V Discussion

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The Lake Johnston-Hyden Study Area, the most south-westerly of the 12 Study Areas surveyed in the Eastern Goldfields of Western Australia (Figure 1), occupies a region where winter-rainfall (May-August) predominates. The boundary of the South-west and Eremaean Botanical Provinces dissects the Study Area in the north-east, and rainfall varies from *c.* 340 mm in the south-west to about 270 mm in the north-east.

The Biological Surveys Committee (1984) when designing the Eastern Goldfields survey, decided to place greater sampling emphasis on the Lake Johnston-Hyden Study Area in recognition of (a) its biogeographic position, (b) the large tracts of eucalypt woodland that remain, but which have been extensively cleared and fragmented in adjacent areas, and (c) the increasing pressure for the release of natural areas for dryland farming. Sampling of the vegetation and flora was the most extensive of the Eastern Goldfields programme with several additional surveys undertaken during the study. Four, instead of the usual two, faunal survey areas were selected for examination.

Seven of the 10 Landform Units recognised in the Eastern Goldfields are recorded in the Study Area. The most extensive Landform Units are Sandplain (47%), Broad Valley (36%), and Salt Lake Feature (13%); the latter contains the Johnston Lakes from which the Study Area derives its name. The Undulating Plain (greenstone) contains the mineral rich greenstone belts that have been the focus of mining exploration within the Study Area. Exposures of granite are common on the lower slopes where Sandplain join Broad Valley, and on valley bottoms close to Salt Lake Feature. Hill (Granite) contains Peak Charles and Peak Eleanora, prominent peaks in the south-east corner of the Study Area. Three landforms, Drainage Line, Dunefield and Calcareous Plain are not described from the Study Area. Drainage Line is occasionally encountered but on a scale too small to be sampled for vegetation, or mapped at 1 : 250 000; while the only dunes present are the solitary stabilised lunettes adjacent to the eastern margins of many salt lakes.

The catchment of the ephemeral freshwater Lake Cronin, one of only three among the extensive salt lake systems of the Eastern Goldfields, was sampled intensively.

Previous studies (Beard 1969, 1972) broadly described and mapped the vegetation of the Study Area at the formation level from both ground traverses and extensive air-photo mosaic interpretation. A focus of our study has been to re-examine this information in the light of extensive ground surveys and to provide detailed descriptions of the vegetation and floristics from specific sample sites. Several unique vegetation features and species were identified.

Lake Johnston-Hyden covers parts of the Roe Botanical District and Coolgardie Botanical District (or South-western Interzone), districts within the South-west and Eremaean Botanical Provinces respectively. Nine vegetation systems (Beard

1980) are represented within the Study Area, a figure exceeded only by the Boorabbin-Southern Cross Study Area immediately to the north (Newbey and McKenzie in prep.). Several vegetation systems, reach their maximum extent within the Eastern Goldfields (Table 18). These included the Lake Hope (100%), Hyden (100%), Forrestania (97%) and Bremer Range (88%) systems.

Fifty-one vegetation types were recognised in the 198 samples of the vegetation of the Study Area. Although most vegetation types extend to adjacent Study Areas, there were seven unique vegetation types and complexes within Lake Johnston-Hyden; Breakaway Complex (LH1), Banded Ironstone Formation Complex (LH11), Greenstone Complex (LH31), *Acacia jennerae* Tall Shrubland (LH49), *Eucalyptus georgei* Low Woodland (LH15), *Eucalyptus* sp. (KRN5603) Low Woodland (LH30) and *Eucalyptus merrickiae* Mallee (LH47). A further five, *Eucalyptus* sp. (KRN9710) Low Woodland (LH12). *Tecticornia verrucosa* Low Shrubland (LH51), *Melaleuca* spp. Tall Shrubland (LH26), *Eucalyptus* aff. *foecunda* Low Woodland (LH36) and *Melaleuca* aff. *preissiana* Tall Shrubland (LH50) are rare within both the Study Area and the Eastern Goldfields.

Several landform units within the Study Area contain unique mosaics of vegetation types and complexes that differ markedly from those in other Eastern Goldfields Study Areas. Included in these are the Hill (granite) mosaics of Peak Charles and Peak Eleanora, Hill (banded ironstone formation) mosaics of North, Middle and South Ironcap as well as Bremer Range and the mosaics on the greenstone belt from Hatters Hill to Mt Holland.

