Gnangara Sustainability Strategy

An across-government initiative

Groundwater – Biodiversity – Land use

TERRESTRIAL AVIAN DIVERSITY AND THREATENING PROCESSES ON THE GNANGARA GROUNDWATER MOUND, WESTERN AUSTRALIA.

A report prepared on behalf of the
Department of Environment and Conservation
for the Gnangara Sustainability Strategy

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This document has been commissioned/produced as part of the Gnangara Sustainability Strategy (GSS). The GSS is a State Government initiative which aims to provide a framework for a whole of government approach to address land use and water planning issues associated with the Gnangara groundwater system. For more information go to www.gnangara.water.wa.gov.au

Cover Photos (Clockwise from top right): Scarlet Robin, New Holland Honey Eater, Splendid Fairy Wren, Carnaby's Black Cockatoo. Photos by Leonie Valentine

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EXECUTIVE SUMMARY

This report sought to review existing sources of information for birds (avifauna) on the Gnangara Mound in order to:

- provide a synthesis of the existing data on the richness, endemism, rarity and habitat specificity of birds in the GSS area.
- provide a synthesis of the status of birds in the GSS particularly in relation to key threatening processes including fire, habitat fragmentation, *Phytophthora* dieback and groundwater abstraction

The known bird fauna of the GSS area includes 254 species from 6059 surveys (Birds Australia Atlas Database). A large portion of these include species that are mostly or entirely marine, wetland species and migratory shorebirds. These will not be further considered in this review.

Priority species for conservation in the GSS include the Forest Red-tailed Black-Cockatoo *Calyptorhynchus banksii naso* (Vulnerable), Carnaby's Black-Cockatoo *Calyptorhynchus latirostris* (Endangered) and Baudin's Black-Cockatoo *Calyptorhynchus longirostris* (Endangered). The Forest Red-tailed and Baudin's Black-Cockatoos are almost entirely restricted to the forested Darling Range to the east of Perth and are not generally a concern within the GSS area. Carnaby's Black-Cockatoo breeds in the agricultural (wheatbelt) regions of Western Australia's south-west, and migrates to coastal areas during the non-breeding season (December-July) where they feed on proteaceous plants including *Banksia*, *Hakea* and *Grevillea* (Shah

2006). Shah (2006) discovered that the entirety of the Swan Coastal Plain was important feeding habitat for this species and that it was least common in highly developed areas. Ongoing loss of feeding and roosting sites due primarily to urban development, were identified as key threatening processes for this species. Fragmentation of feeding sites is also a concern as this results in birds having to fly further from roost sites and may be very detrimental to birds that are breeding and need feeding sites within close proximity.

The Peregrine Falcon *Falco peregrinus* is listed under Schedule 4 by DEC as "specially protected fauna". This species is widespread and uncommon but is known to nest and hunt in the Perth CBD and is not considered at risk from urbanisation. The Barking Owl *Ninox connivens*, Masked Owl *Tyto novaehollandiae*, Bush-stone Curlew *Burhinus grallarius* and Crested Shrike-Tit *Falcunculus frontatus leucogaster* (south-western subspecies) are all listed as priority species for the Swan Coastal Plain by the DEC. All four species are now considered highly unlikely to occur in this region. The Barking and Masked Owls are represented by occasional records, but there have been no confirmed records of the Crested Shrike-Tit or Bush-stone Curlew on the Swan Coastal Plain for several decades. Fifty nine other species are known to have declined or become extinct on the Swan Coastal Plain since early European settlement.

The GSS study area has no endemic bird species, however the Banskia and Tuart woodland habitats of the region provide core habitat for a number of species that are otherwise rare or restricted on the Swan Coastal Plain. The extensive areas of Banksia woodland as well as the large areas of pine, provide critical feeding habitat for Carnaby's Black-Cockatoo. The largest documented breeding site for Carnaby's Black-Cockatoo in the Perth metropolitan region is at Yanchep (Johnstone *et al.* 2003) emphasising the critical importance of this area of the GSS for both breeding and foraging sites for this species.

The coastal areas, particularly around Yanchep, provide very significant examples of Tuart woodland. A number of species that are extinct or have declined significantly in the GSS area were recorded primarily from the Tuart belt along the Swan Coastal Plain. These included the Yellow-plumed Honeyeater, Rufous Treecreeper, Purple-

crowned Lorikeet, Crested Shrike-tit, Masked Owl and possibly Barking Owl (Alexander 1921; Milligan 1903). All of these species are now virtually unknown from the Swan Coastal Plain and appear to have suffered a regional extinction in the GSS.

Vegetation varies in composition and structure across the GSS area in accordance with the underlying soil type. The distribution of most bird species is determined by this vegetation variation rather than soil type. Although there are no obvious biogeographic patterns in the avifaunal community across dune systems, the different vegetation both at the west and east parts of the GSS will result in some species being more common in some areas of the GSS. Many species in the GSS area are highly dispersive, especially nectar-dependent honeyeaters which follow flowering resources throughout the state.

The impacts of fire are complex and there have been few studies that have successfully examined the impacts of fire on birds. In general it would seem that aiming for a mosaic of burn ages, including a significant proportion of unburnt or at least 10 + years since fire would be a sensible strategy. This would also maximise diversity and provide habitats for those species that benefit from fire, as well as providing for those requiring long-term unburnt habitats and providing source sites for re-colonisation of post-fire landscapes.

A number of bird species are negatively affected by the presence of high density housing while a portion of species are tolerant of bushland-urban edges. For most bird species, a two-pronged approach is recommended. The habitat patch requirements of a species is critical and attention must be paid to the active conservation and management of bushland remnants that are of a suitable size, shape and composition to meet the resource requirements of species. Secondly, it is imperative to establish and maintain connections to surrounding patches. Ecological linkages would facilitate the establishment of a metapopulation allowing the recolonisation of extinct or declining populations in patches that had suffered from stochastic and catastrophic events. The role of gardens in providing the resource requirements of species requires further study.

