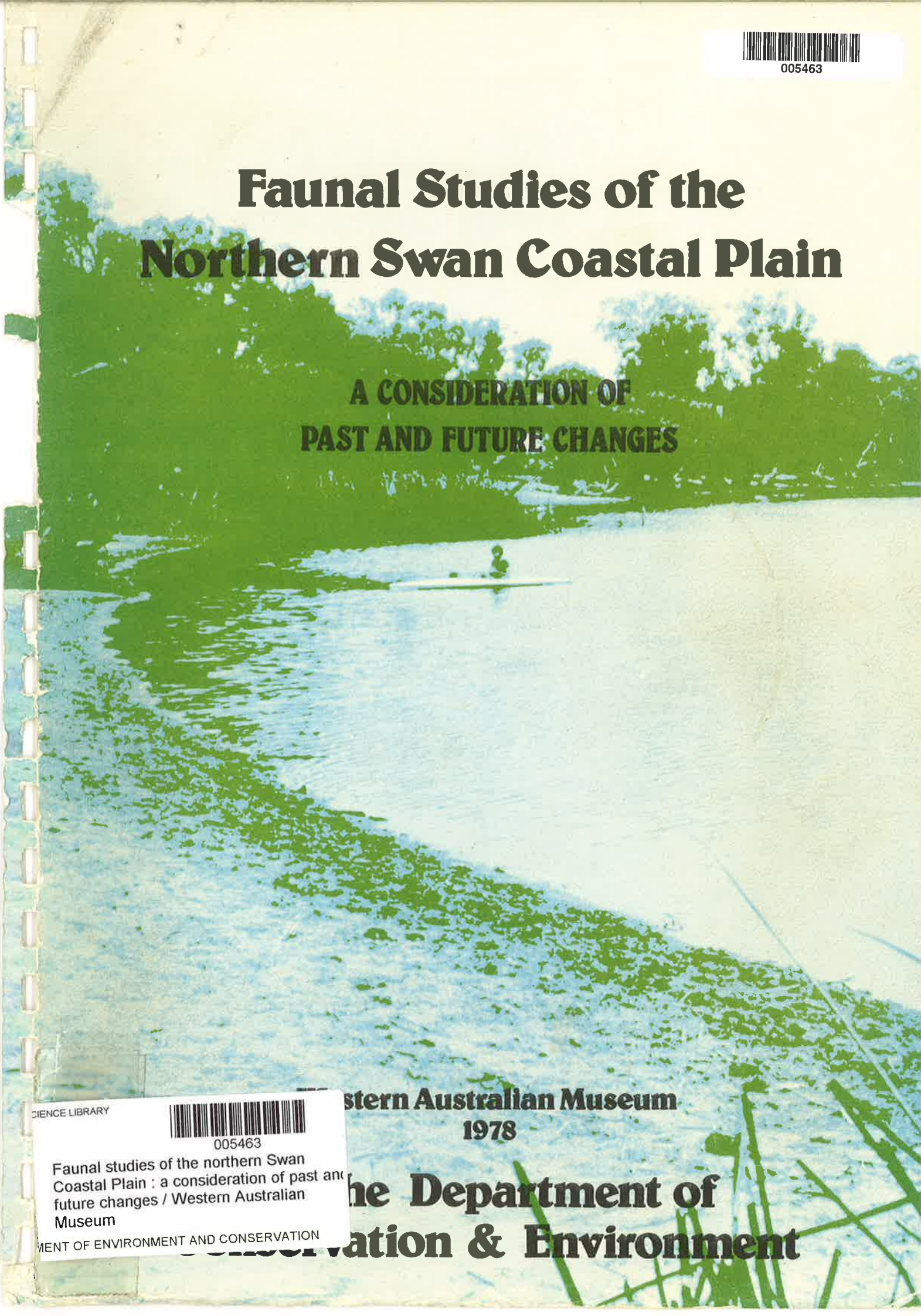
Faunal Studies of the Northern Swan Coastal Plain

A CONSIDERATION OF PAST AND FUTURE CHANGES



stern Australian Museum
1978

he Department of
ation & Environment

FAUNAL STUDIES OF THE NORTHERN SWAN COASTAL PLAIN
A Consideration of Past and Future Changes

Western Australian Museum

THE ENVIRONMENT OF THE NORTHERN SWAN COASTAL PLAIN, CONSIDERATION OF FAUNAL CHANGES AND RECOMMENDATIONS

R.A. How

Dept. Mammals & Survey, Western Australian Museum

The Swan Coastal Plain of Western Australia extends from the Hill River Scarp in the north to Cape Naturaliste in the south and is bound by the Indian Ocean to the west and the Darling Scarp to the east (Seddon, 1972). Within this coastal plain lies the Northern Swan Coastal Plain (N.S.C.P.), the area between the Moore River to the north and the Swan River to the south.

No recent surveys of any magnitude have been carried out to document the existing fauna of the N.S.C.P. or its importance and contribution to the fauna of the south west and west coast.

During 1977-78 the Western Australian Museum accepted a major contract from the Department of Conservation and Environment with the objectives of, (a) identifying and documenting the ecology of the Northern Swan Coastal Plain, (b) assessing the effects of intensive groundwater developments on the fauna, flora and where relevant the social environment and (c) suggesting environmental and water management strategies.

I THE NORTHERN SWAN COASTAL PLAIN

LANDFORMS

The NSCP is part of the Perth Basin and as such consists of Mesozoic and Cenozoic sediments separated from the Precambrian rocks to the east by the Darling Fault.

Superficial Quaternary formations overly older Mesozoic and Tertiary sediments and are separated from them by an unconformity; these older sediments are themselves separated by several unconformities (Allen 1976).

The sediments of the Quaternary formations determine the soil associations of the plain and, in the southern section of the Northern Swan Coastal Plain contain an unconfined aquifer, the Gnangara Mound.

The Quaternary sediments are composed of sand, limestone, silt and clay of varying extents and depths that range from 15 - 90m. These sediments are of both aeolian and alluvial origins and form the five main geomorphic elements of the plain; the oldest being in the east and the youngest in the west.

1. The oldest sediments are the Ridge Hill Shelf sandstones and laterites which are of alluvial origin and form the foothills of the Darling Scarp in the east. The Shelf slopes gradually to the west and has become prominently dissected by stream action.
2. The Pinjarra Plain consists of numerous unconsolidated alluvial sediments and lies to the west of the Ridge Hill Shelf and to the east of the Bassendean Dune System. The Pinjarra Plain is not as extensive north of the Swan River as it is south but still contains numerous soil associations of varying age, texture, colour and fertility (Seddon, 1972; McArthur and Bettenay, 1960; Bettenay, McArthur and Hingston, 1960).
3. The Bassendean Dune System lies to the west of the Pinjarra Plain and is younger than it. The dunes consist of highly leached silicious sands of low nutrient content and they reach their maximum extent on the N.S.C.P. Between the aeolian derived dunes of this system there are numerous small peaty areas and ephemeral swamps.
4. The Spearwood Dune System is also aeolian in origin, but lies to the west of the Bassendean Dune System, is

considerably younger and has greater relief. It consists of an aeolinite base with a capping of indurated travetine limestone and is overlain by yellow and brown sands of varying depths. The limestones of this system are visible as outcrops near the coast and also contain the limestone caves adjacent to Lake Joondalup and Lock McNess.

5. The youngest and most westerly of the Quaternary sediments is the Quindalup Dune System. This is a narrow strip of calcium rich beach sands adjacent to the coast and formed during the last 6000 years.

The topography of the N.S.C.P. is relatively uniform with average relief of between 30 - 60 m. Dunes in the Spearwood and Bassendean Systems may rise to 60 - 80 m above sea level but these are gradual and barely discernible.

The lakes and swamps of the area form an important component (c. 8%). Swamps are mainly central and eastern in their distribution on the N.S.C.P. and occupy about 7% of the area. They comprise the important ephemeral swamps that are central on the Bassendean System, and in the east and north east are the outward expression of the Gnangara Mound aquifer where it approaches its hydrologic boundaries of Gingin and Chandala-Ellen Brooks on the Pinjarra Plain.

CLIMATE

The climate of the Swan Coastal Plain is characterised by dry, hot summers and mild wet winters (Gentilli, 1948; 1951; Anon 1975; Seddon, 1972). The mean daily maxima range from 30^{o}C in January and February to 18^{o}C in July and August. Rainfall decreases from the southeast to the northwest over the Northern Swan Coastal Plain, ranging from 883 mm at Perth and 859 mm at Guildford to 684 mm at Pearce and 635 mm at Guilderton. Over 80% of the annual rainfall occurs during the months May to August.

The term of the present study coincided with the end of the driest and hottest triennium on record. During the 16 months from January 1977 to April 1978 mean monthly maxima were above average for 15 months while rainfall was below average for 12 months. Rainfall between May and August 1977 was 32% below average.

The climate of the Swan Coastal Plain has been reviewed in detail by Seddon (1972).

WATER RESOURCES

As a result of the recent drought and Perths rapidly increasing population and water use, there is growing concern expressed by the press, government departments (Sadler and Field 1976) and individuals (Adams, 1977) about the future demand and supply of this most important resource.

A comprehensive review of the major water resources available in the South West Region of Western Australia has been made by Sadler and Field (1976). These authors examine the current and potential use of water from both surface and underground sources, and illustrate the potentially high yield from development of the latter resource.

The effects of groundwater abstraction on the flora and fauna are of prime importance, particularly on the Northern Swan Coastal Plain where groundwater has been used for horticulture and agriculture for a considerable time and is now being abstracted for the growing domestic and industrial demands.

The Gnangara Mound

Within the area bounded by Gingin Brook, Ellen and Chandala Brooks, the Swan River and the Indian Ocean, the superficial Quaternary sediments contain an unconfined aquifer known as the Gnangara Mound. These sediments being mainly sands are saturated with water to a level determined by topography, sediment characteristics and rainfall. The unconfined aquifer in the superficial formations overlies and has continuity with the confined artesian groundwater of the underlying Mesozoic and Tertiary sediments (Allen 1976).

The groundwater in the Quaternary sediments forms a mound with a crest of 70m and which is in dynamic equilibrium. Groundwater flows laterally through the mound to the hydraulic boundaries bordering it (Gingin Brook, Chandala and Ellen Brooks, Swan River, Indian Ocean) and there is some vertical flows to the confined aquifer below. Rate of movement of water through the aquifer depends on the conductivity of the various formation types but is on average about 40 m/yr.

The volume of the Gnangara Mound has been estimated by Allen (1976) to be 65 x 10^9 m^3 with the volume of stored groundwater (based on a specific yield of 20%) being 13 x 10^9 m^3. Over 90 per cent of the water is fresh, having less than 500 mg/litre total disolved solids.

Seasonal fluctuations in the water table are pronounced; levels are highest in spring and lowest in autumn following the hot, dry summer. The average seasonal fluctuation is about 1 metre, but this may vary between 0.2m and 2.0m depending on topography, location and rainfall (Burton, 1976). There are also long term cyclical trends reflecting climatic variations that may lead to fluctuations in the water table by up to 3m over a 10 year period (Burton, op. cit.)

Historical changes in the level of the groundwater can also be documented (Seddon, 1972). A comparison of the maps of Lakes Jandabup and Joondalup in 1903 (Anon. 1903) with present maps show that present levels are considerably higher. Similarly the presence of old fencelines in Lakes Bambun and Joondalup testify to their use for grazing when water levels were lower in the past. However, not all areas show an increase in groundwater levels to the present, as Muir and Dell (M.S.) illustrate that the vegetation pattern of some swamps in Melaleuca Park can only be explained by a decreasing water table over recent time.

Gnangara Mound Utilisation

The development of production borefields on the Gnangara Mound by the Public Works Department and the Metropolitan Water Supply, Sewerage and Drainage Board in recent years has increased the demands made on that water resource which has previously been used by private bores for domestic, industrial and agricultural purposes. The amount of water abstracted by the many thousand private bores can, at best, be only roughly estimated.

Both Bestow (1976) and Burton (1976) have examined the potential yield and uses of groundwater abstracted from the Gnangara Mound using information from exploratory bores and predictions based on computer simulation of the aquifer.

Under full development of this aquifer there would be a decrease in the water table by more than 1 m over an area of 660 km^2, representing 30% of the area of the Gnangara Mound. A drawdown in excess of 3 m could be expected over 240 km^2 of the above area (Burton, 1976). About 45% of the area where drawdown will be over 1 m and 60% of the area with a drawdown in excess of 3 m will be within State Forest No. 65. Cones of depression occur around the bores where drawdown could be expected to exceed 5 m. Bestow (1976) predicts that pumped abstraction from the Gnangara Mound under full development would amount to 213 x $10^6 m^3$ annually. This would be made up of 40 x $10^6 m^3$ from decreases in plant transpiration, 50 x $10^6 m^3$ from decreases in swamp evaporation and 123 x $10^6 m^3$ from depletion of the annual discharge at the hydraulic boundaries. These represent a decrease of 5%, 25% and 74% respectively in the above categories from the present estimates of the natural situation. Current abstration rate is relatively high with well over 50% of Perth's metropolitan water being supplied from the Gnangara Mound during late summer and autumn. With demands on the aquifer increasing as the borefield is developed and urban demand for water grows, figures on daily consumption from underground supplies could be presented to the public in a similiar manner to present daily consumption figures from surface storage reservoirs.

The environmental implications of lowering the water table have been discussed by Havel (1975) who indicated that the main forms of land use to be affected would be (a) flora and fauna conservation, (b) forest silviculture (c) agriculture and (d) aquatic based recreation. It is the affect of groundwater abstraction on the fauna of the N.S.C.P. that is the main concern of this report.

VEGETATION

Vegetation Formations

The vegetation of the N.S.C.P. belongs to the Darling District of the South-western Botanical Province (Grieve and Blackall, 1975). Within this area lie a number of structural formations containing many floristic associations; these formations have been summarised by Seddon (1972) from

the work of Speck (1952). The major vegetation types of the Spearwood and Bassendean Dune Systems have received considerable attention from Havel (1968) in his appraisal of these areas as plantation sites for the softwood Pinus pinaster, while Smith (1973) has documented the numerous communities that make up the coastal dune and wetland formations.

1. Coastal Dune Complex. This is a successional series of plant communities that range through strand, foredune, primary dune, swale and secondary dune regions. These communities show considerable variation in their floristic and structural complexity over this range. Important as dune stabilisers are species of the genera Spinifex, Scirpus, Ammophila and Lepidosperma, many of which have rhizomatous root systems. Secondary dunes are characterised by the greater occurence of woody shrubs. This complex is characteristic of the Quindalup Dune System.

2. Closed-Heath Formation. This formation occurs in relatively small areas on the Spearwood Dune System wherever the soil is shallow. Heaths that occur on the coastal limestone (Spearwood limestone exposures within the Quindalup System) are generally more open and less complex floristically than those that are further inland and less disturbed. Many genera make important contributions to the dominants of this heath, the more common being Acacia, Melaleuca, Adenanthos, Grevillea and Diplolaena.

3. Tuart-Jarrah-Marri Tall Open-Forest Formation. An important formation of the Spearwood Dune System that shows considerable floristic variation over its latitudinal range. Associations dominated by either Tuart (Eucalyptus gomphocephala), Jarrah (E. marginata) or Marri (E. calophylla) can be found throughout the extent of the formation, though it is more usual to find two or more species as co-dominants. The common understory species are Banksia spp. Casuarina fraseriana, Jacksonia spp. Macrozamia reidlei, Xanthorrhoea preissii and Agonis flexuosa. There is generally a rich flora of shrubs and ground layer species.

4. Jarrah-Banksia Woodland Formation. This is one of the important formations which constitute the structural

and floristic mosaic of the Spearwood and Bassendean Dune System; an open formation dominated by jarrah but with the occasional marri stand. The low tree and small shrub strata are characteristically dominated by Banksia attenuata and B. menziesii with Acacia cyanophylla, Jacksonia furcellata and Casuarina fraseriana locally abundant. The low shrub layer is very rich in species.

5. Marri-Jarrah-Banksia Open-Woodland Formation. This intergrades with the previous formation but is characteristically more open and usually on poorer soils. The co-dominants, jarrah and marri, are associated with smaller trees of Banksia grandis, B. attenuata, B. menziesii, B. ilicifolia, Casuarina fraseriana and Melaleuca preissiana. There are numerous depressions and swamps in the swales where swamp forest is dominant.

6. Banksia-Sheoak-Pricklybark Low Open-Forest Formation. This is the dominant formation in the northern part of the N.S.C.P., extending almost the entire width of the plain. It intergrades with both previous formations on the nutrient poor Bassendean sands and its distribution indicates its suitability to poorer soil types and more arid areas. The dominants are Banksia attenuata, B. menziesii, the Sheoak, Casuarina fraseriana and the prickly bark, Eucalyptus todtiana. Tall shrubs are similar to other formations, but the ground layer flora is remarkably diverse.

7. Marri-Wandoo-Jarrah Tall Open-Forest Formation. An important formation of the eastern edge of the N.S.C.P. and restricted to alluvial soils of the Ridge Hill Shelf and Pinjarra Plain. Due to this formations occurrence on soils best suited to agriculture it has been dramatically reduced in extent since European settlement. Wandoo (E. wandoo) occurs in some areas of the clay soils of the Pinjarra Plain as a pure stand.

8. Flooded Gum Fringing Woodland Formation. A formation whose distribution is determined by soil and water conditions, being commonest on the deeper alluvial soils adjacent to water. The flooded gum (E. rudis) however, does occur locally in association with other water tolerant species around many of the lakes and swamps on the N.S.C.P.

9. Swamp Sheoak Low Open-Forest Formation. This formation is much restricted on the N.S.C.P. and only occurs in the drainage basins of Chandala and Ellen Brooks. The association is almost entirely of Casuarina obesa with the majority of shrub species having been removed by agriculture to enhance pasture.

10. Paperbark-Tea-Tree Swamp and Low Closed-Forest Formation. This formation occurs on the poorly drained soils around lakes and consequently is of relatively wide distribution. Melaleuca rhaphiophylla and M. teretifolia occur in waterlogged soils and may form a very dense closed forest with little shrub or ground cover. M. preissiana usually fringes the more water tolerant species and occurs in slightly better drained soils; its more open canopy favours development of the swamp tea-tree Leptospermum ellipticum. Species fringing these vary with area but may include such species as E. rudis or one or other of the Acacias.

11. Swamp and Fen Formations. Swamp and fen vegetation occurs in very moist soil seasonally innundated by water and is usually surrounded by the preceeding formation. Common sedges and rushes are Cladium articulatum, C. junceum, Scirpus validus, Typha angustifolia and Lepidosperma gladiatum. A detailed appraisal of the swamp and fen formation has been made by McComb and McComb (1967) and Congdon and McComb (1976).

Floristics

Little is known of the floristics of the area apart from the studies mentioned above. It is, however, recognised that some plant species reach the northern limits of their distribution on the N.S.C.P., e.g. Bracken Fern (Pteridium esculentum) and the orchid Epiblema grandiflorum (Morris and Muir, 1975). Additionally some species are known to be restricted to the area and are very localised, e.g. the very rare Rose-fruited Banksia (Banksia laricina) (Holliday and Watton, 1975). Several eucalypts are of restricted distribution on the coastal plain (Tingay & Tingay 1976 (a); Lantzke and McMillan 1978) and several species show disjunct

distributions compared to the majority of their range e.g. Wilsonia humilis, Santalum acuminatum and Pittosporum phylliraeiodes.

Specht et al.(1974) indicated that Jarrah-Marri, Tuart, Peppermint, Banksia-Sheoak-Prickly bark, Limestone heath and mixed coastal heath all have poor conservation status within the Darling Botanical District. All are represented on the N.S.C.P.

Effects of Groundwater Abstraction

Both Havel (1975) and Aplin (1976) give detailed consideration to the consequences of groundwater abstraction on the vegetation pattern, and both predict a shift in the vegetation towards the xeric end of the continuum This would result in the gradual replacement of taller woodlands dominated by Eucalyptus marginata and E. calophylla by lower more open woodlands of Banksia attenuata, B. menziesii and Eucalyptus todtiana. Around lakes the rushes would tend to be replaced by sedges such as Lepidosperma, and concomitant changes to more xeric adapted associations would occur around the seasonal swamps so characteristic of the Bassendean Dune System.

Aplin (1976) makes the concluding remarks of: "The major consequences of drastic variations of the water table level and of some forms of land use on the vegetation of the Swan Coastal Plain may be summed up by saying that these could 1) cause a shift in the vegetation contiuum along the soil-moisture gradient, 2) bring about complex and possibly irreversible changes in floristic composition through the depauperation of native shrub and ground flora species and through invasion by alien species, 3) cause the loss of swamp and lake vegetation, particularly in the Spearwood dune system, and the loss of ephemeral wetland vegetation in the Bassendean dune system, and 4) bring on eutrophication problems in aquatic systems through biological pollution of the ground water. These changes are likely to be progressive rather than sudden. In the long term however they could be substantial".

The most important consideration with respect to the vegetation is the timing and extent of the water table decrease. A sudden drop in the aquifer may produce

rapid and dramatic changes in the vegetation pattern rather than a gradual shift. The rooting pattern and physiological requirements of species, particularly the dominants, need to be determined in order to predict accurately the nature and extent of the changes likely to occur. Further, the flowering time of species may be altered and this could be crucial for both insect or avian pollinators. A study in Melaleuca Park (Muir and Dell, M.S.) has shown that 55% of the species common to dunes, woodlands, jarrah areas and swamps show modification of flowering duration and abundance depending on soil moisture conditions. It can also be assumed from the calculations of Bestow (1976) that the extent of swamps will be decreased by about 25% under maximum abstraction.

MANS ENVIRONMENTAL CHANGES

Since the arrival of the first settlers on the 'Parmelia' in June 1929 there has been significant modifications to the environment of the Swan Coastal Plain. These changes have accelerated rapidly over the last 25 years as Perths population has increased from 351,700 in 1950 to 805,747 in 1976.

The changes brought about by European man have been many in number and varied in intensity. Factors which have modified the pre-European environment have been; (a) the clearing and modification of land for urban, industrial, agricultural and forestry purposes, (b) a probable increase in the d structiveness if not frequency of fires in native vegetation, (c) increased erosion and modification of vegetation on the fragile foredune areas as a result of urbanisation and vehicular use and (d) the introduction and spread of many exotic pathogens, plants and animals with the resultant loss of many native species.

One of the first major environmental consequences of settlement was the draining of lakes and swamps in the vicinity of Perth (Seddon 1972, Serventy 1948).

This increase has continued almost unabated to the present with the result that in 1966 (Riggert, 1966) an estimated 49% of wetlands between Yanchep and Rockingham had been drained. Not all these wetlands have been lost to urban development as many swamps were drained so that their more fertile peat soils could be used for market gardens. Many swamps too deep to drain were reclaimed by filling them (Seddon, 1972). Agricultural development followed the best soils, and consequently the alluvial soils of the Pinjarra Plain were cleared of native vegetation for pastoral and horticultural use. The recent acceleration of this process is best described by de Burgh (1976) who states, "By 1952 it was obvious that all sands which showed colour on the surface, all the calcium sands along the coast and all gravel soils could be developed for grazing purposes and a few people were even talking about growing wheat".

Mining and forestry have probably had a lesser effect on the environment, although large areas of native vegetation have been replaced on the N.S.C.P. by plantations of Pinus pinaster the introduced softwood (Havel, 1976).

Aborigines were known to practise burning regularly in order to catch game, but their fires were planned, controlled and of low intensity. Most of the present fires are accidental, uncontrolled fires that are relatively intense and burn large areas.

Although environmental modifications since European settlement have not been well documented quantitatively, it is apparent that the present day environment is far removed from the pristine condition.

II. WESTERN AUSTRALIAN MUSEUM FAUNAL SURVEY 1977-78

TERMS OF REFERENCE

Principally, initiate a baseline study to assess the nature and condition of the biological environment of the Northern Swan Coastal Plain.

Additionally

1. Document information on the physical and social characteristics of the area utilising available published data, maps and aerial photography;
2. Survey and assess the biological characteristics of the area, taking particular note of unusual, rare or endangered species;
3. Prepare a statement of likely effects of intensive groundwater abstraction on the biological, and if possible the social environment of the area, and where necessary suggest management strategies.

Further terms of reference were set for a complementary study of Lake Jandabup. These were:-

1. Conduct a baseline survey of the bathymetry, hydrology, vegetation associations and fauna of the lake, including the species of waterfowl present (breeding, feeding and over the summer drought);
2. Assess the relationship of the various components of the wetland habitat (e.g. open water, fringing reeds, surrounding vegetation) to the habitat requirements of the birds utilising it;
3. Make an assessment of the wetlands contribution to the present population of waterfowl.

SELECTION AND DISTRIBUTION OF STUDY AREAS

The physical, biological and social environments of the Swan Coastal Plain has been elegantly reviewed by Seddon (1972). The previous section of this report attempted to precis the information presently available on aspects of these environmental divisions with particular emphasis on those aspects directly concerned with affecting the distribution and abundance of the fauna.

The fauna of the Northern Swan Coastal Plain (NSCP) was surveyed regularly over a range of both terrestrial and aquatic habitats (Figure 1). The prime consideration in the choice of study areas was to maximise, as far as possible, the coverage of the environmental heterogeneity of this part of the Swan Coastal Plain. Less regular surveys were made of numerous habitats to document local differences in the faunal assemblages. Complementing the field survey programme was an intensive review of the fauna in the Museum's collections and that in diaries, papers and in published and unpublished reports.

(a) Terrestrial Study Areas

The areas chosen for study sampled the major geomorphic elements and representatives of the great majority of vegetation formations recorded on the plain. Reserves were chosen as these are generally larger areas, relatively less disturbed and consequently most likely to contain extant fauna; these are also areas over which some management may be exerted.

The terrestrial areas surveyed were:

1. Neerabup National Park (Reserve No. A 27575). Vested in the National Parks Authority, this park contains several of the formations common on the Spearwood Dune System.
2. Burns Beach. This land is owned by the Catholic Archdiocese of Perth and contains both coastal dune complex and coastal limestone.

3. Yanchep National Park (Reserve No. A 9868). Vested in the National Parks Authority for recreation and the conservation of caves, fauna and flora. Several terrestrial and aquatic formations occur in this park.

4. Moore River National Park (Reserve No. C 28462). Vested with the National Parks Authority, this area contains large tracts of Banksia spp. woodland, characteristic of the northern sections of the Bassendean Dune System. Fire consumed a large portion of the park during the current survey.

5. Melaleuca Park. This is a Forests Department reserve set aside for conservation purposes and located within State Forest No. 65. Sited on the Bassendean Dune System this reserve contains a large number of ephemeral swamps.

6. South Gingin Proposed Reserve. A large proposed reserve southwest of Gingin and west of Reserve 31241, which contains the following locations on litho 2880: loc. 3461, 3470-3472, 3562-3572, 3560 (part), 3561 (part). It occurs on the eastern edge of the Bassendean Dune System where it abuts the Pinjarra Plain.

7. Twin Swamps Nature Reserve (Reserve No. A 27621). Vested in the Western Australian Wildlife Authority for the conservation of fauna (the Short-necked Tortoise, Pseudemydura umbrina).

8. Ellen Brook (Martyn) Nature Reserve (Reserve No. A 27620). With a similar vesting and purpose as Twin Swamps, these two reserves occur on the Pinjarra Plain.

The only vegetation formations not sampled within these terrestrial survey areas were; (a) Marri-Wandoo-Jarrah Tall Open-Forest and (b) Swamp Sheoak Low Open-Forest. Both of these formations are exceedingly scarce within the study area because they are confined to the soils of the Pinjarra Plain and Ridge Hill Shelf; soils which have been extensively used for agriculture after clearing ofthe native vegetation. Description of the vegetation at specific sampling sites is presented by Kitchener et al. (this report).

(b) Aquatic Study Areas

The lakes and streams surveyed were selected on the basis of their location, bathymetry, hydrological and chemical properties. They are considered to represent the major lentic and lotic systems within the area.

Lake Jandabup (31°45'S; 115°51'E). Reserve No. 7349 vested with the Ministry for Fisheries & Fauna for the conservation of fauna.

Lake Joondalup (31°45'S; 115°47'E). Reserve No. A 31048 vested with Wanneroo Shire and the W.A. Wildlife Authority for recreation and flora and fauna conservation.

Loch McNess (31°32'S; 115°40'E) Located within Yanchep National Park (Reserve No. A 9868) and vested with the National Parks Authority.

Lake Chandala (31°30'S, 115°57'E) This lake is not officially named and is as yet, not a proclaimed reserve.

Lake Bambun (31°25'S, 115°53'E) Part of Reserve No. C 24257; an unvested reserve for the conservation of flora.

Lake Beermullah (31°12'S; 115°47'E) Reserve No. C 22223 and vested with Gingin Shire for recreation.

Lake Guraga (30°52'S; 115°34'E) A proposed but unofficial name. An unreserved salt lake north of the Moore River.

Ellen Brook. A southward flowing stream that forms the eastern boundary of the Gnangara Mound.

Moore River. A westerly flowing river that forms the northern boundary of the Northern Swan Coastal Plain.

Lakes Jandabup, Joondalup, Bambun and Loch McNess are all part of the Gnangara Mound aquifer and consequently in hydrological continuity with it. Lake Chandala and Lake Beermullah lie to the east and north of Chandala and Gingin Brooks respectively, and therefore belong to different hydrological regimes than the other four lakes. Lake Guraga, although not located on the NSCP was initially chosen because of its high salinity and proximity to the defined study area.

A more detailed description of the structure, vegetation and chemical properties of the above lakes appears in Appendix I.

III CONSIDERATIONS OF FAUNAL CHANGES

CONSIDERATION OF PAST FAUNAL CHANGES

The present studies represent the first thorough documentation of certain of the faunal groups that occur on the NSCP, consequently only those taxa where adequate previous documentation exist can be used to indicate changes that have occurred in the past. Both the mammals (Kitchener, et al, this report) and the birds (Storr et al.(a), this report) of the NSCP show that major changes have occurred after European settlement.

The mammals of the NSCP originally numbered 33. Only 15 of these native species are now believed to be extant, and the present survey recorded only 12 (Kitchener et al., op. cit.). Two main agents are believed to be responsible for this decline. Many species disappeared in the late nineteenth century when disease (described as a 'marasmus' or wasting disease) put several species on the verge of extinction. Early in the twentieth century the disappearance of several more species appears to be correlated with the success of many introduced eutherian predators and competitors. Many of the remaining native species have become quite rare on the NSCP, while some such as the mardo, Antechinus flavipes, have disappeared as a consequence of wetland losses. Although nearly all the native species have probably declined numerically since settlement, many introduced mammals such as the mouse Mus musculus, cat, fox Felis catus, and rabbit, Oryctolagus cuniculus, have thrived in the modified environment created by man.

Changes in the avifauna appear to have been less dramatic. Of the 223 species recorded on the NSCP, nine are no longer present and 4 are on the verge of local extinction (Storr et al. (a), this report). A further 18 have suffered a severe decline in numbers during the twentieth century. The majority of the birds that have become locally extinct or rare inhabited either the tall forests or wetlands. The clearing of dense Melaleuca spp. forests and thickets surrounding the wetlands appears to be the main cause for the disappearance of wetland birds, but drainage, land-fill and fire may also have had an effect.

Many urban lakes originally surrounded by paperbark thickets and containing extensive beds of rushes, have been modified to steep-sided, open-water areas surrounded by lawns. This has, in effect, removed roosting and nesting sites and decreased lake diversity by minimising the littoral zone, the most diverse and productive area of a lake (Hembree and George, this report). The regions of tall forest were modified initially by heavy logging of the timber; later forests were extensively cleared for agriculture because they tended to occupy the more fertile soils. These changes probably account for the decline of the forest dwelling species. There are 10 species which have become established on the NSCP as a result of clearing the woodlands and forests for the establishment of pasture, and a further 10 have benefitted by these and other modifications to the environment since settlement (Storr et al. (a), this report).

The reptiles have also shown a marked decline in Perth and its suburbs (Storr et. al. (b), this report). Very few species persist after development occurs, and there is a rapid decline as soon as native vegetation is cleared for farming.

RARE, ENDANGERED AND UNUSUAL SPECIES

The present study identifies only one species which is endemic to the NSCP, the short-necked turtle, Pseudemydura umbrina, although several other species of the area are important because their populations are in general decline.

Indubitably, the most endangered species of the NSCP is the short-necked turtle. It is restricted to a few seasonal swamps along Ellen Brook where its numbers are very low. Its conservation is precarious with only two small reserves set aside for this purpose.

Several species are identified that are rare on the NSCP and are also becoming rare elsewhere; these include the Brown Bittern (Botaurus stellaris), Freckled Duck (Stictonetta naevosa), Blue-winged Shoveler (Anas rhynchotis), Pygmy Possum (Cercartetus concinnus) and the Native Cat (Dasyurus geoffroii). The Freckled Duck is widespread but scarce and the NSCP may have been, and may yet remain, an important refuge area for this species which has declined throughout Australia.

A review of the rare and endangered plants of Western Australia (Marchant and Keighery, in prep.) will indicate those species that are endemic or endangered on the NSCP.

A great many of the faunal species which are rare on the NSCP are so because they are at the northern, southern or eastern limits of their distribution. The significance of this region therefore, lies not so much in its endemic or endangered species, but in its zoogeographic importance to the fauna of the Southwest, West Coast and even Australasia.

Examples of this are the fish, Galaxiella munda, with a disjunct distribution and whose other populations occur between Margaret River and Albany (Sarti and Allen, this report), and the legless lizards (Pygopodidae), where 14 of the 31 Australo-Papuan species have been recorded from the NSCP (Storr et. al. (b), this report). Similarly, the wetlands of the area provide a very important drought refuge area for the waterbirds of the state during summer (Storr et. al. (a), this report).

CONSIDERATION OF FUTURE FAUNAL CHANGES

Considerations of past faunal changes provide some guidelines as to the possible consequences of further environmental modification.

Changes in past faunas can be considered as a product of one or several environmental modifications engineered by European man. These are urban and agricultural development, fire frequency and intensity, introduction of exotic species and the modification of wetlands by draining or land-fill. Future faunal changes will result as a continuation of any one of these or as a consequence of major watertable declines after groundwater abstraction.

The extent and degree of aquifer change has been assessed by Burton (1976). The major watertable decline (> 1m) will be in the areas surrounding the various borefields that are located along the western and southern shoulders of the mound. This area encompasses the central and western parts of the Bassendean Dune System and the adjacent eastern portions of the Spearwood Dune System; areas which have considerable extents of wetlands and an important mosaic of terrestrial vegetation formations. Adjacent to the main line of borefields lie a series of 'circular type' lakes, including Lake Gnangara, Lake Jandabup and Lake Mariginiup, all of whose existence will be seriously threatend by abstraction.

Most of the fauna on the NSCP has adapted to the predictability of the climate with its two distinct seasons of mild wet May-October and hot dry November-April. The aquatic invertebrates have specific adaptations such as drought-resistant eggs or reduced metabolic activity for summer (Hembree and George, this report). Waterbirds use the open water-bodies that act as summer refuge areas after inland water dries up (Storr *et al*. (a), this report). It is important, therefore, to understand the interaction between climate, groundwater and the biological environment in order to predict possible future faunal changes.

Changes in the Terrestrial Fauna

The effects of aquifer modification on the terrestrial fauna will be directly dependent on response of the vegetation to the same modifications.

Both Havel (1975) and Aplin (1976) have predicted a shift in the vegetation towards the xeric end of the continuum; the extent and speed of this shift will depend on the degree and extent of water level change. Aplin (op. cit.) has identified six main formations that will be modified by a lowering of the water table. These predicted vegetational changes will mean a decrease in the fauna occupying formations of moister areas and a concomitant increase in species occupying the more xeric formations as they spread. There should be a general decrease in species diversity as the area becomes less heterogenous.

The work of Muir and Dell (m.s.) illustrates the importance of soil-moisture to the duration and abundance of flowering. Any change in the soil-moisture gradient will alter the flowering regime with major consequences for the birds and insects dependent on this food source, and which may themselves be important pollinating vectors of the plants.

Accurate predictions of the impact of abstraction on the fauna can only be made with a detailed understanding of the dynamics of the aquifer and the effects of changed waterlevels on the vegetation. There is an urgent need to implement more studies on the effect of abstraction on vegetation to complement those already instigated by the Forests Department. Particular emphasis should be placed on determining the changes in vegetation structure and the rooting pattern, soil-moisture requirements, flowering time, longevity and reproductive success of certain key species.

Changes in the Aquatic Fauna

Changed aquifer characteristics will have more obvious effects on the fauna inhabiting the wetlands of the Gnangara Mound area.

Although the wetlands of this region contain only one endemic species, the turtle, Pseudemydura umbrina, they provide the essential habitat for aquatic invertebrates, fish, amphibians, waterbirds and some reptiles and mammals. Lowering the watertable will have deleterious consequences to populations in all these groups particularly in areas where abstraction effects are pronounced.

The projected decrease of 25% in evaporation from swamps (Bestow, 1976) would bring about the loss of considerable areas of swamp margin or marshland. This would decrease the number of waders and amphibians together with the mammals (Rattus fuscipes, Isoodon obesulus) and the reptiles (Chelodina oblonga, Egernia luctuosa, Leiolopisma trilineatum, Notechis scutatus) that make extensive use of swampy areas.

All species of aquatic invertebrates and fish, and nearly all amphibians and wetland birds are entirely dependent on water. Decreases in the area of free water would deplete their populations in the region. Since nearly all species within these groups are widespread it is unlikely that extinctions would occur, however wetland birds are dependent on the open water of this region for summer refuge and food, consequently further losses in open water areas would put added strains on the already overcrowded coastal lakes.

The ecotone between open water and rush beds provides the zone of maximum aquatic abundance and productivity and is an essential area for the spawning and growth of many aquatic organisms (Hembree and George, this report). The loss of rush areas from urban lakes leads to a decrease in the aquatic invertebrates and consequently lowers the food potential for predators such as fish and certain waterbirds. Another cause for the decline in bird species using urban lakes has been the removal of surrounding vegetation which provides breeding and roosting sites (Storr et al. (a), this report).

Lowered groundwater levels will change the ratio between lake volume and surface area with possible increases in lake salinity and nutrient concentrations. Changes in lake chemistry

may also result from the proximity of some to urbanisation with resultant sewerage and effluent input. These changes could lead to lake eutrophication with a consequence decrease in the diversity of organisms within them.

Discharge from the hydraulic boundaries will be significantly decreased under maximum abstraction rates from the aquifer. Although discharge to the ocean is likely to be the most severely decreased, there is also a predicted decrease of 50% in the groundwater flow to Ellen Brook (Bestow, 1976), a lotic area important to the preservation of an endangered turtle and rich in native fish species.

IV RECOMMENDATIONS

CONSERVATION OF WETLANDS

Noting (a) the significant decrease in wetland areas over both the Northern and Southern Swan Coastal Plain since European settlement;

(b) the rapidly growing urban extent of Perth and the increasing demand for water;

(c) the need to abstract groundwater to partially meet this demand;

(d) that wetlands on the Swan Coastal Plain depend on groundwater to persist;

(e) the critical requirement of many species of plants and animals on wetlands for their survival;

(f) that wetlands in conservation reserves are relatively few in number and do not adequately represent major wetland types;

(g) that many reserves are inadequately protected by surrounding land from the perturbations of agriculture, urbanisation and domestic animals; and

(h) that there is an urgent need for further detailed studies on the interactions between water-table fluctuations and the fauna, vegetation structure, floristics and physiology:

It is recommended that

1. *a greater number of wetland conservation reserves be gazetted to protect a wider representation of the major lake and swamp types on the Swan Coastal Plain, and that reserves should be protected by fenced areas at least 200 m from the wetland margin; and*

2. *a Committee of Management be created to*
   - *(i) resolve future conflicts for wetlands and water use by conservation, agriculture, forestry, urban and recreational interests,*
   - *(ii) initiate active management of wetlands to ensure minimum water levels are maintained, to protect margins of swamps and lakes and to increase their vegetation diversity,*

(iii) initiate and integrate biological studies that monitor biota in wetlands and their surrounds so that the effects of groundwater abstraction on selected communities and species are constantly evaluated.

WATER LEVELS IN WETLANDS

Noting (a) the importance of natural fluctuations in water-levels to the annual cycle of most wetland species;

(b) the importance of various types of open water as feeding and refuge sites for waterbirds during summer and autumn;

(c) that lower groundwater levels will occur as a result of the total dependence on groundwater abstraction by suburbs in the northern corridor; and

(d) that there will be a significant decrease in the depth and extent of wetlands as a result of groundwater abstraction:

It is recommended that water levels of wetlands in and adjacent to present and future conservation reserves by managed by selectively

(i) pumping water into them,
(ii) dredging and underpinning, and
(iii) seasonally inactivating specific bores so that the naturally occurring lower lake levels of summer and autumn be least affected.

URBAN LAKE MANAGEMENET

Noting (a) the aesthetic value of lakes in urban areas;

(b) the importance of water of different depths to waterfowl and other aquatic species;

(c) the value of rush swamps and surrounding shore and tree vegetation to the breeding, feeding and roosting of waterbirds;

(d) the species richness of aquatic invertebrates in rush swamps; and

(e) the higher species richness associated with the recently urbanised Lake Joondalup:

It is recommended that urban lakes be managed to maintain a greater diversity of habitats by

(i) providing open water of different depths,
(ii) planting desirable rushes, herbs, shrubs and native trees in and around the water body,
(iii) controlling excessive spread of rushes in shallow lakes by dredging, and
(iv) restricting public access to parts of specific lakes and their surrounds.

IMPORTANT WETLAND HABITATS

A. Ellen Brook

Noting (a) the importance of this stream to the preservation of the short-necked turtle;

(b) the richness of native fish species, including the presence of a rare species, in this stream and flood-plain; and

(c) that the hydrology of the stream and the environmental conditions necessary to support the present populations of the turtle and fish are unknown:

It is recommended that

(i) a detailed hydrological and biological investigation of the stream and its environment be initiated, and
(ii) that the utmost attempt be made to preserve natural populations of the turtle and fish.

B. Lake Jandabup

Noting (a) the dependence of many species of plants and animals on open water of different depths;

(b) the importance of the littoral zone to the productivity of the whole lake;

(c) the requirement of fringing trees for waterbird nesting and roosting sites; and

(d) the proximity of the western section of the Wanneroo borefield to Lake Jandabup:

It is recommended that

(i) more of the littoral area of this lake be acquired for inclusion into the Reserve, and

(ii) that this wetland habitat be managed to provide varying habitats and water depths by

1. *planting trees, peripherally,*
2. *digging trenches to limit the spread of Cladium,*
3. *fencing the reserve to exclude domestic stock, and*
4. *maintaining a water depth of more than 25 cm during autumn.*

PUBLIC INFORMATION

Noting (a) the significance of the groundwater to Perth's environment;

(b) the uncertain nature of the consequences of abstraction;

(c) the irregularities of the annual rainfall;

(d) the importance of groundwater to flora and fauna;

(e) the increasing use of private bores; and

(f) the lack of regular information available on the quality and quantity of water abstracted and the fluctuations in groundwater levels:

It is recommended that regular information be presented on the effects of abstraction so that the public's priorities for groundwater use can be determined.

ACKNOWLEDGEMENTS

The preparation of this report has been greatly assisted by the co-operation of Government departments.

We are grateful to the Metropolitan Water Supply, Sewerage and Drainage Board for providing information on the bathymetry, chemistry and water levels in several lakes and bores and to the Department of Fisheries and Wildlife, National Parks Authority, Forests Department, Gingin Shire and Catholic Archdiocese of Perth for permission to survey and collect fauna on their reserves, parks and lands.

Officers of several Government departments gave freely their time and we are particularly grateful to Mr Colin Sanders of the Department of Conservation and Environment, Dr. Tony Allen of the Geological Survey of W.A., Dr. Libby Mattiske of the Forests Department, Dr. Neville Marchant of the W.A. Herbarium, Mr Maurice Caldwell and Mr Chris Pollett of the M.W.S.S.D.B. and Dr. Brenton Knott of the Zoology Department, U.W.A. for their assistance.

To numerous generous colleagues go my thanks for many helpful discussions and exchanges of ideas.

Finally, the Western Australian Museum wishes to acknowledge the very substantial contribution and support of the Department of Conservation and Environment to this study.

REFERENCES

Adams, G.M. (1977). 'Perth metropolitan water supply'. Private publication.

Allen, A.D. (1976). The Swan Coastal Plain - II Hydrogeology of superficial formations. In 'Groundwater Resources of the Swan Coastal Plain', (Ed. B.A. Carbon.) pp. 12-33. C.S.I.R.O. Division of Land Resources Management.

Anon. (1903). Miscellaneous mineral notes. Geol. Survey W.A. Annual Progress Report : 144-145.

Anon. (1975). 'Climatic averages' Melbourne. Bureau of Meteorology.

Aplin, T.E.H. (1976). Consequences of variations of water table level - II. Vegetation and flora. In 'Groundwater Resources of the Swan Coastal Plain', (Ed. B.A. Carbon.) pp. 126-139. C.S.I.R.O. Division of Land Resources Management.

Bettenay, E., McArthur, W.M. and Hingston, F.J. (1960). The soil associations of part of the Swan Coastal Plain, Western Australia. C.S.I.R.O. Soils and Land Use Series, No. 35, 24pp.

Bestow, T.T. (1976). Water balance of the coastal plain - I Present. In 'Groundwater Resources of the Swan Coastal Plain', (Ed. B.A. Carbon.) pp. 77-88. C.S.I.R.O. Division of Land Resources Management.

Burton, C.W. (1976). Water balance of the coastal plain - II Future. In 'Groundwater Resources of the Swan Coastal Plain', (Ed. B.A. Carbon.) pp. 89-109. C.S.I.R.O. Division of Land Resources Management.

Congdon, R.A. and McComb, A.J. (1976). The nutrients and plants of Lake Joondalup, a mildly eutrophic lake experiencing large seasonal changes in volume. J. Proc. Roy. Soc. W.A. 59 : 14-23.

de Burgh, W.J. (1976). 'Neergabby; a history of the Moore River and lower Gingin Brook'. Shire of Gingin.

Gentilli, J. (1948). Bioclimatic controls in Western Australia. W.A. Natur., 1 : 81-84; 104-107; 120-126.

Gentilli, J. (1952). Present climatic fluctuations in Western Australia. W.A. Natur., 3 : 155-165.

Grieve, B.J. and Blackall, W.E. (1975). 'How to know Western Australian Wildflowers'. Part IV. Univ. W.A. Press.

Havel, J.J. (1968). The potential of the northern Swan Coastal Plain for Pinus pinaster Ait. plantations. For Dept. W.A. Bull., No. 76.

Havel, J.J. (1975). The effects of water supply for the city of Perth, Western Australia, on other forms of land use. Landscape Plann., 2 : 75-132.

Havel, J.J. (1976). Consequences of variations of the water table level - V Pine forests. In 'Groundwater Resources of the Swan Coastal Plain', (Ed. B.A. Carbon) pp. 178-181. C.S.I.R.O. Division of Land Resources Management.

Holliday,I. and Watton, G. (1975). 'A field guide to Banksias'. Rigby, Perth.

Lantzke, L. and McMillan, P. (1978). A record of the Slender-leaved Mallee, Eucalyptus foecunda, in Reabold Park, Perth. W.A. Natur., 14 : 57-59.

McArthur, W.M. and Bettenay, E. (1960). The development and distribution of the soils of the Swan Coastal Plain, Western Australia. C.S.I.R.O. Soil Publication, No. 16.

McComb, J.A. and McComb, A.J. (1967). A preliminary account of the vegetation of Loch McNess, a swamp and fen formation in Western Australia. J.Proc. Roy. Soc. W.A. 50 : 105-112.

Morris, K. and Muir, B.G. (1975). Vegetation. In 'A spring, 1975, biological survey of the proposed Mussel Pool Complex and recommendations for its future management,' W.A. Museum (unpublished report).

Muir, B.G. and Dell, J. (m.s.). Relationship between vegetation, soils, drainage and the birds and herpetofauna of Melaleuca Park.

Riggert, T.L. (1966). Wetlands of Western Australia, 1964-66. Department of Fisheries and Fauna, Perth.

Sadler, B.S. and Field, C.A.R. (1976). Population and water needs - I Water supply and alternative sources. In 'Groundwater Resources of the Swan Coastal Plain', (Ed. B.A. Carbon.) pp. 37-60. C.S.I.R.O. Division of Land Resources Management.

Seddon, G. (1972). 'Sense of Place. A response to an environment, the Swan Coastal Plain, Western Australia'. Univ. W.A. Press.

Serventy, D.L. (1948). The birds of the Swan River District, Western Australia. Emu, 47 : 241-286.

Smith, G.G. (1973). A guide to the coastal flowers of south-western Australia. W.A. Naturalists Club Handbook, No. 10, Perth.

Speck, N.H. (1952). 'The ecology of the metropolitan sector of the Swan Coastal Plain'. M.Sc. Bot. Thesis, U.W.A.

Specht, R.L., Roe, E.M. and Boughton, V.H. (1974). Conservation of major plant communities in Australia and New Guinea. Aust. J. Bot. Suppl. No. 7.

Tingay, S. and Tingay, A. (1976a). 'Eucalypts from the Perth area'. Campaign to Save Native Forests, Perth.

Tingay, A. and Tingay, S. (1976b). Report on Lake Chandala with recommendations of its importance as a fauna reserve. Dept. of Fisheries and Wildlife Report, No. 26.

