

**VEGETATION SURVEY OF
KONDININ SALTMARSHES AND
NORTH KARLGARIN**

**DEPARTMENT OF CONSERVATION AND LAND
MANAGEMENT**

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**REPORT FOR THE DEPARTMENT OF CONSERVATION
AND LAND MANAGEMENT (CALM)
VEGETATION SURVEY OF
KONDININ SALTMARSHES AND NORTH KARLGARIN**

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Summary

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

The Kondinin Salt Marsh Recovery Catchment and the North Karlgarin Target Landscape are located in the Kondinin Shire, between Kondinin and Hyden, approximately 300 km east of Perth.

This study area includes approximately 9 621 ha of Crown Reserves and 462 ha of private property. Within this area 5 vegetation formations and 44 vegetation associations / land use units were mapped.

Eucalyptus Woodlands, Eucalyptus Mallees and Melaleuca Heath/Shrublands were the most common vegetation formations.

Although the Melaleuca Heath/Shrubland associations cover extensive areas, approximately 56% have been degraded by salinity. This level of degradation contrasts dramatically with the remainder of the other vegetation formations which have low levels of degradation.

The majority of the study area had very few weeds. Weed infestations mainly consisted of exotic grasses along drainage lines. The most extensive weed infestations were in the drainage lines on the northern boundary of the portion of Avon Location 27519 west of Government Dam Road and the northern boundary of the Kondinin Saltmarsh.

Approximately 43% of the remnant perimeters had not been fenced but this has had little influence on vegetation condition as unfenced areas predominately occurred where roads bordered the remnants or where bushland was contiguous with the remnants.

The survey recorded up to the five dominant species in each strata for up to five strata at each site. A total of 176 taxa were recorded in the study area as 352 records in 32 quadrats which were generally located in the upper parts of the landscape.

New populations of the Priority 1 *Eucalyptus myriadena subsp. parviflora* and Priority 4, *Grevillea asteriscosa* were found. The collection of specimens of the *Eucalyptus myriadena subsp. parviflora* at numerous sites within the Kondinin Saltmarsh may indicate that the species is more abundant and widespread than previously thought.

Three undescribed species were also found: *Tetradlea aff. virgata* 213 (sp. Nov Ryonen Butcher); *Melaleuca aff. manglesii* 113 (Mike Hislop); and *Baekea sp.* 187 (sp. Nov Malcolm Trudgen). These have been lodged with the West Australian Herbarium and are currently under study.

The presence of *Isopogon ?polycephalus* (specimen field number 106) could not be confirmed as its inflorescence was not comparable with other *Isopogons* previously recorded in area, however if this determination is correct, then this is a range extension for a species predominately occurring on the Esperance Plains.

Opportunistic observations were made of Malleefowl at North Karlgarin Nature Reserve, Roe Nature Reserve and Scrivener Nature Reserve.

The vegetation maps in *Biological Survey of the Western Australian Wheatbelt Part 2: Vegetation and Habitat of Bending Reserve* (Muir, 1977a) and *Biological Survey of the Western Australian Wheatbelt Part 3 & 4 Vertebrate Fauna of Bending & West Bending Nature Reserves & Vegetation of West Bending Nature Reserve* (Muir, 1977b) were digitised and attempts made to make them compatible with the datasets currently being produced for CALM. These attempts were impeded by differences in techniques used to produce the vegetation maps and possible changes in vegetation over the last 25 years. Further surveying would be required to re-interpret the maps by Muir (1977a and b) and make them fully compatible. Despite a level of incompatibility with more recent datasets, the maps produced by Muir (1977a and b), and the associated flora inventories, remain useful references for work undertaken in the area.

1.1 Objectives

The Department of Conservation and Land Management (CALM) has developed a comprehensive geographic information system (GIS) relating to the attributes of native vegetation within the Wheatbelt to assist landscape scale decision making.

The Vegetation Mapping and Survey of the Kondinin Salt Marsh Recovery Catchment and North Karlgarin Target Landscape Area provides data for this GIS by :

- describing and categorising vegetation units and mapping their occurrence, structure and distribution on a scale of 1:25 000;
- compiling an inventory of the vascular flora; and
- identifying species and communities of significance.

The project was undertaken in three parts:

- Digitising existing vegetation maps for the Bendering Nature Reserve and North Karlgarin Nature Reserve;
- Categorising vegetation units and mapping; and
- establishing survey sites.

1.2 Study Area

1.2.1 Location

The Kondinin Salt Marsh Recovery Catchment and the North Karlgarin Target Landscape study areas are situated in the Kondinin Shire, between Kondinin and Hyden, approximately 300 km east of Perth.

The study area shown in Map R1 includes approximately 9 621 ha of Crown Reserves and 462 ha of private property.

1.2.2 Climate and Weather

Hyden experiences a Mediterranean climate with warm, dry summers and cool wet winters, as is indicated in Figure 1.1.

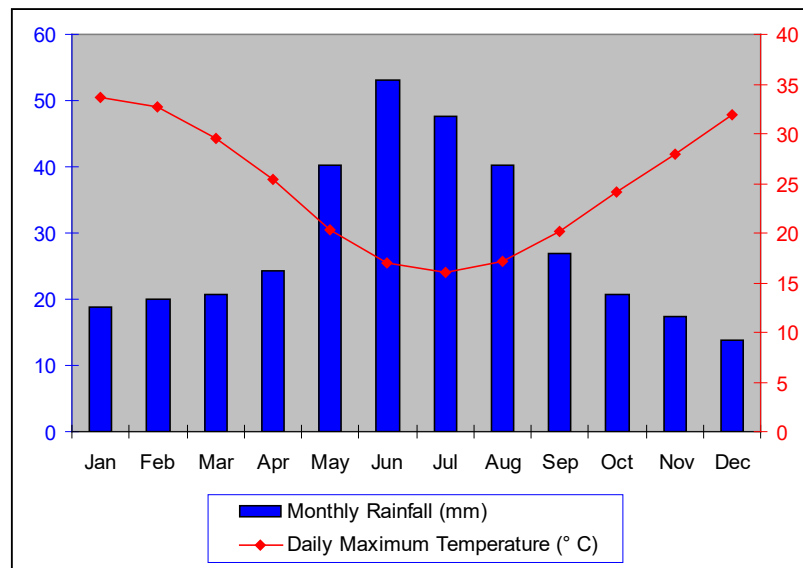


Figure 1.1 Average Climate of Hyden (1928 -2001)

2.1 Timing of Survey and Extent of Groundtruthing

The majority of the survey was conducted between September 30 and November 6, 2003 and during this time all quadrats were established. The Kondinin Saltmarsh was surveyed in the last week of May 2004, and at this time several sites previously mapped were inspected and vegetation boundaries or attributes revised.

The Kondinin Saltmarsh was surveyed separately due to rain restricting vehicle access through the reserve during fieldwork in 2003. Access was again restricted vehicle access in May 2004, resulting in much of the groundtruthing being undertaken on foot.

The extent of groundtruthing is shown in Map R1.

2.2 Digitisation of Existing Vegetation Maps

In addition to mapping the vegetation within the study area, Ecoscape was commissioned to digitise the vegetation maps produced by Muir (1977a & 1977b).

The vegetation maps in *Biological Survey of the Western Australian Wheatbelt Part 2: Vegetation and Habitat of Bendering Reserve* (Muir, 1977a) and *Biological Survey of the Western Australian Wheatbelt Part 3 & 4 Vertebrate Fauna of Bendering & West Bendering Nature Reserves & Vegetation of West Bendering Nature Reserve* (Muir, 1977b) were scanned and imported into Microstation®.

These scanned images were then morphed to fit the cadastral boundaries that are part of DOLA's electronic cadastral dataset for the state, supplied by CALM. The common boundary of the northern and southern maps for Bendering Reserve was Bendering Reserve Road. It should be noted that the northern map does not show a dogleg on the eastern end of the road but the southern map does show this road deviation. In the absence of detailed information on how the original maps were prepared, each map was individually morphed for a line of best fit along the road.

The scanned maps were digitised as lines (rather than polygons) as many of the original vegetation formations are not fully enclosed by boundaries. Whilst the original maps were printed as various scales less than 1:15 000, the digitisation was undertaken onscreen in Microstation® at a scale of 1:2000, or greater.

The linework was then imported in Arcview® and the linework was attributed as according to the classes used by Muir (1977a and b), that is the lines were described as representing boundaries that were either:

- Abrupt (less than 60 m wide);
- Clearly defined but not abrupt (60 – 120 m wide); or
- 'Fairly well defined' but exceeding 120 m.

An attempt was made to further morph the linework to fit aerial photomosaics. Whilst some of the linework could be matched in some areas to the aerial photomosaics, the linework could not be made without complicated morphing and much of the linework does not match apparent boundaries visible in the aerial photomosaics. This may in part be due to be related to differences in seral stages over a twenty year period. After morphing the linework in numerous ways it was decided that the linework should be left only morphed to the cadastral dataset, to avoid introducing confusion as to the accuracy and precision of the dataset, and any further potential error. For the same reason vegetation boundaries were not closed to form polygons.

2.3 Vegetation Mapping

Vegetation mapping was undertaken in accordance with Level 1a & 1b described by Muir (1977a) and consist of the following methods:

- (a) Each formation discernable on the air photographs was examined on the ground, and numerous transects made throughout the reserve; and
- (b) at least one location was described in detail within each association type, and a list of perennial species made for that location. Muir does not state whether the perennial species list includes all species or just dominant species. Dominant species were recorded in each association for this project (with up to 25 species recorded in quadrats).

The attribute of this data set is the vegetation type, which is defined as an association of plants that can be identified as being sufficiently different from neighbouring plant associations, in terms of both floristics and structure.

Vegetation associations were therefore determined on the basis of:

- the floristics and structure within quadrats and the distribution of these components on aerial photographs; and
- visual assessment of floristics and structure of additional vegetation types which did not contain quadrats.

Each nominated vegetation type was considered sufficiently distinct from all others to warrant separate description.

2.3.1 Weed Cover Mapping

The attribute of this data set is weed cover, which is defined as a level of weed cover within a reserve, that was identified as being sufficiently different from neighbouring areas of weed cover. Weed cover was determined from field assessments of the extent of weed cover within a reserve, using five classes of cover with 20% intervals. The extent of weed cover was assessed, by traversing reserves, paying particular attention to areas of disturbance (drainage channels, roadsides, tracks, gravel pits etc.). The delineation of weed cover classes within a reserve is considered to be somewhat arbitrary and represent zones of transition from one cover class to another.

2.3.2 Ground truthing

Where possible, tracks within reserves and the boundaries of Reserves were traversed by vehicle and broad vegetation types mapped onto aerial photos in the field. Combined with quadrat sampling of known vegetation types, these maps formed reference points for mapping vegetation that could not be accessed during fieldwork. Vegetation mapping of reserves was then refined using stereographic interpretation of aerial photos, and comparing these with the appearance and topographic position of areas of known vegetation types.

2.3.3 Structural Description

The National Vegetation Inventory System (NVIS) Structural Formation Nomenclature was used to describe the vegetation types. The stratum codes in used in this system are shown in Table 2.1.

Table 2.1 NVIS Stratum Codes and Descriptions

NVIS Stratum Code	Description	Traditional Stratum Name	Growth Forms
E	Emergent. The tallest layer with crown cover that is not dominant in the dominant stratum	Emergent	Trees, shrubs
U1	Tallest strata when not emergent. For forests and ±woodlands this will generally be the dominant stratum. For a continua (eg. no distinct or discernible layering in the vegetation)the tallest stratum becomes the defining stratum.	Upper Overstorey / Canopy -if only one upper layer described, it is coded U1	Trees, shrubs, ☐grasses
U2	Sub-canopy layer, second tree layer		
M1	Tall shrub layer, third tree layer	Mid (if only one mid layer occurs it is coded M1)	Low trees, shrubs, ☐grasses
M2	Mid shrub layer		
G1	Low shrub or tall ground species		
G2	Ground	Lower, ground	grasses, forbs, ☐shrubs

The maximum number of strata used in a description is five. The tallest stratum, is always U1. When describing the strata at the Sub-Formation and the Association level of data codes U, M and G are obtained from U1, M1 and G1 respectively.

2.4 Quadrat Basis for Sampling

2.4.1 Quadrat Location

The locations of the 32 sites were selected by CALM and Ecoscape to measure vegetation dissimilarity at remnant scale. Due to budgetary constraints, not all mapped vegetation associations were sampled with a quadrat and not all reserves in the study area had quadrats placed in them. Quadrats were preferentially placed in mid and upper landscape positions.

Sites were subjectively placed, in areas considered to be representative of the vegetation type at each location and were chosen to avoid vegetation boundaries and areas of local disturbance, such as roads, tracks and gravel pits. Additional sites within each vegetation type sampled different geographic locations and variations in the physical environment.

The GPS reading and location of each quadrat is listed in Appendix 6.

2.4.2 Quadrat Naming

All remnants were labelled with a prefix of 'TL33' which stands for Target Landscape 33. This was followed by a two digit number, which was assigned incrementally on the basis of the order in which the quadrats were established.

2.4.3 Quadrat Establishment

Thirty two quadrats were surveyed to enable detailed assessment of vegetation and soil characteristics in areas representative of each broad vegetation type identified. Survey sites consisted of a 100m² (10 m x 10 m) quadrat nested within the north west corner of a 400 m² (20 m x 20 m) quadrat (except for TL33-06, TL33-07 & TL33-08 for which is the SW corner to allow easier relocation). Wherever possible, quadrats were aligned north-south. Any variations from this orientation were noted. The common corner was marked with a permanent galvanised steel star picket with a stamped aluminium plate to identify the site number. The corners of the 100 m² quadrat were temporarily marked with galvanised fence droppers. The location of survey quadrats are shown in Map R1

The 100m² quadrats were established in the field using a triangulation method. The star picket in the north-west corner was positioned and then a compass and tape measure were used to place a fence dropper in the south-west corner of the 100m² quadrat. The measuring tape was then attached to the south-west peg and the location of the south-east peg was determined by positioning a peg at the 10m mark on the tape measure and then running the tape measure a further 14.14m (the hypotenuse of the triangle) back to the star picket. The south-east peg was then moved until the tape measure was taut. This method was rapid (approximately 5 minutes to establish the 100m² quadrat) and accurate. The use of a tape measure rather than a piece of string is recommended as string tends to stretch and knots in the string tend to move with use.

The 400m² quadrats were established by running a tape measure along the north-south axis of the 100m² quadrat to a distance of 20m, at which point flagging tape was used to indicate the south-west corner of the 400m² quadrat. This procedure was repeated for the north-east corner of the 400m² quadrat. The triangulation method was then used to locate the south-east corner of the 400m² quadrat (using a hypotenuse of 28.28m).

2.4.4 Physical Description

The following information was recorded on a standard data form at each survey site:

- quadrat number;
- reserve number;
- GPS location (WGS84);

- landform and soil profile information;
- vegetation structural formation, floristic association;
- evidence/no evidence of fire, and an estimate of the number of years since the most recent fire; and
- any other features of ecological relevance.

A colour photograph was taken of the site from the north west corner of the quadrat looking in a south easterly direction, showing the star picket in the foreground and the general appearance of vegetation at each site. Any variations in the direction the photo was taken were also noted.

Examples of the datasheets used are included in Appendix 8.

