

Ecological determinants of birdlife on Stockton Beach and the associated dune complex

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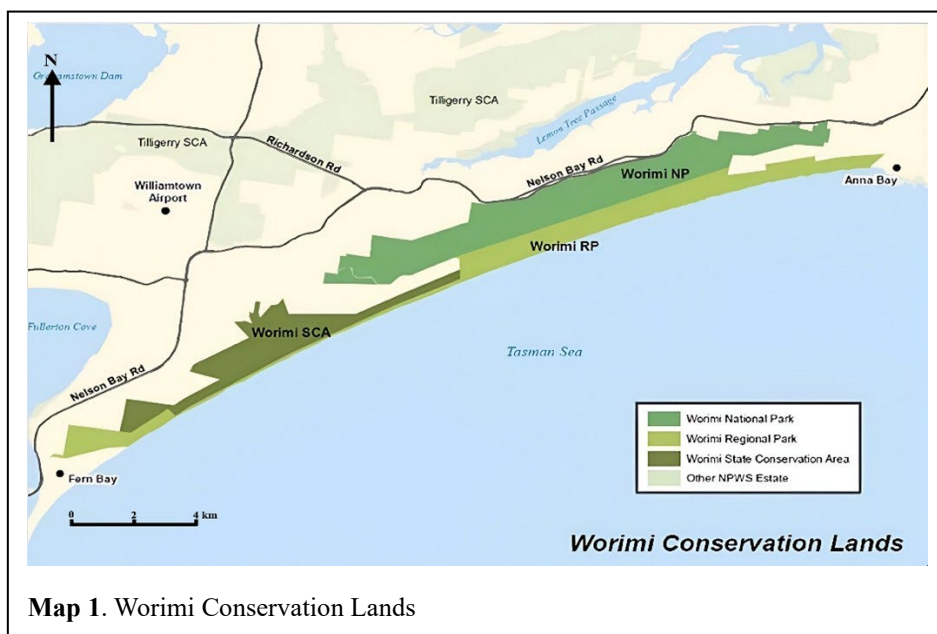
This study examines some of the complex interactions between the physical environment and the distribution of bird species from the ocean shore at Stockton Beach, through the sand dune system, to the associated coastal forests further inland. The study area, which is immediately north of Newcastle in NSW, displays a succession of ecological niches, which determine the bird species most likely to be found in each zone. This study examines each zone in terms of the determining factors and physical characteristics with a view to understanding the distribution of the various species of birds. Understanding these relationships helps planning for the protection of the birdlife, which is of paramount importance for endangered and vulnerable species such as the Pied Oystercatcher *Haematopus longirostris*, Little Tern *Sternula albifrons*, Bar-tailed Godwit *Limosa lapponica* and Sanderling *Calidris alba*.

INTRODUCTION

Much attention in birdwatching is given to identifying birds and recording their geographic distribution. Less attention is given to recording the habitat in which they live and hence identifying the many reasons for their spatial distribution. This study aims primarily to examine the ecological factors determining the distribution of birds within the following designated area: Stockton Beach, Stockton sand dunes and the associated coastal forests immediately further inland. This area lies immediately north of Newcastle Harbour in New South Wales (NSW) and extends 32 km further north-east to Birubi Point, which is 9 km south of Nelson Bay. The study area is bounded on the north-

west by private property and Nelson Bay Rd and on the south-east by the ocean. It spans from latitude 32.77° S to 32.92° S. Most of this area is owned by the Worimi Conservation Lands and is leased to the National Parks and Wildlife Service (NPWS). It is covered by the Worimi Conservation Lands Management Plan (Office of Environment and Heritage 2014).

The birds of the shoreline in the study area have been well surveyed by members of the Hunter Bird Observers Club (HBOC), who have conducted monthly surveys with the National Parks and Wildlife Service (NPWS) since 2009 (Fraser & Lindsey 2018; Fraser 2023; Lindsey & Fraser 2024; Lindsey & Newman 2010; Lindsey & Newman



2014; Russell & George 2012). However, it was recognised that the area further inland, which is not very accessible, has not been well studied. Factors for its relative inaccessibility include: 1) the beach and sand dunes are too long to walk easily (32km); 2) vehicles are generally not permitted behind the fore dunes; 3) the study area is bounded on the west by private property (and large uncompacted sandhills); and 4) it is bounded on the east by the ocean.

On 16 February 2025, two HBOC members, Andrew McIntyre and Neil Fraser, co-ordinated a team from the club to survey the birds of the swales (the depressions behind the foredunes) and the beach front simultaneously, with the aim of surveying the whole length of the beach. As part of the survey team, I surveyed some of the southern swales, along with Greg Little, another HBOC member. This was the stimulus for me to further study the plants and animals in the whole beach/sand dune/forest complex.

The undisturbed beaches of Australia display a natural progression of plant and animal life, starting at the ocean and extending inland to the coastal forests (Walker *et al.* 1981). The pattern of this progression can vary with latitude. Every stage of this progression has its own micro-climate and hence has plants and animals that are specialized for each of these habitats (Schlacher *et al.* 2008). Every species of bird has its own preference regarding habitat and hence there is a stratification of bird life along each zone from ocean to forest, determined by factors such as: sources of food and water; suitability for nesting; suitability for roosting; and safety from predators.

