



Vegetation Response to Fire Monitoring in Narrawallee Creek Nature Reserve, Conjola and Morton National Parks



prepared by



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1. INTRODUCTION

A vegetation fire response monitoring system was established in the NSW NPWS South Coast Region following the 2001/2002 Shoalhaven Hylands fires that affected a significant proportion of conservation reserves in the Nowra Area (EcoGIS, 2002). A total of 29 plots were placed in both burnt and unburnt reserve areas across the range of vegetation ecosystems found in the area. They were established in April and June 2002 to monitor the effects of fire on vascular plant species and communities, recovery rates, species sensitivity, and any changes to floristics and vegetation structure after fire.

The current survey, conducted in October 2003, established an additional twelve fire response monitoring plots to complement existing sites for incorporation into the Vegetation Response to Fire Monitoring Project and state-wide fire response database. Information collected will in time be useful for managers when selecting appropriate fire regimes, especially for areas known to contain rare or fire sensitive species and communities. The plots were established using the fire response sampling method developed in the Nowra area (EcoGIS, 2002). They were placed in Narrawallee Creek Nature Reserve, Conjola and Morton National Park (eastern extension), between Ulladulla and Nowra. The majority of plots went into sites which had been burnt in the Hylands fire, although two plots had been only partially burnt and one site was unburnt.

Narrawallee Creek Nature Reserve (875ha) gazetted on 22 August 1986 is located on coastal land adjacent to Narrawallee Inlet between Sussex Inlet and Ulladulla. The nature reserve protects diverse coastal ecosystems including coastline, extensive dunal systems, estuaries and important bird breeding and feeding areas at Pattimores Lagoon.

Conjola National Park gazetted on 30 November 1994 with new additions gazetted as a result of the Southern RFA on 1 January 2001 protects diverse coastal landforms, plant communities and animal habitat including extensive dunal systems, estuaries and the catchment of important bird breeding and feeding areas. Swan Lake and Conjola Lake are listed as bioregionally significant wetlands in the Sydney Basin Bioregion because of their seagrass beds, and value to waterfowl as feeding and roosting areas (NPWS website, Bioregions of NSW, 2004). Conjola Lake provides nesting habitat for three threatened species of shorebird (little tern, hooded plover and pied oystercatcher). Twenty one threatened species of fauna and 18 regionally significant fauna species have been recorded in the Park, plus the listed Vulnerable leafless tongue orchid (*Cryptostylis hunteriana*), the ROTAP listed shrub (Briggs & Leigh, 1995) *Pultenaea villifera* and 19 regionally significant plants, many of which have their southern limit of distribution in the area. There is a high diversity and occurrence of Aboriginal sites and some features of local historical significance are protected within the Park.

The Morton National Park (eastern extension), gazetted on 1 January 2001, protects areas of rainforest, heath and dry and moist forest types. It is also the only (RFA 2001) addition in South Coast Region recording a European historic site.

1.1 Scope of Works

The scope of works for the project was as follows:

1. 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 or TSC Act) species and/ or areas of highest fire risk potential.
2. permanently mark the sites so that they can be re-located precisely for repeat surveys;

3. undertake full-floristic plot based sampling and record fire response for each species as per methodology developed in the Nowra area;
4. establish photo points at each monitoring site and
5. provide a stand-alone report on the exercise, to contain:
 - an introduction referring to the Project Brief;
 - a literature review of previous relevant studies;
 - methodology employed;
 - fuel sampling and plant species fire response plot data;
 - a review of the fire history of each site;
 - completed field survey sheets and an electronic database in MS EXCEL format for a minimum of 12 monitoring plots;
 - photographs of each fire response-monitoring plot in digital, print or slide format.

1.2 Literature Review

The report of the Nowra fire monitoring exercise (EcoGIS, 2002) was consulted for information on methodology. Field botanist, Jackie Miles, was involved in the Nowra exercise, as well as conducting all the data collection in the present survey, so the methodology could be replicated more or less exactly.

Limited information about individual plant species response to fire is available from the regular series in the NSW Botanical Gardens journal *Cunninghamia* compiled by Doug Benson and Lyn McDougall that spans nine volumes from 1993 to 2002. The authors of the compendium, *Ecology of Sydney Plant Species*, have catalogued the known fire responses of most plant species in families found in the Sydney Basin, excepting monocotyledons (grasses, sedges, orchids and lilies) to date. As the Nowra and Ulladulla fire monitoring plots were established within the Sydney Basin bioregion (which extends to just north of Batemans Bay), comparison of observation of plant responses on the fire monitoring plots with those of Benson and McDougall is likely to be valid.

Information on forest ecosystem types is derived from the report of the Southern Region Comprehensive Regional Assessment (Thomas, Gellie & Harrison, 2000).

2. METHODOLOGY

2.1 Selection

Six fire monitoring quadrats and a further six full floristics quadrats were located in Conjola NP. Three fire monitoring and three full floristics quadrats were placed in Morton (East) NP. Two fire monitoring quadrats and eight full floristics quadrats were located in Narrawallee Creek NR, one of which, NARJM04F, was placed in vegetation which had been burnt in the Hylands fire.

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 and the presence of flowering, seeding or seedlings is collected.

For unburnt quadrats established for fire monitoring information about presence of seedlings, flowering and seed production is also collected, which is omitted from full floristics quadrats. However, full floristics quadrats can readily be converted to fire monitoring quadrats 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 when access difficulties arose or when target vegetation types could not be located in the area in which they were mapped. A description of all 28 quadrats is provided in Appendix 2.

2.2 Quadrat survey method

To identify each site a steel post was driven either centrally (for fire monitoring quadrats) or in the north-east corner (for the full floristics quadrats) of each plot. A metal tag with the plot name was attached and the post was capped with a yellow plastic top to assist in relocation.

For the full floristics plots, two 20m tapes were run out from the post, one to the south and one to the west. For the fire quadrats a tape was run out 10m either side of the post either parallel and perpendicular to the adjacent access track, or if 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-blauquet score from 1 to 6). On full floristics quadrats (but not fire monitoring quadrats) an additional 20m x 30m area was checked for the presence of any extra canopy species not recorded in the 20m x 20m quadrat. This methodology is consistent with that employed for Southern CRA surveys.

For fire quadrats located on burnt sites additional information was collected on recovery mechanisms of each plant species 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 3. Where the site had been only partially burnt 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. The proportion of plants flowering or seeding and numbers of seedlings present were recorded in broad abundance categories (see blank data sheet reproduced in Appendix 3).

2.3 Photography

Digital photographs were taken of all quadrats. The sign provided for use 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 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 rather than from a corner.

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 consistently done and if this information conflicts with that given by the photo name then it is the photo name information which is correct.