2.5 Vegetation & Floristic Sampling

All vegetation and soil data collected followed the methods of McDonald *et al.* (1998). This ensured that the data collected as part of this study is compatible with previous studies.

Data was collected through field assessment and recorded on standard data sheets (refer to Appendix 8). Data management is discussed below.

2.5.1 Floristics

All vascular plant species within or overhanging the 100 m² quadrat were identified and assigned a stratum (emergent, upper, middle, lower or ground stratum) and a percentage cover class (0-5%, 5-25%, 25-50%, 50-75%, 75-95% or 95-100%) for each stratum. All vascular plant species in the upper strata within a 400 m² quadrat were also recorded.

Plant nomenclature and taxon identification codes followed the MAX Collecting Book database produced by the Western Australian Herbarium.

Voucher specimens were collected for all dominant/co-dominant species surveyed within quadrats. Voucher specimens were only collected if fertile material (buds, flowers and fruit) were available or if positive identification could be made without fertile material. These have been lodged with the CALM Regional Herbarium at Narrogin. All species were identified at the WA Herbarium, with reference to collections and experts as required.

Where populations of Declared Rare or Priority Flora were subsequently identified from voucher specimens, their location was estimated using the GPS readings from the quadrat that the specimen originated from.

2.5.2 3.4.3.2. Vertical Structure

Data on vertical structure was recorded for each survey site according to the methodology and coding of McDonald *et al.* (1998). The growth form, average height and height class were recorded for each of the dominant / co-dominant species in the tallest stratum across the 400 m² quadrat. The same information was also recorded

for each of the dominant/co-dominant species in the remaining strata in the 100 m² quadrat.

2.5.3 3.4.3.3. Vegetation Cover

A transect was established that diagonally intersected both nested quadrats, with its origin in the north-west corner. This was used to assess the vegetation cover of the upper strata using the methodology of McDonald *et al.* (1998). Crown width and the distance between plant crowns were measured along the transect, as well as an estimate of the percentage of crown width occupied by epicormic regrowth, mistletoe or dead leaves and branches. A total of twelve measurements were taken although for some sites, large distances between plants in some strata (e.g. very scattered mallee in heath formations or sparse middle storey under woodlands) meant that it was not possible to take 12 measurements along the transect before intercepting another vegetation type or disturbed area such as an access track.

The following information was calculated using the methodology of McDonald *et al.* (1998):

- average crown width and gap;
- crown separation ratio;
- crown cover class; and
- percentage crown cover.

2.6 Soil and Landform Sampling

Information was collected on the soil profile, landform and soil chemistry at each survey site using the methods and coding of McDonald *et al.* (1998).

2.6.1 Landform Description

At each quadrat site, the following landform data were obtained:

- underlying geology;
- soil-landscape unit;
- surface coarse fragments (abundance, size and lithology);
- landform element, using the landform element glossary of McDonald *et al.* (1998);

2.6.2 Soil Profiles

Soil profiles were taken from a point adjacent to the common corner of both quadrats but outside the quadrats. The following soil profile information was recorded for each soil horizon to a total depth of 100 cm or hardpan:

- depth;
- moist colour (Munsell);
- field texture grade;
- boundary distinctness;
- coarse fragments;
- soil water regime (permeability and drainage);
- effervescence (carbonates): and
- pH

2.7 Mapping and Database Compilation

The following section describes the methods used in the preparation of vegetation association maps for reserves and adjoining road reserves.

2.7.1 Metadata

Each spatial dataset used had information on the following core metadata elements provided. These follow the ANZLIC metadata guidelines:

- title;
- custodian;
- description (abstract);
- date currency;
- access (stored data format);
- projection;
- datum;
- data quality (lineage, positional accuracy, attribute accuracy, completeness); and
- metadata date.

A brief written summary was provided for each dataset. The summary contained information about how it was created, any limitations, and any other information that will assist third parties to assess the dataset.

2.7.2 Data Storage and Database Structure

A Microsoft® Access 97® relational database was used as the prime means of storing all survey data and a single ESRI® ArcView® 3.2 project containing multiple themes was created as the main interface through which spatial data can be queried. Photos were stored digitally on Kodak® Photo CD®, and were hotlinked to relevant ESRI® ArcView® themes.

Survey data was entered into the database in the following tables:

- | | |
|----------------------------------|---|
| • Projects | (bibliographical information on project); |
| • Codes | (codes for all data recorded); |
| • Polygon Data | (identification numbers for each reserve); |
| • Quadrat Descriptions | (location and characteristics within quadrats); |
| • Vegetation Descriptions | (floristics and structure within quadrats); |
| • Crown Cover Data | (vegetation cover within quadrats); |
| • Soil Profile Data | (soil horizons within quadrats); |
| • Soils and Landform Data | (landform and soil within quadrats); |
| • Reserve Details | (soils and geology within reserves); |
| • DRF and Priority Flora | (significant flora recorded within reserves). |

Each table was linked via common fields, and each field in each table was linked to a separate Access table in which data codes were defined. The relationship between each table is shown in Figure 4.

The database was constructed as a normalised database, using codes rather than descriptions.

2.7.3 GIS Layers

Broad vegetation types (including degraded areas) have been provided as single ESRI® ArcView® 3.2 shapefiles (polygon themes). Each polygon was attributed with a unique polygon identifier, reserve number, land district, lot number, class/type/value, area (ha) and perimeter (m) value. All layers were projected in decimal degrees (4 decimal places). Quadrat locations were also included with this map.

Each occurrence of the same vegetation unit within a reserve was mapped as a separate polygon. For each vegetation polygon mapped, the following information was recorded:

- polygon number;
- reserve number;
- land district;
- location number;
- lot number;
- the area of the polygon (ha), and the percentage of the reserve's area the polygon occupies;
- for degraded or modified vegetation polygons - a name describing the unit in terms of the likely original vegetation and type of degradation;
- for all remaining vegetation polygons, a site identifier (quadrat number) and a vegetation name; and
- a brief comment, where appropriate.

3.0 Results and Discussion

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

3.1 Vegetation Mapping

3.1.1 Digitisation of Existing Vegetation Maps

The vegetation maps in *Biological Survey of the Western Australian Wheatbelt Part 2: Vegetation and Habitat of Bendering Reserve* (Muir, 1977a) and *Biological Survey of the Western Australian Wheatbelt Part 3 & 4 Vertebrate Fauna of Bendering & West Bendering Nature Reserves & Vegetation of West Bendering Nature Reserve* (Muir, 1977b) were digitised.

The boundaries of vegetation associations were only mapped by Muir (1977a and b) where they were distinct. As a result the vegetation maps produced by Muir (1977a and b) are not entirely compatible with the vegetation maps produced during the current 2003/2004 survey. The datasets produced in the current survey are stored as polygons rather than lines in Arcview® to allow the calculation of the areal extent of associations and production of thematic maps, and this requires that vegetation associations are fully enclosed by boundaries.

Attempts were made to match the linework to current aerial photos and to convert the lines in the maps produced by Muir (1977a and b) into polygons. This was fraught with difficulties because some of the linework could be matched to the aerial photomosaics in some areas, but the lines could not be matched to large areas without complicated morphing. This maybe due to how the map was produced, errors in the original linework and/or changes in the vegetation in the last 25 years.

Muir (1977a and b) does not provide details of the mapping process in terms of whether the linework is directly transposed from aerial photos or if alterations were made to mitigate parallax error in the photographs. Without this detail, intrinsic distortions in the map due to the methods employed can not be predetermined.

There is at least one apparent error in the linework, the alignment of Bendering Reserve Road is mapped differently on the northern and southern maps for Bendering Reserve. The northern map does not show a dogleg on the eastern end of the road but the southern map does show this road deviation. This does not mean that all the discrepancies between the linework and apparent boundaries visible in the aerial photomosaics is due to error as there may have been significant changes in the vegetation related to fires and differences in seral stages over a twenty year period.

The digitised maps were left unaltered after morphing for the best match to cadastral boundaries.

The interpretation and extrapolation of floristic lists produced in association with the vegetation maps by Muir (1977a and b) also should not be undertaken without re-

examination of at least some of the taxonomy, due to changes in botanical taxonomy in the last 25 years such as the division of species into more taxa, renaming of taxa and reclassification of taxa.

Further surveying would be required to re-interpret the maps by Muir (1977a and b) and make them fully compatible with the datasets produced using current techniques. Despite a level of incompatibility with more recent datasets, the maps produced by Muir (1977a and b), and the associated flora inventories, are useful references for work undertaken in the area.

3.1.2 Aerial Photograph Interpretation and Vegetation Delineation

At a scale of 1:250 000, Beard (1980) only found it possible to accurately map categories that produced pronounced photo patterns (e.g. rock outcrops, woodland relative to shrublands, salt flats and lakes) and difficult, or impossible, to distinguish types of shrublands. These difficulties are also encountered in mapping vegetation associations a scale of 1:25 000. It was only at below this scale (1:10 000) Muir (1977a) could distinguish between heathlands and shrublands.

Several reserves had distinctive topography, such as Karlgarin Nature Reserve, and this tended to result in more vegetation associations being mapped at such sites as the vegetation boundaries were more distinctive. Muir (1977a) observed similar issues in noting that whilst Bendering Reserve had 'fairly well defined' associations, West Bendering had extremely complex vegetation mosaics.

More vegetation associations were observed than were mapped during this project. Some of these could be mapped at a larger scale, while the boundaries of others could not be defined as vegetation associations graded into each other. Muir (1977a) dealt with the issue of boundaries varying from abrupt to undetectable by classifying boundaries as:

- Abrupt (less than 60 m wide);
- Clearly defined but not abrupt (60 – 120 m wide);
- 'Fairly well defined' but exceeding 120 m; and
- No discernible boundary.

Given this approach, Muir (1977a) did not always provide boundaries on all sides of a vegetation association, however this method was not appropriate for this project, given that the vegetation association were to be mapped as closed polygons within Arcview™ GIS.

3.1.3 Inferred Vegetation Descriptions

Vegetation communities were mapped on the basis of aerial photo interpretation, in conjunction with groundtruthing. The descriptions for the communities are derived or inferred from the vegetation sampling at one or more reference sites within the communities.

The reference sites that were established during the survey were standard 10 x 10 m quadrats. The use of such small sites to represent extensive communities requires the careful placement of quadrats to ensure they provide representative floristic and structural descriptions and this may require quadrats be established at an atypical 10 x 10 m site (e.g. in a woodland with a very sparse understorey, very few species would be recorded unless a site where a number of species co-occur is specifically chosen and then consideration needs

to be given to whether such a site is also representative in terms of plant density). Larger quadrats would reduce the amount of deliberation required for the placement of quadrats and consequently reduce bias between different surveyors, although this would also make the establishment of the quadrats more cumbersome in dense vegetation communities.

Although vegetation descriptions at points (within quadrats) are intended to be representative of extensive vegetation communities, the community descriptions are not identical to quadrat descriptions. The reasons for this are that:

- even adjacent quadrats would not necessarily yield identical descriptions;
- sites may be at different successional stages due to different disturbance regimes (e.g. fire), with understorey and heaths taking 6-10 years to climax and shrublands formations probably requiring at least 15-20 years (Muir, 1977a); and
- quadrats were located to sample variation and dissimilarity within remnants and within vegetation communities and at a scale of 1:25 000 for aerial interpretation vegetation formations such as heathlands and shrublands can not be distinguished (Muir, 1977a). Whilst quadrats TL33-19 and TL33.26 both have *Allocasuarina huegeliana* as the dominant overstorey species they are considered to occur in different vegetation associations on the basis of the broader context.

3.2 Vegetation Description

3.2.1 Overview of Vegetation System

The study area is situated at the western edge of the Hyden System of the Roe Botanical District. This landscape is very gently undulating with wide flat valleys and long gentle slopes rising to broad laterite ridges. The laterite rarely has definite edges such as breakaways exacerbating the problems of determining boundaries within the vegetation mosaics. (Beard, 1980)

Within the Hyden System Beard (1980) described the general vegetation pattern as consisting of:

- Kwongan (heath and thicket) on sand plains;
- Mallee on slopes;
- Mallee with patches of woodland on upper valley slopes;
- Woodland on lower valley soils; and
- a mosaic of woodland, shrubland and samphire in saline areas.

This catena was evident within the study area. In addition, the vegetation could be stratified on the basis of the influence of soil and geology as being sandy laterite, granite and wetland areas. On this basis the vegetation could be grouped as:

1. Locations 27519, Roe N.R. and the northern portion of Scriveners N.R. as sandy laterite (which supports shrub mallee and heath);
2. Reserve 2366, Kondinin N.R., parts of Gounter and the southern portion of Kargarin N.R. as Wetland systems (which supports woodland and herbs); and
3. Biglin, southern Scrivener, Camel Peaks, parts of Gounter, Toy Hill as Granite (which supports shrub mallee and heath).

3.2.2 Extent of Vegetation Formations

The extent of the vegetation formations in the study area are shown in Table 3.2.

Table 3.2 Extent of Vegetation Formations

Formations	Area (hectares)	Percentage
Cleared	16.8	0.2
Heath - Allocasuarina	463.2	4.4
Heath - Banksia	257.4	2.4
Heath - Melaleuca	1778.0	16.9
Lithic	111.6	1.1
Mallee - Eucalyptus	3237.0	30.8
Shrubland - Allocasuarina	384.9	3.7
Shrubland - Melaleuca	172.8	1.6
Shrubland - Xylomelum	88.9	0.8
Waterbody	2737.0	26.0
Woodland - Acacia	31.4	0.3
Woodland - Allocasuarina	39.7	0.4
Woodland - Casuarina	2.2	0.0
Woodland - Eucalyptus	1196.8	11.4
Total	10517.8	100.0

The distribution of the formations is shown in Map R2.

The formations mapped during this project are compared to the Pre-European Vegetation Map produced by Hopkins, Beeston and Harvey (2000), on the basis of earlier work by J.S. Beard from 1969-1984, in Map R3. While exact matches of linework are not expected, due to the Beard mapping at a scale of 1:250 000 compared to 1:25 000, a general agreement should be expected and this is the case.

3.2.3 Extent of Vegetation Associations

McDonald *et. al.* (1998) state that: a vegetation association is based on the vegetation structure and floristics; and that '[a]n association can be named using several criteria, for example dominant species, indicator species or species combinations.' Indicative species in combination with the formation type was used as the basis for associations in this project. The overstorey species and the vegetation formation recorded at each quadrat is listed in Appendix 5.

The extent of the vegetation associations recorded during this survey is shown in Table 3.3.