There have been significant modification to the vegetation of some sections of the Study Area since European settlement. Clearing for agriculture occurred during the '3500 farm scheme' of the 1920s, although little evidence of this is now visible either on the ground or from aerial photos. The resourceful Sandalwood *(Santalum spicatum)* cutters have operated continuously over most of the Study Area and few parts remain that are unaffected by this activity. The limited extent of chenopod shrublands and the scarce supply of free surface or aquifer freshwater ensured that grazing has never been extensive. Large areas of Woodlands and Low Woodland in the eastern third were cut between 1950 and 1977 to provide timber for mine shafts and furnaces (W.G. Brennan, pers. comm.). More noticeable recent activities are the proliferation of tracks and gridlines established during mining exploration in the 1960s and 70s, particularly in the greenstone belt.

The single most important modifier of the vegetation within the Study Area is fire. Heaths and mallees, particularly on Sandplain, show evidence of regular burns (front cover). The myrtaceous species which predominate in these vegetation formations have high resin and volatile oil content which assist fire. In contrast, Woodlands and many Low Woodlands have remained unburnt for periods in excess of 100 years, principally due to their open structure, sparse or fire resistant (chenopod) understory, and low rates and extent of litter accumulation.

The Lake Johnston-Hyden Study Area contains the richest flora of the Eastern Goldfields with 1076 species, 17 subspecies and 29 varieties of flowering plant

Table 18 Representation of Vegetation Systems within the Study Area and Eastern Goldfields.

VEGETATION SYSTEM	AREA (km²) TOTAL	AREA (km²) WITHIN EASTERN GOLDFIELDS	AREA (km²) WITHIN STUDY AREA	AREA (km²) WITHIN RESERVES J	F	L	P
Boorabbin	17265	17265	630	0	0	0	0
Bremer Range	975	975	855	0	0	0	0
Cave Hill	10820	10820	5220	0	0	0	399.59
Forrestania	2365	2355	2280	62.0	0	3.2	0
Hyden	23845	795	795	0	0	0	0
Lake Hope	11595	9035	8900	40.0	498.77	0	0
Muntadgin	7380	1365	90	0	0	0	0
Salmon Gums	2210	1305	405	0	0	0	0
Skeleton Rocks	4975	4310	1825	92.0	0	0	0
Total			21000	194.0	498.77	3.2	399.59

J = Jilbadgie Nature Reserve (part of)
F = Frank Hann National Park
L = Lake Cronin Nature Reserve
P = Peak Charles National Park

(20 species were introductions) and 6 species of fern recorded. This contrasts to the 780 species at Jackson-Kalgoorlie (Newbey and Hnatiuk 1985), and 535 species at Widgiemooltha-Zanthus (Newbey and Hnatiuk 1984). The families with the greatest number of species in the Study Area were Myrtaceae, Leguminosae, Proteaceae and Asteraceae, while the richest genera were *Acacia, Melaleuca, Eucalyptus, Lepidosperma* and *Grevillea.*

Twenty new species were recorded in the Study Area, 79 rarely collected species, 38 species endemic to the Study Area, 4 gazetted as 'rare' and 14 which were major extensions of range (Table 4). The rare taxa were *Banksia sphaerocarpa* var. *dolichostyla, Eremophila viscida, Drummondita hassellii* var. *longifolia* and *Grevillea prostrata.*

Species composition changes widely from both the west and south, towards the north-east of the Study Area. This is because the Study Area is part of a large 'ecotone' between the South-west and Eremaean Botanical Provinces. Families which decreased markedly in their number of taxa from the South-west through the interzone included Cyperaceae, Orchidaceae, Proteaceae, Restionaceae and Stylidiaceae. Along the same gradient, families that increased included Chenopodiaceae, Euphorbiaceae, Myoporaceae and Zygophyllaceae.

Common South-west species whose distribution extends into western and southern sections of the Study Area include: low trees of *Acacia lasiocalyx;* tall shrubs of *Acacia trigonophylla;* annuals of *Quinetia urvillei, Stylidium calcaratum, Waitzia citrina* and *W. paniculata;* geophytes of *Anigozanthos rufus, Caladenia hirta, Polypompholyx tenella, Spiculea ciliata* and *Stylidium petiolare;* and

sedges of *Gahnia drummondii, Lepidosperma carphoides* and *Mesomelaena stygia.* Those with wide South-western Interzone distribution include: tall shrubs of *Acacia resinostipula, A. warramaba, Atriplex nummularia* ssp. *spathulata, Bertya quadrisepala, Eremophila ionantha, E. pachyphylla, E. scoparia* and *Ricinocarpos stylosus;* low shrubs of *Cratystylis conocephalus;* annuals of *Angianthus conocephalus* and *Goodenia havilandii;* and sedges of *Schoenus brevisetis.*

An interesting point is the relatively large number of *Melaleuca* species present in southern mallee vegetation types. This also occurs in some areas south of the Study Area (Burgman and Newbey 1987).

