A.J.M. Hopkins & G.T. Smith (eds). The Natural History of Two Peoples Bay Nature Reserve, Western Australia. *CALMScience Supplement*

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MEMORANDUM

To: Dr Graeme Smith
From: Angas Hopkins
Date: 21 June, 1993
Subject: Two Peoples Bay Nature Reserve Publication

Please find enclosed your copy of the mock-up of this publication.

The thing is now going through the final stages of the publication approvals process.... and the production is being costed. Don't hold your breath but at least this represents an advance.

Chris Robinson
098 42 21 50

The Natural History of Two Peoples Bay Nature Reserve, Western Australia

The following items are not included with this mock-up:

1. Vegetation map. There is to be a fold-out vegetation map in a pocket at the end of the publication. This is the key resource map for the Reserve and therefore needs to be well produced. The map is at the scale of 1:25,000 and is 650mm x 650 mm in size. The map will have the following information:
coastline and reserve boundaries (in black)
contours (in grey)
drainage lines (in blue)
vegetation unit boundaries (in black) preferably with colour coding of the four major structural types
vegetation type descriptors/codes within each of the polygons (in black)
The information is in digital form and so producion of the necessary colour separations for printing is straight forward

2. Cover Photograph. This is an oblique colour photograph taken from an aircraft at low altitude and shows particularly well the variety of landscape types within the Reserve. The photo was taken in about 1960 before the Reserve was created and so has considerable historical and scientific value.

3. Frontispiece. This is to be a colour plate of the air photo mosaic of the reserve.

4. Colour Plates. It is planned to include a 4 page centrefold of colour photos of the rare birds, their habitats, some interesting plant and animal species and some of the exceptional scenery. There are numerous colour slides throughout the text but these can be printed in black and white if necessary.

5. Index. A listing of words for an index has been compiled. The final index can be produced once page numbers have been allocated in the final layout stage of publication. The index can be printed in a small typeface- if this is done it will probably require about 6 pages.

The Natural History of Two Peoples Bay Nature Reserve, Western Australia

Editors A.J.M. Hopkins and G.T. Smith

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Preface

Two Peoples Bay Nature Reserve is one of the more important nature conservation areas along the south coast of Western Australia. This importance is based on two factors. Firstly, it contains remnant populations of rare fauna and flora of which the best known is the Noisy Scrub-bird. Secondly, it is a place where considerable research effort has been concentrated over almost 30 years; therefore it has the potential to serve as a model for development of management practices for the region.

This publication had its genesis in 1981 when it was proposed to prepare a management plan for the Reserve. There was a clear need to prepare a comprehensive background document to provide a basis for planning and, at the same time, it was recognized that such a document would encourage further research. The collation of information would also facilitate production of educational and interpretive material and thereby engender a greater interest in, and understanding of, the nature conservation issues of the Reserve and the State in general.

Some of the findings reported here result from studies that we began in the 1970s. Because these studies were limited in their scope and because of the need to prepare a comprehensive document, we actively solicited contributions from other people who had relevant knowledge. We wish to acknowledge the very willing support and encouragement that we received from these people and ultimately, their patience while the document was being edited.

Much has changed since the initial decision to begin writing a Bulletin on Two Peoples Bay Nature Reserve. A new Department was established in 1985 to manage nature conservation lands and waters, and vesting was formally transferred to the National Parks and Nature Conservation Authority in 1987. More importantly for the Reserve, new discoveries were made about the biota as new people became involved with the place. For example, the present Reserves Management Officer Alan Danks has continued to record new species of birds, since commencing duty in 1985. Management issues have also changed, as public pressure has continued to increase and the full impact of *Phytophthora cinnamomi* became apparent. The challenge for us as editors was to respond positively to these changes without unduly holding up publication.

This Bulletin is comprehensive but not absolutely complete. It contains a wealth of information about Two Peoples Bay Nature Reserve that will aid future management and research. It will need to be updated in due course, so we urge readers to make constructive input so that revision is possible.

Finally, we thank the many people who have contributed to the diverse studies reported here and to the preparation of this Bulletin. The studies were supported by the Western Australian Department of Fisheries and Wildlife, now incorporated into the Department of Conservation and Land Management, by CSIRO, and by a number of individuals. This support is gratefully acknowledged. We also thank Jan Rayner, Raelene Hick and Jill Pryde for word processing and typesetting. Computing support was provided by Mike Choo and Paul Gioia. Cartography was by the Mapping Branch, Department of Conservation and Land Management and the Australian Survey Office, with technical assistance from Greg Beeston, Department of Agriculture. Peter Chalmer and Roland Taylor of Environmental Drafting Services drafted most of the figures and a number of the maps.

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(b) 1982: Heath and thicket vegetation. The emergent trees and shrubs have increased in height and canopy cover since 1960 (~~L.A. Moore and~~ G. Chapman, photo).

(c) 1990: Note that changes since 1982 are relatively minor (N.J. Coy, photo).

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(c) 1990: Photo shows further growth of *Dryandra sessilis* in the midground and the mallee eucalypts in the swale in the foreground (N.J. Coy, photo).

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CHAPTER 1

Introduction

A.J.M. Hopkins and G.T. Smith

STATUS, LOCATION, ACCESS AND SIZE

Two Peoples Bay Nature Reserve is a Class A Reserve (No A27956) for the Conservation of Flora and Fauna. It is vested in the National Parks and Nature Conservation Authority, the authority established under the Conservation and Land Management Act 1984.

The Reserve is located between 118°05' and 118°13' East and 34°56' and 35°02' South, on the south coast 30 km east of Albany (Figs 1.1 and 1.2). Motor vehicle access is via the Two Peoples Bay Road which turns off the road to Nanarup about 20 km from the Albany Post Office. It is within the Department of Conservation and Land Management's South Coast Region which is administered from Albany.

The Reserve has an area of 4774.6618 ha to the low water mark. This is made up of two portions on the mainland and four adjacent islands: Coffin and Inner Islands, Rock Dunder and Black Rock. These range in size from Coffin Island (c. 28 ha) to Black Rock (c. 3 ha). The main section of the Reserve, of about 4685 ha, takes in some 25 km of coastline from Two Peoples Bay around almost to Nanarup on the south coast. The smaller mainland section (c. 89 ha) comprising Angove Lake, its northern margin and part of the Angove River, is located about 2 km north of the main section of the Reserve. The Angove Lake section has legal access through Reserve 13802 (Albany Water Supply Catchment Area - Angove River) but practical access is gained through farming land, by vehicle through the farming property 'Tandara', or by foot from the Two Peoples Bay beach. Access to the islands by boat is difficult because of the lack of easy landing areas and the normally heavy swells.

GENERAL DESCRIPTION OF THE RESERVE

The Two Peoples Bay Nature Reserve incorporates a wide variety of habitats; these include the coastal areas and islands already mentioned and many different terrestrial environment types. The topographic map of the Reserve provided in Figure 1.3 illustrates this point. Figure 1.4 gives all the place names within the Reserve and Figures 1.1 and 1.2 give the place names referred to in the text of this publication.

Two Peoples Bay is flanked by rocky headlands and backed by a 5 km long, crescent-shaped, fine sandy beach. Behind the beach are well-vegetated sand dunes up to 10 m high. There are two smaller, but equally attractive, sandy beaches south-east of South Point called Little Beach and Waterfall Beach. The remainder of the shoreline of the Mt Gardner headland is mainly steeply sloping, bare exposures of granite. Along the southern coastline to Rocky Point there is a c. 50 m high limestone cliff with a gentle landward slope and a steep scarp to seaward. At the foot of the scarp are the remnants of an old wave-cut platform and then a wide intertidal reef (Sinker Reef). To the west of Rocky Point and all the way to Nanarup a sandy beach is backed by steep dunes of between 30 to 40 m in elevation.

The most conspicuous feature of the Reserve is Mt Gardner, a conical hill some 408 m in elevation, consisting of Pre-Cambrian granite (adamellite). The slopes of Mt Gardner have been deeply dissected to produce well-vegetated gullies which form important habitat for Noisy Scrub-birds. This eastern portion of the Reserve is referred to as the Mt Gardner headland (Fig. 1.4).

An isthmus of partially lithified calcareous sandstone with heath communities (isthmus area, Fig. 1.4) separates Mt Gardner from the remnants of the late-Tertiary to early Pleistocene lateritic plateau which takes in most of the Tandara property. The lateritic plateau is well vegetated with jarrah (*Eucalyptus marginata*)/*Allocasuarina fraseriana* forest.

Below the lateritic plateau is the coastal plain of lithified and partially-lithified sands. Gardner Lake, which is brackish, and Moates Lake, with fresh water, are major permanent waterbodies on this coastal plain. They are associated with low-lying terrain which is seasonally wet. Drainage of this area is restricted. Moates Lake is fed by small streams and rivers which include the Goodga River and Black Cat Creek. A series of waterways that flow for a large part of the year drain into Gardner Lake from the upstream Moates Lake. Water may also seep through to Gardner Lake when there is no superficial flow. This second lake drains into the sea via Gardner Creek, however, the bar at the mouth of the creek is usually closed from late summer through to winter.

As noted above, the Reserve includes the freshwater Angove Lake and part of the Angove River, in an outlying block to the north of the main body of the Reserve. Drainage is to the south via a drain which enters Gardner Creek near the traffic bridge.

Immediately to the south of Moates Lake there is a large, mobile sand dune covering about 300 ha. The area generally circumscribed by the dunes, Moates and Gardner Lakes, the lateritic plateau and the sea cliff is referred to as the 'between-the-lakes area' (Fig. 1.4). To the west of the dune is the western boundary area. These two coastal plain areas are vegetated with a variety of woodland and shrubland types with a predominance of those dominated by *Agonis flexuosa, Banksia littoralis, Adenanthos sericea* and *Dryandra sessilis*.

So far little attention has been given to the marine habitats adjacent to the Two Peoples Bay Nature Reserve. However, the presence of the islands, reefs and the variety of rocky and sandy shorelines suggests that they too might have important conservation values.

SIGNIFICANCE OF THE RESERVE

The Two Peoples Bay Nature Reserve was created in 1966 following the rediscovery there in 1961 of the Noisy Scrub-bird *(Atrichornis clamosus)*. This bird is but one of four species of rare vertebrate fauna known to occur there. The invertebrate fauna have been poorly documented. The aquatic fauna have also been poorly recorded and are in need of a study because there is superficial evidence of uncommon associations. In addition, the Reserve has a rich and interesting flora.

The Reserve has a significant place in the maritime exploration and early commercial history of Western Australia, as well as being a place of importance for nature conservation. The Bay, with its sheltered anchorage and reliable supply of fresh water, was a popular stopping place in the 19th century for maritime explorers, and travellers, and for sealers and whalers. Later, the area became popular as a local recreation spot and has remained so, to this day.

The Reserve and its biota have been the subjects of extensive research by CSIRO, State Government agencies, academic institutions and private individuals since 1961. Much of the research has focused on the Noisy Scrub-bird; however, other features of the Reserve have also received attention. The Reserve, and related research findings, and the various innovative management initiatives that have been implemented over the past *c.* 20 years, have all generated considerable public interest at local, national and international levels.

The Two Peoples Bay Nature Reserve has long been considered the jewel in the conservation reserve system, principally because of the presence of the rare birds. The information compiled in the succeeding chapters clearly shows that the Reserve has many additional, important values. The information also permits the Reserve to become the model for the development of management theory and practices for the region and possibly the State.

