WETLANDS OF THE COOBIDGE CREEK CATCHMENT, THEIR CLASSIFICATION AND RESPONSE TO PROLONGED FLOODING.

Report to:
Water Authority of Western Australia and the Department of Conservation and Land Management

by:
Raymond H. Froend[1] and Paul G. van der Moezel[2]

1. School of Biological and Environmental Science
Murdoch University, Murdoch
2. Department of Botany
The University of Western Australia, Nedlands.

January 1991

CONTENTS

List of Figures

List of Tables

List of Plates

1. GENERAL INTRODUCTION

The Southern Catchments Study was initiated by the Water Authority of Western Australia with the overall objective to guide the present and future management of the water resources of the Southern Catchments region. Within the broad aim of protecting wetland values for the community and environment, one of the specific objectives of the study is to define the primary uses for particular wetland systems. Before resource use can be defined and management systems applied thereon, the resource or wetland system must first be adequately identified and categorised. A system of wetland classification was developed for the Perth-Bunbury wetland study which encompassed all wetland types in the Darling System (Semeniuk, 1987). This wetland classification system identifies wetland categories according to geomorphic and water features and includes wetland vegetation to assist in further defining particular wetland types. Application of the Semeniuk wetland classification system has not been tested outside the Darling System. In this report we apply the Semeniuk system to the Coobidge Creek catchment on the south coast, west of Esperance, and include some more detailed wetland characteristics in a numerical classification of selected wetlands.

Wetlands in agricultural regions throughout Western Australia are under increasing pressure as on-farm water management gains momentum. Diversion of excess water via a system of contour banks and drains is one means considered for controlling salinisation and waterlogging of productive agricultural land. Excess water is drained into dams if water is suitable for stock, otherwise saline water is discharged into areas of natural or semi-natural vegetation, particularly low-lying wetland systems. The wetlands may therefore receive far more water input than under natural conditions. During the winter of 1989, massive rainfall events in the Esperance district resulted in spectacular rejuvenation of old drainage lines while lake levels were among the highest in living memory. The resulting changes in vegetation in and around overflowing lakes provided a unique opportunity to study the possible effects of using wetlands for storage of excess farm water. Such storage might artificially elevate lake levels above that normally experienced by wetland vegetation. The second part of this report details the effects of persistent, high water levels in Coomalbidgup Swamp, one of the largest and most significant wetlands in the Coobidge Creek area.

2. *CLASSIFICATION OF THE COOBIDGE CREEK WETLANDS.*

2.1 INTRODUCTION

The natural wetlands covered in this study are defined as areas of seasonally, intermittently or permanently waterlogged soils or inundated land (Wetlands Advisory Committee, 1977). Within this definition, wetlands cover areas of waterlogged soil, ponds, billabongs, swamps, fens, marshes, lakes, tidal flats, estuaries, creeks and rivers. Wetland classification systems have used a variety of biological, chemical, physical, geological, geomorphic and genetic features (see Semeniuk 1987). In a review of wetland classification systems overseas and in Australia, Semeniuk (1987) found that no system was adequate to classify the variety of wetlands in the Darling System. A new system was therefore developed based on geomorphic and water permanence characteristics. Seven wetland types are described using these primary criteria. Wetlands can be further defined using secondary characters such as wetland size, shape, water salinity and consistency of water salinity. The use of secondary descriptors is not limited and the system allows for addition of other features if considered important in discriminating between wetland types. For example, wetland vegetation categories, as described by Semeniuk *et al*. (1990), can be included in the classification. Wetland vegetation can be very complex but can be simplified with classification into categories according to scale, structural and floristic organisation and degree of complexity. Both primary and secondary wetland descriptors may be incorporated into a Geographical Information System for mapping the various characteristics over whole catchment areas in some cases.

The south coast of Western Australia between Esperance and Ravensthorpe contains many intermittent watercourses draining from 10-100 km inland in a southerly direction towards the Southern Ocean. The main drainage lines in this region are the Phillips River, Jerdacuttup R., Oldfield R., Munglinup R., Young R., Lort R., Coobidge Creek and Dalyup River. Only a few rivers and creeks reach the ocean and have estuaries. Other rivers and creeks degenerate into scattered lakes and swamps ponded behind the coastal dune system. River drainage in this region is generally unco-ordinated into small depressions and swamps and is only well developed near the coast where incised valleys 30-40 m deep are common. Near the coast, swamps take the form of small rounded depressions of varying size with flat-bottomed beds 1-10 m below the surrounding sandplain level. These swamps fill with freshwater during winter and generally dry up in summer. Most of these swamps contain *Eucalyptus occidentalis* trees or mallees or, where the substrate is sandy, *Melaleuca cuticularis* scrub occurs. Only a few of these freshwater swamps have large areas of open water free of vegetation. The character of wetlands changes inland from freshwater swamps to saline lakes. These salt lakes are free of vegetation in the shallow lake beds but contain a varied fringing vegetation of sandplain or mallee species depending on the nature of the soil.

The Coobidge Creek catchment has a wide variety of wetlands from fresh deepwater swamps to hypersaline salt lakes. The vegetation in and around the wetlands varies in the degree of disturbance from relatively undisturbed to disturbance from grazing, fire and increased salinity and water levels. Although the Coobidge Creek region is only a small part of the Southern Catchments Study, the broad spectrum of wetlands provides a neat system in which to examine wetland classification techniques. The results attained from the Coobidge Creek wetland classification study would be highly relevant to the other drainage systems of the south coast.

The classification system used in this study is that of Semeniuk (1987, 1990) and an expanded version incorporating more chemical and biological characteristics. Numerical analysis of the wetland characters was used to provide a more objective quantitative assessment of the influence of physical and chemical factors on the wetlands of the area.

2.2 STUDY AREA

Coobidge Creek is situated approximately 40km west of Esperance aligned north-south on a latitude of 121° 30'E (Fig.). The creek drains from 35km inland (33° 30'S) into a series of large shallow salt lakes around Lakes Carbul, Kubitch, Gidong and Gore. In very wet years the diffuse lake system into which Coobidge Creek drains is connected up and covers a broad area from Lake Gore to the Barker Inlet, 15km west. Coobidge Creek itself is an intermittently flowing drainage line with no major tributaries along its length. Shallow depressions are scattered throughout the catchment with one particular section on the east side, about half way along the length of the creek, which contains a dense region of salt lakes aligned along a WNW-ESE gradient.

Most of the catchment was cleared for agriculture during 1964 - 1972 with parts towards the south still being cleared in 1990. Remnant vegetation exists in the Nature Reserve at the very top end of the catchment as well as among the dense system of salt lakes previously mentioned plus the wetland system south and west of Lake Gore.

2.3 METHODS

Aerial photographs of the catchment were examined prior to the ground survey and all observable wetlands were identified, numbered and located on a 1:50 000 map of soils and landforms produced by the W.A. Department of Agriculture. A total of 45 wetlands were then chosen for detailed classification which represented the broad range of wetlands, soil types and landforms. Each of these wetlands was visited in June, 1990 for collection of data to be incorporated into the classification process.

2.3.1 Classification

Each wetland was categorised according to size, shape, landform, land system, soil unit, water longevity, water salinity, water pH, vegetation disturbance, extent of grazing, salinity and waterlogging damage, water trophic status, vegetation organisation and cover, vegetation formation type and association type.

Landform, Land System, Soil Type

The landforms and soils of the area have been mapped by the W.A. Department of Agriculture at the 1:50 000 scale. The soil types are distributed within three Land System categories : Esperance, Scaddan and Young Land Systems (Table 2.1).

Size and Shape

Refer to Table 2.2 and Figure 2.3.

Wetland Type

Each wetland was categorised according to landform as either a Basin, Channel or Flat and then according to water longevity as either permanent inundation, seasonal inundation or seasonal waterlogging. Combining these two categories produces seven wetland types:

LAKE	permanently inundated basin
SUMPLAND	seasonally inundated basin
DAMPLAND	seasonally waterlogged basin
RIVER	permanently inundated channel
CREEK	seasonally inundated channel
FLOODPLAIN	seasonally inundated flat
PALUSPLAIN	seasonally waterlogged flat

Water Salinity

Water salinity was measured *in situ* with a conductivity meter and categorised as follows:

less than 1 000 mg/l	FRESH
1 000 - 3 000	SUBHALINE
3 000 - 20 000	HYPOSALINE
20 000 - 50 000	MESOSALINE
50 000 - 100 000	HYPERSALINE
100 000 and greater	BRINE

Water pH

Water pH was measured *in situ* and highly acidic water samples were taken for verification in the laboratory. The following categories were used:

less than 3.5	HIGHLY ACIDIC
3.5 - 5.5	ACIDIC
5.5 - 6.5	MILDLY ACIDIC
6.5 - 7.5	NEUTRAL
7.5 - 8.5	MILDLY ALKALINE
8.5 - 10.5	ALKALINE
10.5 and greater	HIGHLY ALKALINE

Vegetation Disturbance

The condition of vegetation in the immediate vicinity of the wetland was classified according to Semeniuk (1987) thus:

NATURAL VEGETATION IN WETLAND AND SURROUNDING AREAS
NATURAL VEG. IN WETLAND, UPLAND AREAS PARTLY MODIFIED
NATURAL VEG. IN WETLAND, UPLAND AREAS TOTALLY MODIFIED
WETLAND VEGETATION PARTLY MODIFIED OR WITH WEEDS
WETLAND VEGETATION TOTALLY CLEARED OR DESTROYED

Grazing

Most wetlands in the area are on farming land and are in varying degrees of protection from grazing stock. Three categories were recognised:

NOT GRAZED
GRAZING IN THE PAST (but now fenced)
STILL GRAZED

Salt and Waterlogging Damage

The vegetation in and around wetlands ranged from apparently healthy to destruction of all vegetation due to short-term or long-term increases in salinity and/or waterlogging levels. No attempt was made to separate the two effects. Three categories were selected:

NO APPARENT DAMAGE
MINOR DEATHS DUE TO SALT AND/OR WATERLOGGING
MAJOR DEATHS DUE TO SALT AND/OR WATERLOGGING

Water Trophic Level

The trophic status of wetlands with above-ground water at the time of surveying was classified subjectively on a scale of 1 (eutrophic) to 5 (oligotrophic) judging by the presence of algal blooms.

Vegetation Organisation and Cover

Nine basic wetland vegetation categories are recognised according to areal extent of vegetation and vegetation organisation (Semeniuk *et al.*,1990).

Organisation of vegetation	Areal extent of vegetation cover: Peripheral	Mosaic	Complete
Homogeneous	Periform	Paniform	Latiform
Zoned	Zoniform	Gradiform	Concentriform
Heterogeneous	Bacataform	Heteroform	Maculiform

Vegetation Formation and Association Type

The dominant vegetation formation types were broadly classified into Forest, Woodland, Mallee, Shrubland, Heath or Sedgeland. The main species associations were also recorded,.based on the dominant species of the overstorey.

2.3.2 Numerical Classification

Wetland characteristics were coded according to the fifteen major categories listed above. Within these major categories there were 95 sub-categories identified in the Coobidge Creek System. For the purposes of numerical classification and ordination, each sub-category was considered as a 'species' and each wetland as a 'site' in the conventional terminology of vegetation numerical analysis. The data set was treated as qualitative data and classified with a two-way indicator species analysis (TWINSPAN, Hill, 1979b) and ordinated using detrended correspondence analysis (DCA, Detrending-by-polynomials method, Ter Braak, 1988). Classifications and ordinations were performed on a Macintosh SE 30 micro-computer using the Fortran program CANOCO (Ter Braak, 1988). Three combinations of data sets were used in analyses. Firstly all data were included, secondly vegetation characteristics were omitted and finally only categories identifiable from aerial photographs were used in the analyses.

2.4 RESULTS

Forty of the 45 wetlands surveyed were basin types with an almost even distribution between permanently inundated (LAKES) and seasonally inundated or waterlogged basins (SUMPLAND, DAMPLAND). Five sites were studied on Coobidge Creek itself.

Only one wetland was of large scale (macroscale) being Lake Gore, 7 were medium scale and most were small scale wetlands. The creek samples were considered as small individual microscale wetlands rather than one very large megascale unit in Coobidge Creek.

The shape of basin wetlands was generally round to ovoid (31 sites) with some irregularly shaped (6) and a few elongated (3). Creek channels were sinuous (4) for most of the length of Coobidge Creek with one anastomising channel in the lower reaches where the channel spreads out into the sand dune system around Lakes Kubitch, Gidong and Karbul.

Only two wetlands contained fresh water, Moonanup Swamp and its neighbouring lake. The wetlands south of the South Coastal Highway were in the lower range of salinity being either fresh, hypo- or meso-saline. Between the South Coast Highway north to Boydell's Rd (mid-section) the range shifted to higher salinity categories from hypo-, meso-, hyper-saline and brine. In the top third of the catchment north of Boydell's Rd the range again shifted higher with meso-, hyper-saline and brine wetlands. Coobidge Creek was dry in the upper reaches, hypersaline towards the mid-section and meso-saline in the lower third. There were 14 dry wetlands sampled throughout the catchment at the time of surveying.

The pH levels of wetlands varied widely from highly acidic to alkaline. All 7 highly acidic wetlands were located in the north of the catchment. Wetlands in the lower two-thirds were mildly alkaline to alkaline except for an acidic section of Coobidge Creek in the mid-region which was presumably draining from acid wetlands further north.

All of the wetlands surveyed still had natural vegetation in the actual wetland environment with 5 sites having partly modified or partly cleared wetland vegetation. The surrounding upland area was partly or totally modified/cleared in 29 of 40 wetlands. 'Surrounding uplands' was taken as within 100-200m from the wetland proper. Many wetlands which were identified on the Department of Agriculture 1:50 000 map of the area were no longer wetlands, being totally cleared and incorporated into the farm's crop or pasture system. Traces of these totally cleared wetlands were visible on aerial photographs as a different colour shade to the surrounding cleared land.

Seventeen of the 45 surveyed sites had been extensively grazed by stock in the past but were subsequently fenced off from stock A further 17 sites were still being grazed due to lack of fencing or inadequate fencing. Eleven sites were regarded as ungrazed although this is difficult to interpret on an historical basis and there may have been some light grazing in the past.

Four sites were greatly affected by salinity and/or waterlogging with nearly complete death of wetland vegetation. Half the sites had minor deaths, particularly at the presumed 1989 high water level around the perimeter of basins. Creek lines had very few deaths attributable to high salt or water levels.

The trophic status of wetlands containing water was generally towards the oligotrophic end of the scale with 19 of the 31 sites containing water recording values of 4 to 5. Twelve sites were becoming eutrophic (trophic levels 2-3) including Lake Gidong, one of the largest lakes in the system. There was no apparent relationship between eutrophic wetlands and the degree of wetland vegetation disturbance.

Vegetation organisation was mostly peripheral (27 sites) with complete cover of 14 sites and mosaic or patchy cover on 4. Creek lines were difficult to assess and the 5 sites were classified as peripheral around a very narrow meandering watercourse (3) or as patchy with diffuse water flow through a flat-bottomed creek (2). The three main types of vegetation organisation were peripheral zoned (Zoniform, 13 sites), peripheral mosaic (Gradiform, 11 sites) and complete homogeneous (Latiform, 11 sites).

Melaleuca cuticularis dominated the association types in the catchment. Nine sites contained *M. cuticularis* predominantly by itself, 8 had a mixture of *M. cuticularis* and *Eucalyptus occidentalis* while 11 had *M. cuticularis* with other species. *Eucalyptus occidentalis* was the sole dominant at two wetlands while in the north it was associated with *Melaleuca calycina* in the understorey. Various Mallee and Shrubland associations were dominant in the northern part of the catchment. Creek lines in the north were commonly associated with *Melaleuca thyoides* and *Melaleuca bracteosa* Shrublands with a change to *Melaleuca cuticularis* and *Eucalyptus occidentalis* vegetation in the south.

2.4.1 Numerical Analysis

Complete Data Set

Twinspan classification of the 45 sites using all physical, chemical, biological and vegetation categories was interpreted at the third division where eight groups were identified (Fig. 2.9). The initial dichotomy was determined by the indicators: mallee vegetation formation and wetlands containing water for groups A-D with groups E-H indicated by dry wetlands and complete homogeneous (Latiform) vegetation organisation. Characteristics of each classification group are summarised in Table 2.3. Group A wetlands were all highly saline (hypersaline and brine), highly acidic, round-ovoid lakes with upland vegetation modified and peripheral wetland vegetation organisation dominated by *Melaleuca nesophila* and *Eucalyptus redunca*. All six group A sites were located in the north of the catchment in the Scaddan Land System (Fig. 2.10). Group B sites were a variety of wetland types but were highly saline, mostly mildly alkaline, with natural wetland and upland vegetation containing mallee and shrubland formations peripheral around the wetland. *Melaleuca cuticularis* Shrublands were indicative of groups C and D which were all mildly alkaline to alkaline and hypo- to meso-saline. The two sites in group D were all creek wetlands. Sites on the right half of the classification were either dry or relatively low salinity water quality. Group E sites all have seasonal water coverage with vegetation mostly covering the wetland (Latiform, Concentriform), upland vegetation modified or cleared and some form of grazing in the past or present. The three wetlands in group F have more permanent water (Lakes) than those in group E and contain sites 92 (Moonanup Swamp) and 93, two large freshwater lakes which are not strictly in the Coobidge Creek catchment but were included for comparison as freshwater lakes are rare in the district. The final arm of the classification containing groups G and H were all located in the Scaddan soils in the north of the catchment (Fig. 2.10) and contained heath vegetation, particularly *Eucalyptus occidentalis* and *Melaleuca calycina*. Site 1 in group H should probably be grouped with the four sites in group H except that it contained water at the time of survey. If site 1 were grouped with 76 and 77 then the other arm would probably contain sites 80 and 82, both sinuous creeks with different vegetation associations than 1, 76 and 77.

Ordination of this data set produces a distribution of sites which can be interpreted on water quality characteristics (Fig. 2.11a-b). Disregarding the dry sites in the top right of the ordination, there is a tendency for decreasing salinity from hypersaline and brine sites on the left of axis 1, meso- and hypo-saline sites to the centre and the two fresh wetlands on the right side. Highly acidic and acidic sites are towards the high end of axis 2, mildly alkaline sites generally in the middle of axis 2 and alkaline sites low on axis 2. There was no particular pattern of distribution of Semeniuk wetland types on the ordination (Fig. 2.11c). Vegetation associations followed a 'loose' pattern with sites not containing *Melaleuca cuticularis* in the top left of the ordination, and *Eucalyptus occidentalis* sites generally high on axis 1 (Fig. 2.11d). Axis 2 was associated with the location of sites in the catchment with an increase in distance north corresponding with an increase in position along axis 2 (Fig. 2.11e).

Physical, Chemical and Biological Data Set

Sixty four attributes ('species') were used in the numerical analysis of wetlands using physical, chemical and biological data i.e. without vegetation organisation, formation and association types. The first division of the Twinspan classification was determined mainly by dry wetlands for the left half of the classification (Fig. 2.12). Group A wetlands were in the Scaddan system with a Scaddan Sand soil type and had no salinity/waterlogging damage. The two sites in Group B were both hypersaline, highly acidic lakes with no salinity/waterlogging damage. Groups C and D were mainly dry Damplands and Sumplands in the Esperance Land System. The largest groups in the second half of the classification, groups E and F were separated by Group E being generally more saline and less alkaline than Group F which also had a predominance of Lakes. There were other trends but not consistent differences between these two groups. Group G contained the highly saline, acidic wetlands (mostly lakes) in the north of the catchment that contained water. The only site in Group H was a creek site in the Young Land System.

Ordination of this modified data set again split the dry sites off to the high end of axis 1. The salinity and pH gradients were less obvious in this ordination (Fig. 2.13a-b). The different land systems are reasonably well identified on the ordination (Fig. 2.13c) with the Gore system on the left of axis 1. The Semeniuk wetland types are better defined in this second ordination with Creeks on the low end of axis 2, Damplands grouped in the middle of axis 2 and the right of axis 1, Sumplands grouped in the middle of axis 2 and Lakes loosely spread out in the top left of the ordination (Fig. 2.13d). The position of the wetlands in the catchment followed a pattern of increasing distance north along a diagonal moving from top left to bottom right of the ordination.

Although vegetation characteristics were not used in this ordination, overlaying vegetation association types onto the ordination (Fig. 2.13e) resulted in a favourable grouping of *Melaleuca cuticularis* - dominated sites left on axis 1, *Eucalyptus redunca* and *Melaleuca nesophila* sites towards the middle of the ordination, but *E.occidentalis* sites are spread out further than in Figure 2.11d.

Aerial Photograph Data Set

Numerical analysis of the 45 wetlands using the criteria assessable from aerial photographs included 46 attributes from the categories of wetland type, size, shape, vegetation organisation and vegetation formation type.

The first division of sites in the Twinspan classification divided the 45 sites into 29 in groups A-D and 17 in groups E-H, mostly on the basis of creeks and lakes in A-D and Sumplands and Damplands in E-H (with some exceptions). All creek sites are grouped together in group B with the group A site possibly a mis-classified site. The largest group, group C, are all Lakes which are mostly round shaped and with zoniform vegetation organisation. Bacataform lakes and sumplands dominate group D. Groups E and F are mostly damplands with Shrubland/Woodland vegetation formations in group E and a mixture of sites in group F. Group G are all sumplands with mostly latiform vegetation organisation. The final group H includes two lakes of meso-scale with latiform vegetation organisation.

The ordination resulted in a good separation of Semeniuk wetland types with creeks low on axis 1, damplands high on axis 1, sumplands in the middle of axis 1 and low on axis 2 and lakes all in the middle of axis 1 and towards the high end of axis 2. (Fig. 2.14a). The ordination does not identify patterns in water quality (Fig. 2.14b) and vegetation (Fig. 2.14c) associations are also scattered throughout the ordination even more so than in the other ordinations. There was no relationship between wetland position in the catchment with site distribution on the ordination.

2.5. DISCUSSION

The categories adopted by Semeniuk (1987) in describing wetlands in the Darling System were generally easy to apply. Wetland size and shape categories are readily assessed from aerial photographs with little need for ground truthing. However, water permanence may be assessed wrongly from once-only site surveys and sites may be classified as permanent when in fact they may be seasonal.

We interpreted creek survey sites along Coobidge Creek as individual components (micro scale) rather than as one large creek system (macro scale). The differences in water quality and vegetation types along the length of Coobidge Creek indicates that this step was warranted. It was also difficult to assess gradational wetland types i.e. wetlands that could be described by more than one category. In particular, small elongated wetlands could be categorised as either a sumpland or a short creek. In periods of high rainfall such wetlands may form continuous creek lines but otherwise act as sumplands. An intermediate category such as sumpland/creek may be the appropriate terminology in such cases to identify that the wetland is intermediate and not one or the other. The use of such intermediate categories could be extended to all the type descriptions where necessary, but should be kept to a minimum to maintain simplicity.

The classification of vegetation organisation was mostly straightforward particularly after the publication of the wetland vegetation classification paper of Semeniuk *et al.* (1990). However, the decision on where exactly the wetland vegetation stopped was sometimes arbitrary for peripheral vegetation which can change very quickly with several sequences of vegetation associations upslope from the wetland floor. The accuracy of vegetation classification decreased with increasing disturbance and clearing of the wetland vegetation.

Water quality consistency i.e. the variation in water salinity classes over time, was not assessable with just one site visit. A more conclusive assessment of wetland water quality would require analysis over time of not only salinity but pH, nutrient levels and turbidity data. Trophic level, as recorded in this report, was of limited value in defining wetland groups. This is due, in part, to trophic level being dependent on recent man-induced changes to the wetland/catchment and is not necessarily related to geomorphology or origin.

A possible refinement of water salinity categories is suggested. The hyposaline (3 000 - 20 000 mg/l) range was regarded as too wide. On the basis that biological threshholds (particularly vegetation composition) exist within this range, a greater definition between wetland types would be achieved if the range were to be split into two narrower ranges. Flora and fauna species composition is expected to vary greatly over the range as salinity tolerances vary markedly between species. Suggested ranges are 3 000 - 10 000 mg/l and 10 000 - 20 000 mg/l.

While many of the Semeniuk categories can be determined from aerial photographs, classification using only these categories was not sufficient in the Coobidge Creek system and, presumably, in all south coast wetland systems. The same can be said if just the primary categories of Semeniuk were used. The reason behind this is because water quality was extremely important in defining wetlands The results of this study strongly recommend the use of water quality parameters in refining the classification of wetlands. The variation in salinity in the small Coobidge Creek system was extreme with a range from fresh (0.5 ppt) to brine (>200 ppt) and followed a gradient of increasing salinity with increasing distance north. This pattern was identified in the ordination using all categories and also when vegetation characteristics were omitted. Therefore, in this study, the use of only geomorphic characters in defining groups would not have reflected the diversity of wetlands and all their biological implications. The detail of a classification system, however, should be in accordance with its intended use. Inventories may require very simple or no information on water quality. The Semeniuk classification system is flexible enough to enable the addition of more categories as required and this is important if the system is to be applied to the wetland diversity of the south coast region. The wetlands of the Darling System do not vary in water quality to such an extreme as on the south coast and apparently can be more readily classified just by aerial photography and identification of geomorphic units (Semeniuk, 1989).

The presence of waterbirds was noted during the wetland survey and, although the survey was very minimal, some interesting patterns were observed. Wetland sites with waterbirds were positioned low on axis 2 in ordination Figure 2.15. These sites corresponded to lakes or sumplands with relatively low salinity water (hypo- and meso-saline) and mildly alkaline to alkaline pH. The use of secondary wetland water quality characters is again emphasized as being as important as geomorphic characters in describing wetland types.

Incorporation of disturbance categories added little to the wetland classification and ordination. However, such categories of wetland and upland vegetation clearing, weeds, grazing, and salinity/waterlogging damage could provide useful information for management of important individual wetlands or groups of wetlands.

Table 2.1 Soil types and landform descriptions within the Coobidge Creek catchment

	SOIL TYPE		
	a. <u>Esperance Land System</u>		
1	Gravelly, yellow, mottled duplex soil. Gravel layer <30cm deep	Fleming gravelly sand	Dy5.02
2	Gravelly, yellow, mottled duplex soil. Gravel layer 30-80cm deep	Fleming and Gibson sand	Dy5.82
3	Podzol (deep uniform sand)	Corinup sand	Uc2.21
4	Yellow, mottled duplex soil with a columnar strucutred subsoil	Boyatup sand	Dy5.42
	b. <u>Scaddan Land System</u>		
3	Podzol (deep uniform sand)	Heart Echo sand	Uc2.21
7	Alkaline, yellow, duplex soil with a columnar structured subsoil	Scaddan sand	Dy4.43
8	Alkaline, yellow duplex soil	Circle Valley sand	Dy4.83
9	Olive-grey clacareous gradational soil	Beete calcareous sandy loam	Gcl1.12
10	Brown uniform sand	Red Lake sand	Uc5.11
11	Red-brown, calcareous gradational soil	Kumarl clay loam	Gcl1.12
	c. <u>Young Land System</u>		
Y3	Podzol (deep uniform sand)	Corinup sand	Uc2.21
Y4	Alluvial sand	Dalyup sand	Uc5.11
Y1	Yellow, duplex soil - rock association		Dy4.82

Table 2.1 (cont.)