Species richness is highest in western and southern sections, decreasing towards the north-eastern corner of the Study Area. The numbers of conservationally important plant species are also greater in the south and west with the southern section (22), Lake Cronin (16), Peak Charles area (11), Murray Rocks (5), Ironcaps (3), Bremer Range (2) and Hatters Hill (2) all having several important species. In general, plant species important for conservation are widespread in western and southern sections. Most of the species from the southern section have been recorded in Frank Hann National Park, however, populations within the park are often small (Appendix II). Lake Cronin and Peak Charles are also areas with large concentrations of important species. One important area not studied in sufficient detail is the Bremer Range.

Amphibians clearly reflect the biogeographic affinities and significance of the Study Area. Five of the nine species recorded, *Helioporus albopunctatus, Limnodynastes dorsalis, Myobatrachus gouldii, Pseudophryne guentheri* and *Ranidella pseudinsignifera* have distributions centred on the mesic south-west of the State and have not been or are infrequently recorded elsewhere in the Eastern Goldfields. The three *Neobatrachus* species, and *P. occidentalis,* have distributions centred on semi-arid and arid inland areas (Tyler *et al.* 1984).

The Lake Cronin area is particularly rich in frogs with seven species recorded. These comprise the winter breeding *Helioporus albopunctatus, Limnodynastes dorsalis* and *Neobatrachus pelobatoides,* the summer breeding *N. centralis* and *Pseudophryne occidentalis* (Tyler *et al.* 1984). The sympatry of species with such diverse breeding patterns highlights the importance of this area with its predominantly winter rainfall but occasional summer storms.

Reptiles also illustrate the transitional nature of the biota of the Study Area. Several species with distributions focussed on the south-west are replaced between survey areas with ecologically similar arid zone species. Lake Cronin is the only known locality of the rare elapid snake, *Denisonia atriceps.*

In all four survey areas, the richest reptile assemblage occurs in the eucalypt Low Woodlands and Woodlands that predominate in the Study Area. At McDermid Rock reptiles were also rich in *Allocasuarina campestris* ssp. *campestris* Tall Shrubland over *Triodia scariosa.* Our findings are in accord with those of Kitchener *et al.* (1980a) and Chapman and Dell (1985) who emphasised the richness of reptiles in woodlands of the Wheatbelt of Western Australia and accordingly the conservation value of woodlands for the herpetofauna of these extensive regions.

The avifauna of Lake Johnston-Hyden is rich and diverse in comparison to other Eastern Goldfields Study Areas and has a relatively high proportion of passerine species. Numerous passerine species including the Yellow Robin, Gilbert Whistler, Crested Strike-tit, White-browed Scrubwren, Grey Fantail, Western Warbler, Shy Hylacola, Spotted Pardalote, Purple-gaped and Tawny-crowned Honeyeaters were recorded more frequently in this than other Study Areas. The Lake Cronin Study Area had a particularly rich passerine fauna in adjacent vegetation while numerous waders and waterfowl, not recorded elsewhere in the Study Area, occurred on the lake.

The passerines of the Lake Johnston-Hyden Study Area are dominated by Bassian faunal elements with the White-tailed Grey Fantail the only typically Eremaean element. This is in contrast to more northern Study Areas and reflects the dominance of south-western vegetation types, particularly the widespread eucalypt woodland, mallee and proteaceous/myrtaceous shrubland.

Earlier surveys of the adjacent Wheatbelt (Kitchener *et al.* 1982) identified 20 passerine species restricted to and resident in native vegetation on isolated reserves, and whose conservation status was insecure in that region. Fourteen of these species have distributions which overlap the Eastern Goldfields and all have been recorded both within the Study Area and at Lake Cronin.

The extant mammalian fauna contains species with both south-western affinities *(Tarsipes rostratus, Sminthopsis gilberti, Pseudomys albocinereus)* and arid zone affinities *(Sminthopsis dolichura, Ningaui yvonneae* and *Pseudomys bolami)* but the present-day terrestrial fauna is impoverished when compared to the sub-fossil terrestrial fauna described by Baynes (pers. comm.). The contemporaneous occurrence of numerous locally extinct native mammals with species introduced since European settlement indicates the rapid decline in the native mammals of the Study Area in the last 100 years. For example, 10 species were recorded over superficial cave deposits at Peak Charles by Baynes (pers. comm.) that were neither collected nor observed during this survey.

Numerous populations of the rare dasyurid, *Sminthopsis granulipes,* were recorded in the Study Area, usually in shrublands and mallee on sand. This species persists on small fragmented isolates in the adjacent Western Australian Wheatbelt (Kitchener *et al.* 1980b) and is considered endangered.