Photos have been provided as .jpg files.

3. RESULTS

Table 1 below outlines what is known of the vegetation type and previous fire history for each of the fire monitoring quadrats. The first three letters of the site identifier indicates which reserve the site is in. Site locations are outlined in Appendix 1. Any special features of the site, such as proximity to settlements which might indicate a need for frequent hazard reduction, or presence of significant plant species, are listed.

Data on previous fire history was provided by NSW NPWS. The level of detail depends on past tenure of the reserves, all of which have only passed into National Parks estate recently. Morton (eastern extension) and parts of Conjola were formerly State Forest and as such have some level of information available about past wildfires and hazard reduction (HR) fires. However, the fact of a fire having occurred in the vicinity of the quadrat in those years does not necessarily imply that the quadrat itself burned, since fires can be patchy. Nor does it provide any indication of fire intensity. Both wildfire and hazard reduction are indicated to have occurred in 1980-81, which was a drought period.

Limited information was available on the fire history of Narrawallee Creek Nature Reserve, which was formerly Crown Land.

The same information for the additional 15 full floristics quadrats is provided in Appendix 2.

Table 1. Details of Vegetation, Special Features, and Known Fire History at Fire Monitoring Plot sites

Site ID	Likely FE*	Description in the field	Special features	Known fire history
NARJM04F	139	Scribbly Gum woodland with impeded drainage		Unknown, only partially burnt in 2001
NARJM09F	28	Coastal Sands Bangalay-Banksia Forest, with burrawang understorey	Close to Lake Conjola village	HR 1994 or 95-96, unburnt 2001
CONJM01F	139, heath	Dry Heath with sparse Red Bloodwood	Presence of orchid, <i>Diuris aurea</i>	Dec 2001
CONJM03F	27	Ecotonal Coastal Swamp Forest – Swamp Oak/ Bangalay	Close to Swanhaven village	Dec 2001
CONJM04F	139, heath	Dry Heath with sparse Red Bloodwood and Yertchuk		91, 92, 2001
CONJM06F	2/21 transitional	Lowland Red Bloodwood-Turpentine Dry Shrub Forest		68-69, 80-81, 2001
CONJM08F	139	Dry Heath with sparse Red Bloodwood		68-69, HR81-82, 91-92, 2001 (about every 10 years)
CONJM09F	2	Lowland Red Bloodwood-Turpentine Dry Shrub Forest	Presence of <i>Pultenaea villifera</i>	91, 92, 2001
MORJM01F	139 heath	Dry Heath with sparse low Red Bloodwood	Presence of <i>Grevillea scabrifolia</i> .	68-69, HR80-81, HR81-82, 91, 92, 2001 (high frequency if the site actually burnt in all these years)
MORJM03F	2	Lowland Red Bloodwood-Turpentine Dry Shrub Forest		68-69, HR80-81, 2001
MORJM05F	20	Ecotonal Gully Rainforest		68-69, 2001

*FE = Forest Ecosystem, as defined by Thomas *et al* (2000).

3.1 Response of Threatened Species in Conjola National Park

Cryptostylis hunteriana

The leafless tongue orchid is listed as Vulnerable under both the NSW *Threatened Species Conservation Act 1995* and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*. The NSW NPWS Wildlife Atlas database shows 18 records of this species clustered in five locations in Conjola National Park. Locations are east of the Princes Highway near the southern boundary of the park, west of Swan Lake, and three sites clustered in the south-eastern corner of the park west from North Bendalong. None of the quadrats in this study were located in any of these sites, nor was the timing of the survey in October appropriate for detecting this species, which flowers in summer and is undetectable outside the flowering season.

All of the sites where the species has been recorded are within the area burnt in 2001. The location near the Princes Highway also burnt in wildfires in 1968-69 and 1991-92. The location west of Swan Lake is on the edge of the 1991-92 fire and may have burned. The other three sites do not appear to have been burned in any of the earlier fires for which location data are available.

Little specific information is available with respect to a suitable fire regime to ensure the persistence of this species. The NPWS fire response database (2003) indicates that this species resprouts after fire and would reach reproductive maturity in under two years after fire. It also suggests that it would not be particularly sensitive to either too frequent or too infrequent fire, being able to establish and grow both after disturbance and in mature vegetation. However, Bell (2001), discussing the results of a Central Coast survey for this species, suggests that very little is known of its reproductive requirements. It is a cryptic species which does not flower consistently from year to year in any site. Bell indicates that from Central Coast data it appears that searches of sites burnt 12-36 months previously are most likely to be successful in locating the orchid. Potential threats to this species are listed as including "altered fire regimes" (Backhouse and Jeanes 1995). These authors enlarge on this by suggesting that flowering may be inhibited by a hot fire the previous summer. It would seem logical that fire during the flowering season is detrimental as it would be likely to prevent seed production in that season. December to February is the period generally quoted in orchid texts as the flowering season, although flowering in November has been recorded by Bell on the Central Coast, and in August for the single Queensland record (Logan 1998, cited in Bell, 2001). The species was seen flowering in Barnunj SRA in early December during surveys in 2001 in the Ulladulla district (J Miles, pers. obs.).

Detailed work reported in Cropper (1993) on the reproductive ecology of two rare orchid species in Victoria, one (*Thelymitra epipactoides*) a heathland and one (*Diuris fragrantissima*) a grassland species has shown that fire is important for both, to open up the vegetation and improve subsequent flowering, seed set and recruitment. In the former species marked adult plants which had disappeared recovered from dormancy after a fire and recruitment "improved dramatically several years after the fire". This may well be a common pattern in orchids, which tend to be over-topped and shaded out by taller vegetation, particularly in heathlands.

Galium australe

This small herb is listed in Schedule 2 of the *Threatened Species Conservation Act* as Presumed Extinct in NSW. However in recent years a number of confirmed records (and a few which have yet to be confirmed) have been made from the South Coast and nearby tablelands. Keith McDougall (NPWS Threatened Species Unit) has recently prepared a nomination to the Scientific Committee to change the listing to Endangered, as although the species has been found in a number of locations, all have been very small populations of one to a few plants. One of these locations was close to Conjola National Park, being on the edge of Swan Lake 1km south-south-west of Swanhaven. Other recent confirmed records on the South Coast are from Lake Windemere at Jervis Bay and Cullendulla Creek Nature Reserve north of Batemans Bay. There is an unconfirmed record from Beehive Point in Morton NP (McDougall, 2003).

On the present survey *Galium australe* was found in two locations. It occurred in quadrat CONJM07 on Slaty Box Road in Conjola and was collected below Twelve Mile Road west from the Whalebone Road junction in Morton (East), both burnt sites. Voucher specimens have been forwarded to the Herbarium of the Royal Botanic Gardens, Sydney for confirmation. In both cases only one or two plants were seen, but the plant is very inconspicuous and more could have been present. In each case only a small area was searched.