Table 3.3 Extent of Vegetation Associations

Association	Area (hectares)	Percent of study area
Acacia acuminata Low Forest	31.4	0.3
Allocasuarina acutivalvis Shrubland	375.8	3.6
Allocasuarina campestris Heath/Shrubland	463.2	4.4
Allocasuarina huegeliana Forest	39.7	0.4
Allocasuarina acutivalvis / Banksia sphaerocarpa Shrubland	9.1	0.1
Banksia / Dryandra Heath	257.4	2.4
Bare	4.4	0.0
Casuarina obesa / Callitris tuberculata Woodland	2.2	0.0
Eucalyptus alipes Shrub Mallee	162.0	1.5
Eucalyptus extensa Forest	1.4	0.0
Eucalyptus horistes Shrub Mallee	567.6	5.4
Eucalyptus longicornis / E. kondininensis / E. extensa Woodland	38.6	0.4
Eucalyptus longicornis / Eucalyptus myriadena Woodland	498.5	4.7
Eucalyptus longicornis Woodland	14.4	0.1
Eucalyptus loxophleba ssp gratiae Shrub Mallee	254.5	2.4
Eucalyptus loxophleba ssp lissophloia Shrub Mallee	75.4	0.7
Eucalyptus melanoxylon Woodland	271.6	2.6
Eucalyptus myriadena / Eucalyptus alipes Shrub Mallee	13.1	0.1
Eucalyptus myriadena Open Low Woodland	5.3	0.1
Eucalyptus myriadena Woodland	48.7	0.5
Eucalyptus olivina Shrub Mallee	1.3	0.0
Eucalyptus ornata Low Forest	29.6	0.3
Eucalyptus salicola Woodland	4.7	0.0
Eucalyptus salmonophloia Woodland	36.2	0.3
Eucalyptus salubris / Eucalyptus kondininensis Woodland	20.3	0.2
Eucalyptus salubris / Eucalyptus myriadena Woodland	22.7	0.2
Eucalyptus salubris Woodland	162.9	1.5
Eucalyptus salubris Woodland - Modified	17.4	0.2
Eucalyptus urna Woodland	18.0	0.2
Eucalyptus urna Woodland over Shrub Mallee	6.4	0.1
Granite	111.6	1.1
Gravel Pit – Active	2.7	0.0
Gravel Pit – Inactive	9.6	0.1
Melaleuca thyoides Heath - degraded	3.0	0.0
Mixed Melaleuca Dense Heath/Shrubland	172.8	1.6
Mixed Melaleuca Heath/Shrubland	677.5	6.4
Mixed Melaleuca Heath/Shrubland - degraded	1097.5	10.4
Mixed Shrub Mallee	2153.5	20.5
Mixed Shrub Mallee - Modified	9.5	0.1
Rubbish Tip - Active	1.7	0.0
Rubbish Tip - Inactive	2.8	0.0
Salt Lake	2732.6	26.0
Xylomelum angustifolium Shrubland	81.3	0.8
Xylomelum angustifolium / Allocasuarina acutivalvis Shrubland	7.6	0.1

Total	10517.8	100.0
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The understorey in the mallee systems varied from none to a Heath B of Melaleuca. At any site a pattern in terms of understorey could be discerned, such as an increase in understorey as elevation decreased, but there was no consistent pattern across all sites. There was great difficulty in discerning ecotones within the mallee systems given the gentle topography and relatively consistent structure, and this has resulted in relatively few vegetation associations being mapped in Location 27519 and Roe Nature Reserve in comparison to Karlgarin and Toy Hill Nature Reserves.

The Sheoak Heath on granite often intergraded with mallee and Jam (*Acacia acuminata*) stands at a very fine scale under the influence of very small and localised changes in soil and therefore these associations were mapped on the basis of the dominant species in each area.

Salmon Gum (*Eucalyptus salmonophloia*) was widespread in the Wheatbelt and Goldfields, though it has largely been cleared in the Wheatbelt as it tends to occur on good agricultural soils on red, sandy loam (which is sometimes gravelly) in flat or slightly sloping country. It often forms pure stands but also frequently associates with Gimlet (*E. salubris*) as well as Red Morrel (*E. longicornis*), Redwood (*E. transcontinentalis*), York Gum (*E. loxophleba*) and Old Man Saltbush (*Atriplex nummularia*).

Black Morrel (*E. melanoxydon*) is the dominant species on the southern portion of Karlgarin Nature Reserve, on the interface with the wetland system further to the south. Gimlet (*E. salubris*) also occurs as pure stands on the upper slopes within this community, and these have been mapped separately.

There is a strong relationship between vegetation associations and landform and soil. Examples of this are:

- Tamma (*Allocasuarina campestris*) Heath tending to occur in areas where there is abundant granite at or near the surface, as do Jam / York Gum Woodlands;
- Black Tamma (*Allocasuarina acutivalvis*) Shrublands tending to occur in sand where there is a water impediment;
- Gimlet and Salmon Gum Woodlands tending to occur in duplex soils and where there is a break in slope;
- Mixed Shrub Mallee occurring in sand on broad slopes.

3.2.4 Significance of Vegetation Associations

No Threatened Ecological Communities were identified in the study area.

The significance of the vegetation associations that were identified needs to be determined on the basis of the extent and distribution of the associations, and the abundance and distribution of the dominant / indicator species. The extents of the vegetation associations mapped within the study area are shown above in Table 3.3. The distributions of associations and dominant / indicator species are considered below.

All specimens of *Eucalyptus myriadena* collected were confirmed as *Eucalyptus myriadena* ssp *parviflora*. This is a Priority 1 taxon and therefore this association should be considered

significant, although the Conservation Code for this taxon may be revised if further populations are located.

The *Eucalyptus ornata* Woodland is significant because it is limited in extent and distribution within the study area. This association was only located within two reserves and given that Brooker and Kleinig (2001) identify Silver Mallet (*Eucalyptus ornata*) as having a limited distribution that is restricted to the east and north-east of Kondinin, this association would also be expected to also be highly restricted at a regional scale.

The *Eucalyptus ornata* Woodlands superficially appear similar to the *Eucalyptus urna* Low Woodland due to the similarity in the dominant overstorey species. *Eucalyptus urna* Low Woodland and *Eucalyptus urna* Low Woodland over *Eucalyptus urna* Shrub Mallee associations may represent the same community at different seral stages.

The *Eucalyptus salmonophloia* Woodland is limited in extent but is distributed across a number of sites. The remaining stands of Salmon Gum are significant due to the large-scale clearing of this association, that has occurred as a result of it occurring on soils that are highly suited to agriculture.

Almost all of the Banksia / Dryandra Heath are contained on Roe Nature Reserve (Reserve 20339), with a very small area on the north-east side of Scriveners Nature Reserve (17662). The Sheoak Shrubland on the northern boundary of Camel Peaks also had some elements of this Banksia / Dryandra Heath. The Banksia / Dryandra Heath appeared to be the most floristically diverse of all the associations but the total number of species in each quadrat was not recorded. As a result there is no basis for the quantitative comparison of species diversity between vegetation associations. In future surveys, the number of species in each quadrat could be estimated or counted to provide a more precise indicator of relative species richness between vegetation associations and the degree to which floristics is being under sampled.

There were also a Banksia / Dryandra Heath in the Kondinin Saltmarsh, and whilst superficially similar to the heath on Roe Nature Reserve did have some differences in the species present.

There were a number of associations that were restricted in extent and distribution within the study area but the dominant/indicative plants of the associations are widely distributed within the study area. These associations are therefore of limited significance. These include the:

- *Acacia acuminata* Woodland;
- *Allocasuarina huegeliana* Woodland;
- *Eucalyptus longicornis* Woodland;
- *Eucalyptus melanoxydon* Woodland; and
- *Eucalyptus salicola* Woodland.

Associations that were restricted in extent and distribution within the study area but with dominant/indicative plants that are widely distributed in Western Australia include:

- *Casuarina obesa*, *Callitris tuberculata* Woodland;
- *Eucalyptus horistes* Shrub Mallee;
- *Eucalyptus extensa* Forest;

- *Eucalyptus olivina* Shrub Mallee;
- *Eucalyptus urna* Woodland; and
- *Melaleuca thyoides* Heath (which was entirely degraded);

It is worth noting that Camel Peaks Reserve (which is not part of the conservation estate) and the contiguous bushland on private property support a number of vegetation associations that are restricted in their extent in the study area (including Rock Oak Woodland, Salmon Gum Woodland and Banksia / Dryandra Heath).

3.3 Floristics

3.3.1 Overview

The flora of the West Australian agricultural zone is highly diverse, it is estimated to support in the order of 4 500 vascular plant species, of which over 60% are endemic to the area (Keighery, 2003).

The survey only recorded up to the five dominant species in each strata for up to five strata at each site, however this still resulted in 163 taxa being recorded in the study area as 352 records in 32 quadrats. Opportunistic records were made of a further 50 taxa within the study area. Previously, Muir (1977a) recorded 187 species in West Bendering Reserve and 288 in Bendering Reserve, with a total of 350 species.

Some of the eucalypts listed as present in Bendering and North Karlgarin Nature Reserves were not recorded in the site reconnaissance. This may in part be due to:

- undersampling;
- no breakaways being sampled and
- Bendering and North Karlgarin Nature Reserves being closer to the Avon / Roe Botanical District interface.

No breakaways were sampled although some were observed just outside the remnants being surveyed and there appears to be a small breakaway visible from the northern perimeter firebreak of Roe Nature Reserve and one may also be present in the central portion of the Location 27519 towards the western end.

The species recorded in the study area are listed in Appendix 1 and the number of quadrats each species was recorded in is listed in Appendix 2.

Melaleuca and *Eucalyptus* species are the dominant genera are in the area as is evident in Table 3.4, below.

Table 3.4 The Most Diverse and Abundant Genera in Quadrats

Genera	Number of Taxa	Number of Occurrences
<i>Melaleuca</i>	16	35
<i>Eucalyptus</i>	14	35
<i>Hakea</i>	6	13
<i>Acacia</i>	9	22
<i>Allocasuarina</i>	6	19

The number of times each taxa was recorded as a dominant in a strata is listed in 2. The 10 most commonly occurring dominant species are listed in Table 3.5, below.

Table 3.5 The 10 Most Common Taxa Recorded

Taxa	Number of Records
<i>Allocasuarina campestris</i>	8
<i>Melaleuca cordata</i>	7
<i>Allocasuarina acutivalvis</i>	6
<i>Eucalyptus salubris</i>	6
<i>Hakea sulcata</i>	6
<i>Phebalium tuberosum</i>	6
<i>Acacia erinacea</i>	5
<i>Beaufortia interstans</i>	5
<i>Lomandra effusa</i>	5
<i>Platysace maxwellii</i>	5

Of the 163 taxa, 63 taxa were only recorded at 1 site. As shown in Figure 3.1, 78% of species occurred in 5 or less sites and more than 88% of species were recorded in 10 or less sites.

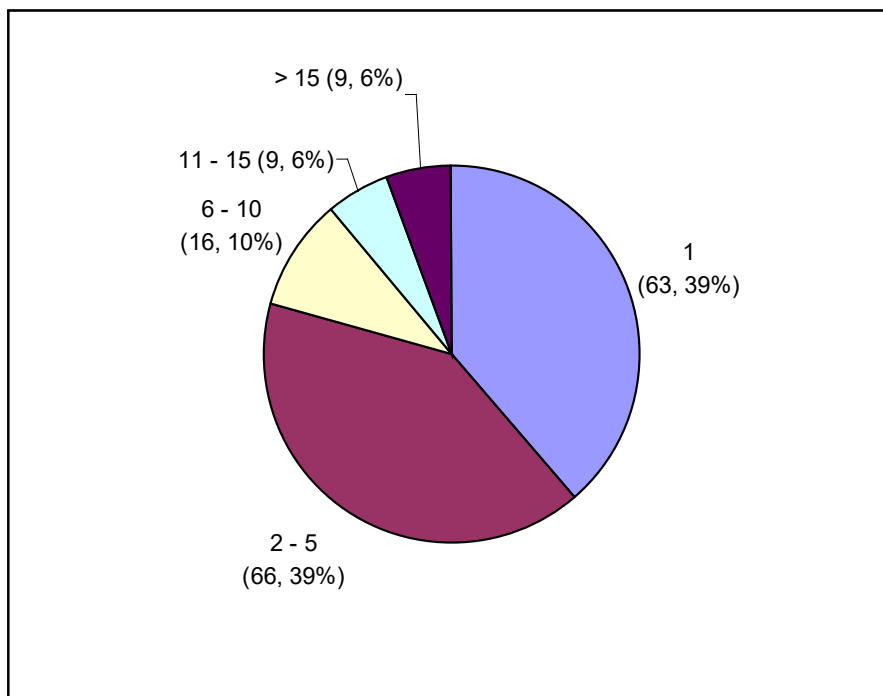


Figure 3.1 Number of Quadrats each Taxa was Recorded In

The number of times each species should be interpreted with caution given the low number of quadrats, and their distribution is biased in terms of vegetation associations, landscape units and geographic location.

In accordance with the attribute requirements for describing vegetation at sub-association level, up to 5 species in up to 5 strata were recorded. Therefore all species in a 10 x 10 m

quadrat were not necessarily recorded (especially in species rich communities with most species concentrated in relatively few strata such as some heath and mallee communities). It may be useful in similar projects to record the total number of species in each quadrat to gain an insight into the relative species richness between vegetation communities and the degree to which floristics is being under sampled.

3.3.2 Priority and Declared Rare Flora

Previously recorded Priority and Declared Rare Flora populations were not re-recorded during this project. New populations of *Grevillea asteriscosa* (P4) were recorded on the western firebreak of Scriveners Nature Reserve (against Roe Location 2172) and the southern firebreak of Lot #2 diagram 77125. The location of these is shown in Map R4a. A voucher specimen was collected of the *Grevillea asteriscosa* lodged with the Conservation Officer (Rare Flora) at CALM Narrogin along with a Rare Flora Report Form.

New populations of *Eucalyptus myriadena* subsp. *parviflora* (P1) were recorded at numerous sites within the Kondinin Saltmarsh and at quadrat TL33-16 at Toy Hill.

Eucalyptus myriadena subspecies *parviflora* (P1) and *Eucalyptus myriadena* subspecies *myriadena* are differentiated on the basis of a small difference in fruit size. The difference is:

- *Eucalyptus myriadena* subsp. *arviflora* (P1) has smaller fruits (0.2 - 0.3 mm wide) and buds 0.3 - 0.15 mm; and
- *Eucalyptus myriadena* subsp. *myriadena* has larger fruits (0.3 - 0.4mm wide).

Eucalyptus myriadena subsp. *parviflora* (P1) appears to be abundant within the Kondinin Salt Marsh. Given the small diagnostic difference between the two subspecies, specimens were collected at numerous locations and all specimens collected have been supplied to Flora Conservation Officer at CALM Narrogin along with a Rare Flora Report Form. The sites from which samples were collected are shown in Map R4b. The GPS co-ordinates for the specimens are shown in Table 3.6.

Table 3.6 Collection sites for *Eucalyptus myriadena* subsp. *parviflora* specimens

Northing	Easting	Specimen ID Number	Collection Date / Time
6393163	634252	011	24-MAY-04 23:57
6392905	632708	014	25-MAY-04 01:04
6395582	631715	048	25-MAY-04 05:01
6395051	631587	051	25-MAY-04 05:19
6394720	631241	065	25-MAY-04 06:19
6395313	631334	084	25-MAY-04 06:49
6394562	632169	093	25-MAY-04 07:31
6394236	627920	137	26-MAY-04 02:07
6394415	627214	149	26-MAY-04 02:42
6393722	626678	156	26-MAY-04 03:08
6393906	626235	158	26-MAY-04 03:42

3.3.3 Undescribed Flora

The following specimens have been lodged with the West Australian Herbarium as they are undescribed new species currently under study.

