AN ASSESSMENT OF HERPETOFAUNA ON NEAR-COASTAL LANDFORMS BETWEEN DAWESVILLE AND BINNINGUP, SOUTHERN SWAN COASTAL PLAIN

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1. Background

The settlement of the west coast of Australia in 1829 by European colonists commenced a major shift in the environment as landscapes, vegetation and both flora and fauna were altered by anthropogenic mitigated factors. The next 180 years has witnessed a continuing and escalating change to the environment as agriculture, mining, urbanization and their associated introductions and modification intensify. These changes are most apparent in two Western Australian bioregions, the Avon-Wheatbelt and the Swan Coastal Plain, where the centers of population and agricultural development are greatest.

Coastal areas, particularly the Swan Coastal Plain and Geraldton Sandplain, are recognized as having the highest biodiversity for many groups within south-western Australia (Hopper and Gioia 2004; How and Cowan 2006) and this contributes to making the south-west of Australia one of the 32 biodiversity hotspots recognised on a global scale (Mittermeier *et al*. 2005).

Modification of natural ecosystems, through the loss or alteration of the native vegetation, has been associated with urban expansion on the Swan Coastal Plain and there is continuing growth of the city of Perth and adjacent farming land (Seddon 1972). Habitat fragmentation and degradation caused by European land-use practices have had a pronounced impact on the fauna with significant local and regional extinctions in many faunal groups. Native vegetation on the Swan Coastal Plain around Perth has decreased to only 28% of its original extent (Government of Western Australia 2000). As a consequence of this loss, parts of the Swan Coastal Plain outside the Perth Metropolitan Region now assume high regional significance for fauna conservation. This is especially so in the region between Dawesville and Binningup where relatively large, near-coastal areas of natural vegetation still remain and are likely to maintain relatively intact assemblages of many fauna groups which were previously widespread on the Swan Coastal Plain.

The significance of native vegetation in maintaining vertebrate biodiversity on the Swan Coastal Plain has been established by earlier research (How and Dell 1989, 1994) that examined a diverse array of vegetation types across the Swan Coastal Plain in the vicinity of Perth.

On the Swan Coastal Plain, 21 of the 33 native mammal species have become locally extinct since European settlement (Kitchener *et al.* 1978), although many species of mammal began to disappear well before the landscape had been substantially altered by Europeans. There have been six local extinctions of birds and 83 (47%) of the 176 species of land birds have decreased in abundance (How and Dell 1993). In contrast, only two local extinctions have occurred among the 71 reptile species with no extinctions of the 15 species of amphibians (How and Dell 1993). This pattern of species loss on the Swan Coastal Plain is mirrored in the Western Australian Wheatbelt where mammals have suffered the most marked decline since the onset of land clearing and settlement, birds have been less affected and lizards the least affected (Kitchener *et al.* 1980a, 1980b, 1982).

Herpetofauna studies on the Swan Coastal Plain (Storr *et al*. 1978; How and Dell 1994, 2000) have revealed an extraordinarily high level of reptile richness. Zoogeographic patterns indicate a number of species reach their distributional limits on the Swan Coastal Plain around Perth with some species not found south, and other not found north, of the Swan River. How and Dell (1994) also found that there was a species richness gradient across the Coastal Plain with 52 species on the western near-coastal dunes decreasing to 35 species on the Darling Plateau. Thus the highest reptile diversity is in vegetations types associated with the near-coastal Spearwood and Quindalup geomorphological units. They also found that smaller areas of native vegetation retained fewer species of reptiles than larger ones, but cautioned that the presence of species on larger vegetation remnants did not necessarily equate to long-term persistence as many species are exceptionally long-lived, have long generation times and may remain on remnants long after populations are no longer viable. Consequently, many species may yet still disappear from small bushland remnants. It is important for the conservation of populations and assemblages that numerous larger natural areas are maintained throughout a species range to accommodate episodic environmental events which destroy reptile populations. In fragmented environments there is no possibility of natural recruitment.

Since these studies additional information is gradually being revealed on the occurrence of some reptile species further south than previously known on the Swan Coastal Plain (Youngson and Harold 1989, Davis and Bamford 2005, Davis and Wilcox 2008, Thompson *et al.* 2008) in various locations between Mandurah and

Binningup. Of particular importance is the fact that Spearwood and Quindalup geomorphological units between Dawesville and Binningup are known, or likely to contain, reptile faunas that have been separated from other relictual populations, including those on islands, for up to 8,000 years. These areas are particularly important to conservation of reptiles as they may contain genetically isolated populations of species that are becoming locally or regionally extinct on other parts of the Swan Coastal Plain as a consequence of habitat fragmentation. This conservation importance is supported by recent studies (Smith and Adams 2007, Melville *et al*. 2008) which provided an insight into the high levels of reptile endemism in coastal habitats which are rapidly disappearing.

In late 2008 the Department of Environment and Conservation approached the Western Australian Museum to undertake a herpetofauna examination of the near coastal landforms of the area between Dawesville and Binningup. The objective of such a program was to assist in providing more comprehensive advice to the EPA on the likely impact of urban development in the region on its globally significant biodiversity values

2. Scope

The scope of work included:

- Compile a database of all available reptile records from the study area to include all published records, site-based published and unpublished data in environmental impact assessment reports and field note books, and specimen-based records in the WA Museum collections database.
- Undertake a systematic field survey including appropriate pitfall trapping techniques in each of the major habitats in the study area.
- Undertake an opportunistic field survey including appropriate micro-habitat searching techniques in each of the major habitats in the study area.
- Provide a comprehensive report incorporating all data obtained as part of the scope outlined above.

3. Study Area and Methods

A preliminary examination of the study area was undertaken by two representatives from each of DEC and the WAM on January 29-30th 2009. Study transects were identified in the south of the area based around Myalup and in the north along White Hill Road in the Yalgorup National Park. Several observations of herpetofauna were also made during this reconnaissance survey. The location of the major study sites and other opportunistic sample locations are shown in Figure 1.

3.1 Study Locations

Five sampling sites were identified for intensive quantitative survey in the north of the Study Area in the Yalgorup National Park off White Hill Road and a further four sampling sites in the south of the area on private lands in the Myalup area and as far east as adjacent to the Perth-Bunbury Highway (Figure 1).

The selection of quantitative sampling sites was based around their representation of the major landforms of the Swan Coastal Plain in the region, the variety and integrity of the remnant vegetation remaining and the tenure of land, such that permission was granted from landowners and custodians for sampling to be undertaken. There were logistic issues that prevented a fifth site being surveyed on the coastal blow-out Quindalup dunes in the Myalup area.

Detailed descriptions of the vegetation of quantitative survey sites appear in Appendix 1. These sites cover vegetation types on the Quindalup and Spearwood landforms of the Swan Coastal Plain and the major vegetation types sampled are depicted in Figure 1. In the south of the study area much of the vegetation is both fragmented by farmland and occurs as pockets on private land, thus impacting on the likely movement of biota between remnant vegetation patches.