Few studies have examined the impact of *Phytophthora cinnamomi* on avifauna but dieback is now known to be a key threatening process in south-west WA and the impacts of dieback on birds are likely to be through changes to the vegetation structure and floristics. Further studies in this area are required. It is predicted that species that will be most impacted by dieback are those that are insectivorous, particularly ground-pouncing and ground-feeding insectivores such as the Scarlet Robin, Western Yellow Robin, White-breasted Robin and Yellow-rumped Thornbill as well as species that require dense understorey such as Splendid Fairy-wren, White-browed Scrubwren and Inland Thornbill.

For the purposes of this review, I will not consider the impacts of wetland draw-down on waterbirds or wetland-associated birds as this will be the focus of a future workshop and review, but will focus instead on the impacts on terrestrial birds.

Studies on the Gnangara Mound have identified that Banksia woodland is a wetland-dependent ecosystem as it is dependent on the subsurface presence of groundwater. The impacts of draw-down can vary from subtle changes in vegetation and community structure to widespread vegetation death. Although no studies exist regarding the impact of abstraction on birds or other fauna, it is apparent from these vegetation studies, that abstraction has potentially serious and widespread consequences for all fauna species on the Swan Coastal Plain. Whilst all species of birds in Banksia woodland could be potentially affected by the widespread impacts of draw-down, ten species are considered more sensitive as they are either understorey-dependent or rely on the fringes of wetlands and wetland-associated woodlands.

These species are as follows: Western Rosella, Splendid Fairy-wren, White-browed Scrubwren, Inland Thornbill, Western Thornbill, Scarelt and White-breasted Robin, Golden Whistler, Restless Flycatcher and Grey Fantail. All are considered to be at high risk from continued abstraction in the GSS. Abstraction needs to be mitigated to prevent the loss of riparian vegetation and the associated decline of already rare species that utilise these habitats. The widespread collapse of Banksia woodland across the mound could have severe implications for the persistence of all Banskia woodland bird species especially those that are more sedentary and cannot readily disperse to new sites.

INTRODUCTION

The objective of this review is to assess the avian biodiversity and determine the current or potential impact of several key threatening processes; fire, *Phytophthora cinnamomi* dieback, habitat fragmentation and groundwater abstraction, on the terrestrial bird fauna of the GSS area. Specifically, we will synthesise the current knowledge on the richness, endemism, rarity and habitat specialists of the GSS area and identify any gaps in our current state of knowledge.

Bird assemblages are known to be strongly influenced by habitat structure (MacArthur and MacArthur 1961) and any disturbance event that impacts habitat structure is therefore likely to have an impact on species. Similarly, like all vertebrates, birds have resolute resource needs including food sources such as insect prey, nectar, fruit or seed. Any events which impact the abundance and diversity of these food resources is also likely to have a significant impact on bird species. This review will focus on the impacts of fire, dieback, urbanisation and wetland draw-down on the abundance and diversity of bird populations in the GSS area. The mechanism for such changes is likely to be regulation at the habitat and resources level.

METHODS

Approach

The review comprised an examination of both existing data sets as well as published material. Initially an extensive literature review was undertaken of all references relating to bird ecology in the Gnangara Groundwater area. This incorporated locally relevant research such as published government reports, journal articles, books, unpublished research and other reports. I also reviewed national and international studies to compare and contrast threatening factors.

A number of survey databases were also available and were obtained and queried to provide information on the avifauna of the GSS area. This review element allowed for the identification of any gaps in the existing datasets as well as some meta-analysis.

The datasets available are displayed in Table 1, along with a brief descriptor of the type and extent of data.

Table 1: Datasets available concerning birds in the GSS area.

Dataset	Description	Availability
Birds Australia Atlas of Australian Birds	Comprehensive point and area-based data for the GSS area and elsewhere. Data for 254 species with 6059 records.	Obtained by request to Birds Australia. Dataset held by DEC now.
Faunabase	Point-based and area-based observational and specimen records	By querying online database of WA Museum. More detailed data available for a fee. Not requested as yet.
Storr and Johnstone Database	Point-based and historic data. Possibly one of the most comprehensive for the Perth region.	Privately held and available for a fee from Ron Johnstone
Perth Biodiversity project/Birds Australia Survey database	Site-based data for an average of 12 months, from 121 remnants.	Available by request from Cheryl Gole. Meta-analysis already completed for Ecological Linkages Project.
Suburban Bird Survey Project	Locality-based data, often home gardens. Long-term and ongoing for at least 10 years.	By request to Birds Australia (WA)
Australian Bird and Bat Banding Scheme	Records of dispersal in banded birds as well as species lists form banding site locations	By request to DEWR in Canberra.
Mt Claremont Bird Banding Group	Long-term data for Bold Park, Mount Claremont and Campbell Barracks. Only includes records of captured and banded birds. 20 year dataset.	By request to Boyd Wykes, Department of Defence.
Herdsman Lake Bird Banding Group	Long-term data for Herdsman Lake including captured and banded birds.	By request to Bill Rutherford.

RESULTS AND DISCUSSION

The known bird fauna of the GSS area includes 254 species from 6059 surveys (Birds Australia Atlas Database). A large portion of these include species that are mostly or entirely marine, wetland species and migratory shorebirds. These will not be further considered in this review but a workshop will be undertaken to gather further information on these species.

Priority species for Conservation

Land birds listed under the Wildlife Conservation Act as "species that are rare or likely to become extinct" in the Perth metropolitan region, include the Forest Red-tailed Black-Cockatoo *Calyptorhynchus banksii naso* (Vulnerable), Carnaby's Black-Cockatoo *Calyptorhynchus latirostris* (Endangered) and Baudin's Black-Cockatoo *Calyptorhynchus longirostris* (Endangered).