Stockton Beach and its dunes system can be considered as six discrete ecological zones:

- The ocean close to the beach
- The intertidal zone
- The foredune
- The swales
- The hind dunes
- The coastal forests

There had been a paucity of literature regarding the vegetation in the study area until the work done by Bell & Driscoll (2010). Because of the existence of a small number of sand mines on the western edge of the sand dunes, there have been environmental impact studies that have also examined the vegetation in the study area (HLA EnviroSciences Ptd Ltd 1995; Orotan 2009; Outline Planning Consultants 1995). There is very little published

literature specific to the ecology of this beach and dune system (Pidgeon 1940).

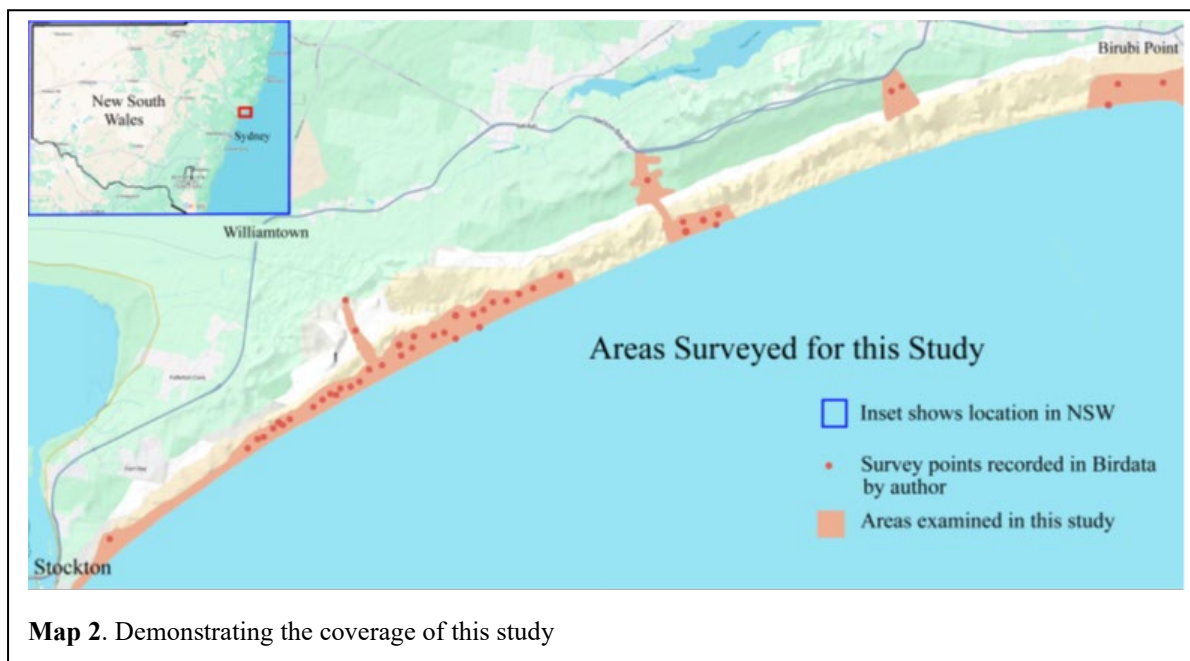
The southern section of Stockton Beach faces east to south-east. It is “reflective”, i.e. there is little protection from the full force of the waves. Here the beach is a little steeper and the sand is relatively coarser than the northern parts of this beach. It is less rich in microflora and micro-/macrofauna. Ocean currents tend to move sand in a north-easterly direction along the beach (Bluecoast Consulting Engineers 2020). In the most north-eastern section, the beach faces south-east, facing the dominant wave direction. Here the beach is “dissipative”, i.e. the wave energy is reduced by shallow ocean sand bars and the relatively flat topography. The sand tends to be finer. Species richness and total biomass of the micro-organisms living in these sands tend to be significantly increased in dissipative beaches compared to reflective beaches (Brown & McLachlan 2010) and this is an important factor in the distribution of the shorebirds.

The landform of Stockton Beach is dynamic. Winds generally drive sand inland, resulting in the dunes traveling westward at a rate of about 4 m per year. These dunes are slowly engulfing some of the coastal forests. The sand dunes are up to 40 m above sea level and the depressions between the sand dunes (swales) can be as low as sea level.

Whilst the Stockton sand dune system is unique in being the longest beach in NSW and having the largest active beach sand dune system in Australia, many findings from this study can be applicable to other NSW beaches.

Map 2 shows the study area.

This study has a companion document, published on the Hunter Bird Observers Website at <https://www.hboc.org.au/publications/publications/> (Goswell 2025). The document provides much more detail than space allows in this article, in particular on the plant and animal life in each zone and specific details on the survey points (see Map 2).



METHODS

This study recorded the birdlife using fifty-two data points surveyed by me between 16 February 2025 and 11 July 2025. The first nineteen of these were recorded together with Greg Little, as part of the HBOC bird survey of the swales on 16 February. I simultaneously recorded the vegetation in each swale. On 11 July 2025 I was partnered with Archie Brennan in the second bird survey of the swales. That survey covered sixteen swales (two overlapped with the February survey). Between these dates, I also targeted different sections of the beach/sand dune complex as well as the coastal forest in order to obtain representative information along the full length of the study area and have data from the differing ecological zones. At each survey point I examined the birds, animals and plant life as well as the physical characteristics of the area. Surveying was done by foot and hence all the areas between bird survey points were also examined. The birdlife in each survey point was recorded in Birdata.