LANDFORM

MAP SYMBOL	LANDFORM DESCRIPTION
	a. Esperance and Scaddan Land System
I	Level plain; slope <1%; relief <9m
G	Gently undulating plain; slope 1-3%; relief <9m
U	Undulating plain; slope 3-10%; relief 9-50m
Ur	Undulating rises; slope 3-10%; relief 9-50m
V	Minor incised river valleys; slope 3-10%; relief <30m
D	Longitudinal sand dunes
H	Lunettes
	b. Young Land System
Y4	Alluvial floodplain
Y1	Major incised river valleys; slopes 3-10%; relief >30m
Y5	Poorly drained, saline valley floors
	c. Common Landform Elements to All Systems
S	Salt affected land
Sd	Saline drainage lines
R	Outcrops of granite bedrock
Cs	Salt lakes
Cp	Paperbark swamps
Cy	Yate swamps
Cd	Winter wet waterlogged depressions

Table 2.2 Wetland categories according to scale

(A) BASINS AND FLATS

-	Megascale:	Very large scale wetlands larger than 10km x 10km
-	Macroscale:	Large scale weltands between 1000m x 1000m to 10km x 10km
-	Mesoscale:	Medium scale wetlands between 500m x 500m to 1000m x 1000m
-	Microscale:	Small scale wetlands between 100m x 100m to 500m x 500m

(B) CHANNELS
(width to length relationship)

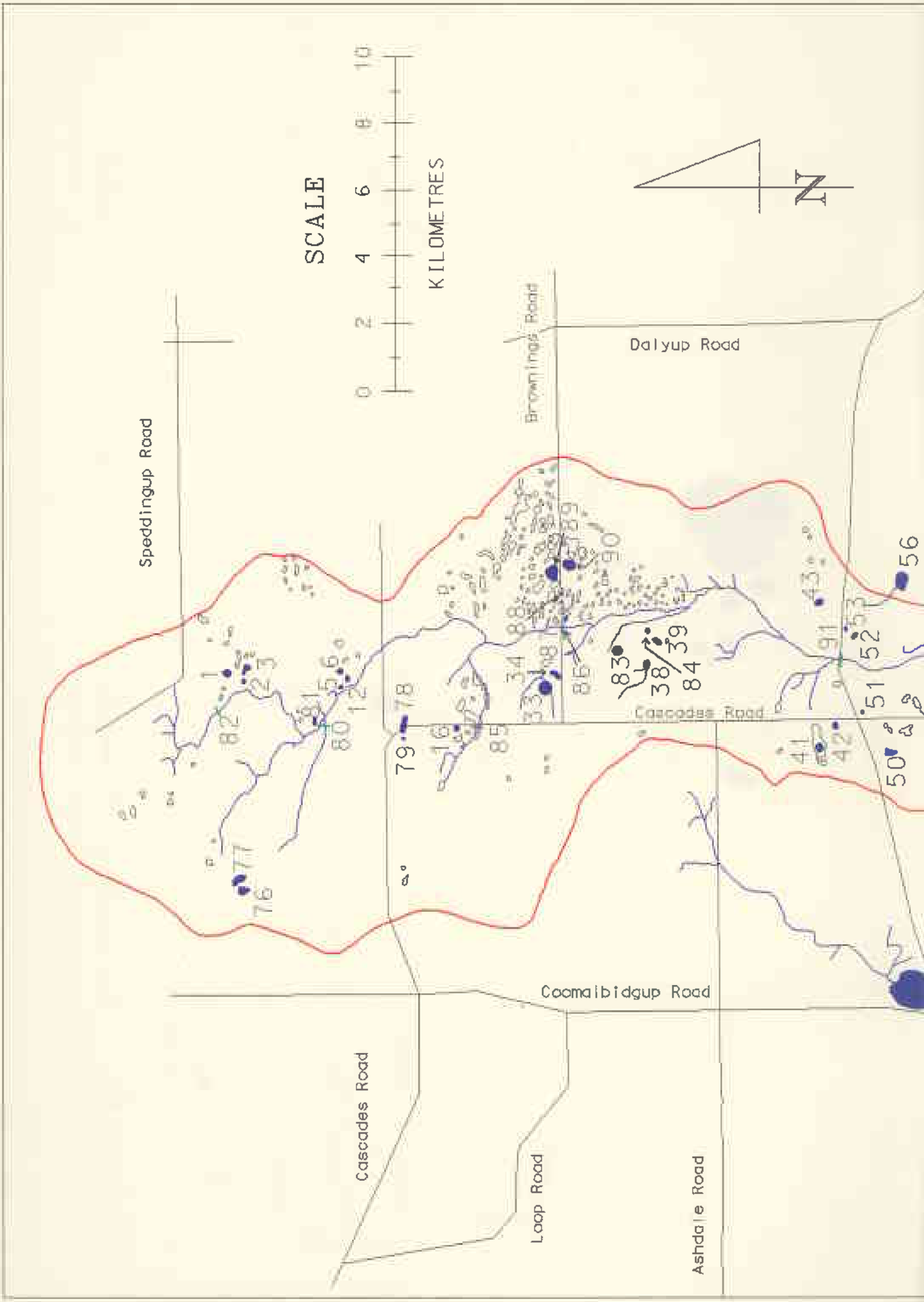
-	Macroscale:	Large scale channels 1 km and greater wide, by several to tens of kilometres long.
-	Mesoscale:	Medium scale channels hundreds of metres wide, by thousands of metres long.
-	Microscale:	Small scale channels tens of metres wide, hundreds of metres long.
-	Leptoscale:	Fine scale channels several metres wide, tens of metres long

Table 2.3 TWINSPAN classification groups with indicators for each category

	LANDFORM	LAND SYSTEM	SOIL TYPE	TYPE	FORMATIONS	ASSOCIATIONS
GROUP A	UNDUL., LEVEL PLAIN	SCADDAN	G2, G7, G10, L7	LAKE	SHRUBLAND/MALLEE	E. redunca, M.nesophila, M. uncinata
GROUP B	LEVEL PLAIN, LUNETTE	ESPERANCE	L1, L2, H3	SUMPLAND, LAKE, CREEK	SHRUBLAND/MALLEE	M.bracteosa, M. cuticularis, M. uncinata
GROUP C	UNDUL. PLAIN, SAND DUNE	ESPERANCE, GORE	D3, G1, G2, H1, L1	LAKE	SHRUBLAND/MALLEE	M cuticularis
GROUP D	PR. DRAIN PL, VALLEY	GORE, YOUNG	W16, Y1	CREEK	SHRUBLAND/WOODLAND	M.cuticularis/E occidentalis
GROUP E	UNDUL.-LEVEL PLAIN	ESPERANCE	G1, L2, G2, L2, L1, G3, G4	SUMPLAND-DAMPLAND	SHRUBLAND/WOODLAND	M cuticularis/E occidentalis
GROUP F	UNDUL. PLAIN	ESPERANCE	G4, G1	LAKE	SHRUBLAND/WOODLAND	M cuticularis/E occidentalis
GROUP G	UNDUL. PLAIN	SCADDAN	G7, L7	SUMPLAND, CREEK	HEATH/SHRUB, WOOD, MALLEE	E.occidentalis/M.calycina
GROUP H	LEVEL PLAIN	SCADDAN	L7	SUMPLAND	HEATH/WOODLAND	E occidentalis/M.calycina

	SALINITY	PH	VEGE. DISTURBANCE	GRAZING	SALINITY DAMAGE	TROPHIC LEVEL
GROUP A	HYPERSALINE-BRINE	HIGHLY ACIDIC	WETLAND NAT. UPLAND MOD	GRAZED PAST OR STILL	NONE-MINOR	4 - 5
GROUP B	HYPERSALINE-BRINE	MILDLY ALKALINE	NATURAL- WETLAND MOD	NOT GRAZED, PAST	NONE-MINOR	4 - 6
GROUP C	MESO-HYPOSALINE	ALKALINE	NATURAL- MOD	NOT GRAZED, STILL, PAST	NONE-MINOR	2 - 4
GROUP D	MESOSALINE	MILDLY ALKALINE	WETLAND NAT. UPLAND MOD	STILL GRAZED	NONE	3 - 4
GROUP E	DRY-MESOSALINE	DRY-ALKALINE	WETLAND NAT. UP MOD	GRAZED IN PAST, STILL	NONE-MAJOR	6
GROUP F	FRESH-HYPOSALINE	NEUTRAL-ALKALINE	WETLAND NAT. UP CLEARED	GRAZED STILL, PAST	MINOR DEATHS	3
GROUP G	DRY	DRY	WETLAND NAT. UPLAND MOD	GRAZED IN PAST	NONE	1
GROUP H	MESOSALINE	HIGHLY ACIDIC	WETLAND NAT. UPLAND MOD	STILL GRAZED	MINOR DEATHS	3

THIS IS A BLANK PAGE



E:\PROJ\SOUTH\COOBIDGE.DGN Jan. 25, 1991 11:31:30 SCALE 1:150 000

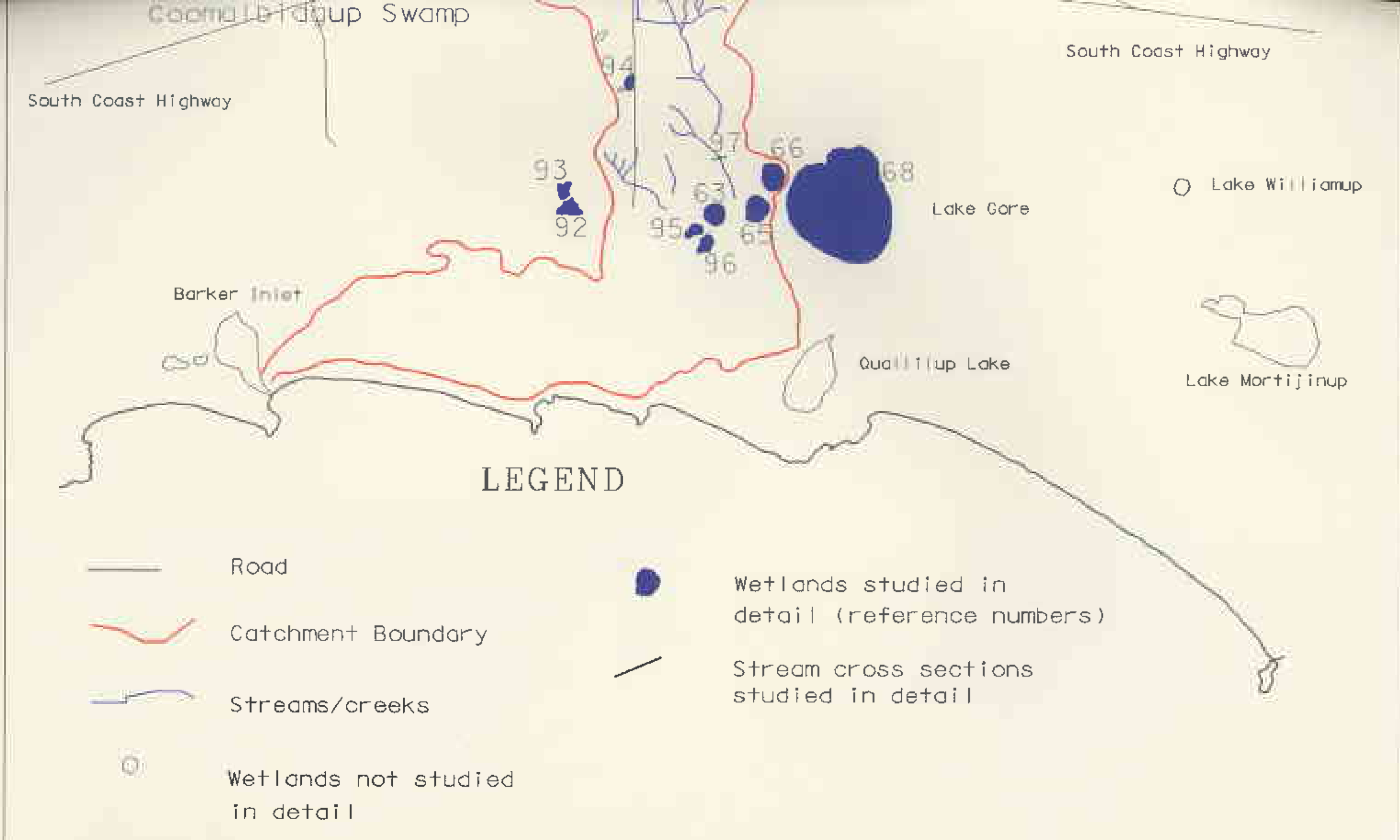
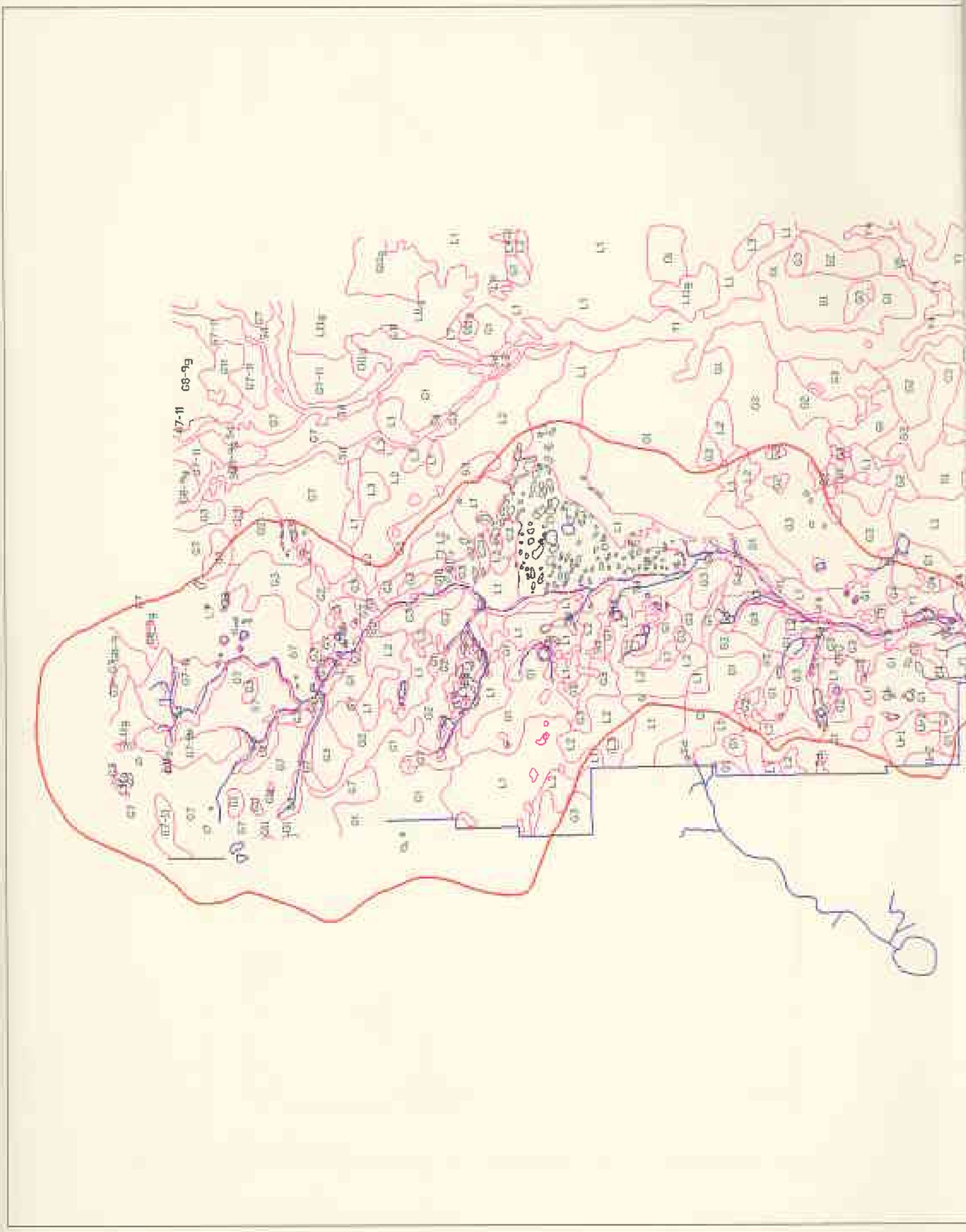


Figure 2.1 Location of Wetlands in the Coobidge Creek Catchment



C:\SOUTHCAT\COOBIDGE\COOBIDGE.DGN Jan. 25, 1991 12:24:57 SCALE 1:150 000

Figure 2.2 Soil unit categories around wetlands of the Coobidge Creek Catchment

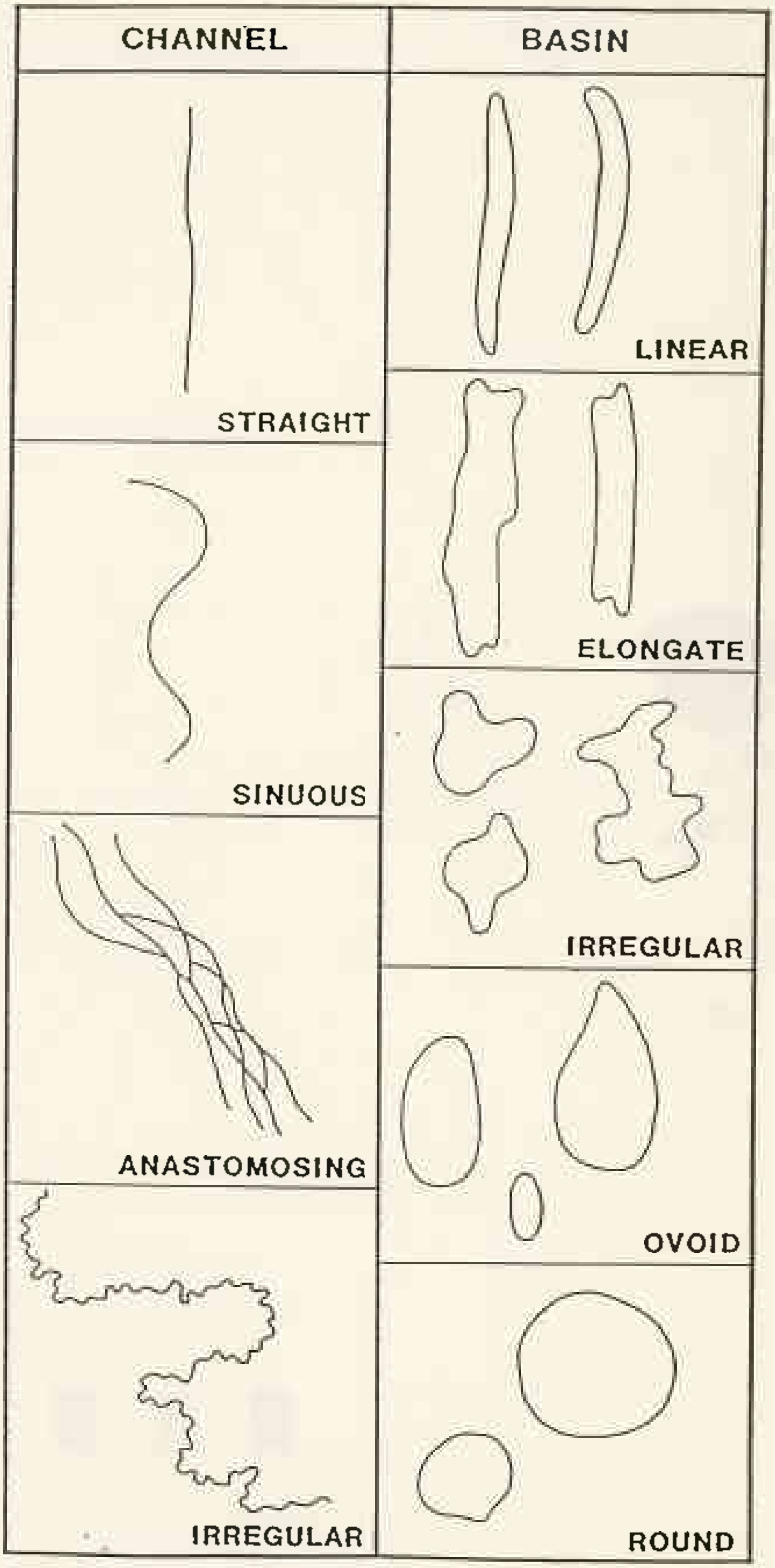
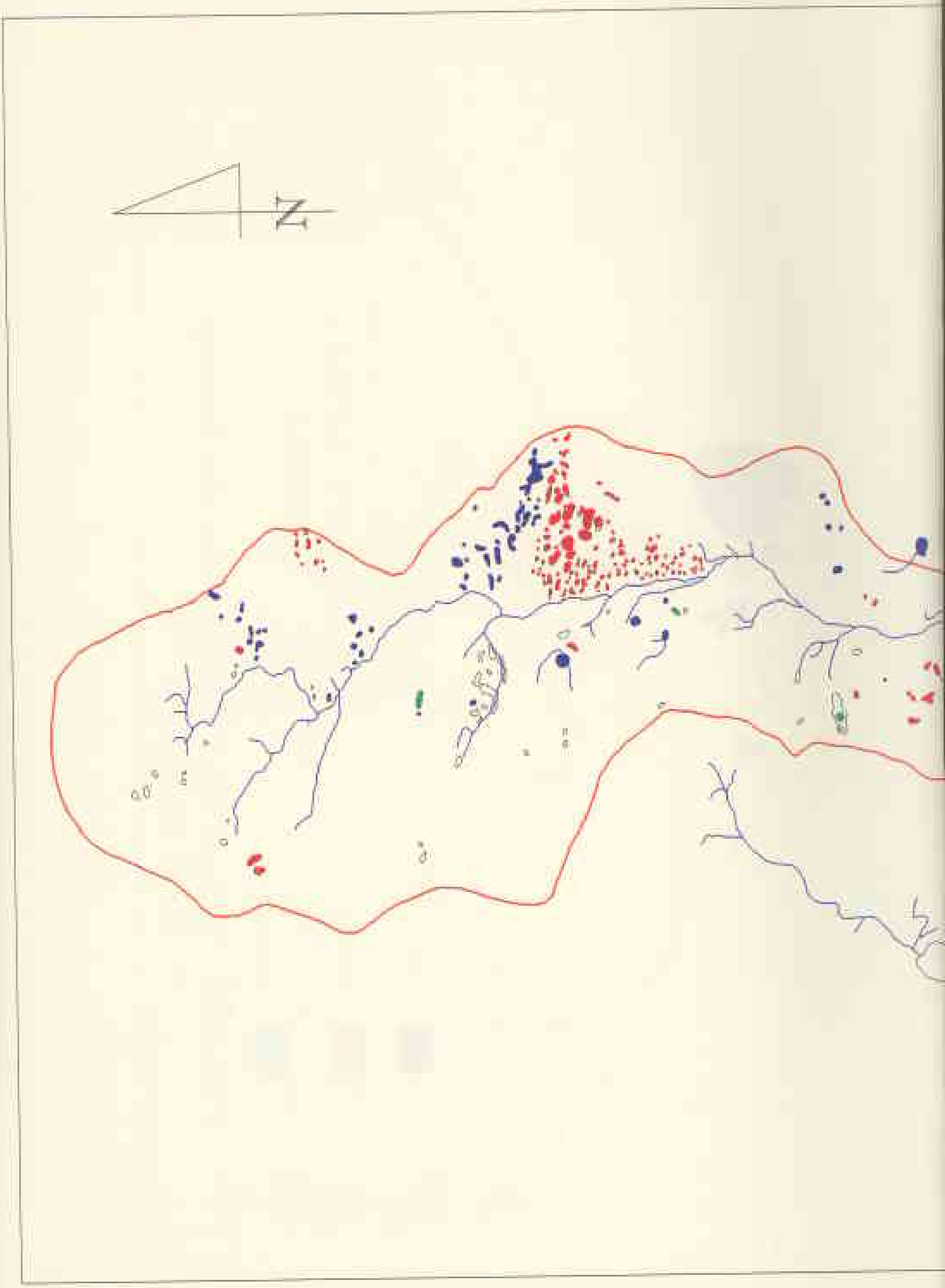


Figure 2.3 Plan geometry of wetlands (from Semeniuk 1987b)

THIS IS A BLANK PAGE



C: \SOUTHCAT\COOBIDGE\COOBIDGE.DGN Jan 25, 1991 11:55:24 SCALE 1:150 000

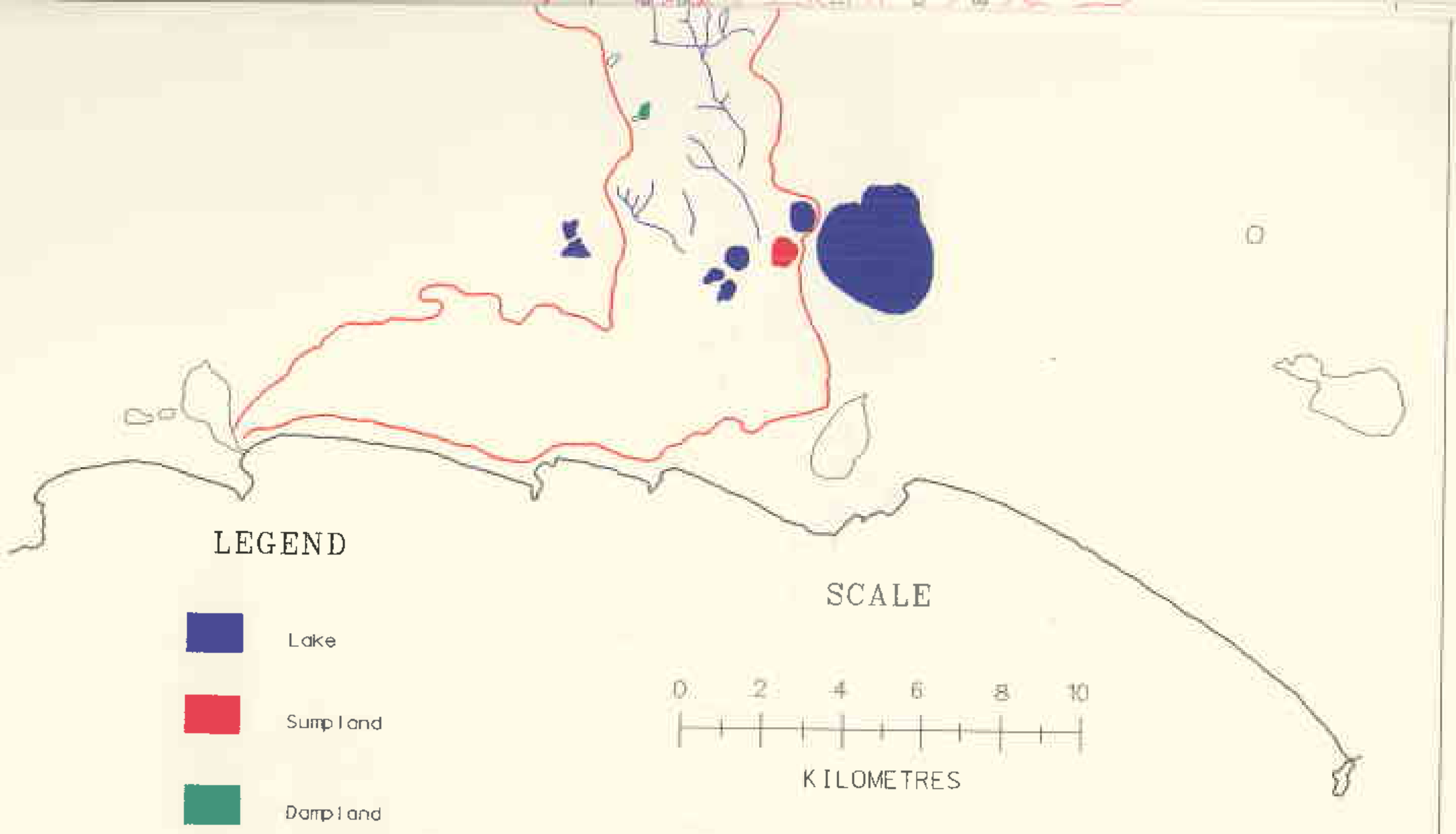
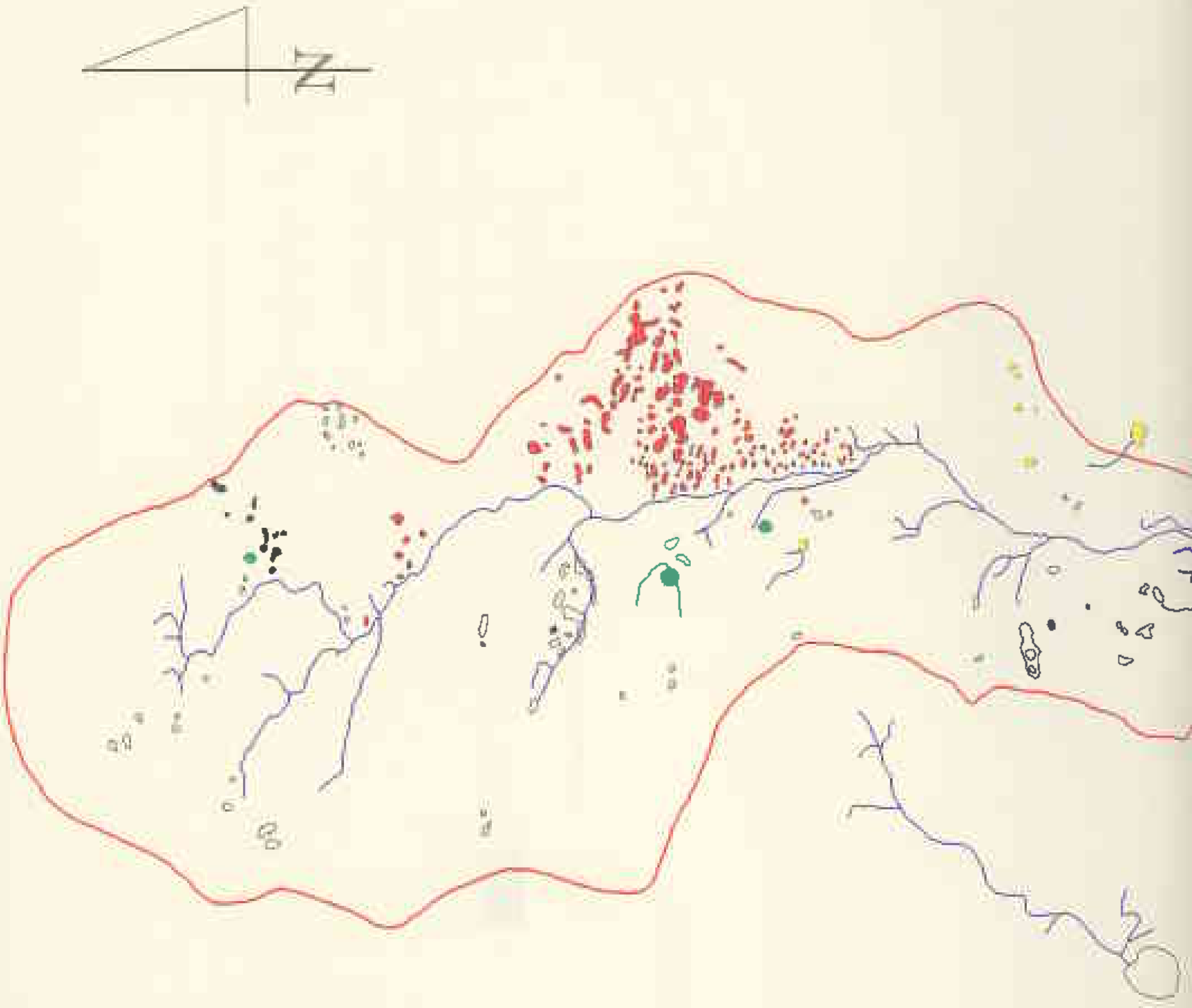