The Forest Red-tailed and Baudin's Black-Cockatoos are almost entirely restricted to the forested Darling Range to the east of Perth and are not generally a concern within the GSS area. Carnaby's Black-Cockatoo breeds in the agricultural (wheatbelt) regions of Western Australia's south-west, and migrates to coastal areas during the non-breeding season (December-July) where they feed on proteaceous plants including *Banksia*, *Hakea* and *Grevillea* (Shah 2006). Shah (2006) discovered that the entirety of the Swan Coastal Plain was important feeding habitat for this species and that it was least common in highly developed areas. Ongoing loss of feeding and roosting sites due primarily to urban development, were identified as key threatening processes for this species. Fragmentation of feeding sites is also a concern as this results in birds having to fly further from roost sites and may be very detrimental to birds that are breeding and need feeding sites within close proximity.

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western subspecies) are all listed as priority species for the Swan Coastal Plain by the DEC. All four species are now considered highly unlikely to occur in this region. The Barking and Masked Owls are represented by occasional records, but there have been no confirmed records of the Crested Shrike-Tit or Bush-stone Curlew on the Swan Coastal Plain for several decades.

Bird Species at Risk in the Perth Region

There is generally a paucity of information on the ecology and viability of bird populations in the Perth metropolitan region, making it difficult to identify threatening processes and "at risk" species.

In their cornerstone long-term study, Recher and Serventy (1991) compared the status of birds in Kings Park, central Perth, between the 1920's, 1950's and 1986. The data was collected on replicable transects and was powerful enough to permit observations of changes in the abundance of many bird species, over time. Recher and Serventy (1991) documented the extinction of 9 species from this large, now isolated remnant, and noted the decline of a further 14 species (Table 2). The list they compiled provides an insight into which species are at most risk from increasing urbanisation on the Swan Coastal Plain.

The major extinctions in Kings Park have been of insectivores including the Western Yellow Robin *Eopsaltria griseogularis*, Scarlet Robin *Petroica multicolor*, Western Thornbill *Acanthiza inornata* and Golden Whistler *Pacycephala pectoralis*. The Golden Whistler and Western Thornbill have occasionally been recorded since 1986 as vagrants in Kings Park (Recher 1997), indicating some ability to disperse through the suburban matrix. Conversely, no species of Robin has been resighted for over 50 years in Kings Park, indicating that this group is unable to disperse through the urban matrix.

The West Australian Government's habitat conservation program Bush Forever, recognises species that are declining or have become locally extinct on the Swan Coastal Plain. Nearly 50% of the 71 naturally occurring passerines and 40% of the non-passerines have declined in abundance since European settlement (Government

of Western Australia 2000). This list includes 22 wide-ranging species and 22 habitat specialists (Table 2). A further 9 species are regarded as extinct (or nearly so) on the Swan Coastal Plain and these include the Rufous Treecreeper *Climacteris rufa* (but see Kolichis 1978), Red-winged Fairy-wren *Malurus elegans*, Yellow-plumed Honeyeater *Lichenostomus ornatus*, Australian Bustard *Ardeotis australis*, Brush Bronzewing *Phaps elegans*, Western Long-billed Corella *Cacatua pastinator*, Barking Owl, Crested Shrike-tit and Western Whipbird *Psophodes nigrogularis* (Table 2).

In contrast to Recher and Serventy (1991), a long-term bird study at Whiteman Park (a large natural bushland remnant > 2000 ha, north-east of Perth) found no evidence of an overall decline in species richness, although the number of exotic species increased and some native species decreased (Brooker 2004). Brooker (2004) noted a decline in Australian Ringnecks *Barnardius zonarius*, Red-capped Parrots *Purpureicephalus spurius*, Elegant Parrots *Neophema elegans*, Splendid Fairy-wrens *Malurus splendens*, Yellow-rumped Thornbills *Acanthiza chrysorrhoa*, Red Wattlebirds *Anthochaera carunculata*, Singing Honeyeaters *Lichenostomus virescens* and Grey Butcherbirds *Cracticus torquatus*, but suggested that further research was needed to confirm these trends and their cause.

A review of historical data suggested that wetland birds had been particularly impacted by large-scale loss of Perth's coastal plain wetlands (How and Dell 1993). Species such as Black Bittern *Ixobrychus flavicollis* and Australasian Bittern *Botaurus poiciloptilus* and Whistling Kite *Haliastur sphenurus* had all suffered major declines on the Swan Coastal Plain. How and Dell (1993) also noted the decline of most species of raptor due to the loss of coastal plain woodlands and reported that 46 of the 70 naturally occurring passerines on the coastal plain had decreased, with only 8 species having increased.

A number of early accounts by Alexander (1921) and Milligan (1903), document bird species that are now rare or extinct on the Swan Coastal Plain (Table 2).

Converse to these decreases, a number of species have increased over time. Alexander (1921) lists the Painted Button Quail, Buff-banded Rail, White-backed Swallow and

Black-shouldered Kite as rare or uncommon but all have increased in numbers since this time and are common, with the exception of the White-backed Swallow which remains uncommon but is still regularly reported.

Community trends and biogeographic patterns

The GSS study area has no endemic bird species, however the Banskia and Tuart woodland habitats of the region provide core habitat for a number of species that are otherwise rare or restricted on the Swan Coastal Plain. The extensive areas of Banksia woodland as well as the large areas of pine, provide critical feeding habitat for Carnaby's Black-Cockatoo. The largest documented breeding site for Carnaby's Black-Cockatoo in the Perth metropolitan region is at Yanchep (Johnstone *et al.* 2003) emphasising the critical importance of this area of the GSS for both breeding and foraging sites for this species.

