was not investigated and is likely to be beyond the Reserve boundary.

Swamp Oak-Swamp Paperbark Forest (FE24)

This community generally occurs in a narrow band around the upper parts of saline or brackish coastal lakes and estuaries. Swamp paperbark (*Melaleuca ericifolia*) forms a dense low canopy 2-5 metres in height with swamp oak (*Casuarina glauca*) emergent above it at variable densities. The small tree

Myoporum acuminatum may also occur. Other commonly associated species are salt-tolerant rushes and sedges *Juncus kraussii* and *Baumea juncea*, and herbs *Lobelia alata, Apium prostratum, Leptinella longipes, Samolus repens* and *Selliera radicans*. The tall sedge *Gahnia clarkei* may form an almost impenetrable groundcover layer to 2m high, but this is usually more typical of more freshwater wetland communities further upstream.

Swamp Oak Forest (FE25)

This community can be more extensive then the preceding one on low flats adjacent to tidal creeks such as Narrawallee Creek. It appeared that this was the case on the banks of both Narrawallee and Croobyar Creeks extending outside the Reserve boundary. Few areas of FE25 were detected within the Reserve during field work but additional areas were included in the re-mapping from the CRA and new API work.. The quadrat NARJM07 is located in this community. Typically swamp oak forms the canopy, with occasional *Myoporum acuminatum* and *Melaleuca ericifolia* forming a very open small tree layer. A shrub layer is generally absent or may consist of a patchy cover of the sprawling semi-woody herb *Rhagodia candolleana*, and the groundcover will vary depending on the frequency of inundation, but usually includes salt tolerant species ranging from couch grass (*Cynodon dactylon*) at the drier end of the spectrum, to samphire (*Sarcocornia quinqueflora*) and *Baumea juncea* at the wetter end. The herbs listed above for FE24 are likely to occur. The large vine common silkpod (*Parsonsia straminea*) is very typical of FE25, and epiphytic orchids *Dendrobium teretifolium* and elkhorn ferns (*Platycerium bifurcatum*) may grow on the casuarina trees.

Dune/Headland Scrub and Beach Strand Grassland (FE22/23)

These communities are generally mapped as a single unit because they almost invariably occur side by side as variable width bands on beach dunes. FE23 occurs on the beach, and is usually dominated by the grasses *Spinifex sericeus* and *Austrofestuca littoralis* and salt and dessication tolerant herbs including *Actites megalocarpa, Calystegia soldanella, Carpobrotus glaucescens* and the exotics **Hydrocotyle bonariensis* and **Cakile* spp. This grades via low wind-pruned coast wattle (*Acacia longifolia* ssp *sophorae*) into FE22, which occurs on the hind dunes. It generally consists of a canopy of coast banksia (*Banksia integrifolia*) and a shrub layer of *Leucopogon parviflorus, Acacia longifolia* ssp *sophorae, Rhagodia candolleana* and occasionally *Correa alba* or the exotic bitou bush (**Chrysanthemoides monilifera*). The groundcover may include bracken (*Pteridium esculentum*), *Lomandra longifolia,* grasses *Poa poiformis*, couch (*Cynodon dactylon*) or the very similar *Zoysia macrantha* and herbs including *Carpobrotus glaucescens, Oxalis rubens, Pratia purpurascens* and *Dianella caerulea*. The vine *Kennedia rubicunda* is typical, and occasionally *Muehlenbeckia adpressa* also occurs.

The headland suite of species which has been lumped into FE22 is really quite a distinct community, although it does include a few of the same salt tolerant species. Typical small trees are *Allocasuarina verticillata* and *Melaleuca armillaris*, with shrubs *Alyxia buxifolia, Myoporum boninense, Rhagodia candolleana* and occasionally the exotics bitou bush and mirror bush (**Coprosma repens*). In long unburnt situations *Pittosporum undulatum* may become a major component of this community. Typical groundcover plants include *Lomandra longifolia, Poa poiformis, Austrostipa stipoides* and the herb *Pelargonium australe*.

This dune/headland complex has been re-mapped along the entire length of the coastline in the Reserve. No field sites were located in this type.

3.2.2 Eucalypt communities

Coastal Sands Bangalay-Banksia Forest (FE28)

This community occurs in a restricted range of locations on deep Quaternary sand deposits behind beaches, on bars at the mouths of coastal lagoons and alongside small creeks such as Narrawallee Creek where they flow through such sand deposits. It has been re-mapped along most of the coastline in Narrawallee. Bangalay (*E. botryoides*) is generally the only eucalypt species. Saw banksia (*Banksia serrata*) forms a sub-canopy layer, or in wind-pruned stands mingles with the bangalay in a low tangled canopy. Typical shrubs are *Acacia longifolia* ssp *sophorae* or *A. longifolia* ssp *longifolia* and *Monotoca elliptica*. Burrawangs (*Macrozamia communis*) may be present or even dominant. Bracken is the dominant groundcover species, with *Lomandra longifolia*, grasses, blady grass (*Imperata cylindrica*) and kangaroo grass (*Themeda triandra*) and herbs *Schelhammera undulata, Desmodium*

gunnii, Dianella caerulea, Gonocarpus teucrioides and *Viola hederacea*. In long unburnt stands rainforest elements such as the trees *Glochidion ferdinandi, Elaeocarpus reticulatus, Pittosporum undulatum* and *Acmena smithii* and various vines may appear. Mills (1995) in his discussion of forest types in Cudmirrah-Conjola lists this community as Cu5, Bangalay Open Forest.

Coastal Sands Blackbutt–Banksia Forest (FE29)

This community is very similar to the preceding one but tends to occur a little further inland. This may just be a function of the relative salt tolerance of the dominant tree species, with *E. pilularis* not capable of surviving as close the sea as *E. botryoides*. Red bloodwood (*Corymbia gummifera*) may be co-dominant and *Banksia serrata* is often present as a small tree layer. In understorey composition this community is transitional between FE28 and Lowland Red Bloodwood-Turpentine Dry Shrub Forest (FE2), described below. It occurs only on flat sand sheets, unlike FE2 which is found on low ridges on sandstone-derived soils rather than wind-deposited sand. In Narrawallee it is the main community on the flat sandy area between Buckleys Point and Narrawallee Creek, where it runs inland for just over a kilometre. A second location is south east of Pattimores Lagoon. Mills (1995) describes this community as Cu4, Blackbutt Open Forest.

Lowland Red Bloodwood-Turpentine Dry Shrub Forest (FE2)

This community is widespread in Narrawallee Creek NR, occurring on ridges and slopes with a variety of aspects. It has been re-mapped over the majority of the northwestern and central parts of the Reserve. The CRA FE map incorrectly placed FE29 in areas where FE2 is present. It is typically dominated by either or both of red bloodwood (*Corymbia gummifera*) and blackbutt (*E. pilularis*), with turpentine (*Syncarpia glomerulifera*) present as either a component of the canopy or the understorey depending on the site quality and fire history. Under drier conditions or more frequent fire, turpentine is more frequently a small tree or mallee form, owing to its habit of coppicing after fire. The understorey is shrubby and includes some "heathy" species such as *Lambertia formosa, Gompholobium latifolium* and *Banksia spinulosa*, but also a number of shrubs more typical of dry forest than heath such as *Podolobium ilicifolium, Acacia obtusifolia* and *Tetratheca thymifolia*. Typical groundcover species are the grasses *Entolasia stricta* and *Panicum simile*, the ferns *Lindsaea linearis* and *L. microphylla* and herbs *Dianella caerulea, Phyllanthus hirtellus*, *Marsdenia suaveolens* and *Pomax umbellata*. At the wetter end of the spectrum, such as in gully heads or long unburnt sites species such as Christmas bush (*Ceratopetalum gummiferum*) and blueberry ash (*Elaeocarpus reticulatus*) may be present, with ferns *Calochlaena dubia* and *Gleichenia dicarpa*.

Mills (1995) refers to this community as Cu2, Blackbutt-Turpentine Open Forest, and FE2 may also include his Cu6, Bloodwood-Peppermint Open Forest/Woodland, dominated by *C. gummifera* and *E. piperita*, with a heathy understorey. He places Cu2 in less harsh locations in the landscape such as gullies and areas with deeper soils, but not on dunes.

Scribbly Gum-Red Bloodwood Heathy Woodland (FE139)

This community occurs on the poorest soils, usually shallow and derived from sandstone. They may also be poorly drained. Bloodwood tends to dominate in drier sites, with yertchuk (*E. consideniana*) co-dominant or sometimes dominant. Silvertop ash (*E. sieberi*) is occasionally present in more elevated ridgetop sites although it was not seen in Narrawallee. Scribbly gum (*E. sclerophylla*) is more likely to occur in poorly drained sites. The understorey includes a wide variety of heathy shrubs and small trees with some of the more common being *Leptospermum trinervium, Hakea sericea, Lambertia formosa, Isopogon anemonifolius, Persoonia levis, Petrophile sessilis, Kunzea capitata, Bossiaea heterophylla* and *Bossiaea ensata*. Numerous sedges, various *Lomandra* species, the grasses *Anisopogon avenaceus* and *Entolasia stricta* and numerous herbs such as *Actinotus minor* and various orchids form the groundcover.

Depending on the exposure of the site to sea winds, the shallowness of the soil and possibly fire frequency, this community may become almost treeless. Many patches in nearby Conjola National Park were mapped as "scrub" on the API maps and translated into heath on the FE map. However, all those investigated proved to be FE139 with a sparse, low tree cover. In drier sites tall grass trees (*Xanthorrhoea australis*) may occur, while in sites with very poor drainage the smaller, blue-foliaged *Xanthorrhoea resinifera* may be common and sedges dominate the groundcover. In intermediate areas such as around the fringes of upper drainage lines *Leptospermum polygalifolium* is a common understorey shrub. Other shrubs typical of poorly drained sites are *Viminaria juncea, Sphaerolobium* spp, *Callistemon linearis* and *Hakea teretifolia*.

Mills (1995) divides this community into a number of variants, mostly influenced by drainage and soil depth. His Cu7 (Scribbly Gum-Casuarina Open Forest), Cu9 (Scribbly Gum-Bloodwood Woodland/Heathland), Cu10 (Scribbly Gum-Hakea Open Woodland/Open Shrubland), Cu11 (Scribbly Gum - Teatree Open Woodland/Open Shrubland) and Cu12 (Blackbutt Open Woodland/Heathland) would all be part of the FE139 complex.

Very little of this type of vegetation was seen in Narrawallee, although it is common in Conjola National Park to the north. The quadrat NARJM04F is located in FE139 which intergrades with FE2 and combines the features of Cu7 and Cu11 on one quadrat.

Spotted Gum-Blackbutt Moist Forest (FE21)

This community occurs on better quality sites such as those on sheltered aspects and in gullies on either sandy soils, where blackbutt dominates, or soils with a higher clay content where spotted gum (*Corymbia maculata*) is more likely to occur. Stringybarks (*E. globoidea* and *E. eugenioides*) and Sydney peppermint (*E. piperita*) may be present. Turpentine may also be present as a canopy co-dominant and rainforest species and cabbage tree palms (*Livistona australis*) are likely to occur in the gullies. Tree wattles such as *Acacia mabellae, A. binervata, A. longifolia* ssp *longifolia* and *A. irrorata* are generally present. Mesic shrubs such as *Notelaea longifolia* are likely to occur. The groundcover is variable and may include a wide range of grasses, herbs and trailing vines.

FE21 appears to overlap with Mills' Cu2 and Cu1 (Blue Gum Tall Open Forest) although the latter appears from his description to be a wetter forest type restricted to creek flats and co-dominated by Sydney blue gum (*E. saligna*), rough-barked apple (*Angophora floribunda*) and blackbutt. His descriptions fit the observed vegetation better than the FE21 description in Thomas, Gellie and Harrison (2000). The latter appears to have been derived more from wet spotted gum forests on clay soils around Batemans Bay. Spotted gum was not detected in Narrawallee, but wetter blackbutt forest with a dense small tree and shrub understorey is located north of Lake Conjola Entrance Road. This is the only location of FE21 included in the re-mapping.

Coastal Lowlands Swamp Mahogany Forest (FE175)

This community occurs in flat drainage lines on sandy soils close to the sea. It is listed as an Endangered Ecological Community (as Sydney Coastal Estuary Swamp Forest Complex) within the Sydney Basin Bioregion, which includes the Ulladulla area. Typically swamp mahogany (*E. robusta*) forms an open canopy above smaller trees with a tolerance for waterlogged soils such as *Melaleuca linariifolia, M. ericifolia, M. squarrosa* and *Acacia longifolia*. There may be a dense tall groundcover of the large sedge *Gahnia clarkei*, or of other sedges including *Baloskion tetraphyllum* ssp *meiostachyum, Schoenus brevifolius, Leptocarpus tenax* and *Baumea juncea*. The fern *Blechnum indicum* was seen in this community and is at its southern limit of distribution in the region.This community was seen at three locations in Narrawallee Creek NR and in the southern part of the Reserve, it intergrades with FE29.

Mills does not describe this community from Conjola National Park, where it appears to be replaced by his Cu8, Woollybutt (*E. longifolia*)-Paperbark Woodland in the more accessible parts of the park. However, it was found to occur around the northern end of Swan Lake in the now expanded Conjola NP.

Coastal Red Gum Grassy Forest (FE171)

This community is confined to better quality soils, often derived from volcanic rocks or alluvium. It would formerly have been common on the monzonite-derived soils around Milton, but has been largely destroyed by farming activities. It is dominated by the trees forest red gum (*E. tereticornis*), rough-barked apple (*Angophora floribunda*) and white stringybark (*E. globoidea*), with the small tree *Acacia mearnsii* and occasional shrubs including *Bursaria spinosa, Kunzea ericoides* and *Breynia oblongifolia*. The groundcover is generally low and consists of a mixture of numerous grasses and herbs. Common species are *Microlaena stipoides, Oplismenus imbecillis, Lomandra* spp, *Dichondra repens, Glycine clandestina, Commelina cyanea, Pratia purpurascens, Geranium solanderi* and *Hydrocotyle laxiflora*. In Narrawallee Creek NR a small and rather disturbed area of this vegetation was found in the vicinity of what appeared to be an old quarry extracting monzonite rock, located north and west of Silica Ridge Fire Trail near the north-eastern corner of the Reserve. Site NARJM06 was located in this area.

Any occurrence of this vegetation community in a conservation reserve should be regarded as a bonus regardless of the level of disturbance, since it is very infrequently found on public land. The

level of weed invasion in this area was not too high, although numerous minor weed species are present in small numbers.

This community does not appear to be present in Conjola NP and is not described by Mills (1995).

Jervis Bay Lowlands Dry Forest (FE5)

This community is described by Thomas, Gellie and Harrison (2000) as mainly being dominated by grey gum (*E. punctata*), which is apparently present in Conjola, although not recorded on this survey. However, other common eucalypts include *C. gummifera* and *E. eugenioides*, and less commonly *C. maculata, E. paniculata, E. longifolia* and *E. globoidea*. A sub-canopy layer of the small tree *Allocasuarina littoralis* is frequently present. From the description it appears that shrubs are typically smaller species such as *Pimelea linifolia* ssp *linifolia, Pultenaea villosa, Pultenaea retusa* and *Daviesia ulicifolia*, and the understorey is predominantly grassy.

This description appears to fit some of the vegetation seen in Conjola NP and it was included in the re-mapping of some areas in the north of the reserve.

This forest ecosystem type was identified in field sites at two locations in Narrawallee, one being upstream of the junction of Narrawallee and Croobyar Creeks (NARJM08) and the other near the junction of the Conjola Lake Road and Northern Fire Trail (NARJM10). *Eucalyptus pilularis* was the dominant canopy species at both. Neither of the CRA maps were correct in these locations.

3.3 Overall Findings and Conclusions

The upgraded forest ecosystems map is a significant improvement on the former forest ecosystems modelling, in that it has the benefits of more intensive field assessments and more intensive API mapping, which hopefully improves the accuracy of boundaries and assignment of vegetation types.

The vegetation map has been improved by re-interpretation of the CRAFTI API map, using CRAFTI linework and assigning CRAFTI codes to forest ecosystems on the basis of field experience in the reserve. However, the correspondence between CRAFTI codes and FE codes is (as is usually the case) not a one to one relationship. For example, much of the reserve is dominated by blackbutt (*E. pilularis*) but this species is a component of several forest ecosystems, so the decision as to which FE is indicated has to be made on the basis of other clues such as topography and aspect. It is unlikely that the decision is invariably correct, and the final map may need some further refining with additional field work in the future. Major re-mapping using digital orthophotos was carried out for all of the non-forest types along the coast, along Narrawallee Creek and around Pattimores Lagoon. Additional air photo interpretation was used to clarify matters in some locations and this resulted in some significant improvements over the previous CRAFTI API work.

The forest ecosystem types which are present in the final map, and those eliminated as not expected to be present, are summarised in Appendix 1 – Table A1.1 and A1.2. Table A1.3 sets out where changes have occurred in each of the two parks in the study area. Of the ten FE types originally modelled as occurring, three were found not to exist in the study area, being Coastal Hinterland Gully Rainforest (FE20), the combined Southern Coastal Dune Scrub Complex and Coastal Dune Herb/Swamp Complex (FE23/26) and Coastal Headland Heathlands (FE187). Six additional types; Lowland Red Bloodwood - Turpentine Dry Shrub Forest (FE2), Jervis Bay Lowland Dry Forest (FE5), Scribbly Gum - Red Bloodwood Heathy Woodland (FE139), Coastal Shrub/Grass Forest - *E. tereticornis* (FE171), Coastal Lowlands Swamp Mahogany Forest (FE175) and Mangrove Forest (FE185) were included in the re-mapping which were not in the original FE model for this area but has been mapped and described in other parts of the area covered by the CRA mapping.

The forest ecosystems recognised during the project were all accommodated within the scope of previously defined types without the need for defining of entirely new types. However, some of the descriptions by Thomas, Gellie and Harrison (2000) relate more specifically to locations outside the study area, requiring expanded or revised descriptions and lists of diagnostic species. The revised details are incorporated in the forest ecosystem profiles contained in Appendix 4.