Fig 1
This map has been digitized by ESRI

TWO PEOPLES BAY

MOATES LAKE

GARDNER LAKE

ANGOVE LAKE

TWO PEOPLES BAY NATURE RESERVE

North Point

Bettys Beach

Herring Beach

Point Valiant

Little Beach

Waterfall Beach

Rocky Point

BLACK ROCK

Sinker Reef

Point Gardner

COFFIN ISLAND

INNER ISLAND

FALSE ISLAND

Cape Vancouver

ROCK DUNDER

SOUTHERN OCEAN

35°00'

REFERENCE

HOLOCENE	Qs	Beach sand
	Ql	Lakes and swamps
	Qsp	Peaty sand (lake and s
	Qsm	Dune sand (mobile)
	Qsf	Dune sand (fixed)
	Qsr	Dune sand, beach ridge
HOLOCENE/ PLEISTOCENE	Qs/Tc	Quartz sand, residual, d part overlying calcareo
PLEISTOCENE	Qc	Calcareous quartz sands
TERTIARY – ? PLEISTOCENE	Tl	Laterite
QUATERNARY/ EOCENE	Qs/Tc	Sandy soils overlying Pl
EOCENE	Tp	Plantagenet Group – sa
PROTEROZOIC	Xp	Porphyritic granite and g

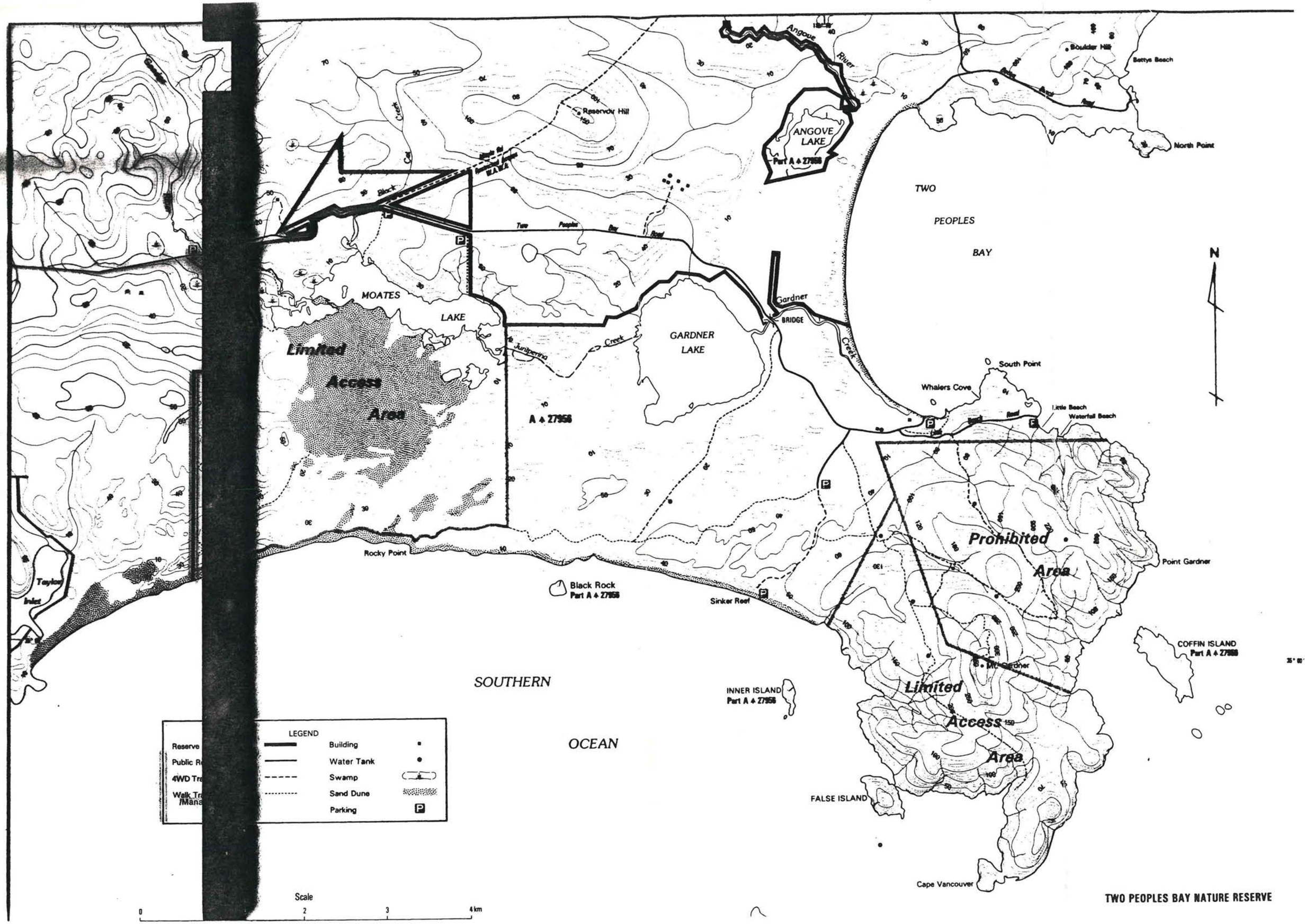
SYMBOLS

- Road
- Track (four-wheel-drive vehicles only)
- Reserve boundary
- Building
- Tank, dam
- Creek
- Pipeline
- 50 — Contour in metres

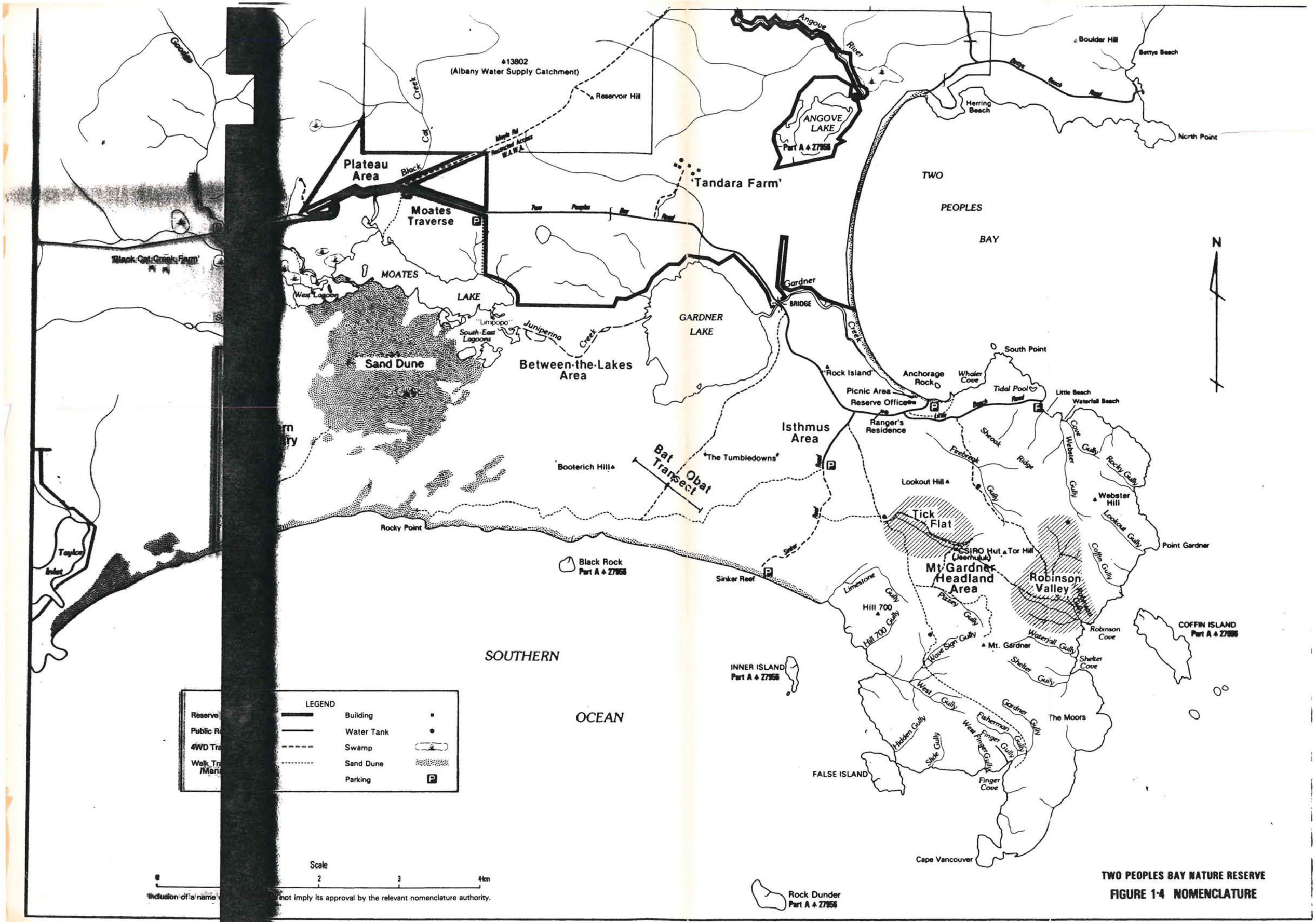
HON. P. DOWDING, M.L.C.
MINISTER FOR MINES
A.F. TRENDALL, DIRECTOR, GEOLOGICAL SURVEY

SCALE 1 : 40 000

GEOLOGICAL MAP OF THE TWO PEOPLES BAY AR



TWO PEOPLES BAY NATURE RESERVE



TWO PEOPLES BAY NATURE RESERVE

FIGURE 1·4 NOMENCLATURE

List of Colour Plates

To All Field Staff

Now that Selcal has been installed in your radio the question remains as to whether you want to be contacted. If your radio is left on at all times then people can set off the alarm and contact you. This of course means leaving your whip attached and running the risk of having it damaged. Whips are expensive to replace and the money will come from your C.R.F. The other alternative is that other mobiles wishing to make contact should make prior arrangements to ensure that mobiles have their whip on and radio switched on.
The results of this survey will go a long way to determining which course of action we at Woodvale adopt. Please tick one the options below and return to my Pidgeon Hole A.S.P.

Option 1 Leave radio on at all times

Option 2 Make prior arrangements with staff you wish to contact

Mike Onus

4 July 91 ✓

CHAPTER 2

History and Establishment of Two Peoples Bay Nature Reserve

G.R. Chatfield

INTRODUCTION

Any person perusing a map of south-west Western Australia will become aware of the multi-national heritage of the area from the various names of coastal features. The first European explorers and merchants progressively named the coastal features as they became known to them. First one nationality, then another, would name sections of the coast, so that today the different languages of the names are intermingled along the entire coast. However, the present names do not demonstrate as clearly as they might the mixture of their national origins. Examples in the vicinity of King George Sound include the Kalgan River which was originally named *Rivière des Francais* and Two Peoples Bay, the subject of this history, was Anglicized from the French *Baie de Deux-Peuples*.

The subjects covered in this chapter are many and varied. The early explorers and exploration, and the rivalry between and within various exploration parties, are covered first. The arrival of the sealers and whalers, from both overseas and local settlements, significantly influenced the course of Two Peoples Bay's history, as did the establishment of the Albany settlement. More remote, but nonetheless significant in its influence on the history of the area, were foreign and defence policy decisions made at Westminister. Debates on the rights of British subjects versus those of foreign nationals affected the Bay's development, as did local decisions on such things as the construction of railway lines in the Albany area. Matters of recreation and holiday leisure activities became a focal point later in the history of the Bay, to be dominated after 1961 by the issue of conservation, particularly that of a near-extinct species, the Noisy Scrub-bird (*Atrichornis clamosus*).

In many ways the topics touched on in this history are representative of issues and events that have shaped the whole of Western Australia's history and development, in particular the coastal areas and especially those of the south-west coast. It is hoped that a greater understanding of the history of Two Peoples Bay Nature Reserve will help in the development of policies that will conserve areas for future generations, and provide more effective management of those areas already committed to conservation.

DISCOVERY AND EXPLORATION

Early Explorers

Descriptions of prominent coastal land forms as seen from seaward were essential to the early maritime explorers. By recognizing a described feature a captain was able to establish his position on an uncharted coast. Knowing his position, a ship's captain could determine other information, such as the relative proximity of safe anchorages, watering and timbering points, and reefs and shoals.

In September 1791 Captain George Vancouver named and described one such prominant feature at Two Peoples Bay - the high cone-shaped Mt Gardner to the east of King George Sound. When sailing eastward from there, Vancouver did not stay close in shore and failed to notice the small sheltered bay immediately north of Mt Gardner.[1]

Matthew Flinders provided the first recorded sighting of the Bay when, in the *Investigator*, he surveyed the immediate vicinity of King George Sound in December 1801 and January 1802. He had written in April 1801 to Sir Joseph Banks:

> My greatest ambition is to make such a minute examination of this extensive and very interesting country that no person shall have occasion to come after me to make further discoveries.[2]

Though not specifying any person or group, there is no doubt that Flinders had in mind the French expedition under the command of Nicolas Baudin, which also had the specific mission of charting and exploring the coast of north, south and west Australia. Flinders had previously commented to Banks: 'I fear a little longer delay will lose us a summer and lengthen our voyage at least six months; besides the French are gaining time upon us'.[3] On 5 January 1802 Flinders, in his haste to discover as much of the coast as possible before his French rivals, sailed from King George Sound toward the Recherche Archipelago and noted in his journal:

> Mount Gardner is a high, conic-shaped hill, apparently of granite, very well delineated in Captain Vancouver's atlas. It stands upon a projecting cape, round which the shore falls back to the northward, forming a sandy bight where there appeared to be shelter from western winds; indeed, as the coastline was not distinctly seen round the south-west corner of the bight, it is possible there may be some small inlet in that part.[4]

It is ironic, in view of Flinders' comment to Banks, that the sandy bight sheltered from western winds he described should be minutely examined and named the following year by the French expedition.

On the morning of 17 February 1803, Captain Nicolas Baudin was sailing toward King George Sound in the corvette *Geographe*. He thoroughly surveyed the channel between Bald Island and the mainland, then continued west. Baudin noted:

> ...we saw several inlets along the coast to Mt Gardner which seemed to indicate that there might be some good shelter there. I did not go investigating them with the ship, but resolved to have them examined in detail by one of my boats as soon as we were in a safe place. I also pointed out to the officer for whom I intended this work the parts that I considered of greater importance... [5]

That evening Baudin anchored the *Geographe* between Seal Island and Frenchman Bay, just east of Waterbay Point, where Vancouver had previously noted a watering-place (Fig. 1.2 this publication).