The coastal areas, particularly around Yanchep, provide very significant examples of Tuart woodland. A number of species that are extinct or have declined significantly in the GSS area were recorded primarily from the Tuart belt along the Swan Coastal Plain. These included the Yellow-plumed Honeyeater, Rufous Treecreeper, Purple-crowned Lorikeet, Crested Shrike-tit, Masked Owl and possibly Barking Owl (Alexander 1921; Milligan 1903). All of these species are now virtually unknown form the Swan Coastal Plain and appear to have suffered a regional extinction in the GSS.

The location of the GSS area and its connection with the northern sandplains as well as the Darling Range to the east, enables seasonal visitation by uncommon species such as the Crested Bellbird and Crimson Chat that are usually present in more arid regions. Maintenance of this biogeographic connection is likely to be very important in ensuring that species diversity and annual movements are maintained, especially in the face of impacts such as climate change.

Vegetation varies in composition and structure across the GSS area in accordance with the underlying soil type. The distribution of most bird species is determined by this vegetation variation rather than soil type. Although there are no obvious

biogeographic patterns in the avifaunal community across dune systems, the different vegetation both at the western and eastern parts of the GSS will result in some species being more common in some areas of the GSS. Near-coastal vegetation provides opportunities for species that prefer dense heathland, such as the White-winged and Variegated Fairy-wrens and the White-browed Scrub-wren. Marri and Jarrah woodland in the east of the GSS, Tuart woodland in the west and scattered wetlands containing Flooded Gum provide suitable habitat for forest species such as the Spotted Pardalote and Golden Whistler which are otherwise scarce across the Banksia-dominated Bassendean complex. Many species in the GSS area are highly dispersive, especially nectar-dependent honeyeaters which follow flowering resources throughout the state. Scant data exists on the broad-scale movement patterns of these species in WA but maintaining landscape-level connectivity is likely to be very important for these species.

Threatening Processes

Fire

The impacts of fire are complex and there have been few studies that have successfully examined the impacts of fire on birds. Burbidge (2003) conducted an extensive review on the impacts of fire on birds in south-western Australia and the major findings of this review along with management recommendations are summarised in Table 3.

Fire clearly has a varied impact depending upon the species of interest. In general it would seem that aiming for a mosaic of burn ages, including a significant proportion of unburnt or at least 10 + years since fire would be a sensible strategy. This would also maximise diversity and provide habitats for those species that benefit from fire, as well as providing for those requiring long-term unburnt habitats and providing source sites for re-colonisation of post-fire landscapes.

Although fire is unlikely to cause the loss of any species in the GSS area, it is apparent that a high burn frequency in isolated remnants has caused the extinction of sedentary species such as the Splendid Fairy-wren. Fire suppression in isolated

remnants, possibly through mosaic burning, may be critical to ensuring the regional persistence of these species at a regional level.

Urban Habitat Fragmentation and Dispersal

Habitat fragmentation in the GSS is primarily an issue in the urban and peri-urban zone, rather than in the large areas of continuous bushland to the north of the study area. This review will focus on fragmentation in urban environments in the GSS, and its impact on birds.

One of the primary reasons for dispersal may be for juveniles needing to find new habitats. The importance of this was exemplified by a study of the White-winged Fairy-wren *Malurus leucopterus* on the urban fringe of Perth (Rowley and Russell 1995). This study found a high annual mortality of 50% for females and suggested that rather than true mortality, dispersal to a location outside the 32 ha study remnant was probably occurring. Population studies on the Splendid Fairy-wren indicated that 12.9% of males and 24.3% of females left their natal territories by their first year and that this was correlated with population density (Russell and Rowley 1993).

Similarly, a study on the Blue-breasted Fairy-wren in the Western Australian wheatbelt showed the importance of connected patches for population survival (Brooker and Brooker 2001). A further study reinforced the importance of connectivity in maintaining population growth rates and survival (Smith and Hellmann 2002)

Many species also move around seasonally or in response to resources such as mass-flowering events. Mawson and Massam (1995) noted the presence of vagrant species that appeared only once or twice during several years of surveys in Forrestfield, in the Perth metropolitan area. Of 55 bird species recorded over three years, 36% were vagrants. Although some of these were clearly nomads following nectar resources (e.g. New Holland Honeyeater, White-cheeked Honeyeater and Yellow-plumed Honeyeater – the latter now considered extinct in the Perth region), sedentary insectivores such as the Varied Sittella, Golden Whistler and Western Thornbill were also recorded as vagrants (Mawson and Massam 1995).

Given that these are conspicuous species that re-appeared after an absence of several surveys, we can presume that they have a reasonable dispersal capacity through the urban landscape. Mawson and Massam (1995) remarked on the unusual absence of several other expected sedentary species such as Splendid Fairy-wren and White-browed Scrub-wren and suggested that these species may not be able to disperse successfully navigate the urban matrix.

Other studies have also recorded bushland-associated insectivores as vagrants visiting small urban isolates in Perth. In a five year bird-banding study at Pelican Point Nature Reserve (a small near-city bushland isolate), Rufous Whistlers were captured only twice by the writer and both were juveniles. Given the absence of this species from the nearby campus of The University of Western Australia and surrounding suburbs it is likely that these juveniles were dispersing from their natal territory, perhaps to or from nearby Kings Park. Similarly, Cooper (1995) recorded the Rufous Whistler, Western Gerygone and Yellow-rumped Thornbill from an isolated 1 ha reserve in suburban Inglewood where they were presumably vagrants. Turpin (1990) also recorded the Rufous Whistler in an isolated 6 ha reserve in South Perth. Given the small size of these remnants it is highly unlikely that these species are resident and were probably using sites as part of a regional network. This implies an ability to move through urban habitats.