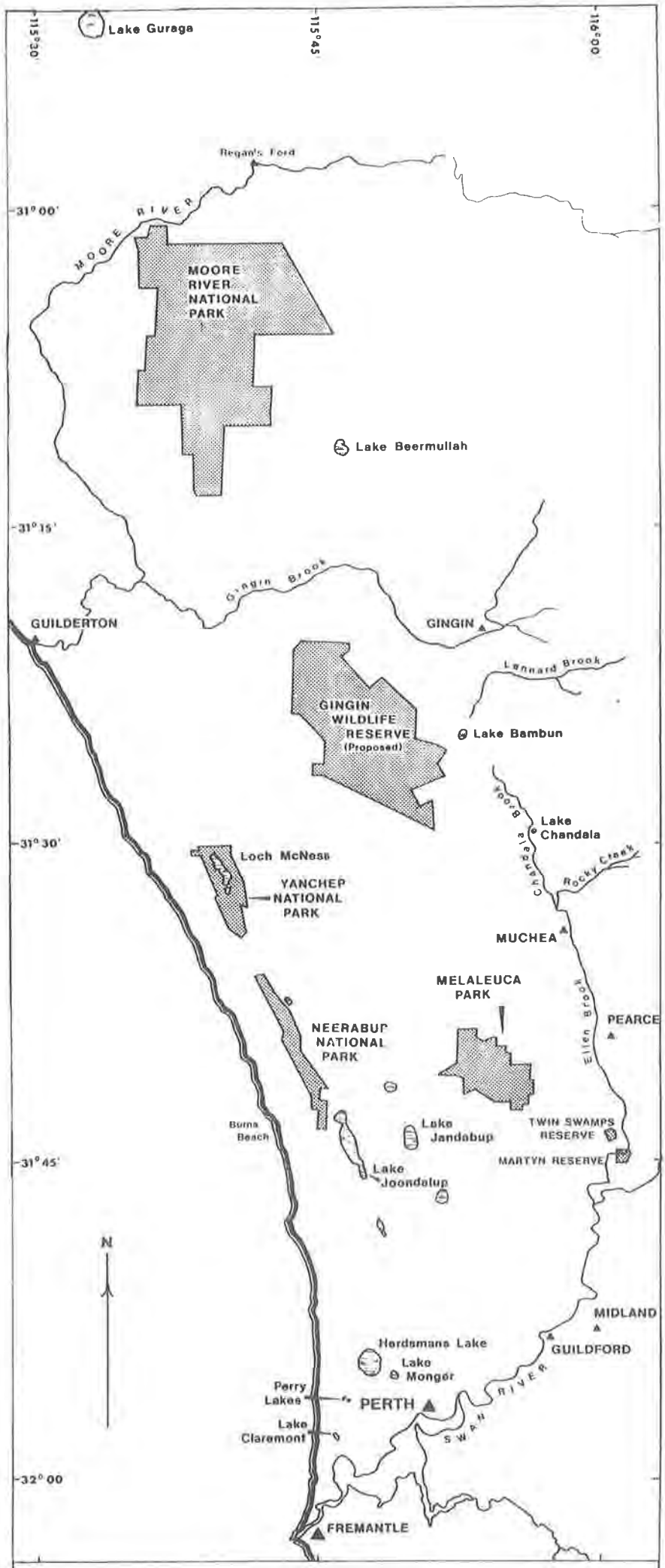


FIGURE 1: Study areas and locations mentioned on the Northern Swan Coastal Plain.

APPENDIX I.

DESCRIPTIONS AND VEGETATION MAPS OF THE LAKES STUDIED

LAKE JANDABUP

A large 'circular' lake situated on the junction of the Bassendean and Spearwood Dune Systems. The bottom is mainly sand in the eastern and clay in the western half, with a smaller zone of rounded rubble separating the two.

There are no flooded gum or paperbark forests surrounding this lake although there are large areas of rush, Cladium spp., beds (Fig. 2 over), and a smaller central area of open water. The total area of the lake is c. 360ha with c. 103ha of open water and a shoreline of c. 6.9km. Average depth of the lake is just under 1m with a maximum depth of c. 2m after winter rains.

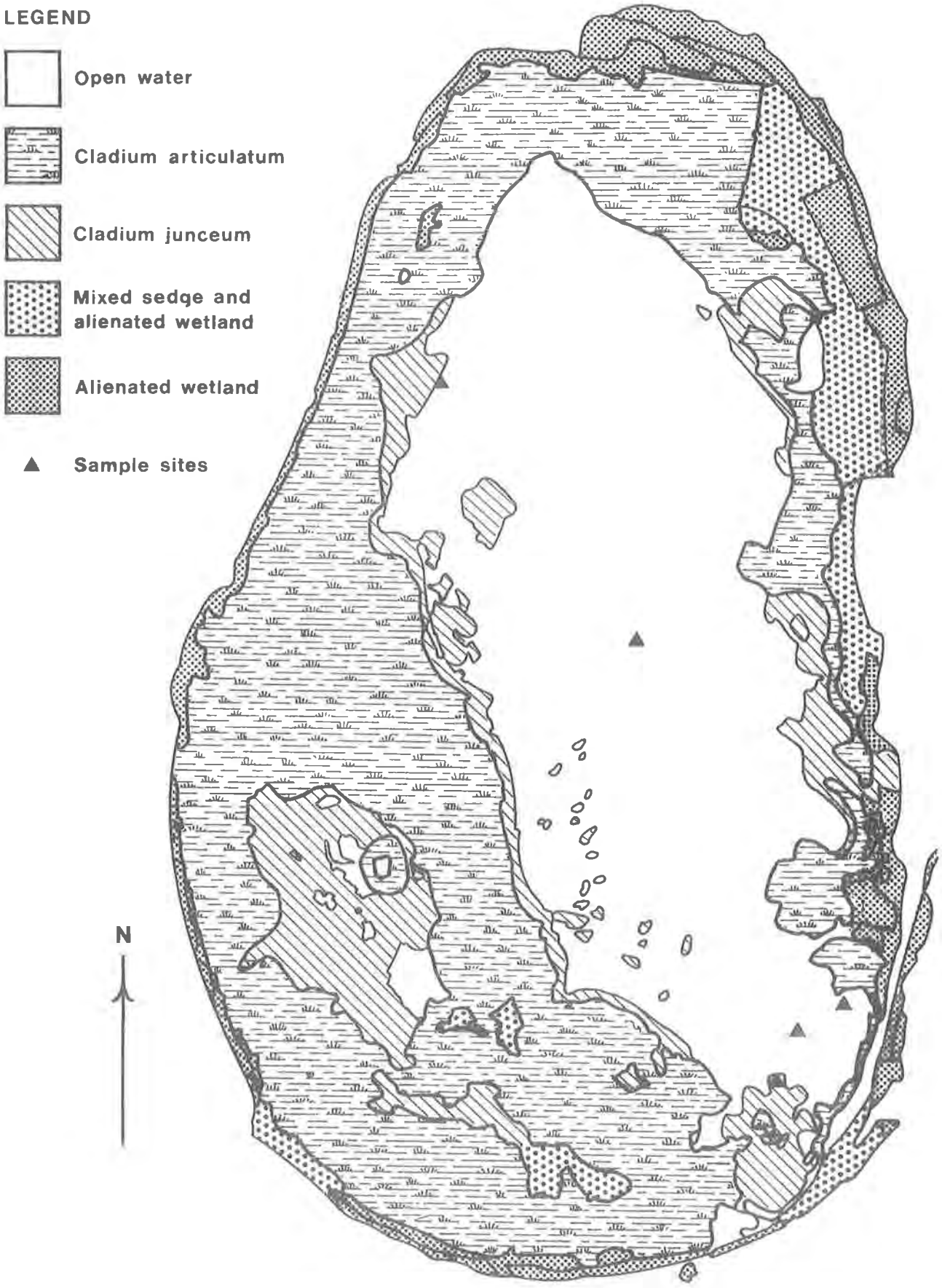
The vast majority of the shoreline and littoral zone of this lake is privately owned, and already major modifications have been made to these areas. In April 1978 a large, deep channel was dredged in the south eastern littoral area (Plate 1).

Mean fluctuation in the water level for the last 10 years has been 0.647 $\pm$ 0.327(10)m. Fluctuation in 1977 was 0.490m, while in April 1978 the lake was only 0.25m at its deepest. Water temperatures reached a maximum of 31^{o}C in February and March.

Lake Jandabup is fresh, with levels varying between 200-900 mgl^{-1} T.D.S., and has low levels of nitrogen and phosphorous (Table 1).

The Wanneroo borefield lies to the east of this lake and under maximum abstraction is expected to decrease water levels significantly. The low lake level of April 1978 is probably a reflection of the three drought years and abstraction from adjacent bores since November 1976.

A specific examination of the fauna of this lake occurs in the discussion and appendices of Storr et al.(a), Sarti and Allen, and Hembree and George in this report.



Scale is 1:11,800

LAKE JANDABUP

From N. Marchant

TABLE 1

Concentrations of selected elements in the lakes sampled during the present survey (mgl^{-1})

LAKE	DATE	Cl	Na	K	Mg	Ca	N	P
Jandabup	early v/77	373	319	19	30	19		
	late v/77	355	524	21	20	11		
	28/x/77	185	112		9	5	0.02	<0.005
	23/v/78	240	128		18	21	0.02	<0.01
Joondalup	early v/77	657	558	21	47	55		
	late v/77	625	442	17	38	47		
	28/x/77	565	245	-	22	29	0.02	0.02
	25/v/78	534	291		34	49	0.05	<0.01
McNess	early v/77	68	67	4	9	44		
	late v/77	77	132	8	12	70		
	3/xi/77	92	46		5	26	<0.02	<0.005
	25/v /78	97	49		6	37	0.02	<0.01
Chandala	4/xi/77	763	317		29	7	0.01	0.41
	23/v/78	337	178		44	15	<0.1	0.63
Bambun	4/xi/77	371	259		21	9	0.1	0.23
	23/v/78	1010	531		71	34	<0.02	0.08
Beermullah	14/xi/77	13200	6380		190	51	0.02	0.006
night	14/xi/77	8490	4910		175	54	0.02	0.005
	22/v/78	25000	12500		600	700	<0.02	0.02
Guraga	14/xi/77	27700	9650		213	13	0.03	<0.005
Mean Sea Water		19700	10600		1200	400	0.03	0.1

LAKE JOONDALUP

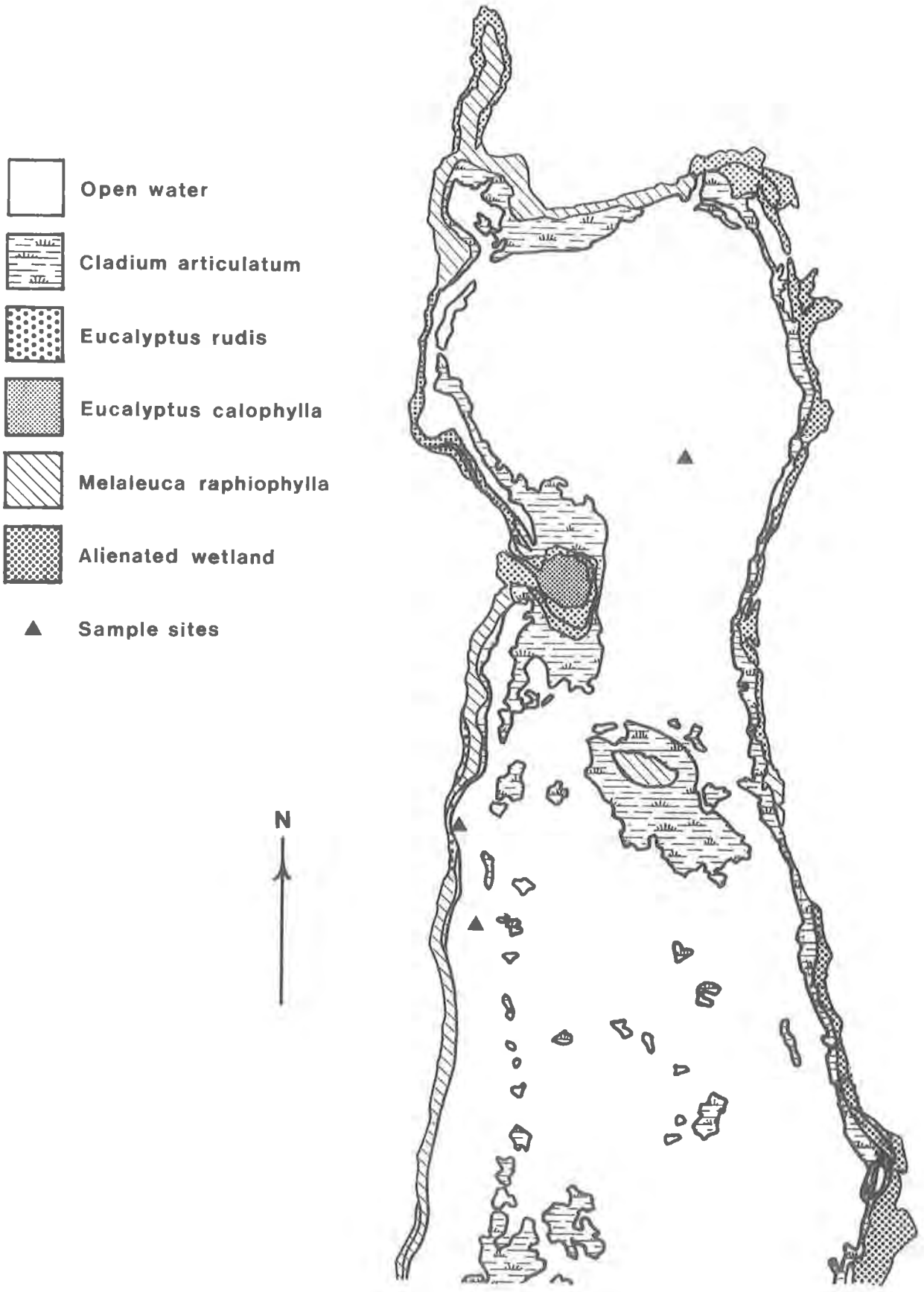
A 'linear' type lake located on the Spearwood Dune System. Bottom sediment consists of sand, clay and in areas considerable extents of semi-compacted organic material.

The vegetation of the lake has been described by Congdon and McComb (1976) and has been examined by Marchant (pers. comm; Figure 3 opposite). There are extensive Cladium spp. and Typha sp. areas around the lake margins and surrounding the islands. Fringing these rush beds are paperbark forest consisting of Melaleuca rhaphiophylla and the occasional Eucalyptus rudis. Open water species are Nitella congesta, Chara baueri, and Potamogeton pectinatus.

Total area of the lake is 610ha (Congdon & McComb) with the majority being open water. The shoreline is c. 20km of which 2km surrounds islands contained within it. Average depth of the lake fluctuates seasonally but maximum depth has never exceeded 3.3m; the maximum depth recorded during this survey was c. 2m. Average annual fluctuation in water level is 0.810 $\pm$ 0.298(9)m; the fluctuation in 1977 was only 0.515m. Maximum temperature recorded was 35^{o}C in April

The environment surrounding this lake has changed considerably from the original pristine woodland and forests. Old submerged fencelines indicate a lower water level and grazing during the past, while rapid urban development (Plate 2a & b) with the Joodalup City Project and the planned northwest corridor will modify the environment in the future.

Congdon and McComb (1976) describe this lake as 'mildly eutrophic' and the water varies from marginal to brackish (Table 1).



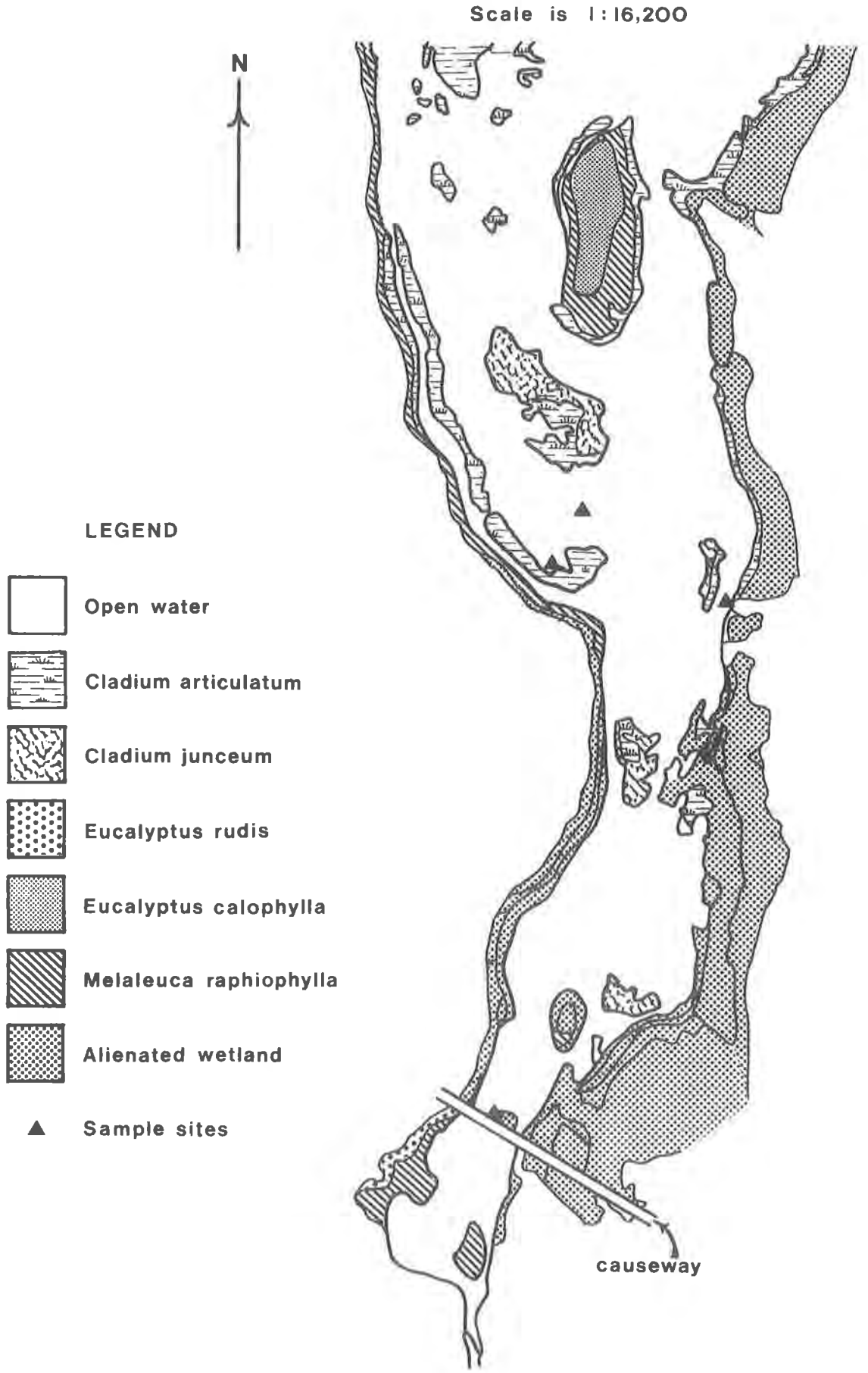
Scale is 1:16,200

LAKE JOONDALUP (NORTH SECTION)

From N. Marchant

LAKE JOONDALUP (SOUTH SECTION)

Scale is 1:16,200



From N. Marchant

LAKE GURAGA

This lake is not within the area designated as the Northern Swan Coastal Plain, but was selected for sampling on the basis of its proximity and its highly saline nature (Table 1).

It is a large lake of between 400-500ha and with a shoreline of c. 7.5km (Plate 7).

The immediate shoreline consists of large dunes and areas of samphire (Arthrocnemum spp.) with little or no emergent vegetation.

The lake was 61cm deep in November 1979 but dry by late Summer 1978.

Sampling was infrequent.

LOCH McNESS

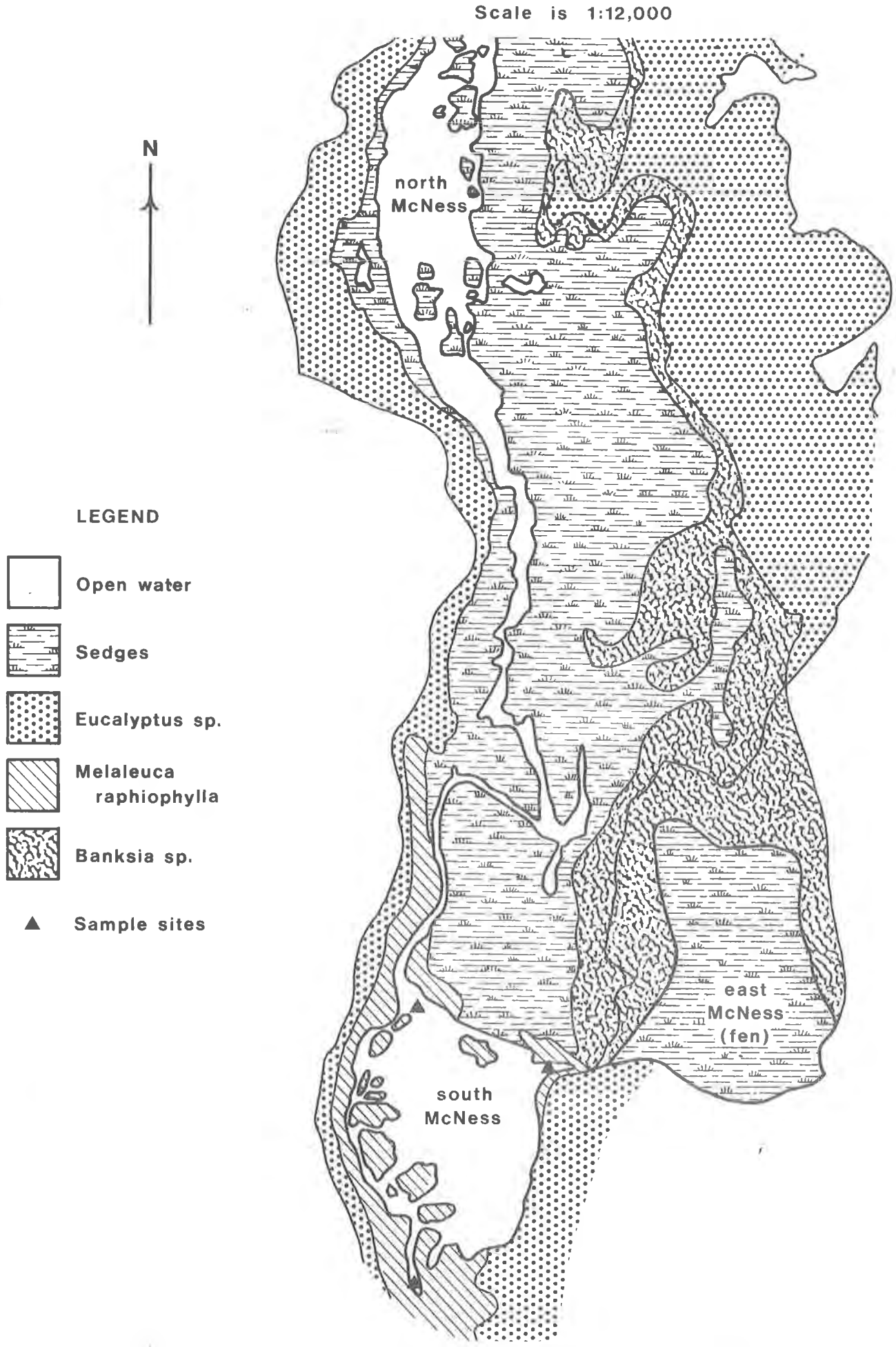
Another of the 'linear' type lakes located within the Spearwood Dune System. The south end of the lake is the main area of open water and the substrate is heavy mud and detritus overlain by flocculent organic debris.

The history and alterations of Loch McNess together with a description of the vegetation of the area have been presented by McComb & McComb (1967) which is redrawn in Fig. 4 (opposite).

The lake comprises 3 main areas; the eastern of 16.2ha consists mainly of sedges; the southern of 26.7ha contains fringing vegetation of sedges, rushes and Melaleuca rhaphiophylla surrounding a prominant area of open water; the northern section of 151.8ha is covered by extensive areas of sedges and banksias with smaller shallower areas of open water (Plate 3a & b). The total area of open water is c. 54.2ha (McComb & McComb 1967).

Dredging around the periphery of the southern section has provided a deeper channel with a firmer substrate and less flocculent debris. Water flows continuously into the southern section of the lake and is discharged into limestone caves, an import scenic factor of Yanchep National Park.

LOCH McNESS


Scale is 1:12,000
N
north McNess
east McNess (fen)
south McNess
LEGEND
Open water
Sedges
Eucalyptus sp.
Melaleuca raphiophylla
Banksia sp.
Sample sites

LAKE CHANDALA

This lake is on the Pinjarra Plain and has had its present and past connections with Chandala Brook interrupted several times as a result of conflicting agricultural interests. The area of this unofficially named lake has been the subject of a study by Tingay and Tingay (1976(b)) for the Fisheries and Wildlife Department.

The vegetation of the lake region is comprised of three main formation types; Melaleuca rhaphiophylla and Eucalyptus rudis forming a low closed forest around the central pool of the lake and its drain (Figure 5 opposite);a woodland of M. rhaphiophylla and M. hamulosa surrounding this area; and a series of samphire (Arthrocnemum halocnemoides)areas adjacent to some areas that are seasonally unindated (Plate 4a & b). The bottom sediments are mainly clay and silt.

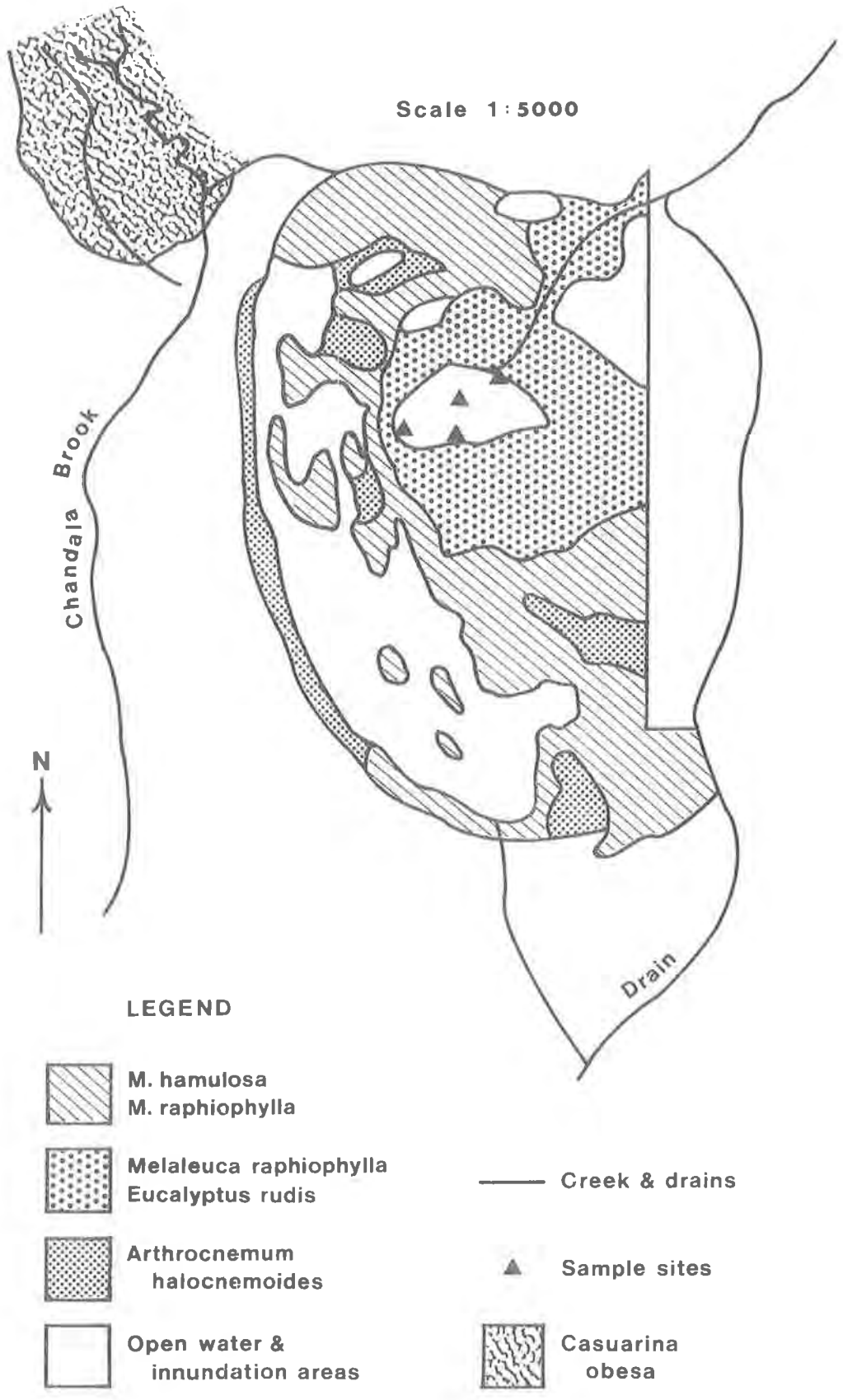
The central pool of Lake Chandala consists of about 1.5ha of open water, but the lake proper which fills up at the end of the winter rains is considerably larger but is unlikely to occupy the 148ha suggested by Tingay & Tingay (1976(b)). This lake is an important Straw-necked Ibis, Threskiornis spinicollis, rookery.

Depth varied from c.1.0m at the end of winter to 23cm in late February, while maximum water temperatures of 41^{o}C were recorded in February and March.

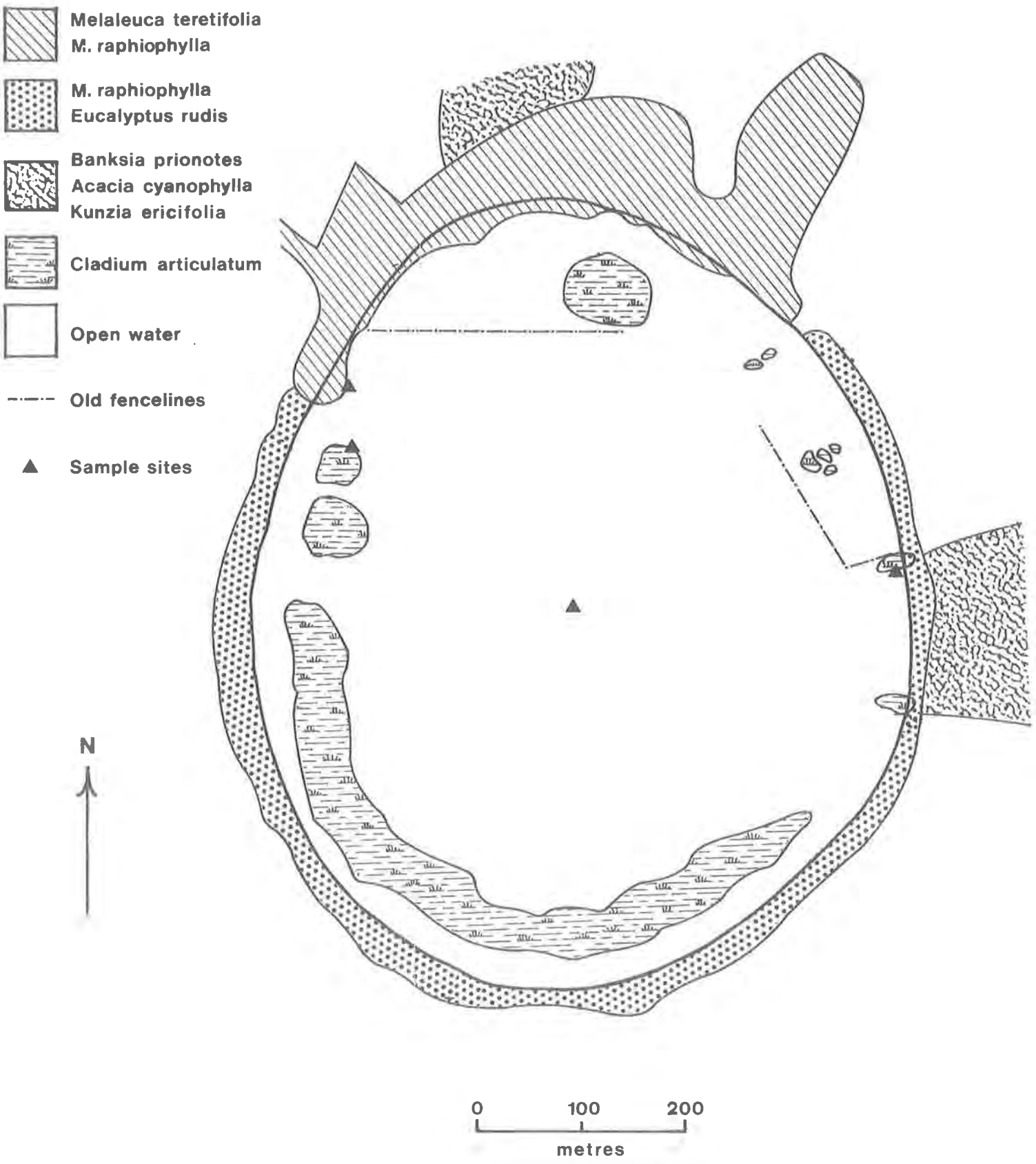
The lake is slightly acidic with a pH range of 7.5 to 6.0. Relatively high levels of P(orthophosphate) occur in this lake, probably as a result of intense agriculture on surrounding areas within the drainage area (Table 1).

LAKE CHANDALA

(After Tingay and Tingay 1976)



LAKE BAMBUN


Melaleuca teretifolia
M. raphiophylla
M. raphiophylla
Eucalyptus rudis
Banksia prionotes
Acacia cyanophylla
Kunzia ericifolia
Cladium articulatum
Open water
Old fencelines
Sample sites
N
0
100
200
metres

LAKE BAMBUN

This circular lake (Plate 5) is situated on the junction of the Bassendean Dune System and the Pinjarra Plain and is hydrologically associated with the Gnangara Mound aquifer, lying as an outward expression of it in the northeast boundary.

Vegetation consists of large areas of Cladium articulatum inside the margins of the lake, an area of closed forest consisting of Melaleuca rhaphiophylla and M. teretifolia on the northern edge, and open woodland of M. rhaphiophylla and Eucalyptus rudis surrounding the majority of the periphery of the lake (Figure 6 opposite). Behind these formations are a shrubland of Banksia prionotes, Macrozamia reidlei and Acacia cyanophylla which has been largely cleared for agriculture. Summer grazing around the lake ruined the shoreline Cladium beds. The bottom is mainly sand with areas of silt and clay. Submerged fenceposts testify to recent increases in the water levels of this lake.

The lake is the deepest examined during this survey with a maximum depth of 2.7m in October and a minimum depth of 1.2m in April. The area of the lake is 36.5ha with a shoreline of 2.1km. The proximity of Lennard Brook to the north would probably result in the connection of these two water bodies during late winter after heavy rains. Water temperatures reached 34^{o}C in February.

This lake becomes considerably more saline in late summer (Table 1), while phosphorous levels are highest after winter rains.

LAKE BEERMULLAH

Located on the Beermullah Soil Association of the Pinjarra Plain, and lying north of Gingin Brook this lake is hydrologically quite distinct from the Gnangara Mound.

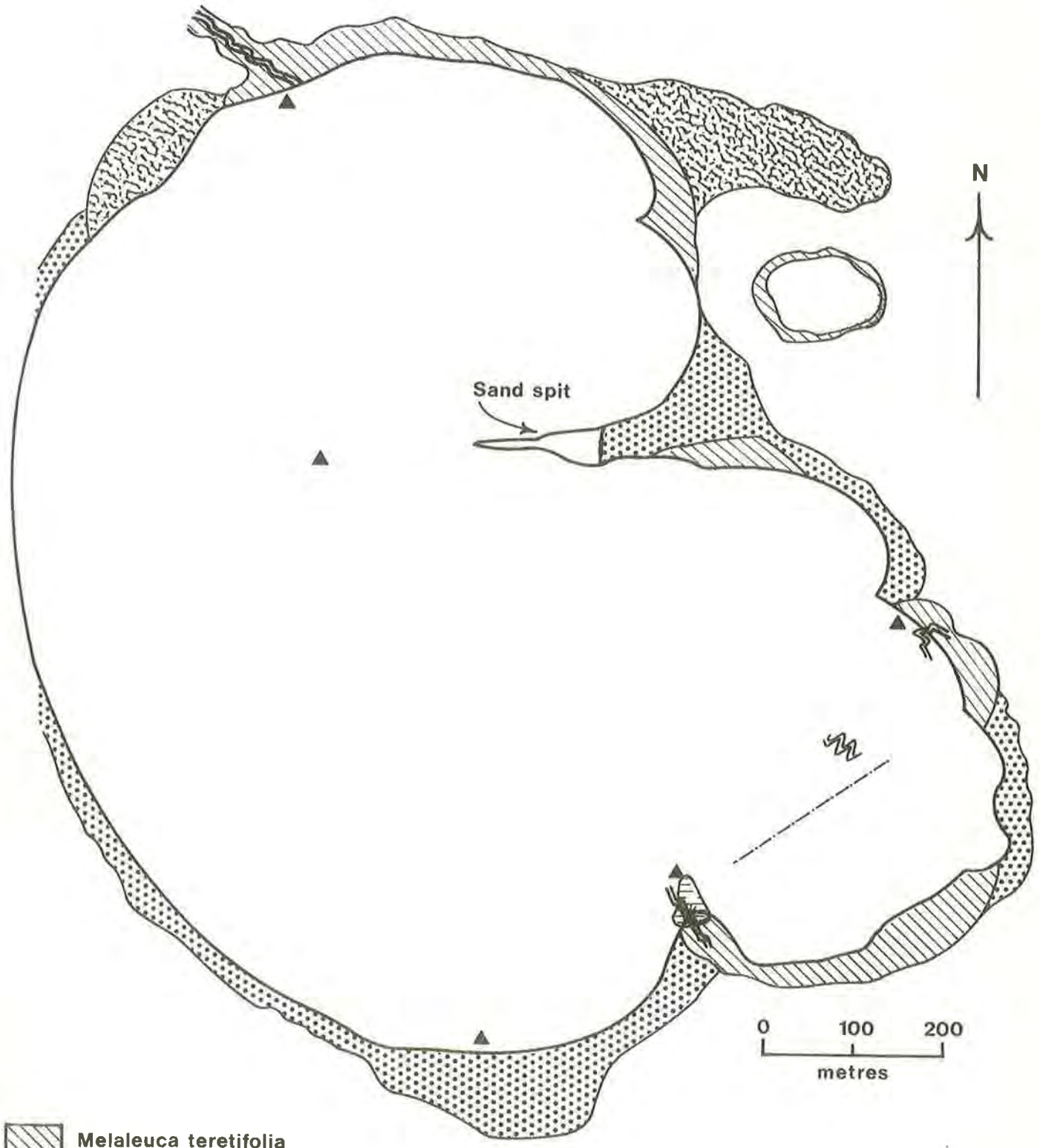
Several small springs feed this lake (Figure 7 opposite). and there is a seasonal watercourse to the north which flows directly into the lake.

There are small thickets of Melaleuca rhaphiophylla and M. teretifolia but the majority of the lake margin is very open M. rhaphiophylla - Eucalyptus rudis woodland with some Acacia acuminata interspersed. Small areas of Banksia prionotes, E. rudis and E. calophylla occur adjacent to these major associations. There is a small area of Cladium articulatum on the southern bank but this was heavily grazed during summer as cattle made use of the freshwater spring in central-southwest portion of the lake.

The surface area of this lake is c. 86ha and the shoreline about 4km. Maximum depth recorded was 1.2m in October, while the lake had dried out except for the small springs by late summer (Plate 6). This is the third time since World War II that the lake has completely dried; the others were in 1961 and 1969 (E. Harris, pers. comm.). Old fencelines and water troughs adjacent to the springs illustrate the uncertain nature of waterlevels in this lake.

Lake Beermullah is saline (Table 1) having high concentrations of most elements. Water and plankton samples taken during the day and night in November, showed significant diurnal variation in chemistry and fauna.

LAKE BEERMULLAH



APPENDIX II

AERIAL PHOTOGRAPHS OF THE LAKES STUDIED

Plate 1. Lake Jandabup on 6 May 1978 looking south-west. South Lake Joondalup is visible in the right background.

Plate 2a. Lake Joondalup on 6 May 1978 looking north-west. Wanneroo is in the foreground and the new Edgewater estate is centre-left.

Plate 26. Southern Lake Joondalup on 6 May 1978 looking north-east. Lake Jandabup visible in the background upper right, behind Wanneroo.

Plate 3a. Loch McNess on 6 May 1978 looking south-east.

Plate 3b. Southern and Eastern Loch McNess on 6 May 1978 looking east. Yanchep National Park headquarters are centre right.

Plate 4a. Lake Chandala on 6 May 1978 looking south-south-east. Drains are visible centre left and middle.

Plate 4b. Lake Chandala on 6 May 1978 looking north-east. Centre pool surrounded by closed forest.

Plate 5. Lake Bambun on 6 May 1978 looking south. Lakes Nambung and Mungala lie behind and are dry.

Plate 6. Lake Beermullah on 6 May 1978 looking north-west. The lake is dry and several freshwater springs and soaks are visible.

Plate 7. Lake Guraga on 6 May 1978 looking south-west. The lake is dry and Lake Namming lies behind.

MAMMALS OF THE NORTHERN SWAN COASTAL PLAIN

by D.J. Kitchener, A. Chapman
& G. Barron

June 1978

HISTORICAL BACKGROUND

Knowledge of the mammal fauna of the Swan Coastal Plain increased rapidly during the first decade of European settlement at the Swan River. For example in 1831 G.F. Moore, who lived 29 kms from Perth on the Swan River (near Guildford) writes that "the animals you meet with are the opossum, the kangaroo-rat, lizards, rats and mice, the rat not much longer than the English mouse, they are abundant and mischievous". In 1840 Drummond (in Glauert 1948) recognised nine species of mammals at Swan River "The animal called the Dolgitch (Macrotis lagotis Reid) burrows in the ground, the Bundit (Bettongia lesueur Quoy & Gairmard) burrows in the ground or lives in holes in rocks and the Manang [Onychogalea lunata (Gould)], a small kind of kangaroo has a horny substance like a claw on the point of its tail." In the appendix to Grey (1841), Gray lists the following marsupials known from the Swan River:-

Phascogale murina	Sminthopsis murina (Waterhouse)
Ph. leucogaster	Antechinus flavipes (Waterhouse)
Myrmecobius fasciatus	Waterhouse
Perameles fusciventer	Isoodon obesulus (Shaw)
P. lagotis	Macrotis lagotis Reid
Phalangista vulpina	Trichosurus vulpecula (Kerr)
Hepoona cookii	Pseudocheirus peregrinus (Boddaert)
Macropus lunatus	Onychogalea lunata (Gould)
Halmaturus manicatus	Macropus irma (Jourdan)
H. brachyurus	Setonix brachyurus (Quoy & Gaimard)

To this list should be added Bettongia graii [Bettongia lesueur (Quoy & Gaimard)] included by Waterhouse in work, which although undated was published in 1841 (see Glauert 1948), before Grey's

journals were made public. Between March 1839-February 1840 and July 1842-December 1843, John Gilbert collected in Western Australia for John Gould, and during his expeditions most of the species known from the Swan Coastal Plain were collected. Specimens in the Gould collection from the "Swan River" are cited in Thomas (1888).

Locality data with these early specimens is sometimes vague and it must be remembered that "Swan River" may have included country to the east in the Darling Range and York and Avon River Valley. For this reason, some species in the below systematic list of mammals known from the Northern Swan Coastal Plain are uncertain records. They are placed on this list only as a result of having a "Swan River" locality.

SYSTEMATIC LIST

MARSUPIALIA

MACROPODIDAE:

Macropus fuliginosus (Desmarest, 1817)

M. irma (Jourdan, 1837)

M. eugenii (Desmanest, 1817)

? *Petrogale lateralis* Gould, 1842

Onychogalea lunata (Gould, 1840)

Bettongia penicillata Gray, 1837

Bettongia lesueur (Quoy & Gaimard, 1824)

Setonix brachyurus (Quoy & Gaimard, 1830)

? *Lagostrophus fasciatus* (Peron, 1807)

PHALANGERIDAE:

Trichosurus vulpecula (Kerr, 1792)

Pseudocheirus peregrinus (Boddaert, 1785)

BURRAMYIDAE:

Cercartetus concinnus (Gould, 1845)

TARSIPEDIDAE:

Tarsipes spencerae Gray, 1842

PERAMELIDAE:

Isoodon obesulus (Shaw, 1797)

THYLACOMYIDAE:

Macrotis lagotis (Reid, 1837)

DASYURIDAE:

Dasyurus geoffroii Gould, 1841

Antechinus apicalis (Gray, 1842)

Antechinus flavipes (Waterhouse, 1838)

Phascogale tapoatata (Meyer, 1793)

Sminthopsis crassicaudata (Gould, 1844)

Sminthopsis murina (Waterhouse, 1838)

Sminthopsis granulipes Troughton, 1932

MYRMECOBIIDAE:

Myrmecobius fasciatus Waterhouse, 1836

RODENTIA

MURIDAE:

Rattus fuscipes (Waterhouse, 1839)

Rattus tunneyi (Thomas, 1904)

Rattus rattus (L.)

Hydromys chrysogaster Geoffroy, 1804

Pseudomys albocinereus (Gould, 1845)

Mus musculus L.

CHIROPTERA

MEGADERMATIDAE:

?*Macroderma gigas* (Dobson, 1880)

VESPERTILIONIDAE:

Nyctophilus geoffroyi Leach, 1821

Eptesicus regulus

Chalinolobus gouldii (Gray, 1841)

C. morio (Gray, 1841)

Myotis adversus (Horsfield, 1824)

MOLOSSIDAE:

Tadarida australis (Gray, 1839)

PTEROPODIDAE:

?*Pteropus scapulatus* Peters, 1862

CARNIVORA

CANIDAE:

Canis familiaris (L.)

Vulpes vulpes (L.)

FELIDAE:

Felis catus L.

MUSTELIDAE:

Mustela putorius L.

LAGOMORPHA

Oryctolagus cuniculus (L.)

MONOTREMATA

TACHYGLOSSIDAE:

Tachyglossus aculeatus (Shaw, 1792)

? Some doubt as to former occurrence on North Swan Coastal Plain.

The last organised collecting of mammals in the Swan Coastal Plain was by Shortridge in 1904-07. An account of his collecting is given in Shortridge (1909 and 1936). Further to this the Western Australian Museum undertook a 4 month trapping programme at Mussel Pool, West Swan, in 1975 (see Jackson & Morris 1975). In 1973 an additional trapping programme was conducted by A. Chapman at Sorrento (unpublished data).

The 1977/78 Survey

For the background to this survey see How, this publication. Areas selected for intensive mammal trapping were Moore River National Park, proposed Gingin Wildlife Reserve, Melaleuca Park, Martyn Reserve, Twin Swamps Reserve, Yanchep National Park, Neerabup National Park, and the Burns Beach Mullaloo area. These areas were selected because they were reasonably large tracts of relatively undisturbed country, and as such are most likely to retain extant populations of mammals in the region. Further they were chosen to provide representative communities of the major soil (and physiographic types) in the region: Quindalup, Spearwood, Bassendean, and Pinjarra Plain Soils.

The schedule of visits to each of these areas is as follows:

Moore River National Park (46 man days)	30.3.77-6.4.77	-	26-30.9.77	20-24.3.78
Gingin Proposed Reserve (42 man days)	8-17.6.77	29.8.77-2.9.77	-	27.2.78-3.3.78
Melaleuca Park (40 man days)	9-14.9.77	2-6.8.77	5-9.9.77	20-24.2.78
Martyn/Twin Swamps Reserve (40 man days)	18-22.4.77	27-31.7.77	3-7.10.77	12-16.3.78
Yanchep National Park (54 man days)	28.4.77-7.5.77	16-20.8.77	20-24.9.77	14-20.12.77
Neerabup N.P./ Burns Beach (68 man days)	12-25.5.77	9-13.8.77	11-16.9.77	29.11.77-6.12.77
Mullaloo (25 man days)	15-20.5.77 2-7.10.77 19-24.2.78	19-24.6.77 23-28.10.77 9-14.4.78	17-22.7.77 11-16.12.77	3-8.9.77 15-20.1.78

Traps were placed in lines and baited following the methods of Chapman & Kitchener (1977), except for the Mullaloo-Burns Beach study area where lines of 10 traps with 5 "Museum Special" kill traps and 5 "Shermann" live traps in alternate sequence were set. Shermann traps were baited with "universal" bait and the "Museum Specials" with linseed oil. The location of the trapping lines is shown in fig. 1; the trapping effort in Appendix I - along with codified descriptions of the vegetation at each trapline following Muir (1977).

The objectives of this mammal survey were to produce an inventory of the extant mammals in the North Swan Coastal Plain and document the presumed decline of species in the area, indicated to have begun as early as the 1880's by Shortridge (1909). Further it is intended to indicate the present habitat preferences of mammals in the region.

ANNOTATED LIST

Macropus fuliginosus, Western Grey Kangaroo
Type locality: Kangaroo Island

Since European settlement Grey Kangaroos have been abundant on the Swan Coastal Plain. For example Moore (1884) described numerous sightings of kangaroos from the Guildford area between 1831-40; on 14 September 1832 he reports on a group of "fifty kangaroos together". They were an important part of the diet of the early Swan River settler and Moore recounts on 12 October 1934 that "many persons have supported their establishments as far as meat is concerned upon kangaroo this season. Some have killed several thousand pounds weight" and Gilbert (in Wagstaffe & Rutherford 1955) writes on 27 March 1843 that "the large Grey Kangaroo is tolerably abundant over the whole colony of Australia, from King George's Sound, South, to forty Miles North of Moore's River, North the furthest point I have been". "In travelling along the road from Guildford to York two to four or five may occasionally be met with, but further in the Interior, particularly Gwangar Plains, herds of thirty to fifty may often be met with but further South, beyond Kojonup, they are more numerous - 500 in a herd at Garden Plains in 1840".

Macropus fuliginosus were common in the study areas on the North Swan Coastal Plain in 1977/78. Approximately 1,800 sightings of animals were recorded during the survey (315 man days). They were recorded in all study areas except Martyn Swamp Reserve which is probably too small and isolated to support them. They utilise woodland, shrubland and heath formations in Quindalup, Spearwood and Bassendean Dune Systems and also the Beermullah formation in Twin Swamps Reserve where they were most abundant; they were also abundant in Banksia menziesii woodland in Moore River National Park in March 1978 in areas which were burnt in March 1977.

Kangaroos were recorded between May 1977 and April 1978 on standard vehicle traverses between Mullaloo and Burns Beach for five consecutive days once a month between 0700-1000 hours. In that study 80 separate sightings were recorded; group size ranged from 1-15, with 2 being the most frequently recorded.