On 20 February, Baudin dispatched two boats to survey sections of the coast. The larger boat under the command of Midshipman J.J. Ransonnet was to:

> ...explore the portion of the coast between Vancouver's Mt Gardner and d'Entrecasteaux's Bald Island. It seems to me that it is particularly useful to know it in detail, as it offers a view of various inlets which could hold resources or a haven in bad weather for the future navigators in these regions. Generals d'Entrecasteaux and Vancouver only saw the coast from a distance; you are going to examine it closely and with scrupulous attention. You will enter all the inlets along it and explore each one in detail. If, as I am inclined to believe, you find some ports there, you are to survey them, take soundings and determine as exactly as possible the points that form their entrances.[6]

The second boat, under the direction of the geographer P. Faure and commanded by Midshipman Charles Baudin, was to survey King George Sound, Princess Royal Harbour, and Oyster Harbour, as well as the coast as far as Mt Gardner.

Ransonnet completed his task by 27 February. In his report he indicated that he was not the first to enter the Bay north of Mt Gardner. On doubling Cape Vancouver and sailing past what is now called Coffin Island, he noted:

> At one o'clock being at the opening of a bay, I found, when we moored, a building towards which we advanced. The Captain, P. Jane Pendleton commanding the Brick [sic], of the American Union, welcomed and informed me that he had been in the bay two days, four months after their departure from New York and that the object of his trip was to look for some pelts that he wished to sell to China.[7]

Having informed the Americans of Baudin's presence in King George Sound, Ransonnet continued his detailed survey of the Bay. In the meantime, Captain Pendleton weighed anchor and sailed to meet with Baudin. He arrived to find Baudin away on his own survey. On 24 February, however, Baudin and Pendleton dined together and, at Pendleton's request, Baudin provided him with charts of the New Holland coast and information regarding sealing there.[8]

Although there is no mention of a name for the Bay in Ransonnet's report, his meeting with the Americans was commemorated in the naming of the Bay. It was Louis Freycinet, who was part of the expedition as commander of the *Casuarina*, who credited Ransonnet with proposing the name, *Baie des Deux-Nations*, in memory of the friendly encounter there with the Americans.[9] Relations between Baudin and Freycinet were, however, less than friendly, and their rivalry has led to conflicting accounts of the naming of the Bay.[10] On the chart drawn for Freycinet, Faure, and Ransonnet (Fig. 2.1) the name is given as *Port des Deux-Peuples*.[11] The Anglicized form of the name became Two Peoples Bay.

The significance of the name Two Peoples Bay was soon lost to the international community as demonstrated by the comment of a young American whaler who came to the Bay in 1849:

> This bay is named Two Peoples, for what reason I know not, for not a soul lives here, nor is there a house to be seen.[12]

Further exploration of the south coast continued with Lieutenant Phillip Parker King in 1818 and Captain Dumond D'Urville, who was at King George Sound in 1826. On 12 October, D'Urville met two parties of sealers, six of whom had been marooned on Coffin Island, and on 17 October he noted two whalers in the vicinity.[13] The sealers and whalers who were to dominate the history of Two Peoples Bay for the next 50 years were already present in the area before any official settlement was established. With D'Urville's departure on 25 October 1826 and the arrival of Major Edmund Lockyer two months later, the period of transient exploration ended. The New South Wales outpost at Albany was established and developed, and subsequently there occurred a corresponding growth of the sealing and whaling industries - part of these being focused on Two Peoples Bay.

The Sealers

The two sealing gangs noted by D'Urville in October 1826 were still in the vicinity of King George Sound when Lockyer arrived in December; one group was based on Eclipse Island, the other to the eastward.[14] The presence of these sealers and their relationships with the local Aboriginal population were to be a grave concern to Lockyer in the early days of the establishment of Albany. Lockyer also noted that the continued, uncontrolled exploitation of the fur seal population would cause the industry to become valueless, as the depletion of the fur seal population would effectively reduce profitability. In a dispatch to the Colonial Secretary of New South Wales he recommended that:

> ...a prohibition should be immediately given against any Individual taking the seals or going at all to the Islands, the Government claiming them as part of the Territory and once in Three Years to Farm the Islands out for the season from November to the end of April following, or such other months as would be found not to interfere with their breeding or the time they shed their Fur.[15]

The Major's recommendation was not acted on and the sealing continued at an even greater rate as settlers of the new colony, hoping to supplement their incomes, joined the ranks of sealers.

Lockyer's prediction that over-exploitation would jeopardize the industry was confirmed in 1831 by surgeon and explorer Captain Alexander Collie. Upon accompanying a sealing gang of settlers from Albany to an island off Mt Gardner he identified as Coffin Island, on 4 June 1831, Alexander Collie wrote:

> That seal have come up and been killed in considerable numbers at one time, is confirmed, in addition to oral information, by the skeletons which still remain; but none of the party saw any alive at this time...[16].

Collie's journey to Coffin Island provided further information on Two Peoples Bay. He crossed from Coffin Island to the mainland and climbed to the top of Mt Gardner. There he briefly described the soils and vegetation of the area, commenting that he planted almond, castor oil and other seeds. (One of the sealing gang planted `a variety of flower seeds on Coffin Island.')[17] From the summit of Mt Gardner, Collie described the surrounding area, noting several lakes, `the nearest and apparently largest communicating by a winding channel with the bay to the N and NE ... it is said to be brackish'.[18] This is Gardner Lake which had been put on the chart by Ransonnet in 1803.

Sealing in Two Peoples Bay appears to have become less frequent from the mid-1830s, while the more capital intensive industry of whaling became the dominant activity in the Bay for the next fifty years. Collie in fact mentioned that `several whales [black] were observed at a short distance off [Coffin Island]'.[19]

Bay Whaling

Two Peoples Bay began a long association with whaling during the 1837 season when Captain Francis Coffin of the *Samuel Wright* established the first bay whaling station there. How Coffin came to set up his station in Two Peoples Bay is of importance to understanding the later use made of the Bay by other international whalers. On 24 March 1837 the *Samuel Wright* arrived in King George Sound, 120 days out of Massachusetts.[20] For almost a month Captain Coffin stayed in the harbour refitting, replenishing supplies and seeking to employ more hands for the approaching season. He also made contact with the settlement's merchants with whom he hoped to trade in whale-bone and whale-oil.[21]

The issue of British subjects' rights to monopolize the whaling industry had been simmering for some time and was inadvertently brought to the boil by Captain Coffin. While attempting to increase his crew he signed on a young man, Andrew Newberry. It so happened that a group of settlers had previously signed up Newberry for their bay whaling enterprise situated at Doubtful Island Bay about 130 km north-east of Two Peoples Bay.[22] The loss of an employee at a time when labour was extremely scarce provoked Mr. T.B. Sherratt, one of the partners of

the Doubtful Island Bay enterprise, to seek official assistance to stop Coffin from whaling at Doubtful Island Bay, as Coffin intended to do.[23] Sherratt made two appeals; one to the Colonial Secretary, the other to the Commander of H.M. Sloop *Friton*, which was in harbour at the time.[24] In both letters he sought to define the rights of a British subject regarding foreign interference to trade.

Sherratt was impatient to act to prevent competition at his whaling station. Using the information from Commander Crozier of the *Friton* he wrote to Coffin on 7 April 1837:

> I acknowledge the receipt of your communication of yesterday to allow one to say that in this far country the attention envinced [sic] by you is highly gratifying, and I beg to return you my best acknowledgments for the same and to assure you that it is my most sincere wish that there be no need to put the Laws in force - but should unhappily our Fisheries be disturbed or my co-partners annoyed in the prosecution of an undertaking I shall be compelled to call for the protection due to a British subject.[25]

The threat was plain enough and the force was immediately present to back it up. Whether it was the threat, or simply that Coffin required a non-hostile population at Albany with which to trade while whaling in the vicinity, the result was that Coffin did not go to Doubtful Island Bay. Instead, he established himself at Two Peoples Bay which was at that time unused by the settlers.[26] It was not long before the American was joined by other American and French whalers in the Bay,[27] again giving the original meaning to its name.

There is a small and protected, gently-sloping, sandy beach between the main beach and South Point at Two Peoples Bay. Behind the beach there is a well-shaded gully where a small stream runs during the winter months. It was on this protected beach and gully that bay whaling at Two Peoples Bay was centred, the whales being flensed on the beach with the try-pots being set up in the gully area.

Whaling at this time was a major income-earner for those nations that were rapidly mechanizing. To protect their interests the French sent a man-o-war to the south coast of Australia to safeguard French whalers.[28]

Although the British subjects of Albany were concerned with their rights, they were also preoccupied with making a living. The foreign whalers provided a focus for a whole range of small enterprises which supported them. Mutton-birders, kangaroo-hunters, vegetable-growers and traders were all involved in some way in supplying the foreign whaling ships. Merchants and traders in particular developed close links with the whalers, trading in bone and oil as well as being ship's chandlers.[29]

Francis Coffin established contacts with Albany's merchants at the outset. Coffin's provocation of Sherratt, however, obliged him to carry out his trading with George Cheyne, one of Sherratt's strongest competitors. This trade, between Cheyne and the Americans and French at Two Peoples Bay, began in 1837. Some time later Cheyne became preoccupied with his own whaling interests at Cape Riche[30] (Fig. 1.1 this publication). This allowed Captain Thomas Symes to replace Cheyne as the principal trader and supplier to the whalers at the Bay, in the 1840s and 50s.[31]

In those days the track to Albany and the Bay was ill-defined and the following comments from Mrs Mary Taylor, who lived in the district in the 1830s, tells of the arrival at Candyup of:

> ...Mr Cheyne, Mr Morley, Mr Drake and the Doctor of a French whaler. They were all dreadfully tired and famished with hunger, having been lost in the bush since daylight, coming from Two Peoples Bay, a distance of fourteen miles.[32]

Whaling activities at the Bay peaked in the early 1840s after which they steadily declined. The foreign whalers were gradually replaced by small parties of settlers who used whaling as a means of supplementing their incomes, much the same as they had done with sealing.[33] Similar to the sealing industry, bay whaling was gradually reduced to insignificance through the depletion of whale numbers.

During its heyday, Two Peoples Bay was an anchorage particularly preferred by foreign whalers, not only for whaling, but also for a number of other benefits. Firstly, the Bay was considered to be a safe anchorage, particularly from westerly winds. However, a south-east wind was a different matter. On 28 August 1842 a south-east gale buffeted several whalers in the Bay. One, the *Avis*, parted both her cable chains and was blown ashore and wrecked, the hulk being two-thirds buried in sand.[34] As was the normal practice, the hulk and all salvageable items including 800 barrels of oil on board were sold.[35]

Secondly, there were no harbour dues or import duties to be paid for items landed at Two Peoples Bay. Albany merchants George Cheyne and Thomas Symes provided the facilities in Albany to allow distribution of such goods as were traded. Trade was particularly good in whale-bone and whale-oil, two commodities easily disposed of in the small colony. Government officials became concerned about this smuggling and trading, yet were helpless to counter it, as the distance and access from Two Peoples Bay

to Albany was sufficiently difficult to make it impossible to police the situation.[36]

Thirdly, by staying at Two Peoples Bay, away from King George Sound, the masters of whalers were able to control their crews to some extent. Drunkenness of crews when in port was a major concern to both the captains and the local officials since the crews usually became a public nuisance.[37] By anchoring out of port, the crew could be given leave to the settlement in small numbers, yet still be close enough to be recalled easily. The Bay also had the added advantage of being within easy reach of supplies and medical assistance, should the captains need these.