Further information regarding the birds in the study area was obtained by searching Birdata and the published literature. The HBOC's publication, *The Whistler*, was an important source. Data on plant distributions obtained from the field surveys were cross-referenced against published information (Bell & Driscoll 2010; HLA EnviroSciences Ptd Ltd 1995; Oron 2009; Outline Planning Consultants 1995). Information regarding microbiota in the surf zone and intertidal areas was obtained from publications (Brown *et al.* 2018; Baring 2014; Bruce 1986) and iNaturalist.

ECOLOGICAL ZONES OF STOCKTON BEACH

The Ocean Adjacent to the Beach

At first glance, this zone appears to be only saltwater and sand, but it is very biologically active. Brown *et al.* (2018) identified over 150,000 species of micro-organisms off the Australian coastline using DNA fingerprinting. As waves approach the shore they stir nutrients into suspension, mixing these with the microflora and microfauna. There is adequate light for photosynthesis by phytoplankton, which are the primary producers; they take basic chemicals and convert them into organic matter and oxygen. The action of the surf also provides rich oxygenation in the water for zooplankton. The zooplankton feed on bacteria and phytoplankton. Both phytoplankton and zooplankton become food for the filter feeders such as shellfish and crabs. Storms can break macro-algae (seaweed and kelp) from their seabed and drive them to the surf zone. As they float freely through the water, they attract invertebrates. Floating macro-algae also provides protection for small fish, who gain the added advantage of increased food from the co-habiting invertebrates (Baring 2014). As the macro-algae decays it becomes food for bristle worms (Polychaeta), amphipods, isopods and other crustaceans. All these, in turn, become food for small fish. A number of birds specialize in feeding on the fish and macrofauna in this zone (**Table 1**).

Table 1. Birds of the ocean adjacent to the beach

Common Name	Scientific Name	Occurrence	Diet	Nest
Great Cormorant	<i>Phalacrocorax carbo</i>	Common resident	Fish caught underwater	W
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	Common resident	Fish caught underwater, crustaceans and also insects	W
Little Pied Cormorant	<i>Microcarbo melanoleucos</i>	Common resident	Fish caught underwater, crustaceans and also insects	W
Australian Pied Cormorant	<i>Phalacrocorax varius</i>	Common resident	Fish caught underwater and also on crustaceans (such as prawns and shrimp), molluscs and cephalopods.	W
Silver Gull	<i>Larus novaehollandiae</i>	Common resident	Surface fish, worms, insects and crustaceans	I
Greater Crested Tern	<i>Thalasseus bergii</i>	Common resident	Dive for small surface fish	I
Australasian Gannet	<i>Morus serrator</i>	Common resident	Fish which they catch and swallow whilst underwater	E
Wedge-tailed Shearwater	<i>Puffinus pacificus</i>	Common migrant August to April	Fish, squid and crustaceans	I
White-bellied Sea Eagle	<i>Ichthyophaga leucogaster</i>	Common resident	Fish, turtles and sea snakes	T

Key: W - typically nest in wetland areas; I - nest on nearby offshore islands; E - nest on islands not local to the Hunter; T - nest in tall Eucalypts

The Intertidal Zone

This is the section of the beach covered by water at high tide and uncovered at low. Again, one would initially think that there was no life in this zone. It is a harsh environment with complete saltwater immersion for many hours. The “soil” is almost pure siliceous sand with a small amount of calcium carbonate from shell fragments and hence it is, by its own nature, nutrient poor. This zone has full sun exposure at low tide and can become very hot at times in the upper few centimetres. The wind can be harsh, with nothing to stop its effect. However, the surface of this zone is rich in oxygen. Water with dissolved oxygen (enhanced by the action of the waves) can travel well beneath the surface of the sand, providing conditions which are crucial to the availability of the scant nutrients and hence microbiological activity (McLachlan & Defeo 2017). Despite the apparent paucity of life in this zone, it is rich in biological forms. A study in California, using modern DNA fingerprinting techniques, logged almost one thousand different life-forms (taxa) in the intertidal zone (Boehm *et al.* 2014).

Feeding on the microscopic life forms are various invertebrates (McLachlan & Defeo 2017) such as shellfish (e.g. the pipi *Donax deltoides*) and surf crabs e.g. *Ovalipes australiensis*. Bristle worms (Polychaeta) and ribbon worms (Nemertea), crustaceans (Isopoda, Amphipoda, Stomatopoda, Mysidae) also live here and feed on micro-organisms and detritus. Beach worms, e.g. *Onuphidae spp.* also inhabit the wet sand and feed

on seaweed and decaying organic matter. Many of these various animals then become food sources for those birds foraging in this zone.