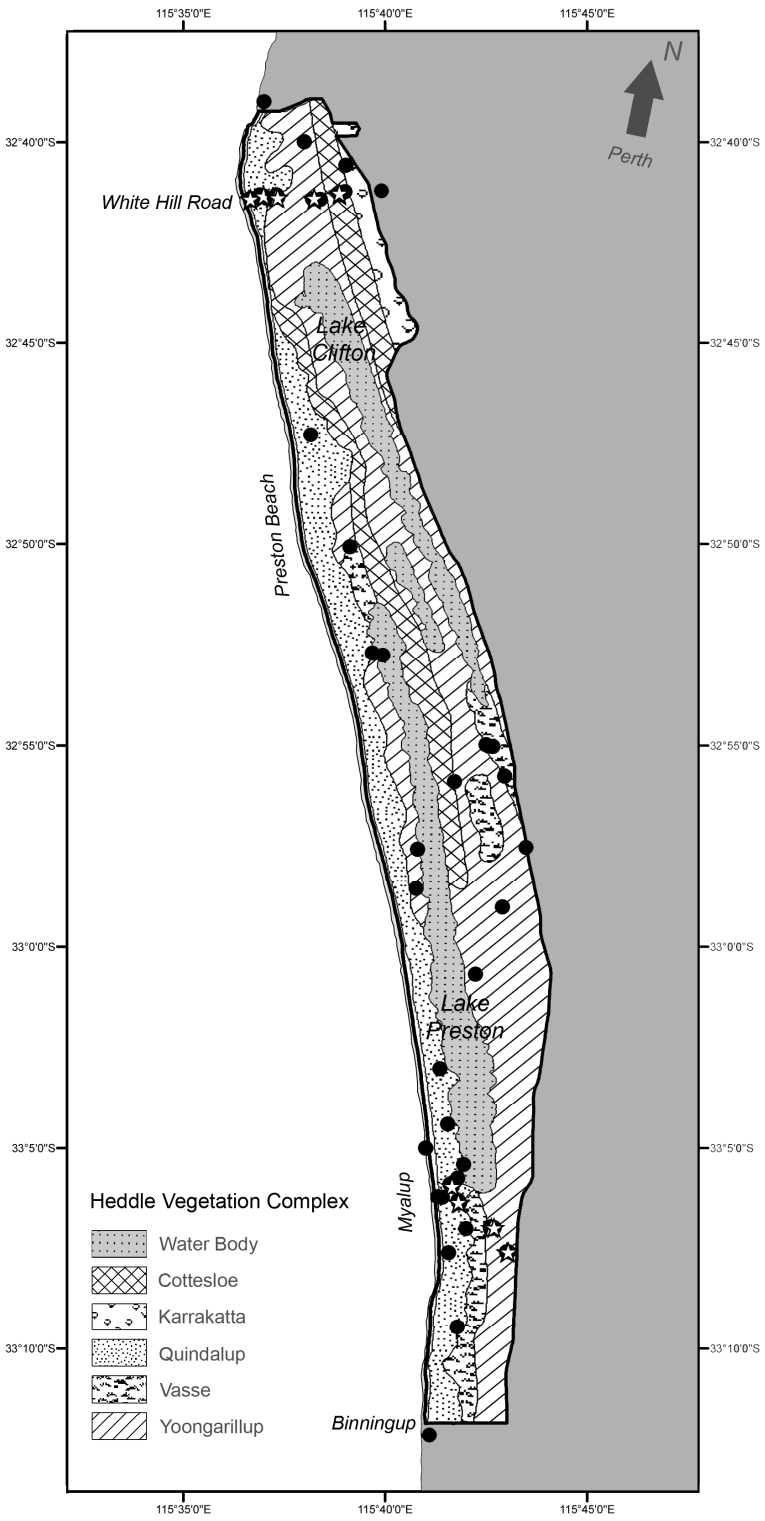


Figure 1. Map of the Dawesville-Binningup Study Area with landforms and locations indicated and also showing quantitative sample sites (stars) and opportunistic sample sites (solid circles) examined for herpetofauna during the present study. The Karrakatta and Cottesloe complexes combine to make the Spearwood Landform System.

3.2 Sampling

Field sampling of the region was undertaken between March 9-19th 2009 when both quantitative and opportunistic methods were employed to document the herpetofauna. The choice of sampling time was predicated by the timing and availability of funding to support the project with the caveat that survey work was to be completed by the end of the financial year.

All individuals captured were weighed measured and examined for sex and general body condition before release. In several cases photographs of species were taken to provide a record of the species occurrence in the region. Where captures represented a significant range extension or were of taxa that were not known to be common in the region, tissue was taken.

3.2.1 Quantitative

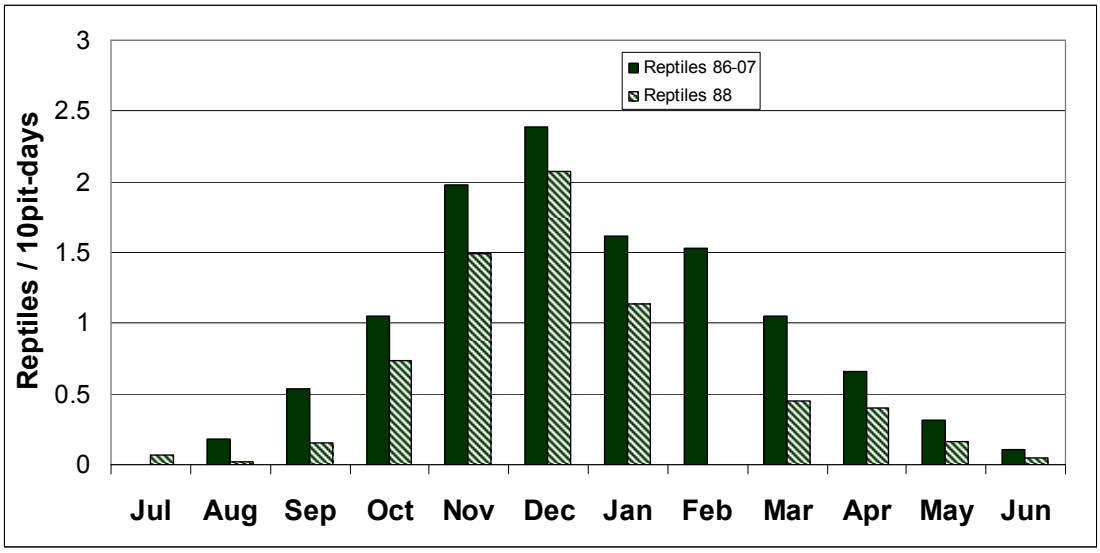
All nine selected vegetation sites near Myalup and off White Hill Road were sampled by pitfall trapping for at least 5 days. Sampling sites comprised eight pitfall traps [20-litre buckets] arranged in two arrays of four traps with 10 m spacing between traps and at least 100 meters between each array. A flywire drift-fence standing 30 cm high was placed vertically over each pitfall trap when they were open and operational. At each end of the drift-fence a wire mesh funnel trap was sited. Fences were rolled up and placed in the buckets that were then capped when sites were not operating. Sample sites were operated between March 11-15 off White Hill Road and between March 16-20 around Myalup.

Quantitative sampling on the Swan Coastal Plain has been examined by How (1998), who indicated that in order to capture around 50% of an areas reptile assemblage some 360-480 pit-trap days were required, while over 960 pit-trap days were required to capture over 80% of the resident herpetofauna assemblage. The current survey consisted of 200 pit-trap days in both the Myalup and White Hill Road sampling sites.

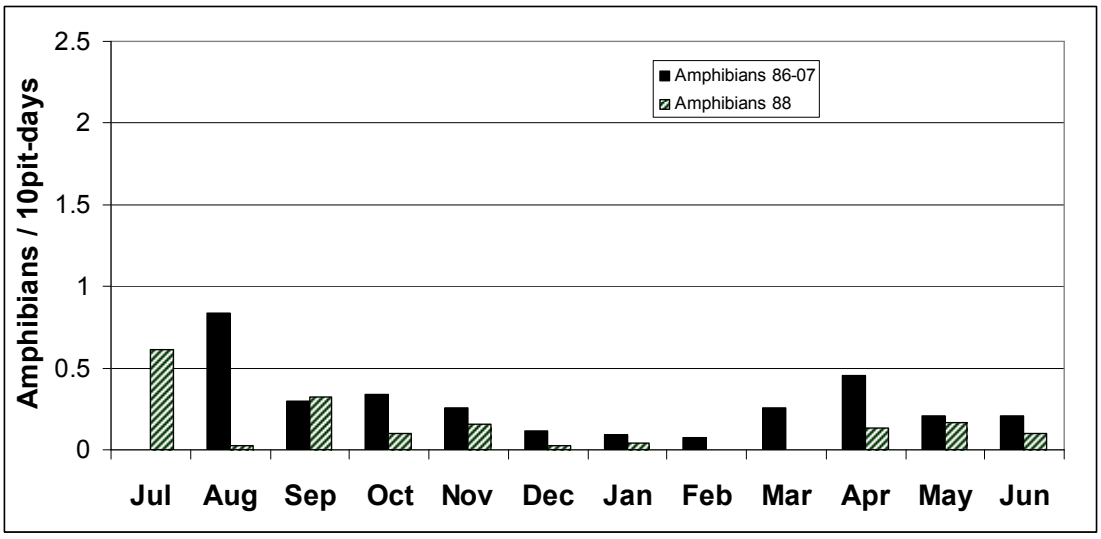
How's (1998) long-term examination of sampling of herpetofauna on the Swan Coastal Plain on a seasonal basis also showed that peak reptile activity occurs in November and December with a decreased capture rate in both early spring and late summer and autumn. Very few reptiles are active from April through to September, the wettest and coolest months in the region (Figure 2A). Contrasting with this was

amphibian activity where peak captures occurred during the wetter months of April through September (Figure 2B).