Figure 2.4. Wetland type categories in the Coobidge Creek catchment



E:\PROJ\SOUTH\CDOBIDGE.DGN Jan. 25, 1991 11:59:46 SCALE 1:150 000

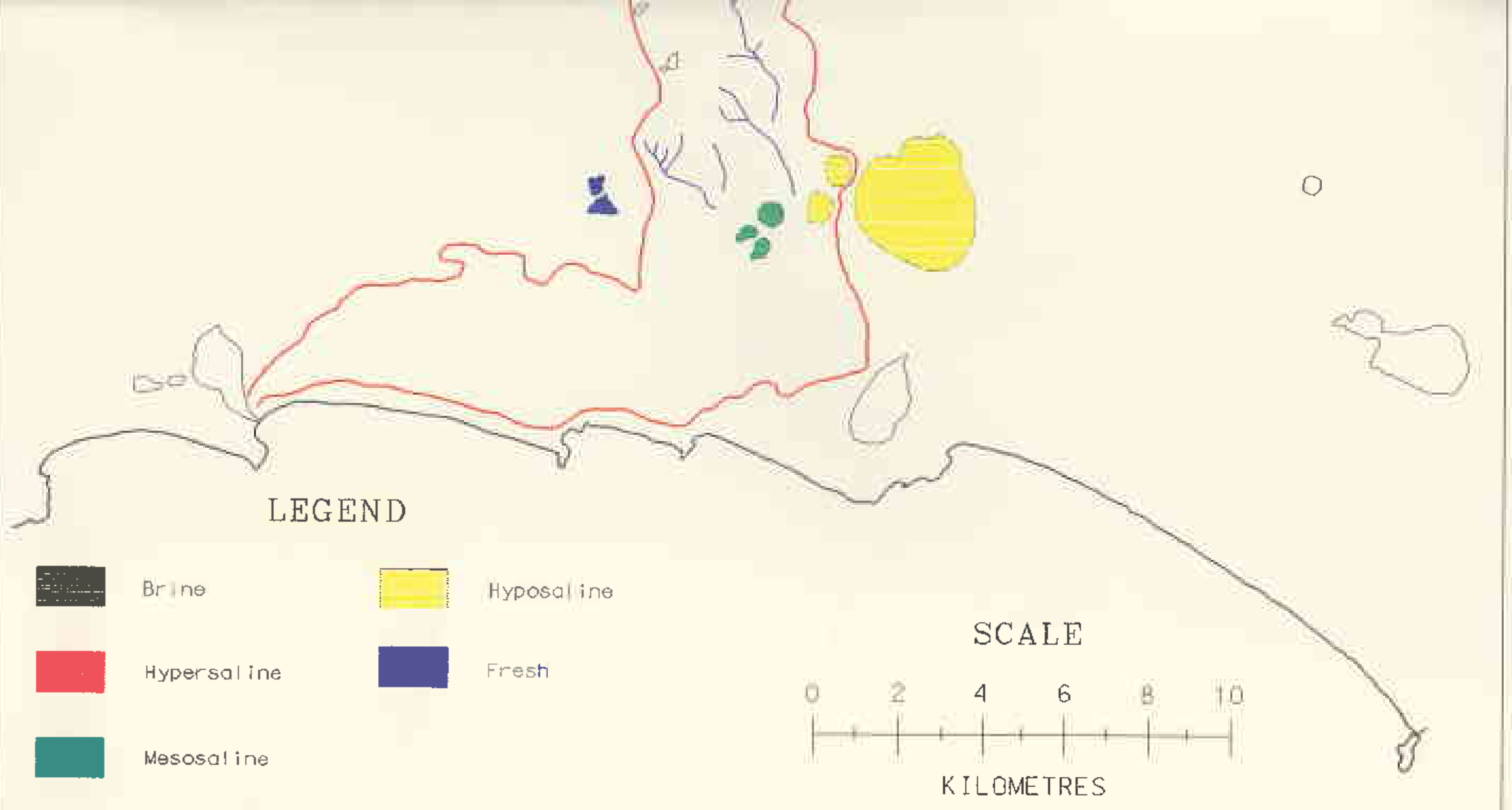
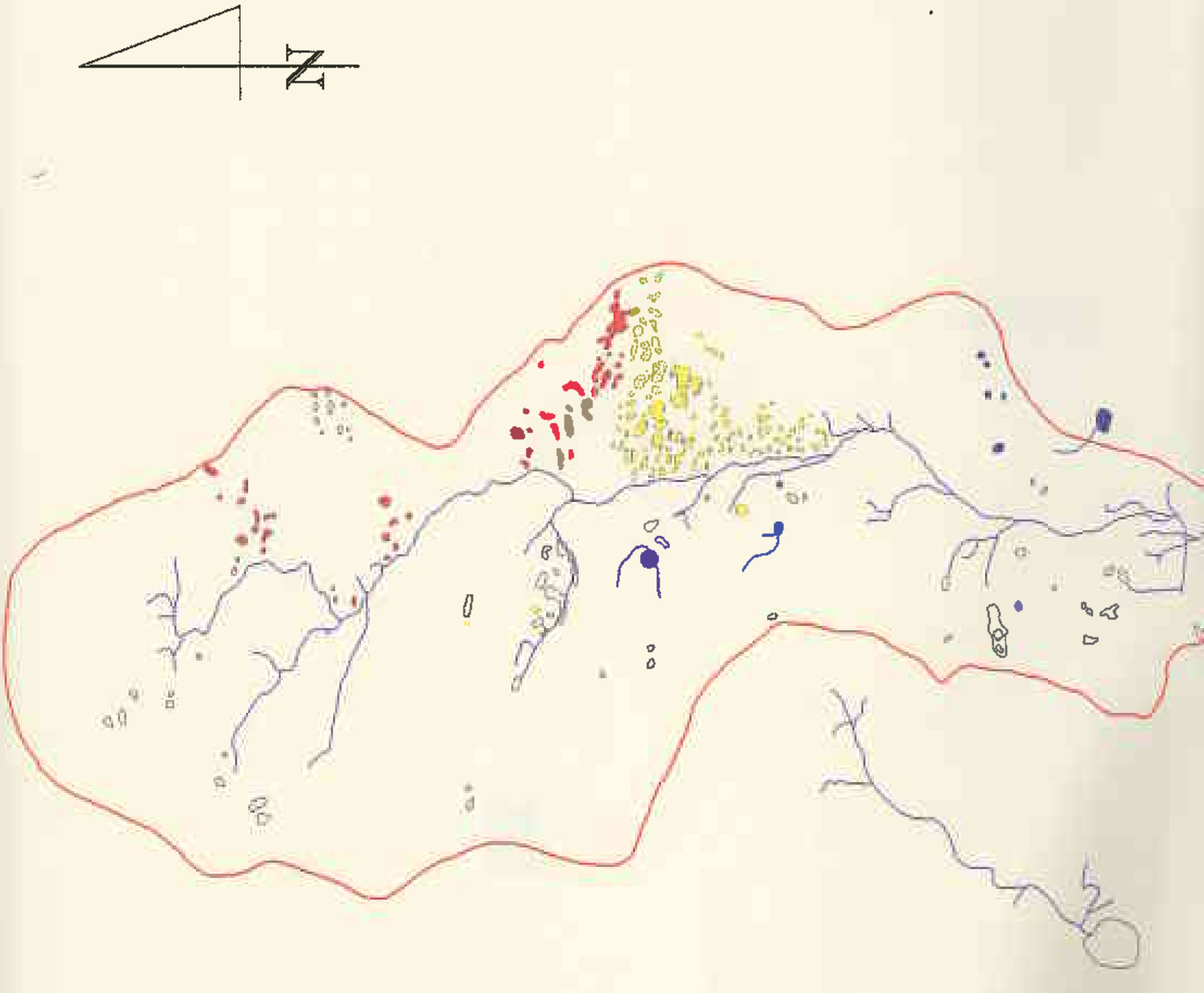


Figure 2.5. Water salinity categories in wetlands of the Coobidge Creek Catchment



E:\PROJ\SOUTH\COOBIDGE.DGN Jan. 25, 1991 12:04:42 SCALE 1:150 000

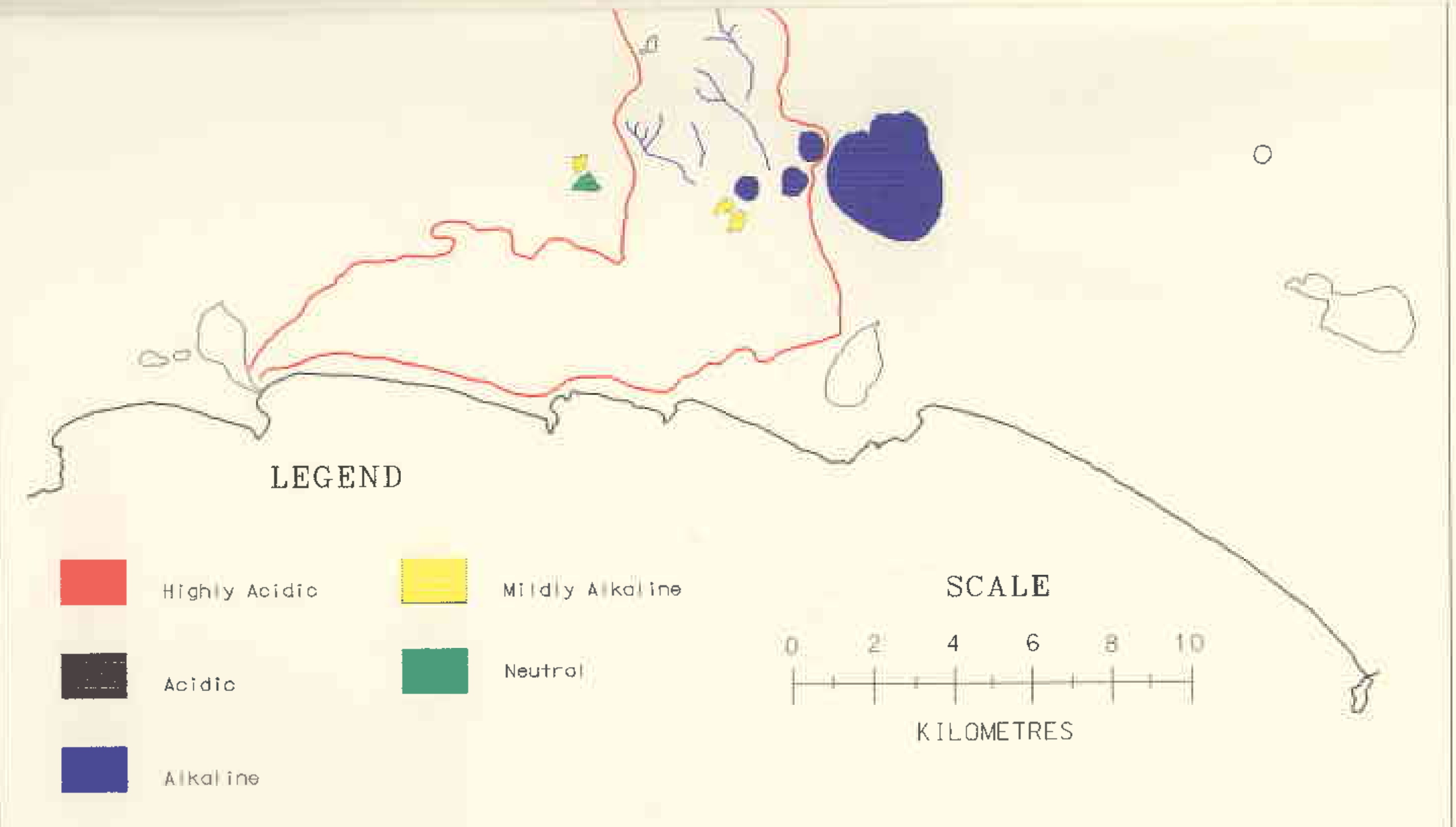
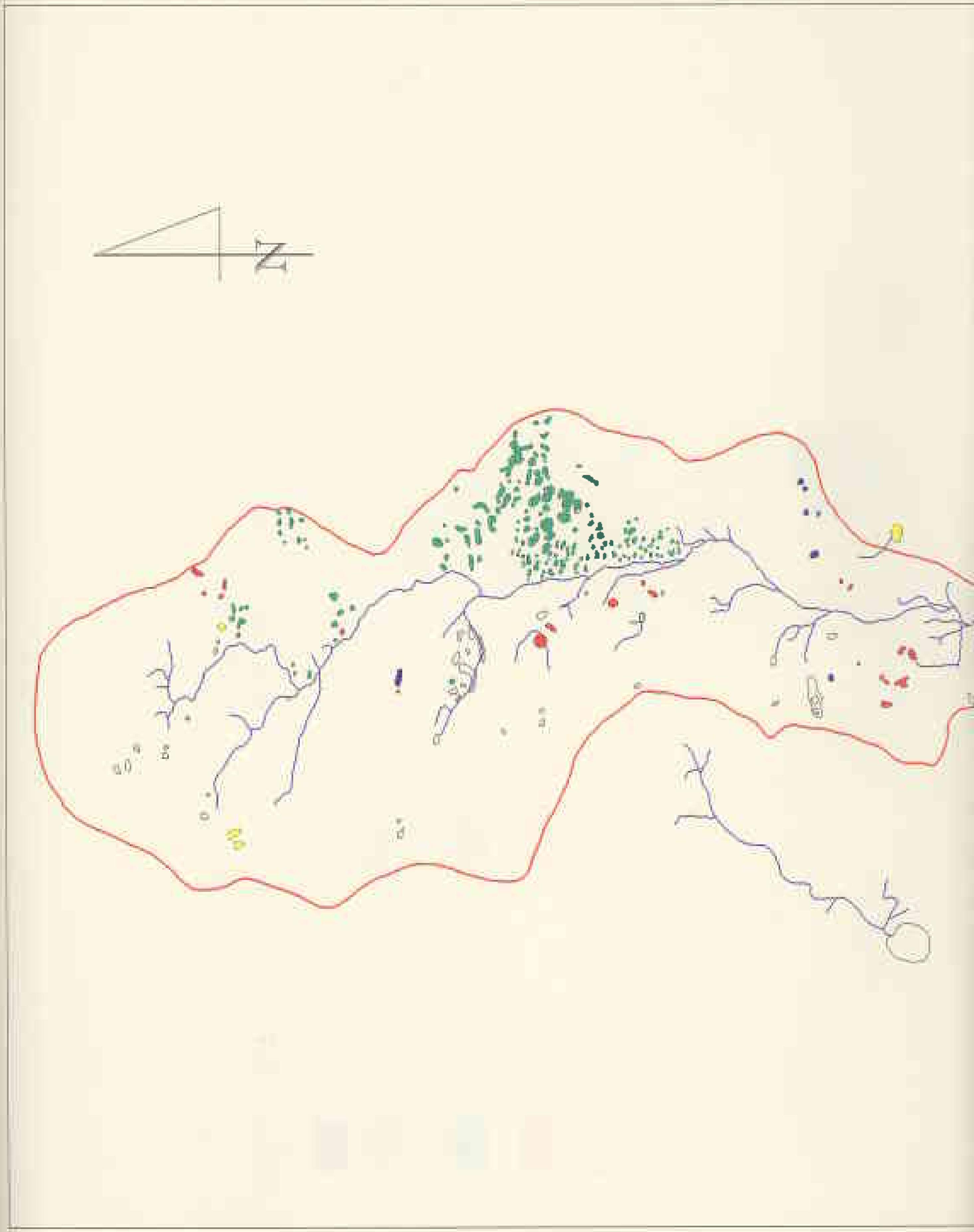


Figure 2.6. Water pH categories in wetlands of the Coobidge Creek Catchment



E:\PROJ\SOUTH\COOBIDGE.DGN Jan. 25, 1991 12:17:47 SCALE 1:150 000

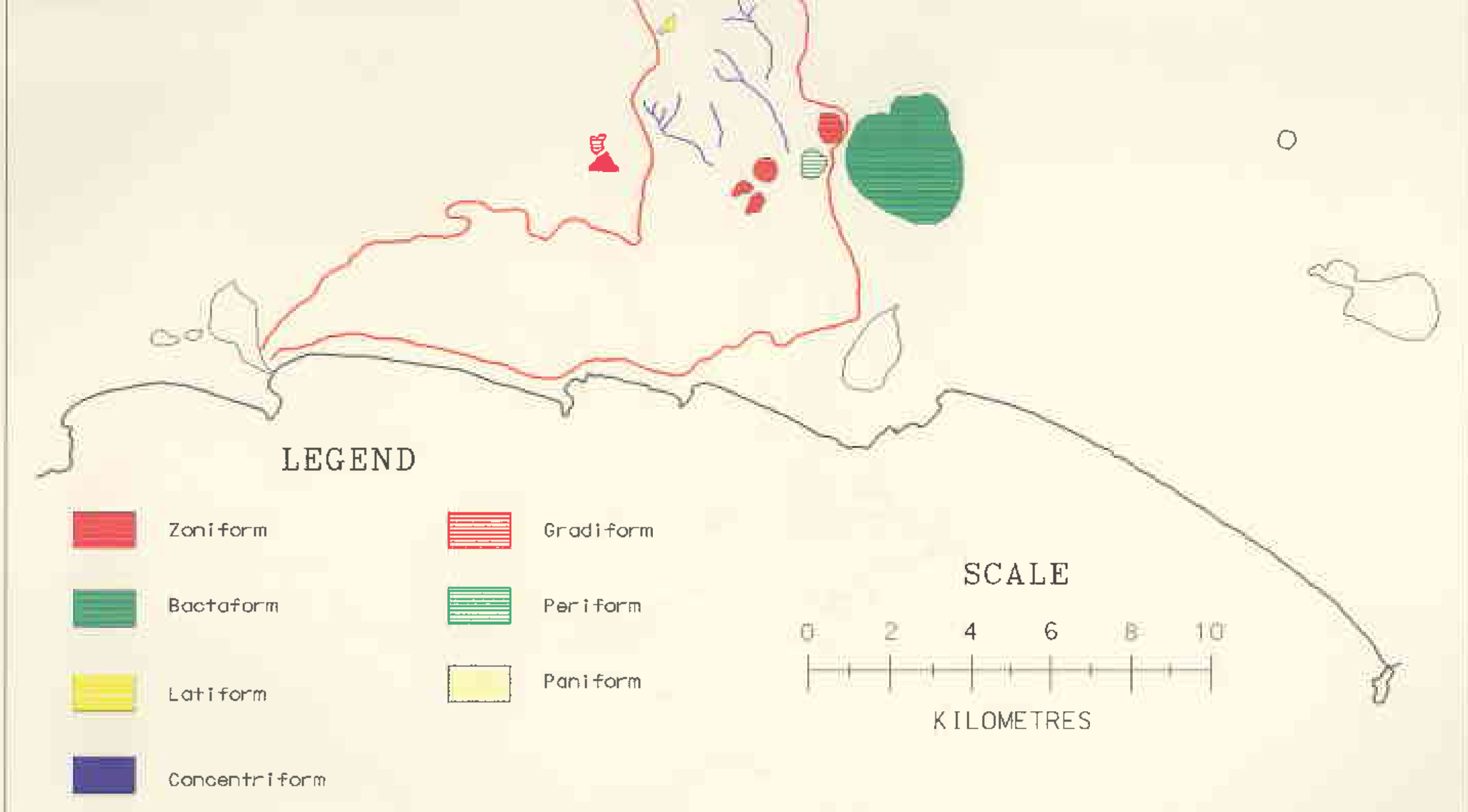
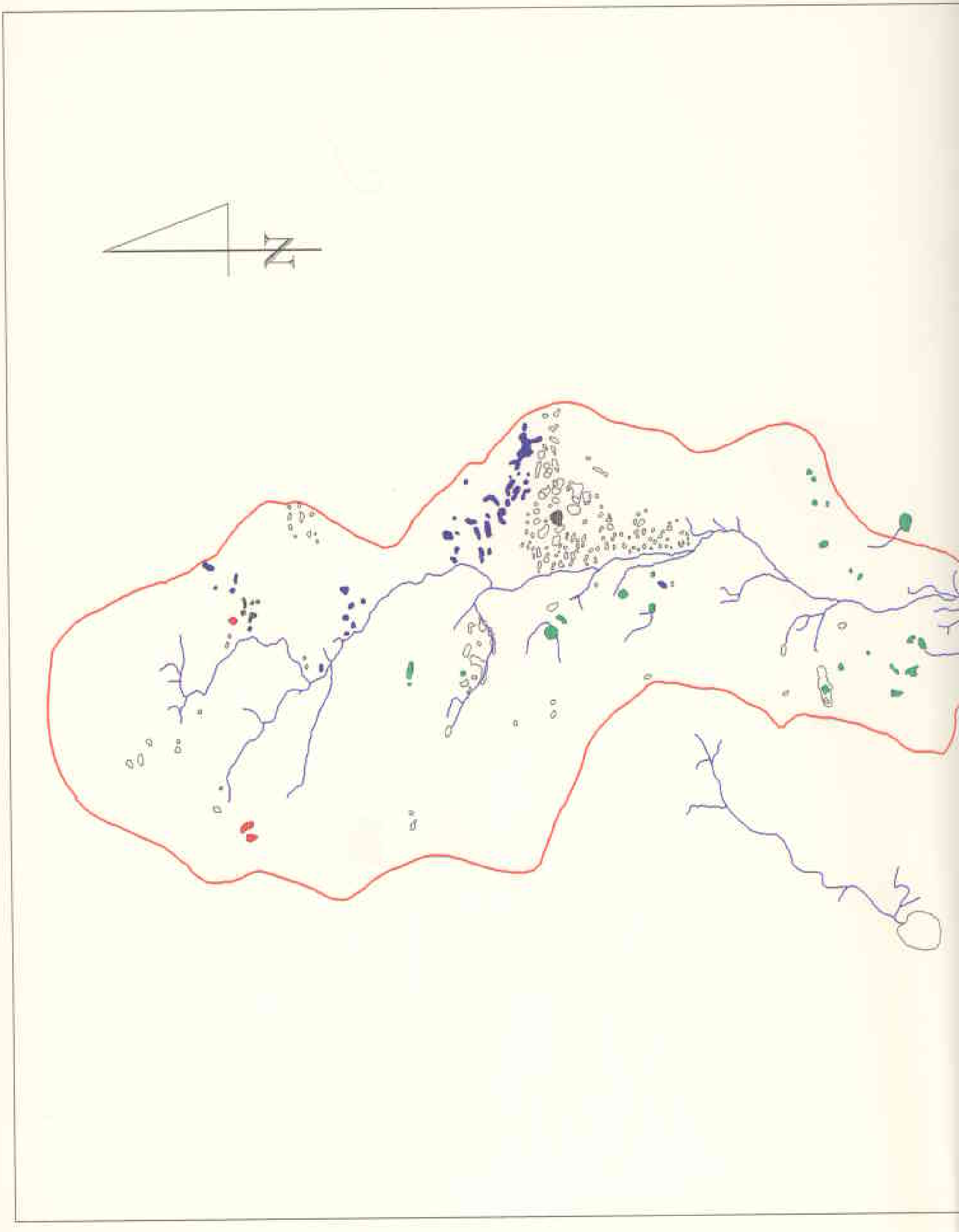


Figure 2.7 Vegetation organisation patterns in wetlands of the Coobidge Creek Catchment



E:\PROJ\SOUTH\COOBIDGE.DGN Jan. 29, 1991 09:10:59 SCALE 1:150 000

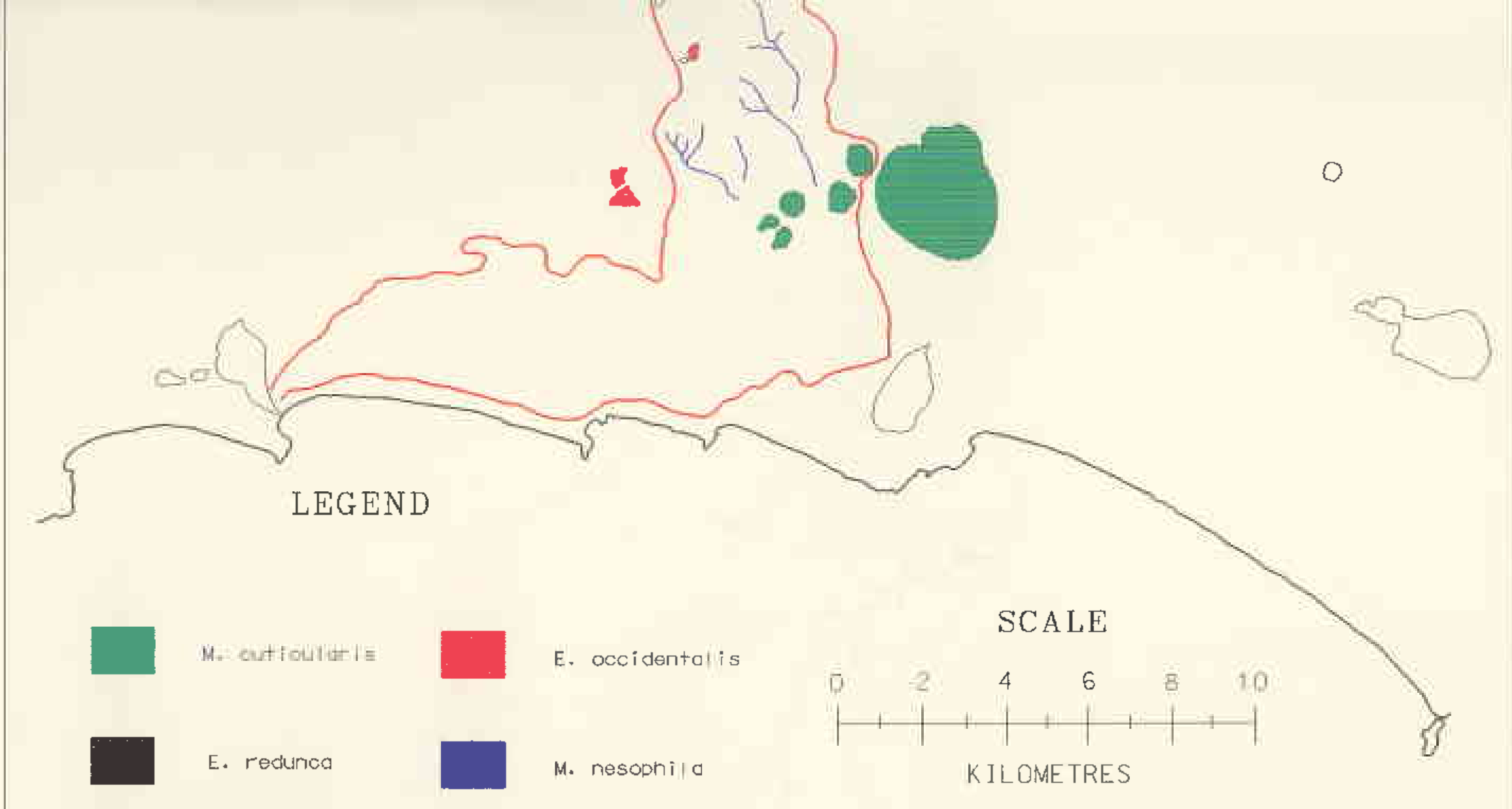


Figure 2.8 Major species distribution in and around wetlands of the Coobidge Creek Catchment