Fourthly, the Bay provided plentiful supplies of water and fresh meat. Water was easily obtained from a stream at the north end of the Bay, while fresh meat could be obtained from a number of sources. Mutton-birders and out-of-work sealers hunted kangaroo and mutton birds to sell to the whalers.[38] The whalers also hunted kangaroos with dogs as the Aborigines had done before them. In November 1841 Archdeacon Wollaston noted in his *Picton Journal* that he purchased four kangaroo-dogs from the captain of an American whaler, Francis Coffin, master of the *Samuel Wright*.[39] Obtaining water was a crucial part of the lives of the whalers. N.C. Haley, a young harpooner who first came to Two Peoples Bay on board the *Charles W. Morgan* (Fig. 2.2) in 1849, described the procedure in detail as the ship took on 100 barrels of water.[40]

In addition to the avoidance of import duties, as described above, there were also other problems for local officials at Albany. Of particular concern was the ease with which felons and deserters could escape justice by gaining passage on whaling ships stationed in the Bay.[41] A documented example of such a case exists: George Dutton, who had been committed to the Albany prison on a charge of robbery, escaped from the cell `by cutting away a portion of the cell door'. Peter Belchers, the Acting Resident Magistrate, continued:

> ...he had gone to Two Peoples Bay where I forwarded with a party of soldiers in the hope of being able to secure him, but I found that he had managed to get on board an American Whaler which sailed from the Bay a few hours before my arrival.[42]

Relations with the Aborigines had improved since Lockyer's account of contacts between sealers and Aborigines in 1826.[43] Haley reported that the Aborigines continued to come to the Bay despite the presence of the whalers:

> The wandering bands of natives from inland used to come here in the whaling days and feast on the carcass of any whale that had drifted on shore and would gorge themselves on it even it it smelt a mile a minute.[44]

This opportunism of Aboriginal groups appears to have been common around the bays of the south coast where whaling occurred.[45] The Aborigines were also employed on occasions as messengers by the whalers. The captain of the *Charles W. Morgan* had, on a previous visit to Two Peoples Bay, `sent a message to one of the leading men in a town sixty miles away'[46] by an Aboriginal messenger, with the promise of a bucket of ship's biscuits as payment. Only thirty hours later a reply had been returned to Two Peoples Bay. The story continued that whereupon the messenger was paid, he sat down by a stream of fresh water, ate all the biscuits, took a long drink, and then hardly moved for two days.[47]

Aborigines were later employed as crew in the settlers' bay-whaling enterprises and were considered to be equal to their fellow white crewmen.[48] If a report from the *Inquirer* in 1858 is correct, the employment of Aborigines as whalemen caused something of an upset in Aboriginal society: `The black ladies now declare they will accept no husbands except if they will go fishing (whaling)'.[49]

Local settlers continued bay whaling at Two Peoples Bay. The foreign whalers had turned their attention to hunting the Sperm Whale, which did not frequent the bays of the coast, as did the Right and Humpback Whales they had hunted previously. Bay whaling progressively became the domain of small groups of local people, who were not able to make the enormous profits of the past, because the number of whales was greatly reduced.

It is interesting to note that during this period (1877) a coastal survey was done on behalf of the British Admiralty by a Royal Navy hydrographer, Staff Commander W.E. Archdeacon. Part of the resulting map of the Albany area and a land profile are shown in Figure 2.3.

LANDWARD DEVELOPMENT

Beverley-Albany Railway

By the mid-1880s, Albany's development was essential to the surrounding countryside and therefore the construction of the Beverley-Albany section of the Great Southern Railway (Fig. 1.4 this publication) became crucial to the development of the entire district. In the colony at that time capital was extremely limited and became the major problem toward laying down the much sought-after railway.

A method in vogue at the time was to attract overseas capital by means of the Government offering large tracts of land in return for a company constructing a railway line. Land thus procured could then be leased or sold as the company saw fit. The land grant contract signed by the Western Australian Government and the W.A. Company, committed the Government:

> ...to grant 12 000 acres [4 800 ha] of land per mile of railway, which were selected in blocks not less than 12 000 acres in size, and within a belt 40 miles [64 km] either side of the line.

Another clause granted the company an extra `50 acres [20 ha], to be selected in blocks no smaller than 5000 acres [2000 ha]' for each migrant brought to the Colony by the company.[50]

After many delays the Beverley-Albany line was completed in 1889, and the W.A. Land Company then set about applying for land grants under the terms of the contract. Location 416, situated east of the Kalgan River, which took in almost all of the present Two Peoples Bay Nature Reserve, was one of the selections made by the Land Company.

The Reserves

When the Two Peoples Bay location 416 was granted to the W.A. Land Company, on 12 May 1892, it did not include the whole area applied for.[51] Two existing reserves, Nos 2015 and 2028 (Fig. 2.4), were excluded from the grant.[52,53] The Company did not agree to the exclusion of these two reserves and carried on a lengthy and sometimes heated debate with the Government, in its attempts to obtain these areas.

Reserve No. 2015 (c.1320 ha) was set aside for `Defence' purposes in March 1892, after the area was withdrawn from the sale lists in May 1890, on the instructions of the Secretary of State. The defence of Princess Royal Harbour had been discussed by the British Government and the Western Australian Government in early 1890. Through instructions cabled to the Department of Lands & Surveys in April and May 1890, the Secretary of State ordered that all land which provided vantage points to King George Sound and Princess Royal Harbour be withdrawn from the lists of Crown land available for sale.[54] This action would allow the development of these vantage points as defence centres and maximize the defence of the Sound and its harbour. Mt Gardner was one of the areas withdrawn from the Crown land lists. However, the pressures that led to its withdrawal from the land lists were not great enough to have the area designated a reserve.

By March 1892, the influence of the Great Southern Railway and the application for the Mt Gardner area by the W.A. Land Company provided the impetus for the W.A. Government to reassess the reserve status of the area. It was considered that the added strategic importance of the harbour and the railway line required the establishment of gun emplacements on Mt Gardner, for the harbour's defence. Mt Gardner was therefore reserved and not made available for private use.[55] To complement the Defence reserve the State Government set aside a 5 acre (2 ha) reserve, No. 2028, as a landing place, though it was officially gazetted Public Utility.

In its attempts to obtain the two reserves the Land Company argued that Reserve 2015 was excessive in size and that, as there had been no further discussion on the establishment of defence works on the site, the reserve should be cancelled. The construction of Fort Scratchley on Mt Adelaide during 1891-2 resolved the question of defending Princess Royal Harbour and for a while discussions ceased on the issue.[56] Upon cancellation of the reserve, the area should be added to Location 416 and the Government could have the right to `resume any portions of the land to set up reserves for defence purposes within 21 years'[57] of Location 416 being granted. It was also argued that by retaining Reserve No. 2028 the Government would `prevent the sale of land in small lots for settlement around the landing place'. The Company continued that `there should be a settlement or village at that place'[58] and that having a government reserve there would inhibit the development of such a townsite. Just how prophetic these words of Mr C.R. Fenwick proved to be, can be judged when the issue of Casuarina townsite is discussed later. The Land Company's representations were not successful and the two reserves remained excluded from Location 416.

Owning land and encouraging its development proved to be two distinct functions for the Land Company. Those areas of land controlled by the Company developed very slowly. The infertile nature of much of the land and the particularly heavy forest covering vast areas were both factors retarding the sale of the land. On Location 416 the land around Two Peoples Bay in particular suffered from soil problems and subsequently was not seen as a profitable investment. Other factors such as high prices for sale and lease of Company land retarded the growth of the Albany district. Eventually, the State Government bailed out the investors who had backed the W.A. Land Company, by purchasing all unsold lands and the Great Southern Railway for one million pounds.[59] Land sale prices and leases were reduced to Government rates and an increase in the

sale of land was noted. However, the land that now makes up Two Peoples Bay Nature Reserve was not purchased, though several long-term leases were taken out for various parts of the area.

According to records, N.W. McKail became the first person to lease land in the general area when he leased Location 3985 from the Company in 1893. Location 3985 is the area east of Gardner Lake and to the western boundary of Reserve 2015 (Fig. 2.4). A second lease in the early 1900s, for an area of land between McKail's block and the eastern end of Moates Lake, was granted to A. de Baun. Later, in 1925, A. and O. Thorne were given a lease for Location 5394 - the land between Moates and Gardner Lakes - including part of de Baun's earlier lease.[60] The more northerly section of de Baun's early lease was reserved as `Common' Reserve No. 17900 on 13 January 1922, but not vested in any authority. Location A82 was surveyed and released in 1898, and forms part of the western boundary of the current Nature Reserve, while Location 3777 was released in 1911 and forms part of the northern boundary.

During these early years of tenure the Reserve area was reputedly used for cattle grazing and a number of people believe the mobile dunes near Moates Lake were part of a sand blow-out caused by the overgrazing of livestock. However, descriptions relating to the coastal survey map of 1877 (Fig. 2.3) note `a bare sand drift one mile square' (1.6 x 1.6 km).[61] This suggests these dunes preceded grazing activities.

Albany Water Supply

In the first decade of the twentieth century Albany suffered from a poor water supply and good freshwater was needed for shipping purposes. A possible solution to this problem was proposed by surveyor W.H. Angove while surveying Location 3777 (`Tandara' on Fig. 1.4 this publication) in 1911, when he relocated a stream in the hills (now the Angove River) he had first recorded in 1898.[62] Mr Angove, who was also an Albany Town Councillor, succeeded in convincing his fellow Members that this stream could provide the water so desperately needed in Albany. An area of 20 000 ha was set aside as a catchment reserve (ch. 14 this publication) and following governmental approval in 1912 work commenced on the Angove weir and pumping station.[63] (Fig. 2.5).

An upstream weir across a `clear pool' (Fig. 14.1 this publication) was constructed to supply water through a 25 cm wooden pipeline, 2.5 km to the pumping station, where a second weir was constructed across the stream. Two small Babcock and Wilcox water tube, wood-fired boilers were installed to generate steam for the pumps to convey water through another 25 cm wooden pipeline to the summit tank on Reservoir Hill. From there the water was gravity fed, via a 20 cm cast iron and wood pipeline, to a reservoir on the top of Mt Clarence, near Albany (Fig. 1.2 this publication).

The water supply scheme was upgraded from steam to electric power in 1953 with the conversion of the power supply and the installation of the present pumphouse and steel pipelines, which run alongside the main road leading to and through the Two Peoples Bay Nature Reserve.[64] Also in 1953 the Water Supply Catchment Reserve No. 13802 was reduced to 4006 ha (ch. 14 this publication). The Angove River is still providing a major part of Albany's water supply (Table 14.1 this publication).

An interesting adjunct to the town water supply scheme was an unfulfilled proposal to establish a trout hatchery below the weir. Toward this end the Fisheries Department of the time had water temperatures monitored daily, and the information was relayed to Perth at regular intervals throughout 1916 and 1917. Temperature record sheets were dutifully maintained by J.A. McCallum, engine driver at the pumping station, under the supervision of A.M. Hutchinson, engineer to the Albany Water Board.[65]

Early Recreational Pursuits

The settling of areas in the immediate vicinity of the Bay, in the early 1900s, led Albany people to come to Two Peoples Bay for picnics and relaxation. Access, usually by horse and cart, was along a sandy track via the pumping station to the northern end of the Bay, and then followed the shore south. This was a different route to the track from Taylor's Inlet via Gardner Lake to the southern end of the bay, as shown on maps issued in 1890.

When World War I commenced in 1914, picnic parties to Two Peoples Bay virtually ceased. Only the pumping station master and his assistant remained at the pumping station to ensure Albany's water supply. However, there was renewed activity at the Bay when the war ended in 1918. Location 3777, known today as `Tandara', was settled permanently and work commenced to make the farm a viable proposition. The farm was bought by H.C. Poole who settled permanently on Tandara and work commenced to make the farm a viable proposition. His son John Poole and two young friends dug the first drains by hand, from Angove Lake to a stream course leading into Gardner Creek, completing the onerous task by

1930. This allowed the fertile swamp flats to be used for potato cropping.[66]

For a number of years two fishermen spent approximately six months of the year living on their boat, or on the shore in the general vicinity of Reserve No. 2028. The fish they caught were smoke-cured in a `kiln of sorts', in the same gully area where the bay whalers had previously rendered the oil from whales they had taken in the Bay.[67]

After the war, Two Peoples Bay again became a popular recreation area for the residents of Albany, with picnics and fishing being the main activities.[68] It was a place where the Albany people could withdraw to for solitude and isolation and in these respects the Bay reflects the atmosphere of Albany itself.[69] During this period a new access route was made to the southern section of the Bay. Instead of going via the pumping station, people followed a track along the southern boundary of Tandara, across a rough crossing at the Goodga River, until they reached the stream flowing from Lake Gardner. At this point the track crossed over the sand dunes to the east, onto the beach. If one did not follow the track it was possible to row down the stream (Fig. 2.6) between Lake Gardner and the Bay.

In the late 1920s a new route was used to cross the stream at Lake Gardner after it was found that sand in the mouth of the stream was very firm underfoot. Mr E.G. Green, an adventurous young man, drove the family car across this firm ground in Lake Gardner and onto the land opposite where the track had ended. A track was then beaten through the scrub to the southern end of the Bay.[70] This track was only servicable in summer as no crossing of the lake was possible in winter. The same track was still in use in the early 1950s as was verified by Mr F. North who had travelled that route when going fishing at Two Peoples Bay.[71]

Between the two World Wars the first very rough, holiday shacks were erected in the vicinity of the Public Utility Reserve No. 2028. They were used primarily for shelter during the day by groups of picnickers. The outbreak of World War II in 1939 interrupted the developing land-use patterns at Two Peoples Bay, as the people of Albany virtually abandoned the area for recreation during the war.

Development Proposals

Since the end of World War II, Two Peoples Bay has remained popular with Albany residents and has been visited by an increasing number of tourists who enjoy the wide variety of recreational pursuits available there. The duration of the visits began to lengthen and the picnic shelters of the early 1930s developed into quite substantial buildings of a fairly permanent nature (Fig. 2.7). By 1953 there were about 17 buildings in the squatter settlement at Two Peoples Bay.[72] The addresses of the shack owners reflected the increase in the number of non-Albany visitors to the Bay. Farmers from neighbouring districts were coming to the area to spend their time relaxing over the summer break. Though Albany residents continued to visit the Bay over weekend periods, the major influx of people came during the summer holidays. The area was seen as ideal - it was isolated from local authorities and there was plenty to do - fishing, swimming, horse riding, and even boating. Perhaps the greatest attribute was that it was free.