Many shorebirds will forage day and night because their preferred foraging zones become available whenever the tide is low. Some birds use more than one type of roost area, e.g. Pied Oystercatchers *Haematopus longirostris* may roost on intertidal flats near their food or move to the rock platforms at Newcastle. There is a population of about 50 to 100 of these birds, mostly along the northern section of this beach (Fraser & Lindsey 2018). Small numbers nest in the swales behind the foredunes between September and January. Double-banded Plovers *Charadrius bicinctus* mostly roost above the high-tide mark (Lindsey & Newman 2014).

Some shorebirds are resident all year round while others migrate vast distances to nesting or feeding grounds on the other side of the globe – for example the Bar-tailed Godwits *Limosa lapponica* which breed in Alaska fly non-stop for up to 13,500 km in 11 days on return migration to Australia! (BirdLife Australia).

The list below includes those seen with an incidence of 10% or more on regular surveys undertaken by HBOC members.

Birds of the intertidal zone are listed in **Table 2**.

Table 2. Birds of the intertidal zone

Common Name	Scientific Name	Occurrence	Diet	Nest
Silver Gull	<i>Larus novaehollandiae</i>	Common resident	Fish, worms, insects and crustaceans	Offshore islands †
Pied Oystercatcher	<i>Haematopus longirostris</i>	Common resident	Pipis, worms, crabs and small fish	Swales
Greater Crested Tern	<i>Thalasseus bergii</i>	Common resident	Fish but will eat crustaceans and insects	Offshore islands †
White-fronted Tern	<i>Sterna striata</i>	Uncommon winter migrant	Fish, typically just beyond the surf zone.	New Zealand
Little Tern	<i>Sternula albifrons</i>	Aug. to March	Small fish, crustaceans, insects, worms and molluscs	Swales and foredunes
Australian Tern	<i>Gelochelidon macrotarsa</i>	Partial migration to inland	Small fish, crustaceans, insects, reptiles, amphibians, and small mammals	Inland
Red-capped Plover	<i>Anarhynchus ruficapillus</i>	Common resident	Molluscs, small crustaceans, worms and some vegetation	Swales and foredunes
Double-banded Plover	<i>Anarhynchus bicinctus</i>	Feb. to Sept.	Molluscs, crustaceans, insects, seeds and fruit	New Zealand
Ruddy Turnstone	<i>Arenaria interpres</i>	Uncommon on beach, migrant	Insects, crustaceans, molluscs and spiders. Wrack and/or associated detritivores (Kirkman & Kendrick 1997).	Northern hemisphere
Red-necked Stint	<i>Calidris ruficollis</i>	Uncommon migrant	Small invertebrates and small insects	Eurasian tundra
Bar-tailed Godwit	<i>Limosa lapponica</i>	Aug. to Oct. Uncommon on beach	Molluscs, worms and aquatic insects	Northern hemisphere
Sanderling	<i>Calidris alba</i>	Uncommon on beach Sept. - April	Invertebrates in the sand.	Arctic tundra

† These nest on nearby offshore islands such as Broughton Island and Moon Island.



Flat areas in the northern section of Stockton Beach – a prime zone for Pied Oystercatchers to feed on pipis. Note the tyre tracks close to the feeding areas.

There is a variation from south to north in the intertidal zone along Stockton Beach. In the south, the beachfront tends to be narrower and steeper, with coarser sand. This limits the zone in which pipis and beach worms can grow. Further north, the shallower ocean dissipates the wave energy before reaching the beach, and the flat sands result in broad wet areas at low tide. The finer sands in the north drain more slowly. These factors produce large areas for pipis and beach worms. Consequently, the northern section of the beach becomes a favoured area for oystercatchers to feed and breed.

The Foredune

Above the intertidal zone is the foredune: a rise of sand deposited by wind and waves. It is sometimes preceded by a lower incipient dune; however, the incipient dune may come and go more readily depending upon erosive and accretive surf conditions. In south-eastern Australia, foredunes form because the colonizing vegetation slows the wind and traps the wind-blown (aeolian) sand (Hesp 1988). Wrack (washed-up seaweed and kelp) and other debris can also trap aeolian sand and contribute to sand deposition. Along Stockton Beach there can be considerable debris following flooding in the Hunter River.

The foredune looks almost bare and barren. It is exposed to the full sun and becomes very hot during summer. The sun and the wind dry this sand, making it hard for anything to live there. The foredune is above the water table and there is little capacity to hold water. The dry sand is more easily moved by wind and this can cause relatively rapid shifts in dune topography, burying any plant life that has started to get a foothold. Any rainfall is quickly lost through the sand and there is essentially no humus to retain moisture. The sand is nutrient deficient. This region does get a little organic matter washed up by the waves, but this is limited. Few plants can tolerate these conditions. The prime colonizer is Beach Spinifex *Spinifex sericeus*, which is uniquely adapted to this zone. Its leaves have fine hairs that protect it from sand abrasion. The roots are long and extensive, allowing for the collection of water. These bind the dune sand to stabilize it. Beach Spinifex can survive various degrees of burial. In poor seasons it produces little seed but in good seasons can produce large amounts. This has been seen as an adaptive process in areas of poor nutrient and variable fresh water supply (Hesp 1991). The seeds have been observed to be eaten by Galahs *Eolophus roseicapilla* (Gosper 1999) so one would expect other birds to be using this food resource. Australian Pipits *Anthus novaeseelandiae* eat seeds as well as insects and so may well eat spinifex seeds as well as seeds from other plants growing in this zone, such as Pennywort *Hydrocotyle bonariensis* and Beach Primrose *Oenothera drumondii*, although published documentation of this appears to

be lacking. Unseen to the naked eye, endomycorrhizal fungal hyphae spread in the sand, helping to bind it and stabilize the dune (Jehne & Thompson 1981). These fungi form symbiotic relationships with the dune plants by exchanging nutrients. Hanlon (2020) noted different species of endomycorrhizal fungi in the incipient dunes compared with established dunes, showing zonation at this level as well.