Fifty percent of animals were seen in Dwarf Scrub D on limestone outcropping with Hibbertia hypericoides, Scaevola paludosa, Bossiaea eriocarpa, Phyllanthus calycinus and Conospermum triplinervium prominent species. This formation which is a regenerating Dryandra sessilis/Acacia pulchella heath which was last burnt in summer 1975/76 occurs throughout the area. There was a marked decline in numbers of animals seen in coastal heaths and woodlands over the transition from winter to summer. This is interpreted as a local movement of animals inland to denser eucalypt (E. marginata and E. gomphocephala) woodlands to avoid heat stress during summer in coastal areas which offer very little shelter. A similar seasonal change in abundance during summer on consolidated sand dunes was observed in Yanchep National Park.

Two females each with one pouch young were seen between Mullaloo and Burns Beach in October 1977.

Macropus irma, Brush Wallaby
Type locality: Swan River, Western Australia.

Since European settlement the Brush Wallaby has been abundant on the Swan Coastal Plain. On 27 September 1832 Moore (1884) describes chasing "four kangaroos and five wallabies, and got three chases, but the dogs killed only one wallabee (sic), weighing 16lb" near Guildford, the wallabies were probably M. irma. In 1843 J. Gilbert writes that this species "is found inhabiting scrubby country (and) appears to be pretty generally distributed over the whole Country yet settled upon or known to the settlers". Shortridge (1909) reports no evidence of population decline in this species such as was noted in the smaller marsupials. Glauert (1933) reports it as still common near Perth.

Between 1931 and 1975, 12 specimens, M1379, M2648, M3306, M3984, M4014, M5003, M10480, M11237, M12448, M12451, M13417, and B43 were sent into the Museum from Wembley, Perth, 20Mi N Gingin, Gingin (3), Burns Beach, Julimar Forest (2), 7 km N Wanneroo, Mullaloo, and 1 Mi E Duncraig. They were frequently sighted during the 1977/78 survey: 14 in Neerabup N.P./Burns Beach (no summer sightings at Burns Beach), 26 in Mullaloo/Burns Beach area, 4 in Melaleuca Park, Yanchep N.P. (3), Gingin (6), Moore River (4). Most sightings were of single animals, never more than 2 individuals.

Unlike M. fuliginosus they were not seen in the open by day; they were most common on the Spearwood Sands and were most frequently seen in mixed Banksia menziesii woodlands, both burnt and unburnt, followed by Dryandra sessilis heathland, burnt Eucalyptus marginata woodland and unburnt Eucalyptus gomphocephala woodland.

Macropus eugenii, Tammar
Type locality: St. Peter's Island, Nuyt's Archipelago, South Australia.

Thomas (1888) lists a specimen from Perth and another from Swan River; these were presented to the British Museum by the Western Australian Government and Lord Derby (through Zool. Soc.).

Shortridge (1909) reports this species as "very plentiful in many parts of the South-West, but rapidly disappearing in the cultivated districts, especially towards the northern end of its range... . Said still to exist in isolated patches in the North between the Swan River and Gingin."

Petrogale penicillata lateralis, Brush-tailed Rock Wallaby
Lectotype: Swan River BM42.5.26.3

Thomas (1888) records several specimens from Swan River, W.A., collected by J. Gilbert and presented to the British Museum as part of the Gould collection.

Onychogale lunata, Wurrung
Type locality: West Coast of Australia

Thomas (1888) records two specimens from Swan River, W.A., collected by J. Gilbert and presented to the British Museum as part of the Gould collection. Shortridge (1909) states that this species frequently occurs together with Macropus eugenii with its western boundary apparently being the Darling Range.

Glauert (1933) considered that it still occurred in isolated localitites to the west of the lower Great Southern Railway, probably on the verge of extinction in settled districts, but surviving further east towards the Great Victorian Desert. Archer (1974) records this species from a superficial cave deposit near Wanneroo.

Bettongia penicillata, Woylie
Type locality: New South Wales

Gilbert (in Wagstaffe & Rutherford 1955) wrote in 27 March 1843 that "this species appears equally abundant in all parts of the Colony, giving the preference perhaps to White Gum Forests. This is one of the most favourite articles of food among the Natives, who are very quick in detecting the Nest".

Thomas (1888) lists a male and a female collected from Perth, Western Australia, presented to the British Museum by the Western Australian Government. In 1904-07, Shortridge (1909) considered it "very plentiful in the South West, where, unlike Bettongia lesueuri (sic), it occurs near the coast, extending as far north as the Moore River, becoming very rare at its northern limit... Although getting scarce in the more settled districts, both species of Bettongia are sufficiently numerous in many places to be rather destructive to crops, on which account they are often trapped and poisoned off in large numbers".

Bettongia lesueur, Boodie
Type locality: Dirk Hartog Island, Shark Bay, West Australia.

On 1 May 1832 Moore (1884) describes a Kangaroo-rat from near Guildford "very like a Kangaroo in miniature but with its head larger in proportion and with fur or hair of coarser texture"; this is thought to be B. lesueur.

Thomas (1888) records an adult male from Swan River (type of B. grayii Gould) collected in 1840. Shortridge (1909) comments that they "do not appear to exist on the mainland at the present time (1904-07) to the north of the Swan River".

Glauert (1933) reports that their "favourite environment would seem to be 'sandplain country' where burrowing is fairly easy". Recorded by Archer (1974) in a superficial cave deposit near Wanneroo.

Setonix brachyurus, Quokka
Type locality: King George's Sound, South-West Australia

Thomas (1888) lists a specimen from Perth collected by John Gilbert between 1839-43. Shortridge (1909) reports them as "very plentiful among coastal thickets and swamps of the South-West... said to occur sparingly as far north as Moore River". Glauert (1933) reports them as occurring from Moore River to the south coast, and White (1952) states that "until recently, an abundant creature in the fertile, thickly scrubbed coastal country".

Lagostrophus fasciatus, Munning
Type locality: Bernier Island, Shark Bay, West Australia

Thomas (1888) records 2 specimens collected from Perth and donated to the British Museum. Shortridge (1909) considered that on the mainland they were restricted to a few isolated localities in the central and southern wheatbelt and the neighbourhood of the Stirling Ranges. Shortridge states that their contraction of range started about 1880 and was "most sudden and unaccountable".

Trichosurus vulpeca, Brush-tailed Possum
Type locality: Sydney, New South Wales

The 'opposum' frequently referred to by the early Swan Settlers. J. Gilbert (in Whittell 1954) writes that they are "most abundant in the extensive Gum forsts of the interior, but is very generally distributed over the whole colony of Western Australia. Shortridge (1909) reports that in recent time their range has contracted "but now almost, if not entirely, confined to the south-western corner of the State, a few stragglers only being found as far north as Gingin, and inland". Glauert (1933) states that they are still very plentiful near Perth.

Between 1914 and 1975, 26 specimens, M1198-9, M1249, M1422, M1562, M2446, M127-M643, M3546, M5290, M5308, M5467-9, M5522, M5526, M6538, M8206, M8373, M8387, M13874, M17083, M17085-8, were sent into the Museum from Perth and nearby areas in the North Swan Coastal Plain; the furthest locality from the

metropolitan area was Wanneroo. One was trapped at the Wildlife Research Centre near Lake Joondalup. They persist semi-naturally in Perth suburbs, particularly Subiaco and also in Kings Park.

1977/78: reported in Yanchep National Park by Rangers (fide R. Waterhouse) but not seen by us.

Pseudocheirus peregrinus, Common Ringtail
Type locality: Endeavour River, North Queensland

Thomas (1888) lists two specimens from Perth and two from Swan River - all collected by John Gilbert between 1839-1843. Gilbert (in Whittell 1954) notes that it "is very generally distributed over the whole colony it is most abundant in the beds of the rivers or other moist places". Recorded by Archer (1974) in a superficial cave deposit near Wanneroo.

Shortridge (1909) considers that their range was contracting in 1904-07 and that they were apparently disappearing in many places. Glauert (1933) suggested the species was on the verge of extinction. Several populations are known to occur near Augusta and in Ludlow State Forest north of Busselton in the South West.

Cercartetus concinnus, Mundarda
Type locality: Swan River, Western Australia

Thomas (1888) lists two specimens from Swan River, Western Australia (co-types) collected by J. Gilbert. J. Gilbert (in Whittell 1954) writes that "this little opossum is tolerably abundant in most parts of the colony on the west coast, inhabiting the smaller trees particularly the Casuarina".

Shortridge (1909) states that it is widely distributed throughout the South-Western districts. Glauert (1933) states that it is still a very common species, even close to Perth.

It appears to be uncommon on the North Swan Coastal Plain. Between 1927 and 1966 20 specimens have been sent into to Museum (M847 , M1003, M1270, M1624-6, M1630, M1632, M1638, M1667, M2329, M2336, M2338, M2339, M2391, M2392, M2393, M3422, M5314, M6740) from Bindoon, Yanchep, Gnangara Pine Plantation, West Swan, Scarborough, Perth 'district', Wanneroo, Leederville.

Tarsipes spencerae, Noolbenger
Type locality: King George's Sound, Western Australia

Thomas (1888) lists two specimens from Perth, W.A. presented by the Government of Western Australia and were collected by J. Gilbert from Swan River, W.A.

J. Gilbert (in Whittell 1954) writes that he does not "think it is abundant in any part of the Colony, or else it is difficult to find... I offered high rewards to the natives (but) they never bought me in more than four specimens".

Shortridge (1909) had difficulty collecting this species and believed them to be rare. Glauert (1933) stated that it still occurs close to Perth in suitable localities. Recent surveys on the south and west coast and in the wheatbelt indicate that this species is common in sandplain heath (Kitchener and Chapman 1975, 1978, Chapman and Kitchener 1977). While it still is found on the North Swan Coastal Plain, nowhere does it appear to be common.

Between 1928 and 1975 20 specimens have been received from the North Swan Coastal Plain (M1212, M1356, M1384, M1410-13, M1599, M2325, M3070, M8112-15, M8117, M8433-35, M12790, B1084) from the mouth of Moore River, Yanchep, Bullsbrook, Gnangara Pine Plantation, West Swan, City Beach, Belmont, Shenton Park, and Sorrento. The 1977/78 survey recorded one specimen, a male, in low heath on Spearwood Dunes ca 1 km south of Burns Beach in December 1977.

Isoodon obesulus, Quenda
Type locality: Sydney, New South Wales

Shortridge (1909) states that although this species extends as far north as the Moore River it is scarce in that area. Glauert (1933) considers it plentiful near Perth.

It is now thought to be sparsely distributed on the Northern Swan Coastal Plain, in thickly vegetated damp situations, although there are still established populations south of the Swan River (e.g. Maddington). Between 1925 and 1975, 12 specimens were sent into the Western Australian Museum from the North Swan Coastal Plain (M522, M1623, M2685, M2823, M4597, M6245,M656], M6770, M7560, M7698, M13712, and M14383)

from Yanchep, Bullsbrook, Midland, Salters Point, Gnangara Pine Plantation, Gnangara, 17 Mi Peg, Wanneroo Road, 13 km E Perth, Mussel Pool, North Perth, Mt. Hawthorn, and Bassendean.

The 1977/78 Survey collected two specimens; (GM53) from Pinjar Road, Wanneroo, and from Melaleuca Park, trapline 8, in dense Melaleuca and Kunzea ericifolia shrubland over low heath and sedgeland.

Macrotis lagotis, Dalgyte
Type locality: Swan River, Western Australia

Thomas (1888) lists both the type specimen and the skull of an adult male from Swan River. It is probable that these specimens did not, however, come from the Coastal Plain because Reid (1836) states that "a friend of Mr. Gould's residing in Western Australia states that these animals are found beyond the mountains of Swan River in the district of York. They feed upon large maggots and roots of trees and do considerable damage to the maize and potatoe crops by burrowing". Glauert (1933) proposes that the species was "driven from the wheatbelt by clearing of land (and) have attempted to establish themselves near Perth where formerly they were either extremely rare or absent". While this is unlikely it appears that the species was able to take advantage of man; there do appear to have been established colonies west of the Darling Range in 1900 as noted by a letter written by John Tunney to Bernard Woodward, Director, Western Australian Museum, on 15 August 1900, where he writes "Mr. Pollard tells me there are some (M. lagotis) about the pool near Kelmskott". Shortridge (1909) considered it widely distributed throughout the South West - except near the coast.

The Museum has specimens from Upper Swan (M703) collected in 1925, from Perth (M787) collected in 1926, and from Gingin (M610) collected in 1923.

Dasyurus geoffroii, Chuditch
Type locality: Liverpool Plains, New South Wales

Thomas (1888) lists an adult female and 2 immature skins from Perth W.A., the former donated to the British Museum and the latter by the Government of Western Australia.

Shortridge (1909) states that it is fairly numerous in the South West as far north as Watheroo or Geraldton, it is predominately coastal in distribution.

Glauert (1933) states that it is quite common near Perth, where it breeds in King's Park and in the roofs of suburban residences.

It is now believed very scarce in the North Swan Coastal Plain. It has been recorded from the following localities: Belmont 1917, 1927, 1951 (M311, M865, M2866), Perth 1909, 1929, 1930 (M16039, M1106, M1337), Subiaco 1921 (M481), Claremont 1925 (M728-9), Crawley 1930 (M1395), Maylands 1931, 1934 (M1603, M1850), West Midland 1934 (M1838), Guildford 1961 (M4702), 7 km NNW Perth (M550), Loch McNess 1921 (M523-4), Yanchep 1972 (M15490).

Antechinus apicalis, Dibbler
Type locality: South Western Australia

Gilbert (in Whittell 1954) writes that this species "is universally dispersed over the whole of Western Australia... it appears to vary a good deal in habits, in different localities. At Moore's River the natives describe it as making a nest beneath the overhanging grasses of the Xanthorrhea. While at Perth its nest is taken either from the dead stump or from among the upper grasses of the same Plant". Archer (1974) records it in a superficial cave deposit near Wanneroo.

Antechinus flavipes, Mardo
Type locality: North of Hunter River, New South Wales

Thomas (1888) lists an adult male, skin and skull collected from Perth on 3 July 1843, and an adult, skin only, from Canning River on 9 April 1839 by John Gilbert. The type locality for Antechinus flavipes leucogaster Gray 1841 is the banks of the

Canning River, Western Australia. The British Museum has an additonal female specimen (92.10.10.2) from Perth, Western Australia.

Gilbert (in Whittell 1954) notes that "this species is found in nearly every part of the Colony of Western Australia... Specimens from different localities differ a good deal particularly in size, those from Perth are the largest".

The nearest W.A. Museum specimen to the Northern Swan Coastal Plain is 2 Mi W Mundaring (M8071) collected in 1970

Phascogale tapoatata, Tuan
Type locality: Sydney, New South Wales

Thomas (1888) lists an adult male, skin, from Perth and an adult male skeleton from Guildford, W.A. collected by J. Gilbert between 1839-43.

Glauert (1933) states they are found in the South West from Fremantle to the South Coast and inland to Merredin.

The Western Australian Museum has a specimen from Mt. Lawley collected in 1945 (M2682) and one from Gosnells, South of the Swan River, collected in 1961 (M4467). Numerous other specimens have been received by the Museum from localities to the south of the Swan River.

Sminthopsis crassicaudata, Fat-tailed Dunnart
Type locality: Williams River, Western Australia

Shortridge (1909) considers it rare in Western Australia but with a wide range.

The specimens (M1122-3) collected in 1929 from Yanchep, North Swan Coastal Plain, and specimens (M10064, M153009-10) collected in 1972 from Lancelin, are notable coastal records, other coastal records are at Greenhead (M12442) and Jurien Bay (M10743, 11907 & 11908). Glauert (1933) states that "at times it has been found on the coastal plain, although its usual western limit is the escarpment of the Darling Range.

Sminthopsis murina, Common Dunnart
Type locality: North of Hunters River, New South Wales

Thomas (1888) lists an adult male specimen collected by Gilbert on 2 July 1843 from Perth. Gilbert (in Whittell 1954) writes that he knows only of "two habitats for this species, viz. the grass lands of the Toodyay Valley and in the thick groves of Xanthorrhoea surrounding the swamps and lakes around Perth". The nearest Western Australian Museum specimens to the Northern Swan Coastal Plain are M1349 from Cannington (1930), M1423 from Kelmscott (1931) and M2464 from Karrakatta (1940).

Sminthopsis granulipes, White-tailed Dunnart
Type locality: King George's Sound, South Western Australia

On specimen collected from Gingin in 1934 (B1830).

Until recently this species was known from few localities. However, recent surveys indicate that it is present on a number of reserves in the wheatbelt areas of Western Australia, and in several coastal localities near Jurien Bay (Chapman & Kitchener 1977). Its preferred habitat appears to be vegetation dominated by low to medium height shrubs (Kitchener and Chapman 1978).

Myrmecobius fasciatus, Numbat
Type locality: 90 Mi SE mouth of Swan River, Western Australia
i.e. in the vicinity of Mt. Kokeby.

Thomas (1888) lists a specimen from Swan River presented to the British Museum by Zool. Soc. (A. Gordon, Esq.) and two specimens collected by J. Gilbert and two other specimens purchased.

Shortridge (1909) states that they are "Fairly numerous although rather scattered, throughout the inland forest districts of the South-West, especially where the prevailing trees are the White Gum (Eucalyptus redunca) and Jam (Acacia acuminata)... Not extending to the West Coast".

The Museum has specimens from Perth (M16055) collected in 1901, and from Bayswater (M2253) collected in 1937.

Rattus fuscipes, Southern Brush-Rat
Type locality: King George's Sound, South Western Australia

Widely distributed in coastal country of the south west from Jurien Bay in the north to Israelite Bay to the south east.

Prior to the 1977/78 survey Western Australian Museum had only one specimen (M13036) from the North Swan Coastal Plain. This was collected at Yanchep in 1975.

1977/78 survey collected 6 specimens (GM24, GM27, GM28, GM29, GM42, GM47) from Yanchep National Park line 5 (4) in Typha angustifolia sedgeland and line 7 (2) in Eucalyptus gomphocephala and Melaleuca woodland with T. angustifolia understory. Both these traplines were on the edge of Loch McNess in mesic environment which is maintained by the permanent fresh water body.

Rattus tunneyi, Tunney's Rat
Type locality: Mary River, Northern Territory

Taylor and Horner (1973) list specimens under Rattus tunneyi culmorum from "bullang", Swan River district, vicinity of Perth [British Museum No. 43.8.21.1 skin (43.9.2.3 skull)] and Perth Lakes, vicinity of Perth [Rijksmuseum van Natuurlijke Historie, Lieden (Mus gouldii) Reg. No. 20365 (skull removed from skin)]. Recorded by Lundelius (1960) in "cave surface fauna" at Jurien Bay, on the coastal plain ca 200 km north of Perth.

Rattus rattus (L.), Black Rat

Widely distributed in the South West coastal plain but uncommon to the west of the Darling Range where it is seldom recorded in natural vegetation.

1977/78 survey collected 15 specimens (GM20, GM21, GM23, GM30, GM32, GM33, GM34, GM41, GM43, GM44, GM46, GM49, GM45, GM52) from Melaleuca Park: line 7 (1) in Eucalyptus rudis woodland over Melaleuca shrubland in a swamp, line 8(1) in mixed Melaleuca and Kunzea ericifolia shrubland. Yanchep National Park: line 7(7) in Melaleuca and Eucalyptus

gomphocephala woodland over Typha augustifolia sedgeland, line 5(4*) in T. angustifolia sedgeland; both these lines were on edge of Loch McNess. Moore River National Park: line 5(1) in Eucalyptus calophylla woodland. Burns Beach: line 15(4) in heath on low coastal limestone cliffs just above the shoreline, line 11(1) in mixed Eucalyptus marginata, Banksia menziesii, Casuarina fraseriana woodland. Twin Swamps Reserve: line 8(1*) in Banksia woodland over sedgeland. Most of these were recorded from mesic environment associated with either permanent or ephemeral fresh water. *Indicates specimen not retained.

Hydromys chrysogaster, Water Rat
Type locality: Bruni Island, D'Entrecasteaux Canal, Tasmania

Widely distributed in coastal areas of the South West and Darling Range along streams and rivers.

Between 1917 and 1976, 9 specimens have been sent into the Museum from the North Swan Coastal Plain (M354, M426, M457, M483, M581, M850, M1420, M2190, M10328) from Moore River, Perth, and Perth metropolitan areas.

The 1977/78 survey recorded one swimming in open water 50 m from cover in Lake Jandabup (fide R. Johnstone). A specimen was collected on Mullaloo Drive on the causeway over Lake Joondalup in 1976 (W.K. Youngson, pers. comm.).

Pseudomys albocinereus, Ashey-grey Mouse
Type locality: Fremantle, Western Australia

Widely distributed in coastal sandplain heath from Kalbarri in the north to Israelite Bay in the south east; it also occurs in pockets of sandplain country throughout the wheatbelt.

First recorded from the Swan Coastal Plain in "sandunes north of Fremantle" in 1843, Shortridge (1936). Next record on the North Swan Coastal Plain is at Mussel Pool in 1975, (Jackson & Morris, 1975). 1977/78 survey collected 8 specimens (GM11, GM12, GM13, GM35, GM36, and GM37, AC1, and AC2) from Moore River National Park: line 3(3) in Nuytsia floribunda woodland over heath. In South Gingin Reserve: lines 1(1), 2(1), and 3(1) in mixed Banksia/Xanthorrhoea preissii and

and Banksia/Adenanthos woodlands and heaths on loamy sand in the Bassendean Dune System. At Burns Beach lines 8(1) in Dryandra sessilis/Xanthorrhoea preissii heath and line 8a(2) in Xanthorrhoea preissii/Banksia menziesii (dwarf life form) shrubland on loamy sand in the Spearwood Dune System. These two specimens were collected in vegetation regenerating from an extensive fire the summer of 1971/72. It is a small patch which avoided a further fire the summer of 1975/76.

Mus musculus, House Mouse

Widely distributed throughout the North Swan Coastal Plain. Mus were recorded from all traplines in all study areas of the 1977/78 survey. A total of 436 were collected but only a small sample was retained. They were considerably more abundant in the Quindalup and Spearwood Dune systems with Neerabub-Burns Beach study area recording 3.575 Mus per 100 trapnights, Yanchep National Park 3.263 Mus per 100 trapnights, Mullaloo 3.857 Mus per 100 trapnights. Figures for the Bassendean Dune System are Melaleuca Park 2.010 Mus per 100 trapnights, Gingin Nature Reserve 0.846 Mus per 100 trapnights and Moore River National Park 2.621 Mus per 100 trapnights. These figures refer to the entire survey and trapping effort is based on breakback and Elliott traps only. Thse figures are interpreted to reflect the different basic vegetation formations of these systems, with low open Banksia dominated woodlands of the Bassendean System offering little cover for Mus - unlike denser heaths and shrublands of the Quindalup and Spearwood Dune Systems. There is another component to this phenomenon and that is the ability of Mus (and Rattus rattus) to colonise the Quindalup Dunes which are a recent (and often unstable) physiographic feature, perhaps at the expanse of the native murids Rattus fuscipes and Pseudomys albocinereus. Furthermore, in the Mullaloo study area Mus were collected in traplines (lines 4a, 2b, 4b) which had been burnt only 10-18 months previously.

Generally numbers of Mus collected fell as the survey progressed i.e. less were captured at each successive trapping session. This may be a seasonal change in population numbers or the effect of constant removal from the population. However elsewhere in Western Australia Mus numbers are highest in autumn following seasonal spring-summer breeding, Chapman (in prep.). In the Mullaloo study area pregnant Mus were only collected in October and December. Ten pregnant females (weight range 14.0-24.5 gm) were collected. Number of foetuses ranged from 3-9.

Macroderma gigas, Ghost Bat
Type locality: Mt. Margaret, Wilson's River, Central Queensland

A skull sent into the Museum (6/9619) by Mr. L. de Burgh from Cowalla. While this appears a very southern locality, its provenance is supported somewhat by the statement in Glauert (1933) that Austin had seen M. gigas in a cave on Mt. Kenneth, ca 30 km E of Geraldton. Recorded by Lundelius (1957) for "pre-european fauna" in a cave deposit at Jurien Bay.

Nyctophilus geoffroyi, Lesser Long-eared Bat
Type locality: King George's Sound, Western Australia

Between 1939-64 4 specimens (M2379, M4806, M5098, M6305) were sent to the Western Australian Museum from metropolitan Perth.

The 1977/78 survey collected one specimen (GM39) from proposed Gingin Wildlife Reserve from under the bark of Banksia menziesii.

Eptesicus regulus, Southern Little Bat
Type locality: King River, King George's Sound, Western Australia.

Widely distributed in North Swan Coastal Plain. The Museum has 15 specimens (M37, M595, M921, M1862, M2576, M2837, M5093, M7812, M8183, M8806, M8836, M10078-9, M10068, M14380) collected between 1913 and 1976 from Moore River, Guildford, Bayswater, Mussel Pool, Perth and Perth metropolitan area.

The 1977/78 survey collected 8 specimens (GM3, GM8, GM9, GM10, GM14, GM15, GM22, and GM40) from Moore River National Park (6), Melaleuca Park (1) and Twin Swamps Reserve (1).

Chalinolobus gouldii, Gould's Wattled Bat
Type locality: Launceston, Tasmania

Widely distributed in North Swan Coastal Plain. The Museum has 28 specimens (B39, M42, M117, M215, M613, M628, M667, M669, M1590, M2482, M2880, M2986, M4433, M6060, M6330, M6610, M6625, M6758, M6888, M6894, M8184, M10327, M10535, M10539, M11000, M12177, M13596, M14373) collected between 1913 and 1976 from Gingin, Moore River, Midland Junction, Guildford, Yanchep, Perth, and Perth metropolitan area.

The 1977/78 survey collected 11 specimens (GM1, GM2, GM4, GM5, GM6, GM7, GM16, GM26, GM38, GM50, AC3) from Moore River National Park (7), Yanchep National Park (1), Gingin Wildlife Reserve (2) and Wanneroo (1).

Chalinolobus morio, Chocolate Bat
Type locality: Tasmania

Not recorded from the North Swan Coastal Plain for some time. Between 1913 and 1951, 6 specimens were received at the Museum (M42, M117, M628, M667, M669, M2880) from Yanchep and metropolitan Perth.

Myotis adversus, Large-footed Myotis
Type locality: South Australia

The British Museum has 2 specimens of Myotis adversus from Swan River collected by Sir George Grey CBM 43.12.30.24 and BM 43.12.30.26 (both skin with skull in situ). In addition a third specimen (BM.7.1.1.513) is listed from Swan River. This is a skin with damaged skull and is from the Tomes Collection. John Hill (Pers. comm.) says that "the Register ascribes this specimen originally to Gould but I am inclined to think that this is in error, the reference to Gould having come from a misreading of the original name Vespertilio macropus Gould on its label. It more probably originated from Sir George Grey".

Tadarida australis, White-striped Mastiff Bat
Type locality: New South Wales

The W.A. Museum has 5 specimens (M382, M666, M1591, M6692 and M6699) - all from metropolitan Perth collected between 1919 and 1966.

Pteropus scapulatus, Red Flying Fox
Type locality: Cape York, Queensland

One specimen collected from Midland Junction (B1087) in 1928. This is almost certainly a stray animal perhaps blown off course by a cyclone. The nearest living colony of flying foxes are Pteropus alecto at Carnarvon.

Canis familiaris, Dingo

On 6 May 1835, Moore (1884) reports 'native dogs' attacking his sheep at Guildford; on 29 May 1838 they carried away ducks from his house in Perth; on 29 May 1838 he reports poisoning 'native dogs'.

In 1900's de Burgh (1976) writes that at Moore River "all other problems were dwarfed by the overwhelming depredations of the dingoes... Dingoes killed 85 lambs and 10 ewes in one night and J. Andrews was paid for 28 scalps in one month". Further he says that dingoes were still a major problem in 1928 and that circa 1945 dingoes were caught in numbers as far south as yeal and swamps south of the Brook (Gingin) and along hills to the east of Beermullah. In 1945 he writes that a trapper was employed and "finally the areas south of the river (Moore River) were cleared altogether (of dingoes)". However, in 1954 de Burgh (1976) states that dingoes were still troublesome "eight dingoes were trapped in paddocks between January 1957 (at Cowalla)".

A dingo was collected at Gingin in 1961 (M4732) and at Gingin Brook in 1966 (M6782).

Vulpes vulpes, Red Fox

Frith (1973) states that the first spread of foxes in Western Australia was across the Nullarbor and up the west coast to Carnarvon, having avoided the forested south-west; in 1928 all the animals presented for bounty had been secured in this region. Between 1932 and 1934 foxes penetrated the forested south west. Mr. Grigson (to Dr. G.M. Storr) stated that foxes arrived at his farm at Cockleshell Gully, ca 230 km north of Perth, ca 1914 so that foxes can have been expected to be on the Swan Coastal Plain soon after 1914.

Specimens have been collected from Gingin (M11555 - no date), Yanchep (M3849 in 1959) and City Beach (M3850 in 1958).

The 1977/78 survey team saw foxes on 14 occasions, they were widely separated areas: Melaleuca Park (1 observation), Neerabup National Park (2), Gingin Proposed Wildlife Reserve (2), Lake Bambun (1), Yanchep National Park (4), and Moore River National Park (3), Caversham (1 - road kill), Burns Beach (1).

Mustela putorius, Ferret

The 1977/78 survey collected one specimen (GM51) from Yanchep National Park - line 1.

Felis catus, Domestic Cat

The first mention of domestic cats in the Swan Colony is on 7-9 May 1835, when Moore (1884) relates drowning one of his own at Guildford.

The Museum has 11 specimens all from metropolitan Perth.

The 1977/78 survey teams saw cats on 17 occasions; they were at widely separated areas: Twin Swamps (4 observations), Martyn Reserve (1), Melaleuca Park (2), Neerabup National Park (1), Burns Beach (1), Gingin Proposed Wildlife Reserve (1), Yanchep National Park (5), Moore River National Park (2).

Oryctolagus cuniculus, European Rabbit

Frith (1973) records that rabbits first arrived at the coast of Western Australia in 1907 from eastern Australia, having expanded their distribution 1609 km in 16 years. De Burgh (1976) states that the first wild rabbit was seen at Gingin in August 1914, but it was about three years later that they appeared on the river. Mr. Grigson (to Dr. G.M. Storr) states that the rabbit appeared at Cockleshell Gully, ca 230 km north of Perth, well before 1914.

The 1977/78 survey collected no specimens from the coastal plain, however they were common on the Spearwood and Quindalup Dune System and the Pinjarra Plain.

Tachyglossus aculeatus, Echidna

Not common on the Swan Coastal Plain; the W.A. Museum has only one specimen B1197 collected in 1929 from this area (Perth). An Echidna crossing Burns Beach Road with Jarrah (Eucalyptus marginata) woodland adjacent on 13 September 1977 was reported to the W.A. Museum by a member of the public. One was killed on Gnangara Road with Banksia woodland adjacent in 1975.

DISCUSSION

A search of the literature and Museum records indicates 33 species of native mammals are recorded with certainty from the North Swan Coastal Plain: these include Macropodidae (7 species), Phalangeridae (2), Burramyidae (1), Tarsipedidae (1), Peramelidae (2), Dasyuridae (7), Myrmecobiidae (1), Muridae (4), Vespertilionidae (5), Molossidae (1), Canidae (1), and Tachyglossidae (1). An additional 4 species are recorded from the region but these records are of doubtful provenance: Macropodidae (2), Megadermatidae (1), and Pteropodidae (1). In addition 6 introduced species are recorded: Muridae (2), Canidae (1), Felidae (1), Leporidae (1), and Mustelidae (1).

As a result of 24,443 trapnights and 315 man days we can confirm the persistence on the North Coastal Plain of only 12 native mammal species: Macropus fuliginosus, M. irma, Trichosurus vulpecula, Tarsipes spencerae, Isoodon obesulus,

Rattus fuscipes, Hydromys chrysogaster, Pseudomys albocinereus, Nyctophilus geoffroyi, Eptesicus regulus, Chalinolobus gouldii, and Tachyglossus aculeatus. A further 3 species, Dasyurus geoffroii, Cercartetus concinnus and Chalinolobus morio, may also still occur there - although the date of their last collection in the area is 1972, 1966 and 1951, respectively.

Extinction of mammal species from the Swan Coastal Plain is part of a Western Australian, and indeed Australian, phenomenon. Their disappearance was not noted by Austin who surveyed the country around Lake Cowcowing and northwards to Lake Austin and then to the mouth of the Gascoyne River in 1854, recording numbers of mammal species, including Petrogale lateralis, Onychogale lunata, Lagorchestes hirsutus, Bettongia lesueur, Macrotis lagotis and Chaeropus ecaudatus (Glauert 1948), nor by Masters who recorded an impressive list of mammals from the South West in 1866, 1868, and 1869 (see Glauert 1948). Shortridge (1909) writes that the disappearance of many species is "said to have been first noted about 1880, being most sudden and unaccountable... The entire disappearance of so many species, over such large tracts of country, is generally considered to be due to some epidemic or disease, which I have been told appeared to be a kind of marasmus, perhaps brought into the country by introduced animals. It may be noted, however, that they have died out chiefly in the drier parts of the country, where except for the introduction of sheep, there has been very little alteration in the conditions. Rabbits, although already very numerous in the Centre and South East, have not yet found their way to the North West.

The mammals of the South West, to about as far north as the Moore River, have not disappeared in the same extraordinary way, although they are rapidly retreating before civilisation, being already very rare to the north of the thickly populated districts around the Swan River, as well as around all the settled-in and agricultureal areas. The burning of forests and general clearing of the country, together with constant raids of dogs and domestic cats, are among the chief causes".

Some species had declined in the South West prior to Shortridge's collecting there in 1904-07. John Tunney writing to B. Woodward on 28 June 1907 asks "did Mr. Shortridge get Perameles bougainvillei. It was numerous in this district (Gracefield, Kojonup) 20 years ago?" and on 30 April 1900 from Baljarrup "I have not been able to find any mice or bougainvillei about here". (W.A. Museum archives). A few years after Shortridge's survey, species which he recorded as plentiful in the South West had become scarce. On 10 May 1903 J. Tunney writing to B. Woodward from Gracefield states "I feel that P. lagotis (=Macrotis lagotis) is getting scarce"; on 15 September 1911 "I have not been able to get any B. penicillata or lesueuri yet the natives say there are some left about 40 miles from here (Kojonup)"; on 12 December 1911 "I have returned from a trip in the South West. I am sorry to say I have not been successful. Everywhere I went the Rats and Boodies had all left or died out 12 months ago, there were some about Lake Muir but now there are no traces around the burrow so I am afraid they must be nearly extinct in the district (Kojonup)"; on 29 December 1911 "Mr. Muir of Deeside tells me all the smaller marsupials are getting very scarce in the South West, he says five years ago the rats and Boodies were a pest and during the last 2 years he has only seen 2 rats; on 7 May 1913, do you want any P. lagotis, there are still a few left about this locality"; and on 2 August 1914 "re M. fasciatus they are about extinct in this part (Kojonup). I have only seen one during the last couple of years around this locality. All the smaller marsupials seem to be getting very scarce even the phalangers are scarcer now than when they were being trapped several years ago" (W.A. Museum archives). Other South West mammal species declined in numbers much later. For example White (1952) documents the decline of the Quokka in the South West at between 1933-1939. White is inclined to believe the Quokkas declined as a result of disease.

The decline in the mammal fauna of the South West was also paralleled in South Australia. In that State, Aitken (1970) considered the most important agency to be wholesale destruction and alteration of natural habitat, with foxes (Vulpes vulpes) and Domestic Cats (Felis catus) being important contributors.

Although some species were undoubtedly greatly effected directly by man, for example fumigation of rabbit burrows exterminating Macrotis lagotis (Jenkins 1974) and commercial hunting of Trichosurus vulpecula (Serventy 1954). The evidence in Western Australia is that many mammal species had begun to disappear long before the landscape was substantially altered by Europeans, and also before the introduction of foxes and rabbits. We consider that while introduced diseases cannot be discounted as an important agency responsible for the disappearance of many mammal species it is likely that the Domestic Cat, widespread throughout Australia, almost certainly played a principle role. In this regard it is of note that in 1843 Gilbert received a Phascogale calura at Williams, Western Australia, killed by a cat (in Whittell 1954). Further, catalogues of the Western Australian Museum Mammal Department record 37 species of mammals "collected" by Domestic Cats.

There is some evidence from this survey that too frequent burning of vegetation is a factor which is currently threatening some extant mammal species on the coastal plain. For example Pseudomys albocinereus and Tarsipes spencerae were only collected between Mullaloo and Burns Beach in small isolated pockets of vegetation which had avoided fires in summer 1975/76. This entire area was burnt previously in the summer of 1971/72 suggesting that these species at least can withstand effect of fires if the interval between burning is not less than 6 years. While the reduction in the mammal fauna of the North Swan Coastal Plain may result to greater or lesser degree from all agencies discussed above, it is likely that the environs of Perth may have been the northern limit in the distribution of some species inhabiting moister situations - such that clearing and filling of the Perth "lakes" about 1860 may have destroyed their habitat and led to their decline; Antechinus flavipes and Pseudocheirus peregrinus may fall into this category.

ACKNOWLEDGEMENTS

The field work for this survey was completed supported from funds provided by the Western Australian Department of Conservation and Environment.

We are indebted to Greg Harold, Western Australian Museum, for his collecting efforts and to Barry Muir, Western Australian Museum, for assistance with plant identification and habitat selection.

REFERENCES

AITKEN, P.F. (1970). Mammals. In South Australian Yearbook. Government Printer. Adelaide.

ARCHER, M. (1974). Excavations in the Orchestra Shell Cave, Wanneroo, Western Australia. Arch. & Phys. Anthrop. in Oceania 9(2) 156-162.

CHAPMAN, A. & KITCHENER, D.J. (1977). Mammals of Cockleshell Gully Reserve, Western Australia. Rec. West. Aust. Mus. Suppl. No. 4, 15-25.

de BURGH, W.J. (1976). Neergabby a history of the Moore River and lower Gingin Brook. Shire of Gingin.

FRITH, H.J. (1973). Wildlife Conservation. Angus & Robertson. Sydney.

GLAUERT, L. (1933). The distribution of the marsupials of Western Australia. J. Proc. Roy. Soc. W.A. 19: 17-32.

GLAUERT, L. (1948). Development of our knowledge of the marsupials of Western Australia. J. Proc. Roy. Soc. W.A. 34: 115-134.

GREY, G. (1841). Journals of two expeditions of discovery in north-west and Western Australia, during the years 1837, 8, 9. T. and W. Boone, London.

JACKSON, M. & MORRIS, K. (1975). Mammals. In A Spring 1975 biological survey of the proposed Mussel Pool complex and recommendations for its future development. Western Australian Museum: unpublished report.

JENKINS, C.F.H. (1974). The decline of the Dalgite (Macrotis lagotis) and other wild life in the Avon Valley. W.A. Nat. 12(8): 169-172.

KITCHENER, D.J. & CHAPMAN, A. (1975). Mammals. In A biological survey of Cape Le Grand National Park. Rec. West. Aust. Mus. Suppl. No. 1 6-19.

KITCHENER, D.J. & CHAPMAN, A. (1977). Mammals of Bendering and West Bendering Nature Reserves. In Biological Survey of the Western Australian Wheatbelt. Pt. 3. Rec. West. Aust. Mus. Suppl. No. 5. pp.17-29.

LUNDELIUS, E. (1957). Additions to knowledge of the ranges of Western Australian mammals. W.A. Nat. 5: 173-182.

LUNDELIUS, E. (1960). Post Pleistocene faunal succession in Western Australia and its climatic interpretation. Proc. 21st. Int. geol. Congr. 4: 142-153.

MOORE, G.F. (1884). Diary of an early settler in Western Australia, 1830-1841. Privately published. Sydney.

MUIR, B.G. (1977). Biological Survey of the Western Australian Wheatbelt, Part 2: Vegetation and habitat of Bendering Reserve. Rec. West. Aust. Mus. Suppl. no. 3.

REID, J. (1836). Description of a new species of the genus Perameles (P. lagotis). Proc. Zool. Soc. (Lond.) 1836: 129-131.

SERVENTY, D.L. (1954). The recent increase of the rarer native mammals. W.A. Nat. 4(6): 128-129.

SHORTRIDGE, G.C. (1909). An account of the geographical distribution of the marsupials and monotremes of south-west Australia having special reference to the specimens collected during the Balston Expedition of 1904-1907. Proc. Zool. Soc. (Lond.) 1909: 803-848.

SHORTRIDGE, G.C. (1936). Field notes (hitherto unpublished) on Western Australian Mammals south of the Tropic of Capricorn (exclusive of Marsupialia and Monotremata), and records of specimens collected during the Balston Expeditions (November 1904 to June 1907). Proc. Zool. Soc. (Lond.) Part 3.

TAYLOR, M.J. & HORNER, B.E. (1973). Results of the Archbold Expeditions. No. 98 Systematics of Native Australian Rattus (Rodentia, Muridae). Bulletin of the American Museum of Natural History. Volume 150: article 1.

THOMAS, O. (1888). Catalogue of the Marsupialia and Monotremata in the collection of the British Museum (Natural History). London, British Museum (Natural History). xiii, 401 pp.

WAGSTAFFE, R. & RUTHERFORD, G. (1955). Letters from Knowsley Hall, Lancashire. The North Western Naturalist. March 1955.

WHITE, S.R. (1952). The occurrence of the Quokka in the South-West. W.A. Nat. 3: 101-103.

WHITTELL, H.M. (1954). John Gilbert's notebook on Marsupials. W.A. Nat. 4(5) 104-114.

MAMMALS OF THE NORTHERN SWAN COASTAL PLAIN

APPENDIX I

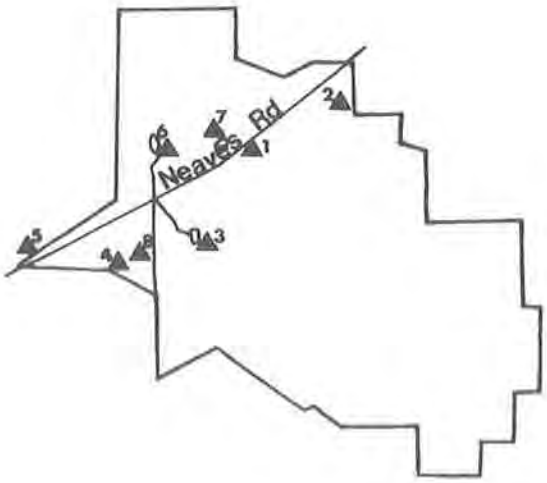
Vegetation Code & Trapping Effort

Trapline	Vegetation Code	Area Surveyed	Number of Trapnights			
			Elliots	B'backs	Cages	Pits
		Neerabup National Park/Burns Beach				
1	nSAi.SDd	n = Xanthorrhoea preissii	40	40	8	20
2	e_1Mi.n_1bLBiSCd	e = Eucalyptus gomphocephala n = Casuarina sp.	40	40	8	20
3	bLBc.SCc		40	40	8	20
4	e_1Mcbn_1LA i$n_2$$n_3$SDc	e_1 = Eucalyptus gomphocephala n_1 = Jacksonia sp. n_1 = Pelargonium capitatum n_2 = Lupinus sp.	40	40	8	20
5	mLAcVTd	m^3 = Melaleuca sp.	40	40	8	20
6	emLAcVTc	e = Eucalyptus rudis m = Melaleuca sp.	40	40	8	20
7	bLBc.n_1SAr.SDc and V Lc	n_1 = Xanthorrhoea preissii	40	40	8	20
8	n_1n_2SBc.SDc	n_1 = Dryandra sessilis n_2 = Xanthorrhoea preissii	40	40	8	20
9	e_1Mi.bn_1LAi.n_2bn_3SAcSDc	e_1 = E. gomphocephala n_1 = Casuarina sp. n_2 = Xanthorrhoea preissii n_3 = Casuarina	210	210	42	70
10	bLBicn$_1$n$_2$SAc.SDc	n_1 = Jacksonia sp. n_1 = Macrozamia riedlei	210	210	42	70
11	e.bn_1LAc.e.bn_1LBc.n_2SAr.SCd	e^2 = Eucalyptus marginata n_1 = Casuarina sp. n_2 = Xanthorrhoea preissii	210	210	34	50
12	n_1Si.n_1n_2SCi.SD and VLc	n_2 = Xanthorrhoea preissii n^2 = Dryandra sessilis	210	210	42	70
13	a.n.SBc.n.SDd and VLd	a = Acacia pulchella n = Dryandra sessilis	210	210	42	70
14	XSCd		210	210	34	50
15	XSCiXSDc		210	210	34	50
16	aSAd. XSDd and VLd		2000	2000	368	640
				TOTAL		5008

Trapline	Vegetation Code	Area Surveyed	Number of Trapnights			
			Elliots	B'backs	Cages	Pits
		Melaleuca Park				
1	bLAi.n.n_2SAi.xSCc and VTc	n = Adenanthos n_2= Xanthorrhoea	180	180	30	55
2	bLAi.n.SAr	n = Xanthorrhoea	180	180	28	50
3	mLAr.xSAd		180	180	30	55
4	mbLBi.n.SAr.xSCd	n = Xanthorrhoea	180	180	30	55
5	n.Sc.xSCc	n = Adenanthos	180	180	28	50
6	mLAr.xSd		180	180	30	55
7	e.LAi.mSd		180	180	28	55
8	mLBdSdSCd		108	108	-	-
				TOTAL		3315
Reserves		Martyn & Twin Swamps Reserves				
TL 1	aLBc.xGLd		160	160	32	40
2	xGLd		160	160	32	40
3	eLAc.mLAc		160	160	32	40
4	xLBi.bSAc.xSDc		160	160	32	40
5	xLAc.LSA.xVTd		160	160	32	40
6	mLAr.n.SAcVLi and GLi	n_1= Regelia sp.	160	160	32	40
7	nLAr.aLAr.xSAc		160	160	32	40
8	bLAc.xVLc		160	160	32	40
9	xLAc.xGLc		120	120	16	20
				TOTAL		3412
		Yanchep National Park				
TL 1	McLBi		190	190	30	50
2	SAd		190	190	30	55
3	LBcn.SAiSCc	n_1= Xanthorrhoea	190	190	30	55
4	SAd		190	190	28	70
5	VTd		190	190	30	50
6	e.LAc.baLBcSDd	e_1= E. marginata	190	190	28	50
7	emLAd.ema.LBcVLd		190	190	30	50
8	eLAc.baLBcSAc	e = E. marginata	190	190	30	50
9	n.Sr.n_2n_3SBd	n_2= Dryandra sessilis n_1= Xanthorrhoea sp. n_3= Acacia pulchella	150	150	30	50
				TOTAL		4086

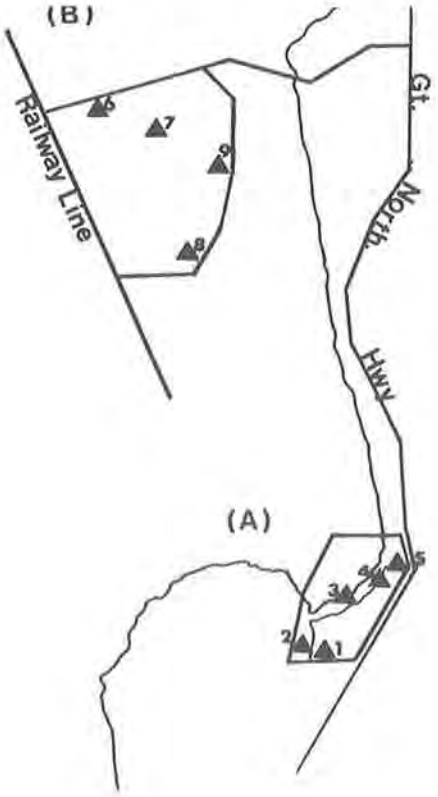
roposed eserve		Vegetation Code	Area Surveyed	Number of Trapnights			
				Elliots	B'backs	Cages	Pits
			South Gingin				
L	1	n_1bLAc.n.bSBi.XSDc	n_1= Xanthorrhoea	160	160	30	55
	2	bLAcbn$_1$SDcX.SDc	n = Xanthorrhoea	160	160	30	55
	3	bLAc.n$_1$SAiXSCc	n_1=Adananthos sp.	160	160	30	55
	4	e.mLAd.e mSAc	e = E. rudis	160	160	30	55
	5	bLBcn$_1$SCd.VLc	n_1= Xanthorrhoea sp.	160	160	30	55
	6	n_1mLAc.aScGLc	n_1= Xanthorrhoea sp.	120	120	22	35
	7	mbLAc.XSAd		160	160	30	55
	8	e_1Mce$_1$mbLBc.XSAc.XSDd & VLd	e_1= E. calophylla	160	160	30	55
					TOTAL		3132
			Moore River National Park				
L	1	bLBcSCc		130	130	26	55
	2	bLBrn$_1$n$_2$n$_3$ScSCc	n_1= Jacksonia sp. n_2= Adenanthos n_3= Xanthorrhoea sp.	130	130	26	55
	3	n_1LAiSBc	n_1= Nuytsia floribunda	140	140	28	50
	4	mSiSDc		140	140	28	50
	5	eLAcLBdn$_1$SAc	e = E. calophylla	110	110	22	35
	6	bLBcb$_2$SCc	b_2= Banksia laracina	120	120	24	40
	7	mLAcVTc		130	130	26	45
	8	mLAcSAdGLc		130	130	26	45
	9	bLBcSBc		50	50	10	25
					TOTAL		2776

Trapline	Vegetation Code	Area Surveyed	Number of Trapnights			
			Elliots	B'backs	Cages	Pits
		Mullaloo/Burns Beach				
2a	xSCc		250	250		
3a	xSBc		250	250		
4a	xSDr		250	250		
5a	xSDc		250	250		
6a	bLBi.xSCi		250	250		
7a	LBr.SAr.SBc.Ji		250	250		
8a	SiSAc		250	250		
1b	cLAiaSAr.xSCc		250	250		
2b	As trapline 1b Burnt		250	250		
3b	SAi.xSBc		250	250		
4b	As trapline 3b Burnt		250	250		
5b	LAr.LBr.SCi		250	250		
6b	LAi.LBiSCi Burnt		250	250		
7b	cMi.xLAi.LBi.xSAi.VLiJi		250	250		
				TOTAL		4000
				GRAND TOTAL	=	25,729.