The three modelled vegetation types which were eliminated, are types which are all regarded as being of conservation significance. The combined Southern Coastal Dune Scrub Complex and Coastal Dune Herb/Swamp Complex (FE23/26) was not recognised as a distinct type within the study area, and

areas modelled as this type were found to be composed mainly of eucalypt forest types. Coastal Hinterland Gully Rainforest (FE20) and Coastal Headland Heathlands (FE187) were both modelled over very limited extents within the study area and since they exist elsewhere in the region, there is no significant change to their conservation status in terms of number of hectares protected in parks and reserves in the region.

Based on the findings that have been discussed in detail in relation to each vegetation type and relating to the re-mapping work as discussed above, the following general conclusions are apparent.

The forest ecosystem modelling carried out for the Southern CRA has provided a generally poor representation of the vegetation patterns occurring in Narrawallee Creek NR. While it has been correct in predicting the occurrence of some of the forest ecosystem types, the actual distribution of these types is very different in reality. Some types have been predicted which do not exist and others have been found which were not modelled.

Along the coastline and around the coastal lakes and estuaries, the modelled distribution of many of the non-forest types was found to be quite inaccurate. Most of the modelled types were found to be present somewhere, if not exactly in the modelled locations. Re-mapping of these areas was necessary using air photo interpretation which had the added benefit of improving the spatial accuracy of the margins of vegetation communities with lake shorelines, estuarine waters, beaches, rock platforms and sea cliffs. Cleared areas or agricultural land and cleared easements along roads and fire trails were also re-mapped. Overall, the re-mapping of the coastline has confirmed the diversity of vegetation types present and helped to identify those areas containing vegetation of particular conservation significance.

The modelling process had failed to predict the occurrence of several widespread eucalypt forest types, notably Lowland Red Bloodwood - Turpentine Dry Shrub Forest (FE2) which occupies most of the northern and western parts of the reserve. This is surprising since the CRA API mapping had correctly mapped this type and could be used to correct the problem. Two significant eucalypt communities Coastal Shrub/Grass Forest - *E. tereticornis* (FE171) and Coastal Lowlands Swamp Mahogany Forest (FE175) were also included in the re-mapping. The estuarine vegetation along Narrawallee Creek was found to be more complex and diverse than the modelling suggested, with narrow fringes of Mangrove Forest (FE185), Saltmarsh (FE186) and the *Casuarina glauca* forests (FE24 and 25). Jervis Bay Lowland Dry Forest (FE5), another community omitted from the modelling, was also found in this area.

Overall, the vegetation of Narrawallee Creek Nature Reserve is more diverse and contains more significant communities than was previously suggested by the forest ecosystems modelling. The reserve is undoubtedly important in conserving a number of coastal vegetation types which are uncommon in the region and this heightens its role in flora and fauna conservation and the need for sympathetic fire management practices.

4 MANAGEMENT IMPLICATIONS

4.1 Conservation Significance and Fire Management

4.1.1 Non-eucalypt Vegetation Types

Swamp Oak and Swamp Paperbark Forests (FE24 and 25)

Swamp forests dominated by *Casuarina glauca* (FE24 and 25) are regarded as being of high conservation significance in the region because they naturally occur in small fragmented stands around coastal lakes and in small coastal creeks, and because the aggregate remaining area of them in the South Coast sub-region was calculated to be low (about 10,000 ha in total for the two types). They are thought to have been relatively heavily affected by clearing, with an estimated 53% of FE24 and 78.5% of FE25 cleared. An earlier map validation project in Meroo and Murramurang National Parks has already demonstrated that these two vegetation types are considerably less common in the Ulladulla area than the CRA mapping suggests. The findings of this project are consistent with this trend, with only a fraction of the predicted distribution of these communities found to be correct.

This makes the existing areas of higher conservation significance. It appeared that stands around Narrawallee and Croobyar Creeks outside the Reserve, may be more extensive than the small areas detected within the Reserve, but in general both these communities tend to occur in narrow strips along lake margins and creek banks. On private property they are vulnerable to degradation through grazing, residential development and recreational pressure. The small stand in the Reserve in fact appeared to have been grazed by cattle, with some browsing of trees and shrubs apparent and dried manure present. This part of the Reserve is accessible only by boat or across private property and so livestock incursions may go undetected. The stand in this area is mature, unlike many of those found previously in Meroo National Park, which had been burnt, killing the casuarina.

This vegetation can be highly flammable if it carries a dense groundcover of sedges, and if lake levels are low so that the ground is dry at the time of the fire. *Melaleuca ericifolia* would also be highly flammable, as least in young stands where there is uniform distribution of fine fuels from close to ground level to the crown. *Casuarina glauca* is not very flammable, but is readily killed by high intensity fires. Previous observations at Meroo Lake indicated that some individuals had survived the fire there, and some had succumbed. Subsequent death or recovery may also depend to some extent on water levels after the fire, since additional stress may be placed on the plant by prolonged flooding, such as might occur in drought periods when closing of the lake mouth raises water levels. If Narrawallee Creek mouth does not close (and the abundance of mangroves along the banks suggests that this is so) then stands in this area may be spared the stress of prolonged flooding. This may be part of the reason why mature stands are present.

If fuel reduction burns are being undertaken in eucalypt forest in the vicinity of this vegetation type, care needs to be taken not to allow the fires to escape into it. The main locations in which it was observed were between Narrawallee and Croobyar Creeks (FE25) and around the edges of Pattimores Lagoon (FE24), with a very small area of FE25 also present around a small tidal backwater north of the Narrawallee Creek estuary.

Dune/Headland Scrub and Beach Strand Grassland (FE22 and 23)

These two communities are of significance because they protect the shoreline from wave erosion and because they are naturally fragmented communities which typically occur in quite small patches. They are often subjected to substantial recreational pressure when they occur close to towns, and tend to be the focal point of visitor activity in coastal conservation reserves. As such they are vulnerable to erosion and weed invasion. Significant weeds which threaten these communities are bitou bush (**Chrysanthemoides monilifera* ssp *rotundata*), bridal creeper (**Asparagus asparagoides*) and a suite of beach weeds including marram grass (**Ammophila arenaria*, formerly planted on some beaches to control erosion), beach daisy (**Arctotheca populifolia*) and sea spurge (**Euphorbia paralius*). None of these weeds were observed on Narrawallee Creek NR beaches or dunes, but as almost no time was spent in these vegetation communities, this does not indicate that weeds are not present. Many of

these weeds arrive independently of human disturbance, either deposited by birds or borne in ocean currents. They can therefore become established on quite remote sites. Bitou bush seedlings were seen (and removed) in a couple of forest locations in the reserve.

Beach Strand Grassland is unlikely to burn due to the high salt levels in many of the plants and its generally sparse cover. Dune and Headland Scrubs may burn in extreme conditions but this is likely to be a rare event. Fire could be considered as a weed management method in stands which are infested with either bitou bush or bridal creeper, as long as follow-up weeding is undertaken to remove surviving plants. Fire will remove the larger plants of bitou bush and improve access for controlling seedlings, which are likely to emerge abundantly after a fire. There is some evidence that regular fire would help to control bridal creeper (Willis *et al* 2003) as germination occurs more readily in the dark conditions which occur under dense vegetation or leaf litter and appears to be inhibited by light, and possibly to some extent by smoke. Since many natives display the reverse pattern of germination, regular burning could help tip the balance in favour of native plants and away from bridal creeper. However, it could also help to destabilise the dunes by removing vegetation cover.

Mangroves and Saltmarsh (FE185 and 186)

These communities are also significant for their foreshore protection role, because they provide breeding and feeding grounds for shorebirds, fish and other aquatic fauna, and because they naturally occur in small, fragmented stands. However, their dispersal ability is high as the seeds of all component species are likely to be resistant to immersion in salt water and able to disperse from one estuary to another via ocean currents. Mangroves particularly are highly capable of colonising suitable habitat and have been observed to be encroaching into saltmarsh in many locations within New South Wales (Harty and Cheng 2003, Saintilan and Williams, 1999, J Miles, pers. obs.). They are doing so in the one location at which they were recorded in Narrawallee Creek and quadrat NARJM02 has been positioned to monitor this process.

Mangroves are common in Narrawallee Creek, although confined to a narrow band in sections with a steep bank. They broaden out into belts up to 100m wide in areas where there are extensive deposits of sediment, such as around the confluence of the two arms of the creek near the western boundary of the Reserve.

Neither community is very prone to weed invasion because of the specialised growing conditions created by frequent inundation and high salinity. However there are a few weeds capable of exploiting these conditions, such as sharp rush (**Juncus acutus*). This species has proven invasive in similar habitat elsewhere on the South Coast, such as at Durras Lake. The Narrawallee Creek estuary may also be susceptible to invasion by caulerpa (**Caulerpa taxifolia*), an exotic aquatic plant which is established in nearby Conjola Lake, and can be transported on boats, diving equipment and even on animals or swimmers.

Neither mangroves nor saltmarsh are likely to be burnt, although it could occasionally happen in extreme conditions. The upper edge of saltmarsh often consists of a dense belt of sea rush, *Juncus kraussii*, which is likely to be quite flammable. However, it is also likely to recover rapidly from underground rhizomes.

4.1.2 Eucalypt Vegetation Types

Coastal Lowlands Swamp Mahogany Forest (FE175)

FE175 was ranked in the CRA report (Thomas, Gellie and Harrison, 2000) as a highly vulnerable ecosystem with a naturally restricted distribution (about 460 hectares in aggregate) on the South Coast. However, not all occurrences have been mapped, as occurrences in Narrawallee had been overlooked in both the FE and API mapping.

FE175 is listed as an Endangered Ecological Community in the Sydney Basin Bioregion (which includes the Ulladulla area) because of its fragmented distribution and threats such as clearing, weed invasion and changes to hydrological conditions

Fire may sweep through this community quite frequently, as although the ground is often wet, the groundcover and shrub layers are often dense and include highly flammable plants such as teatrees (*Leptospermum polygalifolium*) and paperbarks (*Melaleuca* spp). There may also be good fuel continuity from ground to canopy. Most species in this community appear well adapted to regular fires, with resprouting from lignotubers, epicormic buds or root suckers being the most common fire

responses. However, there are some component species which are obligate seeders such as the peas *Sphaerolobium* spp and *Viminaria juncea*, and these could be eliminated by too frequent fire. Conversely the main recruitment of these species appears to be after fire (Benson & McDougall, 1996), and a very long fire-free interval could also eliminate them from the seedbank.

FE175 is represented in Narrawallee Creek Nature Reserve, in a gully flat in the north and on the floodplain north and east of Narrawallee Creek where it intergrades with FE29.

Coastal Red Gum Grassy Forest (FE171)

FE171 was ranked in the CRA report (Thomas, Gellie and Harrison, 2000) as a vulnerable ecosystem with a naturally restricted distribution (about 3500 hectares in aggregate) on the South Coast. Their estimate of 1683 hectares in reserves seems likely to be exaggerated, as it was found in the Eden Region that almost none of the predicted occurrences in reserves of the similar community Bega Dry Grass Forest were correct. Bega Dry Grass Forest has been subsequently listed as an Endangered Ecological Community in the South East Corner Bioregion (south from Batemans Bay), and it is likely that similar red gum communities on the South Coast are equally depleted.

The community is vulnerable to weed invasion because it typically occurs on more fertile soils and in better watered locations such as alluvial flats, and also because remnants generally occur within or close to farming areas. The small patch of this community in Narrawallee Creek NR is remote from farming areas, but has been disturbed by past quarrying. It is more weed infested than the remainder of the Reserve, but no major weeds were seen.

Because of the grassy understorey fires are likely to burn through this community quickly and not very hot. The grassy groundcover is well adapted to recovering from frequent fire. If fire is withheld for lengthy periods a dense sub-canopy layer of black wattle (*Acacia mearnsii*) may develop, and this can reduce groundcover species diversity by shading out some less shade tolerant species. There is also likely to be a species shift to include more bird-distributed and fire-intolerant species such as *Pittosporum undulatum* and *P. revolutum*.

Coastal Sands Bangalay-Banksia and Blackbutt-Banksia Forests (FE28 and 29)

FE28 was identified in the CRA report (Thomas, Gellie and Harrison, 2000) as an ecosystem with a naturally restricted distribution on the South Coast. It has generally been found to be over-mapped in both the South Coast and Eden Region, making it even more restricted than CRA mapping has suggested.

FE28 should be considered to be of at least moderate conservation significance because it is a naturally fragmented ecosystem of limited distribution in the region which is coming under increasing pressure outside reserves for residential development because of its occurrence on flat land close to the sea. The same is true of FE29, which also appears to have been over-mapped, at least in Narrawallee Creek Nature Reserve. As well as coming under development pressure outside reserves, stands in reserves often bear the brunt of recreational usage in the reserve, which tends to be concentrated on the beaches and their access points. They may also be targeted for frequent hazard reduction burning to protect coastal villages such as Lake Conjola.

The understorey of FE28 and FE29 is very similar and generally well adapted to regular fire. Bracken tends to dominate the groundcover and to become more dominant under regular burning. Some shrubs which are relatively slow growing and not capable of re-sprouting, such as *Monotoca elliptica*, are likely to be lost from frequently burnt stands, as may some other obligate seeders such as wattles, depending on the fire frequency.

Scribbly Gum-Red Bloodwood Heathy Woodland (FE139)

FE139 was not identified as an ecosystem of high conservation significance in the region, but it probably should be. Although this type of vegetation is very extensive in the Sydney basin, and is well reserved in the region in Morton National Park, it is at its southern limit of distribution around Ulladulla. Many of the component species, such as *Eucalyptus sclerophylla, Lambertia formosa, Persoonia mollis* ssp *caleyi, Petrophile pedunculata, Kunzea capitata, Epacris pulchella* and *Actinotus minor* are also at or very close to their southern limit at Ulladulla.

FE139 also represents habitat for the orchid *Cryptostylis hunteriana*, listed as Vulnerable under the *Threatened Species Conservation Act*. This species has been recorded in Conjola NP, but not in

Narrawallee Creek NR to date. Very little FE139 was observed in Narrawallee, so the amount of habitat available for it is small. The bulk of it occurs in an area around Silica Ridge Fire Trail, which has been substantially disturbed by past quarrying.

FE139 also requires careful fire management. Having a predominantly heathy shrub understorey with a high proportion of sclerophyllous shrubs, and often a dense sedge layer as well, it is highly flammable. Fine fuels are more or less uniformly distributed from ground level to the low eucalypt crowns, via tall shrubs such as *Leptospermum trinervium*. This makes this vegetation type flammable is almost all weather conditions, and difficult to extinguish because the continuous shrubby understorey makes firebreak creation impossible except at tracks.

Such heathy vegetation is adapted to relatively frequent fire, but too short an interval between fires may eliminate obligate seeders, which are killed by fire rather than re-sprouting, from the species mix. Resprouting shrubs can also be eliminated over a longer period if frequent fires do not allow it sufficient time to replenish seed banks, and if more fire-sensitive juvenile plants are killed.

Lowland Red Bloodwood-Turpentine Dry Shrub Forest (FE2)

FE2 is a common and widespread community identified in the CRA report (Thomas, Gellie and Harrison, 2000) as of low vulnerability to threatening processes such as clearing and weed invasion. It typically occurs on soils of low fertility and in drier parts of the landscape and so has been little cleared to date. It was found to have been incorrectly omitted in the FE map within Narrawallee Creek NR although the API map has it correctly mapped..

One rare plant species is associated with this community in Conjola NP. This is the shrub *Pultenaea villifera* var. *villifera*. It has not been recorded in Narrawallee Creek NR to date, although similar habitat is present. A location was recorded just outside the reserve in the north west near Yatteyattah Bay.

The predominantly shrubby understorey of this community appears well adapted to regular fires, with many re-sprouters, including some members of the Fabaceae family (peas and wattles) which are more commonly seeders. However there would be some species which could be eliminated by too frequent fire. *Pultenaea villifera* is likely to be such a species as it is recorded as re-sprouting after a cool fire, but being killed and regenerating from seed after a hot fire (NPWS Fire Response database).

Spotted Gum-Blackbutt Moist Forest (FE21)

FE21 is a common and widespread community identified in the CRA report (Thomas, Gellie and Harrison, 2000) as of moderate vulnerability to threatening processes such as clearing and weed invasion. It typically occurs on soils of lower fertility and in steeper parts of the landscape and so has been little cleared to date. Although only a small area in the north west of Narrawallee was mapped, FE21 is common in nearby areas outside the reserve and in Conjola and Morton National Parks

This community occurs in less fire-prone situations such as creek flats and gullies and consequently can develop an understorey of mesophyll shrubs and rainforest tree saplings. In the continued absence of fire it is likely to develop into FE20, Ecotonal Gully Rainforest, while under more frequent fire it is likely to lose the shrub component and become more open with a groundcover of grasses, sedges such as *Gahnia* spp, ferns and herbs. The community FE5 (Jervis Bay Lowlands Dry Forest) is likely to be what FE21 would develop into under frequent burning.

Jervis Bay Lowlands Dry Forest (FE5)

FE5 was identified in the CRA report (Thomas, Gellie and Harrison, 2000) as being restricted to an area immediately west of Jervis Bay, where it occurs on flat sites below about 100m elevation. The original area is estimated to have been about 16000 hectares, with about half having been cleared and relatively little reserved prior to the RFA (1000ha). It was regarded as having moderate vulnerability to threatening processes such as clearing. The Jervis Bay hinterland is a growth area for residential subdivision. However, the community may be more widespread than mapping suggested since the CRA mapping did not have it extending as far south as Conjola and Narrawallee.

The understorey of this community is likely to vary between shrubby and grassy depending on fire frequency. As described by Thomas, Gellie and Harrison (2000) it includes a number of obligate seeders such as *Allocasuarina littoralis, Pimelea linifolia, Pultenaea retusa, Pultenaea villosa, Hakea sericea* and wattles *Acacia irrorata* and *A. terminalis*. These are likely to disappear under a regime of

frequent fire, leaving an open grassy understorey. Grasses are also quite prominent and diverse in this community and this may reflect the varying fire histories of the areas in which it was sampled.