Any suggestions about the fire response of this species would be purely speculative. The only information about the genus in the *Cunninghamia* series on ecology of the flora of the Sydney region is “possibly resprouts” for *Galium gaudichaudii*. After the Kosciuszko fires one species (*G. roddii*) appeared in a quadrat where it had not been previously recorded and one species (unspecified) disappeared from a quadrat (K. McDougall, pers. comm.). No information is available for any other species. However, it appears likely that this species, like many other understorey herbaceous plants, would derive a temporary advantage from the release from shading and competition for moisture and nutrients occasioned by the loss of the tree canopy after fire. Observations on the fire monitoring quadrats near Nowra suggest that similar small groundcover species such as *Opercularia aspera*, *Goodenia heterophylla* and *Hydrocotyle geraniifolia* can become temporarily dominant in the first growing season post-fire, but that they gradually return to more normal levels as the tree and shrub layers recover. *Galium australe* is likely to grow to reproductive maturity and produce seed, thus replenishing the soil seedbank, in a single season. It is therefore likely to be relatively tolerant of frequent fire. It may belong to a group of “rare” plants which are generally present as soil-stored seed and only become visible after a disturbance such as fire. Other examples of such species are *Derwentia nivea* and *Pelargonium helmsii*, both thought to be rare in Kosciuszko National Park, and both appearing commonly after the 2002-03 fires (K. McDougall, pers. comm.). Alternatively it may be genuinely rare in NSW, although it is described as “widespread in near-coastal habitats” in Victoria and mapped as occurring right to the NSW border in East Gippsland (Jeanes, 1999), or it may merely be overlooked because of its inconspicuous appearance and the difficulty of distinguishing it from other *Galium* species.

3.2 Significant Species on Fire Plots

Pultenaea villifera* var *villifera

This ROTAP species is reportedly common in Conjola National Park (Mills 1995) where it occurs mostly in blackbutt-bloodwood forest (probably mainly FE2). Mills implies that the species may be fire-sensitive, pointing out that the species is most common in rocky sites, which have good fire protection because of low ground fuel levels, and that some sites where it occurs had not been burnt for many years at the time of his survey.

Pultenaea villifera has been studied by a post-graduate student (Clunas, 2002) in Conjola NP and other south coast sites. This study was undertaken after the Hylands fire, and indicates that the species is indeed fire sensitive. No occurrences of re-sprouting were recorded, but a flush of seedling germination was noted some six months post-fire. Recruitment was also recorded after disturbance events other than fire. Clunas recorded the occurrence of at least one site (near Jamberoo) where almost all plants were old, some sites where young plants predominate and some with an even distribution of age classes. This difference between sites probably relates to the presence or absence of suitable disturbance events to stimulate germination.

Clunas concludes that more study of the reproductive ecology of this species is required. Information is still lacking on the degree to which recruitment occurs in the absence of disturbance, the age at which plants become reproductively mature, the time taken to replenish the soil seedbank after a flush of recruitment, the rate of accumulation of the seedbank, the impact of predation on seed while on the plant and in the soil and the time after the last fire at which the seedbank begins to decline. Long term studies cited (Auld 1986, 1987) of the common shrub *Acacia suaveolens* in the Sydney region indicate that the time to reproductive maturity is 2 years, that the seedbank accumulates to a maximum level at about 10 years post-fire, and that beyond this time it declines due to seed decay and predation (and presumably reduced seed output by older, possibly senescing, plants). Similar information is required for *Pultenaea villifera* before definite recommendations about appropriate fire intervals to conserve this species can be made.

However, Clunas does make the point that pre-reproductive seedlings are the most vulnerable stage in the life cycle of this species and that sites which have been burnt should be protected from fire or other disturbance until such time as they have produced some seed. Populations have persisted in Conjola NP on sites which have been burnt three times at ten year intervals and on-going recruitment was recorded in populations which had not been burnt for 20 years, indicating a degree of latitude in fire requirements in this species.

The population near the junction of Bangalay Road and Cedar Road was the only one observed during this survey. It appeared to be recovering well from fire with seedlings being quite numerous (>100 in the 20 x 20m quadrat CONJM09F and many on the verges of Bangalay Road). A small proportion of plants were flowering some 22 months after the Hylands fire, so it seems likely that the soil seed bank might be substantially replenished within 4-5 years. Continued closer monitoring of this site might help answer some of the questions raised by Clunas.

***Grevillea buxifolia* species complex**

A specimen of this grevillea from Morton (East) has been identified by Peter Olde, who is currently undertaking a revision of the *Grevillea buxifolia* complex. He states that it is referable to *G. scabrifolia*, a published name (Gandoger 1919) which has fallen out of use and is currently in synonymy with *G. buxifolia/sphacelata/phylicoides*. He intends to recognise it as a distinct taxon at species or subspecies level. It is a rare taxon, confined to the area between Conjola and Nowra. This taxon is recognisable by its oval leaves with recurved margins and small greyish flowers in erect terminal clusters. It keys to *G. buxifolia* but lacks an obvious appendage on the pollen presenter, though it does have a slight bump in this location. It was present as numerous seedlings in quadrat MORJM01F. One more advanced individual growing in wetter conditions in a roadside drain was flowering. There was no indication of it re-sprouting. *Grevillea* species are generally seeders rather than re-sprouters.

Diuris aurea

This large species of donkey orchid was recorded growing in coastal heath west from the headland between Berrara Beach and Monument Beach. It occurs in the quadrat CONJM01F. Bishop (1996) describes its distribution as "coast and tablelands north from Marulan" but Harden (1993) does not have it listed as occurring in the South Coast

botanical division (that is, south of the Shoalhaven River). A voucher specimen was taken and forwarded to the Royal Botanic Gardens herbarium, who confirm the identification. It is similar to the more common tiger orchid (*Diuris sulphurea*) but the flowers are rather larger and have fewer brown markings. It seems likely that flowering in this species had been promoted by the 2001 fire as it was present in large numbers in some areas.

4. CONCLUSIONS

This project brings the total number of potential fire impact monitoring sites in the Nowra-Ulladulla area to fifty-seven. This includes eighteen unburnt sites (9 in this project and 9 in the earlier project by EcoGIS). The total number of quadrats located in sites burnt in the Hylands fire or subsequent Agars fire is 39 (19 in this project and 20 in the EcoGIS project).

These quadrats are scattered over a wide geographic area and a range of vegetation types and should in time provide valuable information about the fire response of both individual species and the different forest ecosystems of the region, which will assist in developing fire management plans.