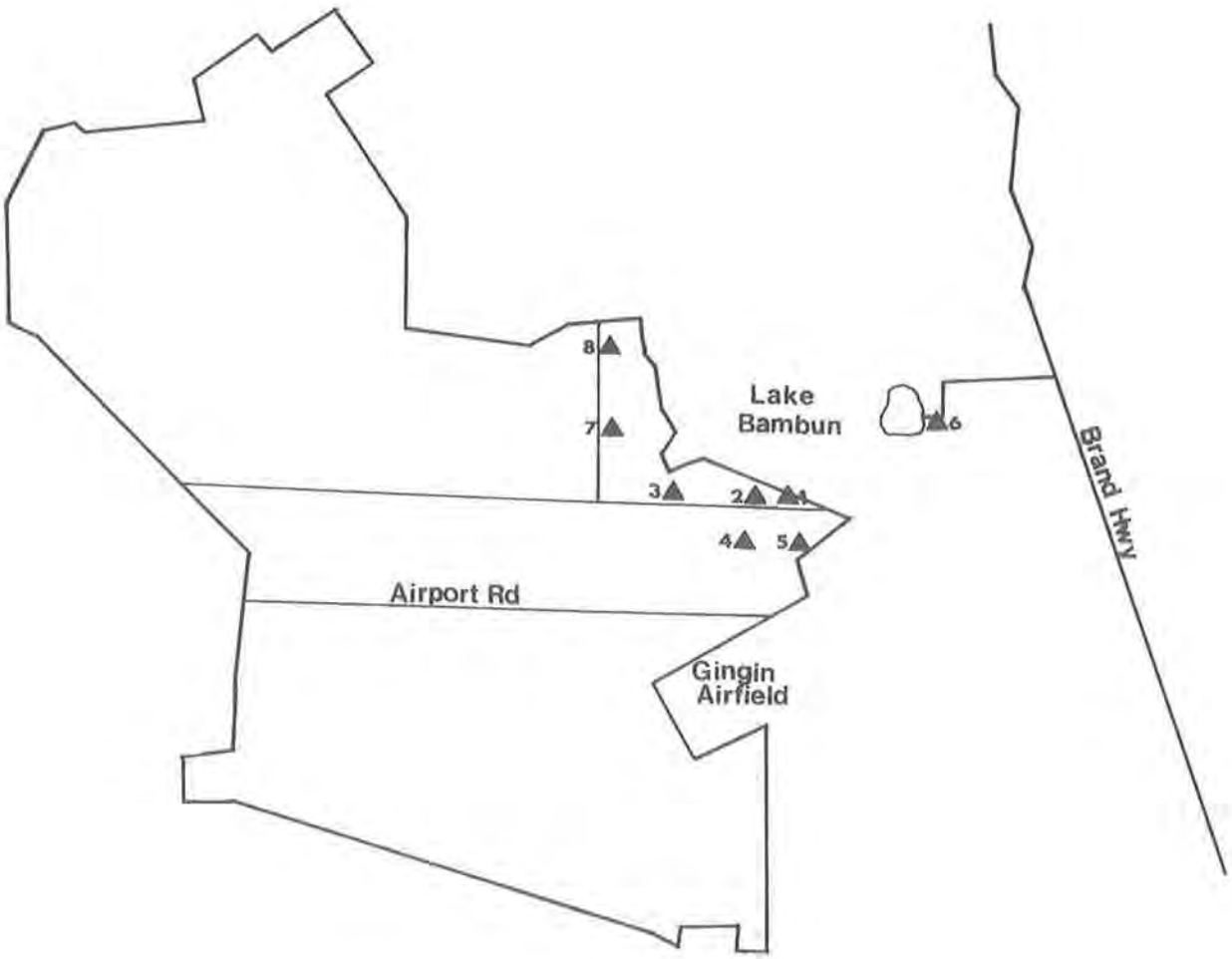
MELALEUCA PARK

Scale: 4 KILOMETRES



MARTYN RESERVE (A) TWIN SWAMPS RESERVE (B)

Scale: 2 KILOMETRES



PROPOSED WILDLIFE RESERVE – GINGIN

Scale 4 KILOMETRES

FIGURE 1 (cont.)

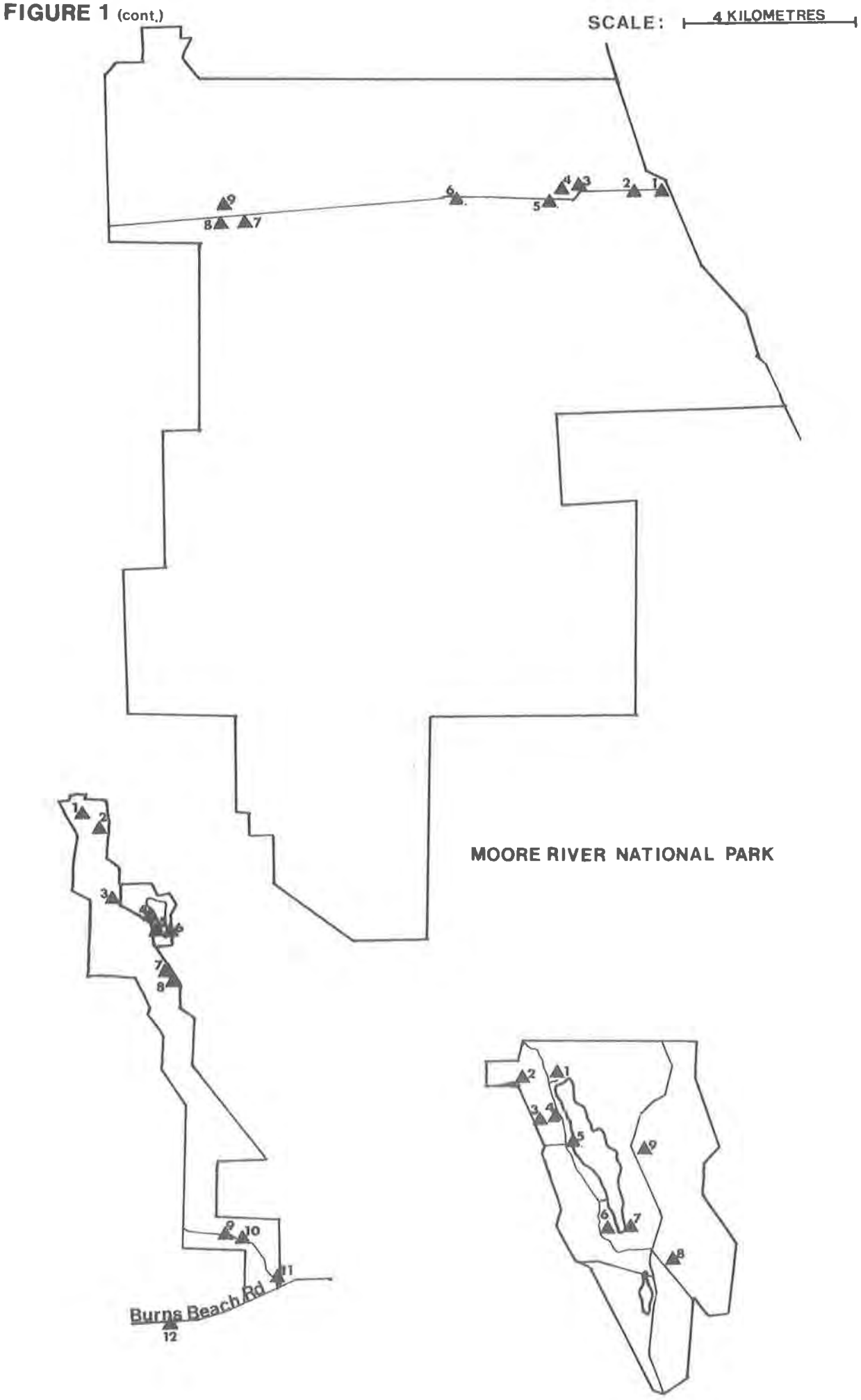
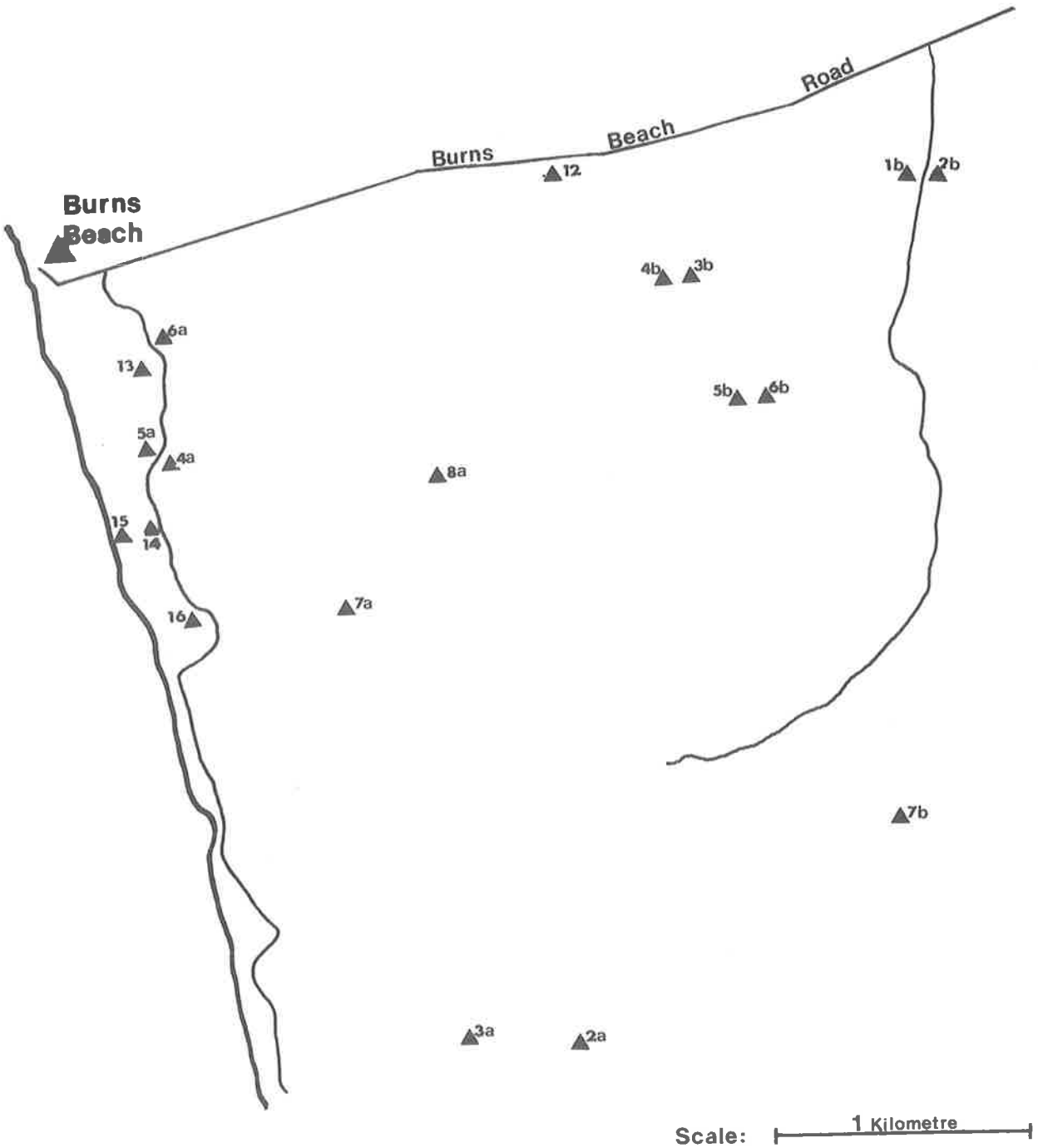


FIGURE 1 (cont)



BURNS BEACH AREA

BIRDS OF THE NORTHERN SWAN COASTAL PLAIN, WESTERN AUSTRALIA

By G.M. Storr*, R.E. Johnstone* and G. Harold*

INTRODUCTION

This paper deals with all the birds recorded from the coastal plain between the Moore River in the north and the Swan and Helena Rivers in the south; only the purely marine species are omitted. In the systematic list we summarise for each species our knowledge of its

1. Local distribution: given in zonal and geographic terms for those species not occurring throughout the area. The zones are the eastern, central and western, respectively the Clay, Sand and Coastal Limestone Zones of D.L. Serventy (1948, "Birds of the Swan River District", reprinted from Emu 47: 241-286).

2. Relative abundance: a subjective assessment of whether the bird is very common, common, moderately common, scarce or rare. An indication is also given of how it associates, e.g. singly, in pairs, family parties or flocks.

3. Faunal status: whether it is a resident (if so its status is unsaid whenever it is implicit in the species account), breeding visitor, non-breeding visitor, passage migrant, vagrant or an established exotic.

4. Habitat preferences.

5. Breeding season, defined by the months in which eggs are laid. Clutch-size is given thus: C/2(5), 3(7), where we have five records of two-egg clutches and seven records of three-egg clutches. Similarly brood data are given, for example, as B/4(2).

---

*Department of Ornithology and Herpetology, Western Australian Museum.

6. Movements, especially migrations.

This paper is based on data from three principal sources:

1. The literature, the catalogues of the Western Australian Museum, and the unpublished journals of G.M. Storr, R.P. McMillan and the late A.G. Kilpatrick. Additional information was kindly provided by N. Kolichis (many nest data), A. Chapman (observations in the Burns Beach and Mullaloo areas), O. Mueller (observations at Herdsman Lake and other wet lands), D.L. Serventy (extracts from his journals covering trips to Yanchep in the 1920s), P.J. Fuller (counts of aquatic birds at Lake Joondalup and some nest data), K.D. Morris and B. Knott (counts of aquatic birds at Lake Claremont), and other people cited in the text.

2. Surveys financed by the Environmental Protection Authority and carried out by R.E. Johnstone between March 1977 and April 1978 at the large saltlake 20 km NW of Regans Ford (for which the name Lake Guraga has been proposed), Lakes Beermullah, Bambun, Chandala, Yanchep (Loch McNess), Adams, Jandabup, and Joondalup.

3. Surveys financed by the E.P.A. and carried out by G. Harold and G. Barron between April 1977 and March 1978 in selected parts of the Moore River National Park, South Gingin Proposed Reserve, Yanchep and Neerabup National Parks, coastal heath near Burns Beach, Melaleuca Park, Twin Swamps Reserve and Martyn (Ellen Brook) Reserve.

In the discussion we comment, inter alia, on historic changes in distribution and abundance and on the vulnerability of the birds.

Appendix I deals with Lake Jandabup: the wetland birds observed on the 1977/78 surveys are listed with brief notes; the value of the lake is discussed, and recommendations are made for its improvement as a haven for waterfowl. Appendix II tabulates the maximum numbers of each species of waterfowl seen on Lakes Guraga, Beermullah, Bambun, Chandala, McNess, Joondalup, and Jandabup during the 1977/78 surveys; this gives some indication of the strengths and weaknesses of each of these wetlands. Appendix III makes use of 80 years of data from Herdsman Lake, Lake Monger and Lake Claremont to illustrate the diversity of waterfowl utilising regional wetlands over a long period.

The classification and nomenclature are those of G.M. Storr's Checklist of the birds of Western Australia (in prep.).

SYSTEMATIC LIST

CASUARIIDAE

Dromaius novaehollandiae (Latham)
Emu

Formerly occurring south to the Swan River (J.G. Hay, 1906, West. Aust. nat. Hist. Soc. No. 3: 31), and still breeding near the Perth-Guildford road in 1838 (Alexander, 1918, J. Proc. R. Soc. West. Aust. 3: 61). Now uncommon to moderately common in central and western zones south to Burns Beach (A. Chapman), 2 km NW of Bunorin Hill (A. Chapman), 3 km S of Gnangara Lake (Hutchinson, 1971, West. Aust. Nat. 12: 21) and Mussel Pool (G. Harold and J. Dell, 1975, cyclostyled report), mainly on sandplains and in consolidated dunes vegetated with banksia woodland and Xanthorrhoea heath; also jarrah woodland and tuart woodland. Occasionally wandering to eastern zone, e.g. R.P. McMillan observed two in wheat stubble 7 km S of Bullsbrook in December 1963 and two at 20 km NNW of Gingin in September 1969, and R.E. Johnstone saw a well-grown juvenile in a Melaleuca thicket at Lake Chandala in May 1977.

PODICIPEDIDAE

Podiceps novaehollandiae novaehollandiae Stephens
Black-throated Grebe

Common; in pairs or family parties. Open, still, fresh or brackish waters. Breeding on freshwater lakes, swamps and ornamental ponds, fringed with Typha, Juncus etc. (viz. Lake Chandala, seasonal swamp on Swan River flood-plain at Guildford, Hyde Park, Lake Monger, Herdsman Lake, Perry Lakes, lake at Shenton Park, Lake Claremont); July to March (mostly August -October).

Podiceps poliocephalus Jardine & Selby
Hoary-headed Grebe

Uncommon resident, in pairs or family parties, on open freshwaters fringed with Typha, Juncus etc. Irregular, but usually common, autumn-winter visitor, in flocks of up to 100, to large, open, fresh or brackish waters (e.g. Beermullah Lake, Lake Joondalup and the former Causeway marshes) and to the Swan River estuary. Breeding only reported on Lakes Chandala and Claremont; spring.

Podiceps cristatus australis Gould
Great Crested Grebe

Scarce visitor; in ones, twos, threes or fours. Large, open, fresh or brackish waters, including in winter the Swan River estuary (Serventy, 1957, West. Aust. Nat. 5: 231). Breeding reports from Lake Goollelal (N. Kolichis saw three young about two weeks old on 8 January 1975) and Lake Monger (O. Mueller saw a juvenile with two adults on 29 February 1976 and two birds in courtship display on 5 August 1976).

PELECANIDAE

Pelecanus conspicillatus Temminck
Australian Pelican

Common non-breeding visitor (all months); in ones, twos or flocks (up to 160). Swan River estuary and large open bodies of brackish or fresh water.

PHALACROCORACIDAE

Phalacrocorax sulcirostris (Brandt)
Little Black Cormorant

Very common, usually in small flocks, occasionally in large flocks (up to 1000) on the Swan River estuary, where, according to Serventy & Whittell (1976, Bds West. Aust. p.113), they feed largely on non-commercial fishes. Common on larger open bodies of fresh and brackish water, usually in small flocks, but in past (e.g. 1955-59) flocks of up to 300 used to rest in dead melaleucas in Lake Claremont. Breeding reported at Lake Chandala (Tingay & Tingay, 1976, Report on Lake Chandala with recommendations of its importance as a fauna reserve. Report No. 26, Dept. of Fisheries and Wildlife, West. Aust.); copulation observed at Lake Claremont in May.

Phalacrocorax carbo novaehollandiae Stephens
Great Cormorant

Scarce in some years (e.g. 1936-37), moderately common in others (e.g. 1943, fide Serventy, 1948, Emu 47: 261); usually in ones or twos. Open fresh or brackish waters, the Swan River (including the estuary), and sheltered seas (e.g. the sewer outfall between City Beach and Scarborough). Breeding reported at Lake Goollelal (Serventy, 1955, West. Aust. Nat. 5: 18); April, May and ?June; B/2(10), 3(6).

Phalacrocorax varius (Gmelin)
Pied Cormorant

Ordinarily a marine species, but present thoughout year on broadwaters of Swan River estuary; usually in ones or twos. Visiting upper reaches of Swan River (Causeway to Guildford) only in summer and autumn. Also visiting the Moore River estuary at Guilderton.

Phalacrocorax melanoleucos (Vieillot)
Little Pied Cormorant

Very common (the most abundant of the local cormorants); usually in ones, twos or small flocks, but sometimes roosting in flocks of thousands (e.g. in dead melaleucas in Lake Claremont, May 1955). Estuaries and open freshwaters (including small pools); rarely visiting open seas. Undated breeding reports from Gingin and Lake Chandala; C/3(3), 4(1).

Anhinga melanogaster novaehollandiae (Gould)
Darter

Scarce; usually single. Major watercourses (the Moore downstream to Cowalla; the Swan downstream ordinarily to the Causeway, occasionally to Perth Water and Matilda Bay) and larger bodies of fresh or brackish water (Lake Chandala, Herdsman Lake, Lake Monger). Breeding reported at Lake Goollelal.

ARDEIDAE

Ardea pacifica Latham
Pacific Heron

Non-breeding visitor, mainly in winter and spring (July-December). Ordinarily scarce or uncommon and single; common and occurring in small flocks in some years, e.g. 1923 and 1926 (Serventy, 1938, Emu 38: 28), 1941 (Serventy, 1948, Emu 47: 268), 1957 (Ford & Teague, 1959, Emu 59: 89) and 1975. Freshwater swamps, inundated pastures and crops, dams and roadside ditches.

Ardea novaehollandiae Latham
White-faced Heron

Very common (much the most abundant ardeid in region); in ones, twos or flocks (up to 100). Shallow fresh or brackish waters and grasshopper-infested pastures and playing fields; occasionally sheltered coasts. Breeding from July to September; C/4(1), B/4(1).

Egretta alba modesta (Gray)
Great Egret

Rare or absent in area before 1919 (Alexander, 1919, Emu 19: 59), but since then (Alexander, 1921, Emu 20: 160; Serventy, 1938, Emu 38: 28) it has become an uncommon to moderately common visitor (mainly winter and spring); usually single, occasionally in small flocks (up to 20). Shallow fresh and brackish waters and samphire swamps. No reports of nests, but R.P. McMillan observed courting displays at Guildford in July 1965 and August 1970.

Egretta sacra (Gmelin)
Eastern Reef Heron

Scarce; usually single. Rocky coasts (Burns Beach, Beenyup Mole and Mullaloo). Two reports from Swan River estuary: Cattermole (1954, West. Aust. Nat. 4: 171) and Stranger (1965, West. Aust. Nat. 10: 18). Only the grey phase occurs in region.

Egretta ibis coromanda (Boddaert)
Cattle Egret

Visiting the area in 1958-60 and possible in 1954 (Jenkins & Ford, 1960, Emu 60: 245). Parties of up to 14 were observed with cattle and horses in dry swamps and pastures at Wanneroo, Balcatta, Doubleview, Middle Swan, Midland and Bassendean.

Nycticorax caledonicus hilli Mathews
Rufous Night Heron

Moderately common; usually single, but aggregating in large numbers at abnormal concentrations of food (Alexander, 1916, Emu 16: 43). Normally roosting by day in small groups in waterside trees, e.g. Eucalyptus rudis and Melaleuca rhaphiophylla, and dispersing in late afternoon or evening to shallow freshwaters. Breeding in September; C/4 (1).

Ixobrychus minutus novaezelandiae (Potts)
Little Bittern

Moderately common, judging from the number of local specimens (14) received at the Western Australian Museum since 1900. Swamps and lake and river margins heavily vegetated with Juncus, Typha, Cladium etc. Breeding in October and November; C/3 (2), 4(1); reports from Herdsman Lake and Lake Claremont.

Ixobrychus flavicollis (Latham)
Black Bittern

Formerly moderately common in flooded gums (Eucalyptus rudis) along the Swan and Helena Rivers at Guildford and around Herdsman Lake and Lake Monger. Last recorded in March 1934, when A.M. Douglas collected a specimen (WAM A4432) at West Midland. A nest was collected at Herdsman Lake in 1901.

Botaurus stellaris poiciloptilus (Wagler)
Brown Bittern

Uncommon. Swamps and lake margins heavily vegetated with Typha, Juncus etc. Formerly breeding at Herdsman Lake (1901), and occurring at Perry Lakes (till at least 1931) and the lake at Shenton Park (till at least 1953).

THRESKIORNITHIDAE

Threskiornis aethiopicus moluccus (Cuvier)
Sacred Ibis

Moderately common; in ones, twos or small flocks (up to 55) or attached to flocks of Theskiornis spinicollis. Shallow fresh or brackish waters.

Not recorded in area till 1952, when it was noted at Gingin (Serventy & Whittell, 1976, Bds West. Aust., pp. 133-4). Two were seen near Gingin in September 1956 (Serventy & Whittell, ibid.). In autumn 1968, there was a small eruption of these birds into the area, and they have been seen here ever since.

Threskiornis spinicollis (Jameson)
Straw-necked Ibis

Now common; usually in flocks (up to 200). Swamps, damp or inundated grasslands, and grasshopper-infested pastures. Breeding at Wellering Swamp (5 km S of Gingin) until 1956 (it is unknown when this colony began, but C.L. Orton found ca 1000 birds nesting there on 1 November 1950) and at Lake Chandala (colony first observed in 1960 by I. Edgar; on 29 October 1962 C.J. Powell estimated that it contained ca 200 nests; on 1 October 1972 N. Kolichis estimated that there were ca 2000 nests); August to October; C/1(1), 2(3), 3(7). No breeding at Lake Chandala in 1977, when inlet drain was diverted and area of water in lake was greatly reduced.

First recorded for area in the drought year 1892, when large numbers were observed at Yanchep (D.L. Serventy, MS) and Perth (Serventy & Whittell, 1976, Bds. West. Aust., p. 132). Within 30 years it was established in the region (Alexander, 1919, Emu 19: 60, and 1921, Emu 20: 159).

Plegadis falcinellus (Linnaeus)
Glossy Ibis

Rare visitor. Four records: T. Ostle collected a specimen (WAM A1366) at Herdsman Lake in April 1918; R.H. Stranger and B. Leaky saw two over Lake Joondalup in March 1959 (Burbidge, 1962, West. Aust. Nat. 8: 101); M. Thompson (pers. comm.) saw three at Lake Joondalup on 15 January 1977; and O. Mueller saw one at Herdsman Lake on 22 January 1977.

Platalea regia Gould
Royal Spoonbill

Rare visitor. Five records: a specimen (WAM A2627) was collected at Herdsman Lake in January 1924; P.E. Serventy saw one at Pelican Point in August 1952 (Serventy, 1953, West. Aust. Nat. 3: 185); Lindgren (1956, West. Aust. Nat. 5:142) saw two on samphire flats east of the Causeway, Swan River, in March 1955; Moss (1968, Fauna Bull. 2(3): 5, Dept of Fisheries and Fauna, West. Aust.) reported one at Lake Joondalup in winter 1968; and R.E. Johnstone saw four at Lake Bambun on 24 May 1977.

Platalea flavipes Gould
Yellow-billed Spoonbill

Visitor to shallow fresh, brackish or saline waters; in ones, twos or small flocks (up to 20). Before 1975 there was only one record: Heron (1970, Emu 70: 156) saw up to 5 birds on inundated grasslands at Middle Swan in July 1965. Recently it has been recorded by Tingay & Tingay (1976, Report No. 26, Dept of Fisheries and Wildlife, West. Aust.) at Lake Chandala; by P.J. Fuller at Lake Joondalup (2 on 21 January and one on 6 July and 11 November 1977); by G. Harold at Lake Chandala (one on 4 November 1977), Lake Joondalup (one on 9 November 1977) and Lake Guraga (2 on 14 November 1977); and by R.E. Johnstone at Lake Beermullah (8 on 5 April 1977, 4 on 27 May 1977 and 20 on 16 February 1978), Lake Chandala (6 on 12 August 1977, 10 on 23 January 1978 and one on 3 April 1978) and Lake Joondalup (4 on 20 May 1977 and one on 7 December 1977).

ANATIDAE

Anseranas semipalmata (Latham)
Pied Goose

Vagrant. Two records: J.W. Baggs saw three at Alfred Cove in February 1953 (Serventy, 1953, West. Aust. Nat. 3: 188), and R.D. McC. Drew (pers. comm.) saw seven at Bushmead in July and August 1977.

Dendrocygna arcuata Horsfield
Chestnut Whistling Duck

Vagrant. One record: a specimen (WAM 742) collected at Wanneroo in December 1899.

Cygnus atratus (Latham)
Black Swan

Common; in pairs, family parties or flocks. Lakes (fresh, brackish or salt), ornamental ponds and lawns, winter swamps, inundated crops and pastures, and saltmarshes and reaches of the Swan River above the Causeway; also occasionally broadwaters of Swan River and along coast. Breeding from June to September; C/3(1), 4(2), 6(1), 7(1); B/2(2), 3(1), 4 (3), 5(5), 6(3), 7(1), 8(3); reports from Wanerie, Lake Chandala, Loch McNess, Wanneroo, Guildford, Herdsman Lake, Lake Monger, Hyde Park, Perry Lakes, Shenton Park and Lake Claremont.

Just to the north of our area, G. Harold observed ca 5000 on Lake Guraga, a large saltlake 20 km NW of Regans Ford, on 14 November 1977; here R.E. Johnstone saw ca 600 in groups of 10-100 on 24 January 1978.

Stictonetta naevosa (Gould)
Freckled Duck

Rare visitor. Three records: three specimens (WAM 417-9) collected at Lake Monger in 1897; one specimen (WAM A1595) collected at Herdsman Lake in 1919; and observation by R.E. Johnstone at Lake Bambun on 24 May 1977 of three single

birds among open beds of Cladium in 70-100 cm of water on west side of lake, and of three birds among dense Melaleuca teretifolia in 70 cm of water at north end of lake. Just to the north of our area, S. Barker (pers. comm.) reported Freckled Ducks at Lake Namming in January 1959 .

Tadorna tadornoides (Jardine & Selby)
Mountain Duck

Common visitor (all months, but mainly November-May), in pairs or flocks (up to 3000); rarely breeding (June-July). Lakes (mainly salt or brackish), saltmarshes and foreshores of the Swan River, and inundated grasslands; also occasionally along the coast and in green but dry pastures. Three breeding records: G.M. Storr saw a pair with four downy young at Perry Lakes on 11 August 1974 (they were almost full-grown on 22 September); R.E. Johnstone observed a pair displaying and copulating at Lake Beermullah on 27 May 1977, and a pair with four young on Loch McNess on 8 August 1977.

Anas superciliosa Gmelin
Black Duck

Very common (the most abundant anatid in the region); usually in flocks (up to 200). Freshwater lakes, pools, swamps, ditches and streams, inundated grasslands, ornamental ponds and brackish lakes; also saltmarshes and shallows of the Swan River above the Causeway. This resourceful duck can be seen in summer on the lawns at Lake Monger feeding on the fallen fruits of Moreton Bay figs (Ficus macrophylla). Breeding in large numbers from June to October (reports from Lake Chandala, Loch McNess, Lake Jandabup, swamp near Mussel Pool, Middle Swan, Guildford, Herdsman Lake, Perry Lakes, Lake Monger, Hyde Park, Queens Gardens, lake at Shenton Park, and Lake Claremont); C/7(1), 8(1), 9(1), 11(1); B/1(1), 2(9), 3(5), 4(1), 5(1), 6(1), 7(4), 8(2), 9(4), 10(5).

Anas gibberifrons gracilis Buller
Grey Teal

Very common (the most plentiful duck on salt and brackish waters, but outnumbered by Black Duck on fresh waters, especially in Perth and suburbs); in pairs or small flocks in winter and spring; often in large flocks (up to 600) in summer and autumn. Most fresh and brackish waters, but rarely the degraded suburban lakes (e.g. Lake Monger and Perry Lakes); also the Moore and Swan River estuaries, especially in autumn. Breeding in relatively small numbers on freshwater lakes and seasonal swamps (reports from Lake Chandala, Middle Swan, Guildford and Lake Claremont); July to September; C/7(1); B/6(6), 7(2), 8(2).

Anas castanea (Eyton)
Chestnut Teal

Scarce visitor. Since Alexander (1921, Emu 20: 160) summarised it as "occasionally met with on the swamps" [of the Swan River District] there have only been five more records: Serventy (1938, Emu 38: 29) saw a male at Pelican Point from 16 June to 2 July 1939; R.P. McMillan saw a pair on a seasonal swamp beside the Swan River at Guildford on 31 August 1969; K.D. Morris and B. Knott saw one at Lake Claremont on 14 September 1977; P.J. Fuller saw 12 at Lake Joondalup on 12 December 1977; P. Griffin (pers. comm.) saw two males and three females at Lake Bambun on 23 January 1978.

Anas rhynchotis rhynchotis Latham
Blue-winged Shoveler

Locally common (e.g. Lake Joondalup, at least in 1977/78), but generally uncommon; in ones, twos or small flocks, rarely in large flocks (up to 200). Fresh or brackish lakes and swamps (especially those wooded with M. teretifolia and other melaleucas) and pastures inundated in winter; rarely estuarine waters. One breeding report (Herdsman Lake, 1971, fide M. Thompson); October; C/9.

Anas querquedula Linnaeus
Garganey

Vagrant. One record: Congreve (1971, West. Aust. Nat. 17: 48) saw two at Loch McNess in March 1971.

Malacorhynchus membranaceus (Latham)
Pink-eared Duck

Visitor (all months, but mainly October-May), occasionally breeding. Formerly rare in region, but increasing since World War II (Serventy, 1948, Emu 47: 268; Ford, 1962, West. Aust. Nat. 8: 103). Now moderately common, in pairs or flocks (up to 200) [just to the north of our area, G. Harold observed ca 5000 on Lake Guraga, a large saltlake 20 km NW of Regans Ford, on 14 November 1977]. Breeding in small numbers at Lake Claremont (Rook and Serventy, 1963, West. Aust. Nat. 8: 187-8), 1965 (G.M. Storr) and 1969 (G.M. Storr); September to February; B/4 (1), 5(1), 6(1).

Aythya australis (Eyton)
Hardhead

Moderately common; in pairs or small flocks. Fresh and brackish lakes, winter swamps, and ornamental ponds; also upper reaches of the Swan River (Guildford, Middle Swan). Breeding in July and August (reports from Herdsman Lake, Lake Monger, Hyde Park and Lake Claremont); C/10(2); B/7(1), 10(1).

Chenonetta jubata (Latham)
Wood Duck

In most parts of region only a scarce visitor, in pairs or small flocks; but in northern agricultural areas (Gingin, Cowalla etc.) now a common resident, often in large flocks. Mainly short grass in vicinity of water (especially farm dams); also visiting fresh and brackish lakes, ornamental ponds and lawns, and the upper reaches of the Swan River (Middle Swan). Breeding at Lake Chandala (Tingay & Tingay, 1976).

Nettapus pulchellus Gould
Green Pygmy Goose

Vagrant. One record: Bond (1967, West. Aust. Nat. 10: 138) saw two at Lake Jandabup on 4 March 1967. [In the previous summer T.L. Riggert collected one at Moora, 50 km NE of our area].

Oxyura australis Gould
Blue-billed Duck

Moderately common. Fresh and brackish lakes. Breeding from October to December; also in autumn, following unusually heavy rains in February 1955 (Serventy & Marshall, 1957, Emu 57: 110); C/10(2) at Lake Claremont, reported by Seyfort (1949, West. Aust. Nat. 1: 173). [Serventy & Whittell (1976, Bds West. Aust., p.154) believe these were combination clutches]; J. Gilbert (in Gould, 1865, Bds Aust. 2: 379) gives the clutch size as 2 to 9 or 10; the only other data we have are B/1(1), 2(1); also breeding at Herdsman Lake and Shenton Park Lake.

Biziura lobata (Shaw)
Musk Duck

Formerly common, now moderately common. Fresh and brackish lakes, occasionally winter swamps, and formerly the Swan River above the Causeway (Hill, 1904, Emu 3: 229; Serventy, 1938, Emu 38:29). Breeding from July to October (reports from Herdsman Lake and Lake Claremont); C/3(3); B/2(1); for description of male display see Stranger (1961, West. Aust. Nat. 7: 210).

ACCIPITRIDAE

Elanus caeruleus notatus Gould
Black-shouldered Kite

Formerly a rare visitor, but since ca 1935 (Serventy, 1948, Emu 47: 271) it has become moderately common in ones or twos. Probably resident in agricultural and horticultural parts of eastern zone (see Heron, 1970, Emu 70: 156), but

only an autumn-winter visitor to coastal heaths south to Mullaloo (judging from A. Chapman's observations). Breeding in July; C/3(1) [Heron's data suggest that it breeds in winter and spring and again in autumn].

Lophoictinia isura (Gould)
Square-tailed Kite

Rare visitor. Two records: specimens (WAM 1902, 5283) collected at Jackadder Lake in January 1900 and Loch McNess in December 1902.

Haliastur sphenurus (Vieillot)
Whistling Kite

Uncommon to moderately common, usually in ones and twos. Mainly in the vicinity of lakes, swamps and watercourses (including the Swan River). Breeding from August to October; C/2(1); nesting in Kings Park till at least 1938.

Milvus migrans affinis Gould
Black Kite

During the "southern invasion of northern birds" (Serventy, 1953, West. Aust. Nat. 3: 195), single birds and small flocks (up to 30) were observed at Gingin, Yanchep, Lake Monger, Dalkeith and Mosman Park in autumn 1952. On 18 May 1973 G.M. Storr had a brief but good view of one flying low over a house in North Perth. On 11 May 1978 N. Kolichis and P.S. Stone (pers. comm.) saw one flying low over a market garden at Osborne Park.

Accipiter fasciatus fasciatus (Vigors & Horsfield)
Brown Goshawk

Common visitor (mainly January-March, least August-November); usually single. Formerly breeding: C/4 (WAM 720) labelled "Swan River 1897".

Accipiter cirrocephalus cirrocephalus (Vieillot)
Collared Sparrowhawk

Uncommon winter visitor (April-September); single. Formerly breeding: C/3 (WAM 1611-3) collected by T. Ostle at Herdsman Lake on 20 November 1899.

Aquila morphnoides morphnoides Gould
Little Eagle

Rare resident in rabbit-infested localities in north of area (e.g. Yanchep National Park, where it breeds in winter, and Melaleuca Park). Scarce winter visitor (April-October) to south of area; single.

Aquila audax (Latham)
Wedge-tailed Eagle

Visitor (mainly April-September). Scarce in south, uncommon in north; in ones or twos.

Haliaeetus leucogaster (Gmelin)
White-breasted Sea Eagle

Rare autumn visitor, mainly to Swan River estuary. Four records: specimen (WAM 153) labelled "Swan River 1895"; specimen (WAM A4970) collected at Mosman Park in March 1839; subadult observed by G.M. Storr at Rivervale on 25 April 1955; and an adult observed by R.E. Johnstone at Lake Bambun on 3 April 1978.

Circus assimilis Jardine & Selby
Spotted Harrier

Only occurring in extreme north of area. One record: an adult observed by G. Harold flying over a paddock 7 km SW of Regans Ford on 22 March 1978.

Circus aeruginosus approximans Peale
Marsh Harrier

Formerly common, now moderately common visitor (mainly March-September). About swamps, lakes and watercourses, especially where ducks are breeding. One breeding record: nest and 3 hatchlings (WAM 1268) collected by T. Ostle in Typha at Herdsman Lake on 9 October 1899.

Pandion haliaetus cristatus (Vieillot)
Osprey

Uncommon visitor (mainly May-September) to coast, from Guilderton south to Waterman; scarce visitor (October-May) to Swan River estuary, upstream to Maylands; single.

FALCONIDAE

Falco subniger Gray
Black Falcon

Vagrant. One record: Storr (1967, West. Aust. Nat. 10: 138) saw one over Wembley on 3 January 1967.

Falco peregrinus macropus Swainson
Peregrine Falcon

Scarce visitor (January-May); usually single.

Falco longipennis longipennis Swainson
Australian Hobby

Uncommon visitor (all months, but mostly March-May); usually single.

Falco berigora berigora Vigors & Horsfield
Brown Falcon

Alexander (1921, Emu 20: 162) classified it as resident and plentiful, which is supported by the Western Australian Museum's receiving 15 specimens from suburban areas between

1895 and 1929 but none subsequently. It apparently began to decline soon after Alexander's time (Serventy, 1948, Emu 47: 271), though it was still nesting at Swanbourne in 1938 (A.G. Kilpatrick). Now apparently only a visitor to the region (mainly March-April and August-September); uncommon in far north of area (where possibly resident), scarce in south; usually single, but up to 4 birds appearing at bush fires. One breeding record: August; C/3.

Falco cenchroides cenchroides Vigors & Horsfield
Australian Kestrel

As a resident formerly common, now moderately common; also a moderately common passage migrant (mainly April and October); usually single, occasionally in small flocks (e.g. 8 attracted to a grass fire at Middle Swan). Mainly clearings or naturally open country, especially in eastern zone; also grassy and heathy coastal hills, and wastelands in city and suburbs. No precise breeding data, but known to nest in city and suburban buildings.

PHASIANIDAE

Coturnix novaezelandiae pectoralis Gould
Stubble Quail

Irregular visitor, occasionally breeding. At times common, e.g. November 1965 at Middle Swan (Heron, 1970, Emu 70: 156), but generally uncommon. Mainly grassy country in eastern zone. One breeding record: C/6 from Osborne Park (WAM A964) received at Museum in February 1916.

TURNICIDAE

Turnix varia varia (Latham)
Painted Button-quail

Status uncertain; apparently a rare visitor. Three records: Milligan (1903, Emu 3: 22) recorded it at Yanchep in late December 1902; Heron (1970, Emu 70: 156) found a dead

female at Middle Swan in July 1965; and G. Harold & J. Dell (cyclostyled report) heard one calling and saw a party of three in jarrah-marri woodland at Mussel Pool in spring 1975.

RALLIDAE

Gallirallus philippensis mellori (Mathews)
Banded Land-rail

Status uncertain; apparently a rare visitor. Five records: 4 specimens in Western Australian Museum (A6854, collected at Osborne Park in June 1951; A6867, collected at Lake Monger in October 1951; A7259, collected at Maylands in June 1953; and A15392, collected near Jackadder Lake in March 1978) and dead bird found by G.M. Storr at Lake Claremont on 21 March 1964.

Porzana pusilla palustris Gould
Baillon's Crake

Status uncertain; apparently common in past at Herdsman Lake. Five records: 6 specimens in Western Australian Museum (3215-6 and 4605-7, collected at Herdsman Lake respectively in January 1901 and January 1902; and A6225 collected at Mt Lawley in November 1945); observations by Milligan (1903, Emu 3: 21) at Yanchep in December 1902; and C/3 in P.A. Sandland Collection, collected by E.W. Bardwell at Claremont.

Porzana fluminea Gould
Australian Spotted Crake

Status uncertain, but clearly rare. Four records: G.F. Moore (diary cited by Alexander, 1918, J. Proc. R. Soc. West. Aust. 3: 44) found "a pretty rail, shaped like ours, but handsomely freckled" near Guildford on 4 November 1831; T. Ostle collected an adult male and a partly fledged juvenile (WAM 3443-4) at Herdsman Lake in January 1901; O. Mueller saw one at Lake Monger on 29 February 1976; and Corfe (1978, West. Aust. Nat. 14: 53) reported one at edge of sedges around lagoon at Pelican Point on 25 November 1975.

Porzana tabuensis (Gmelin)
Spotless Crake

Moderately common. Beds of sedges (especially Cladium articulatum) around lakes and in swamps (recorded from Loch McNess, Lake Jandabup, Herdsman Lake and Lake Claremont). No precise breeding data, but 2 chicks (WAM 67-8) from Herdsman Lake were accessed in January 1913.

Porphyrio porphyrio bellus Gould
Swamphen

Common. Dense vegetation (Typha, Cladium, Juncus etc.) in and around freshwater swamps and lakes and short grass (including ornamental lawns) in the vicinity. Breeding in September and October; C/4(5).

Gallinula ventralis Gould
Black-tailed Native Hen

Irregular visitor, formerly in large numbers, now in much smaller numbers. Recorded in May 1833 (Gould, 1865, Bds Aust. 2: 326; Alexander, 1918, J. Proc. R. Soc. West. Aust. 3: 47), May 1835 (Serventy & Whittell, 1976, Bds West. Aust., winter 1853 and in 1886 (Serventy, 1943, Emu 47: 20), 1902 (Hill, 1904, Emu 3: 299), April and May 1919 (Alexander, 1919 Emu 19: 60), 1952 and 1964 (Serventy & Whittell, ibid.) and 1977/78 (R.E. Johnstone).

Gallinula tenebrosa Gould
Dusky Moorhen

Moderately common. Freshwater lakes, swamps, ornamental ponds, and streams, north to Loch McNess and Gingin Brook; also sedge margins (Scirpus lacustris) of upper reaches of Swan River. Breeding from August to December; C/4(1), 6(1), 8(1), 9(1), 11(1).

Fulica atra australis Gould
Coot

Very common. Fresh and brackish lakes, swamps, and ornamental ponds, and adjacent short grass (including ornamental lawns); visiting Swan River (downstream to Nedlands) in autumn and winter. [Just outside our area, G. Harold saw ca 1000 on Lake Guraga, a large saltlake 20 km NW of Regans Ford on 14 November 1977]. Breeding from July to October; C/4(1), 5(1), 6(2), 7(2), 9(1).

OTIDAE

Otis australis Gray
Australian Bustard

Uncommon; usually single. Mainly coastal heaths, south to Sorrento; also reports from Gingin and Gnangara.

ROSTRATULIDAE

Rostratula benghalensis australis (Gould)
Painted Snipe

Rare visitor. Two records: a pair collected, presumably near Perth in 1841 (Serventy & Whittell, 1976, Bds West. Aust., p. 197), and pair (WAM A14716-7) collected by O. Lipfert at Lake Monger in 1897.

HAEMATOPODIDAE

Haematopus ostralegus longirostris Vieillot
Pied Oystercatcher

Rare visitor. Three records: observations by A.W. Milligan at Lake Yanchep (Alexander, 1921, Emu 20: 158); observation of a pair at Pelican Point in summer 1948-49 (Serventy & Whittell, 1976, Bds West. Aust., p. 198); and observation by A. Chapman of two flying south along limestone cliffs at Mullaloo on 24 December 1976.

CHARADRIIDAE

Vanellus miles miles (Boddaert)
Masked Plover

Rare visitor. One record: specimen (WAM A8355) collected by G.F. Mees and J.R. Ford at Jackadder Lake on 14 March 1959.

Vanellus miles novaehollandiae Stephens
Spur-winged Plover

Rare visitor. One record: observation at Floreat Park (Serventy & Whittell, 1976, Bds West. Aust., p.200).

Vanellus tricolor (Vieillot)
Banded Plover

Recent immigrant; by 1921 only occurring at Gingin (Alexander, 1921, Emu 20: 158), but by 1948 (Serventy, 1948, Emu 47: 265) established throughout "Swan River District". Moderately common; usually in pairs or small flocks (up to 50). Mainly short grass (pastures, airfields, sports grounds etc.); also ploughed land and drying swamps. Breeding from June to August; C/4 (1).

Pluvialis squatarola (Linnaeus)
Grey Plover

Moderately common visitor (September-April) to Swan River estuary, upstream to Rivervale; in ones, twos or small flocks (up to 10).

Pluvialis dominica fulva (Gmelin)
Eastern Golden Plover

Visitor (September-April) to Swan River estuary. Common on marshes above the Causeway, in small flocks (up to 60); uncommon on broadwaters below the Narrows, in ones, twos or small flocks (up to 20).

Charadrius cucullatus Vieillot
Hooded Plover

Rare visitor. W.B. Alexander occasionally noted a few on the beaches at Cottesloe in 1912-20 (Serventy, 1948 Emu 47: 265); also two records from Pelican Point — one observed by Serventy (ibid.) on 31 October 1936, and one by Lindgren (1956, West. Aust. Nat. 5: 143) on 11 October 1955.

Charadrius ruficapillus Temminck
Red-capped Plover

Common; usually in pairs or small flocks. Coastal beaches and dunes, sandy shores of Swan River estuary (but seldom in winter), edge of saltlakes, and sandy or muddy margins of drying freshwater or brackish lakes and swamps. Breeding from August to October; mainly in coastal dunes, but also on Swan River estuary (Pelican Point).

Charadrius bicinctus Jardine & Selby
Double-banded Plover

Rare visitor (April-November) to Swan River estuary; usually single. [See Ford (1967, West. Aust. Nat. 10: 84) for occurrences of this New Zealand species in Western Australia.]

[Charadrius mongolus mongolus Pallas
Mongolian Sand Plover

A single, short-billed sand plover in eclipse plumage at Lake Beermullah on 16 February 1978 was believed by R.E. Johnstone to belong to this species.]

Charadrius leschenaultii Lesson
Large Sand Plover

Scarce visitor (October-February) to Swan River estuary; in ones or twos.

Charadrius melanops Vieillot
Black-fronted Plover

Common; in ones, twos or small flocks. Sandy or muddy shores of fresh or brackish lakes, swamps and ponds; in autumn visiting the Swan River (mainly above the Causeway, rarely the broadwaters). Breeding from October to December; C/2(1), 3(1).

Charadrius cinctus (Gould)
Red-kneed Plover

Scarce visitor (dated records fall in March, October and December); in pairs or small flocks. Samphire swamps (on the Swan River) and muddy margins and shallows of freshwater lakes and swamps. The birds observed by Alexander (1916, Emu 16: 42) near Perth in March 1916 appeared to be breeding, and the two observed by R.E. Johnstone at Lake Chandala on 4 October 1977 reacted strongly to his presence and called continuously; in neither event was a nest found.

SCOLOPACIDAE

Numenius minutus (Gould)
Little Whimbrel

Rare visitor. One record: a single bird seen by Tarburton (1974, West. Aust. Nat. 13: 6) at the marshes above the Causeway, Swan River, on 20 December 1964.

Numenius phaeopus variegatus (Scopoli)
Whimbrel

Rare visitor. Three records (all from Pelican Point, Swan River): Serventy (1938, Emu 38: 25) saw one on 16 October 1936, and Job (1971, West. Aust. Nat. 12: 57) saw one on 7 December 1966 and two on 15 February 1967.

Numenius madagascariensis (Linnaeus)
Eastern Curlew

Scarce visitor (September-March); in ones or twos. Most records are from the Swan River (mainly the marshes above the Causeway, seldom the shores of the broadwaters); also ocean beaches (Alexander, 1921, Emu 20: 159), Herdsman Lake (specimen, WAM 4617), and grassy margin of Lake Monger (Jenkins, 1969, West. Aust. Nat. 11: 53).

Limosa limosa melanuroides Gould
Black-tailed Godwit

Visitor (November-April) to Swan River estuary; at times moderately common (e.g. autumn 1953 at Pelican Point), but generally rare; in small flocks (3-15). Most records are from March and April, in which months the species is scarce or absent in the Kimberley, owing no doubt to the flooding of swamps and rivers.