The intensity and timing of sampling are major factors in determining the composition of the herpetofauna assemblage of any sampled area and this is particularly relevant and also reflected in the results obtained during the present survey.



(A)



(B)

Figure 2. Monthly capture rates for (A) reptiles and (B) amphibians on the Swan Coastal Plain during a 22 year sampling regime [solid bars] between 1986-2007 (How unpubl.) and for an intensive study [shaded bars] in 1988 (Jiang unpubl.).

3.2.2 Opportunistic

Opportunistic collecting was undertaken at an array of locations and in all major

habitat types of the Dawesville–Binningup region between March 10-20. This involved active searching of logs, soil mounds, roadside spoil and litter with the aid of a three-pronged rake. Observations on tracks and diggings of the larger terrestrial species were made during the daily traverses of traplines. All individuals seen and confidently identified, but not captured, were recorded along with their GPS co-ordinates and the habitat type they were occupying.

The major opportunistic sampling sites are identified on Figure 1 and illustrate coverage of locations throughout the region and in all vegetation and landform types,

Additional information on the area was provided from the field note books of John Dell during the occasional days he traversed the area in the six months prior to the survey. Nick Cairns visited the area in early April and provided a sighting of a Carpet Python, *Morelia spilota imbricata* from the Preston Beach area along with an unidentified blind snake, *Ramphotyphlops* sp.

3.3 Database

Records of published and unpublished literature from the area were examined and a search made of the specimen records in the collection of the Western Australian Museum of the herpetofauna of the area between 32^{o} 30’ S and 33 ^{o} 10’ S and 115 ^{o} 30’E and 115 ^{o} 50’E. All previous surveys that provided novel information in the region have, generally, lodged voucher specimens with the Museum so that the Museum database of specimens represents a comprehensive record of species likely to be found in the area.

Searches of note-books recorded opportunistic information on herpetofauna on the area and these were facilitated with the assistance of John Dell and Bridget Hyder of DEC. These observations were then extracted and added to the Museum observational database where the location could be accurately assigned with appropriate geographic coordinates. This information along with the observations and records of the current survey were compiled to form a database of the herpetofauna of the Dawesville-Binningup area. These data occurrences were then compared and contrasted with those from the Perth area and the Bunbury area for regional biogeography context and conservation implications.

3.4 Analysis

Assemblage relationships were analysed using the similarity indices, clustering algorithms and ordination techniques from the Primer E program (Clarke and Warwick 2001). The recommendations of Green *et al*. (2009) were followed with regard to indices of estimation of species richness. These are based variously on the functions of the number of species seen in only one or two samples (Chao 2, Jacknife), the number of species that have only one or two individuals in the entire pool of samples (Chao 1), or the proportions of samples that contain each species (Bootstrap). Similarity between assemblages on different sites was assessed using Sorensen's Index of Similarity, while significant differences between assemblages were calculated using the 'Simprof' routine in Primer E. All clustering was based on UPGMA and ordination on non-metric multidimensional scaling (MDS).

The comparison of assemblages is based on presence data only, and not abundance information. This was predicated on the fact that the surveys of **ATA** (Bamford and Bamford 2003) and **ENV** Australia Pty Ltd (2009) provided only presence data for the sites documented in the present study area, whereas information from our Myalup sites (**MYT**) and White Hill Road sites (**WHT**), along with Metcalf and Bamford (2008) information from Binningup (**M&B**), report abundance data for sample sites. Additionally, herpetofauna assemblages on bushland remnants across the Southern Swan Coastal Plain in urban and peri-urban bushland remnants around Perth were accessed from How and Dell (2000) for comparison with those recorded in the study area, considerably further to the south. These sites reported only on presence data and included Garden Island (**GI**), Rottnest Island (**RI**), Woodman Point (**WO**), Mount Henry (**MH**), Jandakot Airport (**JA,JB,JC**), Perth Airport (**PA,PB,PC**), Rushton Road (**RR**), Hartfield Park (**HF**), Bushmead (**BM**), Cardup Reserve (**CR**), Brickwood Reserve (**BR**) and Norman Road (**NO**).

4. Results

4.1 Species Recorded in the Study Area

The amphibian and reptilian species known to occur in the study area are listed and a brief comment on their distribution and relative abundance from literature and the Museum records is made.

Information collected on the herpetofauna of the Dawesville-Binningup area between March 10th and March 20th are presented in the following list, presented by families. The number in brackets after the species indicates the number of individuals observed and measured during the present survey. The generalized location and habitat of individuals recorded outside the regular sampling sites are also presented together with information on their activity.

4.1.1 Amphibians

HYLIDAE

Litoria adelaidensis

Museum specimens of this species are only recorded from Lake Clifton.

Litoria moorei (1) – adult active on road in salt lake immediately east of Preston Beach town site at 32.87933°S 115.66567°E.

More common in the north of the study area where it is know to be very abundant in several locations.

LIMNODYNASTIDAE

Heleioporus eyrei (2) – adults pit-trapped MY4West.

Probably widespread in freshwater habitats with locally very abundant populations (J. Dell pers. comm.)

Limnodynastes dorsalis

Specimens in the Museum are from Mandurah, Yalgorup and Lake Preston.

MYOBATRACHIDAE

Crinia georgiana

Museum specimens are from Jeegarnyeejip and Culeenup Islands.

Crinia glauerti

One older museum specimen are from the Harvey River.

Crinia insignifera (2) – adults under limestone rocks in damp depression with bulrushes immediately north of Preston Beach town site at 32.87847°S 115.66146°E.

Widespread and abundant throughout the wetlands of the study area with museum specimens from many and varied locations.

Geocrinia leai

Represented by a population just south of Myalup with numerous individuals (J. Dell pers. obs.). These represent the most northerly known population on the Swan Coastal Plain and are in need of detailed biological investigation.

Pseudophryne guentheri

Specimens in the Museum collection are from Culeenup and Jeegarnyeejip Islands as well as Mandurah.

4.1.2 Reptiles

CHELONIIDAE

Caretta caretta

Two beached specimens from the Mandurah area.

CHELUIDAE

Chelodina oblonga

Several specimens are in the Museum from Lake Preston and one from Ravenswood.

AGAMIDAE

Ctenophorus adelaidensis

Two specimens in the Museum collections from Preston Beach and Caddadup Reserve.

Pogona minor minor (4) – 1 juvenile basking on limestone outcrop with heath in Yalgorup National Park (White Hill Road) at 32.68992° 115.61957°E and 3 juveniles pit-trapped WH2North, MY4West and MY2East.

Widespread through the study area and further south with locally abundant populations.

DIPLODACTYLIDAE

Strophurus spinigerus spinigerus (3) – 1 adult active on road in coastal dunes immediately before beach car park at Preston Beach, 2 adults pit-trapped WH1North and WH2North.

Both Museum specimens are from Yalgorup National Park.

CARPHODACTYLIDAE

Nephrurus milii

A single Museum specimen from Mandurah

GEKKONIDAE

Christinus marmoratus (8) – 4 adults and 1 hatchling active on Reading Road immediately north of Myalup town site, 1 adult active on Yalgorup Road at 32.67616°S 115.65034°E, 2 adults under bark on dead trees in Yalgorup National Park (Ellis Road) at 32.93155°S 115.69512°E.

Widespread from the north to the south of the study area and probably reasonably abundant throughout in treed communities.

PYGOPODIDAE

Aprasia repens (1) – adult under dead *Xanthorrhoea* in *Eucalyptus*/*Banksia* woodland in Yalgorup National Park (Ludlow Road) at 32° 57’ 32”S 115° 43’ 29”E.

Numerous museum specimens from Mandurah but also know from Ballee, Culeenup and Jeegarnyeejip Islands within the lakes of the region.

Delma fraseri (2) – adults inside dead *Xanthorrhoeas* in Tuart/Peppermint woodland in Yalgorup National Park (White Hill Road) at 32.68992° 115.61957°E and beside drift fence WH3West.

No Museum specimens from the study area.