Even before World War II an application was received by the Department of Lands and Surveys for the purchase of 6 ha at South Point. The area north-east of the existing squatter settlement was proposed for development as a tourist resort. Activities such as horse riding, boating, swimming and golf were to be available to the tourists.[73] Although the application for the tourist resort was dropped, negotiations between the Department of Lands and Surveys and the Albany Road Board resulted in the establishment of a 15 acre (6 ha) reserve for Camping and Recreation (Reserve No. 22180). This area was set aside in April 1940 and vested in the Albany Road Board so that the Board could, to some degree, control the increasing numbers of squatters using the Bay area. It was also agreed that the Road Board would not have power to lease any of the area as camping sites.[74] To strengthen the Board's control of the area, Location 3985 was set aside as a Common Reserve (No. 18886), vested in the Road Board. (A lease on this location was taken out in 1925, but appears to have been abandoned some time prior to April 1940.)

Increased interest in the Bay as a holiday resort was seen in the large number of applications received by both the Department of Lands and Surveys and the Albany Road Board for leases of areas of land, ranging from half an acre to two acres (0.2-0.8 ha), as building sites. By 1953 public pressure for building sites at Two Peoples Bay strengthened the resolve of the Albany Road Board to provide for more effective control of the squatter settlement. Subsequently the Board applied to the Under Secretary of Lands to have Public Utility Reserve No. 2028 (which had been increased to 45 acres (18 ha) in January 1922) added to its existing Camping and Recreation Reserve No. 22180. It was argued that, if this amalgamation of Reserves was permitted, the existing squatter settlement could be effectively controlled under

existing Government by-laws. Furthermore, the Albany Road Board argued, it was desirous to have power to lease parts of the area to people for periods up to 21 years as camping and caravanning sites.[75]

As a result of this Albany Road Board application and the increase in private applications for sites at Two Peoples Bay, the Department of Lands and Surveys began considering the declaration of a townsite at the Bay. A survey carried out by a Government surveyor in 1954 reported an `air of permanence' about the squatters' settlement. Vegetable gardens had been established in some of the swamp areas and the houses themselves were becoming more sophisticated. One house had a power plant valued at £600 ($1200) in a separate shed.[76]

The idea of building a tourist resort was also revived in 1954, and again in 1957, when separate applications were made to the Under Secretary for Lands to allow the Public Utility Reserve No. 2028 to be opened for a camping area and a hostel respectively. The 1957 application to build a hostel was detailed and supported by the Albany Tourist Bureau and the Member for Albany, Mr J. Hall, MLA. It was planned to develop golfing and tennis facilities, and to allow horse-riding. Pasture was to be grown on the Common Reserve and the hostel was to be self-sufficient in vegetables as the swamps were to be cleared and used to grow vegetables.[77] This was the most complete application, for the development of tourist facilities, received by the Under Secretary for Lands. By this time the idea of establishing a townsite had matured sufficiently, and the reply to the developers made it clear that the development of such facilities would be considered, only as part of an overall concept of a townsite designed for the area.[78]

Casuarina Townsite

From the point of view of those desiring building lots the story of the survey, declaration and opening for sale of what became known as Casuarina townsite, is one of frustration and bad timing. Following completion of the initial survey in December 1954[79] - 50 half acre (0.2 ha) lots - the townsite design was rejected by the Town Planning Department.[80] Having had its first townsite design rejected, the Department of Lands and Surveys sought the assistance of the Town Planning Department to redesign the townsite. A Town Planning representative was sent to the proposed townsite in November 1955,[81] however, the completed design was not submitted to Lands and Surveys until February 1957[82] (Fig. 2.8).

By July 1957 the three authorities concerned with the declaration of the townsite had reached agreement.[83] At this point, administrative procedures involved the checking of the surveyor's calculations and drawings, and the results of those checks delayed any further action until November 1959. The surveyor's calculations were found to have errors that required the survey be redone.[84] By May 1960 the resurvey was completed, the calculations checked, and found to be correct.[85]

The procedure for declaring a townsite required that the townsite be named. The Nomenclature Advisory Committee was asked to propose a name for the townsite and to name the streets. The name chosen by the Committee was `Casuarina' (after Louis Freycinet's ship) and the street names were those of members of the French 1800-1804 expedition and the American ship the *Union*.[86] Casuarina townsite was formally gazetted on 30 March 1961,[87] eight years and five months after the initial proposal to establish a townsite at Two Peoples Bay. In the intervening period, between the declared intention to establish a townsite and its gazettal, interest in the area as a holiday site continued to grow. Every inquiry about obtaining land at Two Peoples Bay was replied to in like manner - progress was being made and as soon as the area was declared a townsite, the inquirer would be informed of the conditions of purchase, sale dates and places.[88]

Now the townsite was gazetted it would appear that the time of frustration was over. The Under Secretary for Lands directed that public notices, advertising an auction of 15 lots at Casuarina townsite, be prepared and displayed at all railway stations between Perth and Albany on the Great Southern Railway line. The auction was to be held at the Albany Court House on 22 June 1961 at 2.30 p.m. Minimum prices on the 15 lots to be auctioned were set.[89] On the 18 April 1961, only five days after the instruction to prepare for the auction of the lots at Casuarina, the following note appeared on file from the Divisional Surveyor for Great Southern:

> Following the altered policy of this and the Town Planning Department re sanitary provision (septic tanks) in the matter of necessary water supply, it has been decided to re-subdivide the "Casuarina" area to provide (about) quarter acre lots. This will necessitate the survey of the broken lines as shown...[90]

This note proved to be a crucial turning point in the destiny of the Casuarina townsite. Instructions were issued for the immediate resurvey of the blocks. However, for some unknown reason the survey was

not completed until March 1962,[91] by which time another issue had arisen, which created a new focus in the debate on land use of the Bay area.

The confirmation of the existence of the Noisy Scrub-bird at Two Peoples Bay, in December 1961, changed the course of development of the area. The resolution of the dispute will occupy part of the following section. It should be noted though, that had the policy on sanitary provisions of the Department of Lands and Surveys and the Town Planning Department not changed until after 22 June 1961, there could now be a town called Casuarina instead of one of this State's most important and valuable nature reserves.

Further recreational developments occurred during the period 1953-61, when fishing was still a dominant pastime. Several dedicated trout fishermen introduced trout into the Goodga River[92], to supplement the marron that had been introduced in the late 1930s (ch. 14 this publication). Spear fishing had also become prominent at the Bay.

Also, it should be noted that professional fishermen, particular salmon fishermen, again established themselves at the Bay on a fairly permanent basis (Fig. 2.9). From 1954 onwards, Mr C. Wilson lived at Two Peoples Bay and worked as a professional fisherman. His persistence in seeking land as a base for his undertaking resulted in a small area being excised from the Nature Reserve after its establishment.[93] The Wilson family set up a stall near the beach at weekends where fresh salmon and Devonshire Teas were sold to picnickers and other visitors to the Bay (R.E.S. Sokolowski, personal communication).

ESTABLISHMENT OF THE RESERVE

The Western Bristlebird

As access to Two Peoples Bay became easier, the number of people using the area increased, with fishing remaining the dominant recreational activity. A growing number of those people who came to fish were also naturalists, who were able to pursue their hobby in the rich diversity of plant and animal species of the area. One such person, Mr C. Allen, had begun a long association with the Bay area in the late 1920s. On his numerous visits he became aquainted with birds that were not readily identifiable and he suspected that one bird with a particularly piercing call was the Noisy Scrub-bird.[94]

In Febraury 1945 Mr. K. Buller, of the W.A. Museum, went with Allen to Two Peoples Bay `with hopes of seeing or hearing something of interest'.[95] Indeed, they did find something of interest, as it was during this excursion that the first sighting of a Western Bristlebird was made since the last specimen was collected in 1907 (by F.B.L. Whitlock, near Wilson's Inlet). The two men moved from the area around Gardner Lake, where the Western Bristlebird had been sighted, to the southern end of the Bay and heard calls of this bird `within a stones throw of an inhabited fisherman's camp'.[96] It is interesting to note that years later, in this same area only a short distance from the squatter's settlement, the Noisy Scrub-bird was found. The two ornithologists were well-pleased with their discovery and in their discussion about the days events, some doubt was raised as to whether or not the bird originally seen by Allen was the Noisy Scrub-bird, or the now confirmed Western Bristlebird.

In many ways 1961 was a pivotal year in the course of events at Two Peoples Bay. During that year two parties of ornithologists independently undertook studies of the Western Bristlebird. A group comprising Messrs. J.R. Ford, K.G. Buller and Mr C. Allen began a taxonomic study[97] while, unknown to them, Mr H.O. Webster began a study on its breeding and behaviour.[98] The group Ford, Buller and Allen, were working on the Western Bristlebird with the knowledge of the W.A. Museum and wrote, in a report on the progress of their work:

> For some time now, we have been hopeful of rediscovering the Noisy Scrub-bird in the Two Peoples Bay district... One of us (Allen) is positive that he saw and heard the species in 1944 but the fact remains that we have been unable to verify our contention by collecting a specimen.[99]

Noisy Scrub-bird Rediscovered

Among ornithologists, the hope of positively identifying the Noisy Scrub-bird never really faded. Occasional reports of sightings were given to the Department of Fisheries and Fauna but mostly these were shown to be incorrect or unsubstantiated.[100] The last of these reports was received from Nannup in August 1961.[101]

Hopes of positively confirming Allen's 1944 sighting were given an added boost when Mr P.J. Fuller returned from a trip to Albany and told Ford that, on 5 November 1961, he and Allen had been at Two Peoples Bay and had again sighted a bird that Allen was certain was the Noisy Scrub-bird.[102] Ford made plans to visit Albany in the company of Buller, the trip being carried out over the weekend 11-12 November 1961. However, Allen did not accompany

them to the Bay and in Ford's words they had `inadvertently worked the margins of Lake Gardner about one mile from the actual place where the scrub-bird had been watched by Allen and Fuller, and consequently missed confirming Allen's record'.[103]

Although Ford and Buller did not confirm Allen's sighting, their trip to Two Peoples Bay was not fruitless. Four specimens of the Western Bristlebird were collected to continue their study.[104] Also, it was very enlightening because, when Ford and Buller visited Allen on the Sunday evening and showed him the Western Bristlebird skins, Allen categorically stated that these were not the same as the species he had seen. Allen then pointed out the differences between the specimens and the bird he had seen.[105] Ford and Buller returned to Perth anxious to co-ordinate their free time, for another trip to search the area near the squatter's settlement, as it was in that area Allen and Fuller had made their observations on 5 November.

Two of the Western Bristlebirds collected on that trip were a breeding pair being studied by Mr H.O. Webster. It was through this most regrettable situation that the two parties of researchers came in contact. Webster found evidence at the site, where he had been observing the Western Bristlebirds, indicating they had been collected by a person or persons associated with the W.A. Museum. Enquiries led him to believe that Mr. Ford had collected the birds, though he made no approach to Ford as he was unknown to Webster at that time.[106] As can be imagined, Webster was very annoyed at having his research so abruptly ended.

The then Director of the W.A. Museum, Dr W.D.L. Ride, became aware of the situation and, through Dr D.L. Serventy, communicated to Ford early in the week 23-30 November, that he should contact Webster to explain the situation surrounding the taking of the two birds. Ford followed up the suggestion by telephoning Webster.[107] During the conversation he passed on information about his group's work on the Western Bristlebird and also mentioned in passing their hope of finding the Noisy Scrub-bird in the Two Peoples Bay area. Ford followed up the telephone conversation by writing a brief note to Webster on 30 November 1961. In it he explained something of the group's work on the Western Bristlebird and then wrote:

> I also mentioned the Scrub-Bird in my phone call. As far as I'm concerned, this bird is not extinct but undoubtedly has disappeared from many of its haunts due to alteration of its habitat. The Two People [sic] Bay area appears to be the type of country in which Webb, Masters and Gilbert found the Scrub-Bird, but as yet I have heard no strange calls nor seen any bird that may have been this species. However I have been informed by a naturalist friend of mine that in 1944 he saw and heard a Scrub-Bird, so this is a promising clue. Perhaps if you saw any strange bird you could let me know?[108]

It can be seen that the most recent sighting of the Noisy Scrub-bird was not mentioned to Webster.