4.2 Rare and Threatened Plant Species

There are no records in the NPWS Atlas of NSW Wildlife of threatened plant species, although the ROTAP listed species *Pultenaea villifera* var *villifera*, has been recorded just outside the north west corner of the reserve. An additional site north of Lake Conjola Entrance Road within Conjola National Park was recently reported by NPWS.

A number of additional rare or threatened species were recorded during the field work for this project as outlined below. The recorded locations of all known rare and threatened species are shown on the vegetation maps accompanying this report.

Eucalyptus punctata

Grey gum has its southern limit "south of Nowra" (Harden 2002), and Mills (1995) states that its southern limit is in the former Cudmirrah National Park, now part of Conjola. During this survey it was also seen near the north-western corner of Narrawallee Creek Nature Reserve, where it occurs in grassy forest which is probably rather atypical Lowland Red Bloodwood-Turpentine Dry Shrub Forest (FE2). This is another slight extension of range to the south. Quadrat NARJM10 includes this tree species.

Eucalyptus robusta

Forest dominated by swamp mahogany Coastal Lowlands Swamp Forest (FE175) could be regarded as belonging to the Endangered Ecological Community, Sydney Coastal Estuary Swamp Forest Complex, listed under the *Threatened Species Conservation Act*. Occurrences within the Sydney Basin Bioregion are covered by this listing, and the Ulladulla area is within this bioregion, which ends just north of Batemans Bay. The community occurs in Narrawallee Creek Nature Reserve. One site was recorded by Phil Craven (NPWS) at the causeway on Narrawallee Creek Road just south of Conjola Road and appears to extend downstream to Pattimores Lagoon. Another two sites were found in Narrawallee. One is north of the lower Narrawallee Creek estuary, between The Mangroves Track and a small tidal lake (AMG 269657 6090929). This stand consists of a narrow belt between FE29 (*E. pilularis*) just south of the track and bands of estuarine associations around the lake. Associated species on this site are *Melaleuca ericifolia, M. squarrosa* and *Gahnia clarkei*.

Also on The Mangroves Track is an extensive stand of swamp mahogany closer to Narrawallee Creek. The track passes through the stand over a distance of about 400m. It starts at AMG 269063 6091855 and ends around 269042 6091492. The stand begins abruptly on a flat sand sheet at the base of a hill at the northern end and is wettest here. It becomes gradually drier to the south and grades into FE28/29. Quadrat NARJM01 was placed in this vegetation type near its drier southern end.

In addition to being a component of a listed EEC, *Eucalyptus robusta* is also listed as a feed tree for the Koala on Schedule 2 of State Environmental Planning Policy No. 44 – Koala Habitat Protection. There are Koala records from the region, the nearest of which was in 1999, about 5 km north of Narrawallee on a boundary of Conjola National Park with farmland.

Blechnum indicum

This fern, swamp water fern or bungwall, grows in sandy soil in coastal swampy areas north from Jervis Bay (Harden 1990). A few plants were seen growing along the verges of The Mangroves Track near Narrawallee Creek. This is a wet area carrying swamp mahogany (*Eucalyptus robusta*) and a dense groundcover of the sedge *Baloskion tetraphyllum* (formerly *Restio tetraphyllus*). Presumably the species is very close to its southern limit of distribution on this site although Conacher Travers also record it as present on the western edge of Narrawallee township a little further south.

Mirbelia rubiifolia

This small shrub is common in heath and occasional in forest in all three of the surveyed parks. Mills (1995) states that it is at its southern limit in Cudmirrah (now part of Conjola) but this is incorrect as it also occurs well south of here in the extensive heathlands of Nadgee Nature Reserve close to the

Victorian border. However, given the scarcity of heathland between Ulladulla and Nadgee, the Ulladulla area may well be a local southern limit.

Trachymene incisa

Seen only in quadrat NARJM04F in FE139, this species is said to be at its southern limit around Ulladulla (Harden 1992). It was common in the plot but could not be identified with certainty as it was not flowering at the time.

4.3 Weeds

The project brief did not include searching for or recording weeds, but notes were made on the occasions when significant weeds were encountered. In Narrawallee Creek NR only one such location was recorded, along Buckleys Point Fire Trail at grid reference 270067 6091980), where a small infestation of bulbil watsonia (**Watsonia meriana* cv. Bulbilifera) was seen. This species is highly invasive, and should be eradicated while the infestation is still small. It is likely to have entered the reserve in soil on a vehicle.

From a weed-management viewpoint, consideration needs to be given to closing as many non-essential tracks as possible, to reduce the scope for weed introduction on vehicles, and deliberate dumping of garden refuse in the bush.

5 PROJECT TEAM

Member	Role	Expertise
Nicholas Graham-Higgs	Project Manager	Holds a BSc Uni. Of Canb. He has managed, and been involved with a large number of large proposals relating to National Parks within South-eastern NSW.
Jackie Miles	Botanist	Holds a BSc, (Hons) from the Aust. Nat. Uni.. Has completed an extensive number of botanical and zoological assignments on contract to a number of organisations and agencies such as the National Parks and Wildlife Service.
Phil Kendall	API mapping GIS work, field data entry, report compilation	Holds a BSc Uni. Of Canb. Worked for 25 years in environmental planning and specialising in GIS for the last 15 years. Has completed many GIS and environmental projects for National Parks and Wildlife Service.

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APPENDIX 1: Forest Ecosystem Summary Tables

Table A1.1 Forest Ecosystem Types Following Re-mapping of the Narrawallee Study Area

FE Type	Forest Ecosystem Description (as used in this project)	Validation Task	Conservation Status	No. of Polygons	Total Hectares
2	Lowland Red Bloodwood - Turpentine Dry Shrub Forest	API conversion & re-mapping		2	728.87
5	Jervis Bay Lowland Dry Forest	Re-mapping		3	43.99
21	Spotted Gum - Blackbutt Moist Forest	API conversion & re-mapping		1	15.37
22/23	Dune/Headland Scrub and Beach Strand Grassland Complex	Re-mapping	Significant	1	45.7
24	Swamp Oak - Swamp Paperbark Forest	Re-mapping	Significant	4	24.64
25	Swamp Oak Forest	Re-mapping	Significant	8	27.02
28	Coastal Sands Bangalay - Banksia Forest	Re-mapping	Significant	8	99.57
29	Coastal Sands Blackbut - Banksia Forest	Re-mapping	Significant	3	122.16
139	Scribbly Gum - Red Bloodwood Heathy Woodland	API conversion	Significant	1	15.61
171	Coastal Red Gum Grassy Forest	API conversion & re-mapping	Significant	1	5.7
175	Coastal Lowlands Swamp Mahogany Forest	Re-mapping	Significant	7	84.74
185	Mangrove Forest	Re-mapping	Significant	7	34.3
186	Saltmarsh	Re-mapping	Significant	9	25.62
cleared	Cleared Land	Re-mapping		5	19.09
urban	Urban Development	Re-mapping		4	71.03
water	Water Body	Re-mapping		7	73.9

Note: Number of polygons and total hectares refer to the expanded study area rather than the actual area of the nature reserve.

Table A1.2 Forest Ecosystem Types No Longer Included in the Study Area Following Re-mapping

FE Type	Forest Ecosystem Type (Thomas, Gellie & Harrison, 2000)	Conservation Status
20	Coastal Hinterland Gully Rainforest	Significant
23/26	Combined Southern Coastal Dune Scrub Complex and Coastal Dune	Significant

FE Type	Forest Ecosystem Type (Thomas, Gellie & Harrison, 2000)	Conservation Status
	Herb/Swamp Complex	
187	Coastal Headland Heathlands	Significant

Table A1.3 Forest Ecosystem Types Present, No Longer Present and New Types Following Re-mapping

FE Type	Forest Ecosystem Type (Thomas, Gellie & Harrison, 2000) [New Description used in this report in brackets]	Status
2	Hinterland Heath Shrub Dry Forest - *Corymbia gummifera*/*Syncarpia glomerulifera* [Lowland Red Bloodwood - Turpentine Dry Shrub Forest]	New
5	Jervis Bay Lowlands Scrub/Grass Dry Forest – mixed tree species [Jervis Bay Lowland Dry Forest]	New
20	Coastal Hinterland Gully Rainforest	N
21	Northern Coastal Hinterland Moist Shrub Forest - *C. maculata/E. pilularis* [Spotted Gum - Blackbutt Moist Forest]	Y
22/23	Combined Southern Coastal Hind Dune/Headland Scrub and Southern Coastal Dune Scrub Complex [Dune/Headland Scrub and Beach Strand Grassland Complex]	Y
23/26	Combined Southern Coastal Dune Scrub Complex and Coastal Dune Herb/Swamp Complex	N
24	Coastal Tall Wet Heath Swamp Forest - *Casuarina glauca/Melaleuca ericifolia* [Swamp Oak - Swamp Paperbark Forest]	Y
25	South Coast Swamp Forest - *Casuarina glauca* [Swamp Oak Forest]	Y
28	Coastal Sands Shrub/Fern Forest - *E. botryoides/Banksia serrata* [Coastal Sands Bangalay - Banksia Forest]	Y
29	Northern Coastal Sands Shrub/Fern Forest - *E. pilularis/Banksia serrata* [Coastal Sands Blackbut - Banksia Forest]	Y
139	Northern Coastal Hinterland Heath Shrub Dry Forest - *C. gummifera/E. sclerophylla* [Scribbly Gum - Red Bloodwood Heathy Woodland]	New
171	Coastal Shrub/Grass Forest - *E. tereticornis* [Coastal Red Gum Grassy Forest]	New
175	Northern Coastal Lowlands Swamp Forest – *E. robusta* [Coastal Lowlands Swamp Mahogany Forest]	New
185	Mangrove Estuarine Low Forest [Mangrove Forest]	New
186	Mudflats/Saltmarshes [Saltmarsh]	Y
187	Coastal Headland Heathlands	N

Y = Originally modelled and still present after re-mapping

N = Originally modelled but no longer present after re-mapping

NEW = Not originally modelled – included in re-mapping

APPENDIX 2: Field Data Sheets – examples of blank forms

APPENDIX 3: Description of Quadrat Sites

All quadrats recorded in Narrawallee NR are described below. Those designated as fire monitoring quadrats are distinguished by the suffix F in the site name. Additional data was collected on regeneration mechanism in these sites, and the marker post is located centrally rather than in the corner of the plot. Other than this there is no difference between fire response and full floristics plots and the latter could be converted to fire response quadrats if desired later.

NARJM01

This site was modelled incorrectly as FE23/26. Located west from a large tree stump on The Mangroves Track, this quadrat samples FE175 (Coastal Lowlands Swamp Forest – *E. robusta*) at the drier end of its species composition. This association covers a large flat area near Narrawallee Creek which is typically under water, although it was dry due to the drought conditions at the time of the survey. *E. robusta* forms an open canopy, with scattered *Acacia longifolia* and a groundcover of sedges and grasses, particularly the distinctive species *Baloskion tetraphyllum* (previously called *Restio tetraphyllus*). Just south from the quadrat site the vegetation grades into FE29 with *E. piluaris, Angophora floribunda* and *Banksia serrata* on very slightly more elevated ground.

The site was not recently burnt.

NARJM02

This site is on a large sandy bar in a bend of Narrawallee Creek close to its mouth.The CRAFTI map shows it as mangrove (FE185) while the FE map shows saltmarsh (FE186). The current (i.e. date of aerial photographs used for the orthophotography) saltmarsh (FE187) and mangrove (FE186) boundaries have been re-mapped more accurately by API.. Mangroves form a tall fringe of mature trees along the water's edge, with a sheet of younger plants up to 1m high covering most of the bar between the tall mangrove fringe and the eucalypt forest behind. There is a small area of saltmarsh dominated by samphire (*Sarcocornia quinqueflora*) and a narrow belt of sea rush (*Juncus kraussii*) along the landward edge. The quadrat is located within samphire at the point where mangroves are just beginning to invade it. Only these two species were found in the plot. It is envisaged that monitoring of this quadrat could provide information about the dynamics of saltmarsh and mangroves in the region. Currently there appears to be a state-wide trend for the invasion of saltmarsh by mangroves (Saintilan & Williams 1999), and the estuarine areas of Narrawallee Creek Nature Reserve appear typical in this respect.

No evidence of past fire was seen and this vegetation association is very unlikely to ever burn.

NARJM03

This quadrat is located just south of Buckleys Point Fire Trail in an area previously mapped as FE29. It appears to be intermediate between FE29 and FE2. The API map shows the site in a large polygon of FE2, which has been used in the re-mapping. However, the site is within 200 metres of the edge of the polygon, which borders areas of FE29 and therefore some intergrading could be expected. Dominant canopy species are *E. pilularis* and *C. gummifera*. The presence of *Syncarpia glomerulifera* and a number of "heathy" shrub species such as *Gompholobium latifolium* and *Petrophile pedunculata* suggest the latter, while the presence of a little *Banksia serrata* and the dominance of the sedge *Lepidosperma concavum* suggests FE29. The site is on deep sand and is more or less flat, which is typical habitat for FE29.

The site appeared to have experienced a moderate fire about ten years ago.

NARJM04F

Located just north of Silica Fire Trail in an area previously mapped as FE29, this quadrat is intermediate between FE139 and FE2. The area immediately south along the ridgetop has been re-mapped as FE139, within a large polygon of FE2. The site has large scribbly gum (*E. sclerophylla*) and various heathy shrubs including *Lambertia formosa* and *Hakea laevipes* (formerly *H. dactyloides*, resprouting form) but also has *Allocasuarina littoralis* and *Leptospermum polygalifolium*, neither really typical of FE139. Mills (1995) describes distinct sub-communities including *E. sclerophylla* and *A. littoralis*, found on deeper soils than typical heathy FE139, and *E. sclerophylla* and *Leptospermum*

polygalifolium found on poorly-drained clayey soils. This quadrat is located just off the top of a ridge in the head of a small drainage line which may account for the *Leptospermum*.

It had been partially burnt with *Leptospermum* resprouting strongly in the north-eastern corner and mature *Allocasuarina* unaffected by the fire in the south-western corner. There was evidence of an earlier light fire and a severe fire possibly 30 years or more previously (giving rise to the present crop of mature *Allocasuarina littoralis*).

NARJM05

This site is located in a minor drainage line head south of Silica Ridge Fire Trail on a southerly aspect. It was previously mapped as FE28 but appeared to be long-unburnt FE2, with *E. pilularis, C. gummifera* and *Syncarpia glomerulifera* dominant. There was some development of a small tree layer including rainforest edge species *Elaeocarpus reticulatus* and *Ceratopetalum gummiferum*.

The site did not burn in the Hylands fire, but there was evidence of a light fire in the last 10 years and a severe fire a long time ago.

NARJM06

This quadrat samples an unusual vegetation community occurring on what appears to be a small patch of monzonite about 1 km south of Conjola township. The area appears to have been quarried in the past, with considerable disturbance and many apparently artificially created hillocks of soil. There is a small tin shed next to Silica Fire Trail near where it joins the Conjola Beach track and the quadrat is located 70m west of this shed in a relatively undisturbed area. The vegetation is dominated by forest red gum (*E. tereticornis*), white stringybark (*E. globoidea*) and rough-barked apple (*Angophora floribunda*), with *Acacia mearnsii* and a grassy understorey. This vegetation type would probably have been common on monzonite around Milton but has been completely cleared for agriculture except for a few remnant red gums. This area is significant in that it provides an indication of the nature of the former understorey in this vegetation community. It fits best into FE171 (Coastal Shrub/Grass Forest –*E. tereticornis*). Even prior to clearing for agriculture it would have been rare in the region because of the dominance of sandstone-derived soils.

There was no evidence of recent fire on the site. The area in which it occurs was hazard reduced in 1994-95 and 1995-96.

NARJM07

Located on a low flat between Narrawallee Creek and Croobyar Creek, this quadrat samples FE25 (*Casuarina glauca* Swamp Forest). This community was previously mapped as being very extensive in this area, but a survey of the creek banks by canoe showed that in fact it is restricted to a narrow band along the waters edge or behind the mangroves. It is much more extensive on the southern bank, outside the reserve.

This quadrat was located close to the boundary between FE25 and the adjacent eucalypt forest, which occurs on slightly higher ground to the north and west. This area (also mapped as FE25 in the API and FE maps) extends about 500 metres north and has been re-mapped as FE5 (seee site NARJM08 below). About 500 metres north, the land slopes towards Narrawallee Creek and again gives way to FE25.

It was envisaged that any changes in the balance between drier forests and estuarine communities such as might occur due to rising sea levels could be observed by monitoring this quadrat. Eucalypts occur immediately to the west of the quadrat, including coast grey box (*E. bosistoana*), which may be a regionally uncommon species. It grows close to the water's edge, just above the mangrove belt.

The site had not been burnt recently, although there were signs of a light fire somewhere in the last 20 years. Cattle had been grazing in the area, although not very recently. Casuarina suckers and some sedges had been browsed.

NARJM08

This quadrat, located 100m west of NARJM07 and 50 metres north of Croobyar Creek , was put in to sample the eucalypt forest in this area, which had been incorrectly mapped as FE25. It was not marked with a permanent stake, but used a large tree stump as the south-east corner. Dominant trees are *E. pilularis* and *Corymbia gummifera*, with *Angophora floribunda* and *Syncarpia glomerulifera* also present. This would imply that the vegetation community is either FE29 or FE2, with the former being more likely on the grounds that it grows on deep sands close to the coast. However, the

predominantly grassy understorey and non-sclerophyll shrub component (*Breynia oblongifolia, Ozothamnus diosmifolius, Olearia viscidula, Pittosporum revolutum*) suggests FE5, Jervis Bay Lowlands Shrub/Grass Dry Forest, even though few of the trees seen on this site are listed as occurring in it.