Several vertebrate species, *Ctenotus atlas, C. xenopleura* and *Ningaui yvonneae,* that are characteristic of *Triodia* communities, reach their southern or western limits within the Study Area concomitant with the edge of *Triodia scariosa* distribution.

Seven of the eight landform Units recorded in the Study Area were sampled for fauna (Table 19). Granite Exposure, Hill (granite), Salt Lake Feature and Broad Valley were adequately sampled while Sandplain, Hill (banded ironstone formation) — sampled once opportunistically — and Undulating Plain, (greenstone) have fewer sample sites. Considering their extent and importance, they may require further examination. Breakaway is isolated in occurrence and was the only unit not sampled.

Fauna was sampled in 23 of the 51 vegetation types recognised within the Study Area, a greater proportion than at either Widgiemooltha-Zanthus (15 of 39) or Jackson-Kalgoorlie (10 of 52) Study Areas (Newbey *et al.* 1984, Dell *et al.* 1985). Several important and extensive vegetation types were not sampled, including *Eucalyptus salmonophloia* Woodland on Salt Lake Feature, *Grevillea eriostachya* ssp. *excelsior* Tall Shrubland on Sandplain, *Eucalyptus diptera* Low Woodland, *E. longicornis* Low Woodland, *E. transcontinentalis* Low Woodland, *E. eremophila* Mallee and *E. incrassata* Mallee on Broad Valley, and could profitably receive investigation. Further investigation is also needed to determine the fauna of the *Eucalyptus loxophleba* Mallee, *Atriplex vesicaria* ssp. *variabilis* Low Shrubland, *Eucalyptus redunca* Mallee and *Eucalyptus flocktoniae* Low Woodland.

Agricultural development in areas adjacent to the Study Area has been by dryland farming techniques for cereal crop production. Initially Broad Valley was cleared; Sandplain soils were too infertile for cereals. The addition of trace elements to Sandplain soils has substantially raised their potential for cereal crop production and, since large areas of Sandplain occur in the Study Area, they may eventually be considered for release for agricultural development. It is imperative that detailed floristic studies be undertaken of any areas prior to their release for agricultural development.

The sampling emphasis on eucalypt woodlands was in accord with the design of the Eastern Goldfields survey (Biological Surveys Committee 1984). These semi-arid woodlands are of international interest and they represent the largest remaining natural tracts of eucalypt woodland which elsewhere has been selectively cleared and fragmented.

Three areas, Lake Cronin Nature Reserve, Frank Hann National Park and Peak Charles National Park, have been gazetted for conservation purposes within the Study Area. Jilbadgi (Barker Lake) Nature Reserve which intrudes in the north has been examined in detail and will be reported in a later number of the present series.

These conservation areas do not at present contain adequate representation of all the major landform units. Breakaway is uncommon and not of sufficient importance to be worth reservation in its own right. Sandplain and Granite Exposure are reserved in the southern section as is Salt Lake Feature, however, representation of these units in the north-east should be undertaken and for the former in western and central areas also. Hill (banded ironstone formation) and Undulating Plain (greenstone) have exceptionally small areas encompassed in Lake Cronin Nature Reserve and are priority landforms for reservation in the Study Area. Hill (granite) has its total areas within Peak Charles National Park. The extensive Broad Valley landform occurs in Frank Hann National Park but is in need of much greater representation in the Lake Cronin Nature Reserve and some major representation in the north-eastern portion of the Study Area.

To accommodate these requirements it is apparent that an area in the north-east of the Study Area is in need of reservation for conservation. This would be best

sited in the north Lake Johnston area where a mosaic of landforms occur including vegetation types characteristic of the South-western Interzone between South-west and Eremaean Botanical Provinces.

The Lake Cronin Nature Reserve of 1016 ha (3.2 km^2) is centred on the lake (Figure 2) but occupies only a small portion of the catchment. The vegetation of the area surrounding Lake Cronin is particularly diverse with representatives of 24 of the 51 vegetation types recognised from the Study Area within 10 km of the lake and within an area of less than 16 000 ha (Figure 4). The rich flora and fauna of the areas surrounding Lake Cronin have been demonstrated in this report and the significance of the freshwater body to amphibians stressed.

The current extent of Lake Cronin Nature Reserve is inadequate to represent either the remarkable biotic diversity of the adjacent area or to preserve the integrity of the unique freshwater lake by protecting its entire catchment. Extension of the existing Nature Reserve, with these considerations in mind, should assume a conservation priority within the Eastern Goldfields.