Webster had not been to the Bay since discovering that the pair of Western Bristlebirds he'd been observing had been collected as specimens. On 17 December, he again went to the area, this time to fish for black bream in the stream that flows from Lake Gardner to the sea.[109] He described in his field notebook how a series of fairly long and very loud, frequent calls distracted him from fishing and drew him away to a rush-covered swamp area to try and identify the mystery caller.[110] He spent the remainder of the day following the bird through very thick swamp and scrub and:

> ...came away in the evening with impressions of a brown bird with a call that really made my ears ring and with the knowledge that it was almost certainly the Noisy Scrub-bird.[111]

A more positive identification was possible the following weekend after good sightings were made of the distinctive:

> ...yellow gape, the inverted white `V' under the beak and the blackish triangular patch below it... the wings were rounded, did not reach to the base of the tail and had darker brown fine barring running across them.[112]

Webster had his news published on 25 December 1961 - a Christmas present to ornithologists of the world. A typical ornithological reaction to such news as the `rediscovery' of a species considered extinct is shown in the notes of Dr. D.L. Serventy:

> When the article appeared in `*The West Australian*' I was partly sceptical, though I respected Harley Webster as a seasoned observer.[113]

Dr. Serventy's scepticism was overcome on 28 December when, in the company of Webster, and later Ford and Allen, he satisfied himself by gaining good views of the bird; that it was in fact the Noisy Scrub-bird.[114] Allen also confirmed that it was the same species he had seen in 1944.[115] As all had confirmed the identity of the species, it was not considered necessary to collect a specimen to verify its identity.[116]

The existence of the Noisy Scrub-bird was now no longer in doubt. The identification of the species at the same place as Allen had seen the bird in 1944 had been verified; it only remained as to who should have the honour of rediscovering the `lost species'. That debate continued in much the same vein as the debate between Flinders and the French over place names on the south coast.[117]

Support from World Ornithologists

H.O. Webster forecast that the effect of the rediscovery would draw the attention of ornithologists from all over the world to Two Peoples Bay. He was proved correct, even more quickly than he might have thought. In January 1962 a well known American ornithologist, Mr D.Lamm, accompanied a group to Two Peoples Bay.[118] It was Dr G.F. Mees, a member of this group, who discovered the second Noisy Scrub-bird in habitat quite distinct from that of the first bird. Instead of living among the rushes in swamps, it was found in the thick scrub of a valley on the watershed of Mt Gardner.[119] This discovery led the ornithologists to explore the Mt Gardner region and they were rewarded by finding a number of other Noisy Scrub-birds.

Two Peoples Bay became the centre of attention for ornithologists, as two rare species were now known to be in the area. The problem was to retain enough of the habitat of these species in its natural state, to ensure the continuance of the species. From this view point, Casuarina Townsite was considered a threat. The area of conflict centred around the Public Utility Reserve No. 2028, where Townsite and Scrub-bird territory overlapped.

Numerous opinions existed among orthinologists, as can be seen by the variety of suggestions put forward in the many national and international representations made to the Government of the day, to establish a reserve in the area. There were those who wanted to have the whole area of Mt Gardner and the land in the vicinity of Moates and Gardner Lakes reserved;[120] those who considered that the townsite should be removed to the Common Reserve No. 17900 to the west of the proposed townsite and a small reserve established in the immediate area of the Scrub-bird habitat;[121] and those who wanted the townsite to stay where it was and for the reserve to be established in whatever other area was considered necessary.[122] Between 1961 and 1967, when the Two Peoples Bay Nature Reserve was finally gazetted at its present size and classification, all of these above options were considered. In September 1962 the then Premier, Hon. D. Brand, wrote to H.O. Webster that it was `proposed to create a reserve of approximately 13 600 acres [5440 ha], of which only approximately 1000 acres [400 ha] would be required for township purposes'.[123] This proposal was to proceed as a matter or urgency, the reserve to be classified `A' Class and vested in the Fauna Protection Advisory Committee, for the purpose of conservation of flora and fauna. The townsite, however, was to stay.[124]

The action to proceed along those lines came to an abrupt halt when, on 28 November 1962, H.R.H. Prince Philip, the Duke of Edinburgh, wrote to the Premier noting that `...efforts to secure the abandonment of the proposed and already surveyed townsite have not been successful...' and appealed for the matter to be reconsidered.[125] The appeal for reconsideration was successful and the proposal to establish the townsite was deferred `until a comprehensive investigation into all aspects of the position has been carried out'.[126] From this time on, much was made of Prince Philip's involvement in the matter, with newspaper articles often referring to his part in the whole affair to have the Townsite abandoned.[127]

Conflict of Opinions

The debate centred on the threat the proposed townsite would be to the Noisy Scrub-bird. Conservationists argued that the threat from fire, feral cats and dogs, as well as increased use of the area which would open up the undergrowth, would all be greatly increased if the townsite were allowed to be developed.[128] Other reasons for establishing the reserve were raised by international conservation bodies:

> ...the enormous value, as an example to the rest of the world, of a firm decision by the Western Australian Government that no town will be built in the Scrub birds territory...[129]

Arguing for the retention of the townsite, Mr. J. Hall MLA suggested that the presence of people in the area would minimise vandalism, reduce the fire risk and retain the presence of the Noisy Scrub-birds, as the birds would withdraw if people were evicted from the area.[130] A member of the squatter community also argued that the presence of people would reduce the risk of fire and vandalism, yet interestingly, then cited the problem of increased use of the area affecting the Noisy Scrub-bird:

> Since the rediscovery of the bird has been publicised, ornithologists and curious tourists have visited the area. As a result of the birds habitat being thus disturbed, it has moved away from the immediate area.[131]

In an attempt to reduce the heat of the debate the South Coast Townsite Committee was established, one of its functions being to make recommendations on the Two Peoples Bay area. After hearing evidence for and against the retention of the townsite the committee made its recommendations. The crucial recommendation was to relocate the townsite, to the west on the Common Reserve No.17900, if the land proved suitable.[132] Other recommendations hinged on this first proposal. However, when surveyors and town planners viewed the proposed site it was

rejected as unsuitable and the arguments began again. With the failure of the compromise put forward by the South Coast Townsite Committee and the appointment of a new Under Secretary for Lands, the Department of Lands and Surveys began to favour the representations made by the Albany MLA, the Albany Shire, and individuals desiring the retention of Casuarina townsite.

Conservation groups became increasingly alarmed and the number of representations, in particular from international bodies, began to increase. One international body, the World Wildlife Fund, gained prominence in reporting of the debate, as it was known that the Duke of Edinburgh was involved with that group. Although the Duke's influence was a reality it was not as great as some newspaper reports made out. By March 1965, the balance had swung in favour of the hardline conservation groups, as shown in a file note on a Lands and Surveys file:

> If the desire is to create a Reserve for the `Protection of Fauna' and vest the area in the FPAC (Fauna Protection Advisory Committee) to exercise overall control, then no action should be taken to establish a townsite. In fact the existing 'squatters' should be removed and development to take place on freehold land some distance away.[133]

Establishing the Nature Reserve

Meetings between the Departments of Fisheries and Fauna, and Lands and Surveys were held during October 1965. In these, it was agreed that the Casuarina townsite should be cancelled and a reserve created for the conservation of flora and fauna, vested in the Fauna Protection Advisory Committee. The Committee alone should be responsible for resolving the squatter problem.[134] By February 1966, the Shire of Albany had agreed to relinquish control of all its vested reserves in the Bay area. The way was now clear to formally establish the Two Peoples Bay Nature Reserve. The formalities were completed when, on 22 April 1966, a notice in the Government Gazette proclaimed the establishment of Reserve No. 27956.

News of the event spread rapidly and letters of congratulations came in, to the Premier and various Ministers, from many conservation groups around the world who had made representations for the establishment of the reserve.[135] Unfortunately the original gazettal notice had not been correct. Only two locations were included in the reserve; Location 5408 (Reserve No. 2028) and Location 6906 (Casuarina townsite). The area thus reserved was greatly reduced compared with the area committed by various Ministers at earlier times.[136] The error was discovered, the original gazettal notice cancelled and a new notice published on 28 April 1967, along with the vesting of the reserve in the Fauna Protection Advisory Committee. On 2 June 1967 the reserve was classified as a class `A' reserve. Two Peoples Bay Nature Reserve had now been established and could not be altered except by Act of Parliament. The problems of managing such an expanse of land with its numerous rare species of flora and fauna, as well as the fragile environment and the `squatter' problem, were now the responsibility of the Fauna Protection Advisory Committee.

The Two Peoples Bay Nature Reserve was established by the Western Australian Government, by a deliberate decision to support conservation, as a result of much debate and discussion involving conservation groups, government departments, individuals and parts of the international conservation community. However, the history of the area shows quite clearly that such deliberate decisions were not solely responsible for the existence of this Reserve. Although matters of remoteness and poor agricultural soil were influential, it is clear that a conservative approach to decisions and matters of policy has been an essential part of the history of the area, thus ensuring that much of it has remained in a natural state. It is hoped this history, up to the time the Two Peoples Bay Nature Reserve was created, will not only provide interesting reading but will also describe the setting for the future management of the area.

ACKNOWLEDGEMENTS

Compiling this history required substantial amounts of time researching written documents and talking with long-term residents of the immediate area, local historians, and those involved in the rediscovery of the Noisy Scrub-bird.

My deepest thanks to Mr and Mrs D.A.P. West for their invaluable assistance in charting the course of developments from 1911; to Mr G.L. Johnson, local journalist and history enthusiast of the area, who provided a number of useful leads into the maritime history of the area. Mr H. White, President of the Western Australian Historical Society, Albany Branch, gave freely of his time and knowledge, as did the staff of the Albany Shire Library. Other long-term Albany residents, Messrs W.W. Green, P. Evans and F. North, supplied some interesting information and photographic records of activities at Two Peoples Bay.

Mrs K. Hendersen of the Battye Library, Perth, patiently dealt with my numerous enquiries and requests in a most helpful and cheerful manner as did

the staff of the Western Australian Maritime Museum. The Head Librarian, Reid Library, University of Western Australia, gave permission for the reproduction of the Baudin expeditions map of Two Peoples Bay; and the Peabody Museum, Salem, Massachusetts, graciously gave permission to use a photograph of the *Charles H. Morgan* to illustrate the text.

Professor L. Marchant, University of Western Australia, provided helpful suggestions concerning the French expedition of 1800-1804.

The former Surveyor General of the now Department of Land Administration permitted research of Departmental files and archive material, and provided facilities to work while in the archive and records sections.

The section on the rediscovery of the Noisy Scrub-bird is controversial. To come to the present conclusions, detailed individual interviews were held with each of the persons involved. The information from these interviews was complemented by examining documentary evidence, both published material and private correspondence, which the individuals supplied. I am grateful for the help of the late Dr D.L. Serventy (1904-1988) and the late J. Ford (1932-1987), and Messrs C. Allen, K.G. Buller, P.J. Fuller and the late H.O. Webster (1909-1990), for without their assistance this section would be incomplete.

ABBREVIATIONS

CALM: Department of Conservation and Land Management

CSIRO: Commonwealth Scientific and Industrial Research Organisation

CSO: Letters to the Colonial Secretaries Office, Perth (held at the Battye Library, Perth, W.A.)

DOLA: Department of Lands Administration

RAOU: Royal Australasian Ornithologists Union

NOTES

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3 Austin, - Flinders to Banks, 3 June 1801, p.90.

4 M. Flinders, *A Voyage to Terra Australis*. Australian Facsimile Edition, (Libraries Board of South Australia, Adelaide, 1966), Vol. 1, p.74.

5 N. Baudin, *The Journal of Post Captain Nicolas Baudin Commander in Chief of the Corvettes Geographe and Naturaliste*. Transcript Christine Cornell, (Libraries Board of South Australia, Adelaide 1974) p.482.

6 Baudin, p.484.

7 M. Ransonnet, *Report to Commander N. Baudin on an expedition between 20-27 February, 1803*. (Translated manuscript held at the Battye Library, Perth.)

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12 N.C. Haley, *Whale Hunt*. The Narrative of a Voyage by Nelson Cole Haley, harpooner in the ship *Charles W. Morgan* 1849-53. (Travel Book Club, reprint, London, 1951), p.50.

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15 E. Lockyer to Macleay, 22 January 1827. Historical Records of Australia. Series 3, p.472, p.490.

16 A. Collie, `Account of an excursion to the north of King George's Sound between the 26th April and the 4th of May 1831', In *Journal of Several Expeditions made in Western Australia during the years 1829, 1830, 1831 and 1832*, ed. J. Cross (J. Cross, London, 1833) p.150.

17 Collie, p.151.

18 Collie, p.151

19 Collie, pp.150-1.

20 Harbour return, 1837. Colonial Secretaries Office, Perth (held at Battye Library, Perth).

21 P. Belchers to Governor Stirling, 9 August 1837, Letters to the Colonial Secretaries Office (CSO).

22 T.B. Sherratt to Colonial Secretary, 7 April 1837, CSO.

23 T.B. Sherratt to Colonial Secretary, 5 April 1837, CSO.

24 T.B. Sherratt to Commander Crozier, 5 April 1837, CSO.

25 T.B. Sherratt to F. Coffin, 7 April 1837, CSO,

26 N. Wace and B. Lovett, *Yankee Maritime Activities and the Early History of Australia,* (Australian National University Press, Canberra, 1973), p. 99; Other American whalers known to have been active in Two Peoples Bay during the 1837 season were the *Delphos* and *Tuscaloosa*. It should also be noted that the question of `fishing rights' followed Coffin when he shifted his whaling station from Two Peoples Bay to Leschenault Bay in 1840. He defended the rights to foreign whalers in a reply to Mr. H. Bull:

`Sir, I hereby acknowledge the receipt of a copy of a letter from the local government in which they say we have no right to whale in this bay but at the same time do not intend to interfere with us so long as there is no English Whaler at the same place this act of Courtisy [sic] I consider our due for having found and proved the best Anchorages on this coast such as Doubtful Island, Cape Riche, Two Peoples Bay, Geographe, Lesunault [sic] and Saftey [sic] Bays all of which have been first proved by Yankee enterprise...' (F. Coffin to H. Bull, 22.6.1840. CSO.)