NARJM09F

Located 1.25km south of Conjola village, this site was originally requested as a full floristics quadrat, but was converted to a fire monitoring quadrat on the grounds that frequent fire could be required in this area to protect the village. The fire quadrat requested in coastal heath on the headland at the southern end of Conjola Beach was not done, on the grounds that there is no heath on this site, only headland scrub (part of FE2223, dune scrub complex), which is very unlikely to burn because of its topographic position. The alternative site chosen is mapped as being FE28 (Coastal Sands Forest – *E. botryoides*) but is in fact FE29, a very similar community with *E. pilularis* dominant (*Corymbia gummifera* and *Angophora floribunda* are also present on this site). FE28 is likely to occur in a narrow band closer to the beach, as it does at the carpark further south and has been re-mapped as this type from the air photos.

The site was unburnt, so no data on regeneration mechanism was collected. However seedling and flowering occurrence was recorded. There were some seedlings present in the absence of recent fire, but the only species for which they were common was burrawang (*Macrozamia communis*).

The area in which it is sited was hazard reduced in 1995-96.

NARJM10

This site is in the head of a gully with an easterly aspect near where Northern Fire Trail leaves Conjola Road. It may be representative of forest on better quality soils, hilly terrain and sheltered aspect. The particular site was chosen for the presence of grey gum (*E. punctata*) which is at its southern limit in the region and was not seen anywhere else during the survey. The site is a grassy forest and although the soil appeared sandy, the presence of grey ironbark (*E. paniculata*) suggests a clay subsoil. The area was previously mapped as FE29, but this is patently incorrect as this type occurs only on lower-lying more or less flat areas on deep sand deposits. FE5 is more accurate, even though *E. pilularis* is the dominant tree present. The area surrounding the site has been re-mapped as FE5 but the full extent of FE5 has not been determined and the majority of the large API polygon surrounding it, has been retained as FE2. A separate location where FE5 is mapped, relates to site NARJM08.

It appeared that there had been a light fire through the site in the last 6-14 years. It is recorded as having burnt in the wildfire of 1968-69.

APPENDIX 4: Forest Ecosystem Profiles

Southern CRA Profile Information

The first page of information on each forest ecosystem is reproduced from Thomas, Gellie and Harrison (2000) and refers to the FE type throughout its distribution in the Southern CRA area. Some corrections to FE descriptions, species names and spellings on these pages, have been made to improve the accuracy of the information. The diagnositic species lists have not been changed and the non-alphabetic order of the lists has been retained, since it in part reflects the fidelity classes.

Descriptive vegetation profiles include information about the floristic composition, structure, habitat, and occurrence of each ecosystem. The written description is designed to provide a general overview of the structure and floristics of each of the derived forest ecosystems. Floristic data comprises a table showing vegetation group frequency and cover-abundance of each species within the described unit, together with its frequency and abundance in all the other vegetation groups. Fidelity classes within the floristic table describe the positive or negative association of that species within the vegetation group and provide an indication of the diagnostic species within vegetation group. Please note that Fidel tables have only been generated for ecosystems 1 to 170, as these were direct outputs of the PATN classification

Vulnerability rankings were set for ecosystems in the South Coast and Western sub-regions to aid in CRA negotiations. These rankings were set and agreed to by the ERG and they indicate how vulnerable each ecosystem is to a range of threatening processes including:

G grazing,

C clearing,

L logging,

W weeds,

U urban development,

R recreational pressure,

F fire,

D general development,

P pigs, and

H hobby farms.

In the ranking, 1 was considered very high while 5 was very low

The mapping reliability of each mapped ecosystem was evaluated, using a score between 1 (very high) and 5 (very low). These reliability scores are indicated for each vegetation type under the heading 'Reliability'.

For further information on the Southern CRA profiles, see the report and appendices by Thomas, Gellie and Harrison (2000).

Narrawallee Study Area Information

This information is specific to the Narrawallee Study Area and has been compiled by reference to the written reports, ArcView map layers, the MS-Access floristics database (GM-Naomi) and the Conjola-Morton-Narrawallee site survey database created during this project. Fire sensitive species and fire management prescription information is derived from Section 4.1 of the report.

The following headings have been used in this section:

- Mills' Classification equivalent type – the corresponding type used in Kevin Mills (1996) report on vegetation mapping in Conjola and Cudmirrah National Parks
- Previous Survey Sites Represented – as included in NPWS survey sites ArcView layer and GM-Naomi database – including Southern CRA sites (full floristics), CSIRO canopy surveys and other earlier survey sites.

- Narrawallee 2003 Sites Represented – those sites which fall clearly within the FE type.
- Survey type - full floristics or fire response monitoring – is indicated for each site.
- Marginal Sites – those sites which are on the periphery of an FE polygon or are a hybrid with another associated FE type and therefore are not necessarily representative of a single FE type.
- Species Recorded at Representative Sites – amalgamated list from the Narrawallee 2003 field surveys which applies to the sites represented within the FE type excluding marginal sites which may have a mixed species composition reflecting an ecotonal situation. Because half of the Narrawallee sites are considered marginal, these sites have not been used in the amalgamated species lists. Weeds are shown with an asterisk in front of the species name.
- Dominant species – according to the FE description in this report
- Threatened Species – known threatened plant species recorded during the field survey or recorded in threatened species or ROTAP records
- Other Species of Conservation Significance – which have been suggested as being regionally uncommon or near their known limit of distribution, based on findings of the field survey, literature review, and records of species considered to be rare or uncommon (Southern CRA rare plants database).
- Relationship to other Forest Ecosystems – closely associated FE types
- Conservation Significance – on the basis of the vegetation assessment
- Threats – including urban interface issues, recreational pressures, weed infestation, fire sensitivity, etc
- Impacts of Fire Regimes - based on observations during the field surveys

FOREST ECOSYSTEM 2: **Lowland Red Bloodwood - Turpentine Dry Shrub Forest**

Southern CRA Profile Information

Description: Lowland Dry Shrub Forest - *Corymbia gummifera / Syncarpia glomulifera*

Lowland Dry Shrub Forest is a medium forest over 20 metres height dominated by *Corymbia gummifera*, sometimes with *E. globoidea, E. consideniana*, and *Syncarpia glomulifera* and *E. piperita* in the Clyde and Shoalhaven catchments. It has a diverse dry shrub understorey, including *Persoonia linearis, Banksia spinulosa, Acacia obtusifolia, Tetratheca thymifolia, Leucopogon lanceolatus, Lomatia ilicifolia, Acacia terminalis, Platysace lanceolata, Bossiaea obcordata*, and *Gompholobium latifolium*. The ground cover contains grasses *Entolasia stricta*, and herbs *Patersonia glabrata, Dianella caerulea* var *caerulea*, and *Gonocarpus teucriodes.*

Lowland Dry Shrub Forest occurs on shallow sandy soils on low lying ridges and moderately dry slopes in the foothills and on ridges and benches on the tops of the northern sandstone plateau areas. Austin (1978) refers to a similar type in his study of the South Coast. This forest ecosystem is equivalent to a similar type, FE46B: Lowland Dry Shrub Forest, which is found in the Eden CRA Region (Keith and Bedward 1999).

Diagnostic Plant Species

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Persoonia linearis	2	0.843	1	0.170	Positive
Entolasia stricta	2	0.814	2	0.137	Positive
Corymbia gummifera	3	0.771	3	0.038	Positive
Acacia obtusifolia	2	0.700	2	0.079	Positive
Banksia spinulosa var *spinulosa*	2	0.700	2	0.042	Positive
Tetratheca thymifolia	2	0.671	1	0.045	Positive
Pteridium esculentum	2	0.614	2	0.303	Positive
Patersonia glabrata	2	0.500	1	0.034	Positive
Dianella caerulea var *caerulea*	1	0.743	1	0.154	Uninformative
Lomatia ilicifolia	1	0.586	1	0.034	Uninformative
Leucopogon lanceolatus var *lanceolatus*	1	0.543	1	0.163	Uninformative
Billardiera scandens var *scandens*	1	0.500	1	0.129	Uninformative
Lepidosperma urophorum	2	0.486	2	0.068	Uninformative
Gonocarpus teucrioides	2	0.471	2	0.087	Uninformative
Lomandra obliqua	2	0.457	1	0.027	Uninformative
Syncarpia glomulifera	3	0.443	3	0.015	Uninformative
Acacia terminalis	1	0.414	1	0.037	Uninformative
Allocasuarina littoralis	2	0.386	2	0.097	Uninformative
Eucalyptus globoidea	2	0.386	2	0.075	Uninformative
Eucalyptus piperita	3	0.386	3	0.014	Uninformative
Phyllanthus hirtellus	1	0.386	1	0.034	Uninformative
Podolobium ilicifolium	2	0.371	2	0.071	Uninformative
Pomax umbellata	1	0.371	1	0.060	Uninformative
Bossiaea obcordata	2	0.343	2	0.020	Uninformative
Gompholobium latifolium	2	0.343	2	0.007	Uninformative
Pimelea linifolia ssp linifolia	1	0.329	1	0.054	Uninformative
Eucalyptus consideniana	3	0.314	3	0.011	Uninformative
Marsdenia suaveolens	1	0.314	1	0.017	Uninformative
Macrozamia communis	1	0.300	2	0.059	Uninformative

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Amperea xiphoclada var *xiphoclada*	1	0.286	1	0.032	Uninformative
Imperata cylindrica var *major*	2	0.286	2	0.058	Uninformative
Hibbertia empetrifolia	2	0.271	1	0.020	Uninformative
Patersonia sericea	2	0.271	1	0.027	Uninformative
Eucalyptus sieberi	3	0.257	3	0.107	Uninformative

Extant area (ha): 86310

Pre-1750 area (ha): 103568

Geographic range: South Coast and small patch within eastern edge of Northern subregion

How much conserved in reserves (ha): 0 in Northern subregion, 24046 in South Coast subregion

Vulnerability: 4(C) in South Coast

Reliability: 3

FE 2 – Narrawallee Study Area

Mills' Classification equivalent type: Cu 2, 6 or 12

Previous Survey Sites Represented: CS_JM16, CSJM_17 and KMU38.

Narrawallee 2003 Sites Represented: NARJM05

Marginal Sites: NARJM03 and NARJM04F

Species Recorded at Representative Sites:

Acianthus ssp.
Amperea xiphoclada var *xiphoclada*
Banksia spinulosa var *spinulosa*
Billardiera scandens var *scandens*
Brunoniella pumilio
Calochlaena dubia
Ceratopetalum gummiferum
Clematis glycinoides
Corymbia gummifera
Cryptostylis erecta
Dianella caerulea var *caerulea*
Elaeocarpus reticulatus
Entolasia stricta
Eucalyptus pilularis
Eustrephus latifolius var *angustifolius*
Gahnia clarkei
Glycine clandestina
Gonocarpus teucrioides
Hibbertia scandens
Imperata cylindrica var *major*
Kennedia rubicunda
Lagenifera gracilis
Lepidosperma laterale
Leucopogon lanceolatus
Lomandra longifolia
Lomatia ilicifolia
Marsdenia suaveolens
Oplismenus imbecillis
Pandorea pandorana
Parsonsia straminea
Persoonia linearis
Pteridium esculentum
Schelhammera undulata
Smilax glyciphylla
Syncarpia glomulifera
Themeda australis
Viola hederacea

Dominant species: Red bloodwood (*C. gummifera*) and/or blackbutt (*E. pilularis)* and possibly other eucalypts (*E. globoidea, E. piperita, E. consideniana* or *E. sieberi*) with a sub-canopy layer of turpentine (*Syncarpia glomulifera)* and a sclerophyll shrub understorey commonly including *Lambertia formosa, Gompholobium latifolium, Banksia spinulosa*, *Podolobium ilicifolium, Acacia obtusifolia* and *Tetratheca thymifolia*. Typical groundcover species are the grasses *Entolasia stricta* and *Panicum simile*, the ferns *Lindsaea linearis* and *L. microphylla* and herbs *Dianella caerulea, Phyllanthus hirtellus*, *Marsdenia suaveolens* and *Pomax umbellata*. Christmas bush (*Ceratopetalum gummiferum*) and blueberry ash (*Elaeocarpus reticulatus*) may be present, with ferns *Calochlaena dubia* and *Gleichenia dicarpa* in wetter or long unburned sites.

Threatened Species: *Pultenaea villifera* var. *villifera* (ROTAP species) was recorded just outside the reserve near Yatteyattah Bay.

Other Species of Conservation Significance: None

Relationship to other Forest Ecosystems: Intergrades with FE21 along gullies and with FE29 on coastal sand deposits. Adjoins FE139 on drier ridges and FE28 on coastal sand deposits.

Conservation Significance: Widely represented in the northern and north western parts of Narrawallee, not of special conservation significance.

Threats: Clearing and logging in un-reserved areas.

Impacts of Fire Regimes: Shrubby understorey appears well adapted to regular fires, with many re-sprouters, including some members of the Fabaceae family (peas and wattles) which are more commonly seeders. However there would be some species which could be eliminated by too frequent fire. *Pultenaea villifera* is likely to be such a species as it is recorded as re-sprouting after a cool fire, but being killed and regenerating from seed after a hot fire (NPWS Fire Response database).

FOREST ECOSYSTEM 5: Jervis Bay Lowland Dry Forest

Southern CRA Profile Information

Description: Jervis Bay Lowlands Shrub/Grass Dry Forest - mixed tree species

Jervis Bay Lowlands Shrub/Grass Dry Forest is a medium forest, mainly dominated by *Eucalyptus punctata*, along with other tree species, such as *Corymbia gummifera and Eucalyptus eugenioides.* This ecosystem has co-dominant shrub and grass layers. The Shrub layer comprises patches of *Allocasuarina littoralis*, in amongst *Daviesia ulicifolia, Melaleuca decora, Persoonia* spp*., and Pimelea linifolia* ssp *linifolia.* The ground layer contains grasses *Entolasia stricta* and *Themeda australis,* small sedges *Lomandra multiflora* ssp*. multiflora, Dianella caerulea* var *caerulea,* and *Lepidosperma laterale,* with herbs *Opercularia diphylla and Brunionella pumilio.*

Jervis Bay Lowlands Shrub/Grass Dry Forest is found on silty clay soils between 5 and 100 metres in elevation on the coastal lowlands south of the Shoalhaven River to Georges Basin up to the base of the sandstone escarpment

Diagnostic Plant Species

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Allocasuarina littoralis	3	0.818	2	0.101	positive
Brunoniella pumilio	2	0.818	1	0.014	positive
Entolasia stricta	3	0.727	2	0.148	positive
Daviesia ulicifolia	2	0.546	2	0.091	positive
Eucalyptus punctata	3	0.546	3	0.029	positive
Melaleuca decora	3	0.273	0	0.000	positive
Billardiera scandens var *scandens*	1	0.727	1	0.134	uninformative
Lomandra longifolia	1	0.727	2	0.416	uninformative
Pimelea linifolia ssp *linifolia*	1	0.636	1	0.058	uninformative
Lomandra multiflora ssp *multiflora*	1	0.546	1	0.144	uninformative
Opercularia diphylla	1	0.546	2	0.010	uninformative
Pultenaea retusa	1	0.546	1	0.007	uninformative
Corymbia gummifera	3	0.455	3	0.050	uninformative
Dianella caerulea var *caerulea*	2	0.455	1	0.164	uninformative
Eucalyptus eugenioides	3	0.455	3	0.008	uninformative
Hakea sericea	2	0.455	1	0.007	uninformative
Lepidosperma laterale	1	0.455	1	0.173	uninformative
Themeda australis	2	0.455	2	0.200	uninformative
Imperata cylindrica var *major*	2	0.364	2	0.061	uninformative
Pteridium esculentum	2	0.364	2	0.308	uninformative
Pultenaea villosa	2	0.364	1	0.004	uninformative
Bursaria spinosa	2	0.273	2	0.075	uninformative
Corymbia maculata	4	0.273	3	0.043	uninformative
Dichondra repens	2	0.273	2	0.207	uninformative
Entolasia marginata	2	0.273	2	0.053	uninformative
Eucalyptus longifolia	4	0.273	2	0.025	uninformative
Eucalyptus paniculata ssp *paniculata*	3	0.273	2	0.032	uninformative
Lomandra obliqua	1	0.273	1	0.034	uninformative

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Persoonia levis	1	0.273	1	0.019	uninformative
Vernonia cinerea var *cinerea*	2	0.273	1	0.029	uninformative
Acacia irrorata ssp *irrorata*	2	0.182	2	0.024	uninformative
Acacia terminalis	2	0.182	1	0.044	uninformative
Boronia polygalifolia	2	0.182	2	0.001	uninformative
Cassytha glabella forma glabella	2	0.182	1	0.025	uninformative
Cassytha pubescens	2	0.182	1	0.035	uninformative
Eucalyptus globoidea	2	0.182	2	0.081	uninformative
Eucalyptus sclerophylla	4	0.182	3	0.009	uninformative
Gahnia sieberiana	3	0.182	2	0.020	uninformative

Extant area (ha): 8916

Pre-1750 area (ha): 16382

Geographic range: South Coast

How much conserved in reserves (ha): 1001

Vulnerability: 3(C)

Reliability: 2

FE 5 – Narrawallee Study Area

Mills' Classification equivalent type: Cu3

Previous Survey Sites Represented: None

Narrawallee 2003 Sites Represented: NARJM08 and NARJM10

Marginal Sites: NARJM07

Species Recorded at Representative Sites:

Acacia implexa
Acacia longifolia ssp *longifolia*
Acacia mearnsii
Angophora floribunda
Austrostipa sp.
Billardiera scandens var *scandens*
Blechnum cartilagineum
Breynia oblongifolia
Brunoniella pumilio
Calochlaena dubia
Carex breviculmis
Carex longebrachiata
Centella asiatica
Clematis aristata
Clerodendrum tomentosum
Cymbidium suave
Cyrtostylis reniformis
Desmodium gunnii
Dianella caerulea var *caerulea*
Dichondra repens
Digitaria sp.
Doodia aspera
Echinopogon ovatus
Entolasia marginata
Entolasia stricta
Eucalyptus globoidea
Eucalyptus paniculata ssp *paniculata*
Eucalyptus pilularis
Eucalyptus punctata
Eustrephus latifolius
Eustrephus latifolius var *angustifolius*
Gahnia melanocarpa
Galium binifolium
Galium propinquum
Geitonoplesium cymosum
Geranium solanderi var *solanderi*
Glycine clandestina
Hibbertia aspera
Hibbertia dentata
Hibbertia linearis
Hibbertia scandens
Hydrocotyle laxiflora
Hypericum gramineum
Imperata cylindrica var *major*
Indigofera australis
Kennedia rubicunda
Lagenifera stipitata
Leucopogon juniperinus
Leucopogon lanceolatus
Libertia paniculata
Lomandra longifolia
Microlaena stipoides var *stipoides*
Notelaea longifolia
Olearia viscidula
Opercularia aspera
Oplismenus imbecillis
Oxalis sp.
Ozothamnus diosmifolius
Persoonia linearis
Parsonsia straminea
Pittosporum revolutum
Poa ensiformis
Poranthera microphylla
Pratia purpurascens
Pseuderanthemum variabile
Pteridium esculentum
Rubus parvifolius
Santalum obtusifolium
Schelhammera undulata
Smilax australis
Stellaria flaccida
Stephania japonica var *discolor*
Syncarpia glomulifera
Tylophora barbata
Viola hederacea

Dominant species: Grey gum (*E. punctata*) is normally dominant but not recorded in Conjola, other common eucalypts include *C. gummifera* and *E. eugenioides*, and less commonly *C. maculata, E. paniculata, E. longifolia* and *E. globoidea*. A sub-canopy layer of the small tree *Allocasuarina littoralis* is frequently present and shrubs are typically smaller species such as *Pimelea linifolia* ssp *linifolia, Pultenaea villosa, Pultenaea retusa* and *Daviesia ulicifolia*, and the understorey is predominantly grassy.