- *Tetralochea aff. virgata* 213 (sp. Nov Ryonen Butcher)
- *Melaleuca aff. manglesii* 113 (Mike Hislop)
- *Baekkea sp.* 187 (sp. N2ov Malcolm Trudgen)

3.3.4 Range Extensions for Flora

Isopogon ?polycephalus (specimen field number 106) can not be confirmed without flowers doesn't match other *Isopogons* previously recorded in area. If the determination is correct then this is a range extension for a species predominately occurring on the Esperance Plains.

3.3.5 Indeterminate Flora

The following specimens could not be fully determined, mostly due to an inability to source fertile specimens in the immediate vicinity of quadrats:

- *Melaleuca scalena/hamata* groups (specimen field numbers 380, 78, 205, 217) due to the circumscription of *Melaleuca uncinata/scalena/hamata* being currently under review;
- *Phebalium ?megaphyllum* (specimen field number 66) due to specimen being sterile and *Phebalium* species hybridising in the area;
- *Isopogon ?polycephalus* (specimen field number 106) as this doesn't match other *Isopogons* previously recorded in area. If the determination is correct then this is a range extension but can not be determined without flowers;
- *Persoonia ?striata* (specimen field number 123) as fertile specimen could not be sourced;
- *Lepidosperma* species (specimen field number 227)
- *Dryandra* species (specimen field number 115) as fertile specimen could not be sourced;
- *?Daviesia benthamii* (specimen field number 354) as fertile specimen could not be sourced;
- *?Goodenia incana* (specimen field number 373) as fertile specimen could not be sourced; 373 sterile. Could be a number of taxa but this one seems most likely; and
- *Hibbertia ?exasperata* (specimen field number 97) could not be resolved despite consulting Judy Wheeler's current draft key for *Hibbertia*.

3.3.6 Miscellaneous Flora Observations

Allocasuarina pinaster was only sighted within the surveyed area on the elevated sand plain in the north-east corner of Roe Nature Reserve and was a conspicuous feature of the roadside vegetation to the north along Roe Road and Billericay Road East. This species is a conspicuous element of the Hyden System (Beard, 1980).

Eucalyptus burracoppinensis was most prolific at Location 27519, but stands also exist at the western end of the southern boundary of Roe Nature Reserve; on the western side of Scrivener Nature Reserve; and on the western side of Camel Peaks Reserve. This species is also present in the nearby Bending Reserve which is outside the study area, but almost

absent in West Bending Reserve (Muir, 1977a). Muir (1977a) speculated that *Eucalyptus burracoppinensis* associations occur exclusively on acid gradational soil profiles and on soil types generally unsuitable for other mallees. Muir (1977a) also noted that *Eucalyptus burracoppinensis* dominated mallee formations have about 5 times as many plant species as other mallee formations. Beard (1980) stated that *E. burracoppinensis* is more typical of the Muntadgin System which lies to the north and east of the study area in the Avon Botanical District however Beard (1980) also suggested its boundary should be extended further south towards the study area.

The following opportunistic observations were made of taxa that were not recorded in quadrats and only noted once within the study area:

- *Leptosema daviesioides* at Biglin Nature Reserve;
- *Casuarina obesa* in and around one lake within Kondinin Saltmarsh Nature Reserve; and
- *Labichea lanceolata* subsp. *lanceolata* around the periphery of the granite outcrop at Camel Peaks;
- *Hakea petiolaris* around the large southern-facing granite outcrop near Quadrat TL33-30 in Kalgarin Nature Reserve; and
- The mallee *Eucalyptus annulata* on private property on the northern-western side of Reserve 23366.

This is not to say any of these species are rare, just that they appear to be uncommon within the study area.

Eucalyptus extensa was noted twice, once in TL33-16 at Toy Hill and on Cunningham Hill in Scriveners Nature Reserve. *Eucalyptus celastroides* subsp. *celastroides* was noted as very small stands along the northern boundary firebreak in the central portion of Kondinin Saltmarsh but did not cover sufficient areas to be mapped as its own vegetation association.

3.4 Vegetation Condition

Most of the area surveyed was not considered modified or degraded. As is shown in Table 3.7 salinisation is the most extensive form of degradation or modification in the study area.

Table 3.7 Extent of Types of Degradation and Modification

Degrading / Modifying Process	Area (ha)	Percentage
Clearing	9.5	0.1
Fire	17.4	0.2
Gravel Pit	10.2	0.1
None	9375.6	89.1
Rubbish Tip	4.5	0.0
Salinity	1100.5	10.5
Total	10517.8	100.0

The distribution of these forms of modification and degradation are shown in Map R5. A brief discussion of these degrading and modifying processes is given below.

3.4.1 Salinity / Waterlogging

The Thicket / Heath A of *Melaleuca* once formed a sizable association along the fringes of the saltlakes but this is now largely degraded and is evident only as the dead trunks over a strata of Herbs (consisting of Chenopods) as is shown in Plates 3.1 and 3.2.



Plate 3.1 *Melaleuca* Shrubland that has been degraded by salinity for some time



Plate 3.2 *Melaleuca* Shrubland that has been more recently degraded by salinity

These could be mapped as degraded Shrubland/Heath (with the overstorey dead) or as a Herb Association (with the overstorey absent). They have been mapped as degraded Shrubland/Heath.

Approximately 56% of the Mixed Melaleuca Dense Shrubland/Heath and Melaleuca Shrubland/Heath has been mapped as degraded.

3.4.2 Weeds

The extent of weed infestations is shown in Table 3.8.

Table 3.8 Extent of Weed Cover Classes in Smaller Remnants (2003 Survey)

Weed Cover	Area (ha)	Percentage
80 - 100%	0	0
50 - 80%	13	< 1
20 - 50%	4	< 1
< 20%	10501	100
Total	10518	100

The majority of the study has very few weeds, with weeds mainly occurring along drainage lines. There were no infestations of serious environmental weeds (*Ehrharta calycina*, *Watsonia* spp., *Freesia* spp., *Asparagus asparagoides*, *Acacia pycnantha*, *Lupinus cosentinii*, *Eragrostis curvula*, *Sparaxis bulbifera* and *Homeria flaccida*) noted during the survey.

The most intensive weed infestations were in the drainage lines on the northern boundary of the portion of Avon Location 27519 west of Government Dam Road. The annual grasses contribute significantly to the fuel load at this site.

3.4.3 Timber Cutting

There was evidence of timber cutting in the woodlands at:

- the northern and southern boundaries of Scriveners Nature Reserve;
- the northern side of Toy Hill Reserve; and
- several small sites in the Kondinin Saltmarsh.

At all the sites the timber cutting had occurred some time ago (more than 10 years) and the structure of the vegetation now appears largely intact.

3.4.4 Artificial Drains

Artificial drains were observed at Camel Peaks (Res. 23164) and Lake Gounter Nature Reserve (Res. 21253) however only drains constructed before 1999, when the base aerial photography was taken were mapped.

The drains at Camel Peaks (shown in Plate 3.3) consist of approximately 800 m of natural drainage lines that have been graded or bladed. These supply the adjacent farmer with water collected from the Granite outcrops.



Plate 3.3 Drain at Camel Peaks (↑23164)

A drain approximately 1270 m long flowing into the southern end of Lake Gounter Nature Reserve (↑21253) was mapped. Since 1999 this drain has been extended into Lake Gounter itself and an additional drain has been constructed carrying water into the eastern end of the reserve. Both drains carry water from farmland and transport it directly into Lake Gounter to the north.

There are also natural drainage lines that carry from farmland into reserves. These were noted on the northern boundary of Lake Gounter Nature Reserve and the Kondinin Saltmarsh.

3.4.5 Rubbish Dumps

Rubbish dumps are present on the southern boundaries of Reserve 22579 and Nature Reserve 21253. The rubbish dump at Nature Reserve 21253 has been fenced and the portion of the rubbish dump that incurred into the Nature Reserve is being rehabilitated. The Shire rubbish dump at the southern end of Reserve 22579 appears, from aerial photographs, to be largely located outside the reserve but encroaching into it. However there is no clear distinction onsite as to the reserve boundary or the extent of the rubbish dump.

There were several very small, old rubbish dumps in the Kondinin Saltmarsh.

3.4.6 Gravel Pits

An active gravel pit was on the north-western corner of Camel Peaks and the northern edge of Location 27519. A number of inactive gravel pits were also mapped and these are in varying stages of regrowth and rehabilitation.

3.4.7 Recreation Sites

A seasonally utilised recreation site was present on the north-western shores of the lake in Reserve 22579. This site appears to be used for swimming and waterskiing, though it did not appear to have been used to any extent recently.



Plate 3.4 Recreation Site at Reserve 22579

3.5 Tracks

A total of 88 km of tracks were mapped, of which 0.5 km was overgrown. The overgrown tracks are in Location 27519.

The track in Scriveners Nature Reserve is being encroached upon from the sides by Sheaks and a large Salmon Gum has fallen across it.

3.6 Fencing

The extent and condition of fencing is shown in Table 3.9.

Table 3.9 Extent and Condition of Fencing

Fence Condition	Length (km)	Percentage
Good (Stock-proof)	92	45
Poor (Not stock-proof)	23	12
Absent	88	43
Total	203	100

The distribution of fences is shown in Map R6.

A significant portion of the remnant perimeters are not fenced. This is predominately the case where roads border the remnants or where bushland is contiguous with the remnants.

There are also portions of the reserves that abut bushland on private land, where the bushland on private property is fenced but there is no fence on the reserve boundary itself. This is the case for the southern boundary of Reserve 23366 and the western portion of the northern boundary of the Kondinin Saltmarsh.

4.0 Fauna

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

4.1 Introduction

Fauna observations were made opportunistically and only significant observations were recorded. During the project only Mallee Fowl observations have been recorded.

4.2 Malleefowl Sightings

Four Malleefowl (*Leipoa ocellata*) nests such as the one shown in Plate 4.1 were sighted. These were in Location 27519 and Scriveners Nature Reserve.



Plate 4.1 Malleefowl nest adjacent to Firebreak in Scriveners Nature Reserve

None of the nests were active but five sightings of Malleefowl were also made. These were at North Karlgarin Nature Reserve, Roe Nature Reserve and Scriveners Nature Reserve. The locations of these observations are listed in Table 4.1.

Table 4.1 Co-ordinates of Malleefowl Sightings

Easting	Northing	Observation	Date
661995	6412064	Nest	08/10/03
661678	6414270	Sighting	08/10/03
661908	6414267	Sighting	08/10/03
662024	6414269	Sighting	08/10/03
662650	6412464	Sighting	08/10/03
659888	6413564	Sighting	04/11/03
657660	6421794	Sighting	03/10/03
637458	6416243	Sighting	03/10/03
643141	6412342	Nest	09/08/03
643267	6412324	Nest	09/08/03

The locations of these observations are shown in Map R7 and Threatened Fauna Report Forms have been submitted to CALM, Narrogin.

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

The relationship between landform, soils and vegetation is evident in the study area, and it has previously been noted by:

- Muir (1977a) who observed that most woodlands tend to have B horizons of clays, decayed granite or laterite and occur on low-lying areas near watercourses or on water gaining sites near lithic complexes; and
- Chippendale (1973) who observed that Gimlet (*E. salubris*) occurs in sandy loam to clayey soils on flat or slightly sloping country and in depressions, Gimlet-Merrit Woodlands occur where the A horizon consists of heavy clays rather than sand and Kondinin Blackbutt (*E. kondininensis*) occurs in loamy soils, and Red Morrel is often found in loam or clay loam on flat country which often has calcareous subsoil.

The vegetation, morphology and soil characteristics at each quadrat are listed in Appendix 7. The relationship between landform and vegetation is at least partly obscured by:

- the fact that landform influences vegetation at different scales but the landform element is measured only at the level of the immediate surrounds of the quadrat; and
- The broad gentle undulations in the landscape obscuring the distinction between morphological types.

There is a strong relationship between vegetation associations and landform and soil. Examples of this are:

- Tamma (*Allocasuarina campestris*) Heath tending to occur in areas where there is abundant granite at or near the surface, as do Jam / York Gum Woodlands;
- Black Tamma (*Allocasuarina acutivalvis*) Shrublands tending to occur in sand where there is a water impediment;
- Gimlet and Salmon Gum Woodlands tending to occur in duplex soils and where there is a break in slope;
- Mixed Shrub Mallee occurring in sand on broad slopes.

It was observed that whilst there was little difference between the structure of vegetation with underlying granite and laterite distinct floristic differences were apparent. The lateritic sites were more floristically diverse and supported a number of species not observed around granite such as *Callitris canescens*, *Callitris roei*, *Allocasuarina microstachya* and *Allocasuarina corniculata*.

Mallee species also varied between granitic and lateritic sites. Some of the mallee species, such as *Eucalyptus loxophleba* subsp *gratiae*, tended to occur on granite, whilst others generally occurred on sand such as *Eucalyptus subangusta* subsp *subangusta*.

6.0 Supplementary Datasets

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

6.1 Relevant Publications

6.1.1 Introduction

At least three other datasets are available that are directly relevant to the study, although some manipulation would be required to obtain the degree of compatibility necessary for comparison. These are:

- Reference Soils of South-Western Australia,
- Salinity Plan Reference Sites, and
- Biological Survey of the Western Australian Wheatbelt Part 2: Vegetation and Habitat of Bendering Reserve.

The location of the references sites in these datasets is shown in Map R8.

6.1.2 Reference Soils of South-Western Australia (McArthur, 1991)

There are five soil and vegetation descriptions of direct relevance due to their proximity to the study area; four Reference Soil Sites established in Bendering Nature Reserve and one Site established adjacent to the Kondinin townsite. The height of the plants were not recorded in classes used in the Muir classification, therefore the Muir descriptions are approximate.

KON 1

Soil (Great Soil Group)

Red Calcareous Soil

Comments

Windblown material from nearby Salt Lakes

Vegetation (Muir Classification)

Eucalyptus longicornis Low Woodland A over

Exocarpos aphyllus, *Santalum acuminatum* and *Templetonia sulcata* Open Low Scrub B over *Scaevola sp.* *Atriplex paludosa* and *Templetonia sulcata* Open Dwarf Scrub C over *Austrostipa elegantissima*, *Enchylaena tomentosa*, *Maireana sp.* *Ptilotus sp.* and many *Asteraceae* Open Herbs

KON 2

Soil (Great Soil Group)

Red Duplex Soil

Comments

Mottled zone formed from granite, near laterite residual

Vegetation (Muir Classification)

Eucalyptus eremophila and *Eucalyptus pileata* Low Forest A over

Allocasuarina campestris Scrub over

Melaleuca hamulosa, *Templetonia sulcata*, *Gastrolobium crassifolium* Low Scrub A over occasional *Olearia muelleri*, *Wilsonia humilis* and occasional *Lomandra effusa*, *Austrostipa variabilis* and *Spartochloa scirpoidea*

KON 3

Soil (Great Soil Group)

Red Duplex Soil

Comments

Freshly weathered granite

Vegetation (Muir Classification)

Eucalyptus loxophleba Open Low Woodland A over*Waitzia acuminata*, *Thysanotus* sp., *Vulpia myuros*, *Stackhousia* sp., *Stipa variabilis*, *Borya Nitida*, many *Asteraceae*, *Orchids*, *Neurachne alopecuroidea* Dense Herbs

KON 4

Soil (Great Soil Group)

Yellow Duplex Soil

Comments

Pediment

Vegetation (Muir Classification)

Eucalyptus salubris Low Forest A overOccasional *Exocarpos aphyllus*, *Olearia muelleri*, *Templetonia sulcata*.