Delma grayii (2) – 1 juvenile pit-trapped WH2Southand 1 adult inside dead *Xanthorrhoea* in low-lying *Melaleuca* thicket in Yalgorup National Park (Preston Beach Road) at 32.91630°S 115.70822°E.

Previously known only from Preston Beach with a voucher specimen in the Museum collections

Lialis burtonis (2) – 1 juvenile pit-trapped WH5North and 1 adult pit-trapped WH1South.

Museum specimens are known from Mandurah, Dawesville and Culeenup Island

Pygopus lepidopodus

Not known from Museum specimens but recorded on previous surveys of the study area – see Table2.

SCINCIDAE

Acritoscincus trilineatum (1) – sub-adult under dead shrub in low-lying *Melaleuca* thicket in Yalgorup National Park (Preston Beach Road) at 32° 55' 01"S 115° 42' 34"E.

Probably widespread in moister habitats and known from Mandurah through to Waroona and Australind south of the study area.

Cryptoblepharus buchananii (11) – 1 adult in funnel trap MY5East, adults observed basking at various locations including on limestone blocks at Myalup Indian Ocean Resort, on power pole at MY3, on fence post at MY5 and inside dead *Xanthorrhoeas* in Yalgorup National Park (Ludlow Road) at 32° 57' 32"S 115° 43' 29"E.

Not well represented in the collections of the Museum but are abundant and widespread in the treed communities of the study area.

Ctenotus australis (6) – 1 adult pit-trapped WH1South, 5 juveniles pit-trapped WH2North, WH3West, MY2East/West and MY3West.

The most abundant of the large terrestrial skinks and distributed throughout the study area.

Ctenotus impar

A series of specimens in the Museum collection from Culeenup Island but also specimens from Lake Mealup, Mandurah and Austin Bay. Locally patchy in distribution.

Ctenotus labillardieri

Known from specimens at Lake Clifton and Yalgorup National Park but with a very patchy distribution. The specimen from Lake Mealup is genetically distinct from specimens of the same species on the Darling Range.

Egernia kingii

Just four specimens in the collections from Mandurah, Yunderup, Jeegarnyeejip and Culeenup Islands. Nowhere abundant.

Egernia napoleonis (1) – adult active on Tuart tree on Reading Road immediately north of Myalup town site opposite MY2.

Relatively widespread but not common in the Museum collections with records from the broader areas of Harvey, North Dandalup, Lake Pollard and Australind.

Hemiergis quadrilineata (24) – 3 adults pit-trapped MY3East/West, adults under leaf litter, debris, dead logs and *Xanthorrhoeas* at various locations including WH2, WH3, WH4, in Yalgorup National Park along Preston Beach, Ellis, Ludlow Roads, Binningup Golf Course and at Leschenault Peninsula.

Widespread throughout the region and the most abundant skink in the study area with populations in all major terrestrial habitats.

Lerista distinguenda (7) – juveniles and adults pit-trapped MY4East and MY5East. Individuals distinctly darker with nasals in point contact or narrowly separated.

Three specimens in the Museum collections from Waroona and Lake Clifton, suggesting locally confined populations in the study area.

Lerista elegans (4) – 1 adult in sand under small stump in coastal fore dunes immediately west of MY2West, juveniles and adults pit-trapped WH2South and WH3West. Individuals distinctly paler with nasals in broad contact.

Generally widespread and locally abundant in most litter and sand dominated habitats.

Lerista lineata

Museums specimen records from Mandurah, Caddadup Reserve, Preston Beach and Lake Clifton.

Lerista lineopunctulata

Just a single Museum specimen record from its southernmost distribution at Lake Clifton.

Menetia greyii (11) – 2 adults under pieces of old fence posts at Preston Beach, 1 adult under dead *Banksia* log in Yalgorup National Park (Ludlow Road) at 32° 57' 32"S 115° 43' 29"E, juveniles and adults pit-trapped WH5South, MY3East/West, MY4East and MY5East.

Museum specimens from several islands in the study area and the species is widespread and relatively common.

Morethia lineoocellata (5) – 1 adult basking on rock at Myalup Indian Ocean Retreat, 1 juvenile active in leaf litter beside drift fence MY2East, 1 juvenile active on log at Preston Beach, 1 adult and 1 juvenile pit-trapped MY2West and MY5East.

Relatively common and widespread with numerous specimens from Lake Clifton and Lake Mealup in the broader study area.

Morethia obscura (3) – juveniles pit-trapped WH3East/West.

Represented by a single specimen in the Museum collections from Macatee Road.

Tiliqua rugosa rugosa (3) - 1 adult under *Acacia* leaf litter in coastal fore dunes immediately west of MY2West, 1 adult active under dense coastal *Acacia* in fore dunes in Leschenault Peninsula at 33.20235°S 115.68480°E, 1 adult active in secondary dunes along Taranto Road at 33.12670°S 115.69281°E.

Just a single Museum record from Mandurah but the species is widely distributed through the study area.

VARANIDAE

Varanus rosenbergi

Seen on Preston Beach Road north of Myalup during the reconnaissance survey.

Varanus tristis tristis (1) – adult basking on Tuart tree near WH4 in Yalgorup National Park (White Hill Road) at 32.69018°S 115.63988°E. Also evidence of tracks observed at this location and on firebreak in Yalgorup National Park (Preston Beach Road) at 32.91630°S 115.70822°E.

The only known record from the study area.

TYPHLOPIDAE

Ramphotyphlops australis

Widespread on the southern Swan Coastal Plain and represented from numerous locations in the Museum collections.

BOIDAE

Morelia spilota imbricata

No Museum records but seen and photographed near Preston Beach during the survey period.

ELAPIDAE

Demansia psammophis

Just two specimens in the Museum from the broader areas of Harvey and Mandurah.

Echiopsis curta (1) - adult under *Acacia* leaf litter in coastal fore dunes in Leschenault Peninsula at 33.20235°S 115.68480°E.

All known specimen records are from Mandurah.

Elapognathus coronatus

Known from only a single specimen from Mandurah.

Hydrophis elegans

Known from just two beached specimens at Mandurah

Neelaps bimaculatus

Two museum specimens, both from Mandurah

Notechis scutatus

Four Museum specimens from the Mandurah area. Possibly occurs around wetlands further south.

Parasuta gouldii

Museum records from Mandurah, the Harvey Estuary and Binningup.

Pelamis platura

Beached specimens in collections from Mandurah south to Myalup.

Pseudonaja affinis affinis (2) – 1 juvenile in funnel trap WH5North, 1 juvenile inside dead *Banksia* log at MY4.

Widespread through the study are but few specimens in the Museum. Seen on the reconnaissance survey on Preston Beach Road south of Preston Beach.

Simoselaps bertholdi (4) – 1 adult pit-trapped WH5South, 3 adults found trapped in old valve pit in secondary dunes immediately north of Preston Beach town site at 32.87847°S 115.66146°E.

The majority of Museum records are from Mandurah but also known from as far south as Binningup within the study area.

4.2 Additional Data on Museum Surveys

Information on the herpetofauna of the study area was also obtained from the opportunistic recordings by numerous colleagues. Species observed outside the main sampling period are indicated in Table 2 and Table 3. They include the additional species of *Litoria adelaidensis*, *Limnodynastes dorsalis* recorded by John Dell during spring 2008. The monitor, *Varanus rosenbergi* recorded during the reconnaissance survey in late January 2009 north of Myalup, and the photographic record of the Carpet Python, *Morelia spilota imbricata*, by Nick Cairns during early April 2009 near Preston Beach.

5. Discussion

5.1. Methodological Appraisal

All surveys are limited by methodological constraints on both temporal and spatial scales. An appraisal of these limitations is essential prior to the interpretation of the results from the present project.

Contractually, the locations of survey were determined by suitability of landforms and vegetation types that reflected the dominant types in both the northern and southern part of the study area. White Hill Road traverses the northern limits of the Yalgorup National Park and the sampling sites chosen represent the major vegetation of the near-coastal landform types. The sampling sites in the southern location were determined by the presence of, and permitted access to, natural vegetation in the Myalup area.