The foredune is important as it provides nesting sites for some birds. According to NPWS, six species of birds are known to nest along beaches. These are:

- Little Tern *Sternula albifrons* *
- Pied Oystercatcher *Haematopus longirostris**
- Red-capped Plover *Charadrius ruficapillus**
- Sooty Oystercatcher *Haematopus fuliginosus*
- Beach Stone-curlew *Esacus magnirostris*
- Hooded Plover *Charadrius cucullatus*

* These species have been recorded to nest on Stockton Beach.

Pied Oystercatchers would normally nest on the ocean side of the foredune but on Stockton Beach this is frequented by 4WDs. The birds have learned to nest on the west side of these dunes which adds extra work and stress for the birds when feeding their chicks (Fraser 2023; Russell & George 2012). Birds found in the foredune include those shown in **Table 3**.

Table 3. Birds found in the foredune zone

Common Name	Scientific Name	Occurrence	Diet	Nesting
Australian Magpie	<i>Gymnorhina tibicen</i>	Common resident	Small insects, frogs and seeds	In trees from August to January
Australian Raven	<i>Corvus coronoides</i>	Common resident	Small birds and will eat insects, and seeds Wrack invertebrates*	In tall trees from July to September
Silver Gull	<i>Larus novaehollandiae</i>	Common resident	Mostly fish, also worms, insects and crustaceans	On nearby islands
Australian Pipit	<i>Anthus novaeseelandiae</i>	Common resident	Insects and seeds	In spring on the ground
Pied Oystercatcher	<i>Haematopus longirostris</i>	Common resident	Pipis, but also eat worms, crabs and small fish	On the ground
Little Tern	<i>Sternula albifrons</i>	Aug. to March	Mainly fish but also on crustaceans, insects, worms and molluscs.	On the ground
Pacific Golden Plover	<i>Pluvialis fulva</i>	Uncommon Sept. to May	Insects, crabs and other invertebrates	In Alaska and Siberia
Australian Tern	<i>Gelochelidon macrotarsa</i>	Common resident, March to Dec. †	Insects taken in flight, amphibians, crustaceans and small mammals	On the ground

† Lindsey & Newman (2014)

* These are known to eat wrack and/or invertebrates feeding on wrack (Kirkman & Kendrick 1997).



The foredune and intertidal zone. The foredune is stabilized by *Spinifex sericeus*. Note the tyre tracks from multiple vehicles.

The Swales

In many places behind the foredunes and between transverse sandhills, there are depressions, called swales. Many of these swales hold fresh water: some only for a short period of time after rain but many with semi-permanent to permanent water. One would expect the presence of fresh water to be important for birds as a source of drinking water. Some of the swales are at sea level and some are below the level of the water table. According to Woolley *et al.* (1995), various factors contribute to the level of the water in these swales. Rainfall can raise the water level in the swales, particularly because some have developed a semi-permeable pan of sand, salts and organic matter, reducing drainage. Water in the swales can also be an outflow from the extensive water in the sand beds further inland, for example the Tomago sand beds. Between the two HBOC surveys, the region had 1009 mm of rain (Bureau of Meteorology, data for Williamstown), resulting in a rise in water levels of perhaps a metre at the time of the second survey (11 July 2025), with a marked increase in the surface area of the water in each swale.

Because the swales are depressed, dead vegetative material is unlikely to be blown away, allowing humus to build up in the soil. The presence of water and nutrients enable different plants to grow, providing food and shelter for birds. On rare occasions (such as late March and early April 2025), combinations of king tides, strong onshore winds and east coast low-pressure systems, can result in water over-topping the lowest of the foredunes, bringing floating debris into the swales. The swales support an increased diversity of life compared to the surrounding (mostly) bare dunes. The vegetated swales, more correctly called beach wetlands (Bell & Driscoll 2010), occur along most of Stockton Beach and vary in size and type, tending to be small in the south and broad and flat in the north.

With more persistent water there can be rushes (Typha species) and Phragmites. The combination of water and plants allows small animals to exist such as water snails, tadpoles/frogs, lizards, dragonflies, ants, grasshoppers and mosquitoes. These become food for a different subset of birds listed in **Table 4**.



Typical vegetation in the swales consists of an outer ring of *Spinifex* *Spinifex hirsutus* and Pennywort *Hydrocotyle bonariensis* with the occasional Sea Holly *Eryngium maritimum* and Beach Primrose *Oenothera drumondii*.



In swales where there is more water there is an inner ring of sedges: *Juncus acutus* and *Cyperus* species.

Table 4. Birds frequenting swales.