Limosa lapponica baueri Naumann
Bar-tailed Godwit

Uncommon visitor (September-April); in ones, twos or small flocks (up to 14). Swan River estuary (mainly the shores of the broadwaters, also marshes above the Causeway); also sandy ocean beach at Mullaloo.

Tringa stagnatilis (Bechstein)
Marsh Sandpiper

Rare visitor. One record: J.A.K. Lane saw two at Point Waylen, Swan River estuary, in March 1972 (Serventy & Whittell, 1976, Bds West. Aust., p.213).

Tringa nebulari (Gunnerus)
Greenshank

Uncommon visitor (late October to May; also one record in July); in ones, twos or small parties (up to 5). Muddy or sandy margins and shallows of brackish and freshwater lakes and swamps; also samphire swamps on the Swan River (Burswood Island, near the Causeway, and Alfred Cove).

Tringa glareola Linnaeus
Wood Sandpiper

Scarce visitor (August-May); usually in ones or twos. Fresh or brackish lakes and swamps.

Tringa terek (Latham)
Terek Sandpiper

Rare visitor (September-February) to Swan and Moore River estuaries; usually single. For local occurrences see Stranger (1964, West. Aust. Nat. 9: 92) and Job (1971, West. Aust. Nat. 12: 57).

Tringa hypoleucos Linnaeus
Common Sandpiper

Uncommon visitor (September-April); usually single. Swan River (from mouth upstream to at least Middle Swan; usually about rocks, cliffs and stone embankments); also mouth of Moore River and brackish and freshwater lakes (Beermullah, Bambun and Joondalup).

Tringa brevipes (Vieillot)
Grey-tailed Tattler

Rare visitor (September-March) to Melville Water (Swan River estuary). For local occurrences see Serventy (1948, Emu 47: 266), Jenkins (1957, West. Aust. Nat. 6:55) and Corfe (1978, West. Aust. Nat. 14: 53).

Arenaria interpres interpres (Linnaeus)
Ruddy Turnstone

Visitor (September-April); uncommon about rocks on coast, south to Mullaloo, in small parties (up to 5); rare on Swan River estuary (two records of single birds).

Calidris canutus canutus (Linnaeus)
Red Knot

Scarce visitor (late September-May) to Swan River estuary (Pelican Point); usually in small flocks (up to 50).

Calidris tenuirostris (Horsfield)
Great Knot

Uncommon visitor (October-July) to Swan River estuary (Pelican Point); in ones, twos or small parties (up to 7).

Calidris alba (Pallas)
Sanderling

Uncommon visitor (October-April) to sandy beaches, south nearly to City Beach, usually in small parties; rare on Swan River estuary (one at Pelican Point in November 1936).

Calidris ruficollis (Pallas)
Red-necked Stint

Very common visitor (August-July) to Swan River estuary (especially sandy shores of broadwaters; also marshes above the Causeway), usually in flocks (up to 4000); also coast (Yanchep Beach) and brackish or freshwater lakes and swamps (Beermullah, McNess and Herdsman).

[Calidris subminuta (Middendorff)
Long-toed Stint

Status unknown. "Sight observations have been made on freshwater swamps near Perth" (Serventy & Whittell, 1976, Bds West. Aust., p.220).]

Calidris melanotos (Vieillot)
Pectoral Sandpiper

Rare visitor. Two records from Pelican Point, Swan River estuary: single bird trapped on 1 November 1959 (Serventy, 1960, Emu 60: 68), and single bird observed on 18 and 19 October 1967 (Job, 1971, West. Aust. Nat. 12: 58).

Calidris acuminata (Horsfield)
Sharp-tailed Sandpiper

Moderately common visitor (September-April); usually in small flocks (up to 20). Swan River estuary (mainly samphire swamps above the Causeway; also shores of broadwaters, especially in spring); also sandy or muddy shores of fresh or brackish lakes and swamps, especially in autumn. A bird banded at Pelican Point on 5 January 1961 was recovered in Siberia on 28 May 1961 (Nicholls, 1962, Emu 62: 328).

Calidris ferruginea (Pontoppidan)
Curlew Sandpiper

Common visitor (August-July); usually in small flocks (up to 100). Swan River estuary (mainly sandy shores of broadwaters; also mudflats above the Causeway); also brackish Lake Beermullah (6 observed by R.E. Johnstone on muddy spit on 16 February 1968) and, just north of our area, salty Lake Guraga (8 observed at water edge by R.E. Johnstone on 18 August 1977).

RECURVIROSTRIDAE

Himantopus himantopus leucocephalus
Black-winged Stilt

Common visitor (all months, but mainly summer and autumn), usually in flocks (up to 100); occasionally breeding. Fresh, brackish and saline lakes and swamps and floodwaters; also Swan River (mainly marshes above the Causeway; also broadwaters, especially in summer and autumn). Breeding in small numbers on Herdsman Lake in 1967 (Hutchinson, 1969, West. Aust. Nat.

11: 50) and 1973 (N. Kolichis); September and October; C/3 (5), 4(5).

Cladorhynchus leucocephala (Vieillot)
Banded Stilt

Irregular non-breeding visitor (mainly summer-autumn); in ones, twos or small flocks. Salt, brackish or freshwater lakes, and the Swan River estuary (Pelican Point). Despite its regular visits in large numbers to nearby Rottnest Island, there were only two records from our area before the 1976-78 drought: in 1936 Serventy (1938, Emu 38: 25) observed 1-15 birds at Pelican Point from 20 February to 5 June and one bird in mid-July; A.G. Kilpatrick saw 11 feeding in shallows of Lake Claremont on 12 September 1938. On 13 May 1977 P.J. Fuller counted 18 at Lake Joondalup. At Lake Beermullah R.E. Johnstone saw 8 on 18 August 1977 and 16 February 1978, and G. Harold saw 4 on 14 November 1977. At Lake Jandabup Johnstone saw 2 on 30 March 1978. [Just to the north of our area at Lake Guraga, a large saltlake 20 km NW of Regans Ford, Harold saw ca 20 on 14 November 1977, and Johnstone saw flocks of 30 and 45 feeding in 10 cm of water on 24 January 1978].

Recurvirostra novaehollandiae Vieillot
Red-necked Avocet

Common non-breeding visitor (all months); usually in small flocks, occasionally in large flocks (up to 500). Swan River estuary (shallows below the Narrows and marshes above the Causeway; greatest numbers appearing during dredging operations) and salt, brackish and freshwater lakes and swamps; occasionally on coastal beaches (observed by A. Chapman at Burns Beach and Mullaloo).

BURHINIDAE

Burhinus grallarius (Latham)
Bush Stone-curlew

Formerly moderately common, now rare or extinct. Alexander (1921, Emu 20: 159) described it as resident in the Swan River district and still fairly common except in the immediate vicinity of Perth. This is supported by Hill's statement (1904, Emu 3: 229) that it could be heard at Guildford almost every night in 1903. Since the advent of the fox (ca 1930) there is only one record for the area: a specimen (WAM A4623) collected at South Guildford in July 1935.

GLAREOLIDAE

Stiltia isabella (Vieillot)
Australian Pratincole

Vagrant. One record: Lane (1973, West. Aust. Nat. 12: 165) saw one at Pelican Point, Swan River estuary, on 11 December 1972.

Glareola maldivarum Forster
Oriental Pratincole

Vagrant. One record: Serventy (1968, West. Aust. Nat. 10: 172) saw 2 at Pelican Point, Swan River estuary, from 28 January to 3 February 1967.

LARIDAE

Stercorarius skua lonnbergi (Mathews)
Great Skua

Regular visitor to Fremantle Harbour (late May to mid August, single birds occasionally remaining till September or early October); maximum count, 19 on 13 July 1957 (G.M. Storr). [Birds ringed on the Crozet and Kerguelen Islands have been recovered in adjacent seas].

[Stercorarius parasiticus (Linnaeus)
Arctic Skua

Job (1971, West. Aust. Nat. 12: 58) saw a pale-phase skua, probably of this species, at Pelican Point, Swan River estuary, on 26 November 1966.]

Larus novaehollandiae longirostris Masters
Silver Gull

Very common visitor (all months), breeding in large numbers on adjacent offshore islands and occasionally on mainland (Swan River estuary). Mainly the Swan River estuary (especially in vicinity of rubbish tips and dredging operations), but not commonly visiting upper reaches except when the river is in high flood (then flocks of many hundreds have been observed at Guildford and Middle Swan); also coastal beaches and city and suburban freshwaters (Queens Gardens, Lake Monger, Herdsman Lake, Perry Lakes, lake at Shenton Park, and Lake Claremont). A few birds breeding in Matilda Bay: in 1963 at the derelict Crawley Baths (Mathews, 1964, West. Aust. Nat. 9: 72), and in 1977 on a moored boat (M.G. Nelson, pers. comm.); July, August, October; C/2(2).

Larus pacificus georgii King
Pacific Gull

Formerly uncommon on coast (Alexander, 1921, Emu 20: 158) and occasionally entering Fremantle Harbour (Serventy, 1938, Emu 38: 23); now locally extinct. Last record: D.L. Serventy (pers. comm.) saw two immature birds at Yanchep Beach on 19 February 1924.

The decline of this species is almost certainly connected with the enormous increase in the Silver Gull over the last few decades. Under natural conditions in southern Western Australia, i.e. where there are no large rubbish tips or other man-made sources of food, Silver Gull numbers are moderate and the Pacific Gull prospers.

Larus dominicanus Lichtenstein
Kelp Gull

Vagrant. One record: a specimen (WAM A2701) collected at Claremont on 22 August 1924 (Ford, 1965, West. Aust. Nat. 9: 172).

Sterna nilotica Gmelin
Gull-billed Tern

Status and subspecific identity unknown. Two records: observation at Wanneroo in 1959 (Serventy & Whittell, 1976, Bds West. Aust., p.238), and observation of Anderson & Stranger (1964, West. Aust. Nat. 9: 93) of two at Pelican Point, Swan River estuary, on 26 November 1963.

Sterna caspia Pallas
Caspian Tern

Moderately common visitor (all months, but seldom between late April and early September) to Swan River estuary, upstream to Rivervale; resting on sand-spits in small flocks (up to 20); occasionally visiting coastal waters (Mullaloo, Leighton); rarely visiting brackish or freshwater lakes (R.E. Johnstone saw one fishing in 30 cm of water at Lake Beermullah on 18 August 1977; and G.M. Storr saw two at Lake Monger on 8 April 1955, one of them fishing).

Sterna bergii Lichtenstein
Crested Tern

Common visitor (all months, but mainly September-April) to Swan River estuary, upstream to Maylands, resting on sand-spits in flocks (up to 55); moderately common along coast.

Sterna macrura Naumann
Arctic Tern

Rare passage migrant. Two records: two observed and one collected at Pelican Point, Swan River estuary, in October 1955 (Storr, 1956, West. Aust. Nat. 5: 70), and one collected at Wembley on 16 May 1956 (WAM A7827).

Sterna anaethetus anaethetus Scopoli
Bridled Tern

Uncommon visitor to coast in February (just before or during their northward passage). Three records: D.L. Serventy saw several birds flying around the more northerly of the two rocks off Yanchep Beach on 21 February 1924; A. Chapman saw a party of ca 5 (?resting or nesting) on the wrecked freighter "Alkimos" (midway between Yanchep Beach and Quinns Rock) on 12 February 1977; 10 days later Chapman saw some resting on spiny lobster floats off Burns Beach.

Sterna hybrida javanica Horsfield
Whiskered Tern

Formerly a moderately common, now a rare, visitor to the Swan River estuary; occasionally visiting fresh or brackish lakes and swamps (Lake Joondalup, Herdsman Lake and lake at Shenton Park).

Since the reclamation of the marshy flats besides the Swan River estuary this species has markedly declined, e.g. around Pelican Point there were ca 30 birds in most of 1936-37 (Serventy, 1938, Emu 38: 23); on his numerous visits to Pelican Point in 1953-58 G.M. Storr only saw the species in September 1955 (largest party, 9); and in 1966-68 Job (1971, West. Aust. Nat. 12: 58) saw it only once, a single bird on 29 September 1967.

Sterna leucoptera Temminck
White-winged Black Tern

Sporadic visitor (February-April) from northern hemisphere, sometimes in large numbers. A large irruption in Easter 1917, when it was recorded at Bullsbrook, Lake Mariginiup, Craigie Lake (20 km N of Perth), Herdsman Lake and Lake Monger, mainly feeding on the dragon-fly Anax papuensis, then in great numbers (Alexander, 1917, Emu 17: 95). Alexander (1917, Emu 18: 134) reported a small visitation to the Swan River estuary from late April to early May 1918, but the species involved needs confirmation. A large irruption from early March to early April 1956, when it was recorded at Lake Pinjar, West Midland and Lake Monger and on the Swan River from Bayswater downstream to Lucky Bay (West. Aust. Nat. 5: 121, 1956). A small irruption in February 1970, when it was recorded at Loch McNess, Jackadder Lake and Lake Monger (Hutchinson, 1971, West. Aust. Nat. 12: 22). All these irruptions were associated with tropical cyclones (Serventy & Whittell, 1976, Bds West. Aust. p.237). Two were observed by R.E. Johnstone at Lake Jandabup on 26 April 1978.

An observation by Jacobs (1975, West. Aust. Nat. 13: 61) of a Black Tern (Sterna nigra Linnaeus) at Lake Joondalup on 31 December 1973 probably refers to this species.

Sterna nereis nereis (Gould)
Fairy Tern

Formerly a moderately common, now uncommon, visitor (mid September to early May) to the Swan River estuary, upstream to Rivervale, in ones, twos or small flocks (up to 21); formerly breeding; at least some of these birds originate in nearby nesting colonies, e.g. Lake Walyungup (J. Ford, 1967, West. Aust. Nat. 10: 153). One record from Wanneroo: specimen (WAM 5288) collected by A.W. Milligan in late December 1902. Nesting on sandbank at South Perth in 1930 (A.G. Kilpatrick).

Possibly the Little Tern (Sterna sinensis Gmelin) is a rare visitor, during passage, to the Swan River estuary. A flock of ternlets observed by A.G. Kilpatrick at Pelican Point on 26 July 1931 were more likely, in view of the date and of the

turbidity of the river, to be S. sinensis than S. nereis, as was the single ternlet seen by G.M. Storr fishing in Matilda Bay on 14 June 1958.

COLUMBIDAE

Streptopelia chinensis (Scopoli)
Spotted Turtle Dove

An exotic, "acclimatised from the Zoological Gardens since 1899" (Serventy, 1938, Emu 37: 271) and soon "plentiful in Perth and the nearer suburbs" (Alexander, 1921, Emu 20: 155). At present uncommon to moderately common north through the suburbs of Perth to Wanneroo, Mussel Pool and Middle Swan; also at Yanchep. Breeding from August to October: C/2(3).

Streptopelia senegalensis senegalensis (Linnaeus)
Laughing Turtle Dove

An exotic, "acclimatised in the Perth district since 1898 1900" (Serventy, 1938, Emu 37: 266) and soon "plentiful about Perth" (Alexander, 1921, Emu 20: 155). At present common to very common, in pairs or small flocks, in city, suburbs, towns and farmlands north to Yanchep and Lake Beermullah. Breeding from August to February; C/2(10).

Geopelia cuneata (Latham)
Diamond Dove

Vagrant. One record: Lindgren (1956, West. Aust. Nat. 5: 142) saw one at Lake Claremont on 2 June 1955. [Just east of area, Schmidt (1957, West. Aust. Nat. 6: 24) saw one at Lower Chittering in February and March 1957.]

Phaps chalcoptera (Latham)
Common Bronzewing

Moderately common; in ones, twos or small flocks (up to 15 at water). Mainly acacia thickets and banksia woodlands; also eucalypt woodlands. One breeding report; August C/2.

[Phaps elegans (Temminck)
Brush Bronzewing

Probably occurring in past in coastal acacia thickets (cf. Alexander, 1921, Emu 20: 155), but there are no definite records of this declining species from our area.]

Ocyphaps lophotes (Temminck)
Crested Pigeon

"By 1956 it was an occasional visitor to the Perth area" (Serventy & Whittell, 1976, Bds West. Aust., p.264). At present it seems to be established only in the open country on the western side of Herdsman Lake, where it was observed as early as 1960 (V.N. Serventy, 1962, West. Aust. Nat. 8: 101). It is possibly becoming established in farming country in north of area: pairs were observed near the Moore River and on the Gingin-Wanneroo road in March 1978. [At Lake Namming, just north of our area, it appeared in 1964 and has been resident ever since (A. Harris, pers. comm.).]

PSITTACIDAE

Trichoglossus haematodus novaehollandiae (Gmelin)
Rainbow Lorikeet

Recently established in small numbers in western suburbs of Perth (Storr, 1973, West. Aust. Nat. 12: 116). J. Forshaw (pers. comm.) doubts whether this eastern Australian parrot reached southwestern Australia unaided.

Glossopsitta porphyrocephala (Dietrichsen)
Purple-crowned Lorikeet

Irregular visitor (mainly in March-June, e.g. to Nedlands-Crawley when marri flowering, and in October-December, e.g. to Guildford-Middle Swan, when flooded gums flowering); usually in small flocks. Mainly flowering flooded gums (Eucalyptus rudis) along the upper reaches of the Swan River; also flowering marri (E. calophylla).

Polytelis anthopeplus westralis Mathews
Regent parrot

A sporadic visitor in the 1920s (Serventy, 1948, Emu 47: 273). By the 1950s it was apparently established just to the east of our area at Lower Chittering (Loaring & Serventy, 1952, West. Aust. Nat. 3: 110). In the 1950s and 1960s it was a moderately common visitor, in flocks of up to 100, to the farmlands between Bullsbrook and Guildford. Since 1965 it has disappeared from most of the eastern zone and has only been observed near Gingin. Its decline in our area is part of a general decline in southwestern Australia, which is possibly connected with the great recent increase in Platycercus zonarius.

Platycercus zonarius (Shaw)
Ringnecked Parrot

Very common; usually in pairs or small flocks. Open eucalypt forests and woodlands, and clearings, scrubs and heaths in their vicinity. Breeding in spring. This has probably always been the most numerous psittacid in the area, but it was not till the 1960s that it became a common suburban bird. Early this century it was only "occasionally reported" at Guildford (Hill, 1904, Emu 3: 228). In 1948 Serventy (Emu 47: 273) wrote that it "even visits some of the suburban residential gardens after almonds and other fruits" and that it was "only an occasional visitor to Kings Park". At present it is a common inhabitant of suburban gardens, parks and road verges, where it feeds almost exclusively on exotic plants, e.g. the flowers of coral trees (Erythrina indica), the berries of white cedars (Melia azederach) and cotoneasters, the seeds of Queensland box (Tristania conferta) and of various grass and composite weeds.

The birds in our area are intergrades between two subspecies of P. zonarius, namely the "Twenty-eight Parrot" P. z. semitorquatus (Quoy & Gaimard), and the "Port Lincoln Parrot", P. z. zonarius.

Platycercus spurius (Kuhl)
Red-capped Parrot

Moderately common; usually in pairs. Mainly open eucalypt forests and woodlands; also adjacent banksia woodlands. Occasionally visiting suburban parklands, e.g. the marri trees (Eucalyptus calophylla) in the University grounds at Crawley in 1955-56 (G.M. Storr). Breeding in spring.

Platycercus icterotis (Kuhl)
Western Rosella

Scarce; usually in pairs. Open forests of marri and other eucalypts and thickets of Melaleuca teretifolia in the north of our area, e.g. at Lake Beermullah and along the Moore River and Gingin Brook, downstream to Cowalla and Gingin Brook East. In the metropolitan area still visiting foothill suburbs (Koongamia) but no longer occurring at or visiting Herdsman Lake (specimen, WAM 3513, collected by T. Ostle in 1901), Kings Park (cf. Serventy, 1948, Emu 47: 273) or Crawley (cf. Lipfert, 1937, Emu 37: 134).

Neophema elegans (Gould)
Elegant Parrot

A moderately common winter visitor (May-September) to eastern and central zones, from Gingin south to Middle Swan, and west to Lake Jandabup; in pairs or small flocks (up to 50); occasionally breeding. Clearings or road verges in vicinity of open eucalypt forests and woodlands and banksia woodlands. Harold & Dell (cyclostyled report) found two pairs nesting in dead eucalypts at Mussel Pool in spring 1975.

Neophema petrophila (Gould)
Rock Parrot

Sporadic visitor (March-September) to coast; usually in small parties. Observed at Mullaloo and 4 km to northeast (A. Chapman), Cottesloe (Serventy, 1948, Emu 47: 273), and Leighton and Fremantle (Reid, 1951, West. Aust. Nat. 2: 195).

[Pezoporus wallicus (Kerr)
Ground Parrot

Possibly resident in past (Alexander, 1921, Emu 20: 163, and Serventy, 1948, Emu 47: 274).]

Melopsittacus undulatus (Shaw)
Budgerigar

During the 1951 irruption into southwestern Australia, flocks of 25-300 were observed in May and June at Gingin (Glauert, 1951, West. Aust. Nat. 3: 37), Yanchep (Lindsay, ibid., p.38), and Lake Goollelal (Serventy, ibid., p.38). H.A. Shugg (pers. comm.) has seen flocks at Osborne Park.

Nymphicus hollandicus (Kerr)
Cockatiel

Vagrant. Two records: Heron (1970, Emu 70: 156) saw two at Middle Swan in February and July 1965; and Hutchinson (1971, West. Aust. Nat. 12: 21) saw a party of 5 at Hollywood in March 1970.

Calyptorhynchus latirostris Carnaby
Carnaby's Cockatoo

Common visitor (all months, but mainly March-September; in pairs or flocks (up to 2000). Visiting plantations, parks and gardens in search of seeding exotic pines, especially Pinus pinaster (see Saunders, 1974, Aust. Wildl. Res. 1: 45-54) and woodlands, scrubs and heaths in search of proteaceous shrubs (especially Dryandra sessilis, Banksia menziesii, B. attenuata and B. grandis). Only breeding in extreme northeast

of area: D.A. Saunders (pers. comm.) found a nest at Regans Ford on 18 December 1969 with a nestling ca 40 days old (the egg would have been laid in early October).

Until recently this cockatoo was regarded as a subspecies of C. baudinii Lear.

Calyptorhynchus magnificus naso Gould
Red-tailed Black Cockatoo

Formerly occurring in eastern zone; now extinct. In 1831 G.F. Moore noted it about his homestead near Guildford (Alexander, 1918, J. Proc. R. Soc. West. Aust. 3: 41). A specimen (WAM 1, Catalogue No. 1) was collected at Gingin in 1896.

Cacatua roseicapilla (Vieillot)
Galah

Appearing sporadically in 1920s and 1940s (Serventy, 1948, Emu 47: 272). It was established at Gingin, and apparently also on the Moore River just east of our area, by 1950 (Loaring & Serventy, 1950, West. Aust. Nat. 3: 110); at Bullsbrook by 1962 (G.M. Storr); at Swan View by 1964 (Heron, 1970, Emu 70: 156); and at Yanchep and Guildford and in western suburbs of Perth by 1969. At present moderately common in much of area; in pairs or small flocks (up to 30). Farmlands and other clearings.

Cacatua tenuirostris pastinator (Gould)
Long-billed Corella

Formerly common about the Swan River, now locally extinct [though still common to the north of our area: nearest locality 13 km N of Regans Ford, where G.M. Storr saw 4 in March 1964].

In March 1827 botanist Charles Fraser observed large flocks feeding on the roots of "orchidaceous plants" in the vicinity of present-day Gloucester Park (Hay, 1906, J. West. Aust. nat. Hist. Soc. No. 3: 16). In June 1835 G.F. Moore complained in his diary (cited by Alexander, 1918, J. Proc. R. Soc. West. Aust. 3: 49) of their depredations (with crows) in his wheat fields near Guildford.

Cacatua tenuirostris sanguinea Gould
Little Corella

Becoming established in area: origin of stocks unknown, but probably aviary escapees. Since the early 1960s observed in western suburban areas (Nedlands, Claremont, Swanbourne Rifle Range, Perry Lakes and Wembley), building up by 1974 into flocks of up to 100 (R.P. McMillan). Since the early 1970s observed in the Guildford-Middle Swan area, building up by 1978 into flocks of up to 50 (L.A. Smith, pers. comm.). Recently reported further north: Martyn Reserve, Ellen Brook (4 in July 1977, G. Harold), near Wanneroo (one in October 1977, A. Chapman) and near Mullaloo (2 in September 1977, A. Chapman).

Cacatua leadbeateri (Vigors)
Major Mitchell

Rare visitor. R. Coulson of Midland reported two in mid June 1969 (Fauna Bull. 3(3): 21, Dept of Fisheries and Wildlife,1969). It was probably the same pair that McMillan (1970, West. Aust. Nat. 11: 146) observed at Guildford during the following two months.

Cacatua galerita (Latham)
Sulphur-crested Cockatoo

A small colony is now established in the eastern zone about the Swan and Helena Rivers, from Guildford upstream to Middle Swan and Bushmead; in small flocks (up to 20 seen by H.E. Merrifield, pers. comm.). It was first reported by Heron (1970, Emu 70: 156) who saw parties of 2-5 birds in 1964.

CUCULIDAE

Cuculus pallidus (Latham)
Pallid Cuckoo

Common passage migrant and breeding visitor, adults arriving in April-July (mostly June) and leaving in October

to December (extreme dates 10 April-3 December); the young may remain as late as March (Dell, 1973, West. Aust. Nat. 12: 114). Lightly wooded country, including suburban gardens. Breeding from August to October; parasitising Anthochaera carunculata (2 records), Meliphaga virescens (1), Acrocephalus stentoreus (1).

Cuculus flabelliformis flabelliformis Latham
Fan-tailed Cuckoo

Scarce winter visitor (April-September). Open jarrah and tuart forests, banksia woodlands and acacia thickets.

Chrysococcyx osculans (Gould)
Black-eared Cuckoo

Rare visitor. One record: a bird found at Yokine on 16 May 1976 (Nicholls, Spence & Thorpe, 1977, West. Aust. Nat. 13: 205).

Chrysococcyx basalis (Horsfield)
Horsfield's Bronze Cuckoo

Scarce visitor (June-December); immatures may remain till March (Heron, 1970, Emu 70: 157). Lightly wooded country. For an unsuccessful attempt to parasitise Zosterops lateralis see Calderwood (1952, West. Aust. Nat. 3: 92).

Chrysococcyx lucidus plagosus (Latham)
Shining Bronze Cuckoo

Moderately common visitor (late July-December); also recorded in early April (Heron, 1970, Emu 70: 157). Well-wooded country. Breeding from August to December; parasitising Acanthiza chrysorrhoa (2 records), A. pusilla apicalis (3) and A. inornata (2).

STRIGIDAE

Tyto alba delicatula (Gould)
Barn Owl

Uncommon winter visitor (late May to late August). Lightly wooded country. Frequently found dead in suburban gardens.

Tyto novaehollandiae novaehollandiae (Stephens)
Masked Owl

Status uncertain; probably a rare autumn-winter visitor. Four records: specimen (WAM 247) collected by T. Ostle at Lake Monger in 1898; bird observed by G.M. Storr sheltering in a densely foliaged jarrah sucker at Wembley from 3 to 5 May 1965; specimen (WAM A15387) collected at Yanchep in May 1973 after it fell into a fishpond and drowned; and a specimen (WAM A15473) found dead on road near Lake Gnangara on 23 March 1977.

Ninox connivens connivens (Latham)
Barking Owl

Status uncertain; probably a rare autumn-winter visitor. Two records: specimen (WAM 4888) collected by T. Ostle at Herdsman Lake in early May 1902; and a bird "of very dark brown (almost black) plumage with lighter spots" observed by A.G. Kilpatrick asleep in a banksia at the Claremont Asylum on 20 June 1931.

Ninox novaeseelandiae boobook (Latham)
Boobook Owl

Status uncertain; probably an uncommon breeding visitor (mainly August-March).

PODARGIDAE

Podargus strigoides (Latham)
Tawny Frogmouth

Common; in ones, twos or family parties. Open eucalypt forests and woodlands, banksia woodlands and acacia thickets. Breeding in September and October; C/2(2).

AEGOTHELIDAE

Aegotheles cristatus cristatus (White)
Australian Owlet-nightjar

Rare visitor. Two records: one seen by A.G. Kilpatrick entering a hollow tree near Swanbourne at dusk, 30 October 1933; and one flushed by Lindgren (1956, West. Aust. Nat. 5: 143) from a paperbark at Lake Bambun at 3.30 p.m., 16 October 1955.

CAPRIMULGIDAE

Eurostopodus guttatus (Vigors & Horsfield)
Spotted Nightjar

Status uncertain; probably a rare autumn-winter visitor. One record: observation by W.B. Alexander at Blackwall Reach, lower Swan River, May 1919 (Serventy, 1948, Emu 47: 274).

APODIDAE

Apus pacificus pacificus (Latham)
Fork-tailed Swift

Moderately common visitor (late December to early April); in ones, twos or loose flocks (up to 100). Mainly observed feeding at good heights during hot humid weather.

ALCEDINIDAE

Dacelo gigas (Boddaert)
Laughing Kookaburra

Established exotic, introduced from Victoria ca 1897 (Serventy & Whittell, 1976, Bds West. Aust., p.308), reaching the Guildford district in 1903 (Hill, 1904, Emu 3: 228). Now common throughout area; usually in pairs or family parties.

Well-wooded country. Breeding from September to November; C/3(1), 4(1).

Halcyon sancta sancta Vigors & Horsfield
Sacred Kingfisher

Common visitor (mainly September-January; extreme dates 4 August-12 March). Well-wooded country, especially near water. Breeding in October and November; C/3(1), 4(2), 5(2).

MEROPIDAE

Merops ornatus Latham
Rainbow Bee-eater

Moderately common passage migrant (late September to early November, and late December to early March); usually in small loose flocks. Uncommon breeding visitor to tuart belt of western zone, south to Balcatta (formerly to Kings Park and Nedlands). Breeding in November; C/4(1).

HIRUNDINIDAE

Cheramoeca leucosterna (Gould)
White-backed Swallow

Uncommon to moderately common in western zone, south ordinarily to Mullaloo, and inland to Yanchep, the Neerabup National Park and Lake Joondalup; casual further south (on 25 February 1977 A. Chapman saw 3 feeding over sea 3 km off

Swanbourne). Nesting in road banks between Guilderton and Yanchep (Ford, 1965, West. Aust. Nat. 10: 8), and near roads at Yanchep Beach and in a sand-pit in Wanneroo district (Sinagra, 1969, Fauna Bull. 3(3): 49, Dept of Fisheries and Fauna).

For report of torpid birds excavated in winter from a sand-pit at Yanchep see Congreve (1972, Emu 72: 32). For predation of nesting birds by foxes see Sinagra (supra).

Hirundo neoxena Gould
Welcome Swallow

Locally common. Patchily distributed, e.g. common in some suburbs (e.g. Claremont and Midland), absent in others (e.g. Wembley and Guildford). Open country, especially near water. Breeding from August to November; C/3(3), 4(2); fledgingperiod 25-26 days (Nicholls, 1962, West. Aust. Nat. 8: 104); nests placed under shop, railway station and hotel verandas, under bridges and river jetties, and in coastal limestone and hollow trees.

Hirundo nigricans nigricans Vieillot
Tree Martin

Irregular migrant (largely vacating area in late autumn and winter. Very common; nesting colonially (up to 6 pairs per tree) and gradually aggregating into large post-nuptial flocks from late November to early April (flocks of many hundreds observed around lakes in early autumn). In breeding season (August-November) confined to vicinity of nest trees (jarrahs and river gums); after breeding dispersing to open country, especially near water (where they feed on emerging midges and roost en masse in rushes); numbers greatly reduced in April and steadily declining from May to late August when migrants begin to return.

Hirundo ariel (Gould)
Fairy Martin

Confined to eastern zone, from Gingin south to Midland. Uncommon breeding visitor, possibly absent in some years. Open country. Breeding from August to November; nests placed in chalk quarry and kilns (Serventy, 1928, Emu 28: 65) and in clay-pits and under culverts (Amedy, 1965, West. Aust. Nat. 10: 22).

MOTACILLIDAE

Anthus novaeseelandiae australis Vieillot
Richard's Pipit

Moderately common; in ones, twos or small parties (up to 12). Bare or sparsely vegetated ground near coast, along the Swan River estuary (upstream to Rivervale), around lakes and swamps, in farmlands, on airfields, and along road verges and firebreaks. One breeding record (August); display flight observed in late September.

CAMPEPHAGIDAE

Coracina maxima (Rüppell)
Ground Cuckoo-shrike

Rare visitor to eastern zone. Two records: specimen (WAM 4859) collected at Greenmount in April 1902, and observation by W.H. Loaring of three birds between Caversham and Bayswater in May 1930 (Serventy, 1948, Emu 47: 278).

Coracina novaehollandiae novaehollandiae (Gmelin)
Black-faced Cuckoo-shrike

Common passage migrant and winter visitor (February to September); also an uncommon to moderately common resident (or breeding visitor); in ones, twos or small parties. Open forests and woodlands; also suburban parks, gardens and streets during migration. Breeding in tuart belt of western zone and in eastern zone; July to October.

Lalage sueurii tricolor (Swainson)
White-winged Triller

Uncommon breeding visitor and passage migrant (September-January); usually in ones or twos. Lightly wooded country. Breeding in western zone (formerly south to Claremont); October and early November; C/3(3).

PACHYCEPHALIDAE

[Microeca leucophaea assimilis Gould
Jacky Winter

Possibly occurring in far northeast of our area. Loaring & Serventy (1952, West. Aust. Nat. 3: 112) recorded it on the Moore River 25 km W of Mogumber in August 1950.]

Petroica goodenovii (Vigors & Horsfield)
Red-capped Robin

Uncommon visitor (February-October, mainly March-June), mainly to eastern and central zones, in ones or twos. Eucalypt woodlands, banksia woodlands and acacia thickets.

Petroica multicolor campbelli Sharpe
Scarlet Robin

As a resident, formerly common, now scarce or extinct in south and uncommon to moderately common in north; as an autumn-winter visitor (March-August) formerly moderately common, now uncommon; usually in ones or twos. Breeding from late July to early October; C/3(3).

Petroica cucullata (Latham)
Hooded Robin

Confined to northern and central parts of area, south to Burns Beach and Melaleuca Park. Scarce; in ones or twos. Mainly banksia woodlands; also Dryandra sessilis and Xanthorrhoea heaths.

Eopsaltria australis griseogularis Gould
Yellow Robin

Formerly a common resident (Alexander, 1921, Emu 20: 165) and a regular autumn-winter visitor (Serventy, 1957, West. Aust. Nat. 6: 43); now locally extinct. Formerly breeding in July; C/2(2).

It nested at Claremont as late as 1922 (eggs, WAM A13531, collected by A.H. Robinson). Last recorded at Claremont in July 1931 (A.G. Kilpatrick) and at Kings Park in winter 1935 (Serventy, 1948, Emu 47: 277).

Eopsaltria georgiana (Quoy & Gaimard)
White-breasted Robin

Status uncertain. One record (Serventy, 1948, Emu 47: 277): on 19 July 1919 W.B. Alexander saw one near present-day Floreat Park in an Acacia rostellifera thicket [a habitat still occupied by this robin to the north of our area].

Pachycephala caledonica fuliginosa Vigors & Horsfield
Golden Whistler

As a resident formerly moderately common (Gould, 1865, Bds Aust. 1: 208; Alexander, 1921, Emu 20: 165; Lipfert, 1937, Emu 37: 134), but now extinct in south (persisting at Herdsman Lake until at least 1901); possibly surviving in north (R.E. Johnstone saw a male on 19 January 1978 in a Melaleuca rhaphiophylla thicket at north end of Loch McNess). Formerly an autumn-winter visitor (April-August), but no records since 1953.

Pachycephala rufiventris rufiventris (Latham)
Rufous Whistler

Common; usually in ones or twos. All kinds of wooded country. Breeding from September to December; C/2(2), 3(6).

Colluricincla harmonica rufiventris Gould
Grey Shrike-thrush

As a resident uncommon in northern and central parts of area; but now extinct in far south (persisting at Perry Lakes until at least 1955), where it is only a rare winter visitor (McIntosh, 1957, West. Aust. Nat. 5: 231). Open forests and woodlands of Eucalyptus, Melaleuca and Banksia. One breeding record (N. Kolichis): October; C/3.

Falcunculus frontatus leucogaster Gould
Crested Shrike-tit

Status uncertain (i.e. whether it was formerly resident or only a winter visitor). One record: specimen (WAM 8948) collected at Wanneroo in August 1907.

Oreoica gutturalis (Vigors & Horsfield)
Crested Bellbird

Moderately common (at least from June to September) in the northern and central parts of area, south to Mullaloo, Gnangara and Upper Swan. Mainly low open woodlands of sandplains (Banksia spp and Eucalyptus todtiana).

Apart from an adult female specimen in the British Museum (Natural History) said to come from Perth per John Gould (Gadow, 1883, Cat. Bds Brit. Mus. 8: 175), there is no record from the area before 1954 (Rook, 1963, West. Aust. Nat. 8: 173). Hence it is generally believed that the species has only recently colonised the coastal plain. In support of this belief is its discovery by Loaring & Serventy (1952, West. Aust. Nat. 3: 112) in 1950 near Mogumber (just to the northeast of our area), where F.L. Whitlock failed to record it in 1903.

[Psophodes nigrogularis nigrogularis Gould
Western Whipbird

Possibly occurring here in past. One record: observation by John Gilbert in October 1842 in "dry sandhills immediately adjacent to the beach" (Serventy & Whittell, 1976, Bds West. Aust., p.393).]

MONARCHIDAE

Rhipidura fuliginosa preissi Cabanis
Grey Fantail

Common resident and winter visitor (April-October); usually in ones or twos. As a resident, mainly in forests, scrubs and thickets around lakes, in swamps and along watercourses, but no longer in suburban areas (nesting at Perry Lakes till at least 1922); as a winter visitor, all kinds of wooded country but seldom reaching vicinity of coast. Breeding in September and October C/2(2).

Rhipidura leucophrys leucophrys (Latham)
Willie Wagtail

Common resident, with some influx in autumn-winter (March-July); usually in ones or twos. In eastern zone all kinds of lightly wooded country; in central and western zones largely confined to vicinity of lakes, swamps and watercourses (including the Swan River estuary); during winter found in coastal heaths. Breeding from August to November; C/3(4).

Myiagra inquieta inquieta (Latham)
Restless Flycatcher

Scarce autumn-winter visitor (March-August), occasionally remaining to breed. Mainly paperbarks (Melaleuca rhaphiophylla and M. parviflora) and flooded gums (Eucalyptus rudis) around lakes, in swamps and along streams. Two breeding records: at Lake Claremont (C/3, WAM A13522, collected by A.H. Robinson on 18 November 1922) and at Midland (Serventy & Whittell, 1976, Bds West. Aust., p.384).

ACANTHIZIDAE

Gerygone fusca fusca (Gould)
Western Flyeater

Common resident, usually in ones or twos; also some influx in autumn and winter. Mainly eucalypt and melaleuca

forests and woodlands. Breeding from September to December; C/2(3), 3(17).

Smicrornis brevirostris (Gould)
Weebill

Moderately common in tuart belt of western zone and in wandoo belt of eastern zone; usually in pairs in spring and small flocks (up to 15) in autumn and early winter. Open eucalypt forests and woodlands, especially of tuart (E. gomphocephala) and wandoo (E. wandoo). Breeding from September to November; C/2(5).

Acanthiza pusilla apicalis Gould
Brown Thornbill

Common resident and autumn-winter visitor; usually in pairs. Mainly melaleuca and other thickets around lakes, in swamps and along streams; also acacia thickets, jarrah woodlands and banksia scrubs. Breeding from August to November C/2(2), 3(1); parasitised by Chrysococcyx lucidus plagosus (3 records).

Acanthiza inornata Gould
Western Thornbill

Moderately common in tuart belt of western zone; uncommon in central and eastern zones; in pairs or small parties. Open eucalypt forests and woodlands. Breeding in November and December; C/2(1); 3(4); parasitised by Chrysococcyx lucidus plagosus (2 records).

Acanthiza chrysorrhoa (Quoy & Gaimard)
Yellow-rumped Thornbill

Common; in pairs or small flocks (up to 20 in autumn). Open ground near trees and shrubs. Breeding from July to December; C/3(8), 4(1); parasitised by Chrysococcyx lucidus plagosus (2 records).

Sericornis frontalis maculatus Gould
White-browed Scrub-wren

Scarce (or seldom reported); in pairs of family parties. Dune scrubs(especially Acacia rostellifera) from Guilderton south to the Swanbourne Rifle Range; also melaleuca thickets around Loch McNess.

Calamanthus fuliginosus montanellus Milligan
Calamanthus

Confined to far north of area, which constitutes its southern limit on the west coast. Two records: G. Harold observed it in banksia woodland in the Moore River National Park — 2 pairs in April 1977 and one pair in March 1978.

[Dasyornis brachypterus longirostris Gould
Bristlebird

Possibly occurring here in past. Whittell (1941, Emu 41: 125) argues that John Gilbert must have collected the type of this bird near Perth in 1839, not at King George Sound.]

MALURIDAE

Malurus splendens splendens (Quoy & Gaimard)
Splendid Fairy-wren

Moderately common; usually in family parties. Mainly about thickets of Melaleuca and Regelia in swamps, around lakes, and along watercourses (formerly including the Swan River estuary) and Acacia shrubbery in tuart forest and coastal dunes; also banksia scrubs. Breeding from August to December; C/2(4), 3(2).

Malurus lamberti assimilis North
Variegated Fairy-wren

Moderately common in coastal dunes from Guilderton south to Mosman Park; usually in family parties. Acacia rostellifera and other thickets. One breeding report: on 20 November 1958 Ford (1960, West. Aust. Nat. 7: 103) found a nest with 3 half-fledged young at the Swanbourne Rifle Range.

[Records of M. pulcherrimus Gould from our area are based on M. l. assimilis (Ford, ibid., p.104), as are some of the records of M. elegans.]

Malurus elegans Gould
Red-winged Fairy-wren

Scarce; in family parties. Dense vegetation along Gingin Brook: near its source (Dell et al., 1972, West. Aust. Nat. 12: 71), at Gingin (Carter, 1921, Emu 21: 55) and near its confluence with the lower Moore River (Loaring, 1950, West. Aust. Nat. 2: 108, and Ford, 1960, West. Aust. Nat. 7: 105). Formerly occurring at Herdsman Lake (3 specimens, WAM 3206-8, collected by T. Ostle in January 1901).

Malurus leucopterus leuconotus Gould
White-winged Fairy-wren

Western zone, south to City Beach and inland to Lake Pinjar and Wanneroo; casual in central zone at Mussel Pool and Heirisson Island (Swan River). Moderately common; usually in family parties. Mainly coastal heaths, also samphire swamps and partly cleared sandplain scrubs. Breeding in October and November; C/3(2), 4(1).

Stipiturus malachurus westernensis Campbell
Southern Emu-wren

Very rare. Three records: John Gilbert collected a nest near Perth in 1839 (Whittell, 1942, Emu 41: 224); Ford (1965, West. Aust. Nat. 10: 9) observed it in dune scrub at the mouth

of the Moore River; and N. Kolichis (pers. comm.) saw one in a market garden near Herdsman Lake ca 1973.

SYLVIIDAE

Acrocephalus stentoreus australis (Gould)
Clamorous Reed Warbler

Common; present in all months. Beds of Typha, Cladium and Juncus around lakes and in swamps. Breeding from October to January; C/3(5), 4(3).

Megalurus gramineus (Gould)
Little Grassbird

Common. Beds of Typha, Cladium and Juncus around lakes, in swamps and along the Swan River (downstream to Lucky Bay and Pelican Point). Breeding from August to October; C/2(2), 3(4), 4(10).

Cincloramphus mathewsi Iredale
Rufous Songlark

Rare visitor to eastern and central zones. Three records: Sedgwick (1956, West. Aust. Nat. 5: 96) saw one near Muchea on 4 September 1955; G. Harold saw one in banksia woodland in Melaleuca Park in April 1977; and G. Harold & J. Dell (cyclostyled report) found it common in paddocks at Mussel Pool in spring 1975.

Cincloramphus cruralis (Vigors & Horsfield)
Brown Songlark

Scarce visitor (recorded in January, June, October and December) to eastern zone and to Swan River flats downstream to the Causeway. Open grasslands and pastures.

DAPHOENOSITTIDAE

Daphoenositta chrysoptera pileata (Gould)
Australian Sittella

Uncommon to moderately common; in small parties (up to 8). Mainly open eucalypt forests and woodlands (tuart, flooded gum, jarrah-marri); also banksia woodlands. Breeding from September to November; C/2(1).

CLIMACTERIDAE

Climacteris rufa Gould
Rufous Tree-creeper

A declining species, now rare and apparently confined to the tuart belt of western zone. Three, possibly five, records: 2 specimens (male and female, WAM 8932, 8932a) collected at Wanneroo in August 1907; several sightings by N. Kolichis (1978, West. Aust. Nat. 14: 52) of 2 pairs in tuart-jarrah woodland at Balcatta between October and December 1974; an observation by Hill (1904, Emu 3: 227) at Guildford in 1902-03. W.B. Alexander informed D.L. Serventy (1948, Emu 47: 282) that he occasionally saw it on the coastal plain near Perth between 1910 and 1920. Whittell (1941, Emu 41: 119) argues that John Gilbert must have collected the type in the immediate vicinity of Perth.

DICAEIDAE

Dicaeum hirundinaceum hirundinaceum (Shaw)
Mistletoe-bird

Moderately common in eastern zone from Gingin south to Guildford; uncommon in tuart belt of western zone; in ones or twos. Mainly open eucalypt forests and woodlands (flooded gum, tuart and marri).

PARDALOTIDAE

Pardalotus punctatus (Shaw)
Spotted Pardalote

Sporadic autumn-winter visitor (April-August), mainly to tuart belt of western zone (south to Kings Park) and to eastern zone (from Gingin south to Midland), occasionally remaining to breed; common in some years, uncommon or absent in others. Open eucalypt forest.

Pardalotus striatus substriatus Mathews
Striated Pardalote

Common passage migrant (May and September-October), winter visitor and breeding visitor; usually in ones or twos. Open eucalypt forests and woodlands. Breeding from August to November; C/3(1).

ZOSTEROPIDAE

Zosterops lateralis gouldi Bonaparte
Grey-breasted White-eye

Common (most plentiful in western zone, least in central zone); usually wandering in small flocks. All kinds of wooded country, including vineyards, olive groves and suburban parks and gardens. Breeding from August to December; C/2(12); 3(5).

MELIPHAGIDAE

Lichmera indistincta indistincta (Vigors & Horsfield)
Brown Honeyeater

Very common; in ones, twos or small parties. All kinds of woodland, scrub and thicket, especially where B. menziesii and other banksias are flowering; also suburban parks and gardens, where they are attracted to flowering Eucalyptus, Callistemon, Erythrina, Duranta and other exotic trees and shrubs. Breeding in September and October; C/2(3).

Meliphaga virescens (Vieillot)
Singing Honeyeater

Common in western and central zones; uncommon in eastern zone; usually in ones or twos. Mainly banksia woodlands and coastal scrubs and heaths; also suburban and town gardens and parks. Breeding from August to December; C/2(3), 3(1); parasitised by Cuculus pallidus (1 record).

Meliphaga ornata (Gould)
Yellow-plumed Honeyeater

Formerly inhabiting the tuart belt of western zone from Yanchep south to Crawley, where it was plentiful according to Alexander (1921, Emu 20: 167). Last recorded in mid 1930s (Lipfert, 1937, Emu 37: 133, and Serventy, 1938, Emu 37: 272).

Meliphaga penicillata Gould
White-plumed Honeyeater

Rare vagrant. One record: Wilbrey (1969, West. Aust. Nat. 11: 99) observed a pair in a suburban garden at Joondanna on several occasions in July 1969.

Melithreptus brevirostris (Vigors & Horsfield)
Brown-headed Honeyeater

Status uncertain. Generalising for the Swan River district, Alexander (1921, Emu 20: 167) called it an uncommon resident, but there is only one record for our area, namely Alexander's observation of a bird in a flowering Templetonia retusa near the Swanbourne Rifle Range in July 1919 (Serventy, 1948, Emu 47: 283).

Melithreptus lunatus chloropsis Gould
White-naped Honeyeater

In the tuart belt, from Yanchep south to Crawley, formerly a common resident (Alexander, 1921, Emu 20: 167; Lipfert, 1937, Emu 37: 133), but now only a sporadic visitor, observed by Lindgren (1954, West. Aust. Nat. 4: 93; and 1956,

West. Aust. Nat. 5: 142) in the University grounds at Nedlands in October 1953 (one bird) and August 1954 (3 birds). On the upper reaches of the Swan River, possibly resident in past (recorded at Guildford by Ashby, 1901, Trans. R. Soc. S. Aust. 25: 134 and Hill, 1904, Emu 3: 228), but now only a sporadic visitor, ca 8 birds observed by Heron (1970, Emu 70: 158) in flooded gums at Middle Swan in March and June 1964.

Phylidonyris novaehollandiae (Latham)
New Holland Honeyeater

Common; usually in small parties. Thickets of Adenanthos, Melaleuca, Regelia and Pultenaea around swamps and along watercourses; also Banksia woodlands, Dryandra heaths, open eucalypt forests (when marri and tuart flowering) and suburban parks and gardens. Breeding from August to October; C/2(5), 3(1).

Phylidonyris nigra mystacalis (Gould)
White-cheeked Honeyeater

Moderately common; usually in small parties. Mainly towards coast in thickets of Dryandra sessilis, Acacia pulchella and Xanthorrhoea and in low woodlands of Banksia prionotes and B. menziesii; also central and eastern zones in Adenanthos and other waterside thickets. Breeding from August to November; C/2(6), 3(1).

Phylidonyris melanops (Latham)
Tawny-crowned Honeyeater

Coastal limestone belt, south at present to Mullaloo, formerly to Fremantle (Gould, 1865, Bds Aust. 1: 495). Uncommon. Dryandra sessilis and other heaths. Breeding in August; C/2(2).