KON 5

Soil (Great Soil Group)

Red Clay

Comments

Weathered Dolerite on lower pediment slope

Vegetation (Muir Classification)

Eucalyptus salmonophloia Low Woodland A over*Melaleuca acuminata*, *Melaleuca pauperiflora*, *Dodonaea amblyophylla* Scrub over
Occasional *Acacia erinacea* and *Acacia brachyclada*

6.1.3 Salinity Action Plan Reference Sites (CALM, in press)

There are 18 Salinity Action Plan (SAP) Reference Sites in the study area. These are based on 10 x 10 m quadrats in which all species are recorded, but the height of all the species has not been recorded.

6.1.4 Biological Survey of the Western Australian Wheatbelt Part 2, 3 & 4 (Muir, 1977a & b)

There were 314 reference sites established in 1977 in Bending and West Bending Nature Reserves. These recorded vegetation and basic soil descriptions based upon a composite description of an area approximately 60 metres in diameter.

The boundaries for the vegetation associations were mapped as being < 60 m, 60 – 120 m and > 120 m.

The dataset is not entirely compatible without further revision given that:

- Associations were not entirely enclosed where boundaries were indistinct; and
- There appear to be discrepancies between the 1999 aerial photos and the boundaries produced in 1977. Whilst there are some issues in terms of map projection and distortion the main cause of discrepancy appears to be due to successional changes in vegetation communities since 1977. There is also reference to the use of infra-red and larger scale (1:10 000) photography but the extent to which this has been used can not be determined from the published report.

7.0 Conclusions

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

The Vegetation Mapping and Survey of the Kondinin Salt Marsh Recovery Catchment and North Karlgarin Target Landscape Area has provided data for incorporation into the CALM Wheatbelt Region's GIS relating to the attributes of native vegetation within the Wheatbelt to assist landscape scale decision making.

The Vegetation Mapping and Survey provides data by:

- describing and categorising vegetation units and mapping their occurrence, structure and distribution on a scale of 1:25 000;
- identifying vegetation associations of significance;
- compiling an inventory of the vascular flora;
- identifying species of significance; and
- digitising existing vegetation maps for the area.

Within the 10 000 ha study area, 5 vegetation formations and 44 vegetation associations / land use units were mapped. *Eucalyptus* Woodlands, *Eucalyptus* Mallees and *Melaleuca* Heath/Shrublands were the most common vegetation formations.

No Threatened Ecological Communities were identified in the study area but three vegetation associations mapped were considered significant. These were:

- *Eucalyptus myriadena* subsp. *parviflora* Woodlands on the basis that *Eucalyptus myriadena* subsp. *parviflora* is a Priority 1 taxon, although the Conservation Code for this taxon may be revised if further populations are located;
- The *Eucalyptus ornata* Woodland on the basis that it is limited in extent and distribution within the study area and *Eucalyptus ornata* has a limited distribution (restricted to the east and north-east of Kondinin); and
- *Eucalyptus salmonophloia* Woodland on the basis that the association has been subjected to large-scale clearing of this association for prime agricultural land.

Camel Peaks is the one site within the study area, that is not presently part of the conservation estate, that was identified as supporting a number of vegetation associations that are restricted in their extent in the study area (including *Allocasuarina huegeliana* Woodland, *Eucalyptus salmonophloia* Woodland and *Banksia* / *Dryandra* Heath).



The survey only recorded up to the five dominant species in each strata for up to five strata at each site, however this still resulted in 163 taxa being recorded in the study area as 352 records in 32 quadrats. Opportunistic records were made of a further 50 taxa within the study area.

Plant taxa of significance recorded during the survey included two priority taxa, three undescribed species and a possible range extension. The priority taxa recorded were *Eucalyptus myriadena* subsp. *parviflora* (P1) and *Grevillea asteriscosa* (P4). The collection of specimens of the *Eucalyptus myriadena* subsp. *parviflora* at numerous sites within the Kondinin Saltmarsh may indicate that the species is more abundant and widespread than

previously thought. The three undescribed species were *Tetratheca aff. virgata* 213 (sp. Nov Ryonen Butcher), *Melaleuca aff. manglesii* 113 (Mike Hislop) and *Baekea sp.* 187 (sp. Nov Malcolm Trudgen). These have been lodged with the West Australian Herbarium and are currently under study. A range extension may have also been recorded for *Isopogon ?polycephalus* (specimen field number 106) but this could not be confirmed from the specimen.

Fauna observations of significance made during the survey were of Malleefowl at North Karlgarin Nature Reserve, Roe Nature Reserve and Scrivener Nature Reserve.

The vegetation maps in *Biological Survey of the Western Australian Wheatbelt Part 2: Vegetation and Habitat of Bending Reserve* (Muir, 1977a) and *Biological Survey of the Western Australian Wheatbelt Part 3 & 4 Vertebrate Fauna of Bending & West Bending Nature Reserves & Vegetation of West Bending Nature Reserve* (Muir, 1977b) were digitised and attempts made to make them compatible with the datasets currently being produced for CALM. These attempts were impeded by differences in techniques used to produce the vegetation maps and possible changes in vegetation over the last 25 years. Further surveying would be required to re-interpret the maps by Muir (1977a and b) and make them fully compatible. Despite a level of incompatibility with more recent datasets, the maps produced by Muir (1977a and b), and the associated flora inventories, remain useful references for work undertaken in the area.

8.0 Recommendations

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

This report is not intended to be a management document but a number of recommendations are made with regards to species and communities of significance, and improving the survey method utilised. These include:

- Consideration be given to the inclusion of Camel Peaks and the contiguous bushland on private property in the Conservation Estate, given that it supports a number of vegetation associations that are restricted in their extent in the study area (including Rock Oak Woodland, Salmon Gum Woodland and Banksia / Dryandra Heath);
- Consideration be given to the incorporation of drains constructed after the aerial photography was completed in 1999 into the dataset;
- Quadrats be established in the low-lying portions of the study area to complete the dataset;
- Consideration be given to the inclusion of other relevant datasets into the database;
- Electrical Conductivity measurements be included as a soil parameter in future surveys;
- The total number of species in each quadrat be recorded in future surveys to gain an insight into the relative species richness between vegetation communities and the degree to which floristics is being under sampled.
- Consideration be given to increasing the quadrat size from 10 x 10 m would reduce time required to place quadrat and bias arising from the placement of quadrat, while still able to be compared with existing datasets.
- The significance of vegetation associations that are restricted in distribution, in particular *Eucalyptus ornata* Woodlands, *Eucalyptus myriadena ssp parviflora* (P1) Woodlands and *Eucalyptus salmonophloia* Woodlands, be considered in operational activities of the Department;
- The track in Scrivener's Nature Reserve be reopened by removing the fallen Salmon Gum near Mettam Knob.

Map R1 Extent of Survey

Map R2 Distribution of Vegetation Formations

Map R3 Comparison of Vegetation Formations mapped Beard & Ecoscape

Map R4a *Grevillea asteriscosa* Distribution

Map R4b Collection Sites for *Eucalyptus myriadena* Specimens

Map R5 Extent and Form of Degradation

Map R6 Extent and Condition of Fencing

Map R7 Mallee Fowl Observations

References

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

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Appendix One: Flora Inventory for Study Area

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

Species Recorded During Survey

?Daviesia benthamii
?Goodenia incana
Acacia acuminata
Acacia assimilis ssp assimilis
Acacia beauverdiana
Acacia consanguinea
Acacia eremophila var. eremophila
Acacia erinacea
Acacia hemiteles
Acacia intricata
Acacia lasiocalyx
Acacia mackeyana
Acacia merrallii
Acacia nyssophylla
Acacia verricula
Aira caryophyllea
Allocasuarina acutivalvis
Allocasuarina campestris
Allocasuarina corniculata
Allocasuarina huegeliana
Allocasuarina humilis
Allocasuarina microstachya
Allocasuarina pinaster
Aluta appressa
Alyxia buxifolia
Amphipogon strictus
Angianthus tomentosus
Asteridea athrixoides
Astroloma serratifolium
Atriplex paludosa ssp baudinii
Atriplex stipitata
Austrostipa campylachne
Austrostipa drummondii
Austrostipa nodosa
Austrostipa puberula
Avena barbata
Baeckea preissiana
Baeckea sp.
Banksia audax
Banksia sphaerocarpa var. caesia
Beaufortia bracteosa
Beaufortia interstans
Beyeria lechenaultii var. drummondii
Borya sphaerocephala
Bossiaea concinna
Brassica tournefortii
Callitris canescens
Callitris roei
Callitris tuberculata
Calothamnus quadrifidus
Calytrix breviseta ssp stipulosa
Calytrix leschenaultii
Carpobrotus aequilaterus
Casuarina obesa
Chamelaucium ciliatum
Chamelaucium naviculum
Cheilanthes sieberi
Dampiera sacculata
Daviesia argillacea
Daviesia elongata
Daviesia nudiflora ssp nudiflora
Daviesia uniflora
Desmocladius myriocladus
Dianella revoluta
Dodonaea pinifolia
Dodonaea stenozyga
Dryandra erythrocephala var. erythrocephala
Dryandra ferruginea ssp flavescens
Dryandra purdieana
Dryandra sp.
Enchylaena lanata
Eremaea pauciflora
Eremophila decipiens
Eremophila drummondii
Eriochiton sclerolaenoides
Eucalyptus alipes
Eucalyptus annulata
Eucalyptus burracoppinensis
Eucalyptus calycogona ssp calycogona
Eucalyptus celastroides ssp celastroides
Eucalyptus cylindriflora
Eucalyptus eremophila
Eucalyptus extensa
Eucalyptus flocktoniae ssp flocktoniae
Eucalyptus horistes
Eucalyptus kondininensis
Eucalyptus loxophleba ssp gratiae
Eucalyptus loxophleba ssp lissophloia
Eucalyptus melanoxydon
Eucalyptus myriadena ssp parviflora P1
Eucalyptus ornata
Eucalyptus salicola
Eucalyptus salmonophloia

<i>Eucalyptus salubris</i>	<i>Melaleuca carrii</i>
<i>Eucalyptus sargentii</i> sp <i>sargentii</i>	<i>Melaleuca cordata</i>
<i>Eucalyptus subangusta</i> ssp <i>subangusta</i>	<i>Melaleuca ctenoides</i>
<i>Eucalyptus urna</i>	<i>Melaleuca eleuterostachya</i>
<i>Eutaxia neurocalyx</i> ssp <i>neurocalyx</i>	<i>Melaleuca elliptica</i>
<i>Exocarpos aphyllus</i>	<i>Melaleuca hamata</i>
<i>Exocarpos sparteus</i>	<i>Melaleuca hamulosa</i>
<i>Gastrolobium floribundum</i>	<i>Melaleuca lateriflora</i> ssp <i>lateriflora</i>
<i>Gastrolobium spinosum</i>	<i>Melaleuca pauperiflora</i> ssp <i>fastigiata</i>
<i>Glischrocaryon aureum</i>	<i>Melaleuca pungens</i>
<i>Gompholobium laxum</i>	<i>Melaleuca sapientes</i>
<i>Goodenia affinis</i>	<i>Melaleuca scalena</i>
<i>Grevillea acuaria</i>	<i>Melaleuca scalena</i> / <i>hamata</i> group
<i>Grevillea asteriscosa</i> P4	<i>Melaleuca sheathiana</i>
<i>Grevillea didymobotrya</i> ssp <i>didymobotrya</i>	<i>Melaleuca spathulata</i>
<i>Grevillea excelsior</i>	<i>Melaleuca spicigera</i>
<i>Grevillea huegelii</i>	<i>Melaleuca thyoides</i>
<i>Grevillea yorkkrakinensis</i>	<i>Mesembryanthemum nodiflorum</i>
<i>Hakea cygna</i> ssp <i>cygna</i>	<i>Mesomelaena preissii</i>
<i>Hakea erecta</i>	<i>Micromyrtus imbricata</i>
<i>Hakea incrassata</i>	<i>Neurachne alopecuroidea</i>
<i>Hakea lissocarpha</i>	<i>Olearia dampieri</i> ssp <i>eremicola</i>
<i>Hakea newbeyana</i>	<i>Olearia muelleri</i>
<i>Hakea pandanicarpa</i> ssp <i>crassifolia</i>	<i>Opercularia vaginata</i>
<i>Hakea petiolaris</i>	<i>Persoonia</i> ? <i>striata</i>
<i>Hakea preissii</i>	<i>Petrophile glauca</i>
<i>Hakea sulcata</i>	<i>Petrophile merrallii</i>
<i>Hakea trifurcata</i>	<i>Petrophile rigida</i>
<i>Halgania cyanea</i> var. <i>cyanea</i>	<i>Phebalium</i> ? <i>megaphyllum</i>
<i>Hibbertia</i> ? <i>exasperata</i>	<i>Phebalium filifolium</i>
<i>Hibbertia exasperata</i>	<i>Phebalium microphyllum</i>
<i>Hibbertia gracilipes</i>	<i>Phebalium tuberosum</i>
<i>Isopogon buxifolius</i>	<i>Pittosporum angustifolium</i>
<i>Isopogon scabriusculus</i>	<i>Platysace effusa</i>
<i>Isopogon teretifolius</i>	<i>Platysace maxwellii</i>
<i>Jacksonia hakeoides</i>	<i>Podotheca gnaphalioides</i>
<i>Jacksonia racemosa</i>	<i>Psammomoya choretroides</i>
<i>Labichea lanceolata</i> ssp <i>lanceolata</i>	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>
<i>Labichea stellata</i>	<i>Ptilotus spathulatus</i> forma <i>spathulatus</i>
<i>Lepidobolus preissianus</i>	<i>Rhagodia drummondii</i>
<i>Lepidosperma</i> sp.	<i>Rhagodia preissii</i> ssp <i>preissii</i>
<i>Lepidosperma</i> sp. A2	<i>Rhodanthe rubella</i>
<i>Lepidosperma</i> sp. K	<i>Santalum acuminatum</i>
<i>Lepidosperma tuberculatum</i>	<i>Santalum spicatum</i>
<i>Lepidosperma viscidum</i>	<i>Scaevola spinescens</i>
<i>Leptosema daviesioides</i>	<i>Senna artemisioides</i> ssp <i>filifolia</i>
<i>Leptomeria preissiana</i>	<i>Senna artemisioides</i> ssp <i>x artemisioides</i>
<i>Leptospermum erubescens</i>	<i>Spartochloa scirpoidea</i>
<i>Leptospermum fastigiatum</i>	<i>Stackhousia monogyna</i>
<i>Leucopogon cuneifolius</i>	<i>Stylidium neglectum</i>
<i>Logania tortuosa</i>	<i>Stylobasium australe</i>
<i>Lomandra effusa</i>	<i>Stypandra glauca</i>
<i>Lomandra mucronata</i>	<i>Templetonia sulcata</i>
<i>Lysinema ciliatum</i>	<i>Tetratheca</i> aff. <i>virgata</i>
<i>Maireana brevifolia</i>	<i>Trachymene ornata</i>
<i>Melaleuca</i> aff. <i>manglesii</i>	<i>Ursinia anthemoides</i>
<i>Melaleuca brophyi</i>	<i>Verticordia chrysantha</i>

Verticordia densiflora var. *caespitosa*
Verticordia picta
Waitzia acuminata ssp. *acuminata*
Westringia rigida