Threatened Species: None

Other Species of Conservation Significance: *Eucalyptus punctata* which is near the southern limit of its range was recorded at site NARJM10.

Relationship to other Forest Ecosystems: Usually adjoins FE2, however near Narrawallee Creek it adjoins FE24 and 25.

Conservation Significance: Not of particular conservation significance but distribution and amount reserved are not fully known.

Threats: Moderate vulnerability to threatening processes such as clearing, it has been cleared in some areas for housing.

Impacts of Fire Regimes: Understorey varies between shrubby and grassy depending on fire frequency. Includes obligate seeders such as *Allocasuarina littoralis, Pimelea linifolia, Pultenaea retusa, Pultenaea villosa, Hakea sericea* and wattles *Acacia irrorata* and *A. terminalis* which are likely to disappear under a frequent fire regime leaving an open grassy understorey. Prominent and diverse grasses may reflect the varying fire histories in different sites.

FOREST ECOSYSTEM 21: Spotted Gum - Blackbutt Moist Forest

Southern CRA Profile Information

Description: Northern Foothills Moist Shrub Forest - *C. maculata / E. pilularis*

Northern Foothills Moist Shrub Forest is a tall forest over 30 metres tall comprising a variable tree canopy. In the southern end of its range *Corymbia maculata* and *Eucalyptus pilularis* dominate the tree canopy whereas in the north *Syncarpia glomulifera* and *E. saligna* (composite) tend to be more dominant. An intermediate tree layer comprises *Synoum glandulosum, Elaeocarpus reticulatus,* and *Acacia mabelliae.* An intermediate shrub layer contains *Macrozamia communis, Notelaea longifolia, Hibbertia aspera*, *Persoonia linearis* and *Breynia oblongifolia.* A variable ground cover of sedges *Gahnia melanocarpa, Lomandra longifolia,* and *Lepidosperma urophorum,* is intertwined with vines *Smilax australis, Parsonsia straminea, Clematis aristata, Pandorea pandorana* and *Morinda jasminoides*. Ferns such as *Calochlaena dubia* and *Doodia aspera* form small patches in amongst the rest of the ground cover.

This forest ecosystem is found on sheltered slopes on Ordovician sediments in the rolling coastal foothills in the Clyde-Kioloa area. Further to the North, it is found in sheltered gullies and slopes on the Permian mudstone escarpment and in the lower Shoalhaven and Kangaroo Valley valleys. It is found mainly between 20 and 250 metres in elevation on deep clay soils.

Diagnostic Plant Species

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Cissus hypoglauca	2	0.909	2	0.093	positive
Entolasia stricta	2	0.764	2	0.140	positive
Corymbia maculata	3	0.709	3	0.034	positive
Synoum glandulosum	2	0.673	2	0.072	positive
Pteridium esculentum	2	0.655	2	0.303	positive
Notelaea longifolia forma longifolia	2	0.582	1	0.018	positive
Eucalyptus pilularis	2	0.564	3	0.022	positive
Acacia mabellae	2	0.527	2	0.018	positive
Gahnia melanocarpa	2	0.527	1	0.042	positive
Hibbertia aspera	2	0.527	2	0.065	positive
Notelaea ovata	1	0.073	0	0.000	positive
Maytenus silvestris	1	0.055	0	0.000	positive
Poa affinis	4	0.036	0	0.000	positive
Acacia jonesii	1	0.018	0	0.000	positive
Acacia linifolia	1	0.018	0	0.000	positive
Callistemon salignus	1	0.018	0	0.000	positive
Elaeocarpus reticulatus	1	0.818	1	0.094	uninformative
Dianella caerulea var *caerulea*	1	0.764	1	0.156	uninformative
Eustrephus latifolius	1	0.746	1	0.137	uninformative
Macrozamia communis	1	0.746	2	0.053	uninformative
Leucopogon lanceolatus var *lanceolatus*	1	0.709	1	0.162	uninformative
Lomandra longifolia	1	0.691	2	0.413	uninformative
Persoonia linearis	1	0.691	1	0.175	uninformative
Schelhammera undulata	1	0.673	1	0.075	uninformative
Tylophora barbata	1	0.673	2	0.098	uninformative
Breynia oblongifolia	1	0.600	1	0.080	uninformative
Geitonoplesium cymosum	1	0.582	1	0.109	uninformative

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Hibbertia dentata	1	0.582	1	0.050	uninformative
Pseuderanthemum variabile	1	0.564	2	0.058	uninformative
Smilax australis	1	0.564	2	0.141	uninformative
Parsonsia straminea	1	0.546	2	0.058	uninformative
Clematis aristata	1	0.527	1	0.265	uninformative
Desmodium varians	1	0.527	1	0.166	uninformative
Pandorea pandorana	1	0.527	2	0.143	uninformative
Morinda jasminoides	1	0.509	3	0.091	uninformative
Psychotria loniceroides	1	0.509	2	0.052	uninformative

Extant area (ha): 70036

Pre-1750 area (ha): 90370

Geographic range: South Coast

How much conserved in reserves (ha): 10570

Vulnerability: 3(L/C)

Reliability: 2

FE 21 – Narrawallee Study Area

Mills' Classification equivalent type: Cu1, 2 or 3

Previous Survey Sites Represented: None

Narrawallee 2003 Sites Represented : None

Marginal Sites : None

Species Recorded at Representative Sites: None recorded

Dominant species: Spotted gum (*Corymbia. maculata*) or blackbutt (*E. pilularis*)dominate the canopy, stringybarks (*E. globoidea* and *E. eugenioides*) and Sydney peppermint (*E. piperita*) may be present, with a small tree layer including Turpentine (*Syncarpia glomerulifera), Acacia mabellae, A. binervata, A. longifolia* ssp *longifolia* and *A. irrorata.* Mesic elements such as *Elaeocarpus reticulatus, Synoum glandulosum* and *Notelaea longifolia* occur alongside sclerophyll shrubs like *Persoonia linearis* and *Acacia longifolia*. Rainforest species and cabbage tree palms (*Livistona australis*) are likely to occur in the gullies. Vines and ferns are common. The groundcover is variable and may include a wide range of grasses, herbs and trailing vines.

Threatened Species: None

Other Species of Conservation Significance: None

Relationship to other Forest Ecosystems: Commonly intergrades with FE2 and adjoins types 5 and 20.

Conservation Significance: Only represented in Narrawallee in one location but extends beyond the reserve to the west and is a common type in Conjola National Park and parts of Morton (East). Not of special conservation significance.

Threats: Logging and clearing in non-reserved areas. Little clearing of this forest type has occurred.

Impacts of Fire Regimes: Occurs in less fire-prone situations such as creek flats and gullies and consequently can develop an understorey of mesophyll shrubs and rainforest tree saplings. In the continued absence of fire it is likely to develop into FE20, Ecotonal Gully Rainforest, while under more frequent fire it is likely to lose the shrub component and become more open with a groundcover of grasses, sedges such as *Gahnia* spp, ferns and herbs. The community FE5 (Jervis Bay Lowlands Dry Forest) is likely to be what FE21 would develop into under frequent burning, at least in the lowland areas of Conjola NP.

NON-FOREST ECOSYSTEM 22: Dune/Headland Scrub

Southern CRA Profile Information

Description: Southern Coastal Hind Dune/Headland Scrub

Southern Coastal Hind Dune/Headland Scrub is a shrubland dominated by *Banksia integrifolia*. Common shrubs are *Acacia sophorae, Leucopogon parviflorus* and *Monotoca elliptica* and a tall groundcover of bracken, *Pteridium esculentum* and *Lomandra longifolia* is interwoven with a low sparse ground cover of grasses *Poa meionectes* and *Entolasia stricta*, together with herbs *Oxalis perennans*, *Pratia purpurascens*, and *Glycine clandestina*.

Southern Coastal Hind Dune/Headland Scrub is found in coastal hind dunes. No sites of this vegetation type were sampled within the Southern CRA Region . It was mapped in the Southern CRA Region in conjunction with ecosystem number FE23. An equivalent, FE 61 is found in the Eden CRA Region (Keith and Bedward 1999).

Diagnostic Plant Species

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Banksia integrifolia ssp integrifolia	2	1.000	2	0.008	positive
Muehlenbeckia adpressa	1	0.222	0	0.000	positive
Alyxia buxifolia	1	0.111	0	0.000	positive
Austrostipa flavescens	1	0.111	0	0.000	positive
Correa alba	3	0.111	0	0.000	positive
Olearia axillaris	1	0.111	0	0.000	positive
Oxalis perennans	1	0.889	1	0.081	uninformative
Acacia sophorae	1	0.778	2	0.005	uninformative
Pteridium esculentum	1	0.778	2	0.307	uninformative
Leucopogon parviflorus	1	0.667	2	0.001	uninformative
Lomandra longifolia	1	0.667	2	0.416	uninformative
Monotoca elliptica	1	0.667	1	0.013	uninformative
Dichondra repens	1	0.556	2	0.206	uninformative
Carpobrotus glaucescens	1	0.444	3	0.001	uninformative
Correa reflexa var *reflexa*	1	0.444	1	0.039	uninformative
Hibbertia obtusifolia	1	0.444	1	0.212	uninformative
Isolepis nodosa	1	0.444	2	0.006	uninformative
Kennedia rubicunda	1	0.444	1	0.037	uninformative
Lepidosperma laterale	1	0.444	1	0.173	uninformative
Poa meionectes	1	0.444	2	0.140	uninformative
Pratia purpurascens	1	0.444	1	0.103	uninformative
Dichelachne crinita	1	0.333	1	0.027	uninformative
Entolasia stricta	1	0.333	2	0.149	uninformative
Glycine clandestina	1	0.333	1	0.300	uninformative
Imperata cylindrica var *major*	3	0.333	2	0.061	uninformative
Melaleuca armillaris	4	0.333	2	0.002	uninformative
Poa poiformis	3	0.333	2	0.011	uninformative
Rhagodia candolleana ssp candolleana	1	0.333	2	0.004	uninformative
Senecio lautus ssp maritimus	1	0.333	2	0.000	uninformative

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Zoysia macrantha	1	0.333	2	0.001	uninformative
Actites megalocarpa	1	0.222	2	0.001	uninformative
Arrhenechthites mixta	1	0.222	1	0.020	uninformative
Brachyloma daphnoides	1	0.222	1	0.097	uninformative
Dianella caerulea var *caerulea*	1	0.222	1	0.165	uninformative
Eucalyptus botryoides	2	0.222	3	0.027	uninformative
Gahnia radula	1	0.222	2	0.006	uninformative
Juncus continuus	1	0.222	1	0.003	uninformative
Macrozamia communis	2	0.222	2	0.063	uninformative
Opercularia aspera	1	0.222	1	0.037	uninformative
Pelargonium australe	1	0.222	1	0.004	uninformative
Spinifex sericeus	1	0.222	3	0.001	uninformative
Themeda australis	1	0.222	2	0.201	uninformative
Wahlenbergia gracilis	1	0.222	1	0.047	uninformative

Extant area (ha): 1897 (forest ecosystems 22 and 23 combined)

Pre-1750 area (ha): 2676

Geographic range: South Coast

How much conserved in reserves (ha): 583

Vulnerability: 3(C/R)

Reliability: 1

FE 22 – Narrawallee Study Area

Mills' Classification equivalent type: Cu16

Previous Survey Sites Represented: None

Narrawallee 2003 Sites Represented: None

Marginal Sites: None

Species Recorded at Representative Sites: None recorded

Dominant species: Canopy of coast banksia (*Banksia integrifolia*) and a shrub layer of *Leucopogon parviflorus, Acacia longifolia* ssp *sophorae* and *Rhagodia candolleana*. The groundcover may include bracken (*Pteridium esculentum*), spiny matrush (*Lomandra longifolia),* grasses *Poa poiformis*, couch (*Cynodon dactylon*) or the very similar *Zoysia macrantha* and herbs including *Carpobrotus glaucescens, Oxalis rubens, Pratia purpurascens* and *Dianella caerulea*. The vine *Kennedia rubicunda* is typical. Includes headland scrub which is dominated by *Allocasuarina verticillata* and *Melaleuca armillaris*, with shrubs *Alyxia buxifolia, Myoporum boninense* and *Rhagodia candolleana* with a groundcover of *Lomandra longifolia, Poa poiformis, Austrostipa stipoides* and the herb *Pelargonium australe.* Grades into Beach Strand Grassland dominated by coast wattle (*Acacia longifolia* ssp *sophorae*) on the foredunes (FE23).

Threatened Species: None

Other Species of Conservation Significance: None

Relationship to other Forest Ecosystems: occurs as a complex with FE23.

Conservation Significance: Significant because of their naturally limited extent, the protection they afford to beaches and dunes from wind erosion and on-shore sand creep into other vegetation.

Threats: Recreational pressure on sand dunes especially near towns and recreation areas, vulnerability to weed invasion, particularly by the noxious weed bitou bush (**Chrysanthemoides monilifera*) and bridal creeper (**Asparagus asparagoides*) and erosion by wind and waves.

Impacts of Fire Regimes: Dune and Headland Scrubs may burn in extreme conditions but this is likely to be a rare event.

Fire could be considered as a weed management method in stands which are infested with either bitou bush or bridal creeper, however, it could also help to destabilise the dunes by removing vegetation cover.

NON-FOREST ECOSYSTEM 23: Beach Strand Grassland

Southern CRA Profile Information

Description: Southern Coastal Dune Scrub complex

Southern Coastal Dune Scrub complex has a variable shrub and grass layer, made up of *Acacia sophorae, Spinifex sericeus*, and *Banksia integrifolia*. The patchy ground cover includes *Isolepsis nodosa, Carex longebrachiata, Desmodium varians*, and *Carpobrotus glaucescens.*

It occurs from south of Kiama down to Wallaga Lake in moister dunes than forest ecosystem 22.

Diagnostic Plant Species

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Spinifex sericeus	3	1.000	1	0.001	positive
Acacia sophorae	5	0.750	2	0.006	positive
Actites megalocarpa	2	0.500	1	0.001	positive
Austrofestuca littoralis	2	0.500	2	0.003	positive
Calystegia soldanella	2	0.500	1	0.000	positive
Isolepis nodosa	3	0.500	2	0.006	positive
Leucopogon parviflorus	2	0.500	1	0.002	positive
Zoysia macrantha	2	0.500	2	0.001	positive
Banksia integrifolia ssp integrifolia	2	0.250	2	0.010	uninformative
Carex longebrachiata	2	0.250	2	0.025	uninformative
Carpobrotus glaucescens	3	0.250	1	0.001	uninformative
Desmodium varians	1	0.250	1	0.171	uninformative
Dianella longifolia var *longifolia*	1	0.250	1	0.017	uninformative
Dichelachne crinita	2	0.250	1	0.028	uninformative
Dichondra repens	2	0.250	2	0.207	uninformative
Monotoca elliptica	1	0.250	1	0.015	uninformative
Oxalis exilis	2	0.250	1	0.036	uninformative
Rhagodia candolleana ssp candolleana	1	0.250	2	0.005	uninformative
Viola hederacea	1	0.250	1	0.198	uninformative

Extant area (ha): 2348 (forest ecosystems 23 and 26 combined)

Pre-1750 area (ha): 3166

Geographic range: South Coast

How much conserved in reserves (ha): 711

Vulnerability: 4(R)

Reliability: 1

FE 23 – Narrawallee Study Area

Mills' Classification equivalent type: Cu17

Previous Survey Sites Represented: None

Narrawallee 2003 Sites Represented: None

Marginal Sites: None

Species Recorded at Representative Sites: None recorded

Dominant species: Occurs on the upper parts of beaches and on foredunes, and is usually dominated by the grasses *Spinifex sericeus* and *Austrofestuca littoralis* and salt and dessication tolerant herbs including *Actites megalocarpa, Calystegia soldanella, Carpobrotus glaucescens* and the exotics **Hydrocotyle bonariensis* and **Cakile* spp. This grades via low wind-pruned coast wattle (*Acacia longifolia* ssp *sophorae*) into FE22 which occurs on the hind dunes.

Threatened Species: None

Other Species of Conservation Significance: None

Relationship to other Forest Ecosystems: occurs as a complex with FE22. In the Eden Region, Beach Strand Grassland (FE62) was separated from Coastal Scrub (FE61), the latter equivalent to FE22. Beach Strand Grassland occurs closer to the sea than Coastal Scrub. This seems a closer reflection of reality than the FE22/23 breakdown used in the Southern CRA.

Conservation Significance: Significant because of their naturally limited extent, the protection they afford to beaches and dunes from wind erosion and on-shore sand creep into other vegetation.