It is apparent that some species are more capable of traversing the built environment than others. This may be due to the relative habitat and foraging preferences of these species. Splendid Fairy-wrens spend a significant amount of time on the ground and perched on bushes (Tibbetts and Pruett-Jones 1999). This may predispose them to predation in urban settings, and may also preclude them from dispersing through areas with no shrub layer. Schmitz (1992) recorded the con-generic Variegated Fairy-wren mostly in shrubland in Perth, and it is also unlikely this species would disperse through open areas with any regularity. Conversely the Rufous Whistler spent up to 30% of its time in trees, indicating that this species probably has the capacity to disperse through more open areas if a tree canopy is intact (Schmitz 1992).

Although these studies do not provide information on actual landscape-level dispersal, they highlight the fact that species can disperse through the urban matrix and that

dispersal is an essential component of the life history of many bird species. Any changes to the surrounding matrix through intense urbanisation, may impact the ability of a species to disperse and consequently the long-term viability of populations.

The composition of the suburban matrix and a species' autecology will determine its capacity to disperse through urban areas. Garden *et al*. (2006) concurred that the size, connectivity and shape of patches was important to the survival of urban bird populations, but that the importance of these factors to birds, varied with the species under consideration. The spatial characteristics of habitat patches may be especially important for habitat-restricted species (Bentley and C.P. 1997).

Although some species may require larger areas for survival, this is not always as important as other factors such as connectivity and the impacts of urbanisation on dispersal and in changing matrix habitats.

A study in Victoria demonstrated a statistically significant depressive effect of urbanisation on native bird species-richness, but found little evidence of a difference in species between small and large remnants (Yeoman and Mac Nally 2005). The authors did suggest, however, that the experimental design may have been affected by the lack of comparable large remnants.

Conversely, a significant species-area relationship was established for birds in urban remnants in the ACT, but this study did not find a significant relationship between species richness and isolation for urban populations (Watson *et al.* 2005). The author's cautioned that the nature of the matrix is very important and is not necessarily an impenetrable barrier for all species.

Hodgson *et al.* (2007) examined avian movement across habitat edges in urban areas in eastern Australia. They discovered that insectivores (39%) and nectarivores (35%) made the most crossings over a bushland/urban interface. An examination of the frequency of occurrence of birds at high-density housing edges revealed that eight species were tolerant of this interface, with 6 of these being nectarivores and two insectivores. The species from this study that are most comparable to WA included

the Eastern Spinebill *Acanthorhynchus tenuirostris*, Red Wattlebird, Little Wattlebird *Anthochaera chrysoptera*, Rainbow Lorikeet *Trichoglossus haematodus*, Black-faced Cuckoo-Shrike *Coracina novaehollandiae* and Golden Whistler (Hodgson *et al.* 2007). The Western Spinebill *Acanthorhynchus superciliosus* may not be a suitable analogue for the Eastern Spinebill as the Western Spinebill is rare in developed suburbs and seems to be restricted to native bushland in Perth. The Little Wattlebird in WA has now been made a species and renamed as the Western Wattlebird *Anthochaera lunulata*, but is otherwise ecologically analogous.

The Rainbow Lorikeet is an introduced pest species in Perth and the Golden Whistler was formerly common but seems intolerant of urban development in Perth, having become extinct in areas such as King's Park (Recher and Serventy 1991). The Red Wattlebird and Black-faced Cuckoo-shrike are common and widespread in Perth.

Interestingly Hodgson *et al.* (2007) found that several bushland-dependent species were tolerant of low-density housing edges including the Grey Fantail *Rhipidura fuliginosa*, Brown Thornbill *Acanthiza pusilla* and Eastern Yellow Robin *Eopsaltria australis*, fairy-wrens, White-browed Scrub-wren *Sericornis frontalis*, Australian Magpie *Gymnorhina tibicen* and Eastern Rosella *Platycercus eximius*. The Grey Fantail, White-browed Scrub-wren and Australian Magpie all occur in WA. Three species of fairy-wren occur on the Swan Coastal Plain portion of the Perth metropolitan area. The Western Rosella *Platycercus icterotis* is scarce to extinct on the Swan Coastal Plain and is not a suitable analogue to the Eastern Rosella which is common in urban areas. Similarly, the Eastern Yellow Robin persists in urban habitats of the east coast but is known from only one current population on the Swan Coastal Plain.

Although a similar study needs to be undertaken in Western Australia, it is likely that a number of similar species in Perth are negatively affected by the presence of high density housing while a portion of species are tolerant of bushland-urban edges.

For most bird species, a two-pronged approach is recommended. The habitat patch requirements of species is critical and attention must be paid to the active conservation and management of bushland remnants that are of a suitable size, shape

and composition to meet the resource requirements of species. Secondly, it is imperative to establish and maintain connections to surrounding patches. Ecological linkages would facilitate the establishment of a metapopulation allowing the recolonisation of extinct or declining populations in patches that had suffered from stochastic and catastrophic events. The role of gardens in providing the resource requirements of species requires further study.

Predation

There are two principal predators of concern for birds in the GSS area – cats and foxes.

Predation by domestic cats is likely to have a significant impact on local populations of some bird species. One study found that 13 species of bird were predated by domestic cats (Calver *et al.* 2007). The study also occurred in the Darling Range, but included only one introduced species (Laughing Turtle-dove) and includes four species listed as declining under Bush Forever (Table 2). These are the White-browed Scrubwren, Common Bronzewing, Western Wattlebird and New Holland Honeyeater.

There have been no other local studies, but a number of other studies have quantified the impact of cat predation on birds. A study in arid South Australia found that 150 birds per square kilometre were killed by feal cats each year (Read and Bowen 2001). In urban Canberra, 47 bird species were consumed by cats and birds formed 27% of the diet of cats (Barratt 1997).