Common Name	Scientific Name	Occurrence	Diet
Superb Fairywren	<i>Malurus cyaneus</i>	Common resident	Small insects and small arthropods but will also eat a small quantity of seed and fruit
Australian Pipit	<i>Anthus novaeseelandiae</i>	Common resident	Insects and their larvae as well as seeds
White-fronted Chat	<i>Epthianura albifrons</i>	Common resident	Small insects and acacia seeds
Australian Raven	<i>Corvus coronoides</i>	Common resident	Small birds and will eat insects, and seeds
Australian Magpie	<i>Gymnorhina tibicen</i>	Common resident	Small insects, frogs and seeds
Pacific Golden Plover	<i>Pluvialis fulva</i>	September to April†	Insects, spiders, crustaceans, small lizards and seeds
Double-banded Plover	<i>Anarhynchus bicinctus</i>	February to September†	Molluscs, insects (both on land and in water), crustaceans and seeds
Little Tern	<i>Sternula albifrons</i>	August to March	Mainly fish but also on crustaceans, insects, worms and molluscs

† Lindsey & Newman 2014

Table 5. Some birds may be found primarily when water is present in swales.

Common Name	Scientific Name	Occurrence	Diet
White-faced Heron	<i>Egretta novaehollandiae</i>	Common	Fish, frogs, small reptiles and insects
Red-capped Plover	<i>Anarhynchus ruficapillus</i>	Common	Worms, snails, crustaceans, isopods, small crabs, insects, beetles, insects, insects, flies, bees and wasps
Masked Lapwing	<i>Vanellus miles</i>	Common	Insects, earthworms, snails, centipedes and plants
Black-fronted Dotterel	<i>Thinornis melanops</i>	Uncommon	Small molluscs, aquatic and terrestrial insects
Australian Tern	<i>Gelochelidon macrotarsa</i>	Common	Insects taken in flight, amphibians, crustaceans and small mammals
Welcome Swallow	<i>Hirundo neoxena</i>	Common	Insects in flight.

The vast exposed areas along the beach and sand dunes give good visibility for raptors to find food (**Table 6**).

Table 6. Raptors recorded along the beach and sand dunes.

Common Name	Scientific Name	Diet
White-bellied Sea Eagle	<i>Ichthyophaga leucogaster</i>	Fish, turtles, sea snakes and small mammals and birds
Swamp Harrier	<i>Circus approximans</i>	Birds, eggs, large insects, rabbits and other small animals, reptiles, frogs, and fish
Australian Hobby	<i>Falco longipennis</i>	Small birds and large insects
Osprey	<i>Pandion haliaetus</i>	Fish, sea snakes, molluscs, crustaceans, reptiles, insects, birds and mammals
Whistling Kite	<i>Haliastur sphenurus</i>	Small mammals, birds, fish, reptiles, amphibians, crustaceans, insects and carrion
Black-shouldered Kite	<i>Elanus axillaris</i>	Rodents, small reptiles, small birds and insects
Nankeen Kestrel	<i>Falco cenchroides</i>	Mice and rats and other small mammals, reptiles, small birds and a variety of insects
Brown Falcon	<i>Falco berigora</i>	Mice and small mammals, small birds, lizards, snakes, caterpillars, grasshoppers, crickets, and beetles

Note that the small birds need to have a means of escaping predation. The following observations were noted and seem worthy of further research:

- Australian Pipits are well camouflaged even amongst the spinifex, so they can move around areas that have scant vegetation.
- Superb Fairywrens appear to need plants which are a little more raised, for example reeds.
- White-fronted Chats seem to prefer small bushes in which to hide, such as the Bitou Bush *Chrysanthemoides monilifera*. When disturbed they may land on a “lookout post” on a small bush to watch what is happening.

Nesting colonies of Little Terns were observed in a small number of locations on the upper beach and the swales from 2012 to 2023. Breeding success in 2023 was estimated to be 5.6% (6 fledglings from 53 nests and 107 eggs), reflecting a high rate of predation at the time the chicks hatch (Fraser 2023). In 2023 the main predator was thought to be Ghost Crabs *Ocypode cordimana*. Other potential predators included Red Fox *Vulpes vulpes*, Australian Ravens, Silver Gulls, Australian Terns, domestic dogs, feral cats, black rats, goannas, and raptors.

The Hind Dune

In some beach systems in NSW, such as at One Mile Beach immediately north of Stockton Beach, the hind dune merges with the foredune. In this situation there is a succession of plant life from the foredune spinifex to wind-tolerant shrubs such as Sydney Golden Wattle *Acacia longifolia* and Bitou Bush *Chrysanthemoides monilifera*, followed by Coastal Tea Tree *Gaudium laevigatum*. These form a protective wind barrier enabling larger species to grow further inland - Coastal Banksia *Banksia*

integrifolia, and Black She-oak *Allocasuarina littoralis*. Further inland again is the coastal forest. This pattern has been interrupted on Stockton Beach. Blowouts in the foredunes have allowed the onshore winds to carve out the swales and push sand further inland, creating transverse sand dunes in the process, that is, dunes that run at ninety degrees to the foredunes. This process has buried many areas of dune vegetation and has left multiple small “islands” of remnant vegetation stranded in the bare dune system. Large areas of the dune system were also mined in the past for heavy mineral sands (rutile, zircon, monazite and ilmenite) causing further disruption to the dune system. The banksias provide food for nectivorous birds such as White-cheeked Honeyeaters *Phylidonyris niger*. Allocasuarinas and banksias potentially provide food for black cockatoos. This is clearly seen at nearby beaches, for example Blacksmiths Beach (pers. obs.), but it was not documented at Stockton Beach during this study.