27 R. McNab, *The Old Whaling Days*. (Whitcomb and Tombs, Christchurch, 1913), pp.245-6.

28 R. Glover, Captain Symes at Albany. *Journal and Proceedings of the Western Australian Historical Society*, 6 (1953), p.82.

29 P. Belchers to Governor Stirling, 9 August 1837, CSO.

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31 Glover, pp.86-8.

32 Stephens, `Sealing Industry' p.72.

33 B. Hicks, History of Americans in Albany, W.A., (unpublished manuscript, in Battye Library, Perth) 1966, Part 1.

34 G. Henderson, *Unfinished Voyages. (Western Australian Shipwrecks 1622-1850)*. (University of Western Australia Press, Nedlands, 1980), pp.195-6.

35 Henderson, p.195. It is of interest to note that the *Samuel Wright* was itself wrecked in similar circumstances to the *Avis* but at Leschenault Bay. J.R. Wollaston, second part of note in Reference List.

36 I.D. Heppingstone, `The American Whalers in Western Australian Waters'. *Journal and Proceedings of the Western Australian Historical Society*, 7, (1969), pp.39-40.

37 P. Belchers to Colonial Secretary, 3 October 1840, CSO.

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39 J.R. Wollaston (1948). *Wollaston's Picton Journal 1841-1844*: being Volume 1 of the Journals and Diaries (1841-1856) of Revd. John Ramsden Wollaston, M.A., Archdeacon of Western Australia, 1849-1856. Collected by Rev. Canon A. Burton - Perth: (C.H. Pitman, 1948); (reissued University of Western Australia Press, Nedlands, 1975), p.18.

40 Haley, p.40.

41 Heppingstone, `Bay Whaling in Western Australia', p.40.

42 P. Belchers to Colonial Secretary, 10 June 1849, CSO.

43 E. Lockyer to Macleay, Historical Records of Australia, Vol. 6, pp.466-72.

44 Haley, pp.50-1.

45 Heppingstone, `Bay whaling in Western Australia', p.29.

46 Haley, p.51. The destination of the message was only about 20 miles away, in Albany.

47 Haley, pp.51-2.

48 Heppingstone, `Bay Whaling in Western Australia', p.37.

49 Heppingtone, p.37

50 D.S. Gardon, *Albany - A Panorama of the Sound from 1827*, (Nelson, Melbourne, 1977), pp.185-6.

51 DOLA 138/91, Vol.1, p.2.

52 DOLA 782/90, Vol.1, p.6. Reserve No.2015 was gazetted on 12 March 1892.

53 DOLA 138/91, Vol.1, p.66. Reserve No.2028 gazetted on 12 May 1892.

54 Garden, p.211.

55 DOLA 782/90, pp.2-5.

56 Garden, pp.224-5.

57 DOLA 138/91, p.21.

58 DOLA 138/91, pp.30-2.

59 Garden, p.228.

60 Land Titles Office, Deeds and Registrations section.

61 References to the sand dune are as follows:

A. The original map of the area in 1803 does not show the sand dune though it would have been clearly visible from the sea and land where the two teams of Ransonnet & Baudin/Faure went to prepare detailed charts.

B. In 1831 Alexander Collie did not mention the dune when he surveyed the area from the top of Mt Gardner. From the top of Mt Gardner the dune is clearly visible. Collie noted Moates Lake yet did not mention the sand blowout.

C. A description of the coastal features in the Albany area in the Government Gazette of 18 February 1879, includes: `Behind the east end of this beach [Taylor Inlet to Rocky Point] is a black bushy topped peak rising from the southern edge of a bare sand drift over a mile square. Behind the sand drifts are several lakes and swamps...'.

D. The W.A. Land Company maps of location 416 detailed a number of tracks that were in use in 1890-1. One of these tracks passed south of Moates Lake through the heart of the sand dune area. There is no indication of the dunes on these maps.

E. The 1912 map drawn by the Department of Lands and Surveys shows a small sand dune in the same region as the present one.

F. The 1931-2 lithograph of the area shows the dune in its present position and approximately the same size as today. F.G. Medcalf surveyed the area east of Moates Lake in 1925, this area centred on the brackish Lake Gardner was leased as location 5394. No lease was taken out on the area around the freshwater Moates Lake.

62 Garden, p.272; classification roll, Plan 631, December 1898, DOLA.

63 Garden, p.272.

64 Historical Data - Two Peoples Bay: Reference PWWS 759/54 - memo 17 May 1963. Supplied by Water Authority of Western Australia, Albany office.

65 Fisheries Department of Western Australia, File 1894-1964, Albany District Fisheries: Temperatures in streams in vicinity of acclimatisation of fish, AN 108/1, File 271/16, Accession 652, Battye Library, Perth.

66 Mr & Mrs D.A.P. West, personal correspondence.

67 Mr & Mrs D.A.P. West, personal correspondence; E.G. Green, personal correspondance.

68 Green, personal correspondance.

69 Garden, pp.294-298.

70 Green, personal correspondance.

71 Mr. F. North, from private interview.

72 DOLA 782/90. Vol.1, pp.107-9.

73 DOLA 782/90, Vol.1, pp.93-5

74 DOLA 1299/40, Vol,1 p.6.

75 DOLA 138/91,. Vol.2, p.132.

76 DOLA 138/91, Vol.2, pp.135-7.

77 DOLA 138/91, Vol.2, p.147.

78 DOLA 4932/54, Vol.1, p.1. Under Secretary of Lands in reply to the application to develop the area made in 1957.

79 DOLA 4932/54, Vol.1, p.19.

80 DOLA 4932/54, Vol.1, p.22.

81 DOLA 4932/54, Vol.1, p.25.

82 DOLA 4932/54, Vol.1, p.34.

83 DOLA 4932/54, Vol.1, p.1, Department of Lands and Surveys; p.39 Town Planning Department; p.44 Albany Road Board.

84 DOLA 4932/54, Vol.1, p.1, p.80.

85 DOLA 4932/54, Vol.1, p.88.

86 DOLA 189/60 Vol.1, p.4 and accompanying plan of Casuarina townsite.

87 DOLA 4932/54, Vol.1, p.109.

88 DOLA 4932/54, Vol.1, pp.11,20,27,30,32,45,53, 75,79,93.

89 DOLA 4932/54, Vol.1, p.111.

90 DOLA 4932/54, Vol.1. p.114.

91 DOLA 4932/54, Vol.1. p.149.

92 H. White, private interview. For further information see sections on introduced species in Chapter 14 in this publication.

93 DOLA 782/90. Vol.2, pp.115-128.

94 C. Allen, private interview.

95 K.G. Buller, A new record of the Western Bristle-bird. *Emu*, 1945, 45, p.78.

96 Buller, p.79.

97 CALM File No. 015301F3516, Licence to Take Fauna for Scientific Purposes pp.16-19. Mr Ford collected six Western Bristlebird specimens from Two Peoples Bay in two trips on 24-25 January 1961 and 11-12 November 1961.

98 The late H.O. Webster, private interview. Mr Webster began his study on the breeding habits of the Western Bristlebirds in September 1961.

99 CALM File No. 015163F3807 - Rare and Endangered Fauna: Noisy Scrub Bird, Vol.1, p.32.

100 CALM File No. 015163F3807, pp.1-21.

101 CALM File No. 015163F3807, p.21.

102 J.R. Ford, Western Australian Branch Secretary Notes. *Emu* 63, 1963, p.90.

103 K.G. Buller and J.R. Ford, `The Rediscovery of the Noisy Scrub Bird' (Unpublished) 1962.

104 CALM 015301F3516, Vol.1, p.19.

105 Individual interviews with Messrs Ford, Buller and Allen, each occurring without the knowledge of the other participants in the saga. They independantly produced the same story of the meeting at Mr Allen's house on the night of 12 November 1961.

106 Webster, from private interview.

107 The late J.R. Ford, private interview and personal papers.

108 Webster, 30 November 1961; Ford, personal papers.

109 Webster, Field Note Book entry from 17 December 1961.

110 Webster, 17 December 1961.

111 H.O. Webster, Re-discovery of the Noisy Scrub-Bird *Atrichornis clamosus, Western Australian Naturalist,* 8, (1962), p.57

112 Webster (1962).

113 D.L. Serventy to W.D.L. Ride, 30 December 1961, CALM 015163F3807, pp.26-32.

114 D.L. Serventy to W.D.L. Ride, 30 December 1961.

115 D.L. Serventy to W.D.L. Ride, 30 December 1961.

116 D.L. Serventy to W.D.L. Ride, 30 December 1961. Ford had approached Dr Ride of the Western Australian Museum upon reading the news of the rediscovery and had proceeded to the place at Two Peoples Bay which Allen had described to him on the evening of 12 November 1961, to collect two specimens for the Museum. This collection could take place since the Director of the Department of Fisheries and Fauna had full knowledge of the operation and had authorized the collection. Ford was not convinced that Webster had found the Noisy Scrub-bird at Two Peoples Bay as the newspaper article only mentioned the general area of King George Sound.

Ford and Allen met Webster at his home on the evening of 28 December 1961. This meeting was confused and people became agitated when Ford announced his intention to collect two specimens for the Museum and then learnt that Webster's sightings occurred at the very place Ford intended to go to collect the Museum specimens. Serventy to Ride *op.cit.*; Ride to Serventy 5 January 1962, CALM 015163F3807, Vol.1, p.35; Private interviews with J.R. Ford, H.O. Webster and C. Allen.

117 The matter of who should receive the honour for the rediscovery weighed heavily on the minds of some of those involved. See:

29 July 1963, `Finder of Noisy Scrub Bird Annoyed' *Albany Advertiser ; 16 August 1963, `Noisy Scrub Bird' Albany Advertiser* ; Webster, Field Note Book, entry for 17 December 1961; J.R. Ford, `The Rediscovery of the Noisy Scrub-bird' unpublished; Serventy to Ride, 30 December 1961, CALM 015163F3807, Vol.1., pp.26-31.

118 Serventy to Fraser, 22 January 1962., CALM 015163F3807, Vol.1., pp.45-6; H.O. Webster, Re-discovery of the Noisy Scrub-Bird *Atrichornis clamosus* - Further Observations, *Western Australian Naturalist,* 8, (1962), p.81.

119 Webster (1962, pp.81-2.

120 Webster to Under Secretary of Lands, August 1962, DOLA 955/62, Vol.1, pp.25-6.

121 R.A.O.U. to Under Secretary of Lands, 10 February 1962. DOLA 955/62, Vol.1, p.5.

122 Albany Shire to Under Secretary of Lands, July 1962. DOLA 955/62, Vol.1, p.23.

123 Hon. D. Brand to H.O. Webster, 3 September 1962. DOLA 955/62, Vol.1, p.35.

124 File note, Under Secretary of Lands, 13 September 1962. DOLA 955/62, Vol.1, p.35.

125 H.R.H. the Duke of Edinburgh to Minister of Fisheries and Fauna, 28 November 1962. DOLA 955/62, Vol.1, p.43.

126 Minister of Lands to Minister of Fisheries and Fauna, 28 November 1962. DOLA 955/62, Vol.1, p.44.

127 7 *November* 1962 *Daily Mail*; 29 March 1963 *West Australian*; 10 April 1963 *West Australian*; 15 January 1963 *Daily News*; 19 December 1963 *West Australian.*

128 CALM 015163F3807. Vol.1, 6-8 April 1964, pp.5-6.

129 World Wildlife Fund to Minister of Lands, 14 February 1964, DOLA 995/62, Vol.2., p.108.

130 Mr J. Hall, MLA, 7 July 1967, *Albany Advertiser.*

131 Miss J. Reeve to Minister Fisheries and Wildlife, 9 August 1966, CALM 015163F3807, Vol.1, pp.27-8. Miss Reeve's comment agrees with the immediate response of Dr. Serventy who said that the principal threat to the Noisy Scrub-bird would be the scientists; Serventy to Ride, 30 December 1961, CALM 015163F3807, Vol.1, p.28 `The Scientific collector is, as far as we know, the birds greatest peril now...'.