A study in the UK found that cat density in urban areas can be very high, up to 229 cats/km, and that 10 bird species were consumed (Baker *et al.* 2005). Baker *et al.* (2005) also found that predation of birds was so high that for several species it created a dispersal sink for juveniles from surrounding areas. A study in the USA found that 23 bird species were predated by cats, including two species of conservation concern (Lepczyk *et al.* 2004). Lepczyk *et al.* (2004) compared rural and urban landscapes and found no net difference in predation rates, but conservatively estimated that up to 47 000 birds were predated by cats in their study area.

Comparatively little information is available on fox predation and its impact on birds. In arid Australia, a study comparing fox and cat predation, found that birds comprised a very small portion of the diet of foxes, with just two species consumed and only 6 individuals from 92 foxes examined (Read and Bowen 2001). It is presumed that fox predation would have a greater impact on waterbirds and ground birds than other species.

It is difficult to be able to quantify the impact of predation on birds in the GSS area but doubtless baiting may be of benefit to species such as the Rainbow Bee-eater, Painted Button-Quail, Common Bronzewing and Emu which spend significant amounts of time on the ground and/or nest on or in the ground.

Dieback

Few studies have examined the impact of *Phytophthora cinnamomi* on avifauna but dieback is now known to be a key threatening process in south-west WA and the impacts of dieback on birds are likely to be through changes to the vegetation structure and floristics (Garkaklis *et al.* 2004; Shearer *et al.* 2007).

A study in the Jarrah forest found that dieback areas were characterised by bird species that favour more open habitats, edges and farmlands, such as Willie Wagtails and Australian Magpies (Armstrong and Nichols 2000). Cockatoos were observed using dead trees as perches. It was noted that a number of species found in healthy Jarrah forest were in reduced abundances in dieback –affected forest, including Western Yellow Robin, Grey Shrike-thrush and Rufous Tree-creeper (Armstrong and Nichols 2000). Overall bird densities were also lower in dieback-affected sites as opposed to natural forest (Armstrong and Nichols 2000).

A further study of bird utilisation of the Jarrah forest, found that in severely-dieback affected sites, the density, richness and diversity of birds was less than that of healthy forest (Nichols and Watkins 1984). At the moderately dieback-affected site, total bird density was higher than healthy forest, species richness was only marginally less, and diversity was slightly less (Nichols and Watkins 1984).

These differences in the avifauna relate clearly to the structural changes caused by dieback. Severely dieback-affected sites were characterised by a tree density of just 8/ha compared to up to 92/ha for healthy forest, a midstorey density of 32/ha compared to up to 160/ha for healthy forest, an understorey over of 15% compared to up to 70% for healthy forest and a leaf litter density of 10% compared to 95% in healthy forest (Nichols and Watkins 1984). Similar structural change was also noted in another Jarrah forest study which concluded that litterfall and litter mass were severely reduced in dieback-affected areas and that the densities of litter invertebrates were lower in dieback areas (Postle *et al.* 1986). Such structural changes emulate open habitats and consequently, Nichols and Watkins (1984) found the open-habitat species the White-winged Triller, to be most abundant in dieback sites.

Although no further information is available on the impacts of dieback on birds in Banksia woodlands, it is apparent that the primary mechanisms of underlying change are the loss of canopy and understorey creating a more simplified and open woodland, the loss of leaf litter and subsequently invertebrates and the reduced availability of nectar-producing flowers. Although all of these studies were undertaken in the Jarrah forest, the same results are expected in Banksia woodlands.

It is predicted that species that will be most impacted by dieback are those that are insectivorous, particularly ground-pouncing and ground-feeding insectivores such as the Scarlet Robin, Western Yellow Robin, White-breasted Robin and Yellow-rumped Thornbill as well as species that require dense understorey such as Splendid Fairy-wren, White-browed Scrubwren and Inland Thornbill.

The species affected and extent of the impact will obviously depend on the degree of dieback infestation and its intensity.

As dieback progresses, nectarivores particularly those that are smaller and less wide-ranging, will be impacted by the loss of flowering species such as Banksias. Shearer *et al*. (2007) found Banksia's to be some of the most impacted of all native species as well as a number of other nectar-producing plants such as Lambertia. Since most honeyeaters have strong dispersal abilities, this is unlikely to be a significant issue, but could certainly influence local community composition and dynamics. The loss of

eucalypt and Banksia species and the thinning of the canopy is likely to be a significant issue for canopy specialists including the Striated Pardalote, Western Thornbill, Weebill and Western Gerygone.

Although it is apparent that a wide range of bird species may be impacted by dieback, generalists birds, those favouring open habitats, those with good dispersal abilities and birds not reliant upon Banksias or other dieback susceptible species, are unlikely to be impacted and may even benefit from dieback. This is further emphasised by a study which found that the rare Red-eared Firetail was not impacted by dieback in the Jarrah forest as most plant species it utilised, were dieback resistant (Nichols *et al.* 1982).

Wetland Draw-down

For the purposes of this review, I will not consider the impacts of wetland draw-down on waterbirds or wetland-associated birds as this will be the focus of a future workshop and review, but will focus instead on the impacts on terrestrial birds.

Studies on the Gnangara Mound have identified that Banksia woodland is a wetland-dependent ecosystem as it is dependent on the subsurface presence of groundwater (Eamus *et al.* 2006). The impacts of draw-down can vary from subtle changes in vegetation and community structure to widespread vegetation death (Groom *et al.* 2000). In one case reported by Groom *et al.* (2000) groundwater abstraction in Wanneroo resulted in the loss of 80% of *Banksia* trees within the Wanneroo well field. Groom *et al.* (2000) also recorded a 50% reduction in the density of deep-rooted understorey species and a 35% reduction in shallow-rooted understorey species as a result of abstraction. The response of vegetation to abstraction is dependent upon the species involved as well as their topographical position, with species around wetlands more dependent on groundwater throughout the year and thus more sensitive to the impacts of draw-down (Groom *et al.* 2000).