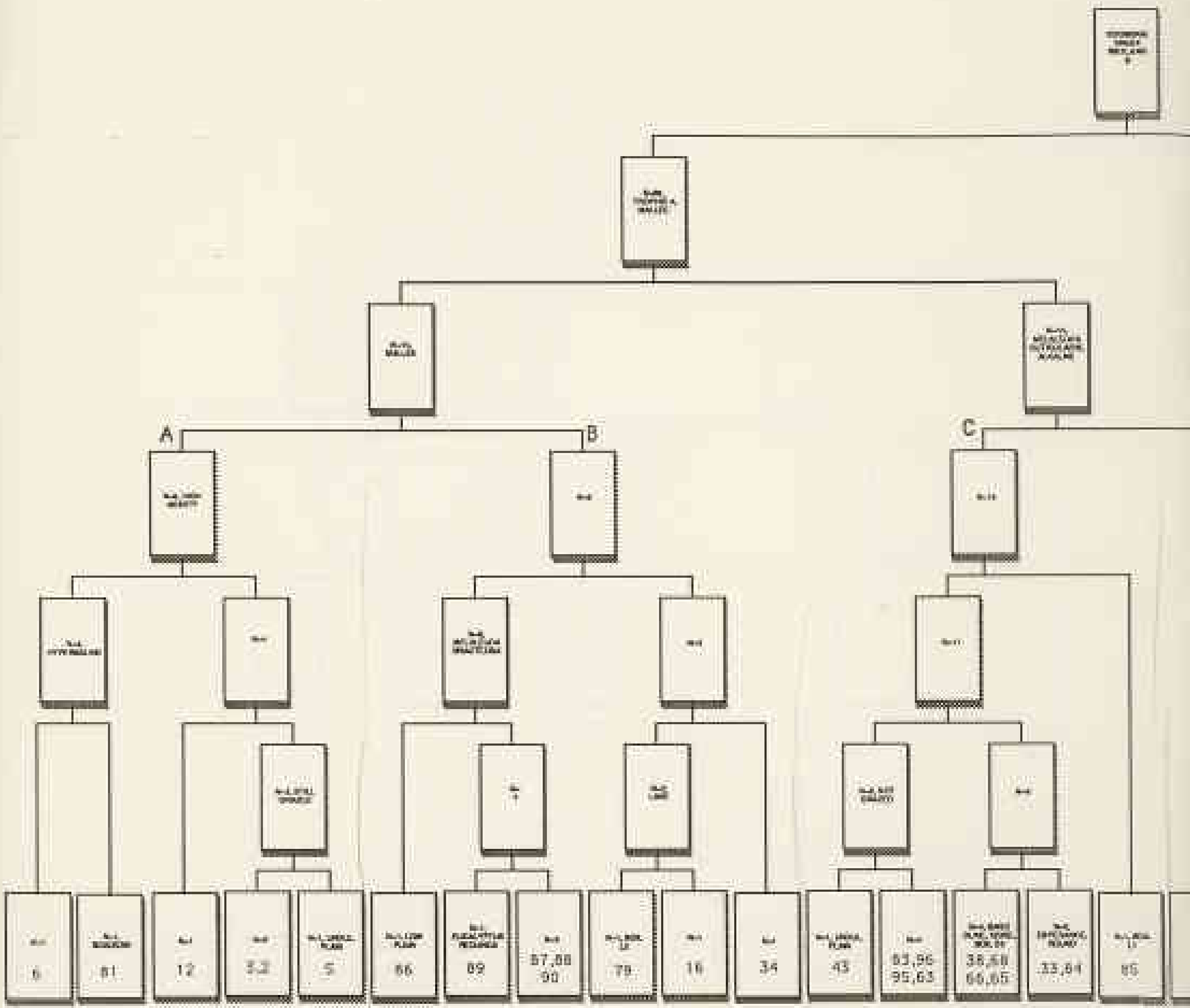
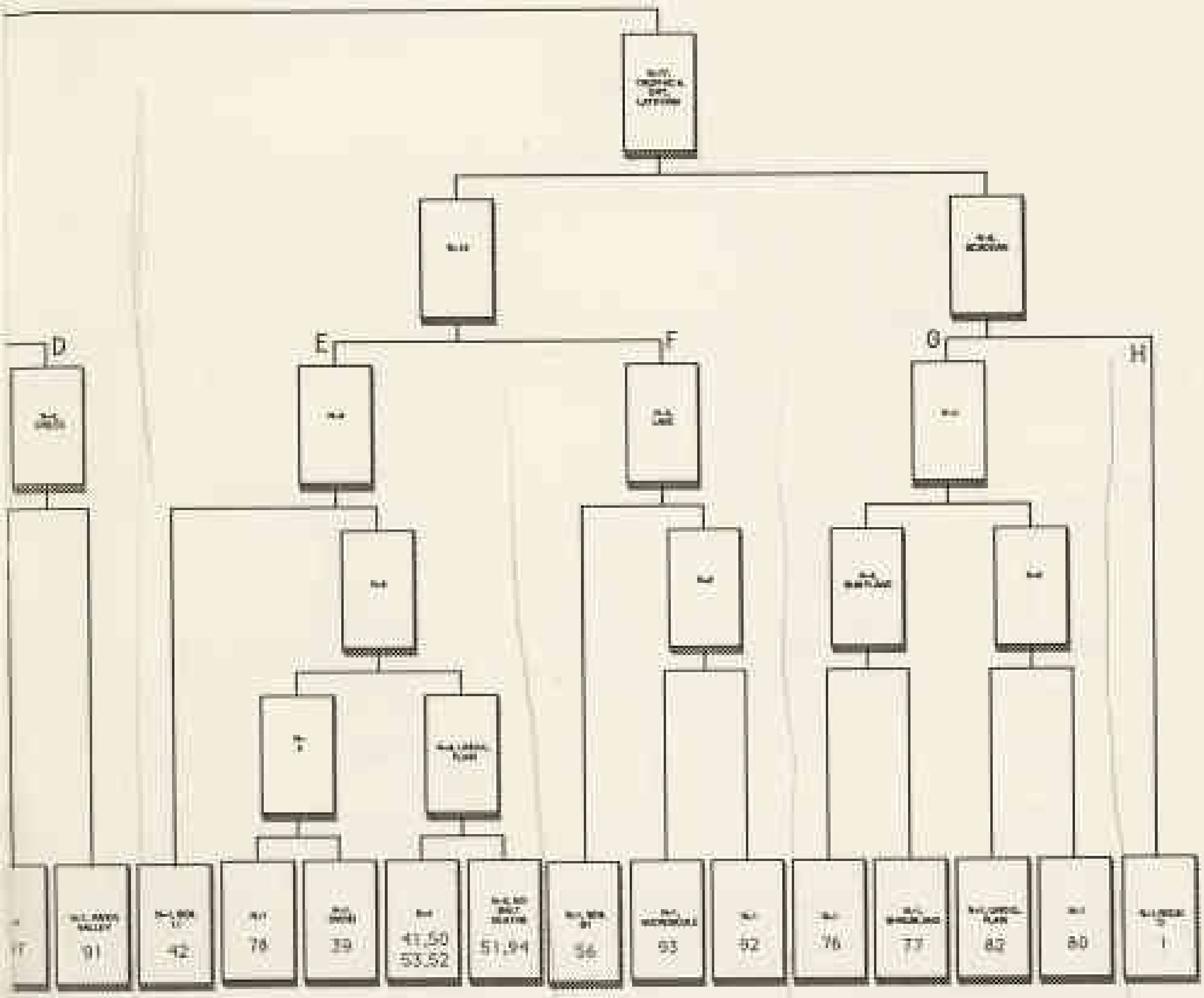
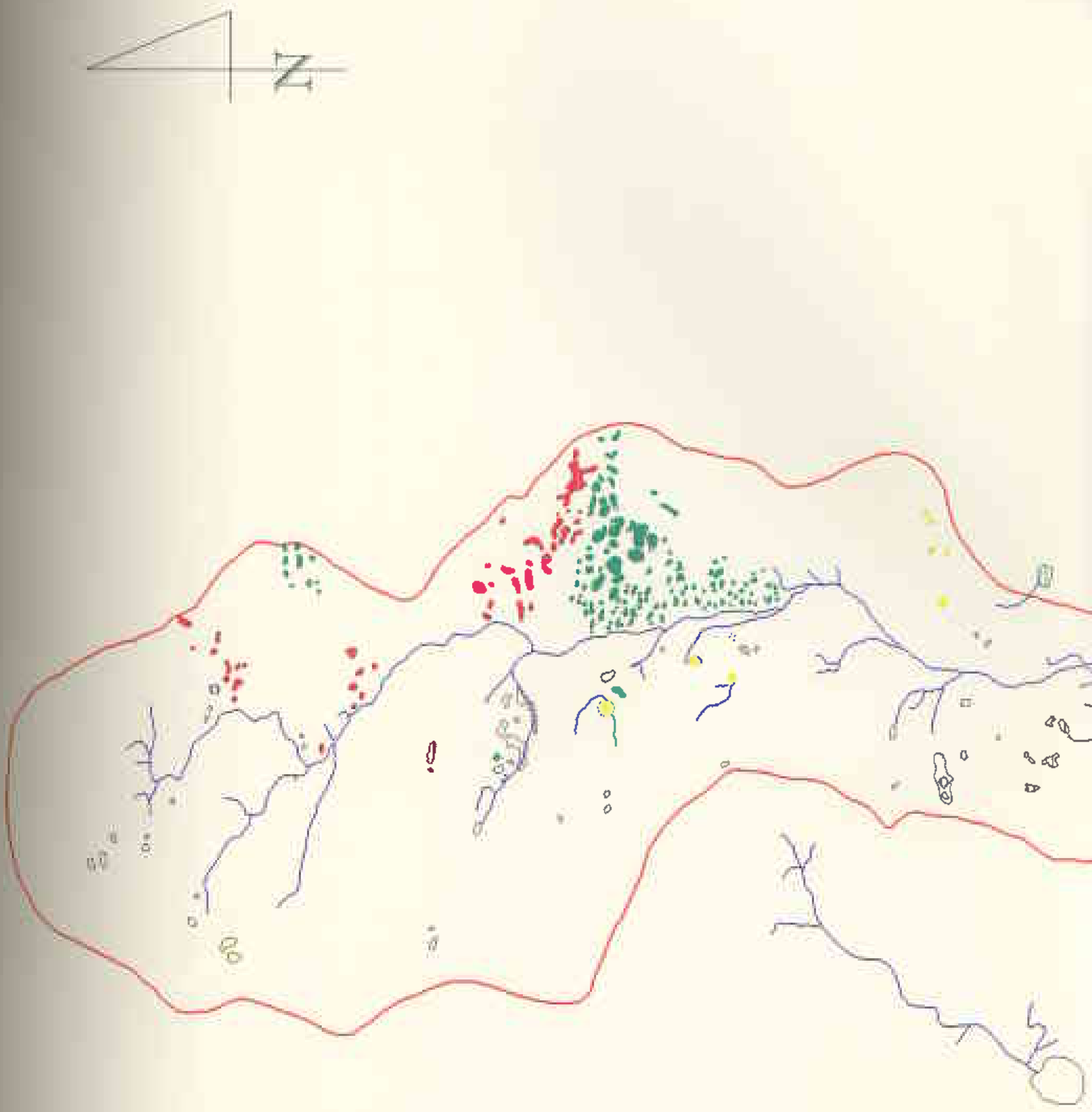


Figure 2.9 TWINSPAN classification of 45 wetlands using the entire data set. Number of wetlands and indicators for each arm of the classification are shown in the boxes. Wetland numbers are shown in the lower boxes.



D
E
F
G
H
91
42
78
39
41,50
53,52
51,94
56
93
92
76
77
82
80
1



COOBIDGE.DGN Jan. 29, 1991 09 18 20 SCALE 1:150 000

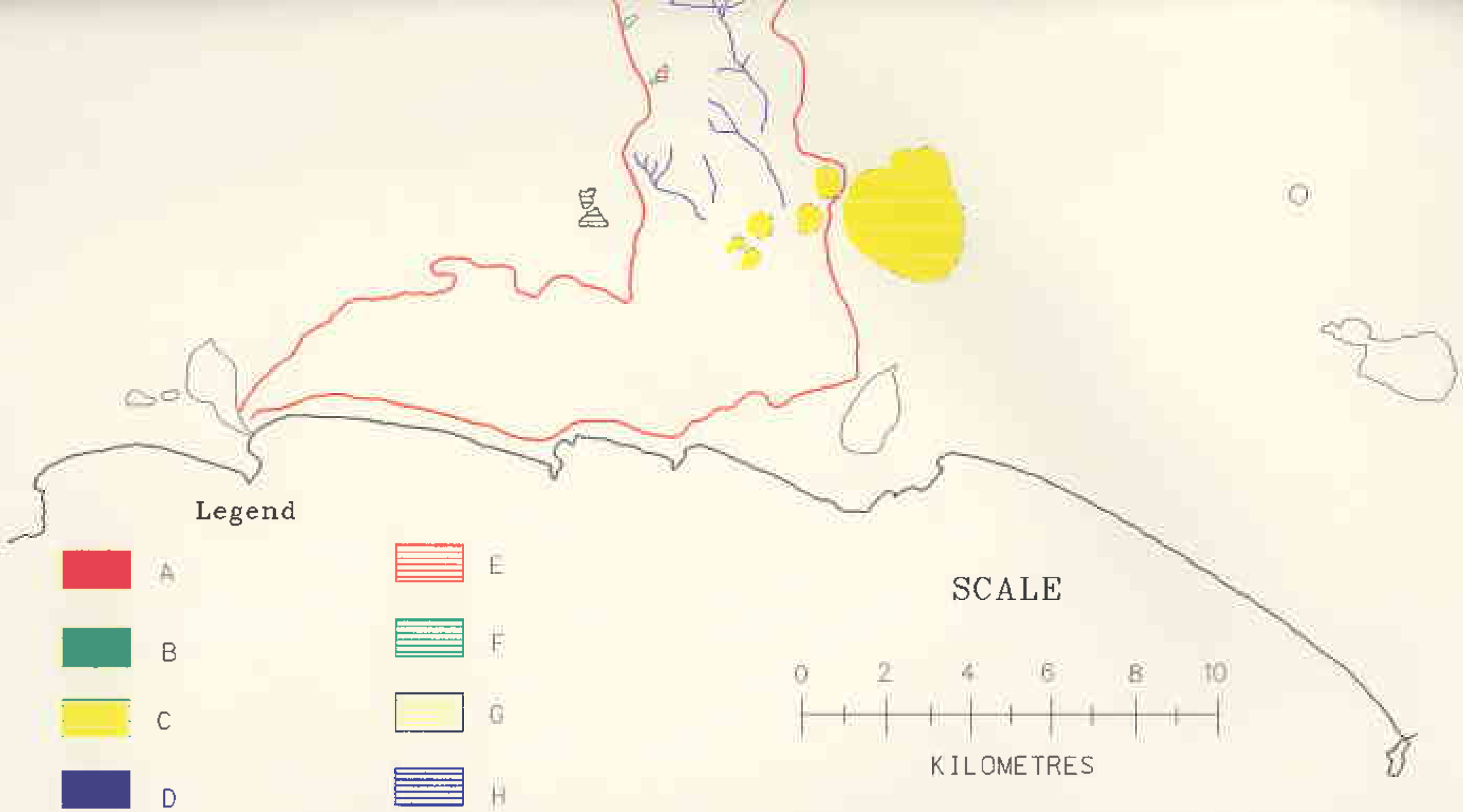


Figure 2.10 Distribution of TWINSPAN classification groups using the complete data set

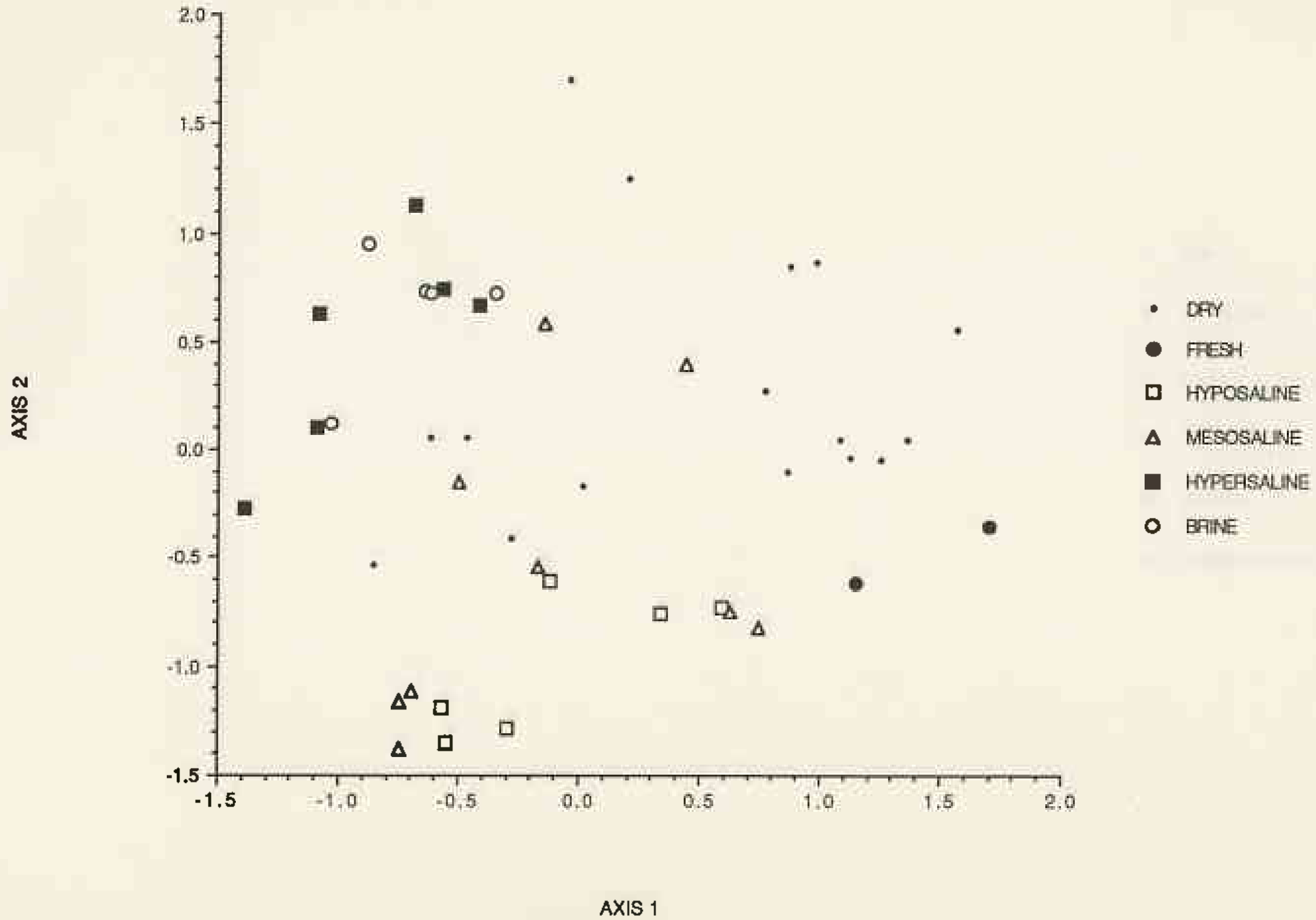


Figure 2.11 a DCA ordination of wetlands using the entire data set with salinity categories overlain

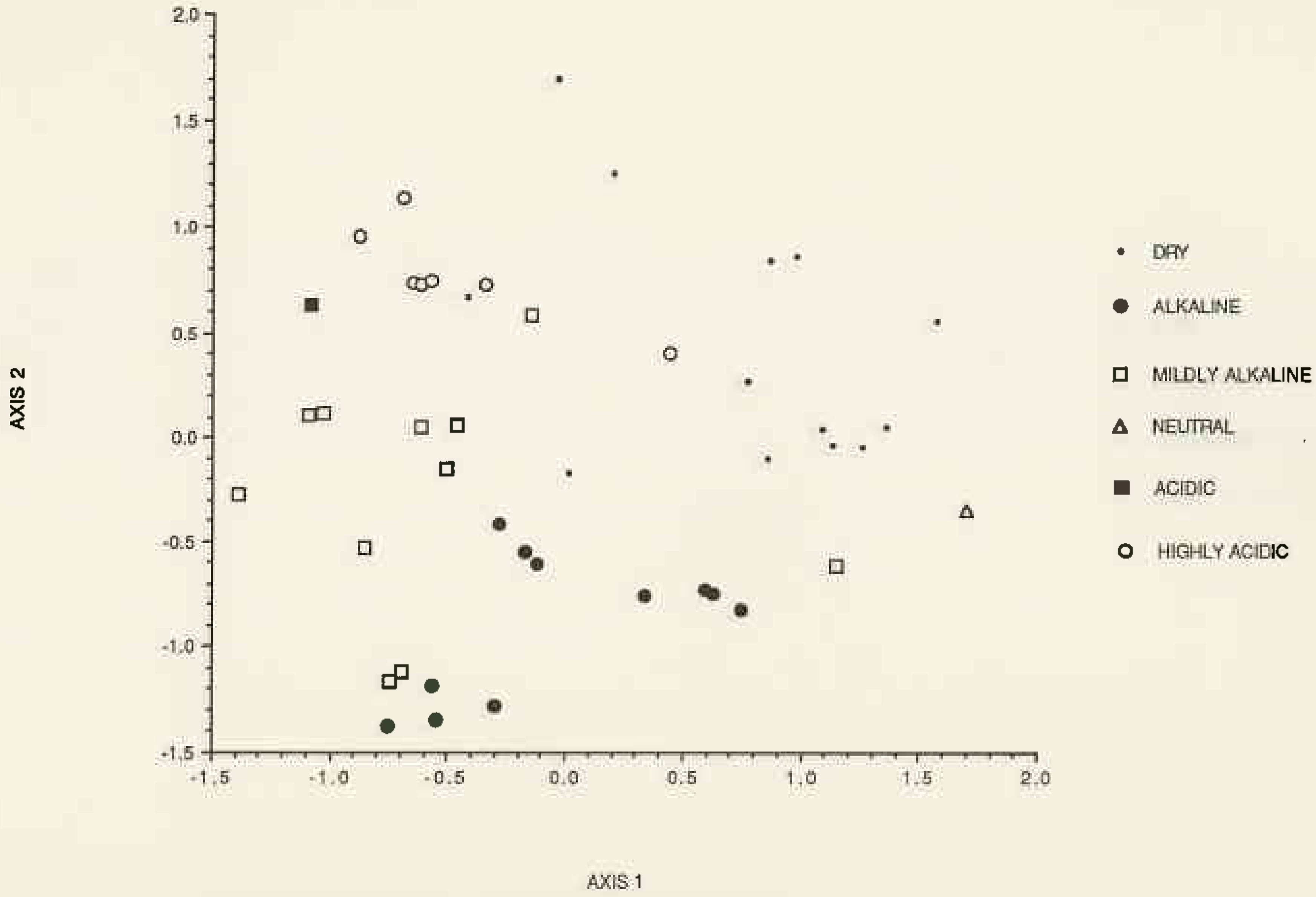


Figure 2.11 b DCA ordination of wetlands using the entire data set with pH categories overlain

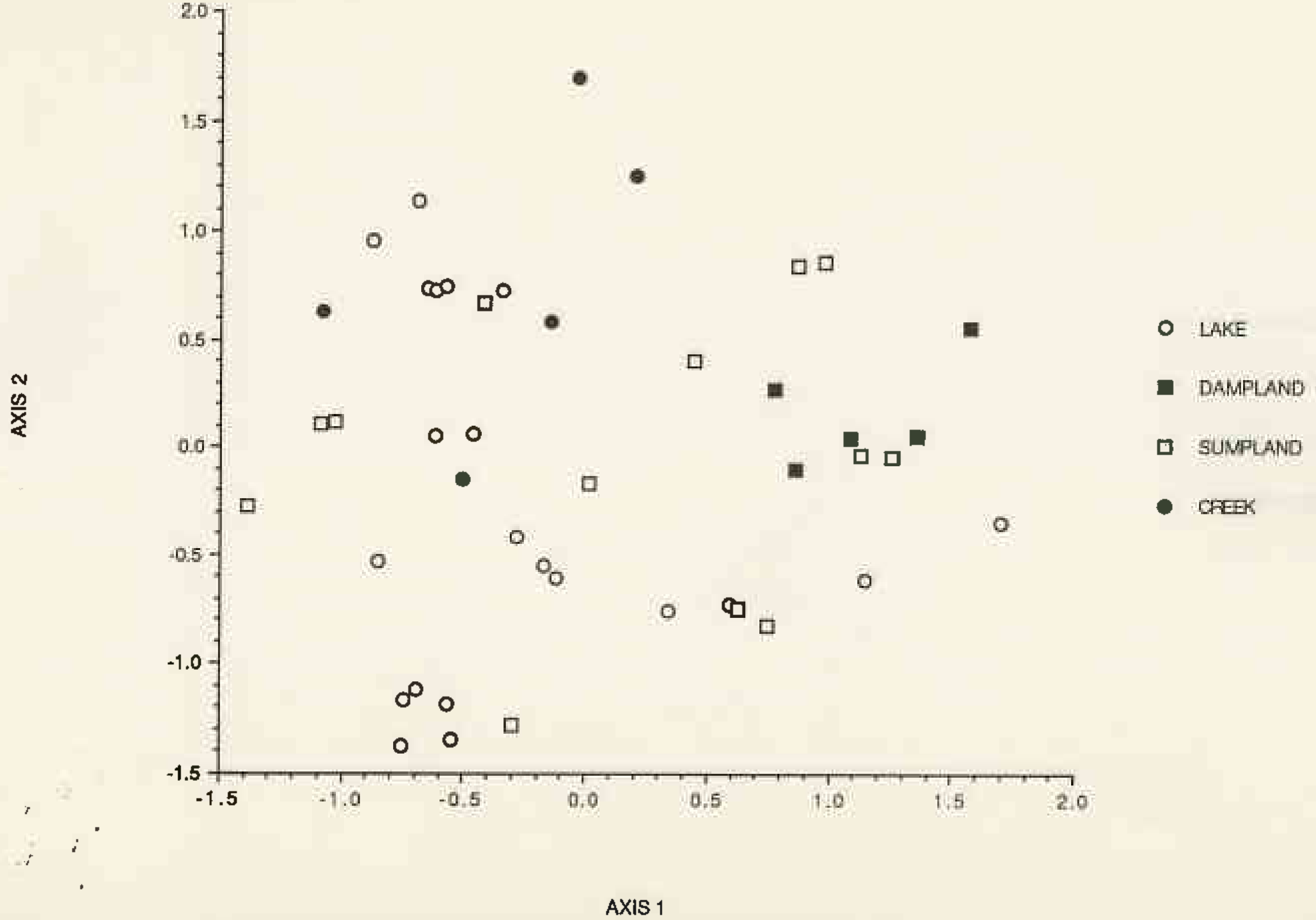


Figure 2.11 c DCA ordination of wetlands using the entire data set with wetland types overlain

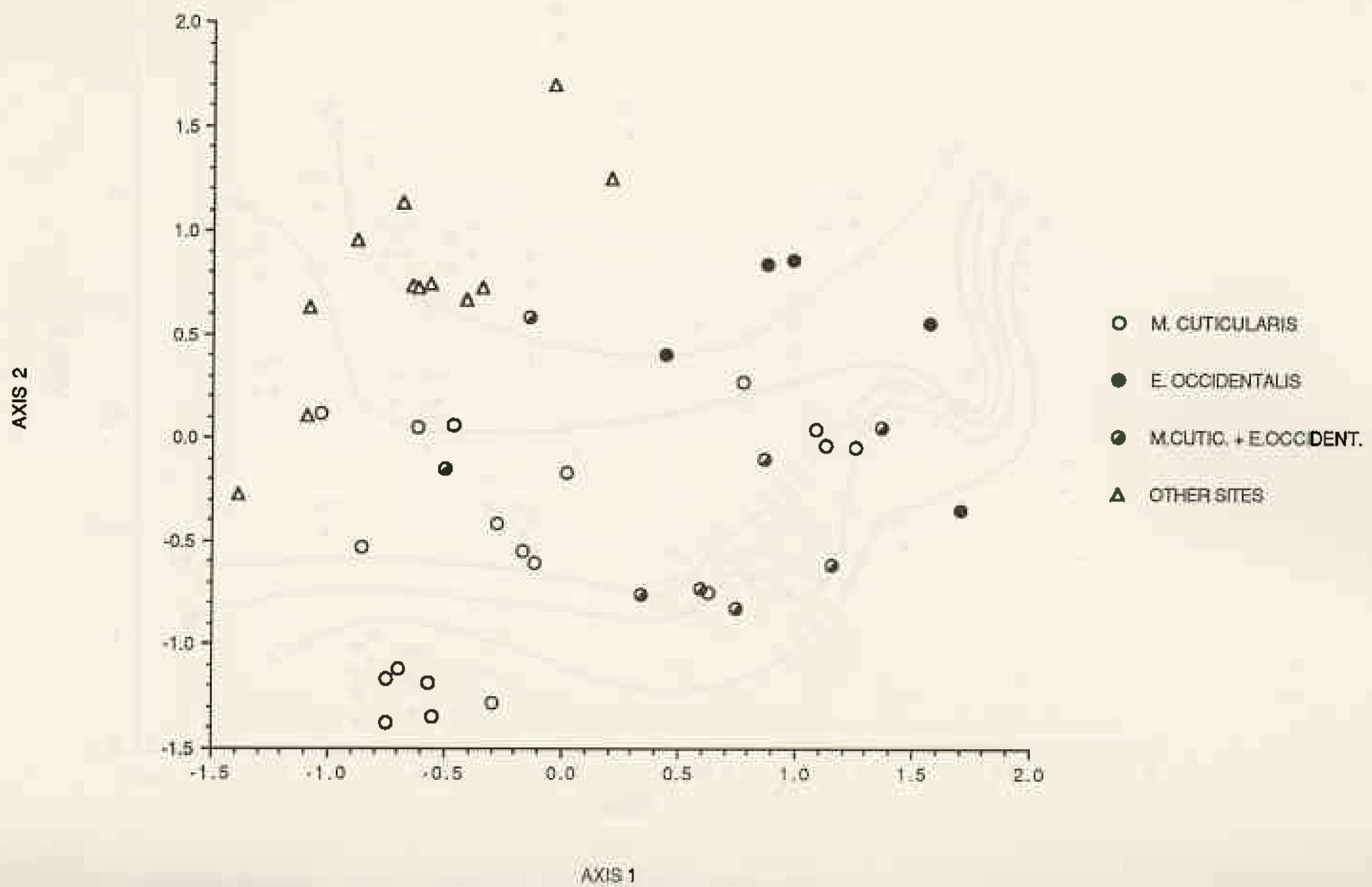


Figure 2.11 d DCA ordination of wetlands using the entire data set with major vegetation associations overlain