The period of survey and sampling of the herpetofauna in the Dawesville-Binningup area has been both brief in seasonal and daily terms. The main survey between the 10th and 20th of March 2009 was conducted at a time that was not conducive to peak activity by either reptiles or amphibians on the Swan Coastal Plain. Figure 2 shows that reptile activity in the Perth area decreases rapidly over the autumn period, while amphibian activity remains low until the first of the late autumn rains occurs, usually in April. Given the unfavourable climatic conditions for a survey in March, the resultant herpetofauna assemblage documented is surprisingly rich and compares favourably with other surveys of the area (see Section 5.2) that were undertaken in more favourable seasons. Similarly, the limitation to 11 days sampling is generally considered inadequate to document any but the more abundant of species in an area (How 1998).

The regular documentation of reptiles and amphibians seen in the area by DEC staff during the six months prior to the detailed survey had shown that reptiles and amphibians were widespread but were not recorded regularly. That information coupled with data collected on the reconnaissance survey in late January 2009, the main survey in March 2009 and opportunistic recordings made subsequently, have shown the area to have a relatively diverse and complete herpetofauna (Figure 3). The species accumulation plot for the survey in Figure 3 indicates that there are still

several species that should be recorded (see Section 5.2), with the Chao2 estimate (33.1), the Jacknife estimate (37.2) and the Bootstrap estimate (33.5) all showing that in excess of 33 species should occur in the study area. The absence of any clear asymptote in the species count (Figure 2) indicates that many more species, over and above these estimates, may be expected with additional time sampling; this is infact supported by Table 1 and 2 that document the species recorded from the area previously.

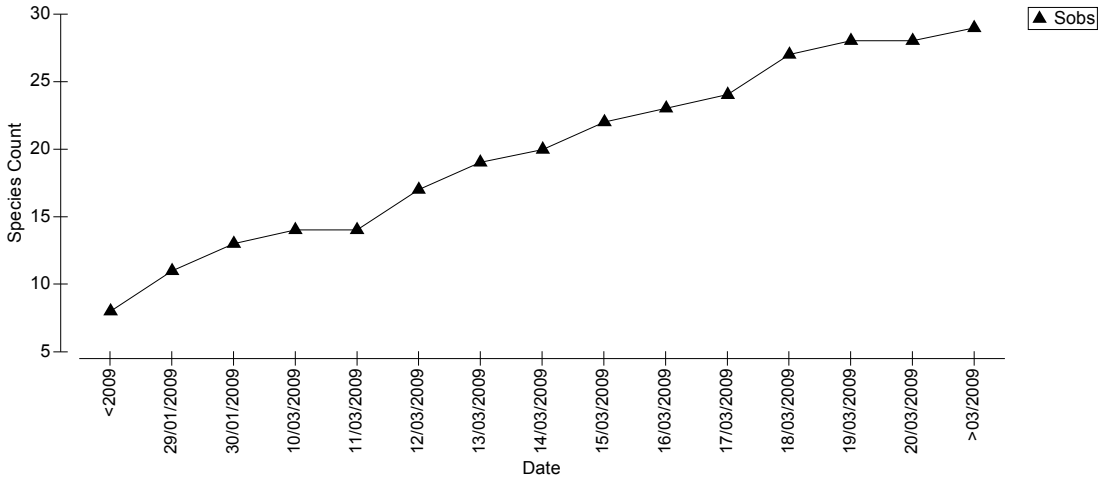


Figure 3. Species accumulation graph for the Western Australian Museum survey of the herpetofauna of the Dawesville- Binningup study area.

When we considered the data on a location specific profile, it was clear that neither the sampling in the White Hill Road of the Yalgorup National Park, or the Myalup area in the southern study area, are adequate to make conclusive remarks about the herpetofauna assemblages in those specific locations.

5.2 Species Occurrence

The caveats identified in the previous section on the limitations of the methodology employed provide background to an examination of the composition of the species assemblage documented during the sampling period.

The recording of 24 species of reptile and 5 amphibians in this survey is comparable to other reports (Table 1 and 2) of the near-coastal herpetofauna in the study area and further to the south (Bow 1999, Bamford and Bamford 2003, Metcalf and Bamford 2008, ENV Australia Pty Ltd 2009). Bow's (1999) study was a year long intensive study of the Maidens Reserve and adjacent areas in the Bunbury metropolitan region and is the only study that has a strong seasonal component to its sampling. The

majority of grey literature from the study area (except those listed above) is based on literature surveys and Museum records and does not provide novel information for analysis or evaluation.

The two previous studies in the northern part of the study area (Bamford and Bamford 2003, Env Australia Pty Ltd 2009) recorded 22 and 28 reptiles and six and five amphibians, respectively, which is slightly higher than the 20 reptiles and two amphibians recorded from the White Hill Road sites during the current survey. The only previous survey of the southern portion of the study area by Metcalf and Bamford (2008), at Binningup, recorded 14 reptiles and three frogs, very similar to numbers recorded by the present surveys of 14 reptiles and a frog from the Myalup area. Bow's more intensive 1999 survey in the near-coastal dunes of the Bunbury area documented 16 reptiles but seven amphibians.

There is one gazetted species of major conservation significance, the python *Morelia spilota imbricata*, and one listed in the Department of Environment and Conservation's Priority List, the skink *Lerista lineata* (P4). Otherwise, all species are thought to be secure and not in need of any special conservation protection.

The predicted herpetofauna assemblage of around 33 species (see Section 5.1), is likely to be an underestimate. By examining the records of terrestrial species in the collection of the Western Australian Museum, and those from other studies from the broader area, it is possible that an additional three frogs and up to 12 reptiles could occur. Those species might include the amphibians *Crinia georgiana, Crinia glauerti* and *Pseudophryne guentheri*, the lizards, *Nephrurus milii, Pygopus lepidopodus, Ctenotus impar, Ctenotus labillardieri, Lerista lineata, Lerista lineopunctulata,* and the snakes, *Ramphotyphlops australis, Demansia psammophis, Elapognathus coronatus, Neelaps bimaculata, Notechis scutatus* and *Parasuta gouldii*. The record of the frog *Heleioporus psammophilus* from the Bunbury area (see Table 1 and Bow 1999) is of questionable authenticity, given the preference of the species for specific substrates not usually found on the Swan Coastal Plain.

An intensive search for frogs during or after the first autumn rains will, doubtless, find some of the expected species. The gecko, *N. milii*, is rare on the Swan Coastal Plain and populations are unlikely to persist in the area. The Scaly-foot, *Pygopus lepidopodus* has been recorded from the region (Bamford and Bamford 2003, ENV 2009) but is nowhere common, while the burrowing skink, *L. lineata*, the legless

lizard, *Delma grayii,* and the Heath Dragon, *C. adelaidensis*, have only recently been shown to occur in the region with isolated populations that represent the southern limits of their ranges (Davis and Bamford 2005, Davis and Wilcox 2008, Thompson *et al*. 2008). Of particular importance to understanding the herpetofauna of this area is the need to have clear access to the 'grey', or unpublished literature; this is clearly exemplified by the published note on the range extension of the burrowing skink, *L. lineopunctulata*, from the Yalgorup area (Davis and Bamford 2005). This species had been known from as far south as Maiden's Reserve near Bunbury since 1999 (Bow 1999) but remains unpublished in his BSc (Hons) dissertation. Current molecular examination of the *Ctenotus labillardieri* species complex has shown that at least three of the isolated populations south of Perth, (Lake Mealup, Cape Naturaliste, Yallingup Brook) are genetically distinct from typical *C. labillardieri* on the Darling Scarp and Range and are probably referable to *C. lancelini* (S. Keogh pers.comm).

Snakes are generally in lower numbers than lizards and considerably more sampling time and effort is required to adequately document their presence. All the above listed snake species are known to occur in the area but are generally rarely seen or captured. Consequently, when comparisons of reptile assemblages are undertaken it is generally more meaningful to eliminate snakes from the analysis due to their inadequate sampling and reporting.

5.3 Assemblage Characteristics

5.3.1 Amphibians

The analysis of the amphibian fauna known from the study area indicates that it is similar to others recorded in the region and from most others recorded on the Southern Swan Coastal Plain (Figure 4). The exceptions to this broad generalization is that a single species (*Limnodynastes dorsalis*) is known from Woodman Point (WO) and the absence of amphibians on Garden Island (GI), consequently, both those areas have significantly different assemblages in Figure 4. The presence of *Geocrinia leai* at Myalup also gives that assemblage a significantly different relationship to all others examined on the Swan Coastal Plain.