Although no studies exist regarding the impact of abstraction on birds or other fauna, it is apparent from these vegetation studies, that abstraction has potentially serious and widespread consequences for all fauna species on the Swan Coastal Plain.

Whilst all species of bird in Banksia woodland could be potentially affected by the widespread impacts of draw-down, ten species are considered more sensitive as they are either understorey-dependent or rely on the fringes of wetlands and wetland-associated woodlands (Table 4).

These species are considered to be at high risk from continued abstraction in the GSS and it is notable that every one of these species is either listed under Bush Forever as at risk, or has otherwise been recorded as declining on the Swan Coastal Plain (Table 1). It is therefore considered that continued abstraction leading to the loss of riparian vegetation and areas of Banksia woodland could have a serious effect for this group of already declining species.

In summary, abstraction needs to be mitigated to prevent the loss of riparian vegetation and the associated decline of already rare species that utilise these habitats. The widespread collapse of Banksia woodland across the mound could have severe implications for the persistence of all Banskia woodland bird species especially those that are more sedentary and cannot readily disperse to new sites.

Table 2: Terrestrial bird species that have declined in distribution or become extinct on the Swan Coastal Plain. Sources include Bush Forever (Government of Western Australia 2000), Recher and Serventy (1991), Recher (1997), Milligan (1903) and Alexander (1921). HS = habitat specialists , WR = wide-ranging, EX = locally extinct and DE = decline. Recher (1997), and Recher and Serventy (1991), includes only the status of birds observed in Kings Park. The Atlas column lists the number of records (for those species with 20 or less records) from the Birds Australia Atlas of Australian Birds.

Species	Bush Forever	Recher/Recher & Serventy	Milligan/ Alexander	Atlas Records
Emu *Dromaius novaehollandiae*	WR		DE	14
Little Button-quail *Turnix velox*			DE/EX	2
Square-tailed Kite *Lophoictinia isura*	WR			
Whistling Kite *Haliastur sphenurus*	WR	DE		
Brown Goshawk *Accipiter fasciatus*	WR			
Collared Sparrowhawk *Accipiter cirrocephalus*	WR			
Little Eagle *Hieraaetus morphnoides*	WR			
Wedge-tailed Eagle *Aquila audax*	WR		DE	
Brown Falcon *Falco berigora*	WR			
Peregrine Falcon *Falco peregrinus*	WR			
Bush Stone-curlew *Burhinus grallarius*	EX		EX	0
Common Bronzewing *Phaps chalcoptera*	HS		DE	
Brush Bronzewing *Phaps elegans*	HS		DE/EX	2
Western Long-billed Corella *Cacatua pastinator pastinator*	EX		EX	0
Forest Red-tailed Black-Cockatoo *Calyptorhynchus banksii naso*	EX		DE	1
Carnaby's Black-Cockatoo *Calyptorhynchus latirostris*	WR	DE	DE	
Baudin's Black-Cockatoo *Calyptorhynchus longirostris*	WR			
Purple-crowned Lorikeet *Glossopsitta porphyrocephala*		EX	DE/EX	9
Red-capped Parrot *Purpureicephalus spurius*			DE	
Western Rosella *Platycercus icterotis*	WR		DE	
Ground Parrot *Pezoporus wallicus*			EX	
Pallid Cuckoo *Cuculus pallidus*		DE	DE	
Shining Bronze-Cuckoo *Chrysococcyx lucidus*		DE		
Barking Owl *Ninnox connivens connivens*	EX			1
Masked Owl *Tyto novaehollandiae*	WR			0
Sacred Kingfisher *Todiramphus sactus*		DE	DE	
Rufous Treecreeper *Climacteris rufa*	HS			
Red-winged Fairy-wren *Malurus elegans*	HS		DE	

Species	Bush Forever	Recher/Recher & Serventy	Milligan/ Alexander	Atlas Records
Splendid Fairy-wren *Malurus splendens*	HS			
Variegated Fairy-wren *Malurus lamberti*	HS			
White-winged Fairy-wren *Malurus leucopterus*	HS			
Southern Emu-wren *Stipiturus malachurus*	HS			
White-browed Scrub-wren *Sericornis frontalis*	HS			
Weebill *Smircornis brevirostris*	HS			
Western Gerygone *Gerygone fusca*		DE		
Inland Thornbill *Acanthiza apicalis*	HS	DE	DE	
Western Thornbill *Acanthiza inornata*	HS	EX	DE	
Yellow-rumped Thornbill *Acanthiza chrysorrhoa*	HS			
White-naped Honeyeater *Melithreptus chloropsis*	WR		DE	12
Brown-headed Honeyeater *Melithreptus brevirostris*			EX	
New Holland Honeyeater *Phylidonyris novaehollandiae*	WR			
White-cheeked Honeyeater *Phylidonyris nigra*	WR			
Tawny-crowned Honeyeater *Phylidonyris melanops*	WR			
Western Spinebill *Acanthorhynchus superciliosus*	DE	DE	DE	
Yellow-plumed Honeyeater *Lichenostomus ornatus*	HS		DE/EX	
Western Wattlebird *Acanthochaera lunulata*	WR		DE	
Yellow-throated Miner *Manorina flavigula*	WR		DE	
Crimson Chat *Epthianura tricolor*			DE	
White-fronted Chat *Epthianura albifrons*			DE	
Scarlet Robin *Petroica multicolor*	HS	EX	DE	
Hooded Robin *Melanodryas cucullata*	HS			
Western Yellow Robin *Eopsaltria griseogularis*	HS	EX	DE	1
White-breasted Robin *Eopsaltria georgiana*	HS			20
Western Whipbird *Psophodes nigrogularis*	EX			
Varied Sitella *Daphoenositta chrysoptera*	HS		DE	
Western Crested Shrike-Tit *Falcunculus frontatus leucogaster*	EX			
Golden Whistler *Pachycephala pectoralis*	HS	EX	DE	12
Grey Shrike-thrush *Colluricincla harmonica*	HS			
Grey Fantail *Rhipidura fuliginosa*		DE		
Willie Wagtail *Rhipidura leucophrys*		DE		