Burnt quadrats should be monitored annually for at least another two years. The best timing would be in summer to detect the maximum amount of seed production information, as species which flower early could be expected to still be carrying evidence of seed production, while later flowering species would probably be at least in flower. After another two years it may be appropriate to drop back to monitoring every two years. It may also be desirable to re-survey unburnt quadrats every few years, so that if a fire does occur on the site there is a better chance of having recent baseline data available. The original data may become less relevant if many years elapse between its collection and a fire occurring. Certainly sites should be re-surveyed prior to any prescribed burn being conducted in the area.

Any future full floristics sampling sites in the region should be marked with a permanent marker post and photographed in the same standardised fashion so that pre-fire data is available for them, in the event that they are subsequently burnt.

It would be desirable to collect more detailed fire response data from sites with rare or threatened species present. This might require monitoring individual plants to determine the time taken to reach reproductive maturity and sampling the soil seed bank at regular intervals. The information acquired would help to determine optimum fire intervals for such species.

Another valuable adjunct to the existing studies would be to select a few sites in areas that are likely to require frequent hazard reduction burns, such as those around the coastal villages and install paired quadrats within the same vegetation type. One quadrat would be located within the fuel reduction zone and one beyond it, so that information could be gathered about changes to the vegetation over time in frequently burnt areas relative to a less frequently burnt control site.

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MAP Forest Ecosystems Validation Map

APPENDIX 1: LOCATION OF ALL QUADRATS

Location Details of Fire Monitoring and Full Floristics Plots

Site ID	Reserve	Map Sheet	Zone	Easting AGD 66	Northin g AGD66	Easting GDA 94	Northi ng GDA94	Locality
NARJM01	Narrawall ee Creek NR	Milton	56	269042	609149 2	269145	609168 3	60m W (bearing 280°) of big stump on Mangrove Track 1.2 km S of Buckley's Point FT (peg in NE cnr, tapes at 270° and 180°)
NARJM02	Narrawall ee Creek NR	Milton	56	269093	609047 5	269196	609066 6	180m on 150° bearing from S-most point on Mangrove Track, near 90° bend in Narrawallee Creek estuary.
NARJM03	Narrawall ee Creek NR	Milton	56	269819	609212 3	269922	609231 4	30m S of Buckley's Point FT, 500m W of junction with The Inlet Track and 1km E from gate on Narrawallee Creek Road (just W of 2 huge fire-scarred blackbutt)
NARJM04 F	Narrawall ee Creek NR	Milton	56	269963	609306 5	270066	609325 6	20m N of Silica FT, 550m in from Narrawallee Creek Road (behind big scribbly gum and just west of small rise).
NARJM05	Narrawall ee Creek NR	Milton	56	270427	609261 9	270530	609281 0	50m S of Silica FT 1.4km in from Narrawallee Creek Road (c. 300m past quarry).
NARJM06	Narrawall ee Creek NR	Milton	56	270900	609266 3	271003	609285 4	70m W of old tin shed on Silica FT, just before junction of Silica FT and track from Lake Conjola to beach carpark, at foot of piles of spoil from old ?quarry.
NARJM07	Narrawall ee Creek NR	Milton	56	268236	609157 8	268339	609176 9	On low point between two arms of Narrawallee Creek, close to bank of southern arm and next to eucalypt forest/casuarina boundary.
NARJM08	Narrawall ee Creek NR	Milton	56	268123	609156 4	268226	609175 5	100m W of NARJM07 on more elevated ground. No permanent stake here, big stump is SE corner of quadrat, tapes to 270° and 360°.
NARJM09 F	Narrawall ee Creek NR	Milton	56	271100	609277 6	271203	609296 7	90m N (bearing 26°) from junction of Silica FT and track from Lake Conjola to beach carpark, 1.25km S of Conjola Fire Shed.

NARJM10	Narrawallee Creek NR	Milton	56	267922	6094134	268025	6094325	50m E (bearing 85°) from gate at start of Northern FT off Conjola Point Road (opposite Sandy Point sign), in head of gully.
CONJM01F	Conjola NP	Sussex Inlet	56	275668	6099818	275771	6100009	40m N of walking track to beach S of Berrara village. Walking track leaves from Cedar Road roughly at its E-most point. Take left fork before swamp, not headland track, to get to quadrat.
CONJM02	Conjola NP	Sussex Inlet	56	274824	6099138	274927	6099329	On point between two arms of Nerrindillah Creek estuary, 500m SE of Nerrindillah Road.

Site ID	Reserve	Map Sheet	Zone	Easting AGD 66	Northing AGD66	Easting GDA 94	Northing GDA94	Locality
CONJM03 F	Conjola NP	Sussex Inlet	56	278235	610497 9	278338	610517 0	From W end of houses at end of Medlyn Ave, follow track to shore of Swan Lake, then 60m W along shore and 50m N (back from water's edge) till ground rises.
CONJM04 F	Conjola NP	Sussex Inlet	56	274237	610407 7	274340	610426 8	30m N of Slaty Box Road, 1.4 km N of Blackbutt Road junction.
CONJM05	Conjola NP	Tianjara	56	269647	610609 4	269750	610628 5	30m SE of Peppermint Road, 100m SE of the intersection of Moandayong Road and Peppermint Road.
CONJM06 F	Conjola NP	Tianjara	56	270283	610748 5	270386	610767 6	About 100m E (bearing 100°) of the powerline easement track, 100m S of the Wents Road crossing of the powerline track.
CONJM07	Conjola NP	Tianjara	56	271615	610598 0	271718	610617 1	50m N of slaty Box Road, about 100m E of its junction with Mondayong Road.
CONJM08 F	Conjola NP	Tianjara	56	271587	610380 2	271690	610399 3	20m N of Stringybark Road, 1.3km from the junction of Stringybark Road and Sheoak Fire Road. Tapes parallel and perpendicular to road.
CONJM09 F	Conjola NP	Sussex Inlet	56	272529	610034 5	272632	610053 6	20m NNE of Bangalay Road, 350m down Bangalay Road from junction with Cedar Road. Two old tracks run through quadrat, with east-west tape following one of the tracks.
CONJM10	Conjola NP	Tianjara	56	270884	609823 9	270987	609843 0	180m N of Red Head Road opposite Palm Cove Road (8km in from highway). Drive in 100m on small track opp. Palm Cove Rd, walk straight down slope, cross creek near fan palm and peg is on rainforest edge on N side of creek.
CONJM11	Conjola NP	Sussex Inlet	56	275822	610705 6	275925	610724 7	10m S of powerline track, 1.5 km east along easement from Old Berrara Road.
CONJM12	Conjola NP	Sussex Inlet	56	274399	610540 0	274502	610559 1	45m N of Slaty Box Road, 500m W of Old Berrara Road junction (junction is 2.8 km S of powerline crossing on Old Berrara Road).
MORJM01 F	Morton NP	Tianjara	56	263564	610184 0	263667	610203 1	30m SE of Whalebone Road, 50m short of (NE of) Halfway Road and 2.1 km W of Deodar Road (using roadside drain for access to quadrat).
MORJM02	Morton NP	Tianjara	56	265539	610228 9	265642	610248 0	30m N of Deodar Road, 100m past (NW of) powerline easement, between easement and road. Top SSW corner has remnant of old track running through it.