Xanthorrhoea nana
Xylomelum angustifolium
Zygophyllum compressum

**Specimens Held at the W.A.
Herbarium for Reserves in the
Study Area**

Lake Gounter

Eucalyptus alipes
Phebalium brachycalyx
Phebalium microphyllum
Phebalium tuberosum
Ptilotus spathulatus

Karlgarin Nature Reserve

Acrotriche patula
Allocasuarina corniculata
Andersonia lehmanniana
Austrodanthonia acerosa
Austrodanthonia ? setacea
Austrostipa flavescens
Baeckea sp. Hyden
Banksia violacea
Blennospora phlegmatocarpa
Caladenia drummondii
Calytrix nematoclada
Calytrix sapphirina
Conospermum brownii
Conospermum stoechadis. ssp.
stoechadis
Cryptandra minutifolia ssp. *brevistyla*
Daviesia purpurascens
Dryandra ferruginea ssp. *obliquiloba*
Dryandra sp.
Eremophila sp
Eriochilus dilatatus ssp. *undulatus*
Eucalyptus flocktoniae ssp.
flocktoniae
Eucalyptus ornata
Gastrolobium parviflorum
Genoplesium nigricans
Grevillea eryngioides
Grevillea hakeoides ssp. *stenophylla*
Guichenotia micrantha
Hakea subsulcata
Hibbertia glomerosa var. *glomerosa*

Isopogon scabriusculus ssp.
stenophyllus
Lasiopetalum fitzgibbonii
Lasiopetalum rosmarinifolium
Logania tortuosa
Melaleuca cf. *brophyi*
Melaleuca condylosa
Melaleuca cordata
Melaleuca coronicarpa
Melaleuca pungens
Microcorys obovata.
Micromyrtus triptycha ssp. *triptycha*
Monotoca leucantha
Parietaria cardiostegia
Petrophile circinata
Phebalium filifolium
Physopsis lachnostachya
Plantago aff. *hispida*
Prasophyllum elatum
Pterostylis roensis
Pterostylis sanguinea
Pterostylis sp. *exserted labellum*
Rhodanthe pygmaea
Schoenus calcatus
Spyridium polycephalum
Stylidium neglectum
Synaphea constricta
Thysanotus patersonii
Trymalium daphnifolium
Verticordia brachypoda
Verticordia chrysanthella
Zygophyllum apiculatum

Biglin Nature Reserve

Eriochilus dilatatus subsp. *undulatus*

Roe Nature Reserve

Astroloma cataphractum
Baeckea preissiana
Bossiaea halophila
Bossiaea leptacantha
Calothamnus villosus
Chrysocephalum apiculatum

Darwinia diosmoides
Daviesia rhizomata
Dicrastylis parvifolia
Eremophila veneta
Eucalyptus gracilis
Eucalyptus uncinata
Grevillea prostrata
Hakea commutata
Hakea gilbertii
Hakea incrassata
Hakea laurina
Hakea pandanicaarpa ssp.
pandanicaarpa

Appendix Two: Abundance of Individual Taxa in Quadrats

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

Taxa	Number of Records	Taxa	Number of Records
<i>Allocasuarina campestris</i>	8	<i>Waitzia acuminata ssp acuminata</i>	3
<i>Melaleuca cordata</i>	7	<i>Acacia assimilis ssp assimilis</i>	2
<i>Allocasuarina acutivalvis</i>	6	<i>Acacia beauverdiana</i>	2
<i>Eucalyptus salubris</i>	6	<i>Acacia lasiocalyx</i>	2
<i>Hakea sulcata</i>	6	<i>Allocasuarina corniculata</i>	2
<i>Phebalium tuberosum</i>	6	<i>Aluta appressa</i>	2
<i>Acacia erinacea</i>	5	<i>Amphipogon strictus</i>	2
<i>Beaufortia interstans</i>	5	<i>Austrostipa drummondii</i>	2
<i>Lomandra effusa</i>	5	<i>Baeckea sp.</i>	2
<i>Platysace maxwellii</i>	5	<i>Beyeria lechenaultii var. drummondii</i>	2
<i>Santalum acuminatum</i>	5	<i>Bossiaea concinna</i>	2
<i>Acacia acuminata</i>	4	<i>Calothamnus quadrifidus</i>	2
<i>Acacia merrallii</i>	4	<i>Dianella revoluta</i>	2
<i>Astroloma serratifolium</i>	4	<i>Dodonaea pinifolia</i>	2
<i>Calytrix breviseta ssp stipulosa</i>	4	<i>Eremophila decipiens</i>	2
<i>Dodonaea stenozyga</i>	4	<i>Eucalyptus burracoppinensis</i>	2
<i>Enchylaena lanata</i>	4	<i>Eucalyptus calycogona ssp calycogona</i>	2
<i>Eucalyptus subangusta ssp subangusta</i>	4	<i>Eucalyptus kondininensis</i>	2
<i>Grevillea didymobotrya ssp didymobotrya</i>	4	<i>Eucalyptus ornata</i>	2
<i>Lepidobolus preissianus</i>	4	<i>Eucalyptus salmonophloia</i>	2
<i>Leptospermum fastigiatum</i>	4	<i>Exocarpos aphyllus</i>	2
<i>Melaleuca hamulosa</i>	4	<i>Glischrocaryon aureum</i>	2
<i>Melaleuca scalena / hamata group</i>	4	<i>Grevillea huegelii</i>	2
<i>Olearia muelleri</i>	4	<i>Hakea cygna ssp cygna</i>	2
<i>Templetonia sulcata</i>	4	<i>Hakea newbeyana</i>	2
<i>Verticordia chrysantha</i>	4	<i>Hibbertia gracilipes</i>	2
<i>Baeckea preissiana</i>	3	<i>Isopogon scabriusculus</i>	2
<i>Borya sphaerocephala</i>	3	<i>Leptospermum erubescens</i>	2
<i>Callitris canescens</i>	3	<i>Melaleuca brophyi</i>	2
<i>Calytrix leschenaultii</i>	3	<i>Melaleuca pungens</i>	2
<i>Eucalyptus cylindriflora</i>	3	<i>Melaleuca scalena</i>	2
<i>Eucalyptus eremophila</i>	3	<i>Melaleuca sheathiana</i>	2
<i>Eucalyptus loxophleba ssp gratiae</i>	3	<i>Mesembryanthemum nodiflorum</i>	2
<i>Eucalyptus urna</i>	3	<i>Micromyrtus imbricata</i>	2
<i>Hibbertia exasperata</i>	3	<i>Opercularia vaginata</i>	2
<i>Lepidosperma sp. A2</i>	3	<i>Petrophile merrallii</i>	2
<i>Lepidosperma viscidum</i>	3	<i>Phebalium filifolium</i>	2
<i>Melaleuca eleuterostachya</i>	3	<i>Pittosporum angustifolium</i>	2
<i>Melaleuca spathulata</i>	3	<i>Platysace effusa</i>	2
<i>Neurachne alopecuroidea</i>	3	<i>Rhagodia drummondii</i>	2
<i>Ptilotus spathulatus forma spathulatus</i>	3	<i>Rhagodia preissii ssp preissii</i>	2
<i>Stypandra glauca</i>	3	<i>Scaevola spinescens</i>	2
		<i>Trachymene ornata</i>	2

Taxa	Number of Records	Taxa	Number of Records
<i>Westringia rigida</i>	2	<i>Grevillea yorkrakinensis</i>	1
? <i>Daviesia benthamii</i>	1	<i>Hakea erecta</i>	1
? <i>Goodenia incana</i>	1	<i>Hakea lissocarpha</i>	1
<i>Acacia eremophila</i> var. <i>eremophila</i>	1	<i>Hakea petiolaris</i>	1
<i>Acacia intricata</i>	1	<i>Hakea preissii</i>	1
<i>Acacia mackeyana</i>	1	<i>Halgania cyanea</i> var. <i>cyanea</i>	1
<i>Aira caryophyllea</i>	1	<i>Hibbertia</i> ? <i>exasperata</i>	1
<i>Allocasuarina huegeliana</i>	1	<i>Isopogon buxifolius</i>	1
<i>Allocasuarina microstachya</i>	1	<i>Labichea lanceolata</i> ssp <i>lanceolata</i>	1
<i>Allocasuarina pinaster</i>	1	<i>Labichea stellata</i>	1
<i>Angianthus tomentosus</i>	1	<i>Lepidosperma</i> sp.	1
<i>Asteridea athrixoides</i>	1	<i>Lepidosperma</i> sp. K	1
<i>Atriplex stipitata</i>	1	<i>Lepidosperma tuberculatum</i>	1
<i>Austrostipa campylachne</i>	1	<i>Leptomeria preissiana</i>	1
<i>Austrostipa nodosa</i>	1	<i>Leucopogon cuneifolius</i>	1
<i>Austrostipa puberula</i>	1	<i>Logania tortuosa</i>	1
<i>Avena barbata</i>	1	<i>Lomandra mucronata</i>	1
<i>Banksia audax</i>	1	<i>Maireana brevifolia</i>	1
<i>Banksia sphaerocephala</i> var. <i>caesia</i>	1	<i>Melaleuca</i> aff. <i>manglesii</i>	1
<i>Beaufortia bracteosa</i>	1	<i>Melaleuca carrii</i>	1
<i>Brassica tournefortii</i>	1	<i>Melaleuca ctenoides</i>	1
<i>Callitris roei</i>	1	<i>Melaleuca elliptica</i>	1
<i>Carpobrotus aequilaterus</i>	1	<i>Melaleuca lateriflora</i> ssp <i>lateriflora</i>	1
<i>Chamelaucium ciliatum</i>	1	<i>Melaleuca sapientes</i>	1
<i>Chamelaucium naviculum</i>	1	<i>Melaleuca spicigera</i>	1
<i>Cheilanthes sieberi</i>	1	<i>Mesomelaena preissii</i>	1
<i>Dampiera sacculata</i>	1	<i>Olearia dampieri</i> ssp <i>eremicola</i>	1
<i>Daviesia nudiflora</i> ssp <i>Nudiflora</i>	1	<i>Persoonia</i> ? <i>striata</i>	1
<i>Desmocladius myriocladus</i>	1	<i>Petrophile glauca</i>	1
<i>Dryandra erythrocephala</i> var. <i>erythrocephala</i>	1	<i>Phebalium</i> ? <i>megaphyllum</i>	1
<i>Dryandra ferruginea</i> ssp <i>flavescens</i>	1	<i>Phebalium microphyllum</i>	1
<i>Dryandra purdieana</i>	1	<i>Podotrochea gnaphalioides</i>	1
<i>Dryandra</i> sp.	1	<i>Psammomoya choretroides</i>	1
<i>Eremaea pauciflora</i>	1	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	1
<i>Eremophila drummondii</i>	1	<i>Rhodanthe rubella</i>	1
<i>Eriochiton sclerolaenoides</i>	1	<i>Santalum spicatum</i>	1
<i>Eucalyptus annulata</i>	1	<i>Senna artemisioides</i> ssp <i>filifolia</i>	1
<i>Eucalyptus flocktoniae</i> ssp <i>flocktoniae</i>	1	<i>Senna artemisioides</i> ssp x <i>artemisioides</i>	1
<i>Eucalyptus myriadena</i> ssp <i>parviflora</i>	1	<i>Spartochloa scirpoidea</i>	1
<i>Eutaxia neurocalyx</i> ssp <i>neurocalyx</i>	1	<i>Stackhousia monogyna</i>	1
<i>Gastrolobium floribundum</i>	1	<i>Stylidium neglectum</i>	1
<i>Gastrolobium spinosum</i>	1	<i>Stylobasium australe</i>	1
<i>Gompholobium laxum</i>	1	<i>Tetrateca</i> aff. <i>virgata</i>	1
<i>Goodenia affinis</i>	1	<i>Ursinia anthemoides</i>	1
<i>Grevillea asteriscosa</i>	1	<i>Verticordia picta</i>	1
		<i>Xanthorrhoea nana</i>	1
		<i>Zygophyllum compressum</i>	1

Appendix Three: Vegetation Descriptions for Quadrats

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

Vegetation Description in accordance with Muir (1977a)	
Quadrat	
L33-01	<i>Eucalyptus loxophleba</i> ssp <i>gratae</i> Low Woodland A over <i>Acacia acuminata</i> Thicket over mixed Herbs
L33-02	<i>Eucalyptus kondininensis</i> Low Forest A over <i>Acacia merrallii</i> Dwarf Scrub C over <i>Enchylaena lanata</i> Very Open Herbs
L33-03	<i>Eucalyptus urna</i> Open Low Woodland A over <i>Acacia merrallii</i> Low Scrub A over <i>Acacia erinacea</i> Open Dwarf Scrub D <i>Enchylaena lanata</i> Very Open Herbs
L33-04	<i>Eucalyptus urna</i> Open Tall Woodland over <i>Dodonaea stenozyga</i> Open Low Scrub B over <i>Acacia merrallii</i> Open Dwarf Scrub C over <i>Ptilotus spathulatus</i> forma <i>spathulatus</i> Very Open Herbs
L33-05	<i>Eucalyptus salubris</i> Low Forest A over <i>Allocasuarina campestris</i> Open Low Scrub B over <i>Mesembryanthemum nodiflorum</i> Very Open Herbs
L33-06	<i>Allocasuarina acutivalvis</i> Scrub over <i>Allocasuarina corniculata</i> Heath A over <i>Grevillea didymobotrya</i> ssp <i>didymobotrya</i> Dwarf Scrub C over <i>Melaleuca cordata</i> Dwarf Scrub D
L33-07	<i>Eucalyptus burracoppinensis</i> Very Open Shrub Mallee over <i>Grevillea didymobotrya</i> ssp <i>didymobotrya</i> Heath A over <i>Astroloma serratifolium</i> Open Dwarf Scrub D
L33-08	<i>Eucalyptus burracoppinensis</i> Open Shrub Mallee over <i>Melaleuca spathulata</i> Low Scrub A over <i>Melaleuca cordata</i> Low Scrub B over <i>Astroloma serratifolium</i> Low Scrub C over Open Dwarf Scrub D
L33-09	<i>Eucalyptus ornata</i> Low Forest A over <i>Allocasuarina acutivalvis</i> Open Low Scrub B over <i>Hibbertia ?exasperata</i> Open Dwarf Scrub D over <i>Lepidosperma viscidum</i> Very Open Low Sedges
L33-10	<i>Leptospermum fastigiatum</i> Open Scrub over <i>Allocasuarina campestris</i> Heath B over <i>Banksia sphaerocarpa</i> var <i>caesia</i> Low Heath C over <i>Verticordia chrysantha</i> Open Dwarf Scrub D
L33-11	<i>Allocasuarina pinaster</i> Open Low Scrub A over Low Scrub B over Dwarf Scrub C over Dwarf Scrub D
L33-12	<i>Eucalyptus flocktoniae</i> ssp <i>flocktoniae</i> Tree Mallee over <i>Allocasuarina acutivalvis</i> Scrub over <i>Phebalium tuberculosum</i> Open Low Scrub B over <i>Acacia erinacea</i> Open Dwarf Scrub D over <i>Platysace maxwellii</i> Very Open Herbs
L33-13	<i>Eucalyptus eremophila</i> Shrub Mallee over <i>Allocasuarina acutivalvis</i> Heath A over <i>Grevillea huegelii</i> Heath B over <i>Acacia erinacea</i> Open Dwarf Scrub D
L33-14	<i>Eucalyptus subangusta</i> ssp <i>subangusta</i> Open Shrub Mallee over <i>Leptospermum erubescens</i> Open Low Scrub A over <i>Melaleuca carrii</i> Low Scrub B over <i>Calytrix leschenaultii</i> Open Dwarf Scrub C over <i>Westringia rigida</i> Open Dwarf Scrub D
L33-15	<i>Allocasuarina acutivalvis</i> Thicket over <i>Grevillea didymobotrya</i> ssp <i>didymobotrya</i> Heath B over <i>Astroloma serratifolium</i> Dwarf Scrub C over <i>Platysace effusa</i> Open Herbs
L33-16	<i>Eucalyptus kondininensis</i> Forest over <i>Pittosporum angustifolium</i> Open Low Scrub B over <i>Atriplex stipitata</i> Dwarf Scrub C over <i>Enchylaena lanata</i> Open Dwarf Scrub D
L33-17	<i>Allocasuarina campestris</i> Dense Thicket over <i>Baeckea preissiana</i> Heath A over <i>Allocasuarina microstachya</i> Low Heath C over <i>Borya sphaerocephala</i> Herbs
L33-18	<i>Eucalyptus subangusta</i> ssp <i>subangusta</i> Shrub Mallee over <i>Melaleuca scalena</i> / <i>hamata</i> Heath A over <i>Gastrolobium floribundum</i> Low Heath C over <i>Westringia rigida</i> Dwarf Scrub D
L33-19	<i>Allocasuarina huegeliana</i> Thicket over Open Low Scrub B over <i>Podotheca gnaphalioides</i> Dense Herbs
L33-20	<i>Eucalyptus salmonophloia</i> Open Woodland over <i>Scaevola spinescens</i> Open Low Scrub B over <i>Carpobrotus aequilaterus</i> Very Open Herbs
L33-21	<i>Eucalyptus salmonophloia</i> Woodland over <i>Pittosporum angustifolium</i> Open Low Scrub B over <i>Scaevola spinescens</i> Open Dwarf Scrub C over <i>Acacia erinacea</i> Dwarf Scrub D
L33-22	<i>Eucalyptus salubris</i> Forest over <i>Santalum acuminatum</i> Open Low Woodland B over <i>Acacia merrallii</i> Open Dwarf Scrub C over <i>Acacia erinacea</i> Open Dwarf Scrub D
L33-23	<i>Eucalyptus loxophleba</i> ssp <i>gratae</i> Low Forest A over <i>Ptilotus spathulatus</i> forma <i>spathulatus</i> Low Heath D