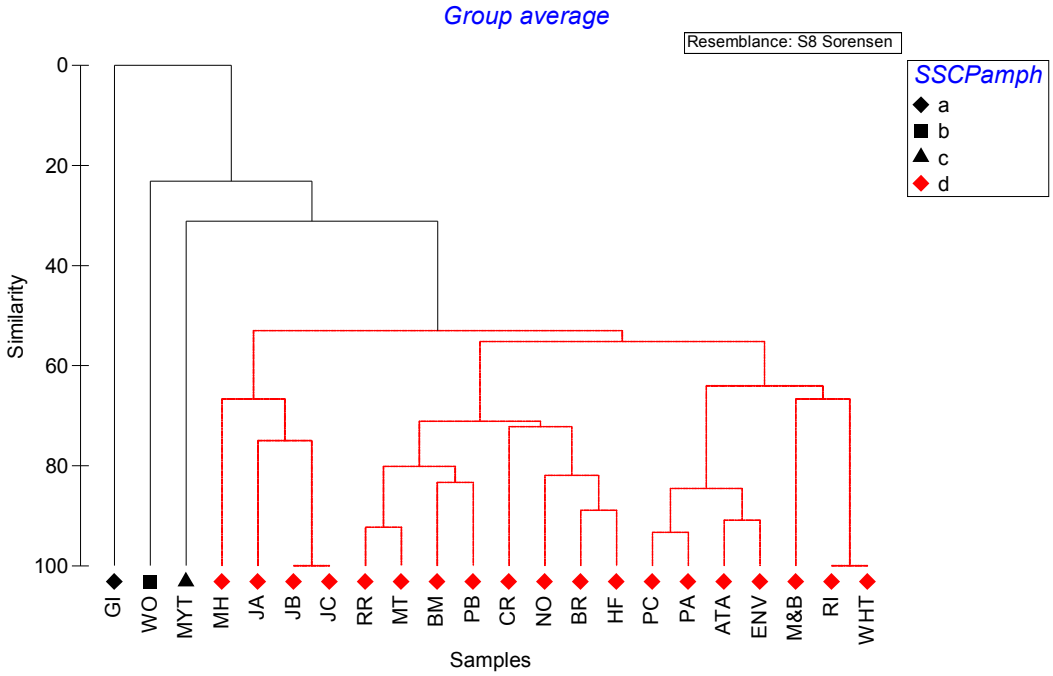


Figure 4. Amphibian assemblages of the locations sampled in the study area and sites sampled by How and Dell (2004) on the Southern Swan Coastal Plain near Perth. Cluster dendrogram from UPGMA on Sorensen's Index of Similarity; black lines demarcate boundaries between the three significant assemblages recognised. Bamford and Bamford (2003) north Yalgorup [**ATA**]**,** Bushmead [**BM**], Brickwood Reserve [**BR**], Cardup Reserve [**CR**], ENV Australia Pty Ltd (2009) north Yalgorup [**ENV**], Garden Island [**GI**], Hartfield Park [**HF**], Jandakot Airport [**JA,JB,JC**], Norman Road [**NO**], Metcalf and Bamford (2008) Binningup [**M&B**], Myalup [**MYT**], Mount Henry [**MH**], Perth Airport [**PA,PB,PC**], Rottnest Island [**RI**], Rushton Road [**RR**], White Hill Road [**WHT**], Woodman Point [**WO**]**..**

5.3.2 Reptiles

The entire reptile assemblage of sites on the Southern Swan Coastal Plain are presented in Figure 5, despite the fact that our data shows that snakes, in particular, are under-recorded by the present study.

Eight discrete assemblages are recognised from the sites evaluated. Of relevance to the present study is that the northern three sites surveyed in the study area (ATA, ENV, and WHT) all link with the reptiles found on Rottnest and Garden Island, while the three southern sites surveyed (MT, M&B and MYT) all form their own significant assemblage. There is no overlap in the assemblages of the Dawesville- Binningup study area with any of those further north on the Southern Swan Coastal Plain from around Perth, whether they are either near-coastal or well inland.

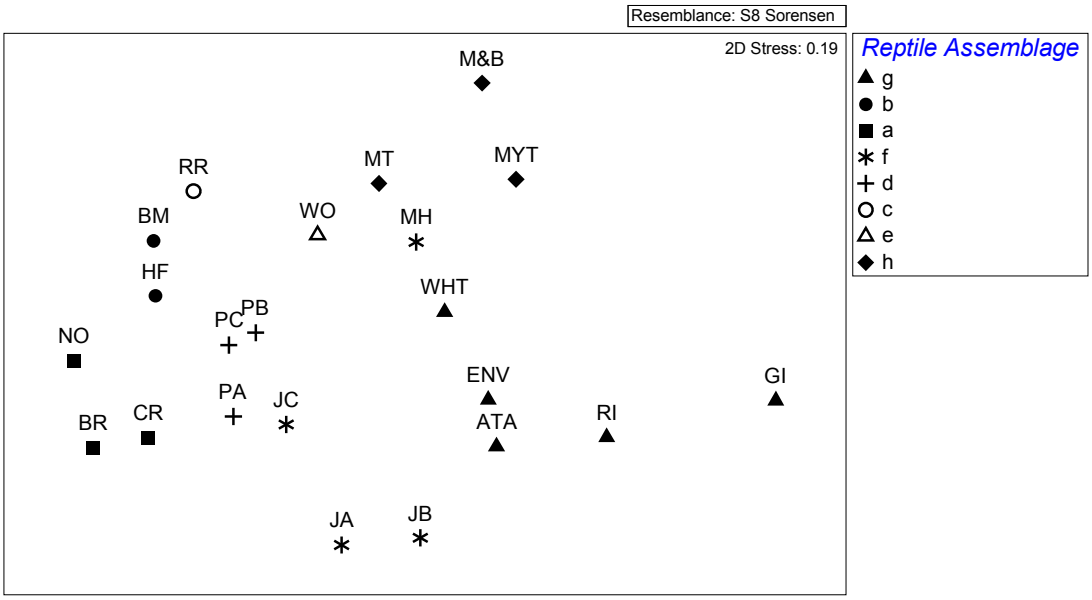


Figure 5. Reptile assemblages recorded from sites on the Southern Swan Coastal Plain based on Sorensen's Similarity Index and non-metric multidimensional scaling ordination plot. Statistically different assemblages are indicated by different symbols. Bamford and Bamford (2003) north Yalgorup [**ATA**]**,** Bushmead [**BM**], Brickwood Reserve [**BR**], Cardup Reserve [**CR**], ENV Australia Pty Ltd (2009) north Yalgorup [**ENV**], Garden Island [**GI**], Hartfield Park [**HF**], Jandakot Airport [**JA,JB,JC**], Norman Road [**NO**], Metcalf and Bamford (2008) Binningup [**M&B**], Myalup [**MYT**], Mount Henry [**MH**], Perth Airport [**PA,PB,PC**], Rottnest Island [**RI**], Rushton Road [**RR**], White Hill Road [**WHT**], Woodman Point [**WO**].

5.3.3 Lizards

Lizards are usually comprehensively recorded by quantitative and opportunistic sampling over relatively short time frames (How 1998) and were used by How and Dell (2000) to examine the detailed changes in reptile assemblage structure on landforms across the Swan Coastal Plain.

With only the lizard species considered for analysis, the pattern of assemblage relationships changes markedly (Figure 6). Six assemblages are recognised for locations on the Southern Swan Coastal Plain and, of particular significance to this study is that, all sites documented in the Dawesville- Binningup study area and that of the Maiden's Reserve near Bunbury fall into one assemblage type. The three separate surveys of both the Jandakot (JA,JB,JC) and Perth (PA,PB,PC) Airports also have a similar lizard assemblage.