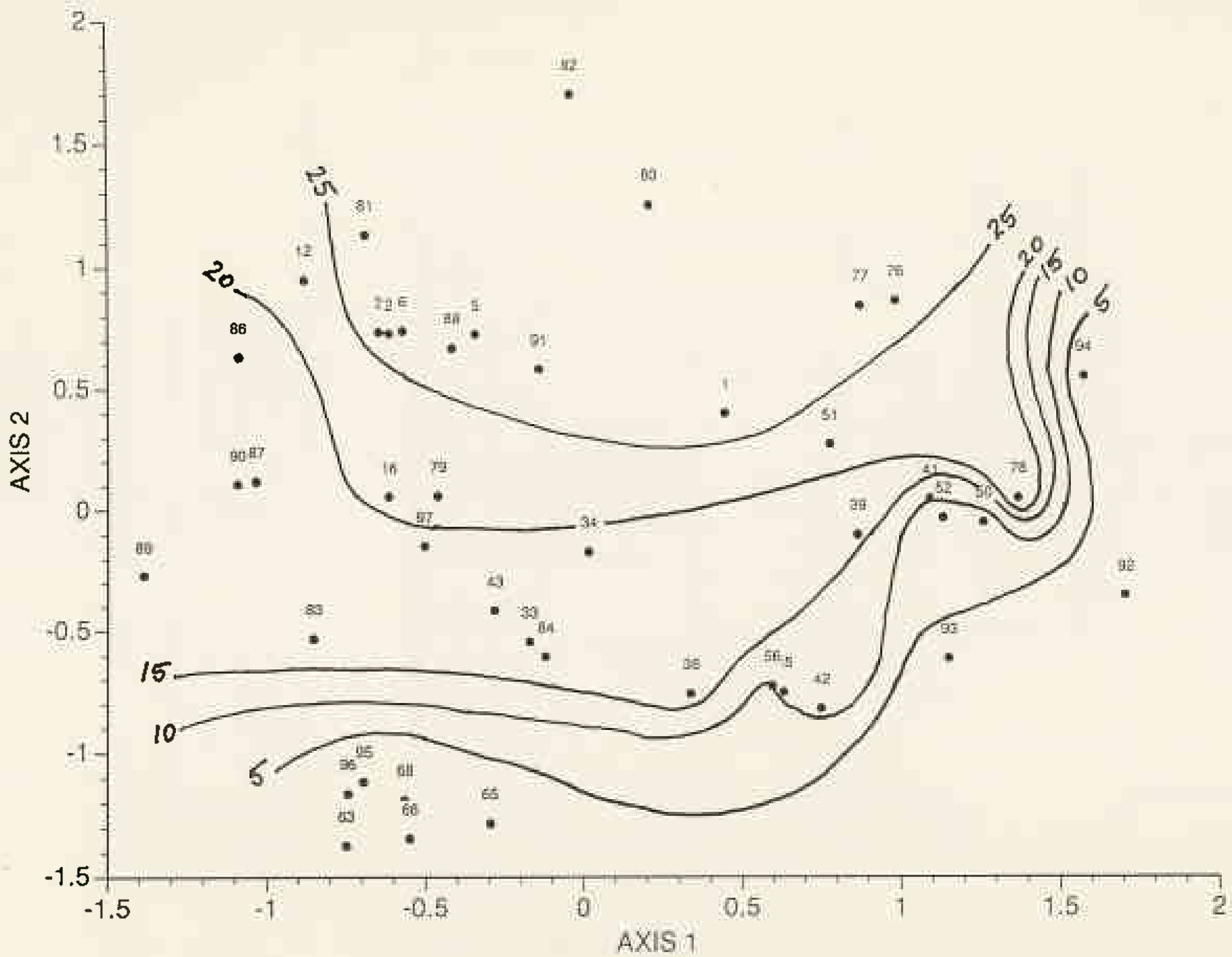


Figure 2.11 e DCA ordination of wetlands using the entire data set with distance (km) north of Lake Gidong overlain for each site

THIS IS A BLANK PAGE

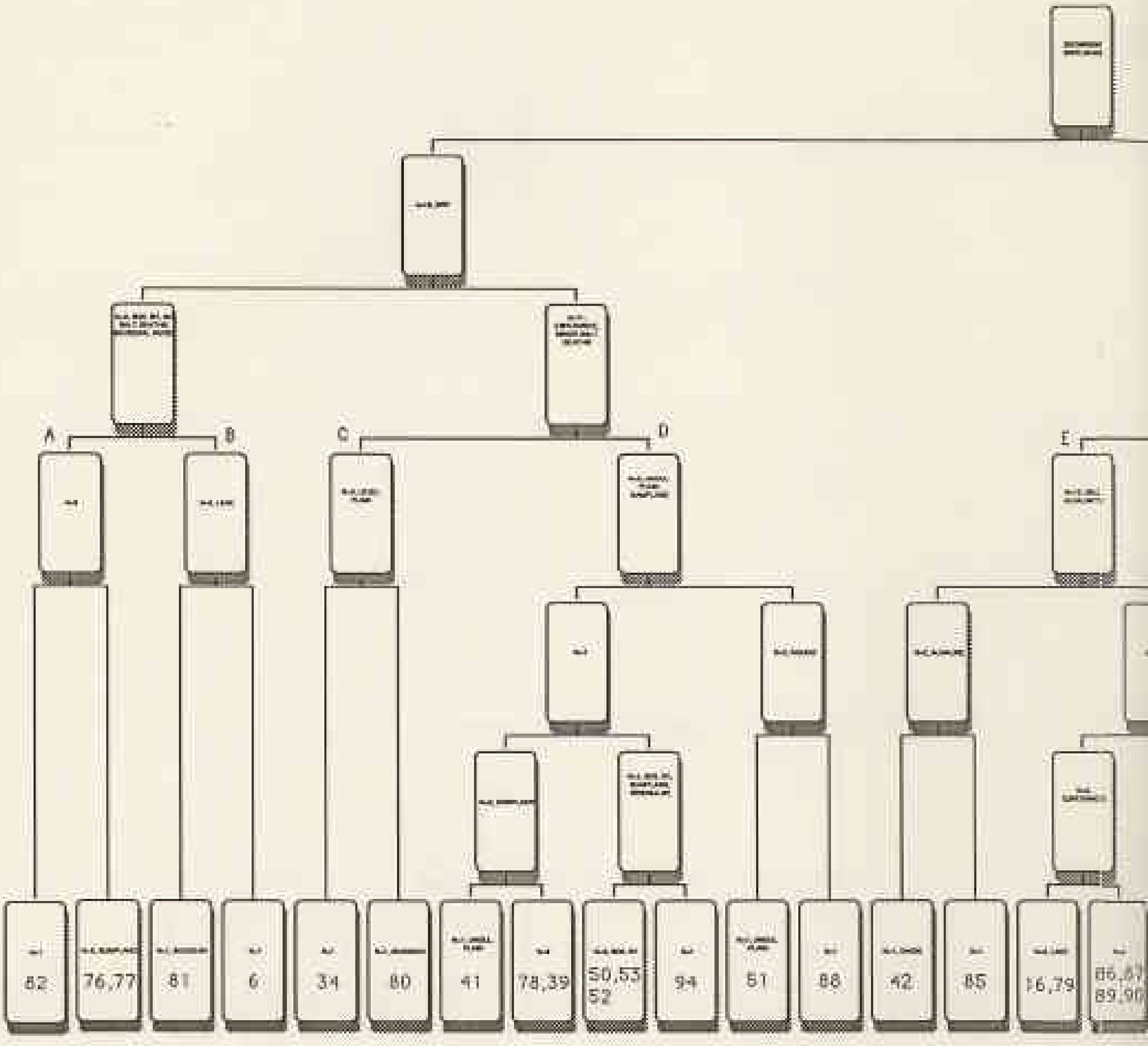
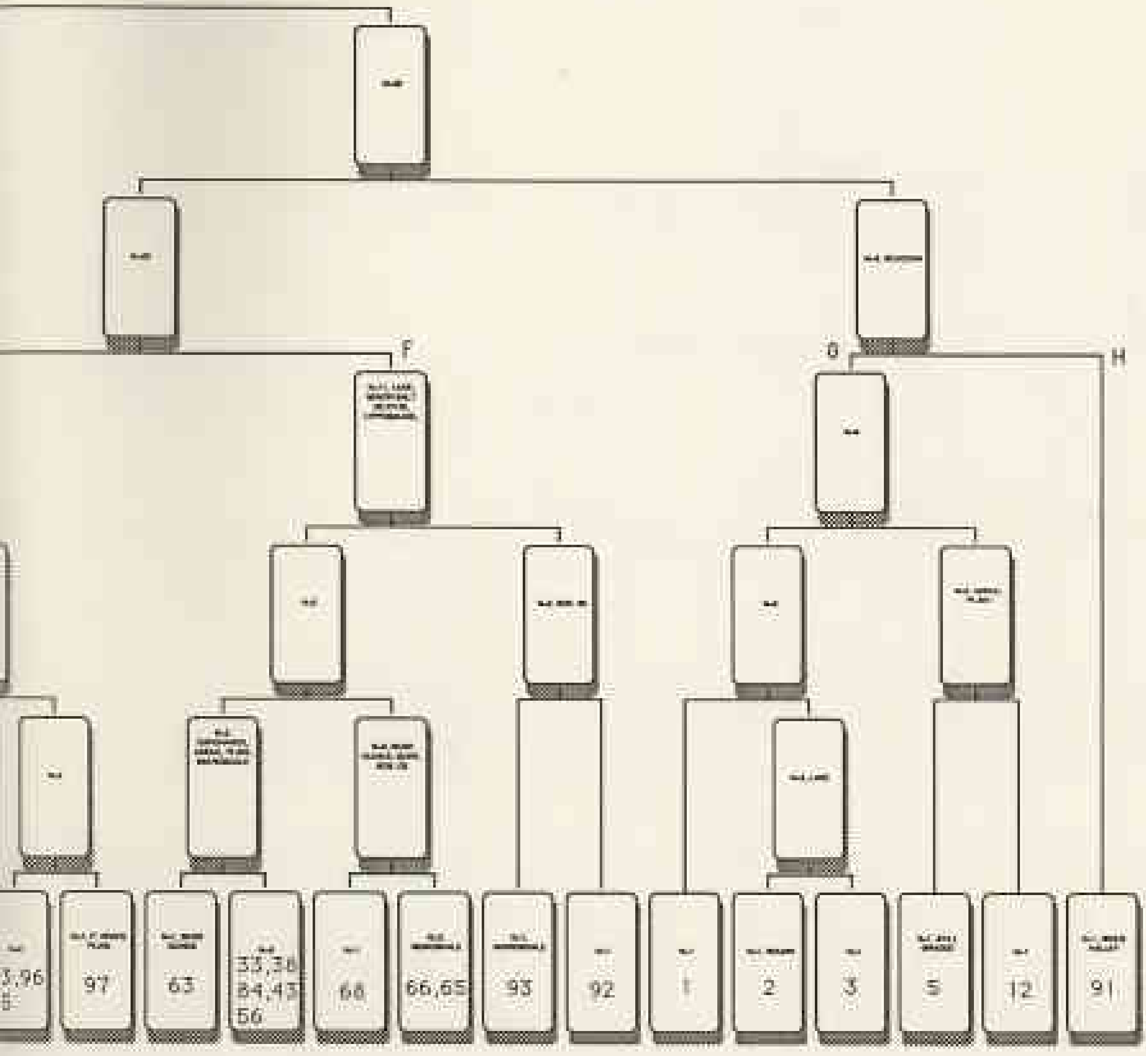


Figure 2.12 TWINSPAN classification of 45 wetlands using physical, chemical and biological data only. Number of wetlands and indicators for each arm of the classification are shown in the boxes. Wetland numbers are shown in the lower boxes.



F
G
H
3,96
5
97
63
33,38
84,43
56
68
66,65
93
92
1
2
3
5
12
91

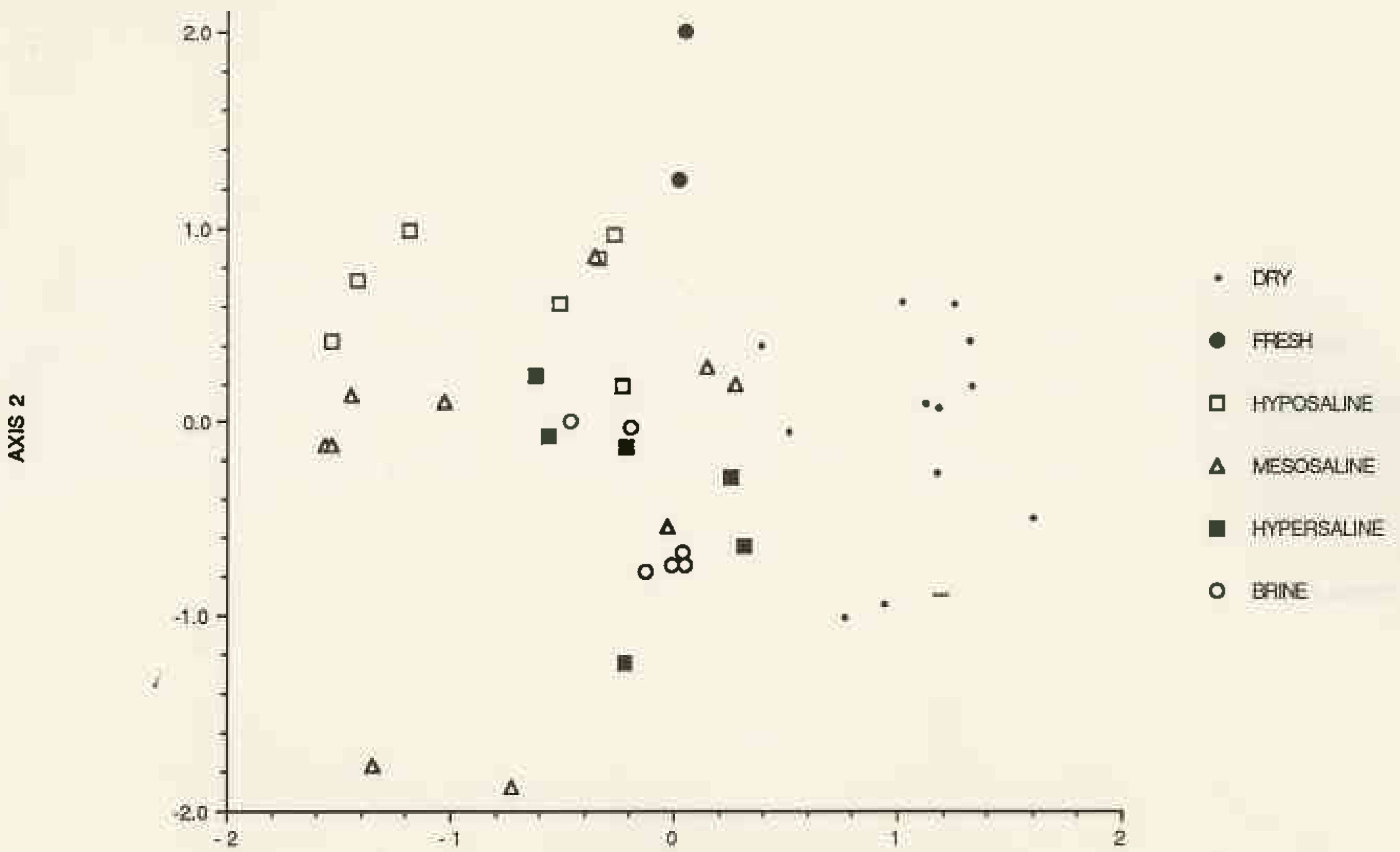


Figure 2.13 a DCA ordination of wetlands using physical, chemical and biological data only
a. salinity categories

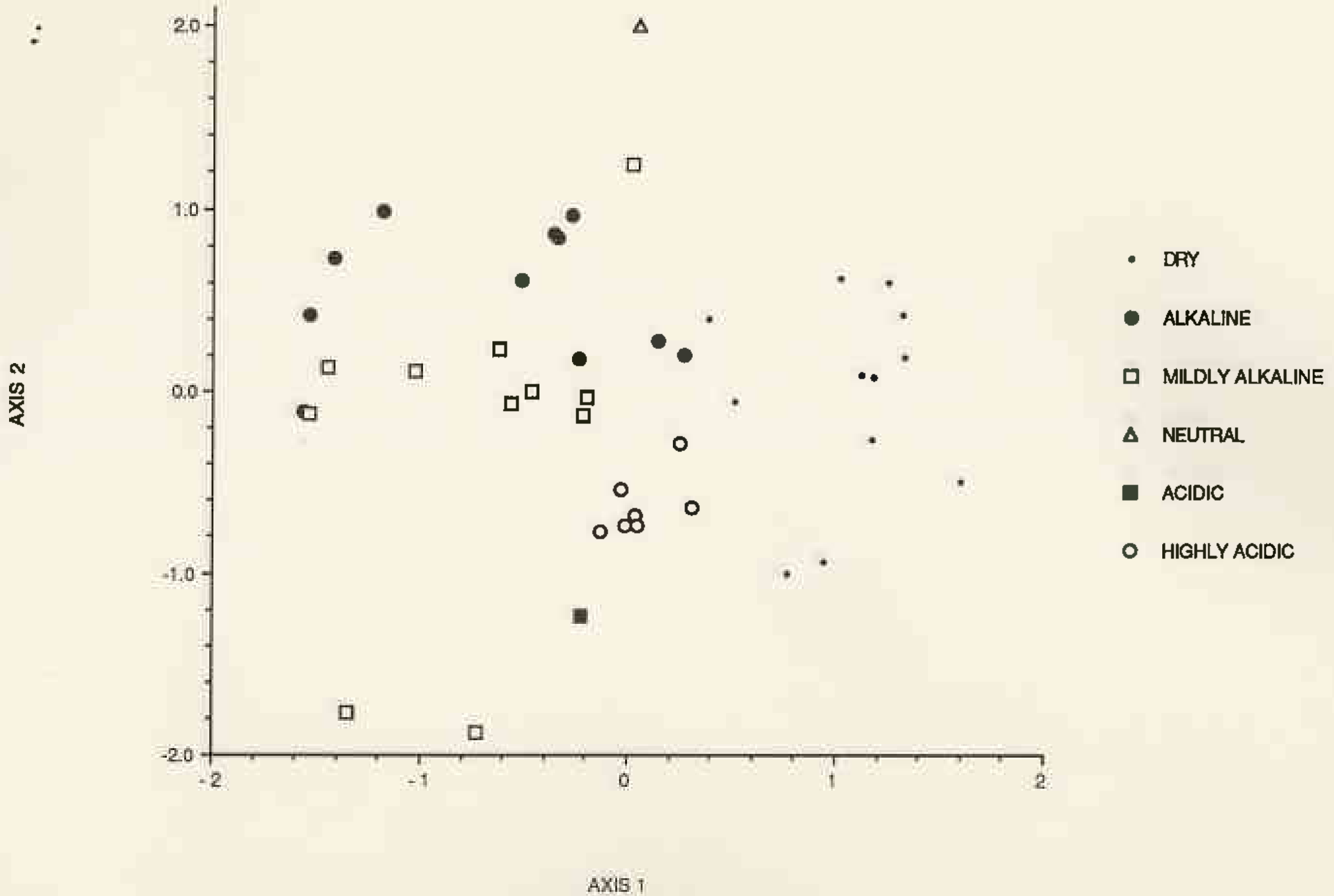


Figure 2.13 b DCA ordination of wetlands using physical, chemical and biological data only
b. pH categories

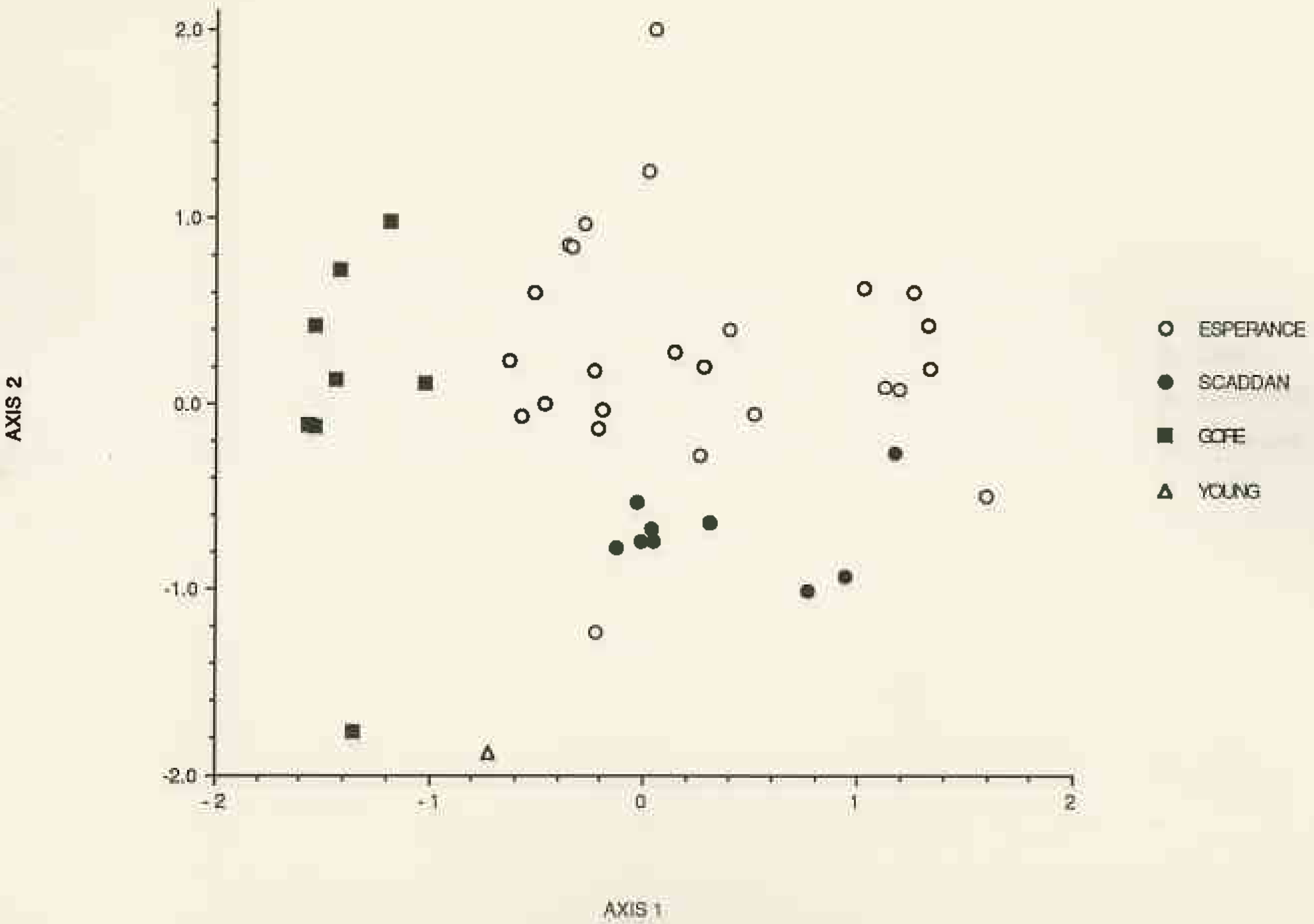


Figure 2.13 c DCA ordination of wetlands using physical, chemical and biological data only
c. Land System categories

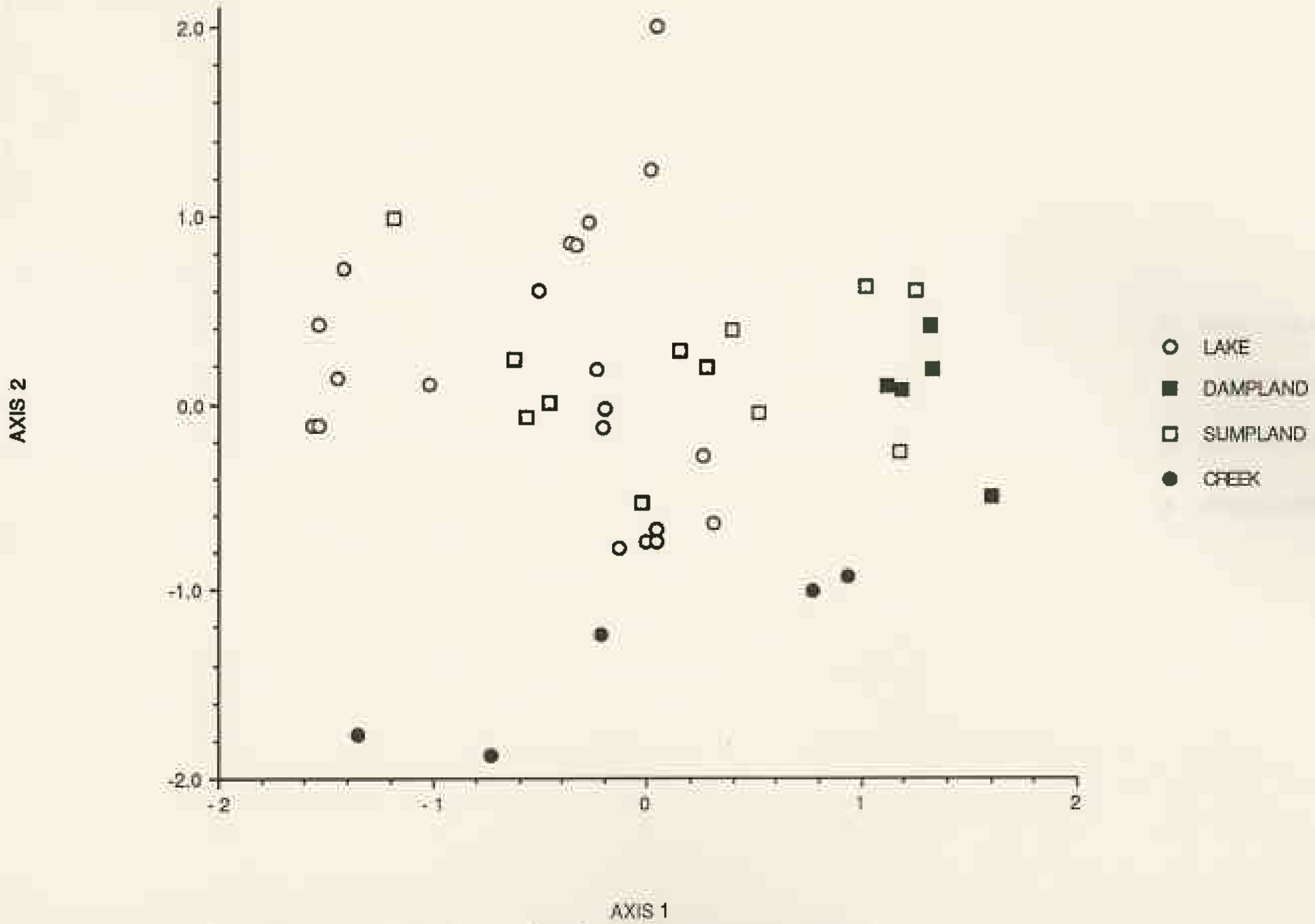


Figure 2.13 d DCA ordination of wetlands using physical, chemical and biological data only
d. wetland types