The plants of the hind dune can form a dense barrier providing protection from aerial predators for small birds such as fairywrens and White-cheeked Honeyeaters.

The loss of the hind dune plant structure in most areas of the Stockton dunes means that sand is blown further inland, encroaching upon the coastal forest system.

Birds of the hind dune are listed in **Table 7**.



The hind dune encroaching on coastal forest in the Bobs Farm district.

Table 7. Birds of the hind dunes

Common Name	Scientific Name	Occurrence	Diet
Superb Fairywren	<i>Malurus cyaneus</i>	Common resident	Insects and arthropods, small quantities of seeds
Variegated Fairywren	<i>Malurus lamberti</i>	Common resident	Insects, small quantities of seeds
White-cheeked Honeyeater	<i>Phylidonyris niger</i>	Common in January to June†	Nectar but will sometimes eat insects
Yellow-faced Honeyeater	<i>Caligavis chrysops</i>	Common resident	Nectar, pollen, fruit, seeds, arthropods, insects, and their products
Silvereye	<i>Zosterops lateralis</i>	Common resident	Small insects, spiders, fruit and nectar
Little Wattlebird	<i>Anthochaera chrysoptera</i>	Common in January to June†	Nectar, insects, flowers, berries and some seeds
Brown Thornbill	<i>Acanthiza pusilla</i>	Common resident	Spiders, beetles, lerp insects, ants and grasshoppers. Sometimes seeds, fruit, or nectar
Eastern Spinebill	<i>Acanthorhynchus tenuirostris</i>	Common resident	Nectar supplemented with small insects and other invertebrates
Eastern Whipbird	<i>Psophodes olivaceus</i>	Common resident	Insects and other small invertebrates usually caught on the ground
Red-browed Finch	<i>Neochmia temporalis</i>	Common resident	Seeds and insects on the ground

† Associated with flowering banksias

The Coastal Forest

With protection from the harsh beach conditions by the wind-stopping cover of the hind dunes, conditions become suitable for trees to grow. Along Stockton Beach these include banksias (*Banksia integrifolia* and *Banksia serrata*), Coastal Red Gum *Angophora costata*, Blackbutt *Eucalyptus pilularis* and Swamp Mahogany *Eucalyptus robusta*. Bark and leaves from these provide significant coverage of the soil (5 cm thick in places). Once decayed, the fallen material adds humus to the soil. The closed canopy shades the soil further, reducing surface temperatures and evaporation.

The surface soil has a dark grey appearance, with leached, whiter sand beneath (a podzol soil). The soil has better water holding abilities, enabling young trees to survive until they can get their roots down to the water table. The combination of shade, lower temperatures, more soil nutrients and greater

availability of water, enables smaller plants (understorey) to survive. These include species such as Prickly Moses *Acacia ulicifolia*, Broad-leaved Geebung *Persoonia levis*, Bracken Fern *Pteridium esculentum*, Blady Grass *Imperata cylindrica*, Kangaroo Grass *Themeda triandra*, Burrawang *Macrozamia communis*, Lance Beard Heath *Leucopogon lanceolatus*, Guinea Flower *Hibbertia scandens*, Spiny Matt Rush *Lomandra longifolia*, Blue Flax Lily *Dianella caerulea*, Purple Coral Pea *Hardenbergia violacea*, Dusky Coral Pea *Kennedia rubicunda*, Common Hop Bush *Dodonaea triquetra*. These provide food, nesting sites and protection for the smaller birds. The larger trees provide food in the form of nectar, lerps and seeds. As will be seen from **Table 8**, this forest produces a wide variety of types of foods for a large number of bird species. The trees also provide roosting sites, tree hollows and branches for nests and arboreal termite nests for Laughing Kookaburras *Dacelo novaeguineae*.