MORJM0 3F	Morton NP	Tianjara	56	262580	610561 0	262683	610580 1	50m NE of old logging track and 320m N of Twelve Mile Road. Logging track leaves Twelve Mile Road 60m W of Jacaranda Road junction.
MORJM0 4	Morton NP	Tianjara	56	264796	610546 2	264899	610565 3	160m N of Twelve Mile Road, 1.7 km E of Roundabout Road junction.
MORJM0 5F	Morton NP	Tianjara	56	264378 (264050)	610678 7 (610670 0)	264479	610677 8	About 100m above gully floor, just above old logging track, 500m down Burrawang Road from Messmate Road junction. GPS not accurate in deep valley and dense tree cover – estimated position on topo map in brackets.
MORJM0 6	Morton NP	Tianjara	56	266206	610785 1	266309	610804 2	100m N of Messmate Road, just W of junction with Cypress Road. Head for big emergent scribbly gums to locate peg.

APPENDIX 2 DESCRIPTION OF ALL QUADRAT SITES

Details of Vegetation, Special Features, and Known Fire History at Full Floristics Plot Sites

Site ID	Likely FE	Description in the field	Special features	Known fire history
NARJM01	175	Coastal Lowlands Swamp Forest – <i>E. robusta</i>	EEC	Wildfire 1996. Unburnt in 2001.
NARJM02	186	Saltmarsh	Progressive invasion by mangroves	Unlikely to have burnt in 1996 (not very flammable vegetation). Unburnt in 2001
NARJM03	29/2 transitiona l	Coastal Sands Blackbutt/Banksia forest with Lowland Red Bloodwood-Turpentine Dry Shrub Forest elements		Wildfire 1996. Unburnt in 2001
NARJM05	Wet end of 2	Lowland Red Bloodwood-Turpentine Dry Shrub Forest with rainforest elements in a gully head		HR 1994. Earlier intense fire (?68-69). Unburnt in 2001
NARJM06	171	Coastal Shrub/Grass Forest – <i>E. tereticornis</i>	Rare and depleted community, forest red gum on good soils	HR 94-95 or 95-96. Unburnt in 2001
NARJM07	25	Coastal Swamp Forest – <i>Casuarina glauca</i>	Rare community.	Unburnt 2001
NARJM08	29 or 5	Between Lowland Red Bloodwood-Turpentine Dry Shrub Forest and Jervis Bay Lowlands Shrub/Grass Dry Forest		Unburnt 2001.
NARJM10	5	Jervis Bay Lowlands Shrub/Grass Dry Forest	Presence of grey gum (<i>E. punctata</i>) at southern limit.	68-69 and probably low intensity fire in 1996. Unburnt 2001.
CONJM02	144	Woollybutt-Paperbark Woodland		Dec 2001
CONJM05	139	Heathy Woodland, Red Bloodwood and Yertchuk		68-69, 81-82, patchy HR 1999, 2001
CONJM07	9 or 5	Spotted Gum-Blackbutt Tall Forest on silty soils.		68-69, 80-81, 2001
CONJM010	20	Ecotonal Gully Rainforest		HR81-82 (unlikely to have penetrated rainforest), 2001 (only penetrated quadrat in NW corner)

Site ID	Likely FE	Description in the field	Special features	Known fire history
CONJM011	141	Coast and Escarpment Wet Heath/Sedge		95, 2001
CONJM012	5	Jervis Bay Lowlands Shrub/Grass Dry Forest on silty soils		95, 2001
MORJM02	Disturbed 21	Northern Foothills Moist Shrub Forest on clay soils	Near powerline, probable control line in future fires	68-69, HR81-82, 91, 92, 2001 (high frequency if the site actually burnt in all these years)
MORJM04	2	Lowland Red Bloodwood-Turpentine Dry Shrub Forest but atypical understorey on Devonian sandstone		68-69, 2001
MORJM06	139	Heathy Woodland, Red Bloodwood and Yertchuk	Topsoil loss, evidence of more frequent fire than indicated by known history.	68-69, HR81-82, 2001

FULL DESCRIPTIONS OF ALL SITES

NARRAWALLEE CREEK NATURE RESERVE

NARJM01

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. pilularis*, *Angophora floribunda* and *Banksia serrata* on very slightly more elevated ground.

The site was not recently burnt but this area burnt in a wildfire in 1996.

NARJM02

This site is on a large sandy bar in a bend of Narrawallee Creek close to its mouth. It was mapped as saltmarsh, and this is correct to some extent, although most of the bar is in fact covered in grey mangrove (*Avicennia marina*). These 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 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 mapped as FE29. It appears to be intermediate between FE29 and FE2. 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, which agrees roughly with the timing of a wildfire in 1996 in this area.

NARJM04F

Located just north of Silica Fire Trail in an area mapped as FE29, this quadrat is intermediate between FE139 and FE2. It 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 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, possibly hazard reduction which is reported to have occurred in the area in 1994, 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 two arms of Narrawallee Creek, this quadrat samples FE25 (*Casuarina glauca* Swamp Forest). This community is 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 west (also mapped as 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 at some time 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 is located 100m west of NARJM07 and 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.

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 1994 or 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 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.

It appeared that there had been a light fire through the site in the last few years, possibly the wildfire in 1996. It is recorded as having burnt in the wildfire of 1968-69.

CONJOLA NATIONAL PARK

CONJM01F

This site is located in coastal heath about 100m west of Berrara Beach, in a location that was mapped as FE24 (Coastal Swamp Forest – *Casuarina glauca*/*Melaleuca ericifolia*), which it clearly is not. There is a narrow belt of a wetter heath type running north-south in a drainage depression on the eastern edge of the heath patch, but this is not close in species composition to any of the wetter heath types described during the Southern CRA, being dominated by the shrub *Viminaria juncea* and sedges.

In the drier heath on the quadrat resprouters dominate the shrub layer, mainly *Lambertia formosa*, *Banksia spinulosa*, *Kunzea capitata* and *Hibbertia riparia*. The main shrub species present as seedlings were *Pimelea linifolia*, *Micrantheum ericoides*, *Acacia suaveolens* and *Hakea teretifolia*, but numbers were low for all but the first of these. The groundcover is largely composed of resprouters (grasses and sedges) but devil's twine (*Cassytha glabella*) was also extremely common. It was not possible to determine whether this was resprouting or had arisen from seedlings, but the latter is more likely, since once this parasitic plant has become attached to its hosts, its connection to the ground usually withers away. Data from Sydney fires indicates that this species is killed by fire and also experiences most recruitment after fire (Benson & McDougall 1997).