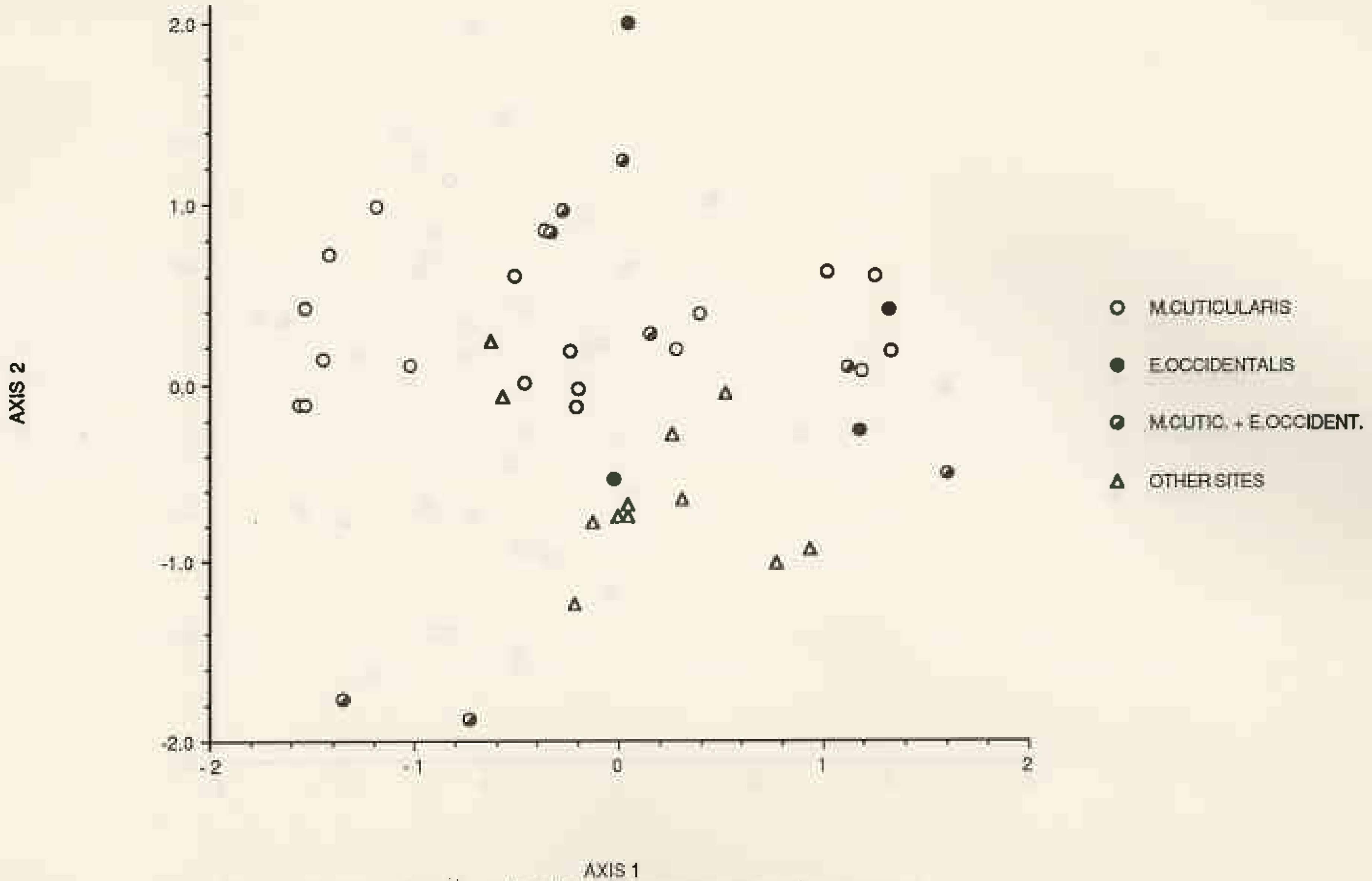


Figure 2.13 e DCA ordination of wetlands using physical, chemical and biological data only e. major vegetation associations

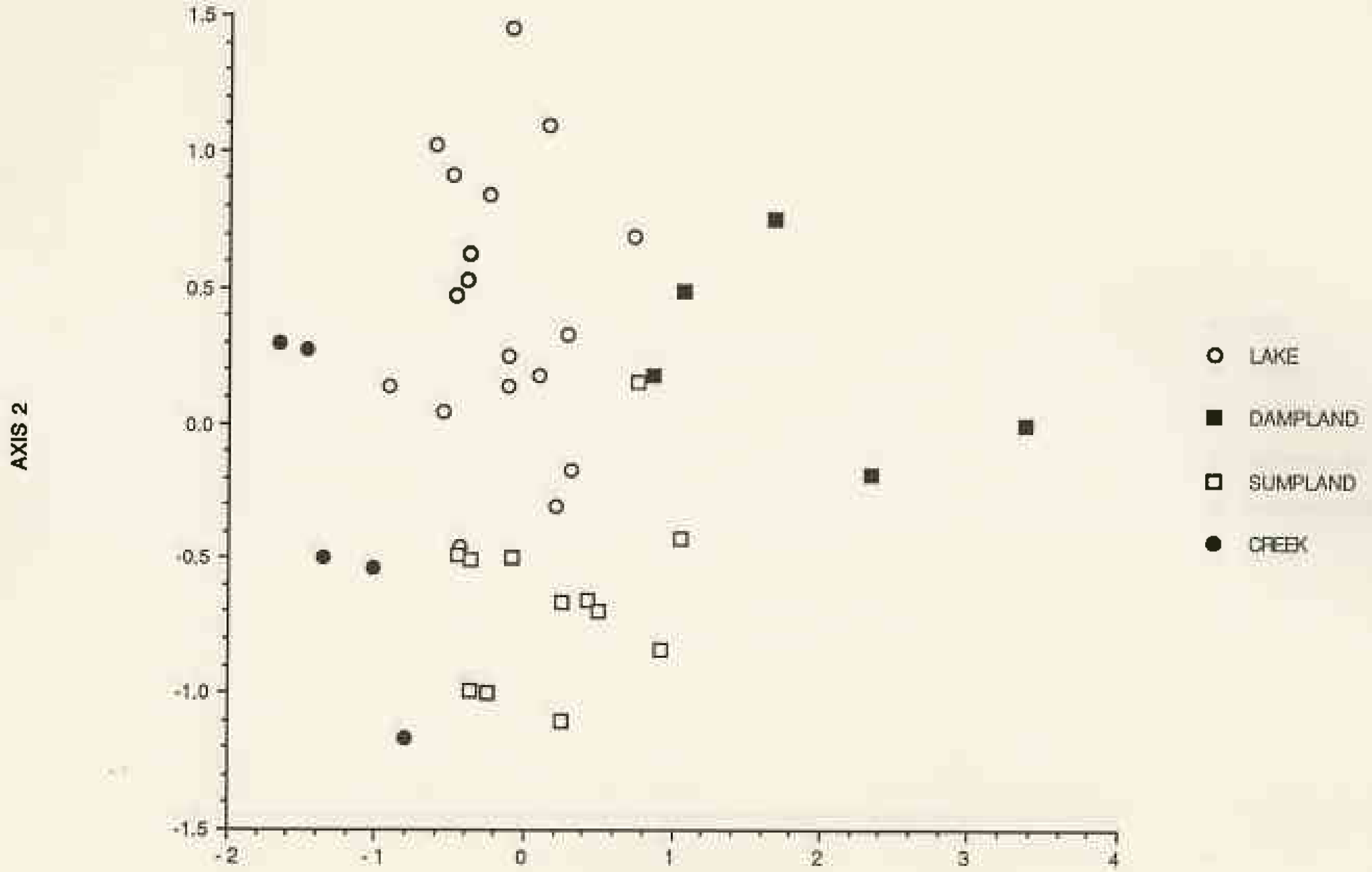


Figure 2.14 a DCA ordination of wetlands using aerial photograph data only
a. wetland types

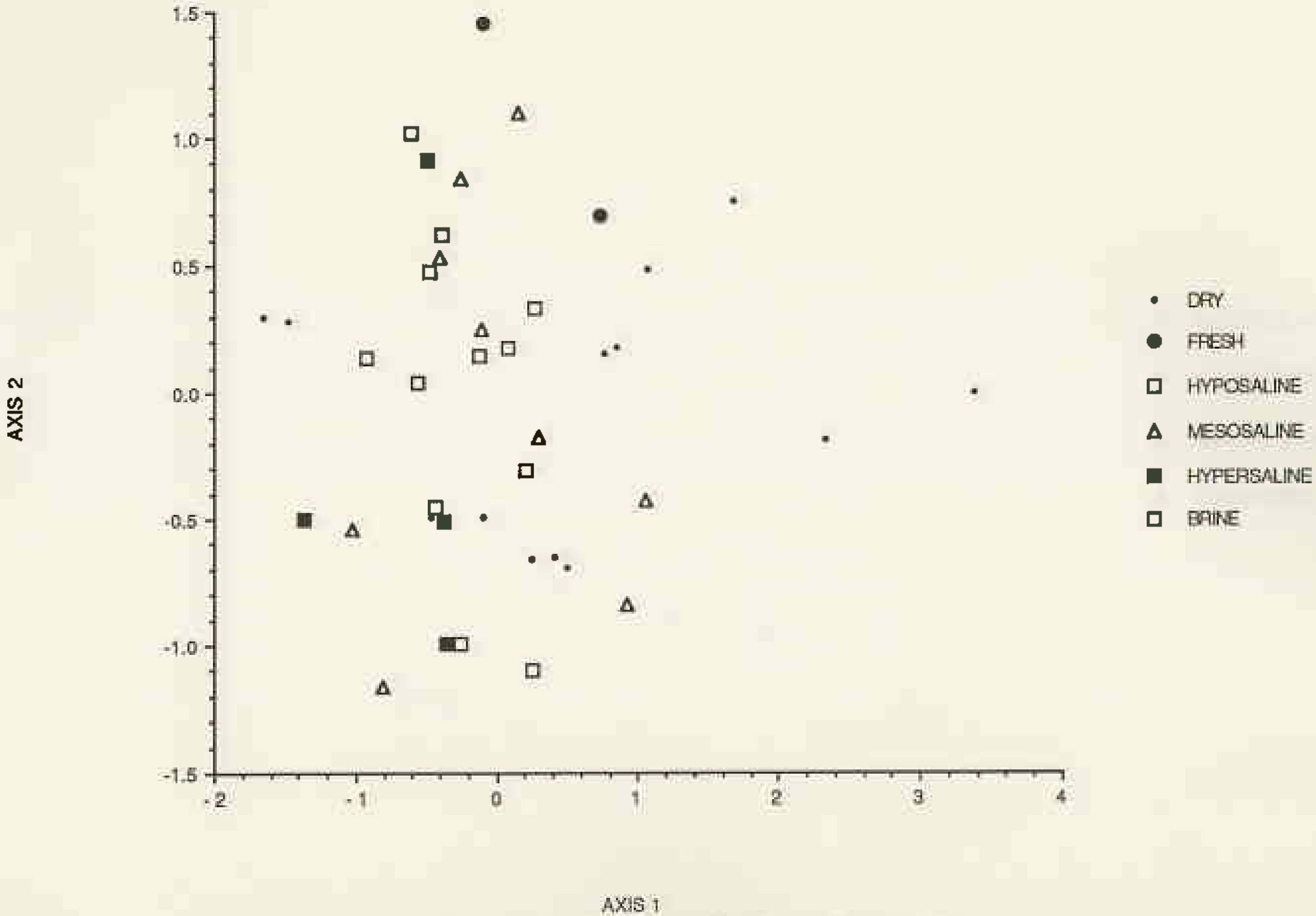


Figure 2.14 b DCA ordination of wetlands using aerial photograph data only
b. salinity categories

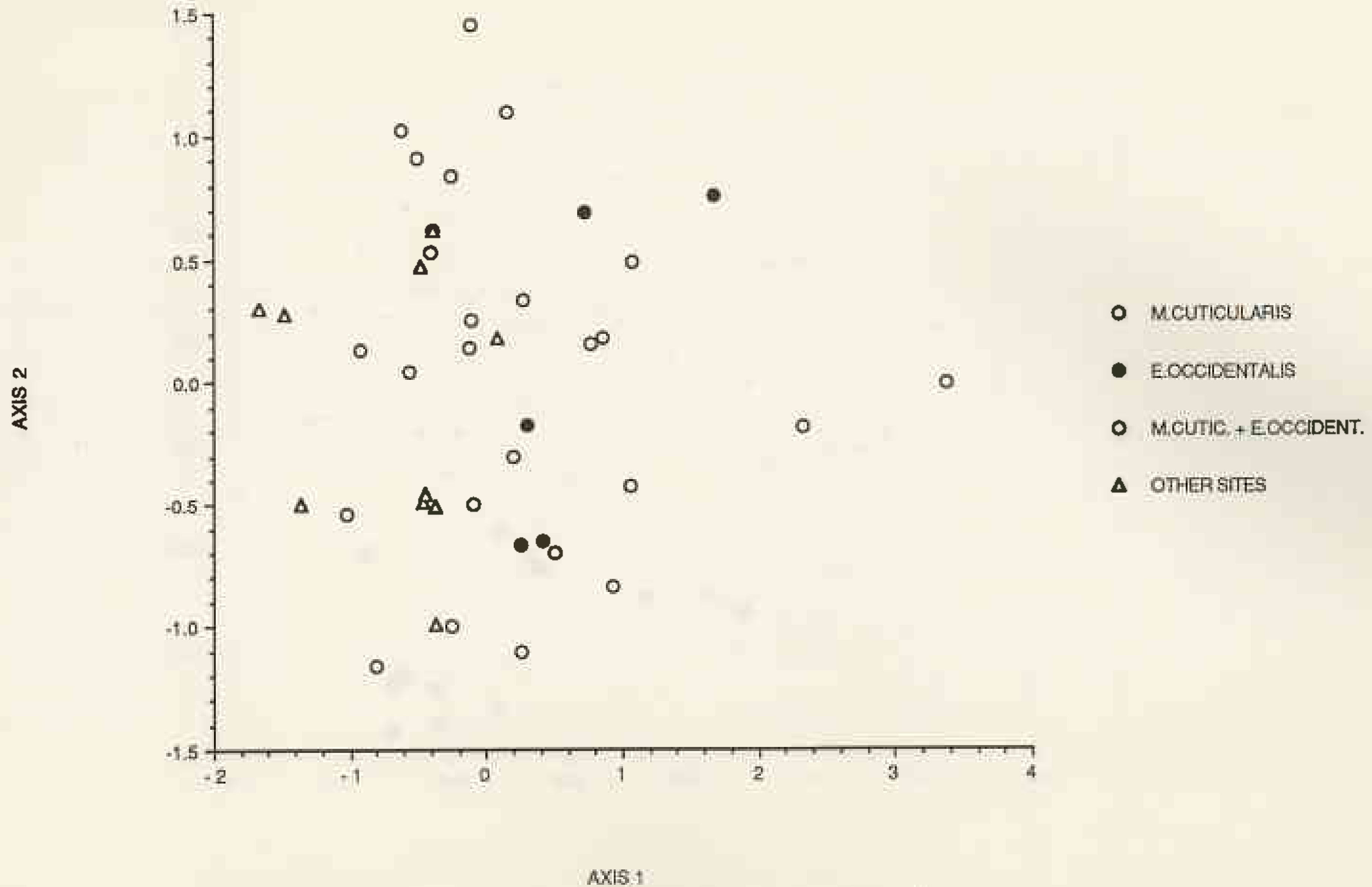


Figure 2.14 c DCA ordination of wetlands using aerial photograph data only
c. major vegetation associations

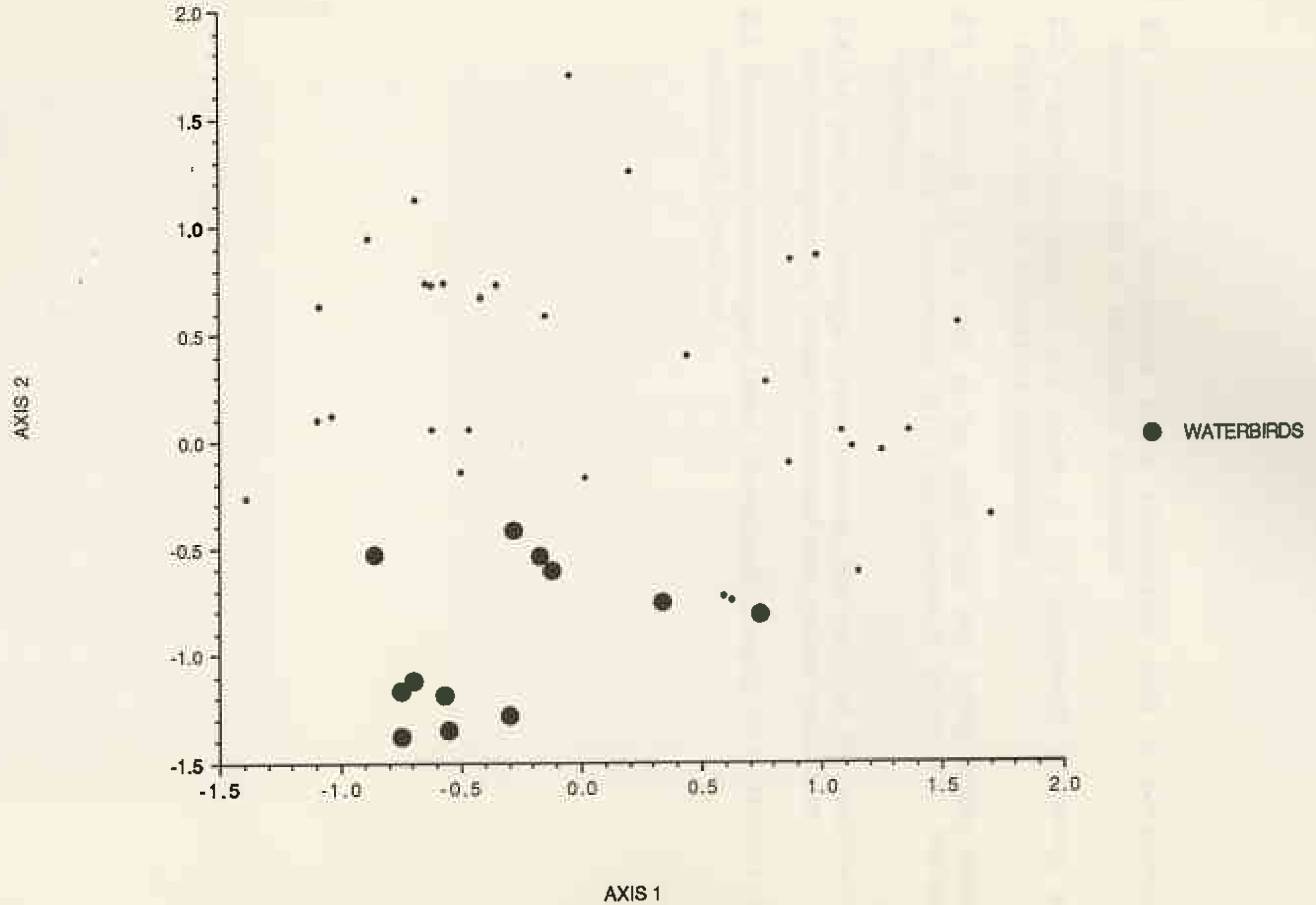


Figure 2.15 Distribution of sites on the DCA ordination (using entire data set) where waterbirds were observed

Plate 2.1 Seasonally inundated basin (Sumpland) with a peripheral vegetation cover of *Melaleuca cuticularis.*

Plate 2.2 Freshwater lake in the south of the catchment containing a mosaic cover of *Eucalyptus occidentalis.*

Plate 2.3 Sumpland in the north of the catchment with highly acidic, brine water and surrounded by heterogeneous peripheral mallee vegetation.

Plate 2.4 An arm of Coobidge Creek towards the north of the catchment with heterogeneous mosaic shrubland and mallee vegetation.

Plate 2.5 Seasonally waterlogged basin (Dampland) covered by a *Melaleuca cuticularis* shrubland.

Plate 2.1

Plate 2.2

Plate 2.3

Plate 2.4

Plate 2.5

3. *IMPACT OF PROLONGED FLOODING ON THE VEGETATION OF COOMALBIDGUP SWAMP*

3.1 INTRODUCTION

The vegetation associated with wetlands is central to wetland processes and continued 'health'; 1) it extracts nutrients from water and sediments, and provides a filtering mechanism for material passing into the wetland; 2) ameliorates the effects of sediment transfer, ie stabilizes and aerates the sediment; 3) provides primary production for wetland ecosystems, ie a food source and range of habitats for aquatic and terrestrial fauna (including migratory birds); 4) may link conservation reserves; and 5) constitute effective buffers minimizing human interference.

The decline of wetland vegetation is usually associated with external disturbances within the catchment but external to the wetland (Froend et al , 1987; Froend and McComb, in press). Removal of natural upland vegetation leads to increased water recharge of wetlands. Associated with these disturbances may be increased mobility of salt stored in sub-soils and increased nutrient levels through broadscale fertilizer application. On the south coast of Western Australia near Esperance, above average rainfall years have caused increased groundwater recharge and surface water retention to such an extent that large areas of pasture have been flooded for weeks while natural ephemeral water courses and basins have retained surface water for prolonged periods. In the Coobidge Creek catchment, landowners have proposed drainage lines to reduce pasture flooding and divert excess water into natural water courses and wetlands. As a consequence, the duration of flooding in many wetlands may be increased dramatically.

The species composition of wetlands is influenced mostly by flooding frequency and duration. Poor aeration of flooded soils results in various physiological changes in woody plants which causes morphological changes and often death. Flooding tolerance can vary from as little as a few weeks to several years before mortality occurs, depending on species, age and water quality of floodwaters. As a consequence of prolonged flooding, increased or complete mortality of the vegetation results in an acceleration in wetland degradation due to; a reduced or ineffective buffer to nutrient input; reduced evapotranspiration resulting in greater capillary rise of saline water; destabilisation of sediment; loss of food source and habitat for fauna. Gradual effects would be a loss in flora and fauna species diversity and changes in species composition.

The Coobidge Creek catchment has a 25 year average (1965-89) annual rainfall of 480mm, however this varies over the catchment, decreasing away from the coast from 600mm to 450mm (Gutteridge Haskins and Davey, 1990). One major wetland, Coomalbidgup Swamp, has reportedly contained surface water since the winter of 1986. According to local landowners, Coomalbidgup Swamp 'filled' after heavy winter rainfall in 1986 and water levels have remained high since. During 1989, winter rainfall in the catchment was heavy, causing severe water erosion and flooding

(GHD, 1990), and increasing water levels in the swamp. The annual rainfall for Esperance and Dalton (within the Coobidge Catchment) was 24% and 35% above average respectively. The GHD report states that 1989, contained the wettest two, three, and four consecutive months ever recorded since 1969. The most extreme rainfall event was 139mm between 14 and 17 June. Catchment runoff is generated after several months of high rainfall rather than by a single wet month or individual high intensity storms of shorter duration. Due to the sandy nature of the duplex soils in the catchment, runoff is primarily generated by the saturation-excess mechanism rather than by the infiltration excess mechanism. Therefore an increased proportion of rainfall is expected to runoff as water tables rise and saturated areas within the catchment increase (GHD, 1990).

In April 1990 the water level in Coomalbidgup Swamp was surveyed (GHD, 1990) as 0.96m below the highwater mark of the 1989 winter. A Coomalbidgup resident indicated the swamp level in March 1989, representing a rise of 1.56m during the 1989 winter. The GHD report concluded that, on the basis of air photography and local knowledge, Coomalbidgup Swamp has been at an equally high level as that in late 1989 in previous years, and it appears to require a sequence of wet years to fill.

Secondary salinity can take many years to develop to a detrimental level, and therefore it may be some time before its full impact will be realised in the Coobidge and Coomalbidgup catchments. Establishment of permanent transects during the relatively early stage in the wetlands degradation may be beneficial in separating the effects of prolonged flooding and potential future secondary salinity. This information on long term changes will assist in the management and conservation of wetlands in rural catchments. The aims of this section of the Coobidge Creek wetland study is to identify the effects of high water levels on wetland vegetation using Coomalbidgup Swamp as a case study.

3.1 METHODS

3.1.1 Species Distribution and Deaths - Transects

Permanent belt transects were established at 4 sites around the swamp in June 1990 (Fig. 3.1) Sites were selected to represent the different plant communities present. Each transect was 30m x 2m with one end at the water's edge; both ends were marked with star pickets. Changes in elevation along the transects were determined at 2m intervals using a dumpy level. For comparison between swamp and terrestrial vegetation, each transect was extended 50 - 60m into the lake to include inundated trees and shrubs on the swamp bed. Due to the depth of water, small understorey species on this part of the transect could not be recorded.

Vegetation physiognomy, species presence and whether plants were alive or dead were recorded at 2m intervals. Sampling took place sufficiently close to the time of death to determine the identity of most species. Specimens were collected from all species and compared with specimens at W.A. Herbarium.

3.1.2 Species Distribution, Vigour and Deaths - Traverse

A permanent transect traversing the swamp between transects 1 and 2 was established in June 1990 (Fig. 3.1). As water levels were high at that time a boat was used to cross the swamp. A compass bearing of 145° (from transect 1) was followed and each tree that occurred within 1m either side of the boat was recorded, live trees tagged, species recorded, diameter (at the height of the tag), height measured and vigour determined. Water depth was recorded at approx every 20m or at major changes in tree composition/distribution. Understorey species were not recorded due to the water depth.

It is envisaged that the vigour, height and survival of each tagged tree be re-monitored on an annual or biannual basis. Vigour was estimated using a scale of 1 to 5; 1 = dead for >1 year; 2 = many dead/dying branches, few green leaves viable; 3 = visible signs of stress but 50 - 70% green canopy ; 4 = visibly healthy with few signs of stress, 70 - 90% green canopy ; 5 = healthy, no signs of stress, 90 - 100% green canopy. A vigour class of 1.5 was assigned to trees which appeared to have died recently, judging by the persistence of dead leaves. Height was determined with an extendable measuring pole. Diameter at tag ht (typically 1m above water level) was measured with a diameter tape.

3.1.3 Seedling Plots

Two permanent seedling plots were established to count the density of seedling recruitment around the lake. Both Plot 1 (S1, Fig. 3.1) and 2 (S2) were situated close to the swamp shore and orientated perpendicular to the shoreline. The size of the seedling transects varied according to the density and distribution of seedlings; S1 was 15x10m and S2 was 10x6m. The sites chosen for the transects were representative of recruitment observed in open shrubland (S1) and closed woodland (S2). Recruitment only occurred along the flotsum or wrack line/s on the shore. Each plot was divided into $1m^2$ "cells" within which the density and max height of each seedling species was determined.

3.3 RESULTS

3.3.1 Transects

The species present and their distribution at each of the transects is shown in Figure 3.2 a - d. Transect 1 vegetation varied from *Banksia speciosa* low (4-5m) woodland on the upper and lower slopes of the present shore, to *Eucalyptus occidentalis* tall (12-14m) woodland on the lake bed. Understorey growth on the shore was dense, the dominant shrubs being *Leptospermum erubescens* and *Jacksonia spinosa*. Apart from a few deaths of *J. spinosa*, more likely due to insect attack or 'natural' senescence, there were no apparent deaths due to flooding on the upper slope of the shore. The lower part of the shore and the nearshore shallows displayed a very high degree of mortality; *Amphipogon sp.* being more tolerant, and the introduced species *Cirsium vulgare* and *Solanum nigrum* invading the saturated soils. There was negligible floristic variation down the shore slope; notable exceptions were the presence of *Kunzea sp., Eucalptus occidentalis* (young mature trees only) and a species of sedge near the June 1990 shoreline, possibly indicating a transition to a littoral community. The presence of dead *Banksia speciosa* in the nearshore shallow water however, indicates that the sandplain vegetation extended below the June 1990 shoreline. Any further floristic changes towards a littoral vegetation was obscured by the deep water. On the lake bed itself *E. occidentalis* was the only species observed. Both recent and earlier tree deaths were observed, the recent deaths being identified by the dead leaves still attached, the earlier deaths by the absence of minor branches and bark.

The shore vegetation of Transect 2 was typified by a mid-high (0.5-1m) shrubland with emergent *Eucalyptus occidentalis* and *Melaleuca cuticularis* trees. Although there was no dominant species of the understorey, common species were *Grevillea nudiflora*, *Leucopogon spp*, and *Hibbertia hypericoides*. The slope of the shore at Transect 2 was shallower than that of Transect 1 indicating wetter conditions over a greater area of the transect. This is supported by the presence of *M. cuticularis* on the mid to lower slopes of the shore. Vegetation on the lake bed consisted of *E. cuticularis* mid-high woodland, with dead *Beaufortia sp., Acacia alata* and *Hakea laurina* closer to the shore. Shrubs common to the upperslopes of the shore showed a high degree of mortality where present on the lower flooded areas. Live plants of the lower shore and nearshore areas where typically those tolerant of waterlogged conditions, *E. occidentalis* and *M. cuticularis,* with the introduced species *Solanum nigrum* invading the saturated sediment. Tree deaths on the lake bed were similar to those of Transect 1. From the remnants of dead vegetation in the nearshore region it is evident that the sandplain vegetation extended 20-30m beyond the June 1990 water level.

Vegetation on Transect 3 was similar in structure to Transect 2, the understorey being mid-high shrubland covered by scattered emergent *Eucalyptus occidentalis* and *Melaleuca cuticularis*. However, the dominant shrubs of the understorey were different; *Hakea corymbosa, Phymatocarpus maxwellii* and *Acacia sulcata*. Emergent *E. tetragona* and the shrubs *Acacia subcaerulea, Hibbertia acerosa* and *Melaleuca striata* were only found at the uppermost, and driest, part of the transect. The pattern of shrub and tree deaths was similar to Transect 2.