Species	Bush Forever	Recher/Recher & Serventy	Milligan/ Alexander	Atlas Records
Restless Flycatcher *Myiagra inquieta*	HS			
Black-faced Woodswallow *Artamus cinereus*	WR		DE	
Dusky Woodswallow *Artamus cyanopterus*	WR		DE	15
Grey Butcherbird *Cracticus torquatus*		DE	DE	
Grey Currawong *Strepera versicolor*	WR		DE	16
Tree Martin *Hirundo nigricans*		DE		
Brown Songlark *Cincloramphus cruralis*			DE	5

Table 3: Summary of the impacts of fire on birds including implications for the GSS.

Variable	Key Findings	Implications for the GSS
Bird diversity and richness	• Species richness is usually highest in long-term unburnt vegetation (15 years post-burn) but is also high for several years following a fire (Burbidge 2003). • Species diversity can increase and be higher in burnt areas for up to 3 years post-burn (Christensen *et al.* 1985). • Species richness of honeyeaters is reduced for three years after fire, whilst other guilds are unaffected (Burbidge 2003).	• In the long-term, longer unburnt vegetation is required for maximum richness and there are short term increases after fire when open habitat species are favoured.
Bird abundance	• Abundance of birds drops to very low levels immediately following a fire but usually recovers within 2-3 years (Burbidge 2003). • Species abundances can be higher in frequently burnt areas than unburnt areas, but diversity may be low or dominated by open-habitat favouring species (Burbidge 2003). • Insectivores generally increase after fire and exceed pre-fire abundance up to 7 years after the burn whereas nectarivores decline. This is primarily due to a reduction in the number of flowering banksias in burnt areas.	• A mosaic is required as not all species are equally affected by fire. Longer unburnt habitats are generally preferred.
Habitat change	• Some species such as birds of prey are favoured by fire due to a preference for open habitats. Many species remain in the same area for several years after a fire (Burbidge 2003). • Open-habitat preferring species may dominate for 2-6 years post fire (Burbidge 2003). • No species in south-west WA occurs only in long-unburnt vegetation (Burbidge 2003), however Bamford (1985) found that Western Thornbill, Shining Bronze-cuckoo and Scarlet Robin were more common in Banksia woodland unburnt for 11-12 years. • Changes in abundance like this are linked to changes to habitat structure and the foraging opportunities that presents. Wooller and Calver (1988) noted significant decreases in abundance of White-breasted Robin, Golden Whistler, Splendid Fairy-wren and White-browed Scrub-wren following fire and surmised that this was due to changes to vegetation structure and prey. • Frequent fires lead to the decline of populations of splendid fairy-wrens by altering habitat and food availability (Brooker 1998) and increasing nest predation as a result of lack of cover.	• Open post-fire habitats favour some species but in the long-term, long-unburnt sites are required to maintain some key species which otherwise decline from food shortages and higher rates of predation.

Variable	Key Findings	Implications for the GSS
Population viability	• Active nests can still recruit fledglings following a low intensity fire (Kimber 1974). • Fire can reduce the recruitment success of some species such as the Splendid Fairy-wren (Rowley and Russel 1990). • Fire in small remnants (under 2000 ha) can cause the extinction of some species such as the Splendid Fairy-wren (Brooker and Brooker 1994) and Western Thornbill (Recher 1997). • Nest predation and brood parasitism increase after fire (Russell and Rowley 1993).	• Fire suppression strategies or mosaic burning, may be essential in small remnants under 2000 ha.
Dispersal and recolonisation	• After an extensive fire, species recolonise from surrounding unburnt patches but this is slow for some species such as Grey Shrike-thrush, which only return after 3 years. • Sedentary species in remnants are more likely to become extinct after fir than dispersive species (Burbidge 2003).	• Burn sites should be well-connected to unburnt blocks that act as source populations. Avoid burning large areas.
Fire Intensity	• Most studies attempting to look at the influence of fire intensity on species ecology have been confounded. • Fire intensity is important with more intense fires causing a greater reduction in species richness than lower-intensity fires (Burbidge 2003). • Reduced abundances are more pronounced for higher intensity fires as opposed to low intensity fires (Burbidge 2003).	• Further research on fire intensity is needed but it would seem that low intensity burns are preferable.

Table 4: Species considered most at risk from the impacts of wetland-drawdown and groundwater abstraction (Johnstone and Storr 1998; Johnstone and Storr 2004).

Species	**Preferred habitats**
Western Rosella	*Eucalyptus rudis*, *Corymbia calophylla* and *Melaleuca* by wetlands
Splendid Fairy-wren	Understorey, *Melaleuca* and waterside thickets
White-browed Scrubwren	Thickets and understorey including watercourses
Inland Thornbill	Melaleuca thickets alongside water and dense understorey
Western Thornbill	*Banksia* woodland dependent
Scarlet Robin	Waterside vegetation including *Melaleuca* and *E. rudis*.
White-breasted Robin	*Banksia* and waterside thickets
Golden Whistler	*Melaleuca rhaphiophylla* woodlands
Restless Flycatcher	*E. rudis* and *Melaleuca* woodlands
Grey Fantail	Understorey and waterside vegetation

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