The fire history of this site indicates only that it was burnt in December 2001.

CONJM02

On a point between two arms of Nerrindillah Creek, this site is mapped as FE25 (Coastal Swamp Forest – *Casuarina glauca*). This is not correct, as no *Casuarina glauca* was seen in the vicinity. The area is a mixture of eucalypt forest on slightly more elevated areas and paperbark forest (*Melaleuca linariifolia*, *Leptospermum polygalifolium*, *Gahnia clarkei* and *Schoenus brevifolius*) in small depressions. The latter vegetation type has been described by Thomas et al as FE144 (Northern Coast and Hinterland Moist Heath) but this is something of a misnomer since it is in fact a low forest dominated by *Melaleuca* species and occasional emergent eucalypts, with no heath elements. "Paperbark wet forest" is suggested as a more appropriate name.

The fire history of this site indicates only that it was burnt in December 2001.

CONJM03F

Located about 30m back from the edge of Swan Lake, this site is mapped as FE27 (Ecotonal Coastal Swamp Forest – *Casuarina glauca*/*Eucalyptus botryoides*). This is reasonably accurate, although at this location such vegetation is only a narrow belt. The 20m quadrat occupies the entire width of this vegetation type. Below it is paperbark/teatree scrub (*Melaleuca linariifolia*, *M. ericifolia* and *Leptospermum polygalifolium*) on the lake shore, which is a hybrid of FE144 (freshwater paperbark woodland type) and FE24 (estuarine swamp oak/paperbark scrub), and above it on ground which is about 2m higher is FE139. The quadrat contains species typical of both these associations, while being dominated by *E. botryoides* and *Banksia integrifolia*, species which are typical of coastal sand deposits (dunes and lake mouth bars). There is

therefore a high species diversity. A high water table on this low-lying site had produced rapid growth, with wattle (*Acacia longifolia*) seedlings up to 2m high (though most were smaller).

Resprouters dominate the shrub layer, mainly *Leptospermum polygalifolium*, but surprisingly including *Banksia integrifolia*. Small trees of this species had been killed to ground level but were resprouting from the base and from the roots. No seedlings were seen. The groundcover is about equally composed of resprouters (grasses and lomandra/sedges, bracken) and seeders (forbs such as *Opercularia aspera* and *Hydrocotyle geraniifolia* which respond vigorously to the post-fire conditions).

The fire history of this site indicates only that it was burnt in December 2001.

CONJM04F

Located on Slaty Box Road in an area mapped as FE140 (Northern Coastal Tall Wet Heath). In this instance this is not accurate. This site is dry heath or FE139 with a relatively low cover of trees. The tree cover would have appeared greater but for the fires, which had temporarily reduced the height and cover abundance of *Corymbia gummifera* and *E. consideriana*.

Structurally resprouters dominate the shrub layer, including *Leptospermum trinervium*, *Kunzea capitata*, *Banksia spinulosa*, *Isopogon anemonifolius* and *Petrophile pedunculata*. However shrub seedlings were also common, but less advanced than the resprouters. Common species were *Hakea sericea*, *Mirbelia rubiifolia*, *Bossiaea heterophylla* and *Acacia suaveolens*. The groundcover is dominated by resprouters (the grass *Anisopogon avenaceus* and the subshrub *Dampiera stricta*).

This site has experienced wildfires in 1991, 1992 and December 2001.

CONJM05

This site is near the junction of Mondayong and Peppermint Roads in an area correctly mapped as FE139. Dominant trees are *Corymbia gummifera* and *E. consideriana* with occasional *E. sieberi*. The understorey is heathy. The patch of FE140 (tall wet heath) mapped nearby is not present, but is just an area of FE139 with fewer trees.

This site has experienced a wildfire in 1968-69, hazard reduction in 81-82 and the December 2001 wildfire. It may also have burned in patchy HR fires in 1999.

CONJM06F

Located about 100m east of the main north-south powerline easement through Conjola National Park, this site is mapped as FE21 (Northern Coastal Hinterland Moist Shrub Forest – *C. maculata*/*E. pilularis*). It was in fact transitional between FE2 (Hinterland Heath Shrub Dry Forest, which is taller than FE139, with substantial cover of *Syncarpia glomerulifera* and a slightly heathy understorey) and the wetter forest type which occurs in Conjola. However this wetter forest is not a good match to FE21, and was not described in the Southern CRA report.

As might be expected in a transitional forest type, resprouters and seeders are about equally abundant in the shrub layer, including *Leptospermum polygalifolium*, *Banksia spinulosa* and *Lambertia formosa* in the former category and *Acacia longifolia*, *Pultenaea daphnoides* and *Hakea sericea* as the most abundant seeders. The groundcover is about equally composed of resprouters (grasses and sedges, bracken) and seeders (forbs such as *Opercularia aspera* and *Goodenia heterophylla* which respond vigorously to the post-fire conditions).

This site experienced wildfires in 68-69, 80-81 and December 2001.

CONJM07

Located 100m north of Slaty Box Road in a patch of spotted gum, this site is mapped as FE9 (Coastal Lowlands Cycad/Shrub Dry Forest – *C. maculata*). This is accurate, in that spotted gum (*Corymbia maculata*) and grey ironbark (*E. paniculata*) are present. Blackbutt (*E. pilularis*) is also dominant on this site, and is not mentioned as a potential component of FE9. However, *E. pilularis* is very widespread on the sandy soils around Ulladulla and seems to occur in almost all forest types, whereas the bulk of the samples used to describe FE9 are likely to have come from further south, between Batemans Bay and Bermagui, where *E. pilularis* is less common.

Seeders are dominant in the shrub layer on this site, mainly wattles *Acacia binervata*, *A. terminalis* and *A. longifolia*. The groundcover is about equally composed of resprouters (grasses and *Lomandra* spp, bracken) and seeders (forbs such as *Opercularia aspera* and *Goodenia heterophylla* which respond vigorously to the post-fire conditions).

This site experienced wildfires in 68-69, 80-81 and December 2001.

CONJM08F

Located on Stringybark Road in an area previously mapped as FE140 (Northern Coastal Tall Wet Heath), which is not accurate. This site is dry heath or FE139 with a very low cover of trees. The tree cover in this instance is naturally low, not just reduced by fire, possibly because of very shallow soils. The species list for the site is not particularly suggestive of poor drainage. Grass trees (*Xanthorrhoea australis*) are a feature of this site, and this particular species of *Xanthorrhoea* is not generally found on wet soils.