Acanthorhynchus superciliosus Gould
Western Spinebill

Common; usually in ones or twos. Mainly banksia woodlands of central and western zones, especially at flowering B. menziesii and B. ilicifolia; commonly visiting other formations in search of flowering shrubs (Adenanthos, Xanthorrhoea, Scaevola crassifolia); occasionally visiting suburban gardens, where it is attracted to flowering Bougainvillaea, Hibiscus and other exotic plants. Breeding from August to November; C/1(3), 2(6).

Manorina flavigula (Gould)
Yellow-throated Miner

At present south to Whitford Beach, Duncraig and Mussel Pool; formerly south to Herdsman Lake (nest and 2 eggs, WAM 1376, and female and 3 young, WAM 1621-4, collected by T. Ostle in November 1899), to Bayswater (specimen collected by Ashby, 1901, Trans. R. Soc. S. Aust. 25: 134, in August 1901), and to Guildford (noted in 1902-03 as "not very common" by Hill, 1904, Emu 3: 228). Moderately common in western and central zones, in small parties; scarce in eastern zone north of Muchea; only a rare visitor (Heron, 1970, Emu 70: 158) to eastern zone south of Muchea. Mainly banksia woodlands; also tuart, jarrah-marri and melaleuca woodlands. Breeding from August to October; C/2(1), 3(5).

Anthochaera chrysoptera lunulata Gould
Little Wattlebird

At present ordinarily south to Wanneroo and Mussel Pool, and only a rare visitor to Kings Park and other localities close to city; formerly breeding south to Swanbourne (nest and fledgling found by A.G. Kilpatrick on 20 September 1938), Perry Lakes (egg, WAM A13605, collected by A.H. Robinson on 5 August 1922), and Lockridge (nest and egg found on 29 September 1903 by Hill, 1904, Emu 3: 228). Common in central

zone and inland better-wooded parts of western zone; scarce in eastern zone north of Upper Swan; absent from eastern zone south of Upper Swan and east of Mussel Pool, and from western zone west of tuart belt. Mainly banksia woodlands and flowering banksias in eucalypt woodlands; also visiting Dryandra sessilis thickets and flowering tuarts and marris. Breeding from August to October; C/1(10).

Anthochaera carunculata (White)
Red Wattlebird

Common; usually in ones or twos; during migration in flocks (up to 100). Mainly eucalypt and banksia woodlands, where attracted to flowering Banksia menziesii, B. ilicifolia, B. grandis, Eucalyptus gomphocephala and Anigozanthos manglesii; also melaleuca and acacia thickets and suburban parks and gardens (where attracted to flowering Erythrina indica and Callistemon viminalis). Breeding from late July to early December; C/2(11); parasitised by Cuculus pallidus (2 records).

Serventy (1937, Emu 37: 92) and Heron (1970, Emu 70: 158) have observed passage movements northwards from April to June and southwards from August to October or November; Heron's observations were made at Middle Swan in the eastern zone; perhaps Serventy's were made in the same zone. In the eastern zone at Guildford in 1902-03 Hill (1904, Emu 3: 228) found it very plentiful at times but scarce from May to August, and he observed that when they were not breeding they gathered into flocks, sometimes of large size. All of R.P. McMillan's records at Guildford in 1962-67 fall into the period September-December except for one observation in May. In the central and western zones there is no evidence for movements.

Epthianura albifrons (Jardine & Selby)
White-fronted Chat

Moderately common non-breeding visitor (August-May, mostly January-early April); usually in small flocks. Mainly bare or open flats around lakes and swamps and along the Swan River; also sparsely vegetated coastal dunes.

Epthianura tricolor Gould
Crimson Chat

Formerly a rare visitor, but no records for more than 50 years. Alexander (1921, Emu 20: 160) said that it sometimes visited the coastal hills with flocks of E. albifrons; he later told Serventy (1948, Emu 47: 279) that he had occasionally seen it on the Cottesloe Golf Course. A male specimen (WAM 512) was collected at Cottesloe in 1898.

FRINGILLIDAE

Carduelis carduelis (Linnaeus)
Goldfinch

Exotic species, formerly established in Perth, suburbs and adjacent farmlands north to Wanneroo and Herne Hill. First observed in October 1933 (Jenkins, 1959, Emu 59: 204), spreading slowly but still not plentiful by 1948 (Serventy, 1948, Emu 47: 286), beginning to decline after 1963 (Serventy & Whittell, 1976, Bds West. Aust., p.429), and not recorded after 16 August 1969 (when G.M. Storr saw 2 flying over Wembley).

PLOCEIDAE

[Emblema oculatum (Quoy & Gaimard)
Red-eared Firetail

Possibly a rare inhabitant of waterside thickets in far south of area in John Gilbert's time (Serventy, 1948, Emu 47: 284).]

Lonchura castaneothorax castaneothorax (Gould)
Chestnut-breasted Mannikin

Exotic species, becoming established in the Osborne Park-Herdsman Lake area (N. Kolichis, 1978, West. Aust. Nat. 14: 51).

STURNIDAE

Sturnus vulgaris vulgaris Linnaeus
Common Starling

Status uncertain: possibly a rare winter visitor from southeastern Australia and Tasmania. One record: a male specimen (WAM A4736) collected by I. Edgar on 1 September 1936 at 3 km N of Gingin.

GRALLINIDAE

Grallina cyanoleuca (Latham)
Magpie-lark

In past only or mainly an autumn-winter visitor. Established as a breeding species in eastern zone by at least 1915 and about some swamps in central and western zones by 1923. At present common in eastern zone as a resident (usually in pairs) and as an autumn-winter visitor (usually in flocks, up to 64); and uncommon to moderately common and patchily distributed in central zone and eastern parts of western zone (Yanchep, Lake Neerabup, Lake Adams, Lake Joondalup, Lake Jandabup, Melaleuca Park, Mussel Pool, Bayswater, Queens Gardens, Shenton Park, Crawley and Lake Claremont). Bare or sparsely vegetated flats, pastures and lawns in vicinity of water. Breeding from August to November; C/3(2), 4(3).

The birds observed by Milligan (1903, Emu 3: 21) at Yanchep in late December 1902 were possibly drought refugees; at any rate none were observed here by D.L. Serventy in 1923 or 1924.

ARTAMIDAE

Artamus personatus (Gould)
Masked Wood-swallow

Rare visitor. One acceptable record: large flocks flying high over the Helena River in October 1972 (Serventy & Whittell,

1976, Bds West. Aust., p.442). Observations about Perth by A.W. Milligan (cited by Serventy, 1948, Emu 47: 281) and by Tingay & Tingay (1976) at Lake Chandala probably refer to other species of Artamus.

Artamus cinereus melanops Gould
Black-faced Wood-swallow

Moderately common autumn-winter visitor (March to September), usually in small flocks (up to 20); uncommon resident, south to Wanneroo and Mussel Pool, usually in pairs. Mainly coastal heaths in western zone (where it is attracted to seeding Xanthorrhoea) and lightly wooded grasslands in eastern zone; also burnt country and open flats about swamps in central zone. Breeding in October and November; C/2(1), 3(1), 4(1).

Artamus cyanopterus (Latham)
Dusky Wood-swallow

Scarce autumn-winter visitor or passage migrant; usually in small flocks, but on 7 July 1968 R.P. McMillan saw a flock of ca 200 at Guildford. Possibly resident in very small numbers in better wooded northern parts of area, where G. Harold observed it in the same tuart woodland in the Yanchep National Park in August and December 1977, and R.E. Johnstone saw a pair in marri-melaleuca woodland 2 km S of Lake Beermullah on 24 January 1978.

CRACTICIDAE

Cracticus torquatus torquatus (Latham)
Grey Butcherbird

Common; usually in ones or twos. All kinds of forest, woodland, scrub or thicket. Breeding from September to early November; C/2(3), 3(6).

Cracticus tibicen dorsalis (Campbell)
Magpie

Common; usually in family parties (average size of flocks in Kings Park in 1938 was 9 birds, fide Wilson, 1946, Emu 46: 233). Mainly in man-made habitats, such as pastures, farms, parks and road verges; also naturally open areas such as the flats around lakes and swamps. Breeding from August to November (the only November record is a second clutch reported by Hill, 1904, Emu 3: 227); C/2(1), 3(4), 4(1); Wilson (supra) found nests with 3 and 4 eggs equally frequent and nests with fewer or more eggs rare.

Strepera versicolor plumbea Gould
Grey Currawong

A declining species, now scarce and largely confined to north of area. Formerly occurring in the tuart belt of western zone from Yanchep south to the Swan River; it bred at Herdsman Lake in 1900 (nest and young, WAM 2759, collected by T. Ostle in November) and was seen between Jolimont and Perry Lakes as late as 1919 (Alexander, 1921, J. Proc. R. Soc. West. Aust. 6: 48). Since 1924 (when D.L. Serventy saw one at Yanchep) it has only been recorded at Balga (where G.W. Kendrick observed a pair nesting in 1974) and in far north of area: Ford & Teague (1959, Emu 59: 92) saw one on lower Gingin Brook in 1957; G. Harold noted a pair in a melaleuca swamp on the South Gingin Proposed Reserve on several occasions between June 1977 and March 1978; and J.R. Ford (pers. comm.) saw one in damp melaleuca-marri woodland 10 km S of Gingin in May and June 1978.

CORVIDAE

Corvus bennetti North
Little Crow

Moderately common visitor and passage migrant (August-May, mostly January-March); in flocks (up to some hundreds). Mainly farmlands of eastern zone; but also visiting piggeries and open country around lakes in central zone and eastern parts

of western zone.

Corvus coronoides perplexus Mathews
Australian Raven

Common; usually in ones or twos. All kinds of lightly wooded country; also farmlands. Breeding from August to October; C/3(1).

[Corvus splendens Vieillot
House Crow

Although it is occasionally transported on ships from Asia to Fremantle, it has never become established here. The Western Australian Museum has received 6 specimens from Fremantle (collected in July 1945, December 1950 and August 1960) and one from Claremont (April 1951).]

DISCUSSION

Ecological status of the avifauna

The avifauna of the area, past and present, consists of 223 species and possibly an additional 10 species that occurred here in colonial times. This fauna is enumerated under various categories of ecological status. In the table below, each species is only counted once. Where a species belongs to more than one category it is allotted to the higher, e.g. to "breeding visitor" even when most visiting individuals do not breed in the area. Numbers in parentheses refer to additional species that may have occurred in the area; they were formerly found on the coastal plain near Perth, but definite records from north of the Swan River are lacking. The count for exotic species excludes such commensals of man as the domestic pigeon, domestic ducks and domestic goose.

	Non-Passerines	Passerines	Total
Residents	52(3)	48(7)	100(10)
Breeding Visitors	14	5	19
Non-breeding Visitors	73	10	83
Vagrants	12	2	14
Established Exotics	5	2	7
Total	156(3)	67(7)	223(10)

Changes in abundance

European settlement has affected all birds to some extent, but we shall notice here only those species whose status has substantially changed.

First there are the birds that have become locally extinct, viz. Painted Snipe (Rostratula benghalensis), Red-tailed Black Cockatoo (Calyptorhynchus magnificus), Long-billed Corella (Cacatua tenuirostris pastinator), Pacific Gull (Larus pacificus) and Crested Shrike-tit (Falcunculus leucogaster). To these we add the species whose former occurrence is not proved but which are certainly absent from the area now: Brush Bronzewing (Phaps elegans), Ground Parrot (Pezoporus wallicus), Western Whipbird (Psophodes nigrogularis), Bristlebird (Dasyornis brachypterus), and Red-eared Firetail (Emblema oculatum). Then there are the species that are locally on the verge of extinction, if not already extinct: Black Bittern (Ixobrychus flavicollis), Bush Stone-curlew (Burhinus grallarius), Barking Owl (Ninox connivens) and White-breasted Robin (Eopsaltria georgiana).

Another class comprises the species whose numbers have seriously diminished this century: Brown Bittern (Botaurus stellaris), Freckled Duck (Stictonetta naevosa), Blue-winged Shoveler (Anas rhynchotis), Musk Duck (Biziura lobata), Marsh Harrier (Circus aeruginosus), Brown Falcon (Falco berigora), Whiskered Tern (Sterna hybrida), Fairy Tern (Sterna nereis), Scarlet Robin (Petroica multicolor), Yellow Robin (Eopsaltria australia), Golden Whistler (Pachycephala caledonica),

Restless Flycatcher (Myiagra inquieta), Red-winged Fairy-wren (Malurus elegans), Southern Emu-wren (Stipiturus malachurus), Rufous Tree-creeper (Climacteris rufa), Yellow-plumed Honeyeater (Meliphaga ornata), White-naped Honeyeater (Melithreptus lunatus) and Grey Currawong (Strepera versicolor).

Most of the birds that have become rare or extinct inhabit one or other of two biomes: the wetlands and the forests. And most of the birds that have declined in the wetlands depended greatly on the vegetation in or fringing the swamps and lakes. For example, the melaleuca forests and thickets would have provided shelter and nest sites for the Black Bittern, Freckled Duck, Blue-winged Shoveler and Barking Owl, and optimum habitat for the Golden Whistler, Restless Flycatcher, Red-winged Fairy-wren and Red-eared Firetail. Some melaleuca forests and thickets have been cut for fence posts and cleared for summer grazing; and some have disappeared through drainage, fire and land-fill or were drowned through rising water-table in the 1930s (when, for example, Butlers Swamp became Lake Claremont). Other birds gravely affected by the reduction or deterioration of wetlands are the Brown Bittern, Marsh Harrier, Painted Snipe, Whiskered Tern, Southern Emu-wren and possibly the Ground Parrot.

The principal dryland forests on the coastal plain were of tuart (Eucalyptus gomphocephala), marri (E. calophylla), wandoo (E. wandoo) and jarrah (E. marginata). The best of them have been felled for timber or cleared for farming, vineyards and market gardens. The remnants are apparently inadequate for supporting viable populations of the Scarlet Robin (as a breeding species), Yellow Robin, Crested Shrike-tit, Rufous Tree-creeper, Yellow-plumed Honeyeater, White-naped Honeyeater, Dusky Wood-swallow and Grey Currawong.

For most of the remaining species that are locally extinct or considerably reduced in numbers there is no ready explanation. However the decline of the Pacific Gull and Fairy Tern is almost certainly due to the explosive increase in the Silver Gull. Similarly the decline in the Western Rosella (and recently of the Regent Parrot) is probably related to the increase in the Ringnecked Parrot. The decline in the Brown Falcon coincides with the use of DDT in southwestern Australia, and that of the Bush Stone-curlew with the arrival of the Red

Fox.

On the credit side, the clearing of forests and woodlands, the establishment of pastures and the increase in damp or inundated grasslands have permitted several species, originally unknown in the region, to become established, viz. the Great Egret, Strawnecked Ibis, Sacred Ibis, Wood Duck, Black-shouldered Kite, Banded Plover, Crested Pigeon, Regent Parrot, Elegant Parrot and Galah. At the same time open-country birds in general have increased, notably the White-faced Heron, Richard's Pipit, Magpie-lark, Black-faced Wood-swallow, Magpie and Australian Raven. Other species benefiting from European settlement are the Silver Gull, Carnaby's Cockatoo and Grey-breasted White-eye (whose food supply has been greatly increased, respectively by the dumping of garbage, the planting of pines and the cultivation of berry-producing shrubs and trees) and the Welcome Swallow (buildings have provided it with many more nest sites than were available naturally).

Vulnerability of the birds

By and large the birds of the banksia-dominated sandplains have been least affected by European man. The infertility of these sandplains have largely restricted their utilisation to urban development and pine plantations.

As we have seen, it is the wetland birds that have been most affected by man. All of his manipulations of wetlands tend to reduce the original diversity of the flora and invertebrate fauna and thus also the diversity of the birds. The most serious of these activities are the replacement of natural water-land interfaces by retaining walls (such as thosealong the lower Swan River and around many city and suburban lakes) the removal of rushes, sedges and dead trees, and the replacement of waterside flats with lawns.

Away from the wetlands subject to local government "beautification", the waterfowl are threatened by the increasing use of ground water and inevitable lowering of the water-table. Especially vulnerable are the inhabitants of deeper waters: the Musk Duck, Blue-billed Duck, Freckled Duck, Blue-winged Shoveler and Great Crested Grebe.

APPENDIX I

Lake Jandabup

Annotated List of Wetland Birds

This list is based on visits by R.E. Johnstone on 29 March, 15 April, 20 May, 24 May, 30 June, 15 September, and 7 December 1977, and 19 January, 16 February, 30 March and 26 April 1978, and by G. Harold on 3 November 1977. Note that this period was one of severe drought. The surrounding swamps were dry, including the one where Jenkins (1971, West. Aust. Nat. 11: 188) saw a party of 15 Sacred Ibis on 5 February 1970. The only evidence of breeding was three broods of young Black Ducks.

Black-throated Grebe (Podiceps novaehollandiae). Up to 10 birds seen per visit on open water.

Hoary-headed Grebe (P. poliocephalus). Up to 20 birds on open water.

Australian Pelican (Pelecanus conspicillatus). Up to 45 birds on open water, from December to March. Probably visiting lake only for bathing and resting.

Little Black Cormorant (Phalacrocorax sulcirostris). Up to 10 birds perching on partly submerged fence posts.

Great Cormorant (P. carbo). One bird seen on most visits.

Little Pied Cormorant (P. melanoleucos). Up to 7 birds seen, usually perched on partly submerged fence posts.

White-faced Heron (Ardea novaehollandiae). Up to 6 birds feeding in shallows or on mudflats.

Great Egret (Egretta alba). Up to 2 birds feeding in open shallows.

Sacred Ibis (Threskiornis aethiopicus). Up to 55 birds seen, usually feeding in shallows among beds of Cladium. This lake is a favourite haunt of these birds, and perhaps they breed here (two dull-plumaged immatures were observed).

Strawnecked Ibis (T. spinicollis). Up to 70 birds were seen, mainly on flats and in shallows among Cladium.

Yellow-billed Spoonbill (Platalea flavipes). On 20 May 1977 four birds were feeding in 20-30 cm of water among Cladium junceum growing on sandy bottom.

Black Swan (Cygnus atratus). Up to 20 birds seen on open water.

Mountain Duck (Tadorna tadornoides). Up to 81 birds counted. Their number built up in summer, but possibly they only bathe here.

Black Duck (Anas superciliosa). Up to 306 birds counted, the largest flocks from January to April 1978. In December 1977 broods of 3, 5 and 8 fledglings were seen.

Grey Teal (Anas gibberifrons). Up to 300 birds seen. The largest flocks were observed in autumn 1977; numbers fell away in the following winter and remained low for the rest of the study (e.g. from December 1977 to March 1978 not more than 4 birds were seen per visit).

Blue-winged Shoveller (Anas rhynchotis). Only recorded on one visit: 3 pairs on open water on 20 May 1977.

Hardhead (Aythya australis). Only seen on one visit: a single bird on open water on 20 May 1977.

[Green Pygmy Goose (Nettapus pulchellus). This rare vagrant from northern Australia was not observed in 1977-78. Two birds were seen here by B.D. Bond in March 1976.]

Blue-billed Duck (Oxyura australis). Only seen on two visits: one on 30 June and two on 15 September 1977.

Musk Duck (Biziura lobata). Up to 7 birds seen.

Marsh Harrier (Circus aeruginosus). The pair at the lake are possibly resident. They were usually beating over the beds of Cladium or open water. On 30 June 1977 one of them was eating a half-grown turtle (Chelodina oblonga); as the turtle was still wriggling, the hawk had evidently captured it alive.

Spotless Crake (Porzana tabuensis). Up to 3 pairs feeding in beds of Cladium.

Swamphen (Porphyrio porphyrio). Up to 21 birds were seen, mainly feeding in or near the beds of Cladium, but also visiting mudflats, patches of cultivation and young grass growing on peat. This species is probably increasing as the lake becomes shallower and the Cladium articulatum spreads. The stomach of a specimen collected on 30 June 1977 contained wasp, beetle and plant fragments and grains of sand.

Coot (Fulica atra). Up to 110 birds feeding on open water, among beds of Cladium and on a grassy bank. Maximum numbers in late autumn, the birds largely deserting the lake in winter.

Banded Plover (Vanellus tricolor). Only seen on one visit: 2 birds on dry mud on 26 April 1978.

Red-capped Plover (Charadrius ruficapillus). Up to 15 birds on sandy flats in autumn of both years.

Black-fronted Plover (C. melanops). Up to 1 birds on mudflats, dry peat and a sandy spit.

Greenshank (Tringa nebularia). Up to 5 birds in shallows and on drying margins of lake. Only seen in summer and autumn.

Sharp-tailed Sandpiper (Calidris acuminata). Flocks of 8 and 25 on sand and mud flats in autumn 1977.

Black-winged Stilt (Himantopus himantopus). Up to 28, usually feeding in shallow water over sand.

Banded Stilt (Cladorhynchus leucocephalus). Observed only on one visit: 2 in shallow water on 30 March 1978.

White-winged Black Tern (Sterna leucoptera). Two were diving in shallow water on 26 April 1978.

Clamorous Reed Warbler (Acrocephalus stentoreus). Several birds inhabit the beds of Cladium articulatum and C. junceum.

Little Grassbird (Megalurus gramineus). Several birds inhabit the beds of Cladium articulatum.

Discussion

The lake includes the following wetland habitats:

1. Open water, up to 1.5 m deep (ca 40% of the lake)
2. Dense beds of Cladium articulatum (ca 45%)
3. Open beds of Cladium junceum (ca 8%)
4. Mudflats, sandspits and low sedges (ca 7%).

The open parts of the lake mostly lie over a sandy bottom; there is only a little clay and peat. The water is shallow, fairly clear and relatively deficient in algae and aquatic angiosperms. Hence it supports few diving ducks (Hardhead, Blue-billed and Musk Duck). The open water serves mainly as a temporary refuge for transient Hoary-headed Grebes, Pelicans, Mountain Ducks, Black Ducks, Grey Teal and White-winged Black Terns. The water is fresh and evidentaly favoured for bathing.

The beds of Cladium support good numbers of ibises (Sacred and Strawnecked), rallids (Swamphen, Coot and Spotless Crake), Reed Warblers and Little Grassbirds and a pair of Marsh Harriers. They also provide the only nesting sites for ducks.

The shallows around the lakes are inhabited by White-fronted Herons, Great Egrets, Greenshanks and Black-winged Stilts. The sand and mud flats attract Red-capped and Black-fronted Plovers.

A glance at the bird counts in Appendix II shows that Lake Jandabup is about average for coastal plain wetlands with respect to the diversity and abundance of its waterfowl. Its main deficiencies are deep water, muddy bottoms, bulrushes (Typha), paperbarks (Melaleuca spp.), flooded gums (Eucalyptus rudis), and thus nest sites for hole-nesting ducks and tree-nesting herons and cormorants.

Jandabup is the largest remaining lake in the Bassendean System, but unfortunately it is changing into a fen. It is therefore necessary to at least maintain the present water levels and to arrest the spread of the sedge Cladium articulatum. Because it is surrounded by farmlets and other habitation, the lake is vulnerable to dogs and other predators and to gross disturbance by people and browsing horses, cattle and pigs. The excavation of ditches would not only provide deep water but would restrict the growth of Cladium articulatum and render some security to enclosed vegetation and fauna. The value of the lake would be enhanced by the planting of wetland trees and shrubs.

APPENDIX II

MAXIMUM COUNTS OF WETLAND BIRDS AT LAKES STUDIED IN 1977-78

Counts or estimates were complete only at Lakes Beermullah, Bambun, Chandala and Jandabup; counts at Loch McNess were only made at the southern end of the lake, and at Lake Joondalup only at three points; good counts were made at Lake Guraga on only two occasions. Although Lake Guraga lies a little to the north of our area, its fauna is believed to be representative of the saltlakes of the region.

	Guraga	Beermullah	Bambun	Chandala	McNess	Joondalup	Jandabup
Black-throated Grebe	-	50	37	6	8	69	10
Hoary-headed Grebe	-	100	300	5	2	106	20
Great Crested Grebe	-	4	1	1	-	15	-
Australian Pelican	-	57	-	-	1	10	45
Little Black Cormorant	-	67	10	6	8	32	10
Great Cormorant	-	-	4	-	1	7	1
Little Pied Cormorant	-	-	10	2	1	5	7
Darter	-	-	-	-	-	1	-
Pacific Heron	-	-	8	10	1	2	-
White-faced Heron	-	2	20	23	2	10	6
Great Egret	-	20	9	4	-	5	2
Rufous Night Heron	-	-	1	2	-	-	-
Little Bittern	-	-	-	-	1	-	-
Sacred Ibis	-	5	5	4	-	25	55
Straw-necked Ibis	-	10	200	60	-	25	70
Royal Spoonbill	-	-	4	-	-	-	-
Yellow-billed Spoonbill	2	20	-	10	-	2	4
Black Swan	5000	350	20	10	20	250	20
Freckled Duck	-	-	6	-	-	-	-
Mountain Duck	5000	2000	27	6	29	115	81
Black Duck	-	-	200	-	200	125	306
Mallard	-	-	-	-	-	8	-
Grey Teal	-	-	-	-	50	336	300

	Guraga	Beermullah	Bambun	Chandala	McNess	Joondalup	Jandabup
Chestnut Teal	-	-	5	-	-	12	-
Blue-winged Shoveler	-	10	12	1	-	22	6
Pink-eared Duck	5000	210	200	-	-	39	-
Hardhead	-	11	3	2	-	20	1
Wood Duck	-	-	-	2	2	24	-
Blue-billed Duck	-	80	50	-	3	10	2
Musk Duck	-	10	20	-	-	30	7
Marsh Harrier	-	-	-	-	1	2	2
Spotless Crake	-	-	-	-	1	-	6
Swamphen	-	-	1	-	2	5	21
Black-tailed Native Hen	-	-	-	-	-	1	-
Dusky Moorhen	-	-	-	-	1	4	-
Coot	1000	170	80	60	50	622	110
Banded Plover	-	-	-	-	-	-	2
Red-capped Plover	33	28	-	-	-	-	15
Mongolian Sand Plover	-	1	-	-	-	-	-
Black-faced Plover	-	9	6	6	-	22	10
Red-kneed Plover	-	-	-	2	-	-	-
Greenshank	-	-	-	-	-	2	5
Wood Sandpiper	-	-	-	-	-	2	-
Common Sandpiper	-	3	1	-	-	1	-
Red-necked Stint	-	15	-	-	-	-	-
Sharp-tailed Sandpiper	15	-	-	-	-	-	25
Curlew Sandpiper	8	6	-	-	-	-	-
Black-winged Stilt	100	20	-	15	20	107	28
Banded Stilt	75	8	-	-	-	18	2
Red-necked Avocet	43	26	16	-	-	70	-
Caspian Tern	-	1	-	-	-	-	-
Whiskered Tern	-	-	-	-	-	2	-
White-winged Black Tern	-	-	-	-	-	-	2

Note: the Clamorous Reed Warbler and the Little Grassbird were recorded on Bambun, McNess, Joondalup and Jandabup, and the Clamorous Reed Warbler on Beermullah, but it was not possible to estimate their numbers.

	Guraga	Beermullah	Bambun	Chandala	McNess	Joondalup	Jandabup
Chestnut Teal	-	-	5	-	-	12	-
Blue-winged Shoveler	-	10	12	1	-	22	6
Pink-eared Duck	5000	210	200	-	-	39	-
Hardhead	-	11	3	2	-	20	1
Wood Duck	-	-	-	2	2	24	-
Blue-billed Duck	-	80	50	-	3	10	2
Musk Duck	-	10	20	-	-	30	7
Marsh Harrier	-	-	-	-	1	2	2
Spotless Crake	-	-	-	-	1	-	6
Swamphen	-	-	1	-	2	5	21
Black-tailed Native Hen	-	-	-	-	-	1	-
Dusky Moorhen	-	-	-	-	1	4	-
Coot	1000	170	80	60	50	622	110
Banded Plover	-	-	-	-	-	-	2
Red-capped Plover	33	28	-	-	-	-	15
Mongolian Sand Plover	-	1	-	-	-	-	-
Black-faced Plover	-	9	6	6	-	22	10
Red-kneed Plover	-	-	-	2	-	-	-
Greenshank	-	-	-	-	-	2	5
Wood Sandpiper	-	-	-	-	-	2	-
Common Sandpiper	-	3	1	-	-	1	-
Red-necked Stint	-	15	-	-	-	-	-
Sharp-tailed Sandpiper	15	-	-	-	-	-	25
Curlew Sandpiper	8	6	-	-	-	-	-
Black-winged Stilt	100	20	-	15	20	107	28
Banded Stilt	75	8	-	-	-	18	2
Red-necked Avocet	43	26	16	-	-	70	-
Caspian Tern	-	1	-	-	-	-	-
Whiskered Tern	-	-	-	-	-	2	-
White-winged Black Tern	-	-	-	-	-	-	2

Note: the Clamorous Reed Warbler and the Little Grassbird were recorded on Bambun, McNess, Joondalup and Jandabup, and the Clamorous Reed Warbler on Beermullah, but it was not possible to estimate their numbers.

APPENDIX III

THE WETLAND BIRDS OF SUBURBAN LAKES, PAST AND PRESENT

X signifies that the species has been recorded, and B that it has bred.

	Herdsman	Monger	Claremont
Black-throated Grebe	B	X	B
Hoary-headed Grebe	X	X	B
Great Crested Grebe	X	B	X
Australian Pelican		X	X
Little Black Cormorant	X	X	X
Great Cormorant	X	X	X
Pied Cormorant		X	
Little Pied Cormorant	X	X	X
Darter	X	X	
Pacific Heron	X	X	
White-faced Heron	B		X
Great Egret	X		X
Rufous Night Heron	X	X	X
Little Bittern	B	X	B
Black Bittern	X	X	
Brown Bittern	B		
Sacred Ibis	X		
Straw-necked Ibis	X		X
Glossy Ibis	X		
Royal Spoonbill	X		
Black Swan	B	B	B
Freckled Duck	X	X	
Mountain Duck	B	X	X
Black Duck	B	B	B
Grey Teal		X	B
Blue-winged Shoveler	B	X	X
Pink-eared Duck	X	X	B
Hardhead	B	B	B
Wood Duck	X	X	
Blue-billed Duck	B	B	B
Musk Duck	B	B	B
Marsh Harrier	B	X	X

	Herdsman	Monger	Claremont
Banded Land Rail		X	X
Baillon's Crake	X		B
Spotted Crake	B	X	
Spotless Crake	B		X
Swamphen	B	B	B
Black-tailed Native Hen	B	X	B
Dusky Moorhen	B	X	B
Coot	B	X	B
Painted Snipe		X	
Red-capped Plover	X		
Black-fronted Plover	B		B
Eastern Curlew	X	X	
Wood Sandpiper	X		
Red-necked Stint	X		
Sharp-tailed Sandpiper	X		
Curlew Sandpiper	X		
Black-winged Stilt	B	X	X
Banded Stilt			X
Red-necked Avocet	X		X
Silver Gull		X	X
Caspian Tern		X	
Whiskered Tern	B		
White-winged Black Tern	X	X	
Clamorous Reed Warbler	B	X	B
Little Grassbird	B		B

THE AMPHIBIANS AND REPTILES OF THE NORTHERN SWAN COASTAL PLAIN

By G.M. Storr[1], G. Harold[1] and G. Barron[2]

INTRODUCTION

This is an annotated list of the 70 species of amphibians and reptiles recorded from that area bounded in the north by the Moore River, in the south by the Swan and Helena Rivers, in the east by the Darling Scarp, and in the west by the Indian Ocean. It is based on the collections of the Western Australian Museum, the literature (cited in the Bibliography), and observations by G. Barron (G.B.), Mrs K. Farmer (K.F.), G. Harold (G.H.), R.E. Johnstone (R.E.J.), G.M. Storr (G.M.S.) and S. Wilson (S.W.).

In this list we try to give for each species some idea of its relative abundance, habitat preferences, and distribution (in zonal as well as geographic terms). In assessing relative abundance we have taken into account variation between species in the ease with which they are observed or captured. It has often been difficult to generalize on habitat preference; for, apart from the material collected by Harold and Barron during the Gnangara Mound Project (April 1977 to March 1978), most specimens from the area are unaccompanied by ecological data.

---

[1] Dept of Ornithology and Herpetology, Western Australian Museum, Francis Street, Perth, W.A.

[2] Dept of Mammalogy and Survey, Western Australian Museum, Francis Street, Perth, W.A.

As a pointer to zonal preferences, and as a measure of relative abundance, we list all the localities from north to south in which each species has been collected and observed, giving in parentheses the number of specimens from each locality. This includes, where data are available, collections other than those of the Western Australian Museum. In the past, many specimens donated to the Museum were catalogued even though they were not retained; we include such specimens in our counts whenever we are satisfied that the locality applies to the specimens (rather than to the donor) and that specimens were correctly identified.

The coastal plain can be divided into three longitudinal zones: the eastern, central and western. The eastern consists largely of the valleys and floodplains of the Helena, Swan and Moore Rivers, Ellen and Gingin Brooks, Red Gully Creek, and several small streams flowing out of the Darling Range. As the soils consist mainly of fertile loams and clays, much of the zone has been cleared for pastoral and horticultural purposes. However, the Flooded Gums (Eucalyptus rudis) and paperbarks (Melaleuca spp.) that fringed the watercourses, swamps and lakes of the zone have to a large extent survived development.

The central zone comprises the deep white sands of the Bassendean System. They were originally covered with heathy vegetation from which tall shrubs (especially Banksia spp.) and low trees emerged. Much of the zone has been cleared for Perth and its suburbs, pine plantations, and small farms (especially around the numerous freshwater lakes and seasonal swamps).

The western zone is underlain by aeolian limestone, which outcrops here and there in cliffs along the coast and lower

Swan River and on ridges in the Wanneroo - Yanchep district. The inland, sheltered parts of this zone support an open forest of Tuart (Eucalyptus gomphocephala). Towards the sea the vegetation becomes heath-like. Most of the coast is backed by sand dunes.

In the discussion the herpetofauna of the area is briefly analysed with respect to its zoogeography and vulnerability to environmental change.

SYSTEMATIC LIST

LEPTODACTYLIDAE (Ground Frogs)

Crinia georgiana Tschudi

Confined to eastern zone, north to Gingin.

Specimens: Gingin, including town and Molecap Creek (14); east of Gnangara (2); Guildford (1).

Heleioporus barycragus Lee

Confined to the eastern zone, north to Bullsbrook.

Specimens: "foothills near Bullsbrook" (1); Martyn Reserve, Ellen Brook (1); bottom of Red Hill (6); Middle Swan (3); Caversham Recreation Reserve (7); Swan View (3).

Heleioporus eyrei (Gray)

Very common in or near sandy winter swamps.

Specimens: Mission Lake, Moore River National Park (1); 24 km NW of Gingin (1); 3 km S of Gingin (1); South Gingin Proposed Reserve (4); Yanchep National Park (14); Neerabup National Park (3); Melaleuca Park (5); Bullsbrook (1);

Warbrook (2); 4 km N of Wanneroo (1); Wanneroo (1); Gnangara (1); Lake Gnangara (11); east of Gnangara (7); Mussel Pool (8); Herne Hill (1); Middle Swan (7); Swan View (1); Caversham (20); Guildford (2); Inglewood (2); Herdsman Lake (3); Wembley Downs (2); Lake Claremont (44); Kings Park (1); Crawley (2); Dalkeith (3).

Observations: Lake Joondalup (R.E.J.).

Heleioporus psammophilus Lee & Main

Confined to eastern zone.

Specimens: Swan View (3); Caversham (1).

Limnodynastes dorsalis (Gray)

Common in or near freshwater swamps and lakes.

Specimens: Beermullah (1); South Gingin Proposed Reserve (2); Yanchep National Park (13); Neerabup National Park (6); Melaleuca Park (1); Gnangara Lake (4); North Beach (3); Mussel Pool (7); North Midland (1); Caversham (4); Guildford (1); Osborne Park (1); Mt Lawley (8); Nedlands (2); North Perth (1); Leederville (1); Wembley (1); Subiaco (1); Lake Claremont (1); Cottesloe (1); Buckland Hill (1); North Fremantle (1).

Observations: Lake Jandabup (R.E.J.).

Myobatrachus gouldii (Gray)

Common in sandy parts of central and western zones; usually found below ground in termite-infested wood.

Specimens: Gingin (1); South Gingin Proposed Reserve (1); Wanneroo (2); 3 km S of Wanneroo (1); Wanneroo Research Centre (1); Craigie (1); Mussel Pool (7); Morley (2); Dianella (1);

Tuart Heights (1); Nollamara (2); Double View (1); Bassendean (1); Mt Hawthorn (1); Wembley Downs (1); City Beach (2); Reabold Hill (1); Floreat Park (1); Wembley (3); North Perth (1); Kings Park (2); Crawley (2); Nedlands (1); Dalkeith (1).

Neobatrachus pelobatoides (Werner)

Common. Confined to eastern zone.

Specimens: South Gingin Proposed Reserve (21); 8 km N of Bullsbrook (1); Twin Swamps Reserve (5); Martyn Reserve, Ellen Brook (4); Middle Swan (8); Caversham (128); 3 km N of Guildford (3).

Pseudophryne guentheri Boulenger

Moderately common in eastern and central zones; scarce futher west (Neerabup National Park).

Specimens: "banks of Moore River" (1); Moore River National Park (1); Gingin (1); South Gingin Proposed Reserve (5); Lake Nambung (1); Neerabup National Park (1); Melaleuca Park (4); Martyn Reserve, Ellen Brook (11); east of Gnangara (5); Mussel Pool (3); Middle Swan (6); Caversham (19); West Midland (2); Guildford (3).

Ranidella glauerti (Loveridge)

Common in eastern zone; moderately common in central zone.

Specimens: Mission Lake, Moore River National Park (4); Gingin (7); 7 km N of Muchea (1); Melaleuca Park (2); Gnangara (38); foot of Red Hill (29).

Observations: Loch McNess (G.H. and G.B.); Neerabup National Park (G.H.).

Ranidella insignifera (Moore)

Common in eastern zone; moderately common in central zone.

Specimens: Gingin (6); South Gingin Proposed Reserve (3); Lake Bambun (8); 7 km N of Muchea (3); Bullsbrook (5); Melaleuca Park (16); Martyn Reserve, Ellen Brook (3); Upper Swan (4); Mussel Pool (7); Red Hill road (46); Caversham (20); Midland (7).

Observations: Lake Jandabup (calling on 30 June 1977 - R.E.J.).

Ranidella pseudinsignifera (Littlejohn)

Rare [though common to immediate east]. Confined to foot of Darling Scarp, eastern zone.

Specimens: Bullsbrook (1); foot of Red Hill (1).

HYLIDAE (Tree Frogs)

Litoria adelaidensis (Gray)

Common in vicinity of permanent fresh water.

Specimens: Mission Lake, Moore River National Park (2); Gingin Brook East (1); Gingin (3); Yanchep National Park (13); Pearce (1); Martyn Reserve, Ellen Brook (1); 4 km N of Wanneroo (7); Wanneroo (7); Millendon (1); Mussel Pool (8); Osborne Park (14); Herdsman Lake (1); Lake Monger (1); Claremont (13).

Observations: 0.5 km S of Guilderton turnoff, Lancelin road (many calling - G.H. and G.B.); Lake Nowergup (G.H. and G.B.); Melaleuca Park (ca 20 calling at seasonal swamp, August 1977 - G.H. and G.B.).

Litoria moorei (Copland)

Very common in vicinity of permanent fresh water.

Specimens: Regans Ford (1); Gingin (2); Loch McNess (20); Martyn Reserve, Ellen Brook (3); 4 km N of Wanneroo (1); Wanneroo (2); Mussel Pool (8); Midland (1); North Beach (8); Balcatta Swamp (1); Dianella (7); Osborne Park (2); Bayswater (2); Mt Lawley (1); Perry Lakes (7); Lake Monger (6); East Perth (4); Causeway (133); Subiaco (4); Karrakatta (1); Lake Claremont (6); Cottesloe (1).

Observations: 0.5 km S of Guilderton turnoff, Lancelin road (many calling on 14 December 1977 - G.H. and G.B.).

CHELUIDAE (Side-necked Turtles)

Chelodina oblonga Gray

Common in permanent fresh water; also seasonal swamps.

Specimens: Guilderton (1); Lake Bambun (1); Lake Nowergup (1); near Bullsbrook (1); Lake Goollelal (2); West Swan (1); Midland (2); Bassendean (1); Bayswater (5); Maylands (1); Lake Monger (3); Hyde Park (3); Subiaco (1); East Perth (1); Queens Gardens (1); Shenton Park (12); Lake Claremont (2).

Observations: Lake Beermullah (common - R.E.J.); Lake Chandala (R.E.J.); Loch McNess (R.E.J.); Melaleuca Park (G.H. and G.B.); Lake Joondalup (common - R.E.J.); Lake Jandabup (R.E.J.); Mussel Pool (G.H.).

Pseudemydura umbrina Siebenrock

Rare. Confined to seasonal swamps along Ellen Brook, eastern zone.

Specimens: "Bullsbrook"(1); Twin Swamps Reserve (28); Martyn Reserve, Ellen Brook (4).

GEKKONIDAE (Geckos)

Crenadactylus ocellatus ocellatus (Gray)

Scarce. Confined to Tuart belt of western zone and to eastern zone.

Specimens: Yanchep National Park (2); Martyn Reserve, Ellen Brook (1); Wanneroo (2).

Observations: Neerabup National Park (G.H. and G.B.).

Diplodactylus alboguttatus Werner

Scarce, at least in south, where it is confined to western zone.

Specimens: Moore River National Park (2); City Beach (2); Reabold Hill (2).

Diplodactylus polyophthalmus Günther

Scarce [much more plentiful in Darling Range]. On the coastal plain confined to Tuart belt of western zone.

Specimens: 8 km S of Yanchep (1); Neerabup National Park (2); Wanneroo (2); Kings Park (5).

Diplodactylus spinigerus Gray

Common in western zone in coastal dunes and limestone country, where it extends south to the Swan River; uncommon in central and eastern zones, where it is not found south of Melaleuca Park.

Specimens: Moore River National Park (3); "Moore River" (3); 6 km E of Guilderton (1); Gingin (2); Yanchep National Park (9); Muchea (1); Melaleuca Park (3); North Beach (2); Tuart Hill (1); Scarborough (4); Wembley Downs (1); City Beach (2); Wembley Beach (2); Swanbourne Beach (1);

Point Resolution, Dalkeith (1); Cottesloe (8); Buckland Hill (1); Fremantle (2).

Phyllodactylus marmoratus (Gray)

Moderately common in western and central zones; rare in eastern zone.

Specimens: Yanchep National Park (7); Neerabup National Park (2); Mussel Pool (2); Balcatta (1); Midland (1); Guildford (1); Dianella (1); Osborne Park (1); Inglewood (1); Maylands (3); Mt Lawley (1); North Perth (1); East Perth (1); Leederville (1); Wembley (1); Reabold Hill (2); Subiaco (2); Shenton Park (1); Crawley (1); Nedlands (1); Cottesloe (3).

Observations: Point Resolution, Dalkeith (G.H.).

Phyllurus milii Bory

Scarce. Confined to limestone caves, cliffs and outcrops in western zone.

Specimens: Wanneroo (3); Subiaco (1); bank of Swan River, Claremont (2); Fremantle (1).

Observations: near Yanchep caves (G.M.S.).

PYGOPODIDAE (Legless Lizards)

Aclys concinna Kluge

Scarce [much more plentiful north of our area]. Confined to western zone.

Specimens: Yanchep National Park (1); Sorrento (1).

Aprasia pulchella Gray

Scarce [much more plentiful on Darling Range]. Confined to eastern and central zones, in the vicinity of the Swan River.

Specimens: Upper Swan (1); Guildford (2); Bayswater (2).

Aprasia repens (Fry)

Very common in sandy country.

Specimens: West Gingin (1); Yanchep National Park (1); Neerabup National Park (3); Twin Swamps Reserve (4); Wanneroo (5); Duncraig (1); Sorrento (1); Waterman (1); Balga (4); Mussel Pool (1); Karrinyup (2); Doubleview (6); Mt Yokine (4); Osborne Park (2); West Midland (1); Dianella (1); Nollamara (1); Morley (8); Embleton (1); Bassendean (1); Bayswater (7); Meltham (1); Inglewood (1); Wembley Downs (1); Herdsman Lake (2); City Beach (5); Floreat Park (6); Wembley (1); Maylands (2); Mt Lawley (9); Leederville (1); Perth (5); Subiaco (1); Shenton Park (1); Nedlands (7); Claremont (3); Swanbourne Beach (2); Cottesloe (5).

Delma fraseri Gray

Scarce.

Specimens: Gingin (1); Yanchep Beach (1); Malaleuca Park (7); Burns Beach (1); East Perth (1); Hollywood (1).

Delma grayii Smith

Scarce. Confined to western and eastern zones, evidently avoiding the deep white sands of central zone.

Specimens: Yanchep (1); Yanchep Beach (1); Burns Beach (1); Sorrento (2); Marmion (1); Middle Swan (1); Guildford (1).

Observations: Martyn Reserve, Ellen Brook (G.H.).

Lialis burtonis Gray

Very common.

Specimens: Moore River National Park (1); Beermullah (1); Gingin (1); Yanchep (1); Muchea (3); Bullsbrook (3); Melaleuca Park (3); Burns Beach (1); Twin Swamps Reserve (1); Martyn Reserve, Ellen Brook (1); 3 km E of Wanneroo (1); Wanneroo Wildlife Research Centre (4); Sorrento (1); Marmion (1); Waterman (3); Mussel Pool (1); Herne Hill (1); North Beach (5); Trigg (1); Beechboro (2); Midland (5); Morley (1); Yokine (4); Dianella (1); Nollamara (1); Tuart Hill (1); Scarborough (9); Osborne Park (1); Bedford (2); Guildford (1); West Guildford (1); Bassendean (6); Bayswater (11); Inglewood (3); Mt Hawthorn (3); Wembley Downs (2); Maylands (9); Mt Lawley (11); City Beach (5); Perry Lakes (1); Floreat Park (2); Wembley (6); West Leederville (1); Subiaco (5); Jolimont (2); Kings Park (3); Hollywood (3); Mt Claremont (2); Crawley (1); Nedlands (3); Claremont (2); Dalkeith (2); Cottesloe (2); Buckland Hill (2).

Pletholax gracilis gracilis Schlegel

Uncommon in coastal dunes of western zone; scarce elsewhere in western zone and in central zone.

Specimens: Sorrento (1); 2 km N of Marmion (6); North Beach (3); Dianella (2); Maylands (1); City Beach (3).

Pygopus lepidopodus (Lacépède)

Scarce. Apparently favouring vicinity of water.

Specimens: Mission Lake, Moore River National Park (1); Muchea (4); Melaleuca Park (1); Bayswater (1); Maylands (1); East Perth (1); Jolimont (1).

AGAMIDAE

Amphibolurus adelaidensis adelaidensis (Gray)

Common. Sandy country with low vegetation, e.g. banksia scrub and coastal heath.

Specimens: Moore River National Park (4); South Gingin Proposed Reserve (10); Burns Beach (6); Muchea (1); Lake Pinjar (1); Melaleuca Park (11); Sorrento (5); Mussel Pool (5); Inglewood (1); Bayswater (1); Wembley Downs (2); Floreat Beach (1); City Beach (4); Reabold Hill (1); Lake Monger (1); West Leederville (1); Nedlands (1).

Observations: Twin Swamps Reserve (G.H.).

Amphibolurus minor minor Sternfeld

Moderately common in western zone; uncommon in central and eastern zones.

Specimens: Moore River National Park (3); Melaleuca Park (2); Quinns Rock (1); Burns Beach (3); Warbrook (1); Upper Swan (1); Wanneroo Wildlife Research Centre (1); Sorrento (2); Mussel Pool (1); Midland (1); Osborne Park (1); Wembley Downs (1); City Beach (1); Reabold Hill (3); Floreat Park (5); North Perth (1); Mt Lawley (2); Kings Park (2); Subiaco (1); Shenton Park (1); Crawley (1); Cottesloe (1).

Observations: Neerabup National Park (G.H.).

SCINCIDAE (Skinks)

Cryptoblepharus plagiocephalus (Cocteau)

Common in open forests and woodlands, usually feeding on vertical surfaces, e.g. tree trunks, fences and walls; still found in city (Perth).

Specimens: Moore River National Park (2); Guilderton (1); Gingin (1); South Gingin Proposed Reserve (1); Yanchep National Park (3); Muchea (1); Neerabup National Park (1); Melaleuca Park (13); Bullsbrook (1); Warbrook (2); Twin Swamps Reserve (1); east of Gnangara (1); Mussel Pool (3); Middle Swan (1); Guildford (1); Yokine (1); Morley (1); Floreat Park (1); Wembley (2); Subiaco (3); Perth (1); Crawley (5); Dalkeith (3); Cottesloe (2).

Observations: Martyn Reserve, Ellen Brook (G.H. and G.B.); West Leederville (G.H.).

Ctenotus fallens Storr

Moderately common. Tending to avoid the deep white sands favoured by its congener C. lesueurii.

Specimens: Moore River National Park (1); Beermullah (1); Guilderton (1); 3 km S of Gingin (4); South Gingin Proposed Reserve (1); Melaleuca Park (3); 5 km SE of Bullsbrook (1); Burns Beach (8); Twin Swamps Reserve (2); Martyn Reserve, Ellen Brook (1); Sorrento (4); Mussel Pool (1); City Beach (3); Wembley (1); North Perth (2); bank of Swan River, Claremont (1); Point Resolution, Dalkeith (1); Cottesloe (1).

Ctenotus gemmula Storr

Uncommon. Confined to southern quarter of central zone. White sandplains with low to moderately low vegetation, e.g. banksia scrub and heath.

Specimens: Melaleuca Park (5); Mussel Pool (3).

Ctenotus impar Storr

Scarce.

Specimens: Wanneroo (2); Mussel Pool (1); Bellevue (1).

Ctenotus lesueurii (Duméril & Bibron)

Moderately common. Deep white sands (coastal dunes as well as inland sandplains.

Specimens: South Gingin Proposed Reserve (5); Muchea (1); Melaleuca Park (2); Mussel Pool (1); Scarborough (3); Yokine (3); Bedford (1); Maylands (2); North Perth (1); Leederville (1); Kings Park (1); Nedlands (1).

Egernia kingii Gray

Uncommon. Favouring coastal cliffs and vicinity of swamps and watercourses.