L33-24	Allocasuarina campestris Heath A over Melaleuca cordata Open Dwarf Scrub C over Lomandra effusa Open Dwarf Scrub D
L33-25	Allocasuarina campestris Dense Heath A over Calytrix leschenaultii Dwarf Scrub C over Stypantra glauca Low Heath D
L33-26	Allocasuarina huegeliana Low Forest B over Leptospermum fastigiatum Open Low Scrub B over Dodonaea pinifolia Open Dwarf Scrub C over Lepidosperma species Very open Tall Sedges over Waitzia acuminata ssp acuminata Dense Herbs
L33-27	Eucalyptus urna Low Woodland A over Melaleuca sapientes Heath A
L33-28	Eucalyptus ornata Low Forest A over Allocasuarina campestris Scrub over Callitris canescens Low Scrub B over Platysace maxwellii Very Open herbs
L33-29	Eucalyptus eremophila Shrub Mallee over Melaleuca hamulosa Heath B over Grevillea huegelii Open Dwarf Scrub D
L33-30	Acacia lasiocalyx Open Scrub over Leptospermum fastigiatum Heath A over Allocasuarina campestris Heath B over Dianella revoluta Low Heath C over Waitzia acuminata Open Dwarf Scrub D
L33-31	Eucalyptus salubris Shrub Mallee over Melaleuca sheathiana Thicket over Melaleuca eleuterostachya Heath A over Dodonaea stenozyga Open Dwarf Scrub D
L33-32	Eucalyptus subangusta ssp subangusta Very Open Shrub Mallee over Melaleuca hamulosa Heath A over Melaleuca eleuterostachya Heath B

Appendix Four: Muir Descriptions associated with Maps

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

Reference Sites are sites where Muir Descriptions were made (no quadrats were established), reference sites are shown on the vegetation maps for each reserve

Quadr at/ Refere nce Site#	Vegetation Description in accordance with Muir (1977a) (grouped by simplified association names used in maps)
Acacia acuminata Low Forest	
01	Acacia acuminata Low Forest B
Allocasuarina acutivalvis Shrubland	
TL33-15	Allocasuarina acutivalvis Thicket over Grevillea didymobotrya ssp didymobotrya Heath B over Astroloma serratifolium Dwarf Scrub C over Platysace effusa Open Herbs
TL33-06	Allocasuarina acutivalvis Scrub over Allocasuarina corniculata Heath A over Grevillea didymobotrya ssp didymobotrya Dwarf Scrub C over Melaleuca cordata Dwarf Scrub D
Allocasuarina acutivalvis / Banksia sphaerocarpa Shrubland	
02	Allocasuarina acutivalvis, Acacia assimilis ssp assimilis, Alyxia buxifolius, Santalum acuminatum Low Scrub A over Banksia sphaerocarpa var caesia, Hakea incrassata, Hakea lissocarpha, Isopogon teretifolia Heath B
Allocasuarina campestris Heath/Shrubland	
TL33-17	Allocasuarina campestris Dense Thicket over Baeckea preissiana Heath A over Allocasuarina microstachya Low Heath C over Borya sphaerocephala Herbs
TL33-24	Allocasuarina campestris Heath A over Melaleuca cordata Open Dwarf Scrub C over Lomandra effusa Open Dwarf Scrub D
TL33-25	Allocasuarina campestris Dense Heath A over Calytrix leschenaultii Dwarf Scrub C over Stypantra glauca Low Heath D
TL33-30	Acacia lasiocalyx Open Scrub over Leptospermum fastigiatum Heath A over Allocasuarina campestris Heath B over Dianella revoluta Low Heath C over Waitzia acuminata Open Dwarf Scrub D
Allocasuarina huegeliana Forest (occurs adjacent to granite outcrops)	
TL33-19	Allocasuarina huegeliana Low Forest B over Open Low Scrub B over Podotrochea gnaphalioides Dense Herbs
TL33-26	Allocasuarina huegeliana Low Forest B over Leptospermum fastigiatum Open Low Scrub B over Dodonaea pinifolia Open Dwarf Scrub C over Lepidosperma species Very open Tall Sedges over Waitzia acuminata ssp acuminata Dense Herbs
Banksia / Dryandra Heath	
TL33-10	Leptospermum fastigiatum Open Scrub over Allocasuarina campestris Heath B over Banksia sphaerocarpa var caesia, Eremaea pauciflora, Isopogon buxifolius, Petrophile merrallii Low Heath C over Dryandra species, Verticordia chrysantha Open Dwarf Scrub D
TL33-11	Allocasuarina pinaster, Acacia assimilis subsp. assimilis Open Low Scrub A over Petrophile merrallii Low Scrub B over Dryandra erythrocephala var. erythrocephala, Banksia audax Dwarf Scrub C over Dryandra ferruginea subsp. flavescens Dwarf Scrub D
03	Banksia sphaerocarpa var caesia, Allocasuarina campestris, Allocasuarina humilis, Petrophile rigida, Isopogon teretifolia, Hakea incrassata, Hakea lissocarpha, Dryandra species Low Heath C

Casuarina obesa / Callitris tuberculata Woodland (occurs on sandy ridge in centre of saltlake, small stand of Casuarinas also on southern lake edge)	
04	Casuarina obesa, Callitris tuberculata, Eucalyptus alipes Open Low Woodland B over Hakea preissii, Alyxia buxifolius Dwarf Scrub C
Mixed Shrub Mallee	
TL33-07	Eucalyptus burracoppinensis Very Open Shrub Mallee over Grevillea didymobotrya ssp didymobotrya Heath A over Astroloma serratifolium Open Dwarf Scrub D
TL33-08	Eucalyptus burracoppinensis, Eucalyptus cylindriflora Open Shrub Mallee over Melaleuca spathulata Low Scrub A over Melaleuca cordata Low Scrub B over Astroloma serratifolium Low Scrub C over Open Dwarf Scrub D
TL33-12	Eucalyptus cylindriflora, Eucalyptus flocktoniae ssp flocktoniae Tree Mallee over Allocasuarina acutivalvis Scrub over Phebalium tuberculatum Open Low Scrub B over Acacia erinacea Open Dwarf Scrub D over Platysace maxwellii Very Open Herbs
TL33-13	Eucalyptus subangusta ssp subangusta, Eucalyptus eremophila, Eucalyptus calycogona ssp calycogona Shrub Mallee over Allocasuarina acutivalvis Heath A over Grevillea huegelii Heath B over Acacia erinacea Open Dwarf Scrub D
TL33-14	Eucalyptus subangusta ssp subangusta, Eucalyptus cylindriflora Open Shrub Mallee over Leptospermum erubescens Open Low Scrub A over Melaleuca carrii Low Scrub B over Calytrix leschenaultii Open Dwarf Scrub C over Westringia rigida Open Dwarf Scrub D
TL33-18	Eucalyptus subangusta ssp subangusta Shrub Mallee over Melaleuca scalena / hamata Heath A over Gastrolobium floribundum Low Heath C over Westringia rigida Dwarf Scrub D
TL33-29	Eucalyptus eremophila, Eucalyptus calycogona ssp calycogona Shrub Mallee over Melaleuca hamulosa Heath B over Grevillea huegelii Open Dwarf Scrub D
TL33-32	Eucalyptus subangusta ssp subangusta Very Open Shrub Mallee over Melaleuca hamulosa Heath A over Melaleuca eleuterostachya Heath B
Eucalyptus alipes Shrub Mallee (occupies higher ground but often intergrades with Melaleuca Shrubland/Heath on broad low rises in the Kondinin Saltmarsh)	
05	Eucalyptus alipes Shrub Mallee over Hakea preissii, Exocarpos sparteus, Acacia nyssophylla, Alyxia buxifolius, Acacia acuminata Heath B over Eremophila decipiens, Calytrix leschenaultia, Phebalium tuberculatum Dwarf Scrub D over Lomandra effusa, Dianella revoluta Very open Herbs
Eucalyptus extensa Forest	
06	Eucalyptus extensa Forest
Eucalyptus horistes Shrub Mallee (occupies higher sand ridges than Eucalyptus alipes)	
07	Eucalyptus horistes Very Open Shrub Mallee over Santalum acuminatum, Alyxia buxifolia, Acacia consanguinea, Open Low Scrub B over Jacksonia racemosa Low Heath D over Open Herbs
Eucalyptus longicornis, Eucalyptus kondininensis, Eucalyptus extensa Woodland	
TL33-16	Eucalyptus longicornis, Eucalyptus kondininensis, Eucalyptus extensa Forest over Pittosporum angustifolium Open Low Scrub B over Atriplex stipitata Dwarf Scrub C over Enchylaena lanata Open Dwarf Scrub D
Eucalyptus longicornis / Eucalyptus myriadena Woodland	
08	Eucalyptus longicornis, Eucalyptus myriadena Low Forest A over Hakea preissii, Exocarpos aphyllus, Acacia nyssophylla, Alyxia buxifolius, Acacia acuminata Heath B over Eremophila decipiens, Olearia muelleri, Acacia merrallii, Scaevola spinescens Dwarf Scrub D
Eucalyptus loxophleba ssp gratiae Woodland	
TL33-01	Eucalyptus loxophleba ssp gratiae Low Woodland A over Acacia acuminata Thicket over mixed Herbs
TL33-23	Eucalyptus loxophleba ssp gratiae Low Forest A over Ptilotus spathulatus forma spathulatus Low Heath D

Eucalyptus loxophleba ssp lissophloia Shrub Mallee	
09	Eucalyptus loxophleba ssp lissophloia Shrub Mallee over Acacia acuminata, Santalum acuminatum, Melaleuca species Low Scrub A
10	Eucalyptus loxophleba ssp lissophloia Shrub Mallee
Eucalyptus melanoxylon Woodland	
11	Eucalyptus melanoxylon Woodland over Melaleuca sheathiana, Melaleuca eleuterostachya Low Scrub A
Eucalyptus myriadena Open Low Woodland	
12	Eucalyptus myriadena ssp parviflora Open Low Woodland A over Hakea preissii, Alyxia buxifolius, Santalum acuminatum Open Low Scrub A over Acacia merrallii Open Dwarf Scrub C over Dense Low Grass
Eucalyptus myriadena / Eucalyptus alipes Shrub Mallee	
13	Eucalyptus myriadena ssp parviflora, Eucalyptus alipes Open Shrub Mallee over Acacia acuminata, Santalum acuminatum, Melaleuca uncinata, Melaleuca hamata Thicket
Eucalyptus myriadena Low Woodland	
14	Eucalyptus myriadena ssp parviflora Low Woodland A / Low Forest A over Pittosporum angustifolium, Acacia acuminata, Hakea preissii, Olearia merrallii, Alyxia buxifolius, Acacia nyssophylla Low Scrub B over Acacia erinacea, Scaevola spinescens, Atriplex paludosa, Lomandra effusa Dwarf Scrub D
Eucalyptus olivina Shrub Mallee (recorded on ridgeline above broad elevated slopes)	
15	Eucalyptus olivina Open Shrub Mallee over Acacia assimilis ssp assimilis, Alyxia buxifolius, leptospermum erubescens Low Scrub A over Banksia sphaerocarpa var caesia, Hakea trifurcata, Santalum acuminatum Low Scrub B over Open Herbs
Eucalyptus ornata Low Forest	
TL33-09	Eucalyptus ornata Low Forest A over Allocasuarina acutivalvis Open Low Scrub B over Hibbertia ?exasperata Open Dwarf Scrub D over Lepidosperma viscidum Very Open Low Sedges
TL33-28	Eucalyptus ornata Low Forest A over Allocasuarina campestris Scrub over Callitris canescens Low Scrub B over Platysace maxwellii Very Open herbs
Eucalyptus salicola Woodland	
16	Eucalyptus salicola Open Low Woodland A over Acacia erinacea, Acacia merrallii, Scaevola spinescens, Santalum acuminatum Heath B
Eucalyptus salmonophloia Woodland	
TL33-20	Eucalyptus salmonophloia Open Woodland over Scaevola spinescens Open Low Scrub B over Carpobrotus aequilaterus Very Open Herbs
TL33-21	Eucalyptus salmonophloia Woodland over Pittosporum angustifolium Open Low Scrub B over Scaevola spinescens Open Dwarf Scrub C over Acacia erinacea Dwarf Scrub D
Eucalyptus salubris Woodland	
TL33-22	Eucalyptus salubris Forest over Santalum acuminatum Open Low Woodland B over Acacia merrallii Open Dwarf Scrub C over Acacia erinacea Open Dwarf Scrub D
TL33-31	Eucalyptus salubris Shrub Mallee over Melaleuca sheathiana Thicket over Melaleuca eleuterostachya Heath A over Dodonaea stenozyga Open Dwarf Scrub D
Eucalyptus salubris / Eucalyptus eremophila Woodland	
TL33-05	Eucalyptus salubris, Eucalyptus eremophila Low Forest A over Allocasuarina campestris Open Low Scrub B over Mesembryanthemum nodiflorum Very Open Herbs
Eucalyptus salubris / Eucalyptus kondininensis Woodland	
TL33-02	Eucalyptus salubris, Eucalyptus kondininensis Low Forest A over Acacia merrallii Dwarf Scrub C over Enchylaena lanata Very Open Herbs
TL33-05	Eucalyptus salubris, Eucalyptus eremophila Low Forest A over Allocasuarina campestris Open Low Scrub B over Mesembryanthemum nodiflorum Very Open Herbs