Threats: Recreational pressure on sand dunes especially near towns and recreation areas, vulnerability to weed invasion, particularly by the noxious weed bitou bush (**Chrysanthemoides monilifera*) and erosion by wind and waves.

Impacts of Fire Regimes: Beach Strand Grassland is unlikely to burn due to the high salt levels in many of the plants and its generally sparse cover.

FOREST ECOSYSTEM 24: Swamp Oak - Swamp Paperbark Forest

Southern CRA Profile Information

Description: Coastal Wet Heath Swamp Forest - *Casuarina glauca / Melaleuca ericifolia*

Coastal Wet Heath Swamp Forest is a low-medium forest up to 10 metres tall, dominated by *Casuarina glauca.* In the intermediate shrub layer *Melaleuca ericifolia* occurs along with *Myoporum acuminatum, Acacia longifolia* var *longifolia* and *Parsonsia straminea.* The ground cover is variable and includes *Gahnia clarkei, Baumea juncea,* and the herb *Viola hederacea.*

Coastal Wet Heath Swamp Forest is restricted to acid sulphate soils above semi saline flats along the edges and low lying tributaries of coastal lagoons. It occurs between Seven Mile Beach and Bermagui. Further to the south in the Eden CRA Region, Map Unit 63 (Keith and Bedward 1999) replaces this ecosystem.

Diagnostic Plant Species

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Gahnia clarkei	4	1.000	2	0.019	positive
Casuarina glauca	3	0.833	3	0.007	positive
Viola hederacea	2	0.833	1	0.197	positive
Melaleuca ericifolia	4	0.667	3	0.006	positive
Myoporum acuminatum	3	0.667	0	0.000	positive
Parsonsia straminea	2	0.667	2	0.064	positive
Acacia longifolia	2	0.500	2	0.042	positive
Baumea juncea	4	0.500	3	0.001	positive
Lobelia alata	2	0.500	1	0.003	positive
Cladium procerum	5	0.167	0	0.000	positive
Ottelia ovalifolia	1	0.167	0	0.000	positive
Persicaria lapathifolia	1	0.167	0	0.000	positive
Stephania japonica var *discolor*	1	0.833	1	0.048	uninformative
Lomandra longifolia	1	0.500	2	0.417	uninformative
Juncus kraussii ssp australiensis	5	0.333	1	0.001	uninformative
Marsdenia rostrata	3	0.333	2	0.123	uninformative
Pteridium esculentum	3	0.333	2	0.308	uninformative
Baumea articulata	1	0.167	2	0.001	uninformative
Carex appressa	1	0.167	1	0.074	uninformative
Cassine australis var *australis*	3	0.167	2	0.005	uninformative
Centella asiatica	2	0.167	2	0.013	uninformative
Claoxylon australe	3	0.167	3	0.036	uninformative
Cyathea cooperi	3	0.167	2	0.001	uninformative
Desmodium brachypodum	1	0.167	1	0.017	uninformative
Eleocharis acuta	1	0.167	1	0.003	uninformative
Eucalyptus botryoides	5	0.167	3	0.027	uninformative
Eustrephus latifolius	1	0.167	1	0.145	uninformative
Ficus coronata	4	0.167	3	0.044	uninformative
Geitonoplesium cymosum	1	0.167	1	0.115	uninformative
Glochidion ferdinandi var *ferdinandi*	5	0.167	1	0.006	uninformative

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Glycine clandestina	1	0.167	1	0.300	uninformative
Goodenia heterophylla ssp eglandulosa	2	0.167	1	0.003	uninformative
Hemarthria uncinata var uncinata	5	0.167	1	0.006	uninformative

Extant area (ha): 6241
Pre-1750 area (ha): 13293
Geographic range: South Coast
How much conserved in reserves (ha): 792
Vulnerability: 2(C/U)
Reliability: 2

FE 24 – Narrawallee Study Area

Mills' Classification equivalent type: Cu13

Previous Survey Sites Represented: None

Narrawallee 2003 Sites Represented: None

Marginal Sites: None

Species Recorded at Representative Sites: None recorded

Dominant species: Canopy species include *Casuarina glauca*, with lower canopy of swamp paperbark (*Melaleuca ericifolia)* and occasional *Myoporum acuminatum*. Groundcover can vary from dense stands of salt-tolerant sword-sedge (*Gahnia clarkei* or *G. sieberiana*) or other sedges and rushes such as *Baumea juncea* or *Juncus kraussii*, herbs *Lobelia alata, Apium prostratum, Leptinella longipes, Samolus repens* and *Selliera radicans* to bare ground. The rampant vine *Parsonsia straminea* may be present.

Threatened Species: None

Other Species of Conservation Significance: None

Relationship to other Forest Ecosystems: Closely associated with FE25

Conservation Significance: Swamp forests dominated by *Casuarina glauca* (FE24 and 25) are regarded as being of high conservation significance in the region because they naturally occur in small fragmented stands around coastal lakes and in small coastal creeks, but do not extend upstream from the lakes or in other areas away from the lakes. The aggregate remaining area of them in the South Coast subregion was calculated to be low (about 10,000 ha in total for the two types). It appears from the results of this and earlier surveys that this figure may be considerably exaggerated and that they are much less common in the Ulladulla area than the previous CRA modelling suggested.

Threats: Generally vulnerable to clearing and urban development in non-reserved areas. An estimated 53% of FE24 has been cleared. Possibly vulnerable to the effects of interference with natural lake opening regimes, since *Casuarina glauca* may be killed by prolonged flooding (J Miles, pers. obs.).

Impacts of Fire Regimes: Fire may have a severe impact on stands, changing their structure in the medium term. This and the related type FE25 can be highly flammable if they carry a dense groundcover of sedges, and if lake levels are low so that the ground is dry at the time of the fire. *Melaleuca ericifolia* would also be highly flammable, at least in young stands where there is uniform distribution of fine fuels from close to ground level to the crown. *Casuarina glauca* is not very flammable, but is readily killed by high-intensity fires. Previous observations at Meroo Lake indicated that some individuals had survived the fire there, and some had succumbed. Subsequent death or recovery may also depend to some extent on water levels after the fire, since additional stress may be placed on the plant by prolonged flooding, such as might occur in drought periods when closing of the lake mouth raises water levels. If Narrawallee Creek mouth does not close (and the abundance of mangroves along the banks suggests that this is so) then stands in this area may be spared the stress of prolonged flooding. Understorey species, *Melaleuca ericifolia* and various sedges are well adapted to recovering from fire, re-sprouting rapidly from the roots. Under frequent fire regimes the understorey may be converted to very dense stands of small melaleuca stems. Fire frequency may in fact drive the distinction between FE24 and FE25, the latter developing only in less frequently burnt sites. Fire should be kept out of these communities as far as possible. If fuel reduction burns are being undertaken in eucalypt forest in the vicinity of this vegetation type, care needs to be taken not to allow the fires to escape into it.

FOREST ECOSYSTEM 25: Swamp Oak Forest

Southern CRA Profile Information

Description: South Coast Swamp Forest complex- *Casuarina glauca*

South Coast Swamp Forest complex is a medium dense forest up to 15 metres tall, dominated by *Casuarina glauca,* with *Acacia sophorae* and *Avicennia marina.* The ground cover is sparse with herbs and graminoids including *Commelina cyanea, Pratia purpurescens,* and *Rhagodia candolleana* ssp*. candolleana.*

South Coast Swamp Forest complex occurs in less wet situations than vegetation type 24, in the upper reaches of major river estuaries and tributaries between Seven Mile Beach and Wallaga Lake.

Diagnostic Plant Species

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Casuarina glauca	4	1.000	2	0.007	positive
Acacia sophorae	2	0.600	2	0.006	positive
Avicennia marina var *australasica*	3	0.400	0	0.000	positive
Apium prostratum ssp prostratum var *prostratum*	2	0.200	0	0.000	positive
Enchylaena tomentosa	2	0.200	0	0.000	positive
Lyperanthus suaveolens	1	0.200	0	0.000	positive
Solanum pungetium	1	0.600	1	0.055	uninformative
Commelina cyanea	2	0.400	1	0.012	uninformative
Dendrobium teretifolium	2	0.400	2	0.000	uninformative
Dichondra repens	2	0.400	2	0.207	uninformative
Pratia purpurascens	2	0.400	1	0.103	uninformative
Rhagodia candolleana ssp candolleana	3	0.400	2	0.004	uninformative
Samolus repens	2	0.400	1	0.001	uninformative
Sarcocornia quinqueflora ssp quinqueflora	2	0.400	2	0.001	uninformative
Suaeda australis	3	0.400	2	0.000	uninformative
Tetragonia tetragonoides	2	0.400	2	0.001	uninformative
Acacia mearnsii	1	0.200	2	0.060	uninformative
Acacia myrtifolia	1	0.200	2	0.004	uninformative
Acrotriche serrulata	1	0.200	1	0.073	uninformative
Allocasuarina verticillata	3	0.200	2	0.004	uninformative
Banksia integrifolia ssp integrifolia	4	0.200	2	0.010	uninformative
Banksia spinulosa var *spinulosa*	2	0.200	2	0.054	uninformative
Boronia polygalifolia	2	0.200	2	0.001	uninformative
Brachycome spathulata	1	0.200	1	0.066	uninformative
Breynia oblongifolia	2	0.200	1	0.087	uninformative
Cassytha glabella forma glabella	2	0.200	1	0.025	uninformative
Cheilanthes sieberi ssp sieberi	2	0.200	1	0.073	uninformative
Cryptostylis subulata	1	0.200	1	0.004	uninformative
Desmodium varians	2	0.200	1	0.171	uninformative
Einadia trigonos ssp trigonos	4	0.200	1	0.002	uninformative
Entolasia stricta	1	0.200	2	0.149	uninformative
Eucalyptus amplifolia ssp amplifolia	3	0.200	3	0.001	uninformative

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Geitonoplesium cymosum	1	0.200	1	0.115	uninformative
Glycine clandestina	1	0.200	1	0.300	uninformative
Gonocarpus teucrioides	1	0.200	2	0.095	uninformative
Goodenia ovata	1	0.200	2	0.050	uninformative
Hibbertia aspera	3	0.200	2	0.071	uninformative
Hybanthus monopetalus	1	0.200	1	0.006	uninformative
Hypericum gramineum	1	0.200	1	0.172	uninformative
Hypoxis hygrometrica var *hygrometrica*	1	0.200	1	0.010	uninformative
Isolepis nodosa	2	0.200	2	0.006	uninformative
Juncus kraussii ssp australiensis	1	0.200	3	0.001	uninformative
Leptospermum continentale	1	0.200	2	0.012	uninformative
Lindsaea linearis	2	0.200	1	0.020	uninformative
Lobelia alata	1	0.200	1	0.004	uninformative
Lomandra longifolia	3	0.200	2	0.417	uninformative
Marsdenia rostrata	1	0.200	2	0.123	uninformative
Morinda jasminoides	2	0.200	3	0.097	uninformative

Extant area (ha): 3909

Pre-1750 area (ha): 18194

Geographic range: South Coast

How much conserved in reserves (ha): 648

Vulnerability: 1(C/W)

Reliability: 2

FE 25 – Narrawallee Study Area

Mills' Classification equivalent type: Cu15

Previous Survey Sites Represented: None

Narrawallee 2003 Sites Represented: None

Marginal Sites: NARJM07

Species Recorded at Representative Sites: None recorded

Dominant species: Swamp oak *Casuarina glauca* forms the canopy, with occasional *Myoporum acuminatum* and *Melaleuca ericifolia* forming a very open small tree layer. The vine *Parsonsia straminea* is often abundant. Shrub layer is generally absent or may consist of a patchy cover of the sprawling semi-woody herb *Rhagodia candolleana*, and the groundcover of salt tolerant species ranges from couch grass (*Cynodon dactylon*) in drier areas, to samphire (*Sarcocornia quinqueflora*) and *Baumea juncea* in wetter areas. The herbs listed above for FE24 are likely to occur and the large vine common silkpod (*Parsonsia straminea*) is very typical of FE25.

Threatened Species: None

Other Species of Conservation Significance: None

Relationship to other Forest Ecosystems: Closely associated with FE24

Conservation Significance: FE25 is represented along the upper reaches of Narrawallee Inlet both within and outside the reserve. Swamp forests dominated by *Casuarina glauca* (FE24 and 25) are regarded as being of high conservation significance in the region because they naturally occur in small fragmented stands around coastal lakes and in small coastal creeks, but do not extend upstream from the lakes or in other areas away from the lakes. The aggregate remaining area of them in the South Coast sub-region was calculated to be low (about 10,000 ha in total for the two types). It appears from the results of this and earlier surveys that this figure may be considerably exaggerated and that they are much less common in the Ulladulla area than the previous CRA mapping suggested.

Threats: Generally vulnerable to clearing and urban development in non-reserved areas. An estimated 78.5% of FE 25 has been cleared, but because of errors in the mapping of this vegetation type, this figure is unreliable.. Possibly vulnerable to the effects of interference with natural lake opening regimes, since *Casuarina glauca* may be killed by prolonged flooding (J Miles, pers. obs.). Possibly vulnerable to weed infestation, although saline soils would protect against most weeds. However, sharp rush, **Juncus acutus* appears to represent a considerable threat in the South Coast Region.

Impacts of Fire Regimes: Fire may have a severe impact on stands, changing their structure in the medium term. This and the related type FE24 can be highly flammable if they carry a dense groundcover of sedges, and if lake levels are low so that the ground is dry at the time of the fire. *Casuarina glauca* is not very flammable, but is readily killed by high-intensity fires. Understorey species and various sedges are well adapted to recovering from fire, re-sprouting rapidly from the roots. Under frequent fire regimes the understorey may be converted to very dense stands of small melaleuca stems. Fire frequency may in fact drive the distinction between FE24 and FE25, the latter developing only in less frequently burnt sites. Fire should be kept out of these communities as far as possible. If fuel reduction burns are being undertaken in eucalypt forest in the vicinity of this vegetation type, care needs to be taken not to allow the fires to escape into it.

FOREST ECOSYSTEM 28: Coastal Sands Bangalay - Banksia Forest

Southern CRA Profile Information

Description: Coastal Sands Shrub/Fern Forest - *E. botryoides / Banksia serrata*

Coastal Sands Shrub/Fern Forest is a low to tall forest dominated by *E. botryoides.* It has an understorey of *Banksia serrata, Monotoca elliptica, Allocasuarina littoralis, Breynia oblongifolia*, and *Acacia longifolia.* The ground cover is predominantly bracken *Pteridium esculentum* and grasses and graminoids*, Imperata cylindrica* and *Lomandra longifolia,* intermixed with herbs and twiners, such as *Gonocarpus teucrioides, Glycine clandestina,*and *Viola hederacea.*

This forest ecosystem is mainly confined to sandy soils adjoining bays, estuaries, and lagoons in Jervis Bay, Clyde, and Moruya areas.

Diagnostic Plant Species

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Pteridium esculentum	3	0.933	2	0.306	positive
Lomandra longifolia	3	0.867	2	0.415	positive
Eucalyptus botryoides	4	0.800	2	0.024	positive
Banksia serrata	3	0.667	3	0.015	positive
Imperata cylindrica var *major*	2	0.667	2	0.060	positive
Monotoca elliptica	2	0.600	1	0.013	positive
Allocasuarina littoralis	3	0.533	2	0.101	positive
Banksia integrifolia ssp integrifolia	3	0.533	2	0.008	positive
Marsdenia rostrata	2	0.533	2	0.122	positive
Cyperus laevigatus	2	0.133	0	0.000	positive
Pterostylis curta	1	0.067	0	0.000	positive
Pterostylis grandiflora	1	0.067	0	0.000	positive
Gonocarpus teucrioides	1	0.533	2	0.093	uninformative
Acacia longifolia	2	0.467	2	0.041	uninformative
Glycine clandestina	1	0.467	1	0.299	uninformative
Stephania japonica var *discolor*	1	0.467	1	0.048	uninformative
Breynia oblongifolia	1	0.400	1	0.086	uninformative
Hibbertia scandens	2	0.400	1	0.030	uninformative
Lagenifera stipitata	1	0.400	1	0.166	uninformative
Lepidosperma concavum	4	0.400	2	0.009	uninformative
Themeda australis	1	0.400	2	0.200	uninformative
Viola hederacea	2	0.400	1	0.198	uninformative
Desmodium varians	2	0.333	1	0.171	uninformative
Eucalyptus pilularis	3	0.333	3	0.029	uninformative
Hibbertia obtusifolia	1	0.333	1	0.212	uninformative
Macrozamia communis	3	0.333	2	0.062	uninformative
Pratia purpurascens	1	0.333	1	0.103	uninformative
Schelhammera undulata	1	0.333	1	0.083	uninformative
Desmodium brachypodum	1	0.267	1	0.016	uninformative
Dianella caerulea var *caerulea*	1	0.267	1	0.165	uninformative

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Dichondra repens	1	0.267	2	0.207	uninformative
Echinopogon caespitosus var *caespitosus*	1	0.267	1	0.024	uninformative
Microlaena stipoides var *stipoides*	2	0.267	2	0.273	uninformative
Oplismenus imbecillis	2	0.267	2	0.121	uninformative
Pittosporum undulatum	2	0.267	2	0.091	uninformative
Synoum glandulosum	4	0.267	2	0.080	uninformative
Acacia maidenii	2	0.200	1	0.010	uninformative
Acacia ulicifolia	1	0.200	1	0.030	uninformative
Acianthus fornicatus	1	0.200	2	0.006	uninformative
Cissus hypoglauca	3	0.200	2	0.105	uninformative
Eustrephus latifolius	1	0.200	1	0.145	uninformative
Hibbertia aspera	1	0.200	2	0.071	uninformative
Isolepis nodosa	1	0.200	2	0.006	uninformative

Extant area (ha): 3117

Pre-1750 area (ha): 3568

Geographic range: South Coast

How much conserved in reserves (ha): 244

Vulnerability: 3(C/R)

Reliability: 3

FE 28 – Narrawallee Study Area

Mills' Classification equivalent type: Cu5

Previous Survey Sites Represented: None

Narrawallee 2003 Sites Represented: None

Marginal Sites: NARJM09F

Species Recorded at Representative Sites: None recorded

Dominant species: Canopy of Bangalay (*E. botryoides*); saw banksia (*Banksia serrata*) forms a sub-canopy. Typical shrubs are *Acacia longifolia* ssp *sophorae* or *A. longifolia* ssp *longifolia* and *Monotoca elliptica*. Burrawangs (*Macrozamia communis*) may be present or even dominant. Bracken is the dominant groundcover species, with *Lomandra longifolia*, grasses, blady grass (*Imperata cylindrica*) and kangaroo grass (*Themeda triandra*) and herbs *Schelhammera undulata, Desmodium gunnii, Dianella caerulea, Gonocarpus teucrioides* and *Viola hederacea*.