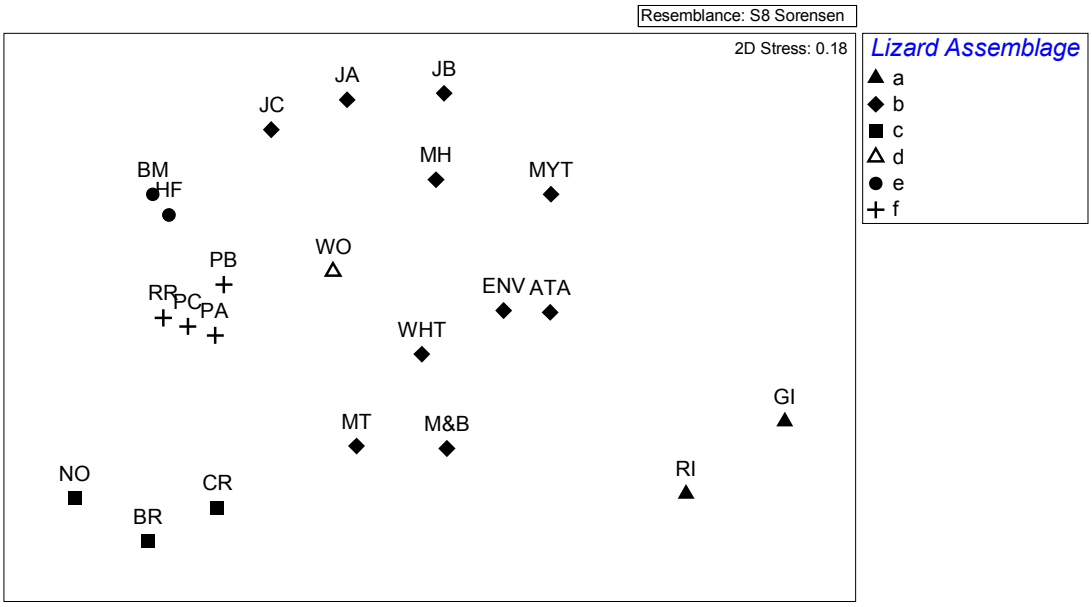


Figure 6. Lizard assemblages recorded from sites on the Southern Swan Coastal Plain based on Sorensen's Similarity Index and non-metric multidimensional scaling ordination plot. Statistically different assemblages are indicated by different symbols. Bamford and Bamford (2003) north Yalgorup [**ATA**]**,** Bushmead [**BM**], Brickwood Reserve [**BR**], Cardup Reserve [**CR**], ENV Australia Pty Ltd (2009) north Yalgorup [**ENV**], Garden Island [**GI**], Hartfield Park [**HF**], Jandakot Airport [**JA,JB,JC**], Norman Road [**NO**], Metcalf and Bamford (2008) Binningup [**M&B**], Myalup [**MYT**], Mount Henry [**MH**], Perth Airport [**PA,PB,PC**], Rottnest Island [**RI**], Rushton Road [**RR**], White Hill Road [**WHT**], Woodman Point [**WO**].

6. Conclusions

The information gained on the brief survey of the herpetofauna of the near-coastal landforms of Dawesville-Binningup area during in autumn of 2009 has complemented that available in prior short-term surveys of the same general area. Only surveys undertaken for EIS assessment of private lands within the region and that provided novel data were considered. Two of the previous studies were in the northern part of the study area (Bamford and Bamford 2003; ENV Australia Pty Ltd 2009) while the third was in the extreme south at Binningup (Metcalf and Bamford 2008) thus allowing for some comparative information to the current survey.

By comparison with areas to the north on the Swan Coastal plain there is a lower species richness and this diminishing species richness continues southward through the study area (see 5.2 above). Four lizard species (*Ctenophorus adelaidensis, Delma grayii, Lerista lineata, L. lineopunctulata*) are known to be at the southern limits of their distribution in the study area and, of these, only *D. grayii* were recorded during this survey. There is a strong probability that additional species will be recorded from the study area when additional sampling is undertaken at a time of the year more conducive to herpetofauna activity (see 5.1 above).

The specific habitat requirements of the taxa recorded by this survey show that the majority are habitat generalists and that there are suitable natural areas remaining for species to persist in the longer-term. The more habitat specific taxa are less likely to be captured at times of the year when herpetofauna activity is much reduced, while species that apparently occur in isolated populations on the Swan Coastal Plain (e.g. *Ctenotus impar, Ctenotus labillardieri)* are unlikely to be recorded without intensive spatial sampling. The latter species is of major significance as its systematic status is currently being reviewed (P. Doughty pers. comm.) and several isolated populations south of Perth have been shown to be taxonomically distinct from current conspecifics on the Darling Range and may, in fact, represent populations of the Lancelin Island Skink, *C. lancelini*.

The composition of the reptile and frog assemblages recorded from the study area show them to be relatively similar to one another, particularly for the lizards and amphibians, and closely related to those outside the area that are located on near-coastal dune landforms. These near-coastal assemblages differ markedly to those

documented on landforms distal to the coast further north, a fact that supports the previous findings of How and Dell (2000) of diverse assemblages being distributed on landforms across the Swan Coastal Plain near Perth.

It is highly probable that the reptile and frog fauna of the near-coastal dunes south of Dawesville represent important contiguous distributions of populations that have been subjected to major fragmentation, alteration and extinctions further north on the Swan Coastal Plain.

7. Acknowledgments

The support and encouragement of the EPA advisory group in the Department of Environment and Conservation, particularly Bridget Hyder and John Dell, is gratefully acknowledged. We are also indebted to them for detailed site descriptors in Appendix 1 and, along with Mark Cowan, for comments on content.

The field component could not have been successfully conducted without the skills and expertise of Mr David Algaba who provided invaluable assistance to BM.

The sampling was conducted under the DEC Reg 17 License No. SF006721 to the Western Australian Museum and the approval of the regional office in Mandurah for study in Yalgorup National Park, We appreciate the support of Mr Steve Dutton and his staff in the Mandurah Regional office of DEC.

The Western Australian Museum operates under the DEC Animal Ethics Committee approval 2006/57.

Table 1. Amphibians recorded from the Dawesville-Binningup near coastal Landforms. Asterix denotes captured by other surveys or in literature survey. [1] Data from Bamford and Bamford (2003) for ATA from Preston Beach area ; [2] Data from Metcalf and Bamford (2005) from Binningup area; [3] Data from ENV Australia Pty Ltd (2009) for the Preston Beach area; [4] Data from Bow (1999) from the Maidens area, Bunbury.

TAXON	Myalup (**MY**)						White Hill Road (**WH**)						WAM Survey	**ATA**[1] 98-03	**M&B**[2] 2008	**ENV**[3] 2009	Maidens Quind	Maidens Spear	Maidens Bassen.	Maidens Total **MT**[4]	WAM Records
Sites	1	2	3	4	5	**T**	1	2	3	4	5	**T**									
HYLIDAE																					
Litoria adelaidensis													*	*		1					2
Litoria moorei												1	1	*	*	1					31
LIMNODYNASTIDAE																					
Heleioporus eyrei				2		2							2	*	*	1		17	181	198	7
Heleioporus psammophilus																			6	6	
Limnodynastes dorsalis													*	*	*	1	24		1	25	9
MYOBATRACHIDAE																					
Crinia georgiana																			3	3	3
Crinia glauerti																			*	1	1
Crinia insignifera												2	2	*		1		1	95	96	38
Geocrinia leai						*							*								
Pseudophryne guentheri																1			19	19	10

Table 2. Reptiles recorded from the Dawesville-Binningup near coastal Landforms. Asterix denotes captured by other surveys or in literature survey. [1] Data from Bamford and Bamford (2003) for ATA from Preston Beach area ; [2] Data from Metcalf and Bamford (2005) from Binningup area; [3] Data from ENV Australia Pty Ltd (2009) for the Preston Beach area; [4] Data from Bow (1999) from the Maidens area, Bunbury.