Eucalyptus urna Woodland	
TL33-27	Eucalyptus urna Low Woodland A over Melaleuca sapientes Heath A
TL33-03	Eucalyptus urna Open Low Woodland A over Acacia merrallii Low Scrub A over Acacia erinacea Open Dwarf Scrub D Enchylaena lanata Very Open Herbs
TL33-04	Eucalyptus urna Open Tall Woodland over Dodonaea stenozyga Open Low Scrub B over Acacia merrallii Open Dwarf Scrub C over Ptilotus spathulatus forma spathulatus Very Open Herbs
Eucalyptus urna Woodland over Shrub Mallee	
17	Eucalyptus urna Woodland over Eucalyptus urna Shrub Mallee over Olearia muelleri Open Dwarf Scrub C
Mixed Melaleuca Shrubland / Heath (occupies lower ground but often intergrades with Eucalyptus alipes Shrub Mallee on broad low rises in the Kondinin Saltmarsh)	
18	Melaleuca hamata, Melaleuca brophyi, Melaleuca pauperiflora ssp fastigiata, Melaleuca carrii, Melaleuca hamulosa Thicket / Heath A over Hakea preissii, Exocarpos sparteus, Acacia nyssophylla, Alyxia buxifolius, Acacia acuminata Heath B over Eremophila decipiens, Olearia muelleri, Acacia merrallii, Acacia erinacea, Atriplex paludosa ssp baudinii, Scaevola spinescens Dwarf Scrub D
Mixed Melaleuca Dense Shrubland / Heath (often occurs along drainage lines)	
19	Melaleuca hamata, Melaleuca brophyi, Melaleuca pauperiflora ssp fastigiata, Melaleuca carrii, Melaleuca hamulosa, Melaleuca eleuterostachya, Melaleuca uncinata Dense Thicket/ Dense Heath A
20	Melaleuca ctenoides, Melaleuca eleuterostachya, Melaleuca hamulosa, Melaleuca lateriflora subsp. lateriflora, Melaleuca scalena / hamata group Dense Shrubland / Dense Heath
Melaleuca thyoides Heath	
21	Melaleuca thyoides Dense Heath A
Xylomelum angustifolium Shrubland (occupies broad elevated slopes)	
22	Xylomelum angustifolium, Grevillea excelsior, Acacia assimilis ssp assimilis Scrub over Santalum acuminatum, Acacia campestris, Calothamnus quadrifidus Low Scrub B over Eremaea pauciflora, Hakea pandanocarpa, Daviesia elongata Dwarf Scrub D
Xylomelum angustifolium / Acacia acutivalvis Shrubland (occupies ridgelines above broad elevated slopes)	
23	Acacia acutivalvis, Xylomelum angustifolium, Grevillea excelsior, Acacia assimilis ssp assimilis Scrub over Acacia campestris, Calothamnus quadrifidus Low Scrub B over Eremaea pauciflora, Verticordia densiflora var. caespitosa Dwarf Scrub D

Appendix Five: Overstorey Species by Quadrat

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

Quadrat	Location	Formation	Overstorey Species
TL33-01	Karlgarin NR	Woodland	<i>Eucalyptus loxophleba ssp gratiae</i> , <i>Acacia acuminata</i>
TL33-02	Karlgarin NR	Woodland	<i>Eucalyptus kondininensis</i> , <i>Eucalyptus salubris</i>
TL33-03	Karlgarin NR	Woodland	<i>Eucalyptus urna</i> , <i>Eucalyptus salubris</i>
TL33-04	Loc 27519	Woodland	<i>Eucalyptus urna</i>
TL33-05	Loc 27519	Woodland	<i>Eucalyptus salubris</i> , <i>Eucalyptus eremophila</i>
TL33-06	Loc 27519	Heath	<i>Allocasuarina acutivalvis</i>
TL33-07	Loc 27519	Mallee	<i>Eucalyptus burracoppinensis</i> , <i>Acacia acuminata</i> , <i>Hakea sulcata</i> , <i>Isopogon scabriusculus</i>
TL33-08	Loc 27519	Mallee	<i>Eucalyptus burracoppinensis</i> , <i>Eucalyptus cylindriflora</i> , <i>Allocasuarina corniculata</i> , <i>Acacia acuminata</i>
TL33-09	Roe NR	Woodland	<i>Eucalyptus ornata</i>
TL33-10	Roe NR	Heath	<i>Leptospermum fastigiatum</i> , <i>Acacia lasiocalyx</i>
TL33-11	Roe NR	Heath	<i>Allocasuarina pinaster</i> , <i>Acacia assimilis ssp assimilis</i> , <i>Dryandra purdieana</i> , <i>Hakea cygna ssp cygna</i>
TL33-12	Roe NR	Woodland	<i>Eucalyptus cylindriflora</i> , <i>Eucalyptus flocktoniae ssp flocktoniae</i>
TL33-13	Roe NR	Mallee	<i>Eucalyptus subangusta ssp subangusta</i> , <i>Eucalyptus calycogona ssp calycogona</i> , <i>Eucalyptus eremophila</i>
TL33-14	Roe NR	Mallee	<i>Eucalyptus subangusta ssp subangusta</i> , <i>Eucalyptus cylindriflora</i>
TL33-15	Roe NR	Shrubland	<i>Allocasuarina acutivalvis</i>
TL33-16	Toy Hill	Woodland	<i>Eucalyptus kondininensis</i> , <i>Eucalyptus longicornis</i> , <i>Eucalyptus extensa</i> , <i>Eucalyptus myriadena ssp parviflora</i>
TL33-17	Camel Peaks	Shrubland	<i>Allocasuarina acutivalvis</i> , <i>Allocasuarina campestris</i> , <i>Hakea sulcata</i> , <i>Leptospermum erubescens</i>
TL33-18	Camel Peaks	Mallee	<i>Eucalyptus subangusta ssp subangusta</i>
TL33-19	Camel Peaks	Shrubland	<i>Allocasuarina campestris</i> , <i>Acacia beauverdiana</i>
TL33-20	Camel Peaks	Woodland	<i>Eucalyptus salmonophloia</i>
TL33-21	Scrivener NR	Woodland	<i>Eucalyptus salmonophloia</i>
TL33-22	Scrivener NR	Woodland	<i>Eucalyptus salubris</i>
TL33-23	Scrivener NR	Woodland	<i>Eucalyptus loxophleba ssp gratiae</i>
TL33-24	Scrivener NR	Heath	<i>Allocasuarina campestris</i> , <i>Grevillea didymobotrya ssp didymobotrya</i>
TL33-25	Scrivener NR	Heath	<i>Allocasuarina campestris</i> , <i>Melaleuca elliptica</i> , <i>Melaleuca scalena</i>
TL33-26	Scrivener NR	Woodland	<i>Allocasuarina huegeliana</i>
TL33-27	Scrivener NR	Woodland	<i>Eucalyptus urna</i> , <i>Eucalyptus salubris</i>
TL33-28	Scrivener NR	Woodland	<i>Eucalyptus ornata</i> , <i>Eucalyptus loxophleba ssp gratiae</i>
TL33-29	Scrivener NR	Mallee	<i>Eucalyptus calycogona ssp calycogona</i> , <i>Eucalyptus eremophila</i>
TL33-30	Karlgarin NR	Shrubland	<i>Acacia lasiocalyx</i>
TL33-31	Karlgarin NR	Mallee	<i>Eucalyptus salubris</i>
TL33-32	Loc 27519	Mallee	<i>Eucalyptus subangusta ssp subangusta</i>

Appendix Six: Quadrat Locations

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

Quadrat	Location	Easting	Northing
TL33-01	Karlgarin NR	645564	6404161
TL33-02	Karlgarin NR	645605	6403675
TL33-03	Karlgarin NR	645460	6402008
TL33-04	Loc 27519	642924	6412184
TL33-05	Loc 27519	643407	6411430
TL33-06	Loc 27519	642805	6410984
TL33-07	Loc 27519	642027	6411031
TL33-08	Loc 27519	641358	6411106
TL33-09	Roe NR	661243	6421422
TL33-10	Roe NR	662668	6421021
TL33-11	Roe NR	662883	6423447
TL33-12	Roe NR	659501	6421671
TL33-13	Roe NR	659514	6422823
TL33-14	Roe NR	659534	6423415
TL33-15	Roe NR	660718	6423478
TL33-16	Toy Hill	656544	6408146
TL33-17	Camel Peaks	671030	6424312
TL33-18	Camel Peaks	671097	6424253
TL33-19	Camel Peaks	671826	6423560
TL33-20	Camel Peaks	671573	6423628
TL33-21	Scrivener NR	662086	6411744
TL33-22	Scrivener NR	662014	6411493
TL33-23	Scrivener NR	662020	6411909
TL33-24	Scrivener NR	662597	6414245
TL33-25	Scrivener NR	660991	6410341
TL33-26	Scrivener NR	660211	6410267
TL33-27	Scrivener NR	660138	6413018
TL33-28	Scrivener NR	662080	6414253
TL33-29	Scrivener NR	661731	6414266
TL33-30	Karlgarin NR	646069	6403431
TL33-31	Karlgarin NR	646078	6402915
TL33-32	Loc 27519	640561	6411394

Datum: GDA 94
Projection: MGA 50

Appendix Seven: Comparison of Vegetation and Soil

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin

Quadrat	Formation	Overstorey	Landform Type	Soil Group	pH (CaCl ₂)	A horizon Depth (cm)
TL33-30	Shrubland	<i>Acacia lasiocalyx</i>	Crest	Shallow loams	6.3	0
TL33-06	Heath	<i>Allocasuarina acutivalvis</i>	Crest	Yellow / brown deep sandy duplex	5.7	0.2
TL33-15	Shrubland	<i>Allocasuarina acutivalvis</i>	Mid Slope	Shallow gravel	5.3	0.23
TL33-19	Shrubland	<i>Allocasuarina campestris</i>	Open Depression	Brown deep sand	6.7	1
TL33-24	Heath	<i>Allocasuarina campestris</i>	Open Depression	Pale shallow sand	5.7	0.78
TL33-25	Heath	<i>Allocasuarina campestris</i>	Mid Slope	Pale shallow sand	5.8	0.56
TL33-17	Shrubland	<i>Allocasuarina campestris</i> / <i>Allocasuarina acutivalvis</i>	Crest	Yellow sandy earth	6.8	0.23
TL33-26	Woodland	<i>Allocasuarina huegeliana</i>	Crest	Pale shallow sand	6	0.57
TL33-11	Heath	<i>Allocasuarina pinaster</i>	Crest	Reticulite Deep sandy duplex	5.1	0.25
TL33-16	Woodland	<i>Eucalyptus annulata</i> / <i>Eucalyptus kondininensis</i> / <i>E. myriadena</i> ssp <i>parviflora</i>	Mid Slope	Calcareous loamy earth	8.4	0.6
TL33-07	Mallee	<i>Eucalyptus burracoppinensis</i>	Crest	Deep sandy gravel	5.7	0.5
TL33-08	Mallee	<i>Eucalyptus burracoppinensis</i> / <i>Eucalyptus cylindriflora</i> / <i>Allocasuarina corniculata</i>	Mid Slope	Duplex sandy gravel	5.5	0.28
TL33-12	Mallee	<i>Eucalyptus cylindriflora</i> / <i>Eucalyptus flocktoniae</i> ssp <i>flocktoniae</i>	Mid Slope	Deep sandy gravel	5.9	0.8
TL33-14	Mallee	<i>Eucalyptus cylindriflora</i> / <i>Eucalyptus subangusta</i> ssp <i>subangusta</i>	Mid Slope	Yellow / brown deep sandy duplex	6.9	0.35
TL33-13	Mallee	<i>Eucalyptus eremophila</i> / <i>E. calycogona</i> ssp <i>calycogona</i> / <i>E. subangusta</i> ssp <i>subangusta</i>	Open Depression	Gray non cracking clay	7	0.28
TL33-29	Mallee	<i>Eucalyptus eremophila</i> / <i>Eucalyptus calycogona</i> ssp <i>calycogona</i>	Crest	Yellow / brown sandy duplex	6.3	0.23
TL33-05	Woodland	<i>Eucalyptus eremophila</i> / <i>Eucalyptus salubris</i>	Flat	Brown loamy earth	7.5	0.3
TL33-02	Woodland	<i>Eucalyptus kondininensis</i> / <i>Eucalyptus salubris</i>	Lower Slope	Calcareous loamy earth	8.7	0.2
TL33-23	Woodland	<i>Eucalyptus loxophleba</i> ssp <i>gratae</i>	Mid Slope	Stony soil	5.1	0.3
TL33-01	Woodland	<i>Eucalyptus loxophleba</i> ssp <i>gratae</i> / <i>Acacia acuminata</i>	Ridge	Red brown non cracking clay	8.7	0.5
TL33-09	Woodland	<i>Eucalyptus ornata</i>	Flat	Stony soil	3	0.7
TL33-28	Woodland	<i>Eucalyptus ornata</i> / <i>Eucalyptus loxophleba</i> ssp <i>gratae</i>	Crest	Shallow gravel Yellow brown shallow sandy duplex	6.1	0.35
TL33-20	Woodland	<i>Eucalyptus salmonophloia</i>	Flat	Yellow brown shallow sandy duplex	7.1	0.15
TL33-21	Woodland	<i>Eucalyptus salmonophloia</i>	Open Depression	Calcareous loamy earth	9.6	0.86
TL33-22	Woodland	<i>Eucalyptus salubris</i>	Mid Slope	Red brown non cracking clays	8.8	0.85
TL33-31	Mallee	<i>Eucalyptus salubris</i>	Crest	Gray non cracking clay	8	0.25
TL33-18	Mallee	<i>Eucalyptus subangusta</i> ssp <i>subangusta</i>	Crest	Yellow brown shallow sand	5.8	0.39

Appendix Four

Quadrat	Formation	Overstorey	Landform Type	Soil Group	pH (CaCl ₂)	A horizon Depth (cm)
TL33-32	Mallee	Eucalyptus subangusta ssp subangusta	Flat	Gray non cracking clay	6.2	0.11
TL33-04	Woodland	Eucalyptus urna	Flat	Brown loamy earth	8	0.8
TL33-03	Woodland	Eucalyptus urna / Eucalyptus salubris	Flat	Brown loamy earth	8.4	0.35
TL33-27	Woodland	Eucalyptus urna / Eucalyptus salubris	Crest	Red / brown cracking clays	8.4	0.8
TL33-10	Heath	Leptospermum fastigiatum / Acacia lasiocalyx	Upper Slope	Deep sandy gravel	5.6	0.8

**Appendix Eight:
Field Sheets and Reserve Maps**

Vegetation Survey of Kondinin Saltmarshes and North Karlgarin