Threatened Species: None

Other Species of Conservation Significance: None

Relationship to other Forest Ecosystems: Often forms a band bordered by FE22-23 along the dunes and FE2 or FE29 inland.

Conservation Significance: Usually restricted distribution on sand deposits behind beaches, and around the mouths of coastal lakes. It occupies the area behind the dunes along most of the Narrawallee coastline and probably behind the village of Lake Conjola. At least of moderate conservation significance because it is a naturally fragmented ecosystem of limited distribution in the region which is coming under increasing pressure outside reserves for urban development. It is substantially less widely distributed than previously thought, having been over-mapped during the Southern and Eden CRAs.

Threats: Subject to residential development pressure in un-reserved areas, being flat and close to the sea. Stands are also vulnerable to recreational pressure, and to invasion by bitou bush, and in areas close to coastal villages, by other weeds. May also be targeted for frequent hazard-reduction burning to protect coastal villages such as Lake Conjola.

Impacts of Fire Regimes: The understorey, dominated by bracken, is generally well adapted to regular fire. Some shrubs which are relatively slow growing and not capable of resprouting, such as *Monotoca elliptica*, are likely to be lost from frequently burnt stands, as may some other obligate seeders such as wattles, depending on the fire frequency. Even relatively fire-tolerant re-sprouters such as *Banksia serrata* may be lost from frequently burnt stands over a longer time-frame, since juvenile plants may take up to ten years to become fire-tolerant. Occasional fires may help reduce the impact of weeds around villages, although there would need to be post-fire monitoring for weed seedlings, since the creation of bare ground and temporary nutrient boost from a fire may also encourage the germination of rapidly growing weeds such as bridal creeper (**Asparagus asparagoides*), which may be able to out-compete natives in some situations. Given a long absence of fire, FE28 can begin to develop a rainforest understorey, but it is doubtful that the fire-free period could be maintained for long enough for mature littoral rainforest to develop, unless there is some topographic feature that provides additional protection.

FOREST ECOSYSTEM 29: Coastal Sands Blackbut - Banksia Forest

Southern CRA Profile Information

Description: Northern Coastal Sands Shrub/Fern Forest - *E. pilularis / Banksia serrata*

Northern Coastal Sands Shrub/Fern Forest is a forest dominated by *E. pilularis,* with *Coyrymbia gummifera,* with some occasional patches of *Syncarpia glomulifera.* The shrub/small tree layer usually comprises *Elaeocarpus reticulatus, Banksia serrata, Monotoca elliptica,* and *Acacia longifolia.* Ground cover is mainly sedges *Lomandra longifolia* and *Lepidopserma laterale,* with the grass *Entolasia stricta,* and herbs *Dianella caerulea* var *caerulea,* and *Patersonia glabrata.*

This forest ecosystem is mainly found in the low foothills behind Jervis Bay and Ulladulla. It occurs on moderately deep silty loam, derived from Permian mudstones at elevations below 100 metres. Some smaller outliers of this map unit are found further south towards Batemans Bay.

Diagnostic Plant Species

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Lomandra longifolia	3	1.000	2	0.415	positive
Pteridium esculentum	3	0.923	2	0.306	positive
Eucalyptus pilularis	4	0.769	3	0.027	positive
Gonocarpus teucrioides	2	0.769	2	0.092	positive
Elaeocarpus reticulatus	2	0.692	1	0.102	positive
Banksia serrata	3	0.615	3	0.016	positive
Monotoca elliptica	2	0.615	1	0.013	positive
Corymbia gummifera	3	0.539	3	0.050	positive
Lepidosperma laterale	4	0.539	1	0.172	positive
Caladenia alata	1	0.077	0	0.000	positive
Leucopogon lanceolatus var *lanceolatus*	1	0.615	1	0.168	uninformative
Entolasia stricta	2	0.462	2	0.148	uninformative
Hardenbergia violacea	1	0.462	1	0.159	uninformative
Hibbertia scandens	1	0.462	1	0.030	uninformative
Acacia longifolia	2	0.385	2	0.042	uninformative
Dianella caerulea var *caerulea*	1	0.385	1	0.165	uninformative
Patersonia glabrata	2	0.385	2	0.041	uninformative
Persoonia linearis	1	0.385	1	0.182	uninformative
Allocasuarina littoralis	4	0.308	2	0.102	uninformative
Gahnia sieberiana	3	0.308	2	0.020	uninformative
Hibbertia linearis	1	0.308	1	0.004	uninformative
Smilax australis	1	0.308	2	0.147	uninformative
Syncarpia glomulifera	4	0.308	3	0.022	uninformative
Acacia suaveolens	1	0.231	1	0.011	uninformative
Anisopogon avenaceus	2	0.231	2	0.011	uninformative
Breynia oblongifolia	1	0.231	1	0.087	uninformative
Cissus hypoglauca	2	0.231	2	0.105	uninformative
Imperata cylindrica var *major*	2	0.231	2	0.061	uninformative
Pimelea linifolia ssp linifolia	1	0.231	1	0.059	uninformative
Schelhammera undulata	1	0.231	1	0.084	uninformative

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Synoum glandulosum	2	0.231	2	0.080	uninformative
Zieria arborescens ssp arborescens	2	0.231	2	0.005	uninformative
Acacia ulicifolia	2	0.154	1	0.031	uninformative
Acianthus fornicatus	1	0.154	1	0.006	uninformative
Angophora floribunda	3	0.154	1	0.073	uninformative
Aotus ericoides	2	0.154	2	0.015	uninformative
Banksia ericifolia var *ericifolia*	2	0.154	3	0.015	uninformative
Banksia integrifolia ssp integrifolia	2	0.154	2	0.010	uninformative
Bossiaea heterophylla	1	0.154	1	0.011	uninformative
Caustis flexuosa	2	0.154	2	0.013	uninformative
Dampiera stricta	2	0.154	1	0.012	uninformative
Dianella caerulea var *producta*	1	0.154	1	0.001	uninformative
Endiandra sieberi	3	0.154	2	0.005	uninformative
Entolasia marginata	2	0.154	2	0.053	uninformative
Eucalyptus botryoides	2	0.154	3	0.027	uninformative
Eucalyptus piperita	4	0.154	3	0.020	uninformative
Eucalyptus sclerophylla	5	0.154	3	0.009	uninformative

Extant area (ha): 13245

Pre-1750 area (ha): 16948

Geographic range: South Coast

Vulnerability: 3(C/U)

How much conserved in reserves (ha): 2920

Reliability: 3

FE 29 – Narrawallee Study Area

Mills' Classification equivalent type: Cu4

Previous Survey Sites Represented: SZ23081

Narrawallee 2003 Sites Represented: None

Marginal Sites: NARJM 03, NARJM09F

Species Recorded at Representative Sites: None recorded

Dominant species: Blackbutt (*E. pilularis*) is the dominant tree, but it may be joined by many other species such as red bloodwood (*Corymbia gummifera*); *Banksia serrata* is often present as a small tree layer. The understorey is transitional between FE28 and FE2 and may include *Acacia longifolia* ssp *sophorae* or ssp *longifolia* and burrawangs (*Macrozamia communis*) along with tussock plants such as *Lomandra longifolia* and *Lepidosperma laterale*, bracken and grasses.

Threatened Species: None

Other Species of Conservation Significance: None

Relationship to other Forest Ecosystems: Similar to FE 28 with which FE29 is transitional. It also merges with FE2 and FE175.

Conservation Significance: Extensive in the southern parts of Narrawallee Creek Nature Reserve but poorly represented in Conjola and not present in Morton (East) National Parks. Has a naturally limited and fragmented distribution in the region. There has been a probable overestimation of its true extent in previous mapping, and pressure from coastal development may raise the conservation significance of this vegetation type to at least a moderate level.

Threats: Clearing and urban development in un-reserved areas. Stands are also vulnerable to recreational pressure.

Impacts of Fire Regimes: Like FE28, the understorey, dominated by Bracken is generally well adapted to regular fire. Some shrubs which are relatively slow growing and not capable of resprouting, such as *Monotoca elliptica*, are likely to be lost from frequently burnt stands, as may some other obligate seeders such as wattles, depending on the fire frequency. Even relatively fire-tolerant re-sprouters such as *Banksia serrata* may be lost from frequently burnt stands over a longer time-frame, since juvenile plants may take up to ten years to become fire-tolerant.

FOREST ECOSYSTEM 139: Scribbly Gum - Red Bloodwood Heathy Woodland

Southern CRA Profile Information

Description: Northern Coastal Hinterland Heath Shrub Dry Forest - *C. gummifera / E. sclerophylla*

This vegetation type comprises mainly medium to low forest dominated by Scribbly Gum (*Eucalyptus sclerophylla*) with Red Bloodwood (*Corymbia gummifera)* usually present as a subdominant. It has a moderately dense heathy shrub layer dominated by sandstone broad-leaved Hakea (*Hakea dactyloides)*, the Banksias (*Banksia paludosa* and *B.spinulosa)*, *Lambertia formosa,* and Rough-barked Tea-tree *(Leptospermum trinervium)*. The groundcover comprises *Lepyrodia scariosa* and *Entolasia stricta.*

This ecosystem is distributed on shallow podzolic soils on flat plateaux and low lying coastal areas from Jervis Bay down to Ulladulla. Small amounts have been cleared around Jervis Bay, although much of it is reserved within Morton National Park.

Diagnostic Plant Species

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Hakea dactyloides	2	0.913	2	0.026	positive
Leptospermum trinervium	3	0.870	2	0.024	positive
Patersonia sericea	2	0.870	1	0.026	positive
Banksia spinulosa var *spinulosa*	2	0.783	2	0.050	positive
Persoonia mollis ssp leptophylla	2	0.739	1	0.005	positive
Lambertia formosa	2	0.696	2	0.007	positive
Banksia paludosa	2	0.652	2	0.009	positive
Corymbia gummifera	3	0.652	3	0.048	positive
Eucalyptus sclerophylla	2	0.652	3	0.005	positive
Lepyrodia scariosa	2	0.609	2	0.005	positive
Petrophile sessilis	2	0.609	2	0.005	positive
Entolasia stricta	2	0.565	2	0.147	positive
Banksia ericifolia var *ericifolia*	3	0.522	3	0.013	positive
Hakea teretifolia	2	0.522	2	0.006	positive
Baeckea diosmifolia	1	0.261	0	0.000	positive
Baeckea brevifolia	2	0.130	0	0.000	positive
Billardiera scandens var *sericata*	1	0.087	0	0.000	positive
Pultenaea paleacea var *paleacea*	2	0.087	0	0.000	positive
Sphaerolobium minus	2	0.087	0	0.000	positive
Boronia thujona	3	0.043	0	0.000	positive
Dampiera scottiana	2	0.043	0	0.000	positive
Eriostemon buxifolius ssp obovatus	1	0.043	0	0.000	positive
Eriostemon scaber ssp latifolius	2	0.043	0	0.000	positive
Eucalyptus multicaulis	1	0.043	0	0.000	positive
Grevillea baueri ssp asperula	1	0.043	0	0.000	positive
Grevillea linearifolia (Southern Sandstone form)	1	0.043	0	0.000	positive
Hibbertia cistiflora	1	0.043	0	0.000	positive
Leucopogon appressus	1	0.043	0	0.000	positive
Xyris Unknown	3	0.043	0	0.000	positive

Species	Group cover	Group freq	Non-group cover	Non-group freq	Fidelity class
Lomatia ilicifolia	1	0.826	1	0.039	uninformative
Persoonia levis	1	0.696	1	0.015	uninformative
Cassytha glabella forma glabella	1	0.609	1	0.022	uninformative
Lomandra obliqua	1	0.609	1	0.031	uninformative
Lindsaea linearis	1	0.565	1	0.017	uninformative
Pimelea linifolia ssp linifolia	1	0.565	1	0.056	uninformative
Isopogon anemonifolius	1	0.522	1	0.011	uninformative
Dampiera stricta	1	0.478	1	0.010	uninformative
Epacris microphylla var *microphylla*	2	0.478	2	0.023	uninformative
Leptospermum polygalifolium ssp polygalifolium	2	0.478	2	0.024	uninformative
Mitrasacme polymorpha	1	0.478	1	0.004	uninformative
Xanthorrhoea concava	1	0.478	1	0.023	uninformative
Actinotus minor	2	0.435	1	0.007	uninformative
Aotus ericoides	2	0.435	2	0.013	uninformative
Bossiaea heterophylla	2	0.435	1	0.009	uninformative
Cyathochaeta diandra	3	0.435	2	0.005	uninformative
Eucalyptus consideniana	3	0.391	3	0.015	uninformative
Eucalyptus obstans	2	0.217	2	0.001	uninformative
Eucalyptus mannifera	2	0.174	3	0.058	uninformative

Extant area (ha): 48899 How much conserved in reserves (ha): 15383 Sth Coast and 35 Northern

Pre-1750 area (ha): 51050 Vulnerability: 5 in South Coast

Geographic range: South Coast and Northern Reliability: 2

FE 139 – Narrawallee Study Area

Mills' Classification equivalent type: Cu 7, 9, 10, 11, 12 or 12

Previous Survey Sites Represented: None

Narrawallee 2003 Sites Represented: None

Marginal Sites: NARJM04F

Species Recorded at Representative Sites: None recorded

Dominant species: Scribbly gum (*E. sclerophylla*) and red bloodwood usually form the canopy. A small tree layer may include *Allocasuarina littoralis* or *Leptospermum trinervium*. The shrubby understorey contains typical "Sydney sandstone" elements such as *Lambertia formosa, Hakea sericea, Persoonia levis, Petrophile sessilis, Isopogon anemonifolius, Kunzea capitata, Bossiaea heterophylla* and *Bossiaea ensata.* Numerous sedges, various *Lomandra* species, the grasses *Anisopogon avenaceus* and *Entolasia stricta* and numerous herbs such as *Actinotus minor* and various orchids form the groundcover.

Threatened Species: Habitat for the orchid *Cryptostylis hunteriana*, listed as Vulnerable under the *Threatened Species Conservation Act*. This species has been recorded in Conjola NP although not in Narrawallee Creek NR.

Other Species of Conservation Significance: *Trachymene incisa* was found at site NARJM04F and is at its southern limit in the Ulladulla area.

Relationship to other Forest Ecosystems: Commonly adjoins FE2 which occurs on lower slopes.

Conservation Significance: Well represented in Conjola and Morton (East) but found in only one location in Narrawallee, where the flatter ground tends to favour less dry forest types. FE139 was not identified as an ecosystem of high conservation significance in the region, but it probably should be. Although this type of vegetation is very extensive in the Sydney basin, and is well reserved in the region in Morton National Park, it is at its southern limit of distribution around Ulladulla. Many of the component species, such as *Eucalyptus sclerophylla, Lambertia formosa, Persoonia mollis* ssp *caleyi, Petrophile pedunculata, Kunzea capitata, Epacris pulchella* and *Actinotus minor* are also at or very close to their southern limit which is possibly in or near Barnunj SRA and Meroo National Park, south of Ulladulla.

Threats: Fire (see below)

Impacts of Fire Regimes: Such heathy vegetation is adapted to relatively frequent fire, but too short an interval between fires may eliminate obligate seeders, which are killed by fire rather than re-sprouting, from the species mix. Re-sprouting shrubs can also be eliminated over a longer period if frequent fires do not allow sufficient time to replenish seed banks, and if more fire-sensitive juvenile plants are killed. Having a predominantly heathy shrub understorey with a high proportion of sclerophyllous shrubs, and often a dense sedge layer as well, it is highly flammable. Fine fuels are more or less uniformly distributed from ground level to the low eucalypt crowns, via tall shrubs such as *Leptospermum trinervium*. This makes this vegetation type flammable in almost all weather conditions, and difficult to extinguish because the continuous shrubby understorey makes firebreak creation impossible except at tracks. FE139 therefore requires careful fire management. Fire intervals in the range of 7-30 years are recommended for shrubby dry sclerophyll forests (NPWS, undated). However, frequencies close to the lower limit would tend to eliminate trees or reduce them to mallee form, converting woodlands to open heathland.

FOREST ECOSYSTEM 171: Coastal Red Gum Grassy Forest

Southern CRA Profile Information

Description: Coastal Shrub/Grass Forest - *E. tereticornis*

Coastal Shrub/Grass Forest is an open medium to tall forest, dominated by *Eucalyptus tereticornis*, with *E. globoidea* and *Angophora floribunda*. *Acacia mearnsii* occasionally occurs as a small tree layer up to 9 metres tall. The upper ground cover mainly comprises *Lomandra longifolia, Kunzea ericoides*, *Bursaria spinosa,* and *Dodonaea viscosa* ssp *viscosa*. *Themeda australis* and *Danthonia longifolia* dominate the grassy ground cover, with scattered forbs including *Dichondra repens* and *Oxalis perennans*.