Specimens: Gingin (1); Yanchep National Park (1); Burns Beach (1); Marmion (1); North Beach (2); Morley (1); Guildford (1); West Leederville (1).

Egernia luctuosa Peters

Scarce in south; apparently absent from country north of Perth and suburbs. Swamp vegetation around lakes and along watercourses.

Specimens: Herdsman Lake (1); Lake Monger (1); Maylands (1).

Egernia napoleonis Gray

Uncommon. Usually found in stumps or under bark of trees and shrubs, including blackboys (Xanthorrhoea).

Specimens: South Gingin Proposed Reserve (1); 13 km N of Yanchep (1); Neerabup National Park (1); Muchea (1); Melaleuca Park (1); Bullsbrook (1); Wanneroo (1); Mussel Pool (3); Guildford (1); Swanbourne (1).

Hemiergis peronii quadrilineata (Duméril & Bibron)

Very common in sandy country (coastal dunes as well as inland sandplains. Seldom found in summer (does it aestivate?).

Specimens: Yanchep National Park (11); Neerabup National Park (2); Twin Swamps Reserve (1); Wanneroo (7); Upper Swan (4); "just east of Gnangara" (1); North Beach (4); Scarborough (2); Tuart Hill (1); Yokine (2); Nollamara (1); Guildford (2); Mt Lawley (3); North Perth (2); City Beach (4); Floreat Park (4); Leederville (2); Subiaco (2); Kings Park (9); Crawley (2); Nedlands (4); Claremont (9); Swanbourne (1); Dalkeith (5); Peppermint Grove (1); Buckland Hill (4).

Observations: Lake Joondalup (G.H.); Subiaco (G.H.).

Leiolopisma trilineatum (Gray)

Moderately common in damp places (in swamps, around lakes and along streams), north to Gingin Brook.

Specimens: Gingin Brook East (1); Gingin (1); Yanchep National Park (1); Lake Neerabup (2); Melaleuca Park (5); Mussel Pool (2); North Beach (1); 4 km NW of Osborne Park (2); Bassendean (1); Causeway, Swan River (1).

Observations: north end of Lake Joondalup (G.H.).

Lerista elegans (Gray)

Moderately common in western and central zones.

Specimens: Moore River National Park (1); South Gingin Proposed Reserve (3); Yanchep National Park (5); Melaleuca Park (5); Burns Beach (4); Yokine (1); Morley (1); Wembley Downs (1); City Beach (1); Wembley (12); Claremont (1); Cottesloe (1).

Lerista lineopunctulata (Duméril & Bibron)

Common in sandy country (inland sandplains as well as coastal dunes) in western zone; scarce in central and eastern zones.

Specimens: Guilderton (1); Gingin (1); Yanchep (1); Muchea (1); Bullsbrook East (1); Burns Beach (7); Wanneroo (1); Gnangara Lake (1); North Beach (1); Karrinyup (1); Osborne Park (1); Nollamara (1); City Beach (3); Floreat Park (1); West Leederville (1); Leederville (1); Subiaco (2); Kings Park (1); Nedlands (1); Mt Claremont (2); Swanbourne (2); Cottesloe (3); Buckland Hill (1).

Lerista praepedita (Boulenger)

Very common in sandy country in western and central zones; rare or absent in eastern zone.

Specimens: Guilderton (1); Gingin (1); South Gingin Proposed Reserve (12); Yanchep National Park (1); Neerabup National Park (1); Melaleuca Park (21); Burns Beach (3); Wanneroo (2); Gnangara (2); Sorrento (1); Waterman (1); Balga (4); Karrinyup (1); Balcatta (1); Yokine (1); Scarborough (1); Doubleview (4); Osborne Park (1); Tuart Hill (1); Dianella (1); Morley (2); Guildford (2); Bassendean (1); Bayswater (3); Inglewood (1); Mt Hawthorn (3); Wembley (4); Mt Lawley (2); North Perth (2); Subiaco (4); Nedlands (3); Claremont (1); Cottesloe (2); Mosman Park (1); Buckland Hill (1).

Menetia greyii Gray

Common in Tuart belt of western zone; uncommon in central and eastern zones; rare near coast.

Specimens: Regans Ford (1); Gingin (1); South Gingin

Proposed Reserve (1); Yanchep National Park (2); Neerabup National Park (1); 8 km N of Wanneroo (1); Melaleuca Park (4); Burns Beach (2); Wanneroo (14); Twin Swamps Reserve (1); Martyn Reserve, Ellen Brook (1); Upper Swan (2); Herne Hill (5); Mussel Pool (1); Guildford (4); West Perth (1); Wembley (10); Floreat Park (1); Reabold Hill (1); Crawley (1); Nedlands (1); Dalkeith (1).

Observations: West Leederville (G.H.).

Morethia lineoocellata (Duméril & Bibron)

Uncommon in western and central zones, in sandy country (coastal dunes as well as inland sandplains); absent from eastern zone.

Specimens: South Gingin Proposed Reserve (5); 20 km W of Muchea (1); Melaleuca Park (7); Burns Beach (1); Sorrento (2); Mussel Pool (3); Morley (1).

Morethia obscura Storr

Uncommon in western and central zones, favouring damper situations than M. lineoocellata; absent from eastern zone.

Specimens: Moore River National Park (2); Lake Neerabup (2); Melaleuca Park (3); Pinnaroo Valley, Wanneroo (1); Sorrento (1); Mussel Pool (1); Crawley (3); bank of Swan River, Claremont (6).

Observations: Burns Beach (G.H. and G.B.); north end of Lake Joondalup (G.H.).

Omolepida branchialis (Günther)

Uncommon. Confined to western zone. Coastal limestone and dunes.

Specimens: Burns Beach (1); near Wanneroo (2); Sorrento (1); Marmion (1); North Beach (2); Scarborough (2); City Beach (2).

Tiliqua occipitalis (Peters)

Uncommon.

Specimens: Upper Swan (1); Duncraig (1); Mussel Pool (1); West Swan (1); Scarborough (1); Osborne Park (1); Beechboro (1); Bayswater (2); Mt Hawthorn (1); Mt Lawley (1); West Leederville (1); Wembley (1); Karrakatta (1).

Observations: Melaleuca Park (G.H. and G.B.); between Mullaloo and Sorrento (A.C.).

Tiliqua rugosa rugosa (Gray)

Common, especially in cleared country.

Specimens: Yanchep National Park (1); Melaleuca Park (1); Mussel Pool (1); Caversham (1); North Perth (2); Kings Park (2); Crawley (1); Pelican Point (2); Cottesloe (1); North Fremantle (1).

Observations: Neerabup National Park (G.H. and G.B.); Burns Beach (G.H. and G.B.); Twin Swamps Reserve (G.H. and G.B.); Martyn Reserve, Ellen Brook (G.H. and G.B.).

VARANIDAE (Monitors or "Goannas")

Varanus gouldii (Gray)

Scarce.

Specimens: Scarborough (2); Osborne Park (1); Mt Lawley (1); City Beach (1); Kings Park (4); Nedlands (1).

Observations: Neerabup National Park (G.H. and G.B.); Mussel Pool (G.H. and G.B.).

Varanus rosenbergii Mertens

In this region only known from Mussel Pool, where only one was seen; it was collected in open Jarrah-Marri-Banksia woodland on 29 October 1975.

Varanus tristis tristis (Schlegel)

Scarce in western and eastern zones, apparently absent in central zone.

Specimens: Neerabup National Park (1); Upper Swan (1); Millendon (1); Sorrento (1); Midland (1); Wembley Downs (1); Floreat Park (1); Swanbourne (1).

Observations: Martyn Reserve, Ellen Brook (G.H. and G.B.).

TYPHLOPIDAE (Blind Snakes)

Typhlina australis (Gray)

Common in eastern zone; uncommon to moderately common in central and western zones.

Specimens: Beermullah (1); Gingin (2); 15 km S of Guilderton turnoff, Lancelin road (1); South Gingin Proposed Reserve (1); Muchea (2); Bullsbrook (1); Twin Swamps Reserve (2); Wanneroo (3); Herne Hill (1); Mussel Pool (1); Beechboro (1); Doubleview (1); Midland (1); Guildford (3); Bedford (1); Bayswater (2); Maylands (2); Wembley Downs (1); Wembley (2); City Beach (1); Leederville (1); Subiaco (1); Nedlands (2); Mt Claremont (1); Claremont (1).

Typhlina bituberculata (Peters)

Uncommon. Confined to eastern zone.

Specimens: Beermullah (2); Upper Swan (2); Herne Hill (1); Midland (1); Guildford (1).

BOIDAE (Pythons)

Liasis childreni Gray

Scarce. Confined to eastern zone and to Tuart belt of western zone.

Specimens: 16 km N of Wanneroo (1); Herne Hill (1); Caversham (1); West Midland (1); Bassendean (1).

Python spilotus variegatus (Gray)

Scarce. Confined to eastern zone and to limestone belt of western zone.

Specimens: Yanchep (2); Midland (1); Beechboro (1).

Observations: Guilderton (K.F.).

ELAPIDAE (Front-fanged Snakes)

Brachyaspis curta (Schlegel)

Moderately common in western zone, including coastal dunes; uncommon in central and eastern zones.

Specimens: Guilderton (1); Two Rocks (1); Muchea (1, a female containing 9 embryos); Pearce (1); Bullsbrook (1); Wanneroo (1); Sorrento (1); North Beach (1); Trigg (1); Scarborough (3); Caversham (1); Guildford (1); Morley (1; its stomach contained a frog, Heleioporus eyrei); Bayswater (6); Maylands (4); Mt Lawley (1); City Beach (5, excluding 8 young born after their mother was captured); Reabold Hill (1).

Observations: Yanchep National Park (S.W.).

Demansia reticulata reticulata (Gray)

Moderately common in western zone (especially the Tuart belt), but quickly disappearing from built-up areas, e.g. last collected at Scarborough in 1936, Dalkeith in 1939, and Nedlands

and Kings Park in 1942; rare in central and eastern zones.

Specimens: Moore River National Park (1); Yanchep (2); 16 km N of Wanneroo (1); Whitford Beach (1); Sorrento (2); Caversham (1); Midland (1); Scarborough (1); Subiaco (1); Jolimont (1); Kings Park (6); Hollywood (1); Nedlands (4; one of these, R8297, had bitten a child twice without serious results); Dalkeith (3).

Denisonia coronata (Schlegel)

Here, at the northern end of its range, this snake is scarce [it is common on the south coast].

Specimens: Muchea (1); Wanneroo (2); Beechboro (1); Bassendean (1); North Perth (1); Subiaco (1).

Denisonia gouldii (Gray)

Generally common, especially in blackboy (Xanthorrhoea) country, though inexplicably not recorded from certain western suburban areas (Kings Park, Nedlands, Dalkeith, Claremont).

Specimens: Gingin (4); South Gingin Proposed Reserve (1); Yanchep National Park (4); Muchea (2); 10 km S of Yanchep (1); 16 km N of Wanneroo (1); Lake Pinjar (2); Neerabup National Park (5); Melaleuca Park (2); North Wanneroo (1); Wanneroo (8); 5 km SW of Wanneroo (1); Upper Swan (1); Lake Goollelal (1); Mussel Pool (3); West Swan (2); North Beach (1); Trigg (1); Lake Gwelup (1); Balcatta (1); Yokine (2); Morley (2); Midland (1); West Midland (1); Guildford (2); South Guildford (1); Bassendean (3); Bedford (1); Dianella (2); Nollamara (1); Tuart Hill (3); Osborne Park (1); Scarborough (1); Mt Hawthorn (3); Inglewood (1); Bayswater (6); Maylands (2); Mt Lawley (4); North Perth (4); Wembley (1); West Leederville (1); Subiaco (1); Leederville (1); East Perth (2); Cottesloe (5).

Notechis scutatus occidentalis Glauert

Common in central and eastern zones and in low-lying eastern parts of western zone. In swamps, around lakes and along the Swan River (above the Causeway).

Specimens: 7 km N of Gingin; Gingin (4); Bullsbrook (1); Twin Swamps Reserve (1); Wanneroo (3); East Wanneroo (1); Upper Swan (3); Gnangara Lake (3); 8 km SSE of Wanneroo (1); Mussel Pool (1); Balcatta (1); Yokine (1); Morley (1); Beechboro (4); Caversham (2); Midland (1); East Guildford (1); West Guildford (1); Bassendean (4); North Beach road (1); Osborne Park (3); Herdsman Lake (8); Mt Hawthorn (1); Inglewood (1); Bayswater (8); Maylands (9); Mt Lawley (2); Lake Monger (3); Wembley (2); East Perth (1).

Observations: 13 km E of Guilderton (K.F.); Lake Bambun (R.E.J.); Lake Chandala (R.E.J.); Loch McNess (G.H.); north end of Lake Joondalup (G.H.).

Pseudechis australis (Gray)

Status unknown. From 1924 to 1939 the Western Australian Museum received ten specimens of Mulga Snake from the southern part of the eastern zone (an area largely given over to farmlets and vineyards). It is possible that these snakes represent a natural population, but it is more likely that they were accidentally introduced, perhaps in hay, from further north or east (cf. Pseudonaja nuchalis).

Specimens: Upper Swan (2); Herne Hill (1); Swan View (2); Greenmount (1); Midland (1); West Guildford (1).

Dugite

Pseudonaja affinis affinis Günther

Locally very common in western and central zones; moderately common in eastern zone. The Dugite, like its principal prey, the House Mouse (Mus musculus), is most numerous on the immediate outskirts of settlement. Its cycle of abundance is thus: (1) relatively low densities in undisturbed bush remote from settlement, (2) increasing densities as settlement approaches, (3) decreasing densities from the beginning of housing developments, (4) extinction as area becomes completely built up.

Specimens: Lake Nambung (1); Lake Pinjar (1); 16 km N of Wanneroo (1); Pearce (5); Twin Swamps Reserve (1); Upper Swan (5); Wanneroo (3); Whitford Beach (2); Sorrento (4); West Swan (6); Herne Hill (2); North Beach (8); Waterman (3); Mussel Pool (1); Middle Swan (2); Trigg (4); Karrinyup (1); Balcatta (1); Beechboro (3); Caversham (10); Bellevue (1); Midland (2); West Midland (4); East Guildford (1); Guildford (15); South Guildford (3); Bassendean (15); Morley (5); Bedford (1); Dianella (1); Tuart Hill (1); Osborne Park (2); Scarborough (11); Wembley Downs (1); Inglewood (3); Ashfield (1); Bayswater (11); Maylands (15); Mt Lawley (15); North Perth (3); Wembley (3); Floreat Park (2); City Beach (17); Reabold Hill (1); Perry Lakes (2); Jolimont (2); Subiaco (2); West Perth (1); Leederville (1); Daglish (1); Mounts Bay Road, Perth (2); Kings Park (12); Graylands (1); Crawley (4); Nedlands (5); Dalkeith (15); Mt Claremont (1); Claremont (10); Swanbourne (5); Swanbourne Beach (1); North Cottesloe (2); Cottesloe (6); Mosman Park (11); Buckland Hill (6).

Observations: Guilderton (K.F.); Yanchep National Park (G.H. and G.B.); Neerabup National Park (G.H.); Burns Beach (G.H. and G.B.); north end of Lake Joondalup (G.H.).

Pseudonaja nuchalis Günther

Confined to the eastern zone. As it was not recorded here before 1936, it is possible that this species was accidentally introduced in hay or other produce from the Wheat Belt. It is now moderately common in the farming country about the Swan River.

Specimens: Regans Ford (1); Gingin (1); Bullsbrook (1); Millendon (1); Herne Hill (3); West Swan (1); Middle Swan (1); Swan View (7); Greenmount (1); South Guildford (1); Morley (1).

Vermicella bertholdi (Jan)

Common in sandy country, i.e. western and central zones; uncommon in eastern zone.

Specimens: Gingin (2); 9 and 10 km N of Yanchep turnoff, Lancelin road (2); Quinns Rocks (1); Neerabup National Park (1); Bullsbrook (3); Melaleuca Park (1); Wanneroo (4); Sorrento (3); Marmion (3); Waterman (4); Padbury (1); North Beach (3); Trigg (2); Karrinyup (3); North Innaloo (1); Balga (1); Caversham (1); Beechboro (1); Yokine (1); Tuart Hill (6); Osborne Park (8); North Scarborough (2); Scarborough (16); Wembley Downs (1); Mt Hawthorn (6); Bassendean (1); Bayswater (3); Maylands (16); Mt Lawley (1); North Perth (3); Lake Monger (1); Wembley (15); Floreat Park (4); City Beach (10); West Leederville (1); Leederville (6); Subiaco (4); East Perth (1); Mounts Bay (1); Kings Park (5); Shenton Park (1); Hollywood (2); Nedlands (10); Dalkeith (8); Mt Claremont (2); Claremont (8); Swanbourne (6).

Vermicella bimaculata Duméril, Bibron & Duméril

Moderately common in deep sands of western and central zones; rare in eastern zone.

Specimens: Neerabup National Park (1); 3 km NE of Bullsbrook East P.O. (1); Melaleuca Park (1); Burns Beach (2);

Wanneroo (2); Gnangara Lake (1); North Whitford Beach (1); Whitford Beach (1); Sorrento (1); Scarborough (2); Dianella (1); South Guildford (1); Bassendean (2); Bayswater (3); Inglewood (1); Maylands (2); Mt Lawley (1); Reabold Hill (1); West Perth (1); Nedlands (1); Claremont (1); Cottesloe (1); Buckland Hill (1).

Vermicella calonotos (Duméril, Bibron & Duméril)

Common in deep white sand of central zone; moderately common in western zone; rare in eastern zone.

Specimens: Guilderton (1); Yanchep (1); Yanchep Beach (1); Quinns Rock (1); Pearce (1); Melaleuca Park (2); Wanneroo (1); Whitford Beach (1); Sorrento (3); North Beach (2); Caversham (1); Bassendean (5); Embleton (1); Bedford (3); Dianella (2); Scarborough (2); Inglewood (2); Bayswater (8); Maylands (5); Mt Lawley (7); North Perth (1); City Beach (1); Reabold Hill (1); Leederville (1); West Perth (1); Jolimont (1); Shenton Park (1); Buckland Hill (1).

Vermicella fasciolata fasciolata (Günther)

Uncommon in western zone; rare in central and eastern zones.

Specimens: Regans Ford (1); Bullsbrook (1); Warbrook (1); Caversham (1); Morley (2); Doubleview (1); Mt Hawthorn (1); North Perth (1); City Beach (2); Reabold Hill (2); Subiaco (1); Mt Claremont (1); Swanbourne (3).

Vermicella semifasciata semifasciata (Günther)

Moderately common. Found in all zones, often in buried or half-buried rotten wood.

Specimens: "Moore River" (1); South Gingin Proposed Reserve (1); 8 km N of Yanchep turnoff, Lancelin road (1);

Muchea (3); 10 km SE of Yanchep (1); Neerabup National Park (2); 10 km N of Wanneroo (1); Wanneroo (3); Upper Swan (3); Henley Park, West Swan (1); Sorrento (2), Waterman (1); Girrawheen (1); Karrinyup (1); Scarborough (3); Yokine (1); Tuart Hill (1); Morley (1); Midland (1); Guildford (1); Bassendean (2); Bayswater (2); Inglewood (2); Wembley Downs (2); Maylands (1); North Perth (2); City Beach (2); Jolimont (1); Subiaco (1); Cottesloe (2).

DISCUSSION

The northern Swan Coastal Plain supports a rich herpetofauna - 42 genera and 70 species distributed among eleven families as follows:

Leptodactylidae (7 genera, 11 species)
Hylidae (1 genus, 2 species)
Cheluidae (2 genera, 2 species)
Gekkonidae (4 genera, 6 species)
Pygopodidae (6 genera, 8 species)
Agamidae (1 genus, 2 species)
Scincidae (10 genera, 19 species)
Varanidae (1 genus, 3 species)
Typhlopidae (1 genus, 2 species)
Boidae (2 genera, 2 species)
Elapidae (7 genera, 13 species)

Particularly well represented are the legless lizards (Pygopodidae), skinks and elapid snakes. The wealth of pygopodids is understandable; for, with two endemic genera and 14 of the 31 species, the west coast and coastal plains of Western Australia constitute the stronghold of the family; in the rest of the Australo-Papuan continent, especially in northern

Australia and New Guinea, the family is becoming relictual. The richness of elapids is largely due to the occurrence of five species of the fossorial genus Vermicella, another group that is becoming relictual elsewhere in Australia.

The amphibians are poorly represented, especially the Hylidae. The local paucity of tree frogs is a reflection of their regional paucity (3 species in southwestern Australia vs 20 in southeastern Australia). Nor are the leptodactylid frogs well represented; of the 11 species found in the eastern zone, only 6 extend to the central zone and 5 to the western.

Only one species, the turtle Pseudemydura umbrina, is restricted to our area. However there are several species and subspecies on the list that are endemic or almost endemic to a larger unit of which the northern Swan Coastal Plain forms part, namely the west coast and coastal plains from North West Cape south to Geographe Bay; in this category are Ranidella insignifera, Diplodactylus alboguttatus, Aprasia repens, Pletholax gracilis, Amphibolurus a. adelaidensis, Ctenotus lesueurii, Hemiergis peronii quadrilineata, Lerista elegans, L. lineopunctulata, L. praepedita, Morethia lineoocellata and Vermicella calonotos.

As we have already noticed, the eastern zone is much richer than the others in leptodactylid frogs; on the other hand it is considerably poorer in skinks. The Western zone, owing to the presence of limestone, is twice as rich as the others in geckos. These and other interzonal differences are indicated in the following table, which gives the number of species in each family recorded for each zone.

	Western	Central	Eastern
Leptodactylidae	5	6	11
Hylidae	2	2	2
Cheluidae	1	1	2
Gekkonidae	6	2	3
Pygopodidae	7	6	6
Agamidae	2	2	2
Scincidae	18	18	13
Varanidae	2	2	1
Typhlopidae	1	1	2
Boidae	2	0	2
Elapidae	11	11	13
total	57	51	57

Seventeen of the 70 species recorded for the area are considered scarce or rare. Most of them are only scarce or rare because of paucity of suitable habitat on the coastal plain and are much more plentiful on the adjacent plateau; such species are Ranidella pseudinsignera, Crenadactylus ocellatus, Diplodactylus polyophthalmus, Aprasia pulchella, Delma fraseri, D. grayii, Pygopus lepidopodus, Ctenotus impar, Varanus gouldii, V. rosenbergii, V. tristis, Liasis childreni and Python spilotus. Two species, Egernia luctuosa and Denisonia coronata, are scarce or rare because they are at the northern limit of their distribution; both are common on the south coast. Another two species, Diplodactylus alboguttatus and Aclys concinna, are scarce or rare because they are at the southern limit of their distribution; both are common north of the Moore River.

Restricted to a few seasonal swamps along Ellen Brook, and in numbers that are precariously low, the endemic turtle Pseudemydura umbrina poses a grave problem for its conservation

as a species. However the conservation of other amphibians and reptiles as viable communities also demands concern in our area, which is one of the most disturbed in the State.

The greater part of Perth and its suburbs lies within our area. Most species decline as the land is built over; the first to go are generally the snakes and monitors; the last to disappear are generally the small skinks, several of which persist in suburban gardens, and one (Cryptoblepharus plagiocephalus) even survives in the city.

Although at least one frog (Ranidella glauerti), one lizard (Tiliqua rugosa) and one snake (Pseudonaja affinis) prosper in partly cleared country, most elements of the herpetofauna gradually decline and disappear from farm lands.

It now remains to notice that part of the fauna which inhabits wet lands. All of the amphibians listed, except Myobatrachus gouldii, require unpolluted surface water for the development of their larvae. Now wet lands are disappearing or deteriorating rapidly in the southern part of our area through drainage, reclamation, garbage disposal, pest control and the destruction of fringing vegetation. With increasing use of subterranean water one can also expect a decline in the wetlands of the north of our area. As well as frogs, certain reptiles require surface water or damp places, namely the turtles Chelodina oblonga and Pseudemydura umbrina, the skinks Egernia luctuosa and Leiolopisma trilineatum, and the snake Notechis scutatus.

BIBLIOGRAPHY

COPLAND, S.J. (1957). Australian tree frogs of the genus Hyla. Proc. Linn. Soc. N.S.W. 82: 9-108.

KLUGE, A.G. (1967). Systematics, phylogeny, and zoogeography of the lizard genus Diplodactylus Gray (Gekkonidae). Aust. J. Zool. 15: 1007-1108.

KLUGE, A.G. (1974). A taxonomic revision of the lizard family Pygopodidae. Misc. Publs Mus. Zool. Univ. Mich., No. 147.

LOVERIDGE, A. (1934). Australian reptiles in the Museum of Comparative Zoology, Cambridge, Massachusetts. Bull. Mus. comp. Zool. Harv. 77: 243-383.

LOVERIDGE, A. (1935). Australian Amphibia in the Museum of Comparative Zoology, Cambridge, Massachusetts. Bull. Mus. comp, Zool. Harv. 78: 1-60.

MAIN, A.R. (1957). Studies in Australian Amphibia. I. The genus Crinia Tschudi in south-western Australia and some species from south-eastern Australia. Aust. J. Zool. : 5: 30-55.

MAIN, A.R. (1965). Frogs of southern Western Australia. Western Australian Naturalists' Club: Perth.

MARTIN, A.A. (1972). Studies in Australian Amphibia. III. The Limnodynastes dorsalis complex (Anura: Leptodactylidae). Aust. J. Zool. 20: 165-211.

PARKER, H.W. (1940). The Australasian frogs of the family Leptodactylidae. Novit. zool. 42: 1-106.

STORR, G.M. (1968). The genus Vermicella (Serpentes, Elapidae) in Western Australia and the Northern Territory. J. Proc. R. Soc. West. Aust. 50: 80-92.

STORR, G.M. (1968). Revision of the Egernia whitei species-group (Lacertilia, Scincidae). J. Proc. R. Soc. West. Aust. 51: 51-62.

STORR, G.M. (1972). The genus Lerista (Lacertilia, Scincidae) in Western Australia. J. Proc. R. Soc. West. Aust. 54: 59-75.

STORR, G.M. (1973). The genus Morethia (Lacertilia, Scincidae) in Western Australia. J. Proc. R. Soc. West. Aust. 55: 73-79.

STORR, G.M. (1974). The genus Ctenotus (Lacertilia, Scincidae) in the South-West and Eucla Divisions of Western Australia. J. Proc. R. Soc. West. Aust. 56: 86-93.

STORR, G.M. (1975). The genus Hemiergis (Lacertilia, Scincidae) in Western Australia. Rec. West. Aust. Mus. 3: 251-260.

STORR, G.M. (1976) The genus Cryptoblepharus (Lacertilia, Scincidae) in Western Australia. Rec. West. Aust. Mus. 4: 53-63.

STORR, G.M. (1976). The genus Omolepida (Lacertilia, Scincidae) in Western Australia. Rec. West. Aust. Mus. 4: 163-170.

STORR, G.M. (1976). The genus Menetia (Lacertilia, Scincidae) in Western Australia. Rec. West. Aust. Mus. 4: 189-200.

STORR, G.M. (1976). Revisionary notes on the Lerista (Lacertilia, Scincidae) of Western Australia. Rec. West. Aust. Mus. 4: 241-256.

STORR, G.M. (1977). The Amphibolurus adelaidensis species group (Lacertilia, Agamidae) in Western Australia. Rec. West. Aust. Mus. 5: 73-81.

STORR, G.M. (1978). The genus Egernia (Lacertilia, Scincidae) in Western Australia. Rec. West. Aust. Mus. 6: 147-187.

STORR, G.M. (1978). Whip Snakes (Demansia, Elapidae) of Western Australia. Rec. West. Aust. Mus. 6: 287-301.

STORR, G.M. (1978). The Diplodactylus vittatus complex (Lacertilia, Gekkonidae) in Western Australia. Rec. West. Aust. Mus. 6:

WERNER, F. (1909). Reptilia exkl. Geckonidae und Scincidae, pp. 251-278 in W. Michaelsen & R. Hartmeyer's Die Fauna Südwest-Australiens 2.

WERNER, F. (1910). Reptilia (Geckonidae und Scincidae), pp. 451-493 in W. Michaelsen & R. Hartmeyer's Die Fauna Südwest-Australiens 2.

WERNER, F. (1914). Amphibia, pp. 403-426 in W. Michaelsen & R. Hartmeyer's Die Fauna Südwest-Australiens 4 .

THE FRESHWATER FISHES OF THE NORTHERN SWAN COASTAL PLAIN

NEIL L. SARTI

and

GERALD R. ALLEN

Department of Ichthyology, Western Australian Museum, Francis Street, Perth, W.A.

INTRODUCTION

Considering its proximity to the Perth metropolitan district there is surprisingly little published information dealing with the fishes of the Swan Coastal Plain. Allen (in press) has given a general summary of the species inhabiting the Southwest. However, he emphasised the paucity of knowledge concerning life history and ecological data, particularly with regards to native fishes. The present paper reports the results of a faunal survey of the Northern Swan Coastal Plain (subsequently abbreviated NSCP) conducted by the Department of Fishes of the Western Australian Museum between March 1977 and May 1978. The primary purpose of this work was to document the resident species with emphasis on their local distribution and ecology. In addition, special consideration was given to the possible effects of a decreased level in the water table as a result of proposed groundwater extraction.

Representative lakes and watercourses of the NSCP were sampled periodically throughout the study period. Sites were selected with the intention of representing as wide a range of habitats as possible. In addition to regular monthly visits to the major sites (i.e. Lakes Bambun, Beermullah, Chandala, Jandabup, Joondalup and Loch McNess) random sampling was conducted at other scattered localities including Ellen Brook, Lake Guraga and Regan's Ford on the Moore River. The specimens taken during the survey have been deposited in the fish collection of the Western Australian Museum.

Sampling methods consisted of fine meshed dipnets, a chemical ichthyocide (derris powder with 6-8% rotenone content), a small box dredge towed behind an outboard powered punt and a small seine net. The first two methods proved to be the most effective as deep layers of detritus and submerged objects such as tree branches greatly restricted the use of the dredge and seine net.

The results of the sampling program are presented below in the form of an annotated species list which is followed by an account of the fish populations for each lake and stream that was studied. In the first section, families are

listed according to the phylogenetic sequence proposed by Greenwood et al. (1966). If more than one species is included in a family they are arranged alphabetically by genus and species. An asterisk after the specific name indicates the fish is endemic to the south-west of Western Australia. Abbreviated literature citations which include the author, year of publication, page number and type locality, are given for the original description. Measurements which appear in the species accounts refer to total length which is the horizontal distance between the snout tip and the rear edge of the caudal fin.

ANNOTATED LIST OF THE FRESHWATER FISHES RECORDED ON THE NORTHERN SWAN COASTAL PLAIN

GEOTRIDAE ... LAMPREYS

POUCHED LAMPREY (Geotria australis)

Geotria australis Gray, 1851: 142. (Inkapinki River, South Australia).

Adult lampreys live at sea, but migrate into rivers at spawning time. Larval lampreys known as ammocoetes live in freshwater for an undetermined period. Here they dwell in muddy burrows and feed by filtering various micro-organisms. Metamorphosis occurs at a length of about 10 cm and involves the development of eyes and changes in coloration, fin structure and shape of the mouth. The resultant stage, known as the macrophthalmic, then migrates to the sea. Maximum size to about 65 cm TL.

Distribution: coastal rivers and streams from the Moore River, Western Australia along the south coast to South Australia, Victoria and Tasmania. Also found in New Zealand and parts of South America.

This species is recorded from the NSCP on the basis of a single individual (approximately 20 cm TL) which was sighted (but unfortunately not collected) during a rotenone collection in the Moore River during November 1977; this record represents an extension of the known range in Western Australia of approximately 120 kilometres northward.

GALAXIIDAE ... NATIVE MINNOWS

This family contains small scaleless, minnow-like fishes which are common inhabitants of lakes, swamps and streams of New Zealand, Tasmania and the southern half of Australia. The life history of Western Australian minnows is very poorly known, but that of Galaxias occidentalis at least, is probably similar to certain species which have been studied in Eastern Australia. It appears that spawning takes place among grasses on the edge of streams during flood periods. After the water recedesthe eggs undergo development in the moist grass. Hatching finally occurs during subsequent heavy rainfalls. The larvae and juveniles are frequently discovered in the midst of flooded paddocks by local farmers. The diet of these fishes consists largely of insects and their aquatic larvae and also small crustaceans.

WESTERN MINNOW (Galaxias occidentalis*)

Galaxias occidentalis Ogilby, 1899: 157. (South of Perth, Western Australia).

This is the most common galaxiid in the south-west of Western Australia. It is a surface swimmer, preferring fast flowing water. Stomach contents examined from this species contained members of the following insect orders: Coleoptera, Diptera, Hymenoptera, Odonata, and Orthoptera. Maximum size to about 15 cm TL.

Distribution: coastal streams, swamps and ponds of the south-west of Western Australia from Two People's Bay, just east of Albany, to Moora.

MUD MINNOW (Galaxiella munda*)

Galaxiella munda McDowall, 1978: 119. (North of Scott River, between Nannup and Augusta, Western Australia).

This recently described species is relatively abundant in the Southwest, where it occurs mainly in pools, ditches and slow flowing streams. In many cases it is found in temporary water and it is likely that these fish are capable of aestivating during drought periods. This phenomenon has been reported for several other galaxiids. Maximum size to 5.1 cm TL.

Distribution: coastal streams and pools from the Albany district to Muchea, south-west of Western Australia.

The record of this species from Muchea (see McDowall, 1978) is noteworthy because it is the only report of this species north of Margaret River, approximately 275 kilometres directly to the south.

CYPRINIDAE ... CARPS

GOLDFISH or GOLDEN CARP (Carassius auratus)

Cyprinus auratus Linnaeus, 1758: 322. (China).

This species was introduced to Australia from Asia in the latter part of the 19th Century as an ornamental fish. It is extremely hardy and tolerates turbid conditions and high temperatures. The preferred habitat consists of slow moving or stagnant waters where it feeds on small invertebrates, fishes, plants and detritus. Spawning occurs during spring and summer, usually when temperatures exceed 16^{o}C. Several thousand small adhesive eggs are attached to aquatic plants or other objects by each gravid female. It is a poor angling fish and the flesh is not considered good eating. Maximum size to about 36 cm TL and 1.5 kg.

Distribution: has a worldwide distribution. In Western Australia it is found in streams and lakes from the Moore River southwards.

PLOTOSIDAE ... CATFISHES

FRESHWATER COBBLER (Tandanus bostocki*)

Tandanus bostocki Whitley, 1944: 260. (Serpentine River, Western Australia).

This bottom dwelling fish occurs in ponds and slow flowing streams. At most localities it does not appear to be particularly abundant. Reproductive habits are probably similar to those of Tandanus tandanus, a close relative from Eastern Australia. In that species spawning occurs from late spring to mid-summer, with the female depositing up to 20,000 eggs. These are laid in a circular nest, consisting of a shallow depression lined with gravel, sticks or small stones. The eggs are guarded and fanned by the male and hatching generally occurs in about one week at temperatures ranging between 19°-20°C. Maximum size to about 37 cm TL.

Distribution: coastal streams and ponds of the south-west of Western Australia between the Frankland and Moore River drainages.

Specimens taken from the Moore River during the survey represent a northward range extension of about 120 km.

POECILIIDAE ... LIVE-BEARING MINNOWS

MOSQUITO FISH (Gambusia affinis)

Heterandria affinis Baird & Girard, 1853: 390. (Central America).

This is a small gregarious species that was introduced into Australia to aid in the control of mosquito larvae. The history of this species in Western Australia was discussed by Mees (1977). It is an extremely hardy fish exhibiting a wide range of tolerance with regards to salinity, temperature, and oxygen extremes. The Mosquito fish bears its young alive with adult females producing up to 80 young at regular intervals during the warmer months. The diet consists largely of insects and their larvae and small crustaceans. It is one of the most abundant species in the southwestern corner of W.A. where it occupies a wide range of stream and pond habitats. It is generally most common in shallow weedy areas and does well in artificial lakes and ponds. Maximum size to about 5 cm TL (males to about 4 cm).

Distribution: native to Central America, but widely introduced in the warmer regions of the world. In Western Australia it is found between the Fitzgerald River, east of Bremer Bay, to the Hutt River, just north of Geraldton.

ATHERINIDAE ... HARDYHEADS

The hardyheads are a large group of mainly marine or estuarine fishes, but a few of the species occur in fresh or saline inland waters. These small fishes generally occur in schools and are characterised by a silvery band extending along the sides.

ELONGATE HARDYHEAD (Atherinosoma elongata)

Atherina elongata Klunzinger, 1879: 394. (King George Sound, Western Australia).

This species is essentially marine and is abundant along the coast in protected embayments or estuaries, sometimes entering freshwater streams. Spawning takes place in the sea during the warm summer months. Maximum size to about 8 cm TL.

Distribution: coastal bays, streams and lakes from Geraldton, Western Australia along the south coast to Nelson, Victoria.

SWAN RIVER HARDYHEAD (Atherinosoma presbyteroides)

Atherina presbyteroides Richardson, 1843: 179. (Port Arthur, Tasmania).

This fish is similar in appearance and habits to A. elongata. The two species sometimes occur in mixed schools. The diet of these fishes largely consists of benthic amphipods, copepods and polychaetes (Ivantsoff, 1978). They in turn provide an important source of food for birds such as cormorants and gulls. Maximum size to about 9 cm TL.

Distribution: coastal streams, estuaries and sheltered bays from the Abrolhos Islands in Western Australia along the south coast to Jervis Bay, New South Wales and also Tasmania.

PERCICHTHYIDAE ... AUSTRALIAN PERCHES

NIGHTFISH (Bostockia porosa*)

Bostockia porosa Castelnau, 1873: 126. (Western Australia).

This is a nocturnal species which feeds on a variety of crustaceans, small fishes and insects. During daylight hours it remains hidden under stones or among vegetation. It exhibits a preference for cool, running water and in some areas is relatively common. It is a solitary species which dwells close to the bottom. Little is known of the reproductive habits except that spawning occurs during late spring and early summer. Maximum size to about 17 cm TL.

Distribution: coastal streams and ponds of the south-west of Western Australia from the Albany district northwards to the Hill River near Jurien.

KUHLIIDAE ... PYGMY PERCHES

WESTERN PYGMY PERCH (Edelia vittata*)

Edelia vittata Castelnau, 1873: 124. (Western Australia).

This species is common in coastal streams and rivers, occurring among vegetation, stones and other debris. It exhibits a fairly wide tolerance to salinity and temperature. It usually occurs solitarily or in small groups. Breeding takes place between July and January. The young feed primarily on tiny crustaceans such as Daphnia sp., whereas the diet of adults consists primarily of caddis-fly larvae (Trichoptera) and other insects. Maximum size about 7 cm TL after five years of age.

Distribution: coastal streams and ponds from the Phillips River at Hopetoun, northwards to the Moore River at Moora.

MUGILIDAE ... MULLETS

FRESHWATER MULLET (Mugilid sp.)

During the survey period a school of mullets containing about 15-30 individuals was sighted at Regan's Ford on the Moore River. Specimens were not obtained, however there are only two mullet species which regularly penetrate inland streams of the Southwest: Aldrichetta forsteri (Valenciennes) which is mainly a marine species inhabiting New Zealand and southern Australia; and Mugil cepahlus Linnaeus, another marine species with a tropical and temperate distribution throughout the Indo-Pacific region. Both are silvery, schooling fishes which forage on crustaceans, molluscs, and algae. Maximum size to 40-60 cm.

GOBIIDAE ... GOBIES

The gobies represent a large family of primarily marine and estuarine species, although a few occur in freshwater. They are relatively small fishes which dwell on the bottom and are characterised by the fusion of the two pelvic fins into a disc-like structure.

BIGMOUTH GOBY (Favonigobius suppositus*)

Gobius suppositus Sauvage, 1880: 41. (Swan River, Western Australia).

This fish is moderately abundant in freshwater and estuarine areas of southwestern Australia. It is a sluggish species which is usually seen resting motionless on the bottom amongst vegetation or debris. The diet consists of small crustaceans, fishes, and insects. Spawning occurs between May and January and the eggs are deposited on the surface of rocks or debris. Maximum size to about 15 cm TL.

Distribution: streams and estuaries in the south-west of Western Australia from the Albany district to the Moore River.

SWAN RIVER GOBY (Pseudogobius olorum*)

Gobius olorum Sauvage, 1880: 43 (Swan River, Western Australia).

This is one of the most abundant fishes found in estuaries and brackish ponds and streams of the Southwest. It readily adapts to freshwater and is sometimes encountered many kilometres inland. It is similar to F. suppositus with regards to ecology, feeding habits, and reproduction. Maximum size to 7 cm TL.

Distribution: coastal streams and lakes in the south-west of Western Australia from Esperance to Kalbarri (Murchison River).

FISH FAUNA OF SELECTED LENTIC AND LOTIC
AREAS OF THE NORTHERN SWAN COASTAL PLAIN

The fish species are listed in order of abundance within each water body, the most abundant being first.

LAKE JANDABUP (Fig. 2, Pl. 1)

Two species of fish were collected, both introduced. The main fish habitats in this lake are - (a) sedge belts, (b) submerged vegetation, and (c) open water.

Gambusia affinis - large schools were found among the sedge belts and submerged vegetation in shallow water around the edge of the lake. None were collected or observed from the northern area of the lake and very few from open water. Gravid females and juveniles were collected from warm water (30°C) among shallow water vegetation in November 1977.

Carassius auratus - a few juveniles, the largest being 1.8 cm TL, were collected from sedge belts at the southern end of the lake in October 1977. On different occasions, individuals estimated to be 8-10 cm TL were seen (but not collected) in open water.

LAKE JOONDALUP (Fig. 3, Pl. 2a, b)

One native and two introduced species were collected in this lake. The main fish habitats in this lake are - (a) sedge belts, (b) submerged vegetation, (c) submerged objects such as tree branches, and (d) open water.

Gambusia affinis - congregates in large numbers in the sedge belts and submerged vegetation in shallow water areas. Usually collected in association with Pseudogobius olorum and the Freshwater Shrimp, Palaemonetes australis. Juveniles up to 9 mm TL and gravid females were collected from October 1977 to February 1978 in shallow areas where water temperatures were high (30°C and above). Rarely seen or collected in open water.

Pseudogobius olorum - collected from sedge belts and under submerged objects. This species is abundant, being only slightly less so than Gambusia affinis. Eggs and embryos were found in submerged reed stalks close to the waters edge in November 1977. Juveniles up to 1 cm TL and gravid females were collected in May 1977 and between October 1977 and January 1978.

Carassius auratus - four large adults, 32-36 cm TL were found washed up at the southern end of the lake in early April 1978. The cause of death is uncertain. Collections during the previous year failed to record this species although its presence was suspected.

LOCH McNESS (Fig. 4, Pl. 3a, b)

Three species of fish including one native and two introduced were recorded. Fish habitats that are provided by this lake are - (a) sedge belts, (b) undercut banks, (c) open water, and (d) a cool water stream outlet.

Gambusia affinis - collected from the sedge belts, undercut banks and the stream outlet. Juveniles up to 1.5 cm TL were collected in April 1977. Gravid females were collected in November 1977.

Bostockia porosa - only collected from the stream outlet which is heavily wooded. Specimens were 3-8 cm TL.

Carassius auratus - sighted at various times during the study throughout the lake. Attempts to collect this species failed, but specimens were estimated to be 30 cm TL.

LAKE CHANDALA (Fig. 5, Pl. 4a, b)

Four native and two introduced species were recorded from the lake and a drain at the northern end. Two of the native species were confined to the drain. The combination of lentic and lotic systems has provided a wider degree of habitat diversity and from that a wider species diversity than other lakes studied.

Gambusia affinis - large numbers were found among the sparse submerged vegetation in the shallow areas of the lake and from the drain. Juveniles were observed several times throughout the study in shallow water areas of inundation around the lake. Gravid females and juveniles were collected from shallow pools in the drain during January-February 1978 in water of 35°C surface temperature.

Pseudogobius olorum - moderate numbers were collected under submerged debris, submerged vegetation around the shoreline and from pools in the drain. Gravid females, up to 4.5 cm TL, and juveniles of 1.2 cm TL were collected in April 1977.

Bostockia porosa - several individuals were collected under submerged logs and branches from the lake and associated drain.

Galaxias occidentalis - occasionally collected from the drain hiding among vegetation and debris.

Edelia vittata - specimens of 3-4 cm TL were occasionally collected from the drain.

Carassius auratus - sighted on one occasion in open water of the lake. In the past this species has been caught in the lake (A. Fewster, pers. comm.).

LAKE BAMBUN (Fig. 6, Pl. 5)

Three native and one introduced species were collected. Sedge belts and open water fringing on sedge belts form the main fish habitats. Seasonal flooding from the nearby Lennard's Brook also provides fish habitats on the adjacent agricultural land.

Gambusia affinis - congregates in large numbers among the sedge belts. Also found along the sandy shoreline of the lake. Gravid females up to 5 cm TL were collected during October 1977.

Pseudogobius olorum - collected in and adjacent to sedge belts. Gravid females up to 4 cm TL were collected during April 1977 and 1978.

Bostockia porosa - specimens up to 3.8 cm TL were collected from sedge belts in April 1978. Also collected from flooded land adjacent to the lake in August 1977.

Galaxias occidentalis - this species was only collected in August 1977 from the sedge belts and the shallow shoreline of the lake. It was not detected again during the study.

LAKE BEERMULLAH (Fig. 7, Pl. 6)

Two native and one introduced species were collected in this lake. The main fish habitats are - (a) isolated sedges, (b) freshwater springs and (c) small patches of submerged vegetation.

Gambusia affinis - collected in and adjacent to sedges, small patches of submerged vegetation and from the springs. It was collected from one of the springs after the lake had dried in April 1978.

Pseudogobius olorum - collected from sedges and the springs. This species was also found in small numbers in one of the springs in April 1978.

Atherinosoma elongata - specimens 4-6 cm TL were collected from the vicinity of the springs among small patches of submerged vegetation. A number of this species were found dead in February 1978, possibly from heat exhaustion.

LAKE GURAGA (Pl. 7)

The paucity of vegetation in combination with a high salinity make this lake unsuitable for fishes. None were recorded here during the investigation.

REGAN'S FORD, MOORE RIVER (see Fig. 1)

Ten native and one introduced species were recorded. A variety of habitats exist including small waterfalls, rapids, pools, submerged trees, sedges and submerged vegetation.

Gambusia affinis - collected in all habitats except for rapids. Juveniles and gravid females were collected among submerged vegetation in shallow water during October 1977.

Galaxias occidentalis - specimens up to 12 cm TL were collected from all habitats, usually in small schools.

Bostockia porosa - individuals up to 10 cm TL were collected from large pools under debris and vegetation.

Favonigobius suppositus - specimens up to 8 cm TL were collected from all habitats except for rapids and other areas of fast flowing water.

Atherinosoma elongata - small schools containing individuals up to 6 cm TL were observed (several collected) around small waterfalls and rapids.

Pseudogobius olorum - several individuals with an average length of 2.5 cm TL were collected from similar habitats as Favonigobius suppositus.

Tandanus bostocki - individuals up to 37 cm TL were collected from a large slow flowing pool.

Edelia vittata - several specimens collected from among vegetation in pools.

Atherinosoma presbyteroides - a few individuals were collected with Atherinosoma elongata.

Mugilid sp. - sighted schooling in midwater.

Geotria australis - not collected but positive identification made from sighting in a pool by G.R. Allen.

ELLEN BROOK (see (Fig. 1)

Seven native and one introduced species were recorded. This watercourse has a variety of habitats similar to those of the Moore River.

Gambusia affinis - collected in all habitats.

Galaxias occidentalis - collected in all habitats.

Bostockia porosa - collected in pools and under submerged debris and vegetation.

Favonigobius suppositus - collected from all habitats except rapids. Maximum length was 4 cm TL.

Atherinosoma elongata - collected from rapids and other areas of fast water.

Pseudogobius olorum - commonly collected from sluggish pools and submerged vegetation and debris.

Edelia vittata - specimens up to 4 cm TL were collected in large pools.

Galaxiella munda - recorded from a springline adjacent to the Brook at Muchea by McDowall (1978).

* * * * * *

The following figure and table illustrate the collection localities of the freshwater fishes of the NSCP determined by this survey.

* * * * * *

TABLE F1

SPECIES OF FRESHWATER FISHES AND THEIR LOCALITY RECORDS FROM THE NSCP

	Lake Jandabup	Lake Joondalup	Loch McNess	Lake Chandala	Lake Bambun	Lake Beermullah	Regan's Ford Moore River	Ellen Brook
GEOTRIIDAE								
Geotria australis							x	
GALAXIIDAE								
Galaxias occidentalis				x	x		x	x
Galaxiella munda								x
CYPRINIDAE								
Carassius auratus	x	x	x	x				
PLOTOSIDAE								
Tandanus bostocki							x	
POECILIIDAE								
Gambusia affinis	x	x	x	x	x	x	x	x
ATHERINIDAE								
Atherinosoma elongata						x	x	x
A. presbyteroides							x	
PERCICHTHYIDAE								
Bostockia porosa			x	x	x		x	x
KUHLIDAE								
Edelia vittata				x			x	x
MUGILIDAE								
Mugilid sp.							x	
GOBIIDAE								
Favonigobius suppositus							x	x
Pseudogobius olorum		x		x	x	x	x	x

DISCUSSION

The freshwater fish fauna of the NSCP is represented by 13 species belonging to 10 families. At first glance this appears to be an impressive total considering the general paucity of inland fishes in the Southwest which totals 23 species. However, only seven of these species (Galaxias occidentalis, Carassius auratus, Gambusia affinis, Atherinosoma elongata, Bostockia porosa, Edelia vittata, and Pseudogobius olorum) were found with any degree of regularity in the areas which were monitored periodically. The remainder were restricted to either the Moore River (Regan's Ford) or Ellen Brook. Of the seven species only Gambusia, Carassius, Bostockia, and Pseudogobius, were generally widespread over the NSCP. Galaxias, Atherinosoma, and Edelia were confined to only one or two locations outside of the Moore River-Ellen Brook areas and these may be subject to the seasonal influence of streams. Their relative abundance at these localities was low.