Resprouters dominate both the shrub and groundcover layers, with the only abundant seedlings being the shrub *Hibbertia riparia*, which can also resprout, and was doing so on the plot.

This site burnt in 68-69, was hazard reduced in 81-82 and experienced wildfires in 1991, 92 and December 2001, giving it a fire frequency of about every ten years on average.

CONJM09F

This site was chosen for the presence of the rare shrub *Pultenaea villifera*, which is abundant on the quadrat. It is located NE of Bangalay Road near the junction with Cedar Road, and two old and well regenerated tracks run through the plot, parallel to Bangalay Road. The nearer track forms the east-west axis of the plot and the other is on the edge

of the plot. Fruits found on the ground indicated that many tree species are present in the vicinity but their proportions on the plot were difficult to judge because there was little to identify them by except epicormic shoots. Several of the species in the area have similar discoloured intermediate foliage (*E. piperita*, *E. botryoides* and stringybarks). *E. piperita* and *Corymbia gummifera* appeared to be the most common, with *Syncarpia glomerulifera* also abundant. This suggests that the site is in FE2 (Lowland Dry Shrub Forest) which generally contains the latter two tree species with a sclerophyll shrub understorey which is slightly "heathy".

Notable features were the high species diversity and relatively dense cover in the shrub and ground layers and high numbers of individual plants. The site is on Permian siltstone with a more clayey soil than most other sites and is on a south-facing slope, providing favourable growth conditions. The soil was very well worked by ants and also very much dug over by either echidnas or bandicoot and/or potoroos. *Acacia* seedlings were up to 2m high, considerably higher than on any other plot except the Swan Lake shore site (CONJM03F). *Pultenaea villifera* had regenerated freely from seed all over the plot and in the roadside drain and a few plants were flowering.

This site experienced wildfires in 1991, 1992 and 2001.

CONJM10

Located on the lower south-facing slope just above a small creek on sandstone, this site was mapped as carrying FE20 (Ecotonal Gully Rainforest) and this proved to be correct. The fire had penetrated a short distance into the NW corner of the plot, but had burnt almost to the edge of the plot right along its upper edge. On the plot a few smaller coachwood (*Ceratopetalum apetalum*) had been scorched and were coppicing from the base. Beyond the plot all the coachwood were coppicing. Several large coachwood and grey myrtle (*Backhousia myrtifolia*) dominate the canopy, with emergent *E. saligna* x *botryoides* above. Most coachwood trees are smaller and consist of several stems coppiced from a medium sized base, suggesting an earlier fire had burnt the site more thoroughly, probably about 20 years previously.

This site was hazard reduced in 81-82 and burnt in 2001.

CONJM11

This site is located south of the east-west powerline easement which crosses Old Berrara Road, in an area mapped as FE24 (Coastal Swamp Forest – *Casuarina glauca*/*Melaleuca ericifolia*). This mapping is not accurate. This site is a low sedge-dominated wet heath, which does not fit into any of the CRA vegetation types well, though it is closest to FE141 (Northern Coast and Escarpment Wet Heath/Sedge).

Structurally resprouters dominate the site, in the form of sedges, all of which were fully recovered from the fire. *Leptocarpus tenax*, *Empodisma minus*, *Lepidosperma quadrangulata*, *Ptilothrix deusta* and *Schoenus brevifolius* were the dominant species. *Eleocharis sphacelata* was also tentatively identified from its dried stems which are distinctively transversely septate (hollow and separated into short segments by partitions). If the identification is correct it suggests that this site is frequently submerged, since this species is generally found only in standing water. The small grass tree

Xanthorrhoea resinifera, a species typical of wet soils, is also common and appeared to have flowered profusely in the season immediately following the fire. Shrubs were sparse, having recovered less fully. The dead remains of wattles were emergent above the sedge layer, and seedlings of *Acacia elongata*, *A. longifolia* and *Hakea teretifolia* were common. The small shrubs *Comesperma retusa* and *Sphaerolobium vimineum* were also common but almost concealed within the sedge layer. Nearby the groundcover is lower and more open and occasional *E. sclerophylla* occurs, suggesting that the quadrat has been located in the wettest part of this area.

This site burnt in wildfires in 1995 and 2001.

CONJM12

This site was chosen as being representative of an open grassy forest apparently occurring on soils with a higher clay content which had not been sampled in any other quadrats. It is located near the eastern end of Slaty Box Road.

Dominant trees are *C. gummifera*, *E. pilularis* and *E. eugenoides*, with a small tree layer including *Syncarpia glomerulifera* and *Banksia serrata*. Seeders are more common in the shrub layer, including several wattles and peas (*Acacia longifolia*, *A. myrtifolia*, *A. ulicifolia*, *Bossiaea* spp, *Aotus ericoides*, *Pultenaea villosa*, *Mirbelia rubiifolia* and *Gompholobium* spp). However a few resprouters are also present. The groundcover is about equally divided between resprouters and seeders.

This site burnt in wildfires in 1995 and 2001.

MORTON NATIONAL PARK.(EASTERN EXTENSION)

MORJM01F

This site is located near the junction of Whalebone and Halfway Road in an area mapped as FE144 (Northern Coast and Hinterland Moist Heath). While the site is in heath, it would be more accurately described as dry heath or FE139 with a relatively low cover of trees. The tree cover would have appeared greater but for the 2001 fire, which had temporarily reduced the height and cover abundance of *Corymbia gummifera* and *E. consideriana*.

Structurally resprouters dominate the shrub layer, including *Leptospermum trinervium*, *Lambertia formosa*, *Banksia spinulosa*, *B. paludosa* and *Hakea laevipes*. Shrub seedlings were present but less common, and structurally far less significant than the resprouters. Commonest species were *Sphaerolobium minus*, *Bossiaea heterophylla* and *Pimelea linifolia*. The groundcover is dominated by resprouters, sedges *Lepyrodia scariosa* and *Gahnia radula* and the grass *Anisopogon avenaceus*. The rare taxon *Grevillea scabrifolia* (currently part of the *G. buxifolia* species complex) was found on this site.

The area in which this site is located has been burnt in the 68-69 wildfire, hazard reduced in 1980-81 and 1981-82, and burnt in further wildfires in 1991, 1992 and 2001.

MORJM02

This site is located in a slightly disturbed area between a powerline easement and Deodar Road in an area mapped as FE21. This appears reasonably accurate, in that the site does carry the wetter forest type present in the area, even though this is not really a very good match to FE21.