The vegetation of Transect 4 was similar in structure and dominant species composition to Transect 1. A *Banksia speciosa* low (3-6m) open forest covered the shore and a *Eucalyptus occidentalis* tall woodland covered the lake bed. Dominant shore species were *Leptospermum erubescens* and *Melaleuca thymoides*. There was high mortality amongst all the species in waterlogged and flooded parts of the transect except seedlings of *E. occidentalis* and *M. cuticularis,* and the introduced species *Cirsium vulgare* and *Solanum nigrum*. The sandplain vegetation had extended 20-30m beyond the June 1990 water level. The mortality amongst the *E. occidentalis* on the lake bed was similar to the other transects.

At all the transects small seedlings of *E. occidentalis* and/or *M. cuticularis* were found within 2-6m of the shore. These seedlings had germinated since the winter of 1989.

3.3.2 Traverse

Mean lake depth along the traverse transect was approximately 5.0m at the time of sampling. The lake appeared to be a flat-bottomed basin with gently sloping sides.

Table 3.1 shows the vigour classes of the trees sampled and the mean trunk diameter of each class. A total of 171 *Eucalyptus occidentalis* and 18 *Melaleuca cuticularis* plants were recorded along the 1100m transect. It was noted that tree deaths (*E. occidentalis*) along the transect could be classified into two groups, those that had recently died (≤ 1 year ago), and those which have been dead for a much longer period of time. This later group consisted of 107 (62.6%) trees which probably perished in a fire in Dec. 1976. This is evident in the lack of bark and minor branches, and a weathered trunk and absence of dead attached leaves. Of the remaining trees most were found to be moderate to healthy (vigour class 3 & 4). Recently dead trees (vigour class 1.5) comprised 14.1% of trees alive prior to 1989 flooding and dying trees (vigour class 2) a further 9.4%. All recent deaths and poor vigour were assumed to be due to prolonged inundation. Live and recently dead trees (n=64, 37.4%) were tagged for future reference. Apart from an area of small diameter trees in the last 250m of the transect (SE end, Fig. 3.3b), there was no apparent pattern of distribution of vigour and diameter classes, and height across the transect (Figs 3.3a-c).

Figure 3.4 shows the diameter classes versus the vigour classes for the trees on the transect. Most trees sampled were of small to medium diameter, 0 - 16cm (therefore younger). However, the numbers in these classes were made up significantly by trees that perished in the 1976 fire. This indicates a combination of 2 things: 1) smaller/younger trees only died in the fire, or 2) older survivors of the fire have matured since, and increased the range of diameter classes. Recently dead and dying trees as a result of prolonged flooding were mainly small in diameter but with a significant number of medium to large diameter trees, up to 26-28cm. Healthy trees (vigour 3, 4 and 5) had the widest range of diameter classes from 2cm tp 36cm with most less than 22cm.

3.3.3 Seedling Plots

Seedlings were found amongst the flotsum (dead leaves, capsules, seeds) that collected in a series of lines along the shore of the swamp. Figures 6a-b shows the variation in density of seedlings at each plot. Plots of mean seedling density changes towards the open water (Fig. 3.5) clearly show peak density at the flotsum lines. At the time of sampling, seedling height on the March flotsum line (Plot 1) was up to 30cm and less than 5cm on the May flotsum line. It is believed that the March line represents seedlings that germinated during Winter/Spring of 1989. Seedlings in the May line would have germinated in Autumn 1990. Only a small proportion of the seedlings observed were *M.cuticularis*. This is probably due to the scarcity of the species on the swamp bed combined with timing of seed release. It is likely that the higher seedling density in Plot 1 was due to the very open tree and shrub canopy and presence of larger areas of bare ground. At Plot 2, where seedling density was lower, the tree and shrub canopy was dense and the ground was covered with a deep litter layer.

3.4 DISCUSSION

The initial results of this study, although without the benefit of long - term data, provide an insight to the detrimental effect of prolonged flooding and the effect of abnormally high lake levels. In all four transects a high degree of mortality was observed for all species typically part of the surrounding terrestrial sandplain flora. The duration and depth of flooding that resulted in plant mortality is difficult to determine. Local farmers recall that the swamp "filled" during heavy rains of 1986 and has not dried, or substantially lowered, since. If this is the case, then some of the plants on the transects would have been partially inundated for 4 years. However, judging by the persistence of dead leaves on plants, dead individuals at higher elevations would have died recently (<=1 year), whereas those of lower elevations may have died up to 4 years ago. The water depths where dead plants were found in June 1990 varied from waterlogged (up to 50cm above June 1990 level) to 3m depth. On all transects the only perennial species displaying flooding tolerance are *Melaleuca cuticularis* and *E.occidentalis*. Both species are naturally found in areas subject to inundation, however, the duration of flooding under normal conditions would be much shorter (few months of the year) compared to the water regime of Coomalbidgup at present.

More than 23% of the trees in the lake that were alive at the time of the 1989 flooding were either dying or had recently died as a result of prolonged flooding. Mortality of the lake bed trees is expected to increase if the water depth does not decrease and, at least dries out on a regular (every 1-2 years) basis.

The effects of flooding the surrounding sandplain vegetation were found to be dramatic in this study. Although the period of flooding was varied and could not be determined, all species showed little tolerance to these conditions and consequently displayed a high degree of mortality. This has reduced the width of the remaining (the swamp is surrounded by agricultural land) peripheral vegetation at some parts of the swamp by half. This vegetation is vital to the conservation of wetlands as it acts as a buffer to agricultural runoff and usually represents the only remnants of native vegetation and habitat for fauna in agricultural areas.

Depending on future changes in water regime, all or part of peripheral sandplain vegetation is expected to gradually regenerate. However, changes in the species composition and diversity are expected. Species such as *Banksia speciosa* require a fire to trigger seed release and unless this occurs, recruitment in unlikely. Open disturbed areas, arising from the death of vegetation due to flooding, can become colonised by weed species, as seen at all four transects. Potential changes in species composition are evident in areas where seedlings of *E.occidentalis* have germinated amongst the dead sandplain vegetation. However, the future survival of the seedlings may depend on the water regime remaining as it is. If water levels remain high, the distribution of *E.occidentalis* will gradually change; all the lake bed trees could die creating a deep open water lake with a peripheral band of trees of similar age.

The true value of monitoring these transects on an annual basis will be realized after 2 or more years. Then the full impact of flooding on the wetland with respect to changes in vegetation composition and survival will be able to be determined. Although seedlings of at least two species were found near the June 1990 shoreline on all transects, successful recruitment cannot be determined without subsequent monitoring over the first few years after seedling emergence. However, the results of this study suggest that stands of *E. occidentalis* will become established on a large proportion of the swamp's perimeter, provided there are only minor fluctuations in lake hydrology.

At present, Coomalbidgup Swamp contains relatively fresh water (≤ 4ppt). However, with increased runoff from the surrounding agricultural catchment, the potential of secondary salinity exists. Subsoil salt store levels in the Coobidge Creek area are suspected to be high (Bob Nulsen, pers. com), adding to the future threat of saline runoff. Although *E.occidentalis* is relatively tolerant of saline surface levels and waterlogging (Van der Moezel *et al.*, 1991), higher salinities are expected to have a detrimental effect on the lake bed and peripheral sandplain vegetation. The adverse effects of higher water levels (without periods of drying) and potential increases in salinity on wetland vegetation has been documented for rural wetlands (Froend et al, 1987; Bell and Froend, 1990; Froend and McComb, 1991). These processes usually follow the extensive clearing of the catchment over a long period of time for agricultural practices. If the disturbance in the water balance of the catchment goes unchecked the result is a gradual degradation of the low - lying wetland areas. It is clear that at Coomalbidgup Swamp, the death of a significant proportion of the surrounding mature sandplain vegetation occurred during the last 1-4 years (1986-1990) and reflects abnormally high water levels and prolonged flooding. Judging from the age of the trees that died from the recent flooding , similar water levels (and duration of flooding) have not occurred within 15-20 years before 1986. Under pristine catchment conditions, flooding events of this magnitude would be extremely rare.

The threat of increasing saline inflow threatens the conservation value of the swamp. Under such conditions, regular flushing (outflow) of the swamp, would decrease its total salt load. To reduce mean water depth, ensure regular drying, and increase through-flow, the frequency of outflow may be increased by lowering the elevation of the outflow channel. Other remedial measures, aimed at the cause rather than the symptom, may include more efficient water management practices on agricultural land.

As agricultural landuse within the catchment is comparatively recent, and given the very real threat of increasing salinisation, the potential for further degradation of Coomalbidgup Swamp and other wetlands is great. Management plans for wetlands of conservation value in the Coobidge Creek area should consider the effects of increased surface and subsurface runoff and associated transport of nutrients and salt, and means of reducing them.

Table 3.1 Trunk diameter statistics for each vigour class.

	DIAMETER (CM)				
VIGOUR CLASS	MEAN	S.E.	RANGE	COEFF. VAR.	N
ALL CLASSES	10.43	0.54	1-36	67.67	171
1 (Dead)	7.93	0.45	1-26.8	59.19	107
1.5 (Recently Dead)	16.22	3.25	1-26	60.07	9
2 (Dying-very Poor Health)	6.68	1.50	3.1-13	54.91	6
3 (Poor Health)	13.19	1.90	5.4-28.5	57.73	16
4 (Fair Health)	16.55	1.37	5.9-34	43.76	28
5 (Healthy)	14.92	5.87	4.8-36	88.02	5
1.5+2+3+4+5 (Live and Recent Dead)	14.61	1.04	1-36	56.83	64
2+3+4+5 (Live)	14.35	1.09	3.1-36	56.55	55

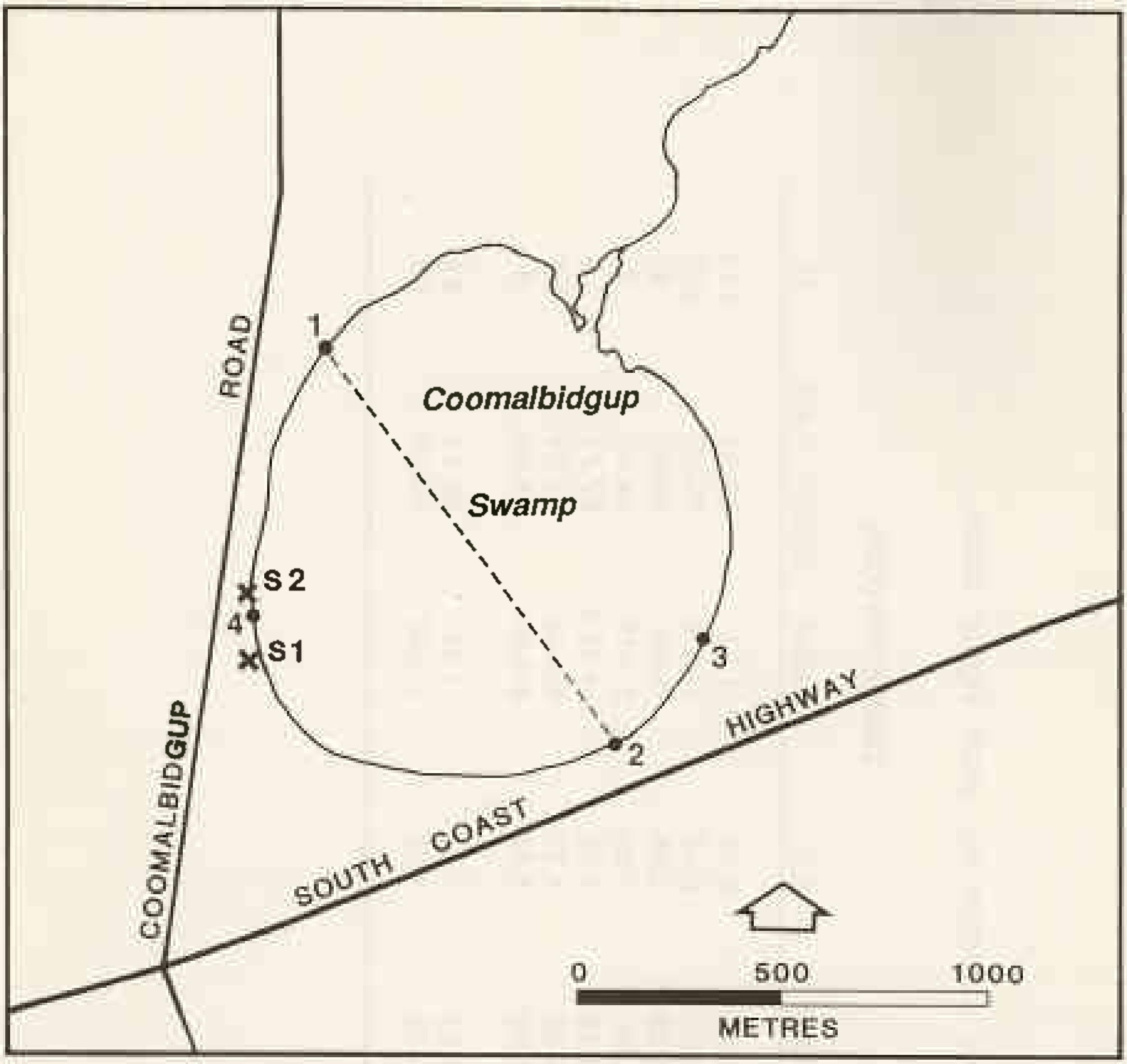


Figure 3.1 Location of sample sites at Coomalbidgup Swamp. Sites 1, 2, 3 and 4 represent the shore transects, and S1 and S2 the seedling plots. The path of the traverse transect is shown by the dotted line between shore transect 1 and 2.

THIS IS A BLANK PAGE

TRANSECT 1

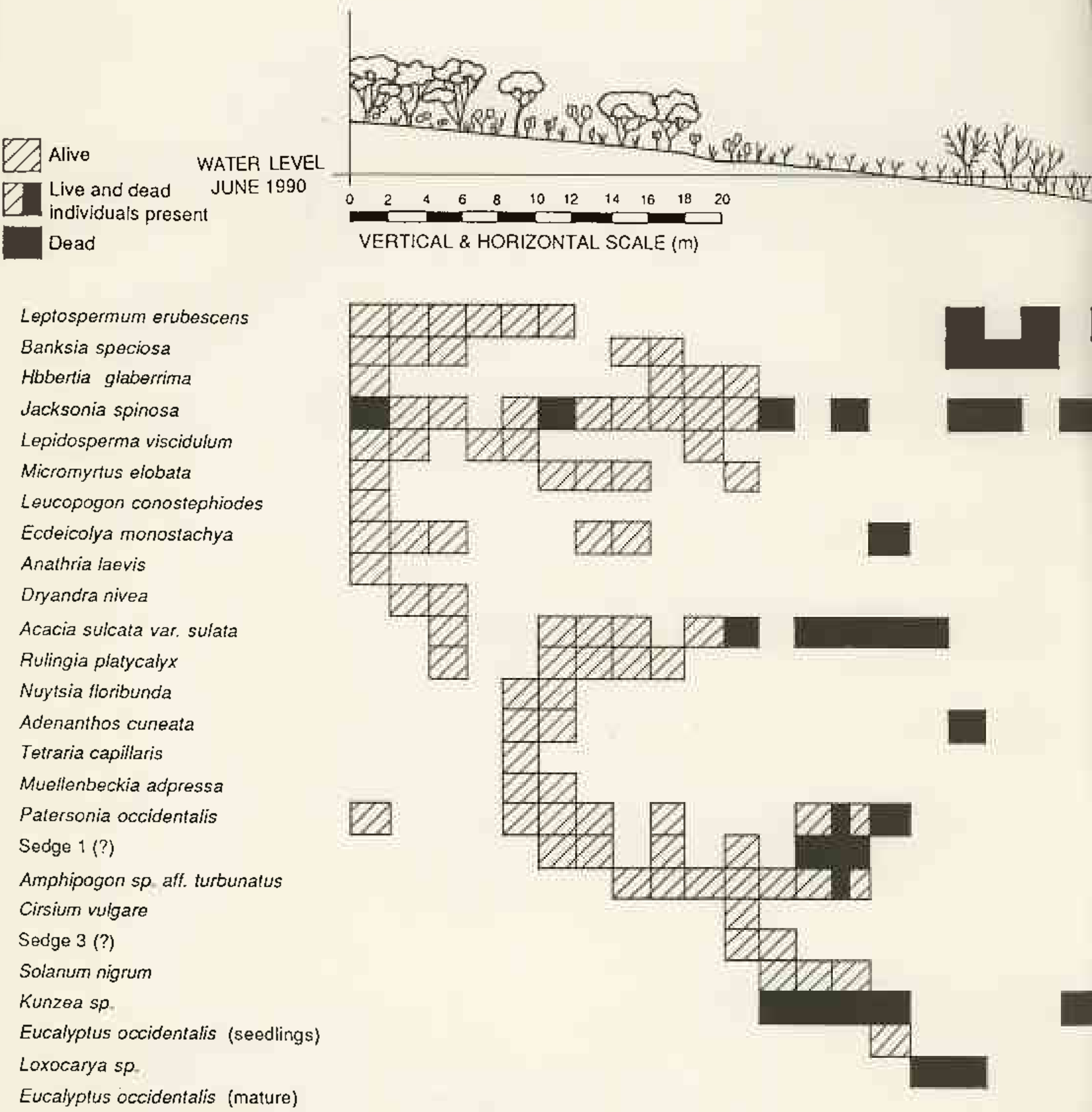
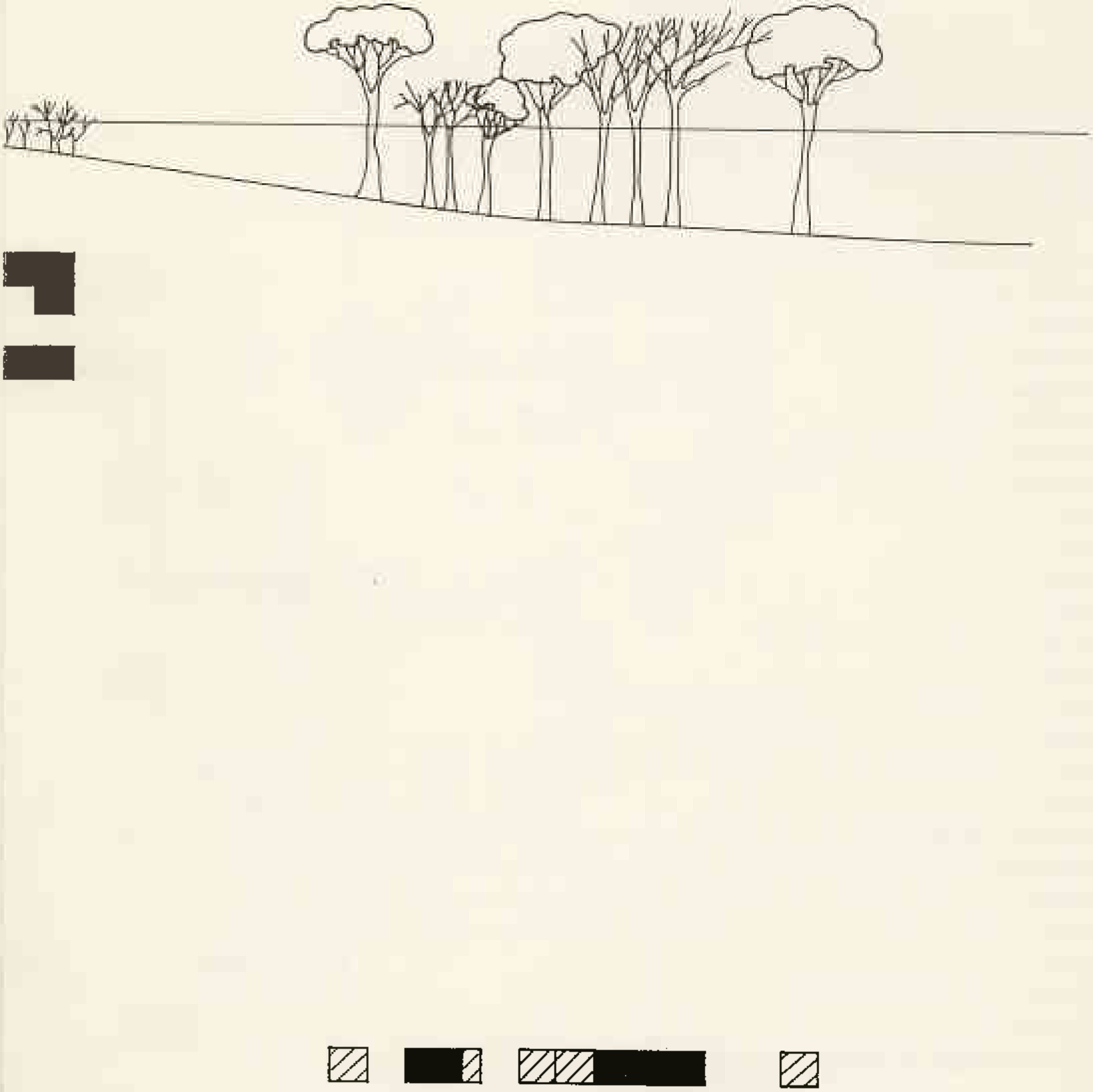
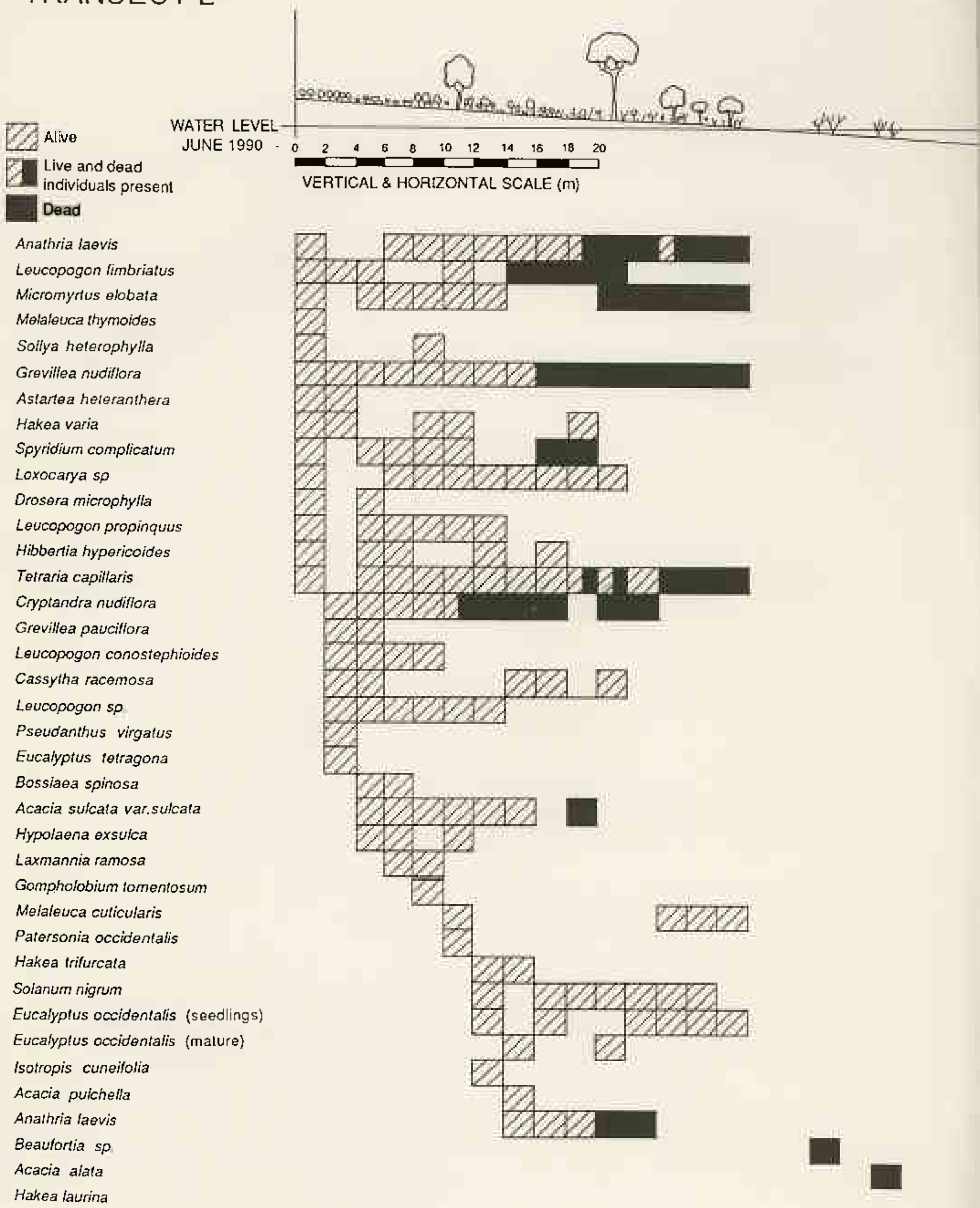


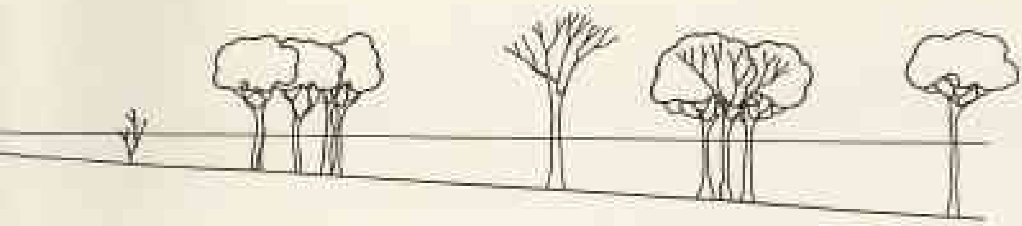
Figure 3.2 Profile diagrams and species distribution al
transects 1-4. Height and distance are to scale. R
for transect descriptions.