Extant area (ha): 3509

Pre-1750 area (ha): 23011

Geographic range: South Coast

How much conserved in reserves (ha): 1683

Vulnerability: 2C

Reliability: 2

FE 171 – Narrawallee Study Area

Mills' Classification equivalent type: None

Previous Survey Sites Represented: None

Narrawallee 2003 Sites Represented : NARJM06

Marginal Sites : None

Species Recorded at Representative Sites:

Acacia mearnsii
Angophora floribunda
*Bidens pilosa**
Breynia oblongifolia
Carex longebrachiata
Centella asiatica
Cheilanthes sieberi ssp *sieberi*
Chrysanthemoides monilifera ssp *rotundata**
*Cirsium vulgare**
*Citrus limonia**
Clematis glycinoides
Commelina cyanea
Cymbopogon refractus
Daucus glochidiatus
Desmodium gunnii
Dianella longifolia
Dichondra repens
Echinopogon ovatus
Entolasia marginata
Eucalyptus botryoides
Eucalyptus globoidea
Eucalyptus muelleriana
Eucalyptus tereticornis
Euchiton gymnocephalus
Eustrephus latifolius
Gahnia clarkei
Galium propinquum
Geranium solanderi var *solanderi*
Glycine clandestina
Hibbertia scandens
Hydrocotyle laxiflora
*Hypochaeris radicata**
Kunzea ambigua
Lomandra filiformis ssp *filiformis*
Lomandra longifolia
Macrozamia communis
Microlaena stipoides var *stipoides*
Notelaea longifolia
Oplismenus imbecillis
Oxalis perennans
*Passiflora edulis**
Pellaea falcata
Persoonia linearis
Pittosporum revolutum
Plectranthus parviflorus
Pratia purpurascens
Rumex brownii
Sigesbeckia orientalis
*Solanum nigrum**
*Stenotaphrum secundatum**
Stephania japonica var *discolor*
Wahlenbergia gracilis

Dominant species: . Forest red gum (*E. tereticornis*), rough-barked apple (*Angophora floribunda*) and white stringybark (*E. globoidea*), with the small tree *Acacia mearnsii* and occasional shrubs including *Bursaria spinosa, Kunzea ericoides* and *Breynia oblongifolia*. The groundcover is generally low and consists of a mixture of numerous grasses and herbs. Common species are *Microlaena stipoides, Oplismenus imbecillis, Lomandra* spp, *Dichondra repens, Glycine clandestina, Commelina cyanea, Pratia purpurascens, Geranium solanderi* and *Hydrocotyle laxiflora*.

Threatened Species: None

Other Species of Conservation Significance: None

Relationship to other Forest Ecosystems: In the one instance in Narrawallee, this type is adjoined by FE28, FE29 and FE2.

Conservation Significance: Restricted distribution in the region, not recognised in Conjola and Morton (East) National Parks and only in one location in Narrawallee. FE171 was ranked in the CRA report (Thomas, Gellie and Harrison, 2000) as a vulnerable ecosystem with a naturally restricted distribution (about 3500 hectares in aggregate) on the South Coast.

Threats: Vulnerable to weed invasion because it typically occurs on more fertile soils and in better watered locations such as alluvial flats, The small patch of this community in Narrawallee Creek NR has been disturbed by past quarrying and is more weed infested than the remainder of the Reserve. The community has been largely cleared in the region as it occurs on the most fertile soils.

Impacts of Fire Regimes: Because of the grassy understorey, fires are likely to burn through this community quickly and not very hot. The grassy groundcover is well adapted to recovering from frequent fire. If fire is withheld for lengthy periods a dense subcanopy layer of black wattle (*Acacia mearnsii*) may develop, and this can reduce groundcover species diversity by shading out some less shade tolerant species. There is also likely to be a species shift to include more bird-distributed and fire-intolerant species such as *Pittosporum undulatum* and *P. revolutum*.

FOREST ECOSYSTEM 175: Coastal Lowlands Swamp Mahogany Forest

Southern CRA Profile Information

Description: Northern Coastal Lowlands Swamp Forest - *E. robusta*

Northern Coastal Lowlands Swamp is a forest up to 25 metres high, dominated by *Eucalyptus robusta*, as well as a variety of other eucalypts fringing the swamp forest. The understorey comprises a moderate to dense cover of *Melaleuca* species, including *Melaleuca ericifolia, M. linearifolia, M. squarrosa*, together a range of *Leptospermum* spp. The ground cover can be a dense mixed sward of grasses and sword grasses, with a fine scattering of herbs and procumbent shrubs.

Extant area (ha): 459

Pre-1750 area (ha): 465

Geographic range: South Coast subregion

How much conserved in reserves (ha): 65

Vulnerability: 1C/W/U

Reliability: 2

FE 175 – Narrawallee Study Area

Mills' Classification equivalent type: None

Previous Survey Sites Represented: None

Narrawallee 2003 Sites Represented: NARJM01

Marginal Sites: None

Species Recorded at Representative Sites:

Acacia longifolia ssp *longifolia*

Baloskion tetraphyllum ssp *meiostachyum*

Baumea juncea

Cymbidium suave

Cynodon dactylon

Entolasia stricta

Eucalyptus botryoides

Eucalyptus robusta

Gahnia clarkei

Gonocarpus micranthus ssp *micranthus*

Hydrocotyle peduncularis

Imperata cylindrica var *major*

Leptocarpus tenax

Lobelia alata

Lomandra longifolia

Melaleuca linariifolia

Parsonsia straminea

Patersonia fragilis

Polymeria calycina

Pratia purpurascens

Pteridium esculentum

Schoenus brevifolius

Selaginella uliginosa

Viminaria juncea

Dominant species: Swamp mahogany (*E. robusta*) forms an open canopy above smaller trees with a tolerance for waterlogged soils such as *Melaleuca linariifolia, M. ericifolia, M. squarrosa* and *Acacia longifolia*. There may be a dense tall groundcover of the large sedge *Gahnia clarkei*, or of other sedges including *Baloskion tetraphyllum* ssp *meiostachyum, Schoenus brevifolius, Leptocarpus tenax* and *Baumea juncea*.

Threatened Species: None

Other Species of Conservation Significance: *Eucalyptus robusta* is the diagnostic canopy species for a threatened community of the Sydney Basin Bioregion which is potentially the same as FE175 in the study area. The fern *Blechnum indicum* was seen in this community and is close to the southern limit of its distribution.

Relationship to other Forest Ecosystems: Occurs in wet sites within taller forest such as FE2 or FE29. Intergrades with FE29.

Conservation Significance: Relatively well represented in Narrawallee although this community is very limited in Conjola NP, and does not occur in Morton (East). FE175 is listed as an Endangered Ecological Community within the Sydney Basin Bioregion, which includes the Ulladulla area. Its occurrences have probably not been very accurately mapped previously. It had been overlooked before being newly mapped in Conjola NP and Narrawallee Creek Nature Reserve.

Threats: Clearing and logging in un-reserved areas, weed invasion and changes to hydrological conditions.

Impacts of Fire Regimes: Fire may sweep through this community quite frequently, as although the ground is often wet, the groundcover and shrub layers are often dense and include highly flammable plants such as teatrees (*Leptospermum polygalifolium*) and paperbarks (*Melaleuca* spp). There may also be good fuel continuity from ground to canopy. Most species in this community appear well adapted to regular fires, with resprouting from lignotubers, epicormic buds or root suckers being the most common fire responses. However, there are some component species which are obligate seeders such as the peas *Sphaerolobium* spp and *Viminaria juncea*, and these could be eliminated by too frequent fire. Conversely the main recruitment of these species appears to be after fire (Benson & McDougall, 1996), and a very long fire-free interval could also eliminate them from the seedbank.

FOREST ECOSYSTEM 185: Mangrove Forest

Southern CRA Profile Information

Description: Mangrove Estuarine Low Forest

Mangrove Estuarine Low Forest is a low estuarine forest dominated by *Aegiceras corniculatum* or *Avicennia marina.*

Mangrove Estuarine Low Forest is restricted to mudflats occurring in the upper tidal zone. It occurs from about Merimbula in the Eden CRA Region up the New South Wales Coast (Keith & Bedward 1999). Map Units 65 and 66 in the Eden CRA Region are mapped as one type in the vegetation map for the Southern CRA Region.

Extant area (ha): 1404

Pre-1750 area (ha): 1685

Geographic range: South Coast subregion

How much conserved in reserves (ha): 287

Vulnerability: 2C/U

Reliability: 1

FE 185 – Narrawallee Study Area

Mills' Classification equivalent type: Areas do not overlap

Previous Survey Sites Represented: KMU16

Narrawallee 2003 Sites Represented: None

Marginal Sites: NARJM02

Species Recorded at Representative Sites: None recorded

Dominant species: Consists solely of the small tree, grey mangrove (*Avicennia marina*).

Threatened Species: None

Other Species of Conservation Significance: None

Relationship to other Forest Ecosystems: Closely associated with FE186 (Saltmarsh)

Conservation Significance: Relatively well represented along Narrawallee Inlet although not recorded in Conjola National Park. Mangroves and associated saltmarsh are significant for their foreshore protection role, because they provide breeding and feeding grounds for shorebirds, fish and other aquatic fauna, and because they naturally occur in small, fragmented stands.

Threats: Not especially prone to weed invasion because of the specialised growing conditions created by frequent inundation and high salinity. However there are a few weeds capable of exploiting these conditions, such as sharp rush (**Juncus acutus*). The Narrawallee Inlet may also be susceptible to invasion by caulerpa (**Caulerpa taxifolia*), an exotic aquatic plant which is established in nearby Conjola Lake, and can be transported on boats, diving equipment and even on animals or swimmers.

Impacts of Fire Regimes: Mangroves are unlikely to be burnt, although it could occasionally happen in extreme conditions.

NON-FOREST ECOSYSTEM 186: Saltmarsh

Southern CRA Profile Information

Description: Mudflats / Saltmarshes

Mudflats / Saltmarshes is a mosaic of mudflats and saltmarshes, which are dominated by the succulent herb *Sarcornia quinqueflora*, and can be associated with a range of other salt tolerant aquatic species.

Mudflats / Saltmarshes occur in the mid-tidal zone of estuaries, lakes, and lagoons along the entire South Coast between Wallaga Lake and Kiama. It is equivalent to FE64 in the Eden CRA Region (Keith & Bedward 1999).

Extant area (ha): 890

Pre-1750 area (ha): 1131

Geographic range: South Coast subregion

How much conserved in reserves (ha): 346

Vulnerability: 2C/U

Reliability: 2

FE 186 - Narrawallee Study Area

Mills' Classification equivalent type: Cu15

Previous Survey Sites Represented: None

Narrawallee 2003 Sites Represented: None

Marginal Sites: NARJM02

Species Recorded at Representative Sites: None recorded

Dominant species: The succulent herb samphire (*Sarcocornia quinqueflora*) or sea rush (*Juncus kraussii*), plus a range of other salt-tolerant herbs, grasses and sedges.

Threatened Species: None

Other Species of Conservation Significance: None

Relationship to other Forest Ecosystems: Closely associated with FE185 (Mangrove Forest).

Conservation Significance: Relatively well represented along Narrawallee Inlet although not recorded in Conjola National Park. Mangroves and associated saltmarsh are significant for their foreshore protection role, because they provide breeding and feeding grounds for shorebirds, fish and other aquatic fauna, and because they naturally occur in small, fragmented stands.

Threats: Not especially prone to weed invasion because of the specialised growing conditions created by frequent inundation and high salinity. However there are a few weeds capable of exploiting these conditions, such as sharp rush (**Juncus acutus*). The Narrawallee Inlet may also be susceptible to invasion by caulerpa (**Caulerpa taxifolia*), an exotic aquatic plant which is established in nearby Conjola Lake, and can be transported on boats, diving equipment and even on animals or swimmers.

Impacts of Fire Regimes: Saltmarshes are unlikely to be burnt, although it could occasionally happen in extreme conditions. The upper edge of saltmarsh often consists of a dense belt of sea rush, *Juncus kraussii*, which is likely to be quite flammable. However, it is also likely to recover rapidly from underground rhizomes.

APPENDIX 5: Fire Response Mechanisms

Mature plants subject to 100% leaf scorch from fire die (therefore must return via seedlings) and:

- Category 1 seeds are canopy-stored (eg Banksias)
- Category 2 seeds are soil-stored (eg Acacia)
- Category 3 no seeds remain on site after fire and must be imported
- Category 8 seed status unknown

Mature plants subject to 100% canopy scorch survive fire and:

- Category 4 resprout from root suckers or rhizomes
- Category 5 resprout from basal stem buds (eg lignotubers)
- Category 6 resprout from epicormic shoots
- Category 7 resprout from terminal aerial buds (eg Xanthorrhoea)
- Category 9 resprout from bulbs, corms or tubers
- Category 10 resprout mechanism unknown.

APPENDIX 6: GIS Details

GIS LAYERS

The new GIS layers which are supplied on the data CD accompanying this report are briefly described below. All layers are in ArcView 3.x shapefile format. Additional ArcView legend files are also included where relevant and wherever possible have the same file name as the shapefile to which they apply. The legends will therefore load automatically on loading each shapefile into ArcView.

The material in this appendix is also included on the data CD to serve as metadata and a guide to using the GIS information.

Study Area

Conjola_morton_narrawallee_study_area.shp – reserve boundaries for the study area extracted from the current NPWS_estate layer

CRA_API_clipping_bdry – boundary used to clip the API layer so as to avoid splitting polygons along the coastline

Study_area_ext_bdry.shp – boundary of re-mapping which includes internal corridors and inholdings and includes all areas within the above clipping boundary

Sheet_layout.shp – map sheets used for the hard copy maps in the report

Background Layers

The following are included:

100m_contours.shp – generated from 25m DEM

10m_contours.shp – generated from 25m DEM

fire_history.shp – records of fire history for each floristic site

note: individual shapefiles for wildfires and hazard reduction for relevant years have been extracted for use in the analysis and are included in the sub-directory 'fire_history'

Drainage - several drainage layers are included in the sub-directory 'drainage' which were used in the mapping. NPWS coastline and drainage layers were edited to avoid overlap with new drainage mapping from API which was part of the vegetation layers.

Powerlines.shp – digitised from orthophotos

Recreation_sites.shp – extracted from NPWS recreation sites layer for the South Coast Region (from earlier work by Phil Kendall/NGH Environmental)

Floristics Site Data

Access database – set of Microsoft Access 97 database files which run under the NPWS site floristics database developed by Michael Bedward and Murray Ellis. The files are arranged in the appropriate directories but need to be linked to the main frontend file (*survey.mde*) when it is first run. The data is contained in the backend file *survey.be*. All of the following data are derived from the access database. Note: Spreadsheet versions of the access tables are contained in the spreadsheets subdirectory. For full details on the attribute information contained in the above database files, see the lookup tables in the NPWS access database.

Con_mor_nar_sites_2003.shp – full floristic survey sites which were recorded on field data sheets and entered in the Access sites database then transferred to ArcView. The attribute table includes locational information as well as the forest ecosystem types from the original modelling and the validation and re-mapping work.

Floristics_data.dbf – a database file which can be linked to the above survey sites attribute table so as to obtain species listings for each site. The data was converted from the floristics database table in

the Access sites database. (note the site number needs to be used as the common field for linking the tables).

Master_species_list.dbf – database file extracted from NPWS access database – the species names and other selected attributes have been copied across to the floristics_data.dbf table.

sites_flora_(sthn_cra)z56.shp – extracted from the NPWS floristics sites database for the study area

FireMon_survdat_con_mor_nar.xls – fire response monitoring site data in an excel spreadsheet developed by Nic Gellie for NPWS.

Some additional spreadsheets are included on the CD which were created during the project along with the blank NPWS proforma data sheets.

Threatened_flora_new_sites.shp – new sites found during the field work or reported by NPWS in 2003-3004.

Vegetation

fe_clipped_z56.shp – derived from the original FE modelled layer by Thomas, Gellie and Harrison (2000) – the grid model was converted to a shapefile and clipped using the study area boundary

The legend **fe_clipped_z56.avl** applies to the above layer.

api_veg_080999_z56_clipped.shp - study area portion clipped from the Southern CRA API floristics layer, with modifications by Nic Gellie (EcoGIS)

fe_ext_ecogis56_cncm.shp- layer supplied by NPWS which contains some additional attribute information to the above layer

Narrawallee_API.shp

Updated API data – Southern CRA API mapping adapted with additional coding and new API work, with forest ecosystems coded according to the modified SCRA classification. Legend has the same filename.

Narrawallee_FE.shp

Versions of above with boundaries between polygons with the same fe_new code dissolved so that the resulting map is essentially a new forest ecosystems map. Legend has the same filename.

The legend file **all_fe_new_types.avl** contains all forest ecosystem types found in the study area and can be used with any of the re-mapped API layers.

POLYGON ATTRIBUTE TABLES

Vegetation Maps

The CRA API layers used for this project are those which have been adapted by Nic Gellie (EcoGIS).While there are no specific changes to the polygon boundaries or coding within the Conjola-Morton_Narrawallee study area, the additional fields in the polygon attribute tables have been utilised for the purposes of recording changes during the validation and re-mapping work.

The attribute codes used in the revised API map **Narrawallee_API.shp**, which are relevant to the re-mapping, are explained below.

Area_ha recalculated areas in hectares for all polygons.

API_code original code used in CRA API layers

FE1, FE_type, FE2, FE_type2 – fe codes and labels corresponding to FE types assigned to API codes during the southern CRA. Where a combined FE type is suggested these have been split into FE1 and FE2.

code_status these are all “changed” since FE codes have been interpreted from the API code

polygon_status reflects updates made during the re-mapping

FE_code Southern CRA forest ecosystem type assigned on the basis of API code to FE code translation tables prior to manual adjustment

notes rules and observations relating to the assignment of FE codes to API

field_site full floristics site(s) present in the polygon

FE_new the finally assigned code which is either the FE_code type unchanged, or a new code assigned on the basis of field or API work

FE_label the description used in this report.

Site Data

In the floristic sites data arcview layer **con_mor_nar_sites_2003.shp** the following attributes have been used for forest ecosystem types:

FE_old – the original modelled type

FE_new – the field assigned type

Mapped - the type used for the corresponding polygon in the new mapping

Multiple FE types separated by a '+" indicates these types are present in the vicinity

Multiple FE types separated by a '/" indicates the types intergrade and may show characteristics of both types.

Sites with intergrading types are not considered representative of a single forest ecosystem and are considered as marginal sites in the Forest Ecosystem Profiles (Appendix 4).

APPENDIX 7: Maps

MAPS