Table 8. Commonly encountered birds in the coastal forests

Common Name	Scientific Name	Occurrence	Diet
Laughing Kookaburra	<i>Dacelo novaeguineae</i>	Common resident	Insects, worms, crustaceans, small snakes, mammals, frogs and birds
Superb Fairywren	<i>Malurus cyaneus</i>	Common resident	Small insects and small arthropods but will also eat a small quantity of seed and fruit
Variegated Fairywren	<i>Malurus lamberti</i>	Common resident	Insects, small quantities of seeds
Australian Magpie	<i>Gymnorhina tibicen</i>	Common resident	Small insects and small arthropods but will also eat a small quantity of seed and fruit
Little Lorikeet	<i>Parvipsitta pusilla</i>	†	Nectar and pollen, sometimes mistletoe
Yellow-tailed Black Cockatoo	<i>Zanda funerea</i>	†	Seeds and insects
Eastern Rosella	<i>Platycercus eximius</i>	Common	Seeds, fruits, buds, flowers, nectar and insects
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	†	Berries, seeds, nuts and roots
Brown Thornbill	<i>Acanthiza pusilla</i>	Common resident	Spiders, beetles, lerp insects, ants and grasshoppers. Sometimes seeds, fruit, or nectar
Rainbow Lorikeet	<i>Trichoglossus moluccanus</i>	†	Nectar and pollen, but also eats fruits, seeds and some insects
White-throated Treecreeper	<i>Cormobates leucophaea</i>	Common resident	Insectivorous (mainly ants) although will eat also nectar
Eastern Spinebill	<i>Acanthorhynchus tenuirostris</i>	Common resident partial migration	Insects and nectar
Golden Whistler	<i>Pachycephala pectoralis</i>	Common resident	Insects, spiders, small arthropods, sometimes berries
Yellow-faced Honeyeater	<i>Caligavis chrysops</i>	Common resident and migratory	Nectar, pollen, fruit, seeds, arthropods, insects, and their products
Rufous Whistler	<i>Pachycephala rufiventris</i>	Common in spring & summer	Insects, sometimes seeds, fruit or leaves
White-cheeked Honeyeater	<i>Phylidonyris niger</i>	†	Nectar but will sometimes eat insects
White-browed Scrubwren	<i>Sericornis frontalis</i>	Common resident	Insects and other small arthropods. Occasionally seeds.
Yellow-throated Scrubwren	<i>Sericornis citreogularis</i>	Common resident	Seeds, insects, small invertebrates
Willie Wagtail	<i>Rhipidura leucophrys</i>	Common resident	Insects
Australian Raven	<i>Corvus coronoides</i>	Common resident	Small birds and will eat insects, and seeds
Welcome Swallow	<i>Hirundo neoxena</i>	Common resident	Insects in flight
Pallid Cuckoo	<i>Heteroscenes pallidus</i>	Summer	Insects and their larvae
Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>	Resident	Insects and their larvae
Eastern Whipbird	<i>Psophodes olivaceus</i>	Common resident	Insects and other small invertebrates usually caught on the ground
Rock Dove	<i>Columba livia</i>	Common Introduced	Seeds
Noisy Miner	<i>Manorina melanocephala</i>	Common resident	Nectar, fruits and insects
Spotted Dove	<i>Spilopelia chinensis</i>	Common introduced	Seeds
Crested Pigeon	<i>Ocyphaps lophotes</i>		Seeds, leaves, insects
Grey Fantail	<i>Rhipidura albiscapa</i>	Common resident	Flying insects
Magpie Lark	<i>Grallina cyanoleuca</i>	Common resident	Insects and their larvae, earthworms and freshwater invertebrates.
Pied Currawong	<i>Strepera graculina</i>	Common resident	Small lizards, insects, caterpillars, berries and small birds

† These birds range over a wider area and their presence often reflects the seasonal availability of food.

Table 8. Commonly encountered birds in the coastal forests (cont.)

Common Name	Scientific Name	Occurrence	Diet
Black-faced Cuckooshrike	<i>Coracina novaehollandiae</i>	Common resident	Insects and other invertebrates, sometimes seeds and fruits
Rufous Fantail	<i>Rhipidura rufifrons</i>	Uncommon October to March	Small insects

CONSERVATION IMPLICATIONS

During this study, many conservation issues became apparent:

1. The importance of protecting the foredunes. Any damage to the foredunes, e.g. from 4-wheel drive activity, can lead to blowouts in the dune and exacerbate the movement of sand inland.
2. Some foredunes are quite low and have lost their Spinifex protection, allowing waves to over-top them under certain conditions. This could potentially result in the erosion of these foredunes leading to significant blow-outs.
3. Human activity, particularly in the north-east section of the beach, might considerably affect the activities of the shorebirds.
4. More study is needed regarding the breeding activity of birds in the swales.
5. Little information appears to be available regarding what some birds in the swales eat.
6. There appears to be little information on the effects of exotic plants on the ecology of Stockton Beach and dune complex. For example, Bitou Bush *Chrysanthemoides monilifera* may have replaced some of the native plants; however removal without establishing a suitable native replacement, may have deleterious effects on the stability of the dunes.

Many of these issues are addressed under the Worimi Conservation Lands Management Plan (Office of Environment and Heritage 2014).

CONCLUSIONS

The study area, Stockton Beach with its associated sand dunes and coastal forests, provides a number of distinctly different habitats. In each of these, the physical environment determines what plants will grow and hence what animals will live there. Every bird species has its own requirements in terms of food and water, nesting and roosting sites and

protection from predators. This means that there are distinct differences in terms of which species are found in each zone. This study has examined these zones and the factors determining which plants (from phytoplankton to large eucalypts) grow in each zone.

This study was temporally limited. Ideally the study should be extended over all seasons of the year and over many years to account for seasonal and longer-term changes. As such, this study provides a snapshot for future comparisons.

The ecology of the Stockton Beach and dune complex has not been well studied, perhaps because of the difficulty of access. Members of the Hunter Bird Observers Club, in conjunction with the National Parks and Wildlife Service have extensive data on the birds of the foreshore and are now seeking to extend the observations into the swales behind the foredunes. Further studies of the birds, animals and plants are needed to better understand the intricate relationships amongst life forms in this dynamic landform.

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