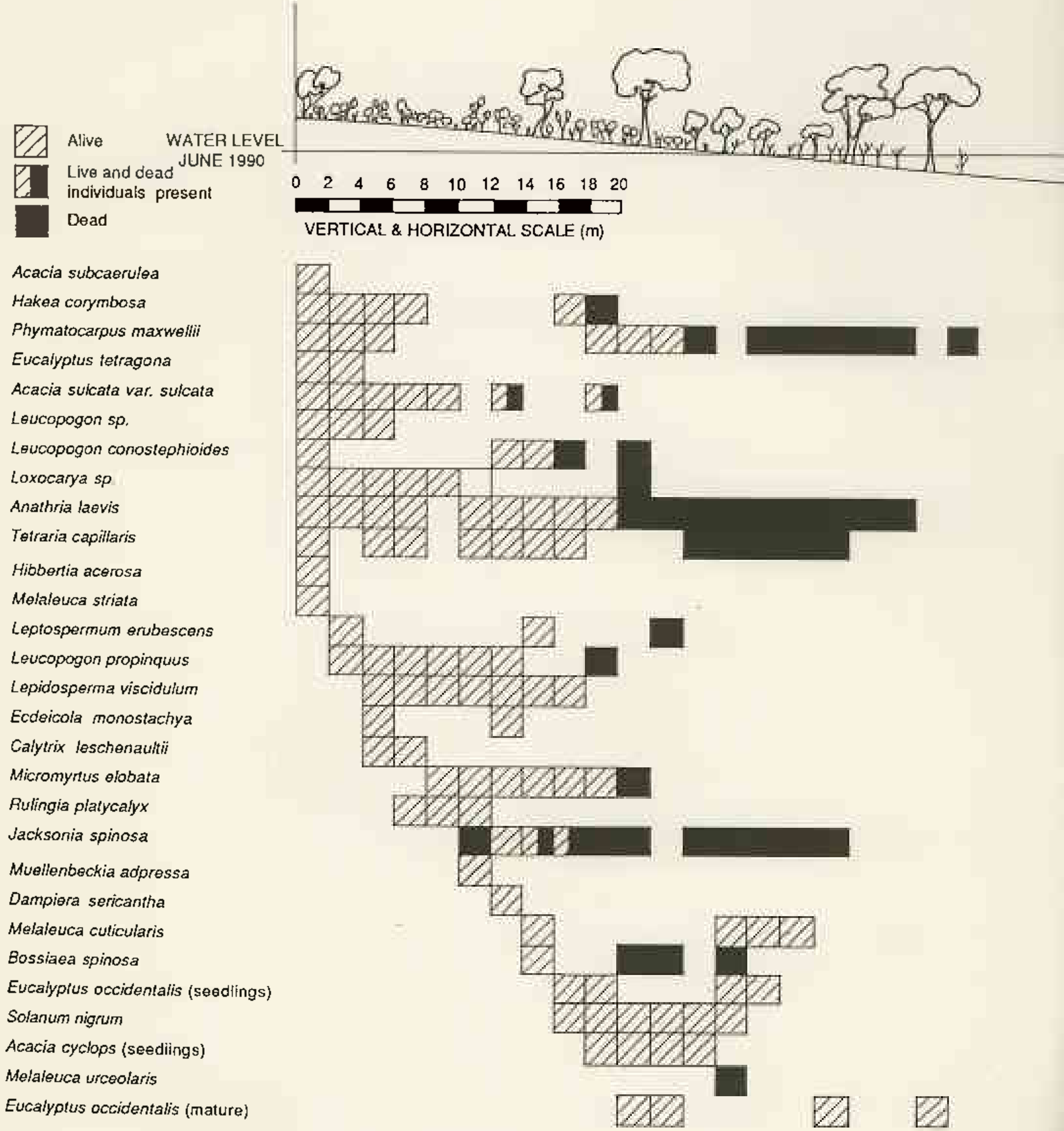
ong shore
efer to text

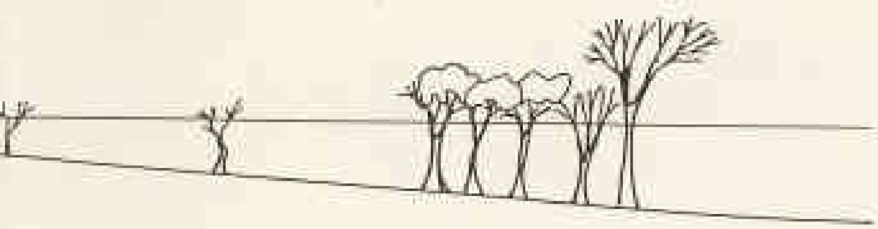
TRANSECT 2


WATER LEVEL
JUNE 1990
0 2 4 6 8 10 12 14 16 18 20
VERTICAL & HORIZONTAL SCALE (m)
Alive
Live and dead individuals present
Dead
Anathria laevis
Leucopogon fimbriatus
Micromyrtus elobata
Melaleuca thymoides
Sollya heterophylla
Grevillea nudiflora
Astartea heteranthera
Hakea varia
Spyridium complicatum
Loxocarya sp
Drosera microphylla
Leucopogon propinquus
Hibbertia hypericoides
Tetraria capillaris
Cryptandra nudiflora
Grevillea pauciflora
Leucopogon conostephioides
Cassytha racemosa
Leucopogon sp
Pseudanthus virgatus
Eucalyptus tetragona
Bossiaea spinosa
Acacia sulcata var.sulcata
Hypolaena exsulca
Laxmannia ramosa
Gompholobium tomentosum
Melaleuca cuticularis
Patersonia occidentalis
Hakea trifurcata
Solanum nigrum
Eucalyptus occidentalis (seedlings)
Eucalyptus occidentalis (mature)
Isotropis cuneifolia
Acacia pulchella
Anathria laevis
Beaufortia sp
Acacia alata
Hakea laurina

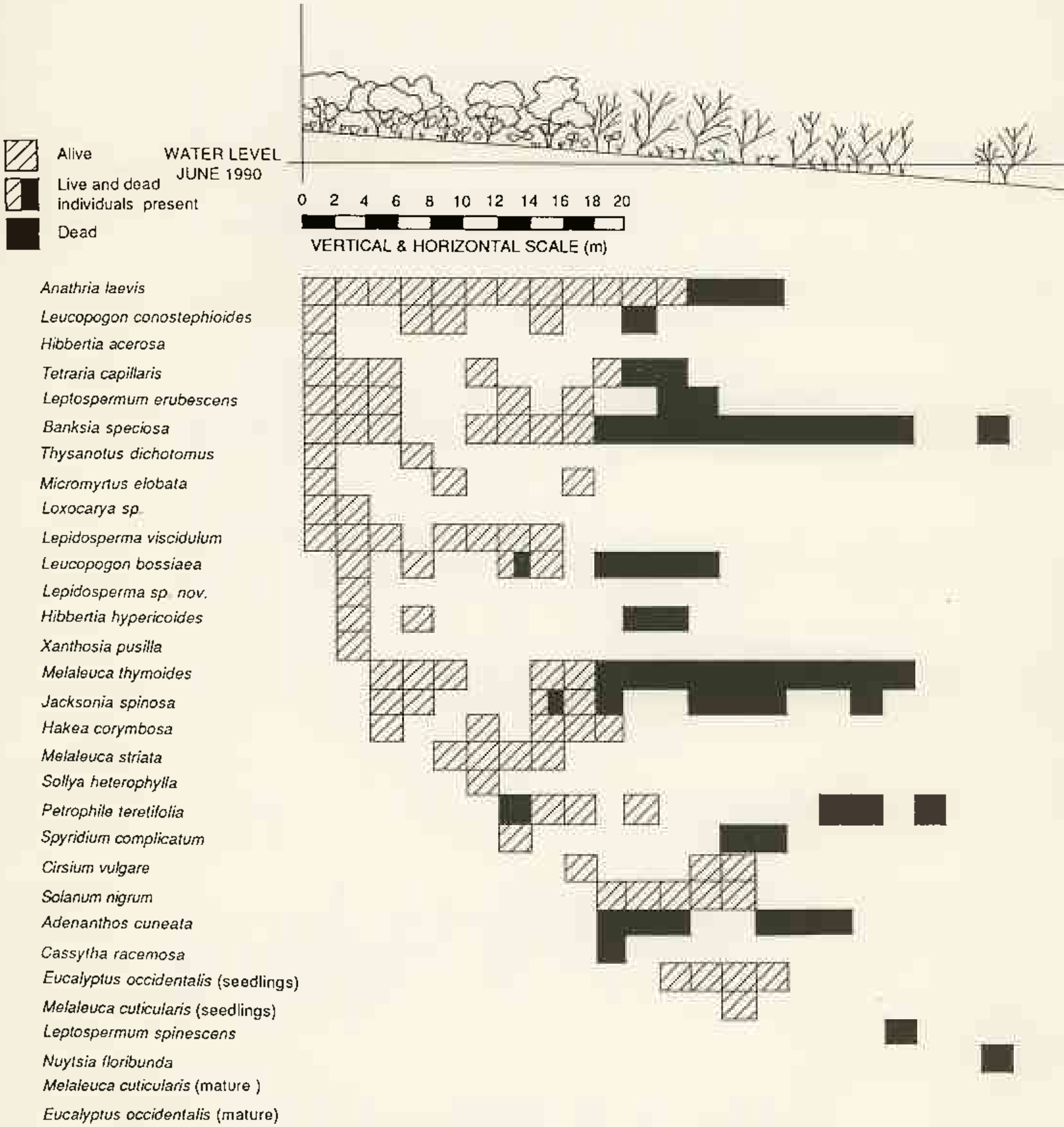


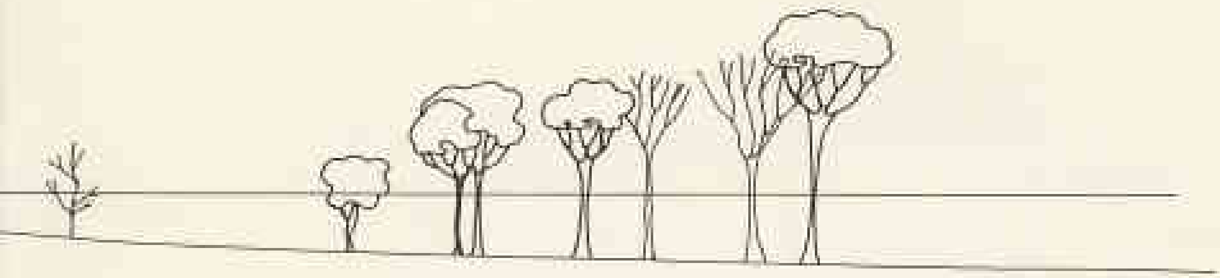
TRANSECT 3

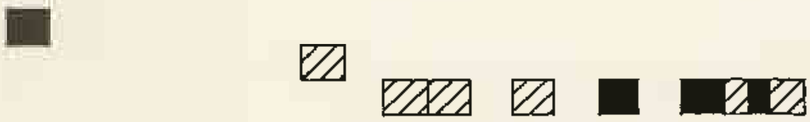

Alive
Live and dead individuals present
Dead
WATER LEVEL JUNE 1990
0 2 4 6 8 10 12 14 16 18 20
VERTICAL & HORIZONTAL SCALE (m)
Acacia subcaerulea
Hakea corymbosa
Phymatocarpus maxwellii
Eucalyptus tetragona
Acacia sulcata var. sulcata
Leucopogon sp.
Leucopogon conostephioides
Loxocarya sp.
Anathria laevis
Tetraria capillaris
Hibbertia acerosa
Melaleuca striata
Leptospermum erubescens
Leucopogon propinquus
Lepidosperma viscidulum
Ecdeicola monostachya
Calytrix leschenaultii
Micromyrtus elobata
Rulingia platycalyx
Jacksonia spinosa
Muellenbeckia adpressa
Dampiera sericantha
Melaleuca cuticularis
Bossiaea spinosa
Eucalyptus occidentalis (seedlings)
Solanum nigrum
Acacia cyclops (seedlings)
Melaleuca urceolaris
Eucalyptus occidentalis (mature)



TRANSECT 4


Alive
Live and dead individuals present
Dead
WATER LEVEL JUNE 1990
0 2 4 6 8 10 12 14 16 18 20
VERTICAL & HORIZONTAL SCALE (m)
Anathria laevis
Leucopogon conostephioides
Hibbertia acerosa
Tetraria capillaris
Leptospermum erubescens
Banksia speciosa
Thysanotus dichotomus
Micromyrtus elobata
Loxocarya sp.
Lepidosperma viscidulum
Leucopogon bossiaea
Lepidosperma sp. nov.
Hibbertia hypericoides
Xanthosia pusilla
Melaleuca thymoides
Jacksonia spinosa
Hakea corymbosa
Melaleuca striata
Sollya heterophylla
Petrophile teretifolia
Spyridium complicatum
Cirsium vulgare
Solanum nigrum
Adenanthos cuneata
Cassytha racemosa
Eucalyptus occidentalis (seedlings)
Melaleuca cuticularis (seedlings)
Leptospermum spinescens
Nuytsia floribunda
Melaleuca cuticularis (mature)
Eucalyptus occidentalis (mature)





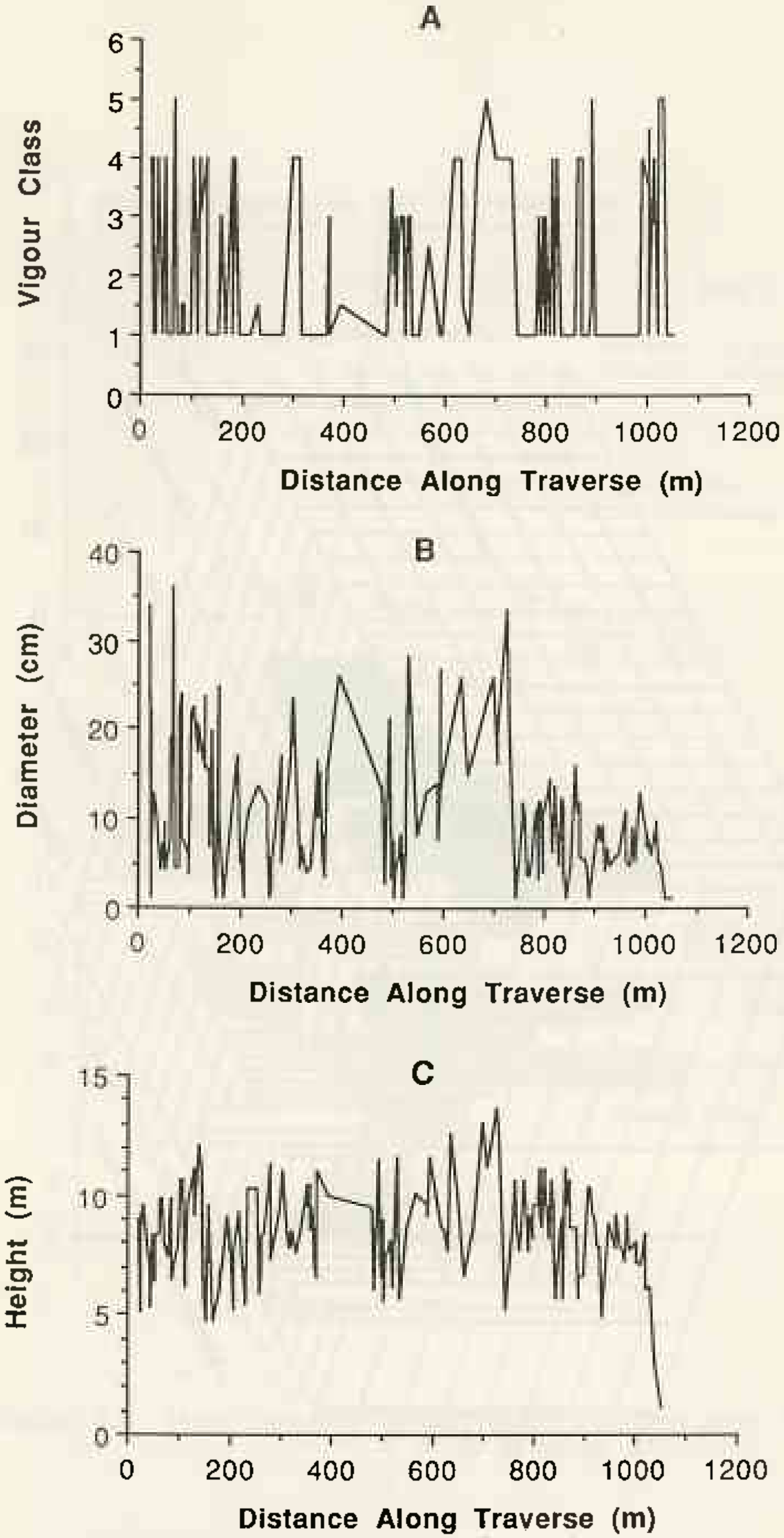


Figure 3.3 Variation in tree vigour class (A), trunk diameter (B) and height (C) along the traverse transect.

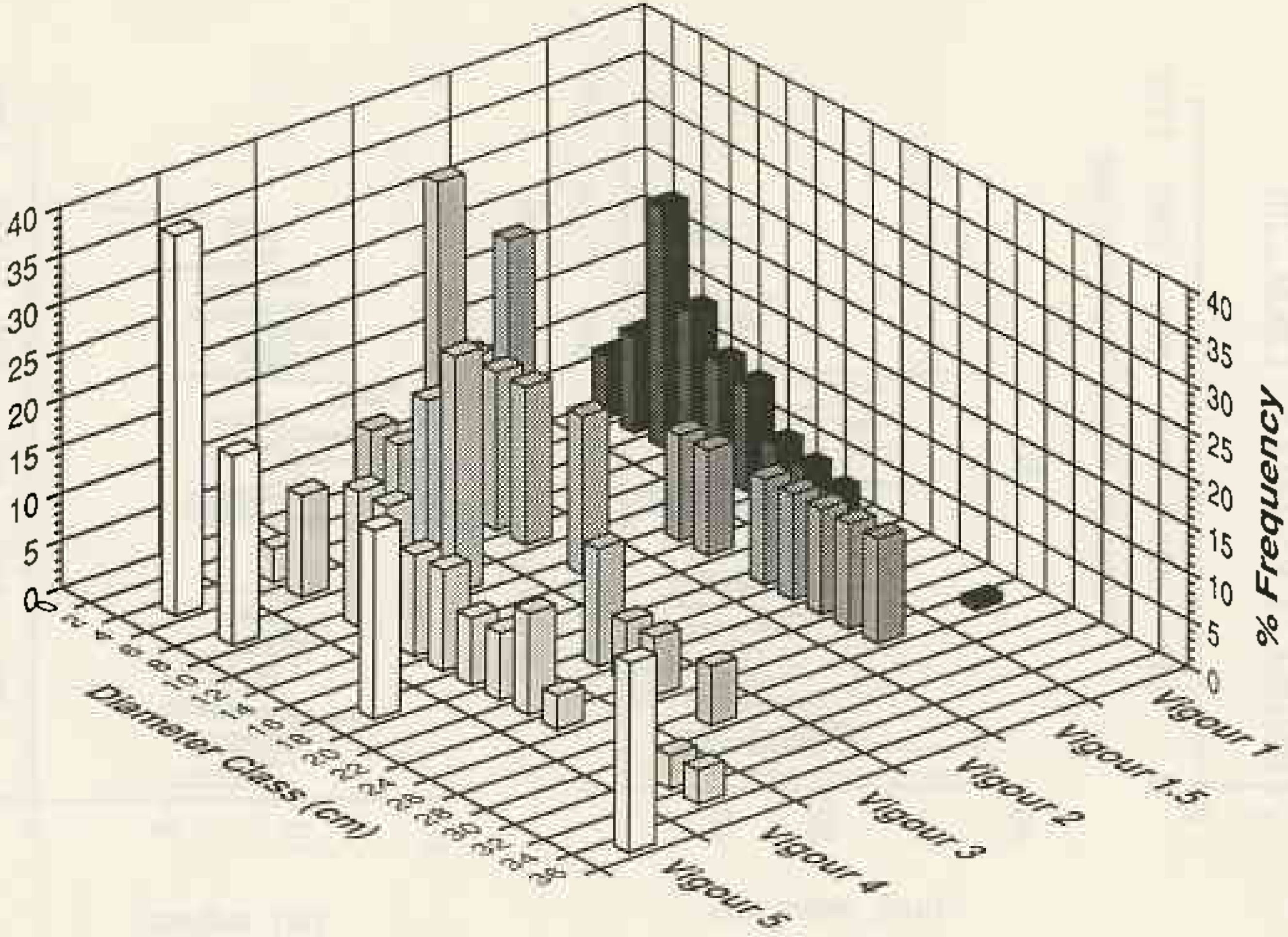
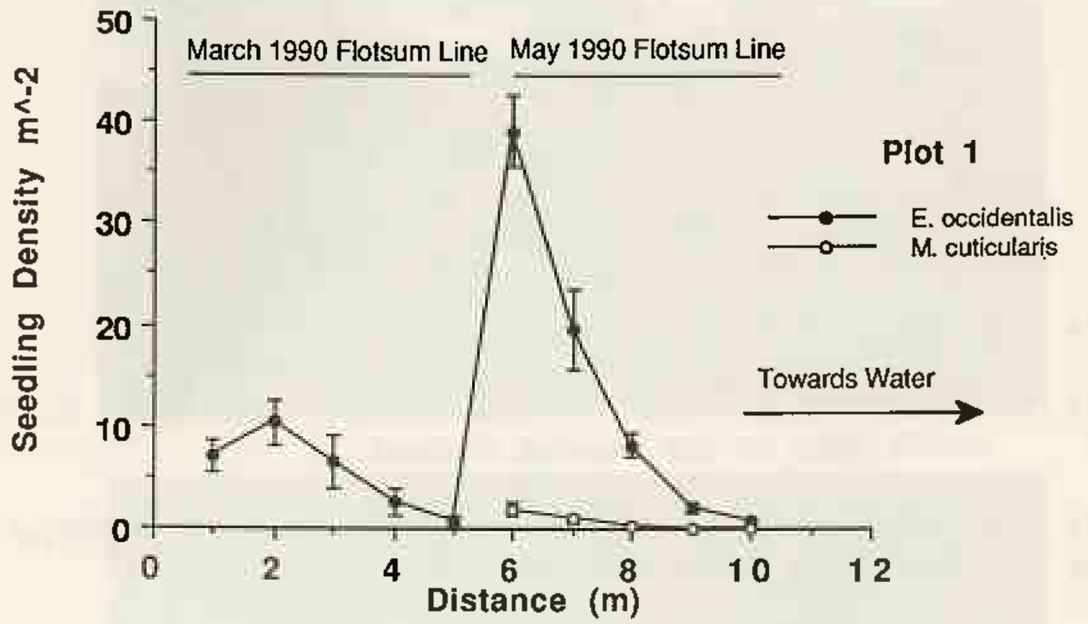


Figure 3.4 Trunk diameter frequency distribution within each vigour class. Refer to section 3.1.2 for definitions of vigour classes.



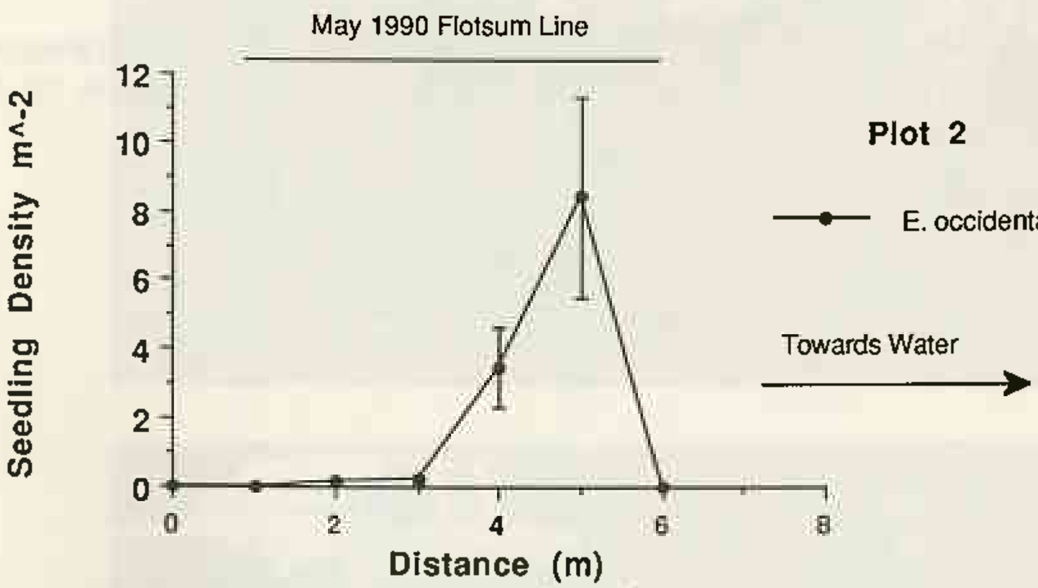


Figure 3.5 Mean seedling density along seedling plots 1 and 2.

Plate 3.1 Dead *Banksia speciosa* near shore transect 4.

Plate 3.2 Dead (vigour class 1) and recently dead (1.5) *Eucalyptus occidentalis* on the traverse transect.

Plate 3.3 *Eucalyptus occidentalis* seedlings on the Coomalbidgup swamp shore. Note their distribution along the flotsum lines.

Plate 3.4 *Eucalyptus occidentalis* at the centre of the lake. Some stressed and recently dead trees are visible. Water depth was up to 5m at this point.

Plate 3.5 Dead *Eucalyptus occidentalis* along the traverse transect, killed by the 1976 fire. The 1989 high water mark is visable on the tree trunks.

Plate 3.1

Plate 3.2

Plate 3.3

Plate 3.4

Plate 3.5

4. CONCLUSIONS

The identification and classification of wetlands within the Coobidge catchment was aided by the relative simplicity and flexibility of the Semeniuk wetland classification system. The primary geomorphic types were, in most cases, easy to identify. Secondary categories such as water quality and vegetation types require more expertise to apply but were found to be crucial in determining wetland types. Minor difficulties can be overcome with 'fine-tuning' of the categories to suit the region to which it is applied. Continued application of this system to different wetlands of the South West, should enable it to define wetlands with a wide range of geological origin, landforms, water quality and vegetation types.

Wetland water quality, ie. salinity and pH, played a key role in identifying the different wetland groups within the catchment. The measurement of further water quality parameters, such as turbidity and nutrient load, would have aided in refining the classification. However, this would have increased the time taken for ground truthing considerably. Sufficient refinement of the wetland groups was achieved with the data collected, and will aid the classification of wetlands and water resources within the Esperance-Ravensthorpe region.

A more rapid method of identifying and classifying wetlands over a large area such as the Esperance region, would be remote sensing using Landsat MSS and TM imagery. Information on wetland seasonality, extent of flooding, nutrient status, salinity, vegetation degradation, and catchment parameters could be collated in a relatively short time. However, a preliminary assessment of the applicability, accuracy and efficiency of the technique would need to be performed on a smaller area. Such an assessment would include extensive ground truthing and image analysis to determine the most efficient procedure for wetland/catchment identification and classification.

Much of the area of the Coobidge catchment has been cleared and as a result, many wetlands have little or no surrounding natural vegetation. Of the wetlands that have some remaining vegetation, stock grazing/trampling has degraded or removed the understorey in most cases, leaving only scattered tall shrubs and trees. Algal blooms were evident at several of these wetlands, indicating the importance of the surrounding natural vegetation and the exclusion of stock in preventing degradation. Several wetlands within the catchment have been rehabilitated and fenced by landowners.

There are only two areas of the catchment where wetlands of conservation value are to be found, the group of playa lakes to the east and the 'coastal' wetlands south of the South Coast Highway. The playa lakes are surrounded by a large area of diverse vegetation more typical of the playa lake systems east of the Esperance - Norseman Highway, and represent the best example of remnant vegetation and fauna habitat in the upper reaches of the catchment. The coastal wetlands comprise an intricate system of basins, sumps and channels amongst an extensive area of diverse sandplain and coastal vegetation much of which was flooded during the winter of 1989 and continuing into 1990 at least. Much of this land is reserve vested in CALM. Only the northern-most wetlands of this group including Lake Gore, Gidong, Kubitch and Carbul, were covered in this study and the effects of the 1989 flooding on the wetlands south and west of these lakes are not known. If flooding continues to occur and water from the catchment increases in salinity, these coastal areas, extending to Barker Inlet, are at risk of being severely degraded. At present the water quality of Lake Gore is suitable for most water birds.

Using Coomalbidgup Swamp as a case study on the impact of increasing inflow to wetlands, it is evident that there has been extensive plant mortality due to prolonged flooding. Large areas of dead vegetation have led to weed infestation and potential destabilization of the swamp shores. With continued higher than normal water levels many more trees on the lake bed will die, and although there will be some re-establishment on the shoreline, the diversity of the surrounding shore vegetation will be greatly reduced. These changes represent a shift from an ephemeral vegetated swamp to a deep lake with mainly peripheral vegetation. As the authors are uncertain of the wetlands value to waterbirds, it is difficult to determine what loss/gain will occur in this regard. However, the (periodically) flooded trees could represent a valuable waterbird nursery. With constant flooding this habitat type will be lost.

The Coobidge Creek Landcare Group has been advised that wetlands may be used as a storage sump for diverted excess water from farms. It was even considered that bunds be built around some wetlands to increase the level and thus water-holding capacity of some wetlands. Clearly, wetlands which have either a mosaic or complete vegetation cover throughout the waterbody will be adversely affected by such artificially raised water levels and increased duration of flooding. Only wetlands with a peripheral vegetation cover should be considered for farm water storage with water levels remaining permanently low enough so as not to cause death of surrounding upland vegetation. Finally, if storage of farm water leads to increased salinisation of the wetland then their significance for waterbirds may be decreased. The highly saline wetlands in the northern half of Coobidge Creek catchment may be most suitable for water storage.

5. ACKNOWLEDGEMENTS

Funding for this project was provided by the Water Resources Planning Division of the Water Authority Of Western Australia and by the Department of Conservation and Land Management. We are grateful to Viv Reid for making available his information on Coobidge Creek catchment and initial talks with Viv gave us the impetus and enthusiasm for the project.

Gary Middle and Karen Grady of the Water Authority of Western Australia provided expertise and facilities for the production of catchment maps.

Peter Muller of the Western Australian Department of Agriculture provided soil maps of the catchment.

We are indebted to Bob Piggott and all the landholders in the Coobidge Creek catchment for access to wetlands and information regarding rainfall patterns, water levels and the history of the catchment.

6. REFERENCES

Bell D T and Froend R H (1990) Mortality and growth of tree species under stress at Lake Toolibin in the Western Australian Wheatbelt. J. Roy. Soc.W.A.72: 63-66.

Froend R H and McComb A J (1991) An account of the decline of Lake Towerrinning, a wheatbelt wetland. J. Roy. Soc. W.A. (in press).

Froend R H, Heddle E M, Bell D T and McComb A J (1987) Effects of salinity and waterlogging on the vegetation of Lake Toolibin, Western Australia. Aust. J. Ecol. 12: 281-294

Gutteridge Haskins and Davey Pty Ltd (1990) Coobidge Creek Catchment Group: Drainage. Report to the Agriculture Department of Western Australia.

Semeniuk C A (1987) Wetlands of the Darling System - a geomorphic approach to habitat classification. J. Roy. Soc. W.A. 69: 95-112.

Semeniuk C A (1989) Assessment of wetland classification and mapping in the Jumperkine SW and Mundaring NW sheet areas. Water Authority of Western Australia, Report No. WP 87.

Semeniuk C A, Semeniuk V, Cresswell I D and Marchant N G (1990) Wetlands of the Darling System, Southwestern Australia: a descriptive classification using vegetation pattern and form. J. Roy. Soc. W.A. 72: 109-121.

Ter Braak, C J F (1988) CANOCO - a FORTRAN program for canonical community ordination by correspondence analysis, principal components analysis and redundancy analysis (version 2.1). Agricultural Mathematics Group, Wageningen, The Netherlands, Technical Report: LWA-88-02.

Van der Moezel P G, Pearce-Pinto G V N and Bell D T (1991) Screening for salt and waterlogging tolerance in *Eucalyptus* and *Melaleuca* species. For. Ecol. Manage. (in press).

Wetlands Advisory Committee (1977) The status of wetland reserves in System 6. Report of the Wetlands Advisory Committee to the Environmental Protection Authority.