Seeders dominate the shrub layer, including *Acacia longifolia*, *Acacia* sp and *Howittia trilocularis*, the latter being extremely common. However resprouters are also prominent in the form of *Syncarpia glomerulifera*, *Bursaria spinosa*, *Notelaea longifolia*, *Pomaderris aspera* and a few rainforest margins species such as *Rhodamnia rubescens*, *Rapanea variabilis* and *Clerodendrum tomentosum*, all of which were resprouting. The groundcover is a mixture of resprouters, sedge *Gahnia sieberiana* and grasses *Entolasia marginata* and *Oplismenus imbecillis* and numerous vines, along with seeders such as *Sigesbeckia orientalis*, *Solanum prinophyllum* and *Opercularia aspera*. The species list for this site was distinctly different from most other sites encountered during the survey. It appeared to be on a different geology from most areas, although what this was could not be determined. It appeared to be either Ordovician or Devonian metasediments, rather than the Shoalhaven or Sydney sandstone underlying much of the Ulladulla to Nowra area.

The area in which this site is located has been burnt in the 68-69 wildfire, hazard reduced in 1981-82, and burnt in further wildfires in 1991, 1992 and 2001.

MORJM03F

This site is located 320m north of Twelve Mile Road near the Jacaranda Road intersection along an old logging track. It was mapped as FE3 (Northern Hinterland Shrub Dry Forest – *Syncarpia glomerulifera*/E. *scias*) but appears to be FE2, which is the dry forest type which occupies much of the eastern extension of Morton NP. The dominant tree species are *C. gummifera* and *S. glomerulifera*.

Acacia obtusifolia and *Persoonia linearis* are the dominant shrubs, both resprouting, *A. obtusifolia* being somewhat unusual among the wattles in doing this. It appeared to be resprouting from the roots rather than from a lignotuber. Seeders are also well represented, but small in numbers of individuals, and include *Pimelea linifolia*, *Zieria pilosa*, *Amperea xiphioclada*, *Astrotricha* sp B, *Dodonaea triquetra* and peas *Pultenaea linophylla*, *Bossiaea kiamensis*, *Gompholobium glabratum* and *Pultenaea daphnoides*. The groundcover is a mixture of resprouters (*Lepidosperma urophorum*, *Entolasia stricta* and ferns), along with seeders such as *Gonocarpus teucroides*, *Hybanthus vernonii*, *Goodenia heterophylla* and *Opercularia aspera*.

The area in which this site is located has been burnt in the 68-69 wildfire, hazard reduced in 1980-81 and burnt in 2001.

MORJM04

This site is located 160m north of Twelve Mile Road on a steep north-facing slope which appears to be on Devonian sandstone rather than the more usual Permian sandstone. The usual tree species of *C. gummifera*, *E. pilularis* and *S. glomerulifera* are present but

the understorey is markedly different to that seen on most sites. Shrubs are sparse, with *Persoonia linearis*, *Acacia obtusifolia* and *Podolobium ilicifolium* being the only common species. The groundcover is dominated by various *Lomandra* species and forbs or subshrubs including *Pomax umbellata*, *Phyllanthus hirtellus* and *Hybanthus monopetalus*. The site is mapped as being FE2, and given the tree species present this has been left as correct, but the understorey is far from typical. The vegetation is about equally distributed between seeders and resprouters.

This area has been burnt in wildfires in 1968-69 and 2001.

MORJM05F

This site is located on a lower slope just above a gully mapped as carrying FE20 (Coastal Hinterland Gully Rainforest). The mapping is correct. The quadrat site had been little affected by fire, although it had burnt the south-west corner of the plot, and patchily in some other areas. The intensity is likely to have been low. Ferns, tree ferns and rainforest trees were resprouting from either rhizomes, roots or woody bases, with some such as bolwarra (*Eupomatia laurina*, a small rainforest tree) sprouting from both the woody base and the roots. The only seedlings seen were judged likely to have germinated independently of the fire.

There are emergent tall *Syncarpia glomerulifera* and *E. pilularis*, with a lower canopy being formed by *Acacia mabellae* and rainforest trees *Cryptocarya glaucescens* and coachwood, *Ceratopetalum apetalum*. Old fire scars on the base of the *Cryptocarya* and *Syncarpia* indicate that a more intense fire has burnt into the edge of this rainforest patch in the past.

This area has been burnt in wildfires in 1968-69 and 2001.

MORJM06

This site is located near the junction of Messmate and Cypress Roads in an area mapped as FE139, with a moist heath (FE144) polygon located within it. The quadrat was located on the boundary of the two polygons. In fact the area is all FE139, with some parts more open and with trees of smaller stature. The site gives the impression of having been burnt twice within a short period, with trees having two obvious points at which their growth has been checked. The soil also seems unusually poor, as if there had been some loss of topsoil after the first fire, such as might happen if heavy rain followed the fire while the ground was still bare.

Resprouters such as *Lambertia formosa*, *Banksia spinulosa* and *Leptospermum trinervium* dominate the shrub layer, although seedlings were also common. The groundcover was very sparse and of relatively low species diversity, perhaps due to the lack of topsoil.

This area has been burnt in wildfires in 1968-69, hazard reduced in 1981-82 and burnt in 2001.

APPENDIX 3: FIELD DATA SHEETS AND CODES FOR COMPLETING THEM.

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Fire recovery mechanisms of plant species

- | | |
|----|--|
| 1 | from seedlings via canopy-stored seed (eg <i>Allocasuarina</i>) |
| 2 | from seedlings via soil-stored seed (eg <i>Acacia</i>) |
| 3 | from seedlings, but seed probably imported to site post-fire |
| 8 | seed status unknown |
| 4 | resprout from root suckers or rhizomes |
| 5 | resprout from basal stem buds (lignotubers) |
| 6 | resprout from epicormic shoots (eg eucalypts) |
| 7 | regrowth from terminal aerial buds (eg <i>Xanthorrhoea</i>) |
| 9 | regrowth from bulbs, corms or tubers (eg lilies, orchids) |
| 10 | resprout mechanism unknown |

% of life stages (ie % of total biomass exhibiting bud, flower or fruit):

- | | |
|---|--------------------|
| N | none |
| F | few (<10%) |
| S | some (10-40%) |
| H | half (40-60%) |
| M | many (60-85%) |
| A | all/most (85-100%) |

Number of seedlings present:

- | | |
|---|-----------------|
| N | none |
| F | few, 1-10 |
| S | some, 10-30 |
| C | common, 30-50 |
| M | many, 50-100 |
| P | prolific, >100. |

Modified Braun-Blanquet cover abundance scores:

- | | |
|---|------------------------|
| 1 | uncommon and <5% cover |
| 2 | common and <5% cover |
| 3 | 5-20% cover |
| 4 | 20-50% cover |
| 5 | 50-75% cover |
| 6 | 75-100% cover |