Thus on close inspection the fish fauna over most of the NSCP appears to be an impoverished one. Perhaps the greatest single reason for this impoverishment is the presence of the Mosquitofish (Gambusia affinis) which was first introduced in W.A. waters in 1936 (Mees, 1977) and since that time has rapidly spread throughout the Southwest. Indeed, this was the only species which was taken at virtually every location sampled during the survey. In most areas it was encountered in prodigious numbers far exceeding the combined totals of any other species. In view of their abundance it is not difficult to understand why other fishes are generally scarce in the area. They are obviously outcompeted by Gambusia with regards to living space and food resources. The only native species present over part of the NSCP, besides Pseudogobius olorum which is basically an estuarine form, is Bostockia porosa, but it was restricted to relatively few sites and does not appear to be particularly common. Unfortunately there are no published records of the species composition of the NSCP prior to the introduction of Gambusia, nor is there sufficient specimens from this area collected prior to 1936 to allow a determination of the effects of Gambusia on native fish populations.

Although the fish fauna of most of the NSCP is relatively impoverished, especially with regards to native species, its importance with regards to the overall food-chain should not be overlooked. The fishes, and Gambusia in

particular represent a valuable source of food for various waterfowl and major decreases in the water table, resulting in periodic total drying of water bodies which are presently permanent, would obviously destroy the fish stocks. Moderate lowering of the table without resultant drying of lakes and ponds would probably not greatly affect the fish populations. Gambusia, in particular, would certainly adjust readily to water level fluctuations, as would Pseudogobius olorum, the only other species which is present in great numbers over much of the Plain outside the Moore River-Ellen Brook areas. A further possible effect of a major lowering of the water table and resultant loss of fish stocks would be to increase mosquito populations which presumably would continue to use the temporary water for breeding sites.

One area within the NSCP which perhaps should be regarded as the "bright-light" as far as fishes are concerned is Ellen Brook and its tributaries. This stream supports a relatively rich faunal assemblage consisting of eight species, all of which are natives except Gambusia. In addition, it appears to be the home of a possible relict population of Galaxiella munda, a species which is otherwise restricted to coastal streams between Margaret River and Albany. Because this stream supports a comparatively rich native fauna it is possible that Gambusia has been present there for only a short time. It is our recommendation that this stream be monitored closely over the ensuing years in order to determine both the effects of a lowered water table and also that of an increased Gambusia population.

REFERENCES

ALLEN, G.R. Field Guide to the Inland Fishes of Western Australia. Spec. Publs. West. Aust. Mus. (in press).

GREENWOOD, P.H., ROSEN, D.E., WEITZMAN, S.H. & MYERS, G.S. (1966). Phyletic studies of teleostean fishes, with a provisional classification of living forms. Bull. Am. Mus. nat. Hist. 131(4): 339-455.

IVANTSOFF, V. (1978). Taxonomic and systematic review of the Australian fish species of the family Atherinidae with references to related species of the Old World. Ph.D. Thesis, Macquarie University, School of Biological Sciences.

LAKE, J.S. (1971). Freshwater Fishes and Rivers of Australia. Thomas Nelson (Australia) Limited.

McDOWALL, R.M. (1978). A new genus and species of Galaxiid fish from Australia. (Salmoniformes: Galaxiidae). J. Roy. Soc. N.Z. 8(1): 115-124.

MEES, G.F. (1977). The status of Gambusia affinis (Baird & Girard) in south western Australia. Rec. West. Aust. Mus. 6(1): 27-31.

SHIPWAY, B. (1949). Notes on the natural history of the Pygmy Perch (Nannoperca vittata). West. Aust. Nat. 2(1): 1-9.

THE AQUATIC INVERTEBRATE FAUNA OF THE NORTHERN SWAN COASTAL PLAIN

by D. Hembree & R.W. George

I. INTRODUCTION

As the wetlands of the Northern Swan Coastal Plain are some of the most biologically strategic ecosystems in South Western Australia and convergent interests are placing increasing stress on the utilisation of these resources, the role and understanding of the wetlands becomes increasingly important. The wetlands are the most biologically productive areas on the plain and directly or indirectly support most of its wildlife (Seddon, 1972). The rivers, lakes, and swamps have been most affected by European settlement and wetlands have decreased by about 50% since commencement of the Swan River colony began (Riggert, 1966).

The aquatic invertebrates of the wetlands of the NSCP have been documented (Serventy, 1938) (Edward, 1964). These studies have experienced specific taxa on localities but have not considered the fauna of the region as a whole.

The purpose of the present study has been to document the fauna of a number of lakes which differ in their physical, chemical and biological environments, and to examine the adaptations of the species present to variations in water levels.

II SAMPLING PROCEDURES

Lakes

Lakes Joondalup, Chandala, Bambun, Beermullah and Loch McNess were sampled for fauna every two months and Lake Jandabup was sampled monthly. Lake Guraga was visited three times and sampled as it filled, at maximum depth, and as it receded. Moore River, Ellen Brook, Lake Adams, Lake Monger and Perry Lakes were also briefly sampled but no attempt was made to include them in a detailed study.

All lakes were divided into major habitat types and sampled accordingly.

Lakes Joondalup, Jandabup, Chandala, Bambun, Beermullah and Loch McNess were sampled for their chemical properties at maximum and minimum depths and also at intermediate stages for comparative purposes. Lake Guraga was chemically sampled when its level was at the recorded maximum.

Faunal Sampling Equipment

A long handled sweep net was swept three times at each sampling station for littoral and shallow benthic collection of invertebrates. The net was a tapered 46 x 33 cm square ended frame containing 1^2 millimetre mesh 'size' with a 0.5 millimetre mesh fine cloth inset for smaller organisms.

A FBA plankton net with ½ metre diameter and .14 millimetre mesh size was used for the collection of zooplankton. The net was pulled behind the boat for a period of three minutes at an approximate speed of ½ knot. The estimated volume of water sampled was about 580 litres. The procedure was undertaken during daylight with the exception of one night sample.

Benthic samples were collected in a 20 x 40 centimetre dredge with a 1 centimetre mesh size and a 1^2 millimetre fine mesh unit. It was towed by boat at an approximate speed of ½ knot between selected distances which varied in the different lakes.

Hoop traps 53 centimetres in diameter with a 2.5 centimetre mesh size baited with meat and sardines were set at night to collect freshwater crayfish.

A 3.7 metre aluminium boat powered by a six horsepower Evinrude engine was used for observation and collection purposes in the deeper areas of the lakes.

Chemical and Physical Equipment

Water quality samples were collected at the subsurface level in 500 millilitre polystyrene bottles, refrigerated at 1°C. and forwarded to the Government Chemical Laboratories in Perth for analysis. Intermediate samples were analysed at the Museum on a Bausch & Lomb mini-spectrophotometer for nitrogen, orthophosphate and chloride.

Water depths were recorded normally with a demarcated staff at fixed points and also reference for some lakes and historical records of water depth were obtained from statistics supplied by the Metropolitan Water Supply.

Water Temperatures were initially taken during sampling periods and later maximum-minimum thermometers were installed to record fluctuation ranges between sample intervals.

Aerial Photography

Aerial photographs of the lakes were taken on the 6th of May, 1978 when lake levels were at or near their minimum levels. Oblique photographs were taken with a Nikkomat equipped with a 28 millimetre wide angle lens at a height of two thousand feet.

Faunal Analysis

Population fluctuations of invertebrates were noted in relative trends. Microscopic invertebrates such as Molluscs an Decapods were recorded as absolute values. The enumeration of microscopic individuals such as copepods was undertaken by subsampling the original collection sample with a fine pipette and placing the subsample in a 9cm circular counting dish under a stereomicroscope. Turbellarians and insects were noted as present or absent.

III BIOLOGICAL FACTORS

Flora

The surrounding and aquatic flora of the different lake systems comprises an important region of faunal interaction and habitat types. Several lakes investigated in this survey have their vegetation previously documented - Joondalup (Congdon and McComb 1975), Chandala (Tingay and Tingay, 1976) and Loch McNess (McComb and McComb, 1967) and the remaining lakes are listed with their principle vegetation associations. Vegetation maps of Joondalup, Jandabup, Chandala, Loch McNess, Bambun, and Beermullah are included in the appendix 1 (How, this report).

Using the classification by Congdon and McComb (1967) the most important vegetation complexes in relation to the invertebrates aquatic fauna of the lakes may be considered as two: 1) Open Water and Littoral Fringe and 2) Paperbark Woodland.

1. Open Water and Littoral Fringe - includes sedges such as Cladium spp. forming dominant open reed swamps common to Joondalup, Jandabup, Bambun, and Loch McNess. Cladium spp. forms extensive stands along the littoral zones of these lakes and the two species show different zonations. Cladium articulatum has a submerged stem and exists in deeper areas of the lake when compared to Cladium junceum which exists just above the water line in damp patches of ground. It is interesting to note that Lake Beermullah contained only one small stand of Cladium, located on a spit which had a freshwater seepage. Beermullah is a saline lake and it is thought that its high salinity may prohibit Cladium growth except where this dilution occurs.

The bulrush Typha is present in smaller communities in Joondalup and Loch McNess. It forms dense mats of partially submerged closed reed swamps which are difficult to penetrate and in some areas appears to colonize disturbed regions (Congdon and

McComb, 1967). Both Joondalup and Loch McNess have undergone considerable shoreline change and continued modification may show an increasing displacement of open reed swamps of Cladium by the closed reed swamp of Typha (Marchant, pers. comm.).

Both genera are adapted to survive the seasonal fluctuation in water levels by production of a rhizostome system extended into damp mud enabling them to endure the dry summer season and show a preference or tolerance to inundation (Muir, pers. comm.).

Plants such as Chara, Nitella, Potamogeton, and Spirogyra were the most common dominant benthic plants of the different lake systems. The specific flora of Joondalup, Loch McNess and Chandala is documented in the previously mentioned papers and a list of the aquatic plants in Jandabup included in the report by Ayre et al,(1977.).The remaining lakes and their primary benthic flora are as follows:

Lake Beermullah - Potamogeton sp., Nitella sp. Chara sp. and Ruppia spiralis. Beermullah ranges from brackish to saline following seasonal patterns and genera such as Chara, Ruppia, and Potamogeton are known to tolerate and be common in moderately saline lakes (Marchant, pers. comm.) (Bayly and Williams, 1973).

Lake Bambun - Chara sp. was found in small colonies in the central region of the lake. Bambun retained relatively high water levels throughout the year with a maximum depth of 2.7 metres and the lack of light penetration may have hindered the production of dense colonies.

Lake Chandala - appeared to have little if any benthic aquatic plants in the main open body of water. The bottom was covered with branches and considerable organic debris from the surrounding Melaleuca rhaphiophylla Water colour was nearly always turbid and deeply discoloured with what was thought to be humic acid. The surface duckweed Lemna minor was common throughout the year and was observed only in this lake.

Lake Guraga - One unidentified benthic plant was collected possibly Chara sp. Highly saline lakes have no submerged macrophyte flora (Bayly and Williams, 1973) and Guraga had an almost sterile appearance. The lake is relatively shallow so that concentrated salts and high summer temperatures create an unfavourable environment.

Spirogyra was observed to be detrimentally affected by conditions created by the receding water level in Lake Jandabup. Much Spirogyra was observed to be dying in January, 1978 and by May, 1978 virtually all aquatic plants were dead.

Benthic plants such as Chara sp. were however able to tolerate minimal conditions throughout the sampling period in neighboring Joondalup. Plants such as Chara are adapted to changes in water level by the ability to produce spores which are able to withstand long periods of drought (Muir, pers. comm.).

Periodic blooms of single celled blue green algae occurred in lakes Joondalup, Bambun and Loch McNess but there appeared to be no direct correlation between these blooms and recorded nutrient levels. Lake Bambun maintained an obvious algal bloom from February to May, 1978.

The decomposition of the various benthic plants and sedges is thought to contribute to the accumulation of thick bottom sediments of black organic detritus found in many of the lakes. Loch McNess had especially thick deposits of this detritus and this flocculent ooze seemed to contain hydrogen sulphide in noxious quantities. An examination of this material from Loch McNess revealed an approximate composition of 60% decaying vegetation matter, 30% mineral content including quartz grains and organic muds, and 10% miscellaneous debris including molluscan shell fragments and numerous bacteria. The decomposition of Cladium is known to be a principle component of peat (Seddon, 1972) production and this contributes to the organic buildup assisting entrophic conditions and eventual successional

movement from swamp to fen stage.

2. Paperbark Woodlands - The fringing overhanging swamp Melaleuca rhaphiophylla and the flooded gum Eucalyptis rudis comprised the principle flora of this category. Of the two, Melaleuca rhaphiophylla proved the most extensive and important, inhabiting water fringes with the base of its trunk submerged for half the year and able to withstand long periods of inundation (Seddon, 1972). The drought resistant qualities of both these species are not known.

Melaleuca rhaphiophylla and M. teretifolia form thick communities around Lake Chandala and Loch McNess and dense copses on other lake margins. Much of the leaf litter on these lake bottoms can be attributed to broken branches and leaves from Melaleuca. Melaleuca also provides an important nesting site for birds as well as an aquatic habitat for invertebrates when submerged.

The combinations of the above formations, their spatial arrangement and relative abundance provide the vegetation mosaic which determines the principal habitats available to aquatic invertebrates.

Habitat

The habitats routinely sampled were divisible into two basic zones: pelagic and benthic. Several recognisable habitats existed within each of these zones.

1) Pelagic Zone

a) Open water fringing Cladium - Open reed swamps provided the principal habitat for crustaceans and fish while the reed stems housed sedentary invertebrates such as gastropods and turbellarians. The habitat also proved valuable areas for egg deposition and nurseries for juvenile fish, molluscs and other aquatic organisms. The aquatic community is very diverse in the open water fringing Cladium interface.

b) Open water - Open water samples were taken primarily for pelagic organisms such as crustaceans, fish and insects.

c) Open water fringing overhanging Melaleuca - Melaleuca overhanging open water occupied large areas of Lake Chandala and Loch McNess and smaller areas in Bambun and Beermullah. Branches extended into the water on the lake sedge and provided habitats for crustaceans and gastropods.

d) Open water fringing Typha - closed reed swamps were present in Loch McNess and Joondalup and the peripheral margins supported active aquatic populations similar to that of Cladium swamps. However, activity was confined to the exterior regions of this due to the dense compacted growth of the Typha bed.

2) Benthic Zone

a) Sand and Submerged Vegetation - As most lakes are situated on sandy soil associations, sand composes either part or all of the major aquatic substrates of most lakes. This substrate in conjunction with the benthic flora discussed under 'Flora', forms important habitats for crustacea, fish, and molluscs. Lake Guraga had the only bottom substrate entirely of sand.

b) Mud and Submerged Vegetation - It was observed that organic silts and clay formed the main substrate association with sand and aquatic vegetation. In Jandabup these sand-mud zones were distinctly defined whereas in Bambun and Beermullah these zones were mixed so a clay or mud layer overlay was interspersed with sand. The bottom of Chandala was composed solely of mud and was the only lake with this character.

c) Flocculent Organic Detritus - Varying amounts of decaying black detritus were present in several of the lakes including Joondalup, Beermullah and Loch McNess. It formed a loose suspension on the bottom and appeared to contain sizeable amounts of hydrogen sulphide. Large amounts of this flocculent detritus were present in the central region of the south and of Loch McNess and some deposits were as deep as two metres. Midge larvae and occasional turbellarians were the only invertebrates found in this substrate. Gastropod shell fragments were commonly scattered through this material.

AQUATIC FAUNA

(a) Crustacea

Crustacea were present in all lakes and were a dominant faunal group. Zooplankton communities were conspicuous in the lake system but generally low in species number. This is usually the case in Australian lakes (Bayly and Williams, 1973). Crustacea were represented by six major groups: 1) Copepoda 2) Cladocera 3) Ostrocoda 4) Amphipoda 5) Isopoda 6) Decapoda.

Copepoda

The copepoda discussed here were collected only from plankton hauls and Calanoid copepoda usually predominate with Cyclopoids and Harpacticoids making up the remaining population. Comparisons of day and night plankton samples in Lake Beermullah, the only lake sampled at night for plankton showed some variations in species composition and relative abundance. Diurnal vertical migration is well documented for zooplankton and may be a response to light or improved feeding possibilities (Hardy, 1965).

The copepod fauna in two of the lakes (Lake Beermullah and Lake Guraga) deserves special consideration.

In Lake Beermullah there was a pronounced population shift from a diurnal sample containing 99% Calanoid and 1% Cyclopoid copepods to a nocturnal sample taken at 2115 hours of 51% to Calanoid, 34% Cyclopoid and 15% Harpacticoid copepods. There was also a marked numerical increase in the samples at night. The increased Cyclopoid population may be due to the suggestion by Powell (1946) that some species of this group avoid strong light. This may be the reason for their low numbers or absence in the daylight plankton collections.

In Lake Guraga, the most saline lake, Cyclopoids made up the entire copepod population but the total numbers were always

very low in relation to all other lakes. The high salinity may have been a limiting factor for other Calanoids although Boeckella triarticulata and Calamoecia salina are known to tolerate salinities from 22-131^{o}/oo respectively (Bayly and Williams, 1973).

Ayre et al. (1977) found the two Calanoids Calamoecia tasmanica and C. attenuata coexisting in Lake Jandabup. Bayly (1964) has shown the coexistance of two unequal sized Calanoids to be common and it may be that this allows more efficient sharing of the food resource (Hutchinson, 1951). Two unequal sized Calanoids are also present in Lake Chandala and in Lake Beermullah.

The Cyclopoid copepods are members of the family Cyclopidae and the Harpacticoid copepods belong to the family Canthocamptidae (Edward, 1968).

Calanoid copepods are known to feed on particulate matter (Bayly and Williams, 1973) and generally copepods may be classified as predators (Edward, 1968).

Cladocera

Cladoceran populations were collected by sweep net in open water and around lake margins. They were present in all lakes investigated and the principle environmental event that coincides with the generation of new cladoceran populations in the lake system is the first winter rains in May and subsequent rise of lake levels.

The family Daphnidae was dominant and most species belonged to the genus Daphnia. The two species of Daphnia collected were thought to be Daphnia carinata and D. thomsoni. The genera Bosmina and Pleuroxus were also represented but numbers were always low. Macrothrix sp. was the only cladoceran collected in Lake Guraga. Daphnia were first recorded from samples taken from Bambun at the end of May, 1977 and numerous individuals were both observed and sampled in Jandabup at the end of June and in

most lakes from this period onward. During July, 1977 Daphnia populations were estimated at 750/litre at Lake Bambun. However, once water levels began to drop rapidly in December 1977 - January 1978, cladoceran populations quickly disappeared. Daphnia reproduce parthenogenetically until environmental conditions deteriorate and the sexual reproduction occurs and either one or two drought resistant ephippial eggs are produced. Sample result show that from May to October, 1977 virtually no ephippial eggs were produced by Daphnia from the various lakes. Approximately 10% of the Daphnia population began to form ephippial eggs in November and when the January 1978 sample was taken cladocerans were absent from all lakes except one area of Joondalup. Large numbers of ephippial eggs were found on the south shore of Joondalup in May but cladocerans were still absent in this lake. The brief May rains had been sufficient to trigger hatching of Daphnia in Bambun and Chandala as cladoceran populations were present only in these lakes.

Macrothrix sp., the only cladoceran collected in Lake Guraga, showed the development of ephippial eggs in all females in November when the lake was at its maximum level. It may be that in this lake Pleuroxus generate only ephippial eggs as the salinity level during November was higher than seawater and environmental conditions would be adverse throughout the year for aquatic fauna.

Daphnia carinata was found in Lake Bambun, Jandabup and Loch McNess and Ayre et al (1977) also collected Bosmina sp. from Jandabup. Small numbers of Ceriodaphnia sp. were collected in Bambun in May, 1977 and this was the only time this species was collected.

Daphnia thomsoni and Pleuroxus sp. (1 specimen) were found in Lake Chandala. The species of Daphnia present in Lake

Joondalup was undetermined.

Cladocerans are filter feeders and stomach contents of Daphnia examined revealed diatoms and organic detritus.

Ostracoda

Ostracoda were present in all lakes examined and were collected by sweep net and dredge amongst benthic and littoral vegetation. All ostracods collected belong to the family Cyprididae. Little information is available in Western Australian ostracods and some individuals collected await further identification. With their preference for well weeded,richly organic habitat, together with their ability to produce drought resistant eggs, ostracods were found to form a dominant group (Barclay, 1966). Ostracods are often found feeding on diatoms, epiphytes and other small organisms and under ephemeral water conditions ostracods are one of the last surviving crustaceans (Edward, 1968).

Ostracod numbers fluctuated, but two facts were clear: 1) populations increased in winter, in some cases as much as eight times the population found in May and declined at the end of winter; 2) ostracods were collected in greater numbers at night.

Ostracods are thought to be opportunistic breeders and eggs are deposited on submerged objects on substrates and may take several years to develop if conditions are unfavourable (Williams, 1968). Small numbers (< 5%) of one species in Jandabup were observed to be gravid in October. It may be that egg formation commences around this period and are laid as the water level begins to recede in these lakes.

Generally, two to four species of Ostracods were found in each lake. Largest populations of ostracods occurred in August, 1977 in Lake Guraga when an estimated two thousand individuals per sample were collected. Heterocypris was numerically dominant in this sample. Heterocypris sp. and Mytilocypris sp. were found in both Guraga and Beermullah and these lakes had comparatively high salinity levels.

Amphipoda

Austrochiltonia subtenuis was the only amphipod collected during this survey and was present in all lakes except Bambun. A. subtenuis was found inhabiting aquatic vegetation such as Spirogyra and Chara in benthic and littoral zones and was collected in sweep net samples and dredge hauls. It is a detrital feeder and known to be euryhaline and able to tolerate a wide range of environmental conditions (Bayly and Williams, 1973).

The largest populations of A. subtenuis were found in lakes Joondalup and Jandabup with approximately 35 individuals per sample during peak periods. Population numbers in Jandabup showed an approximate increase from 12 individual per sample in April 1977 to 35 individuals per sample in October 1977 and a decline to 12 individuals per sample in May 1978.

Amphipods and Isopods do not produce drought resistant eggs. Gravid A. subtenuis were collected in Jandabup from May, 1977 through February, 1978 and it is thought that it is an opportunistic breeder. It is widely distributed throughout Australia.

Isopoda

The Phreatoicid isopod Protamphisopus palustris was found only in Lake Jandabup. It was widespread in bottom situations living in Spirogyra over both mud and sand and was frequently collected in sweep net samples and dredge hauls. P. palustris is a detrital feeder and an examination of gut contents revealed diatoms, organic debris, and bits of green filamentous algae.

The population of P. palustris increased following the May 1977 rains and remained at a relatively constant level during the winter months. The winter population was about four times the level recorded in April 1977. Populations declined quickly after December as Jandabup began to recede, and were not collected again. Apparently phreatoicid isopods are sensitive to increased saline conditions compared to amphipods (B. Knott, pers. comm.) and it could be this factor coupled with the dying aquatic algae in which they lived led to their absence during this period. The combination of relatively high salinity and absence in some cases of the desired aquatic vegetation may have restricted this isopod to Jandabup during this study. P. palustris is known to have occurred on occasions in the south end of Lake Joondalup (B. Knott, pers. comm.).

P. palustris is believed to be an opportunistic breeder as egg carrying females were collected from April to December. Sexual reproduction was observed in June.

Decapoda

Decapod crustaceans were represented by three species: (1) the shrimp, Palaemonetes australis, (2) the gilgie, Cherax quinquecarinatus, (3) the marron, Cherax tenuimanus. One or several of these species were present in all lakes except the saline Lake Guraga. The freshwater decapod fauna of the southwest of Western Australia is distinct from that of the rest of the continent, probably due to the region's remoteness

from the sites of entry (Weatherley, 1967).

(1) The shrimp, Palaemonetes australis - P. australis was present in all lakes except Chandala, Jandabup, and Guraga and was commonly collected in sweep net samples and dredge hauls. The largest concentration of P. australis were found in lake littoral margins fringing open rush swamps. It was also common in the benthic vegetation Chara sp. in Lake Joondalup. It is a detritial feeder and gut contents revealed it to be feeding on vegetative matter, probably Chara sp., in Lake Joondalup. P. australis is known to be euryhaline and able to tolerate a salinity range from fresh to 35‰ (Bray, 1976) and inhabits both lentic and lotic environments from Hill River to Esperance, Western Australia. It has no dessicant-resistant stage to its life cycle and it is thought reappearance of P. australis in lakes previously affected by drought is due to recolonisation (Williams, 1968).

Lake Chandala has periodically dried out (A. Fewster, pers. comm.) and solid fragments of sediments found in some parts of the bottom of Jandabup suggest past drying out has occurred in this lake also. This factor, along with the lack of recolonising circumstances, probably accounts for the absence of P. australis in these two lakes.

It is interesting to note that Serventy collected P. australis in Monger's Lake in 1936 (Serventy, 1938) while it was absent from this lake in 1964 (D. Edwards, pers. comm.) and it was collected again in June 1978 by this author. The recolonisation by P. australis of lakes especially in the metropolitan area may be assisted by fisherman (B. Knott pers. comm.) and aquarium hobbyists.

Seasonal population trends in all lakes showed a steady decline in numbers by 50-70% from May to November 1977. Spawning occurred in November and populations rose sharply so that January 1978 samples showed in some samples a sixfold increase in numbers of Palaemonetes australis. The great majority of these shrimps were juveniles. Populations then began

to decrease slightly and return to a comparable level recorded the previous May and should continue to decrease as juvenile mortality continues.

Palaemonetes australis was observed to be active at night and was commonly seen in the very shallow littoral regions of the lakes during the nocturnal period.

In some circumstances, introduced fish species have been responsible for the eradication of indigenous shrimp populations (Williams, pers. comm.). However, this does not appear to be the case with the lakes and streams visited during this survey as the mosquito fish, Gambusia affinis was present wherever P. australis was found.

(2) The gilgie, Cherax quinquecarinatus - C. quinquecarinatus was found in Lakes Joondalup, Jandabup, Chandala, Loch McNess, Moore River and Ellen Brook, and was collected by hand, dredge, and hoop traps. It ranges from Moore River in the north to possibly almost as far south as Busselton, Western Australia (Riek, 1966). It was found on bottom substrates under rocks and logs and among open Cladium beds. C. quinquecarinatus was most common and in Lake Joondalup and Loch McNess where about three animals per trap hour were collected at night. These individuals were taken from Jandabup and one from Chandala during the entire survey. There was an obvious increase in activity at night and gilgies were observed to be very active in the shallow littoral margins of Joondalup and Loch McNess during this period.

The gilgie is a scavenger, feeding on a variety of living or decaying matter (Edward, 1968). A gilgie collected in Lake Chandala had a distinct blue colour and this characteristic may be due to its vegetative diet (Muir, pers. comm.).

The genus Cherax seems able to withstand great physiological stress due to stringent environmental conditions and is far 'hardier' than any other Australian genus of crayfish (Bishop, 1967). It is also well adapted to conditions in the Northern Swan Coastal Plain by its ability to burrow into damp ground to endure drought conditions.

(3) The marron, Cherax tenuimanus - C. tenuimanus was found only in Loch McNess where it was introduced after World War II. It was collected at night in hoop traps and was most commonly found on the bottom under overhanging banks and often on sand bottoms in open water. The marron inhabits fresh water bodies from Perth to the Kalgan River near Albany, Western Australia (Riek, 1966). Its feeding habits are similar to the gilgie. The marron population of Loch McNess appeared to be thriving and both adults and juveniles were collected at a rate of about 2 individuals per trap hour at night.

The Koonac, Cherax preissii may also inhabit areas within the Gnangara Mound region but it was not collected during this survey.

(b) Mollusca

The number of freshwater species collected in the Northern Swan Coastal Plain lakes was depauperate compared to more humid areas of Western Australia such as the Southwest or Kimberley region (Kendrick, pers. comm.).

The molluscs collected in the lakes investigated were two pulmonate gastropods, Physa sp. and Physastra sp., two bivalves Westralunio carteri and Sphaerium sp., and one limpet, Ferrissia petterdi.

Physa sp. and Physastra sp. comprised the largest and most widespread populations of molluscs and of the two, Physa was the more common. Physa sp. and Physastra sp. inhabited the base of sedges in both open and closed reed swamps and were also present in benthic vegetation such as Chara and Nitella. They were collected by hand, sweep net, and dredge and one or both species were present in all lakes sampled except Guraga.

Physa sp., a recent introduction to Western Australia, is a rapid coloniser and in the present survey has been found from just north of Gingin to Perth in Western Australia. This gastropod was the only mollusc collected in Jandabup, Chandala, Beermullah, Bambun, and coexisted with

Physastra in Joondalup. Physastra has been recorded from Bambun in 1971 (Kendrick, unpublished) but was not collected there on this survey.

Physa sp. appears to show a greater tolerance to some adverse conditions than do most endemic pulmonates. Population trends of Physa fluctuated irregularly with numbers ranging from two to twenty-five individuals per sample, and no direct correlation could be drawn with environmental factors. Physa sp. was present throughout the sampling period, except when lake levels were too low to sample, such as in Beermullah in April 1978. Physa sp. were observed to be gravid in April and May.

Physastra sp. was present in Joondalup and Loch McNess. Physastra coexisted with Physa in Joondalup, but was numerically dominant and composed approximately 90% of the gastropod sample collected in that lake. Physastra population levels also showed a relatively high constant value of approximately 30 individuals per sample and numbers showed a decline in January 1978 to only 2 individuals per sample and comparatively low numbers were present through May 1978,

A small colony of Physastra was discovered in a closed reed swamp in the north end of Loch McNess. This was the only area in Loch McNess where living Physastra were collected. Dead shells of Physastra were plentiful through the south end of Loch McNess but no living specimens were collected.

Physastra shows a preference for fresher water in Western Australia. Most freshwater gastropods occurring in Western Australia tend to recolonise favourable environments rather than persist during adverse conditions. Breeding parameters of these pulmonates are not well known but they appear to be opportunistic breeders (Stoddart, pers. comm.).

Both Physa and Physastra are herbivorous. Dispersal of pulmonates appears to be primarily due to waterbird movement. (Stoddart, pers. comm.).

However, under adverse conditions pulmonates may seal their aperture by an epiphragm and Physastra is also thought to burrow into the damp mud during drought conditions (Kendrick, unpublished).

The freshwater limpet, Ferrissia petterdi was found in an open swamp attached to Cladium stems in the north end of Loch McNess and attached to a partially submerged bird hide in Lake Chandala. Ferrissia inhabits fresh water and seems susceptible to high salinity and little is known of its reproductive history (Stoddart, pers. comm.). It is an effective coloniser of isolated waterbodies and in Western Australia ranges from the south coast region probably through the Kimberley (Kendrick, unpublished).

The naiad, Westralunio carteri was collected in Loch McNess, Lake Bambun and Ellen Brook. This species is restricted to freshwater environments and was found on or half-buried in sand or mud. W. carteri has a contracting distribution in southern Western Australia (Kendrick 1976) the only area in which it occurs (Stoddart, pers. comm.). It existed in small populations of thirty or less and its distribution is not believed to be widespread in Loch McNess or Bambun. Other Australian freshwater mussels burrow deeply into the damp substrate to survive arid conditions and this may also occur with W. carteri. It is a filter feeder and little data is available concerning reproductive ability (Stoddart, pers. comm.).

The pea clam, Sphaerium sp., was collected on one occasion from the north end of Loch McNess. Little data is available for this bivalve and it appears to be associated with organic, muddy substrates in still or slowly moving fresh water. In Western Australia it ranges from about Augusta to Perth and environs.

Other species of mollusc not collected but which may be expected in the Gnangara Mound region are Gycaulus essingtonensis and possibly Lymnaea columella and L. lessoni. Helisoma duryi was collected in Perry Lakes, Floreat, but is thought not yet to extend into the region affected by the Gnangara Mound.

(c) Insecta

Aquatic insects were common in all lakes. No regimented collecting programme was undertaken for the collection of aquatic insects but reprentative species were collected throughout the survey. Insect collection was undertaken with the sweep net in surface littoral zones and dredge hauls were used for benthic samples. Identification of all species is not complete and a partial list of aquatic insects is included in the lake species list in section IV.

Water boatmen, water beetles, dragonflies, and midges were the most common species present. Water boatmen (Corixidae) maintained large active populations in all lakes except Guraga throughout the survey. Water boatmen and water beetles were most common in open shallow littoral areas.

Chironomid midge larvae and dragonfly numphs were present in benthic samples. Chrionomid larvae were the only aquatic fauna to be regularly collected in the benthic flocculent organic detritus and was the only insect collected in Lake Guraga. Dragonfly nymphs were most often found in aquatic vegetation over mud substrate.

Except for the filter feeding midge larvae all insects collected are predators on small insects and other aquatic life. Water mites may be predators or parasites.

It is thought that most of the species are opportunistic breeders and that they have a wider distribution over the South-west of Western Australia. Where adverse conditions prevail adults of all the insects collected are capable of flying to other sources of water (Koch, pers. comm.).

IV. THE LAKES AS BIOLOGICAL UNITS

Lake Jandabup

Invertebrate species collected in Lake Jandabup were as follows.

COPEPODA - *Calamoecia tasmanica*

Calamoecia attenuata

CLADOCERA - *Daphnia carinata* ?

Bosmina hagmanni ?

OSTRACODA - Cyprididae A, B

AMPHIPODA - *Austrochiltonia subtenuis*

ISOPODA - *Protamphisopus palustris*

DECAPODA - *Cherax quinquecarinatus*

GASTROPODA - *Physa* sp.

INSECTA - *Austroagrion coeruleum*

Austrolestes psyche

Synthemis cyanitincta

Procordulia affinis

Trapezostigma stenoloba

Agraptocorixa sp.

Procladius villosimanus

Polypedilum nubifer

- Culicidae

Trichoptera

ARACHNIDA - Hydrachnellae

OLIGOCHAETA - B

TURBELLARIA - Tricladida

Lake Jandabup was sampled monthly from April 1977 to May, 1978. Jandabup is a freshwater lake and is considred by Ayre *et al* (1977) to be less eutrophic than Joondalup or Loch McNess. Jandabup contained four principle habitats: 1) Open water 2) Open water fringing *Cladium* 3) Sand and submerged vegetation 4) Mud and submerged vegetation.

The littoral open water fringing Cladium zone was the most abundant region for aquatic invertebrates. This region was most productive in terms of organisms per sample and also species richness. Jandabup was dominated by crustaceans and insects. The decapod Palaemonetes australis, common to most other lakes in this area, was absent. This lake also maintained the only large isopod population.

Jandabup with its large area of open water and dense sedge communities is approximately equal to Bambun in species diversity and animal numbers per sample. Of the three southernmost lakes investigated, Jandabup is most likely to be affected by groundwater abstraction.

Lake Joondalup

Invertebrate species collected in Joondalup were as follows:

COPEPODA - *Calamoecia tasmanica*

Calamoecia attentuata

CLADOCERA - *Daphnia* sp.

OSTRACODA - Cyprididae

AMPHIPODA - *Austrochiltonia subtenuis*

DECAPODA - *Cherax quinquecarinatus*

Palaemonetes australis

GASTROPODA - *Physa* sp.

Physastra sp.

INSECTA - *Austroagrion coeruleum*

Anisops sp.

Agraptocorixa sp.

Chironomus australis

Dytiscidae

Hydrophilidae

Trichoptera

Culicidae

ARACHNIDA - Hydrachnellae

HIRUDINEA - *Clepsine* sp. ?

OLIGOCHAETA - B

TURBELLARIA - *Planaria* sp.

Lake Joondalup was sampled every second month from April 1977 to May 1978. It is a marginal to brackish lake and Congdon and McComb (1967) consider it to be in a mildly eutrophic state. Joondalup produced the most numbers of organisms per sample of the lakes regularly sampled and contained all major habitat divisions. It had the densest benthic vegetation community and was the largest of the lakes surveyed. Crustacea and insects are the predominant fauna present.

Joondalup, surrounded by intensive agricultural and urban development is thought to be located in the region directly affected by the Gnangara Mound drawdown. The hydrology of the lake may make it less vulnerable to drawdown effects than Lake Jandabup.

Loch McNess

Invertebrate species collected in Loch McNess were as follows:

COPEPODA - *Calamoecia tasmanica*

CLADOCERA - *Daphnia carinata* ?

Macrothricidae

OSTRACODA - Cyprididae A B C

AMPHIPODA - *Austrochiltonia subtenuis*

DECAPODA - *Cherax quinquecarinatus*

Cherax tenuimanus

Palaemometes australis

GASTROPODA - *Physastra* sp.

Ferrissia petterdi

LAMELLIBRANCHIATA - *Westralunio carteri*

Sphaerium sp.

INSECTA - *Anisops* sp.

Agraptocorixa sp.

Chironomus australis

Culicidae

Trichoptera

Odonata

Coleoptera

ARACHNIDA - Hydrachnellae

HIRUDINEA - *Clepsine* sp. ?

OLIGOCHAETA - A

TURBELLARIA - *Temnocephala* sp.

Tricladia

Loch McNess was sampled every two months from April 1977 to May 1978. It is a freshwater lake and its water chemistry shows it to be fresher than all the other lakes. Loch McNess contains all major habitat types discussed under the 'Habitat' section and the widest range of microhabitats of the lakes surveyed including both lentic and lotic divisions. Loch McNess contains the highest number of species but is poor in terms of number of animals per sample when compared to Jandabup and Joondalup. Loch McNess had the highest number of species of both molluscs and crustacea of the lakes samples. The pea clam, Sphaerium and the marron, Cherax tenuimanus, were collected only from this lake during the survey.

The water of Loch McNess remained clear throughout the survey and was the only lake which was not turbid. Loch McNess, also contained the largest amounts of flocculent organic detritus to be found in any lake.

Due to its hydrology, Loch McNess is thought likely to be less affected by the Gnangara Mound borefields than Jandabup.

Lake Chandala

Invertebrate species collected in Lake Chandala were as follows:

COPEPODA - Calanoida

CLADOCERA - *Daphnia thomsoni* ?

Pleuroxus sp.

OSTRACODA - Cyprididae

AMPHIPODA - *Austrochiltonia subtenuis*

DECAPODA - *Cherax quinquecarinatus*

GASTROPODA - *Physa* sp.

Ferrissia petterdi

INSECTA - *Agraptocorixa* sp.

Micronecta sp.

Hydrophilidae

Chironomidae

ARACHNIDA - Hydrachnellae

HIRUDINEA - *Clepsine* sp. ?

OLIGOCHAETA - B

Lake Chandala was sampled every second month from April, 1977 to May, 1978. Chandala is a freshwater lake and contained the smallest amount of open water of any of the lakes investigated. Open water with overhanging *Melaleuca* and the Mud Benthos were the principle habitats. Chandala was devoid of submerged vegetation in its main body. Of the two habitats, open water with overhanging *Melaleuca* was the most important and proved to be the site of greatest species richness. Lake Chandala had the most extensive communities of *Melaleuca* habitat in relation to its size of any lake surveyed and contained the lowest number of animals per sample site of all lakes surveyed. The water of Lake Chandala was stained a humic brown and at times was slightly acidic.

Tingay and Tingay (1976) state that Bestow suspects Lake Chandala will be little affected by the Gnangara Mound borefields.

Lake Bambun

Invertebrate species collected in Lake Bambun were as follows:

COPEPODA - Calanoida A, B

CLADOCERA - Daphnia thomsoni

Ceriodaphnia sp.

OSTRACODA - Cyprididae D

DECAPODA - Palaemonetes australis

GASTROPODA - Physa sp.

LAMELLABRANCHIATA - Westralunio carteri

INSECTA - Austroagrion coeruleum

Agraptocorixa sp.

Micronecta sp.

Eretes australis

Chironomus australis

Procladius villosimanus

Chironomidae (A)

Dytiscidae (A)

Therinidae

Hacipidae

Syrphidae

HIRUDINEA - Clepsine sp.

OLIGOCHAETA B

TURBELLARIA - Tricladia

Lake Bambun was sampled every two months from April, 1977 to May, 1978. Bambun is a marginal to brackish lake with the highest water level recorded during the survey (How, this report) and retained relatively deep levels throughout the survey when compared to the other lakes investigated. Bambun contained four major habitats: 1) Open water, 2) Open water fringing Cladium, 3) Open water with overhanging Melaleuca, and 4) Mud

and submerged vegetation. Species were most abundant and diverse in the littoral open water fringing Cladium zones. Crustacea and insects were the dominant fauna present and large numbers of cladoceran were present throughout the winter. Lake Bambun was also subject to frequent algal blooms. Bambun was approximately equal to Jandabup in numbers of species and numbers of organisms per sample but retained a higher diversity and abundance of organisms during the summer, probably due to its maintenance of a higher water level.

Lake Bambun is thought to be only slightly affected by Gnangara Mound drawdown.

Lake Beermullah

Invertebrate species collected in Beermullah were as follows:

COPEPODA - Calanoida A, B

Cyclopoida

Attheyella ? sp.

CLADOCERA - A.

OSTRACODA - *Mytilocypris* sp.

Heterocypris sp.

AMPHIPODA - *Austrochiltonia subtenuis*

DECAPODA - *Palaemonetes australis*

GASTROPODA - *Physa* sp.

INSECTA - *Austrolestes psyche*

Agraptocorixa sp.

Chironomidae

OLIGOCHAETA - A

Lake Beermullah was sampled every second month from April, 1977 through May, 1978. It is a saline lake and its physical features and location are previously mentioned in this report. The water chemistry shows Beermullah to be somewhat eutrophic when compared to Loch McNess (How, this report). Beermullah had a lower in number of species collected than all other lakes except Guraga while the numbers of individuals per sample was lower than all lakes except Chandala. Five major habitat zones were present: 1) Open water, 2) Open water fringing overhanging *Melaleuca*, 3) Open water fringing *Cladium*, 4) sand and submerged vegetation, 5) Flocculent organic detritus. Of these habitats, open water fringing overhanging *Melaleuca* and open water fringing *Cladium* were the regions of greatest species richness and abundance. Crustaceans were the dominant fauna in this lake while cladoceran numbers were very low and Beermullah did not have cladoceran 'blooms' as was the case in all other lakes.

Beermullah was much less saline about 20 years ago (E. Harris pers. comm.) and has evidently been accelerated to its present state by the clearing of land for agricultural purposes.

Lake Guraga

Invertebrate species collected in Lake Guraga were as follows:

COPEPODA - Calanoida

CLADOCERA - *Macrothrix* sp.

OSTRACODA - *Mytilocypris* sp.

Heterocypris sp.

AMPHIPODA - *Austrochiltonia subtenuis*

INSECTA - Chironomidae

Lake Guraga was sampled during August and November, 1977 and during January, 1978 before drying out. It appeared to have typical characteristics of saline lakes as discussed by Bayly and Williams (1973) with an absence of fish and submerged macrophyte vegetation, the presence of Calanoid copepods and numerical dominance by ostracods. Guraga, the most saline of the lakes sampled, had the lowest number of species and highest numbers of individuals per sample recorded during the survey. The near absence of aquatic vegetation and concentrated water chemisty in this lake are major causes for the limited species diversity. This lake had the lowest water level and least range of habitat types of all lakes investigated. Habitat zones were confined to open water and sand and submerged vegetation. The area of highest faunal abundance was in open water in the shallow littoral zone. The adaptive ability of crustacea, the dominant faunal group to exist in this type of environment has been discussed under 'Aquatic Fauna'.

V. LAKE INTERRELATIONSHIPS AND IMPORTANCE

The lakes examined on the NSCP were basically similar in bathymetry, but different significantly in their chemical and biological environment. It is the purpose of this section to examine the relationship between the physico-chemical and biological characters of the lakes.

(a) Physical characters

The lakes surveyed have relatively large area to volume ratio and are subject to fuctuating water levels and chemical composition. All lakes investigated during this survey were relatively shallow with a maximum recorded depth of 2.7 metres. Low water levels maximise the effect of temperature variation and water chemistry as dictated by the seasonal climate. No distinct thermal stratification was present within the lakes and the diurnal-nocturnal temperature range of the water was closely related to ambient temperatures.

Dissolved oxygen levels recorded at Lake Bambun were 9 mg/litre. Similar levels have been recorded in Joondalup (Congdon and McComb, 1967) and Ayre et al. (1977) recorded comparable levels in Jandabup and slightly lower levels in the south end of Loch McNess. The lower levels in Loch McNess may be due to the large amounts of organic detritus in that lake. It is thought that the large open lakes in the NSCP may have relatively high dissolved oxygen levels during the winter due to the action of wind stirring and, in some cases such as Joondalup, dense benthic vegetation. Barclay (1966) has shown comparable results for some temporary ponds in New Zealand and notes a steady drop in dissolved oxygen values as water levels recede.

The chemical composition of the water of all lakes surveyed generally showed increased concentrations during the summer. The summer concentration level was usually one to three times the level recorded during the winter period (How, this report).

Weatherley (1967) refers to Simpson (1916) as stating that Western Australian waters are almost entirely alkaline in reaction. This appears to be the case with the lakes visited during this survey. Lake Chandala was slightly acidic apparently due to its humified waters.

All lakes except Loch McNess were very turbid and contained large amounts of suspended particulate matter.

Turbidity is a common feature of many shallow temporary lakes in arid parts of Australia (Bayly and Williams, 1973).

(b) Biological character

The importance of the littoral zone and its habitat structure to the diversity and abundance of aquatic invertebrates was a constant dominant factor throughout all lakes. The littoral zone produced the greatest number of individuals and species diversity of any ecological area in the lake zonation. The littoral open water/sedge community interface was the region of greatest aquatic invertebrate activity and significance. The lowest species diversity and abundance was found to be in the flocculent organic detritus.

The NSCP water bodies revealed a low species diversity when compared to some lakes in eastern Australia (Bayly and Williams, 1973) and probably to wetter areas of south western Western Australia. A similarity of faunal types was apparent throughout the surveyed area. Insects and crustacea proved to be the dominant types of fauna with an emphasis on resilient species able to tolerate adverse and fluctuating environmental conditions.

Aquatic invertberate fauna collected during this survey did not appear to be rare or unique. Because environmental pressures have favoured adaptable species, the invertebrate fauna of thelakes is thought to range through much of the south-west of Western Australia and in some cases Australia-wide.

Overall the aquatic invertebrate fauna showed an increase in number and diversity following the initial winter rains and populations were high

throughout the winter period. A successional decrease in species abundance and diversity occurs as the water level recedes during the summer period. The lake systems reflect the divisions between fresh and salt water lakes emphasising gradual reduction in species diversity from fresh to saline and the comparable effect of the reduction of habitat.

Crucial consideration concerning water table reduction seem to be the degree of water drawdown, the drawdown time period, the affect on water chemistry and the affect on vegetation.

Provided these effects are not extreme, the invertebrate fauna of the NSCP should be able to tolerate moderate reductions in water level as their adaptable qualities have oriented them to similar conditions in their natural environment. Species which do not produced drought resistant eggs may be detrimentally affected.

However, as threshold levels of most of the organisms are not well known, water level fluctuations should be in accordance with natural environmental conditions as much as possible and every effort should be made to preserve vegetation habitat structures in the littoral zone.

References

AYRE, D. et al. (1972). A limnological survey of Lakes Jandabup, Joondalup, and Loch McNess. [Unpublished B. SC. Hons. thesis. University of Western Australia.]

BARCLAY, M.H. (1966). An ecological study of a temporary pond near Auckland, New Zealand. Aust. J. mar. freshwat. Res. 17: 238-258.

BAYLY, I.A.E. (1964a). A revision of the Australasian species of the genera Baeckella and Hemiboeckella (Copepoda: Calanoida). Aust. J. mar. freshwat. Res. 15: 180-238.

BAYLY, I.A.E. & WILLIAMS, W.D. (1973b). Inland waters and their ecology. Australia: Longman.

BISHOP, J.A. (1967). The zoogeography of the Australian freshwater decapod crustacea. pp.107-122. In: Australian inland waters and their fauna: eleven studies. ed. A.H. Weatherly. Canberra: A.N.U. Press.

BRAY, D. (1976). A review of two Western Australian shrimps of the genus Palaemonetes, P. australis Dakin 1915 and P. atrinubes sp. nov. (Decapoda, Palaemonidae). Rec. West. Aust. Mus. 4: 65-84.

CONGDON, R.A. & McCOMB, J.A. (1976). The nutrients and plants of Lake Joondalup, a mildly eutrophic lake experiencing large seasonal changes of volume. J. R. Soc. West. Aust. 59: 14-23.

EDWARD, D.H. (1964). The biology and taxonomy of the Chironomidae of south-western Australia. [Unpublished Ph.D. thesis, University of Western Australia.]

EDWARD, D.H. rev. (1968). A guide for naturalists; by A.R. Main. Handbk. West. Aust. Nat. Club No. 4

HARDY, A.C. (1956). The open sea. London: Collins.

HUTCHINSON, F.E. (1951). Copepodology for the ornithologist. Ecology 32: 571-7.

KENDRICK, G.W. (1976). The Avon: faunal and other notes on a dying river in south western Australia, West. Aust. Nat. 13: 97-114.

McCOMB, J.A. & McCOMB, A.J. (1967). A preliminary account of the vegetation of Loch McNess, a swamp and fern formation in Western Australia. J. R. Soc. West. Aust. 50: 105-112.

POWELL, A.W.G. (1946). Ecology of fresh water fauna of Lake St. Clair, particularly the Copepoda, with special reference to diurnal and seasonal variations in conditions. Pap. Proc. R. Soc. Tasm. 1945: 63-127.

RIEK, E.F. (1967). The freshwater crayfish of Western Australia (Decapoda: Parastacidae), Aust. J. Zool., 15: 103-21.

RIGGERT, T.L. (1966). Wetlands of Western Australia, 1964-66. Department of Fisheries and Fauna, Perth.

SEDDON, G. (1972). Sense of place. Nedlands: Univ. West. Aust. Press, Nedlands.

SERVENTY, D.L. (1938). Palaemonetes australis Dakin in south-western Australia. J. R. Soc. West. Aust. 24: 51-57.

TINGAY, A. & TINGAY, S. (1976). Report on Lake Chandala with recommendations of its importance as a fauna reserve, Rep. Dep. Fish Wildl. West. Aust. No. 26.

WEATHERLEY, A.H. (ed. 1967). Australian inland waters and their fauna: eleven studies. Canberra: A.N.U. Press.