TAXON	Myalup (**MY**)						White Hill Road (**WH**)						WAM Survey	**ATA**[1] 98-03	**M&B**[2] 2008	**ENV**[3] 2009	Maidens Quind	Maidens Spear	Maidens Bassen.	Maidens Total **MT**[4]	WAM Records
Sites	1	2	3	4	5	**T**	1	2	3	4	5	**T**									
CHELONIIDAE																					
Caretta caretta																					2
CHELUIDAE																					
Chelodina oblonga															*	1					5
AGAMIDAE																					
Ctenophorus adelaidensis															4	1					2
Pogona minor		1		1		2		1				2	4	*	11	1	6	1	2	9	5
DIPLODACTYLIDAE																					
Strophurus spinigerus							1	1				3	3	*		1					2
CARPHODACTYLIDAE																					
Nephrurus milii																					1
GEKKONIDAE																					
Christinus marmoratus						5						3	7	*	1	1	1		3	4	9
PYGOPODIDAE																					
Aprasia repens												1	1						1	1	9
Delma fraseri									1			2	2	*		1					
Delma grayii								1				2	2			1					1
Lialis burtonis							1				1	2	2	*	1	1	4			4	5
Pygopus lepidopodus														*		1					
SCINCIDAE																					
Acritoscincus trilineatum												1	1	*		1					16
Cryptoblepharus buchananii			1		2	8						3	11	*		1		1	2	3	5
Ctenotus australis		2	1			3	1	1	1			3	6		8	1		47		47	11
Ctenotus impar																		22	11	33	10

Ctenotus labillardieri																	1	1	2	5
Egernia kingii																				4
Egernia napoleonis						1						1	*		1					4
Hemiergis quadrilineata			3			12		*	*	*		12	24	*	1	1	7		9	16	32
Lerista distinguenda				*	*	7							7								3
Lerista elegans		1				1		*	*			3	4	*	8	1	166	1	25	192	9
Lerista lineata (P4)														*		1					6
Lerista lineopunctulata														*	3						1
Menetia greyii			*	*	*	5					*	6	11	*	3	1	5		7	12	21
Morethia lineoocellata		2			1	4						1	5	*		1					18
Morethia obscura									3			3	3		12	1	31	2	18	51	1
Tiliqua rugosa		1				2						1	3	*	*	1		1		1	1
VARANIDAE																					
Varanus rosenbergi						1							1			1			*	1	
Varanus tristis										1		1	1								
TYPHLOPIDAE																					
Ramphotyphlops australis														*		1					15
BOIDAE																					
Morelia spilota imbricata												*	*		*	1					
ELAPIDAE																					
Demansia psammophis														*		1					2
Echiopsis curta						1							1		1						6
Elapognathus coronatus																					1
Hydrophis elegans																					2
Neelaps bimaculatus																1	1			1	2
Notechis scutatus														*							4
Parasuta gouldii														*		1					3
Pelamis platura																					8
Pseudonaja affinis				1		1					1	1	2	*		1	*		*	2	5
Simoselaps bertholdi											1	4	4	*		1					24

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APPENDIX 1.

HABITAT DESCRIPTIONS AND GPS READINGS

GPS readings are presented in degrees and decimal minutes using Datum WGS 84

WHITE HILL [WH] ROAD - NORTHERN SITES

WH1

WH1South 32 41.427S 115 36.670E
WH1North 32 41.399S 115 36.665E
Stratum 1 1.5-2 m 30-70% *Spyridium globulosum, Olearia axillaris* and *Acacia rostellifera*.
Stratum 2 <0.5 m 2-10% *Lomandra* sp. and at least 5 other species.
Leaf litter sparse clumped to 2 cm deep under shrubs. Narrow leaves. No evidence of fire.
Note: part of site in more wind-swept aspect has lower vegetation cover.

WH2

WH2South 32 41.353S 115 37.004E
WH2North 32 41.330S 115 36.985E
Stratum 1 1.5-2 m 70-100% Mixed shrubland with *Acacia rostellifera, Olearia axillaris, Spyridium globulosum* and *Melaleuca ?acerosa* dominants.
Stratum 2 <0.5 m 30-70% *Lomandra* sp. and at least 5 other species.
Leaf litter sparse, clumped to 5 cm deep under shrubs. Narrow leaves. No evidence of fire.

WH3

WH3West 32 41.361S 115 37.299E
WH3East 32 41.369S 115 37.346E
Stratum 1 8-10 m 2-10% *Eucalyptus gomphocephala*.
Stratum 2 6-8 m 10-30% *Agonis flexuosa* and occasional *Banksia attenuate* and *Dryandra sessilis.*
Stratum 3 1.5-2 m 10-30% *Xanthorrhoea preissii,* and *Spyridium globulosum.*
Stratum 4 <1 m ca12% *Hibbertia hypericoides* and *Hakea lissocarpha.*
Leaf litter continuous 2-5 cm deep, clumped deeper under shrubs. Broad leaves and a few logs, numerous dead *Xanthorrhoea*. Last burnt: greater than 10 years.

WH4

WH4South 32 41.419S 115 38.237E
WH4North 32 41.378S 115 38.246E
Stratum 1 8-12 m ca. 2% *Eucalyptus gomphocephala* and *Eucalyptus marginata.*
Stratum 2 5-8 m 10-30% *Banksia attenuata.*
Stratum 3 1-1.5 m 30-70% *Melaleuca* sp*., Hibbertia hypericoides,* and occasional *Hakea lissocarpha* and *Olearia axillaris*.

Leaf litter continuous < 2 cm deep, clumped deeper under shrubs. Broad leaves and some logs. Last burnt: greater than 10 years.

WH5
WH5South 32 41.301S 115 38.871E
WH5North 32 41.255S 115 38.866E
Stratum 1 5-8 m 30-70% *Banksia attenuata, Allocasuarina fraseriana, Zylomelum occidentalis, Agonis flexuosa* and *Eucalypyus marginata* with occasional *E. gomphocephala* and *Corymbia calophylla* emergent to 12 m.
Stratum 2 <1 m 10-30% *Hibbertia hypericoides, Stirlingia* sp., *Macrozamia riedlei, Hakea lissocarpha.* Several other species.
Leaf litter almost continuous 2-4 cm deep, clumped deeper under shrubs. Broad and narrow leaves and some logs. Old logging signs. Last burnt: greater than 4 years.

MYALUP [MY] AREA - SOUTHERN SITES

MY2
MY2West 33 05.938S 115 41.635E
MY2East 33 05.945S 115 41.651E
Stratum 1 5-8 m 10-30% *Agonis flexuosa. Eucalyptus gomphocephala* emergent to 12 m.
Stratum 2 2-3 m 10-30% *Spyridium globulosum* and occasional *Hakea prostrata.*
Stratum 3 <0.5 m 2-10% *Acanthocarpus preissii, Lomandra* sp. and at least 6 other species.
Leaf litter continuous 3-5 cm deep, clumped to 12cm under shrubs. Broad and narrow leaves. Small logs and dead twigs abundant. No recent evidence of fire.
Note: Parts of site are more open and *Lomandra* is more abundant and *Acanthocarpus* less abundant.

MY3
MY3East 33 06.369S 115 41.841E
MY3West 33 06.340S 115 41.818E
Stratum 1 15-20 m 10-30% *Eucalyptus gomphocephala* some mature with large hollows, others immature.
Stratum 2 5-8 m 2-10% *Agonis flexuosa.*
Stratum 3 2-4m 30-70% *Spyridium globulosum* and occasional *Acacia saligna* and *A. cyclops* and *Hardenbergiana comptoniana.*
Stratum 4 <0.5 m 70-100% *Acanthocarpus preissii, Lomandra* sp. and a few other species. Abundant dead grass.
Leaf litter almost continuous 2-5 cm deep, clumped to 12 cm under shrubs. Broad and terete leaves. Large logs and dead twigs abundant. No recent evidence of fire.
Note: Parts of site are more open and dead grass is more dense.

MY4
MY4West 33 06.973S 115 42.632E

MY4East 33 06.978S 115 42.696E

Stratum 1 10-15 m 2-10% *Eucalyptus gomphocephala, E. marginata, Corymbia calophylla.*

Stratum 2 4-10 m 30-70% *Banksia attenuata, Agonis flexuosa, B. grandis* .

Stratum 3 <1m 30-70% *Hibbertia hypericoides, Xanthorrhoea preissii, Desmocladus* sp. and other mixed species.

Leaf litter continuous 2-5 cm deep, clumped to 10 cm under shrubs. Broad leaves. Logs and dead twigs abundant. No recent evidence of fire.

MY5

MY5West 33 07.584S 115 43.016E

MY5East 33 07.582S 115 43.048E

Stratum 1 10-15 m 2-10% *Corymbia calophylla, Eucalyptus marginata*.

Stratum 2 6-8 m 30-70% *Banksia attenuata, B. grandis, Agonis flexuosa, Eucalyptus marginata, Corymbia calophylla,* and occasional *Banksia ilicifolia.*

Stratum 3 <1m 10-30% *Hibbertia hypericoides* and other mixed species.

Leaf litter continuous 3-5 cm deep, clumped to 12 cm under shrubs. Broad leaves. Logs and dead twigs abundant. No recent evidence of fire.