132 CALM 015163F3807, 6-8 April 1964, pp.5-6.

133 Minister of Lands to Minister of Town Planning, 25 March 1965, DOLA 995/62, Vol.1., p.126.

134 Minister of Lands to Minister of Town Planning, 22 October 1965, DOLA 995/62, Vol1, p.135.

135 DOLA 995/62, Vol.2.: p.1, International Council of Bird Preservation, 25 July 1966; p.3, World Wildlife Fund, 15 August 1956; *Le Council International de la Chasse* 25 July 1966; personal papers of Dr D.L. Serventy.

136 The Premier Hon. D. Brand had as early as 3 September 1962 committed approximately 13,600 acres to be a nature reserve. DOLA 955/62, Vol.1., p.30; The Minister of Lands had made similar commitments, DOLA 995/62, Vol.1, p.42; and had been quoted in the daily press, 15 January 1963, *Daily News.*

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Webster, H.O., Private papers, field note books, and correspondence held at Battye Library.

West, D.A.P., Private papers and correspondence held by D.A.P. West.

PERSONAL COMMUNICATION

Allen, C., deceased ornithologist, formerly of Albany.

Buller, K.G., retired taxidermist, Western Australian Museum.

Ford, J.R., deceased professor, Western Australian Institute of Technology (now Curtin University).

Green, E.G., local identity, Kalgan district.

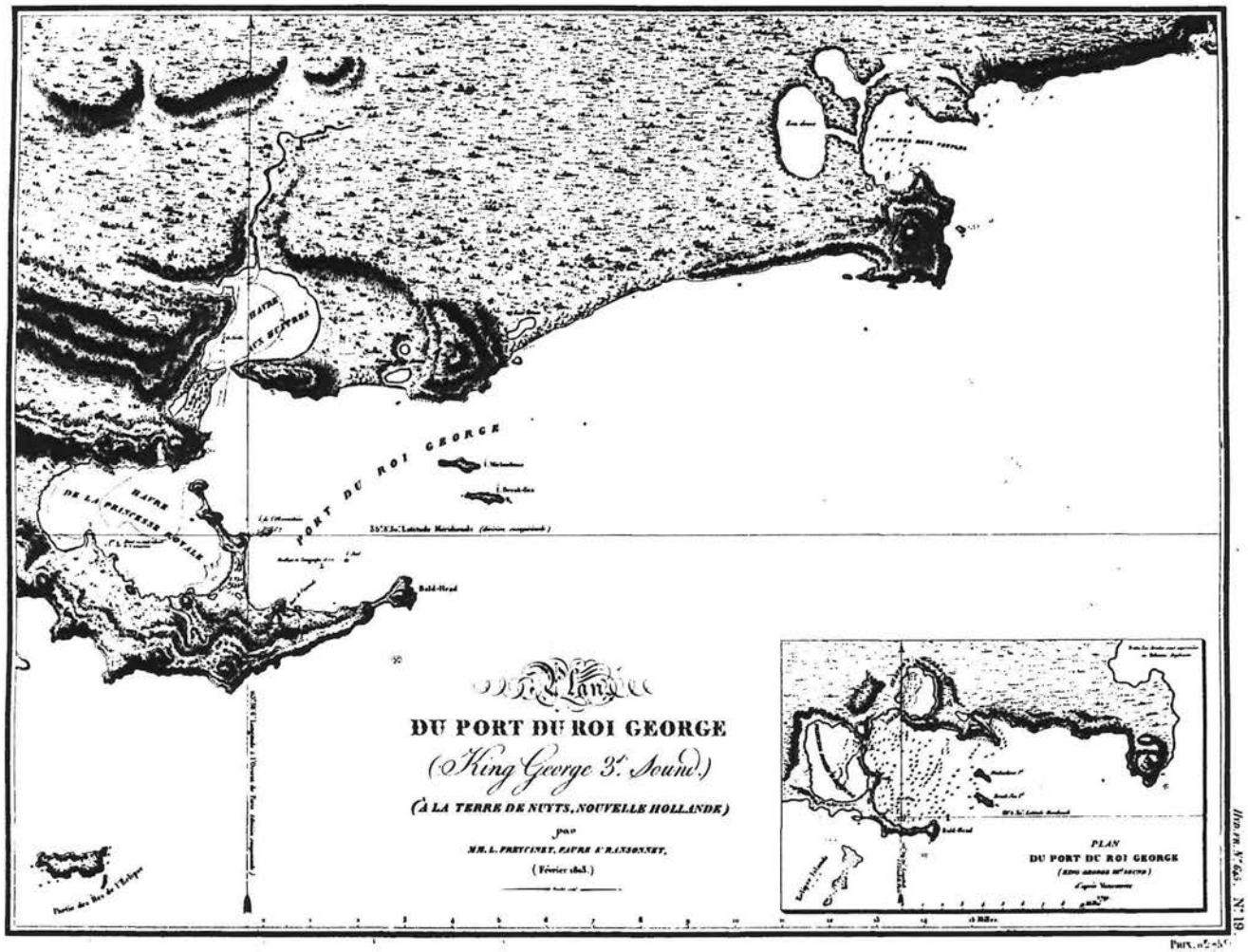
North, F., third generation professional fisherman in Albany district.

Sokolowski, R.E.S., former Reserve Officer at Two Peoples Bay Nature Reserve, now Technical Officer (CALM) at the Western Australian Wildlife Research Centre.

Webster, H.O, deceased headmaster of Albany Primary School.

West, D.A.P., author and local historian, Mt Barker.

White, H., former president of Albany branch of the Western Australian Historical Society.



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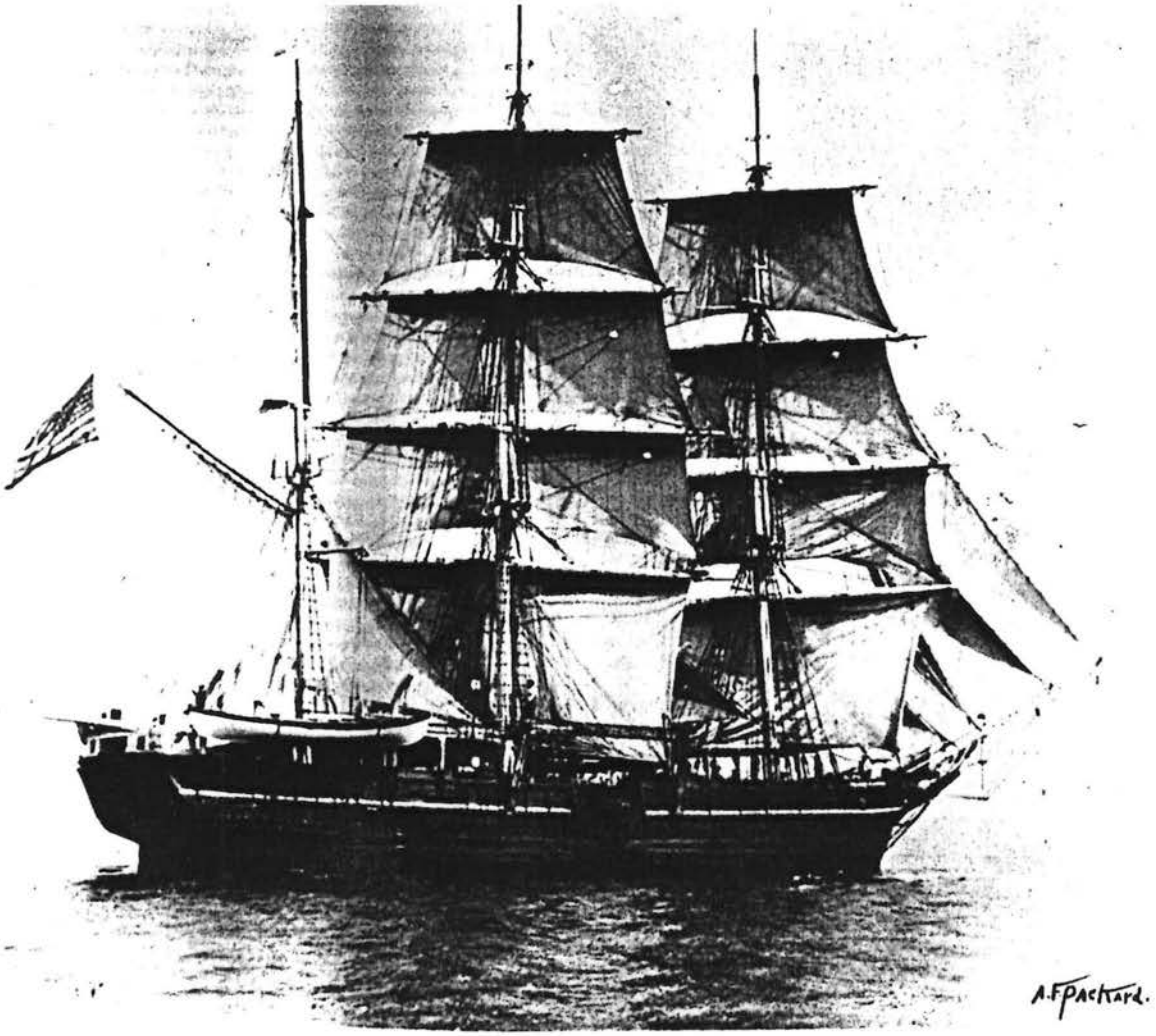

Figure 2.2

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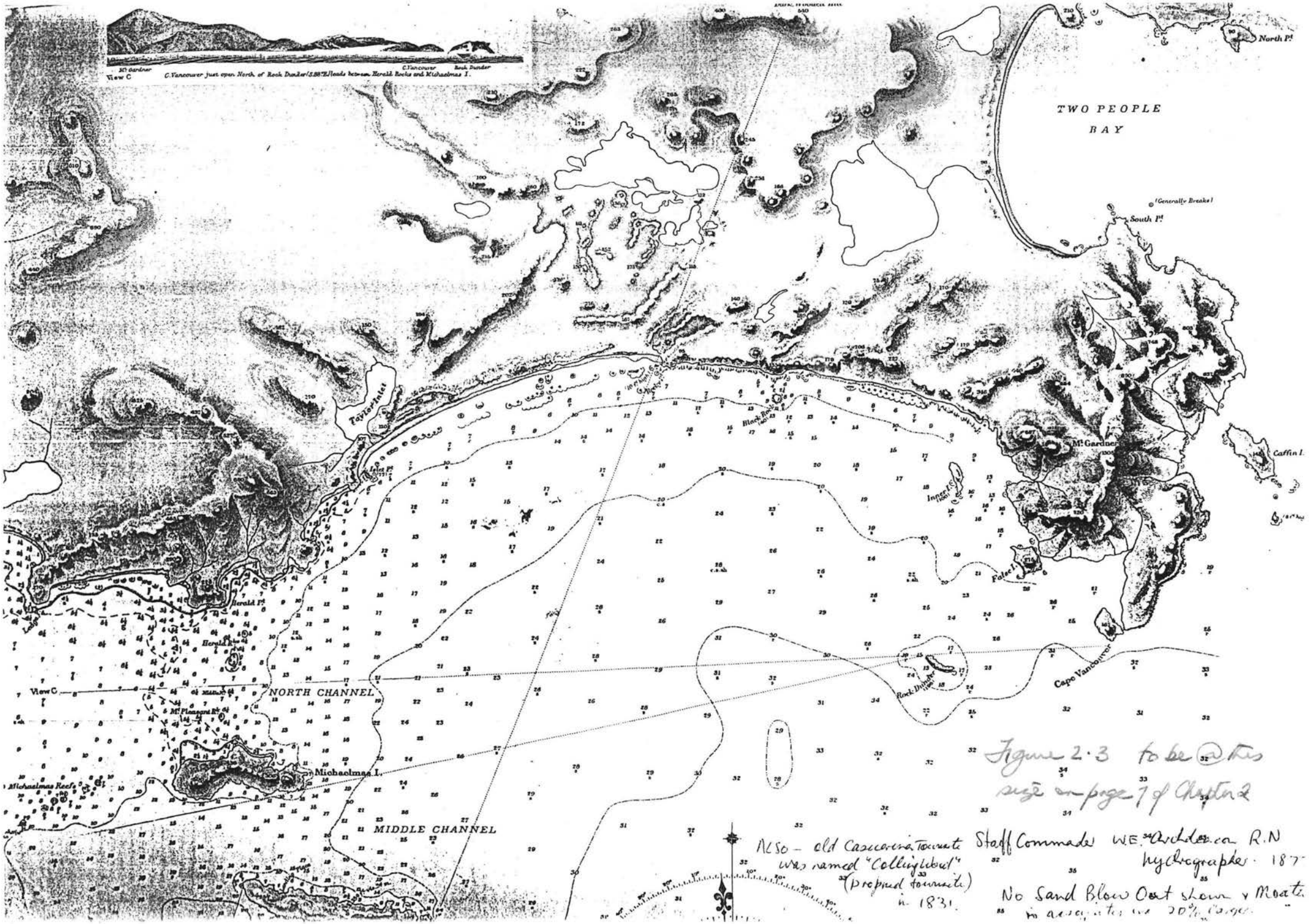
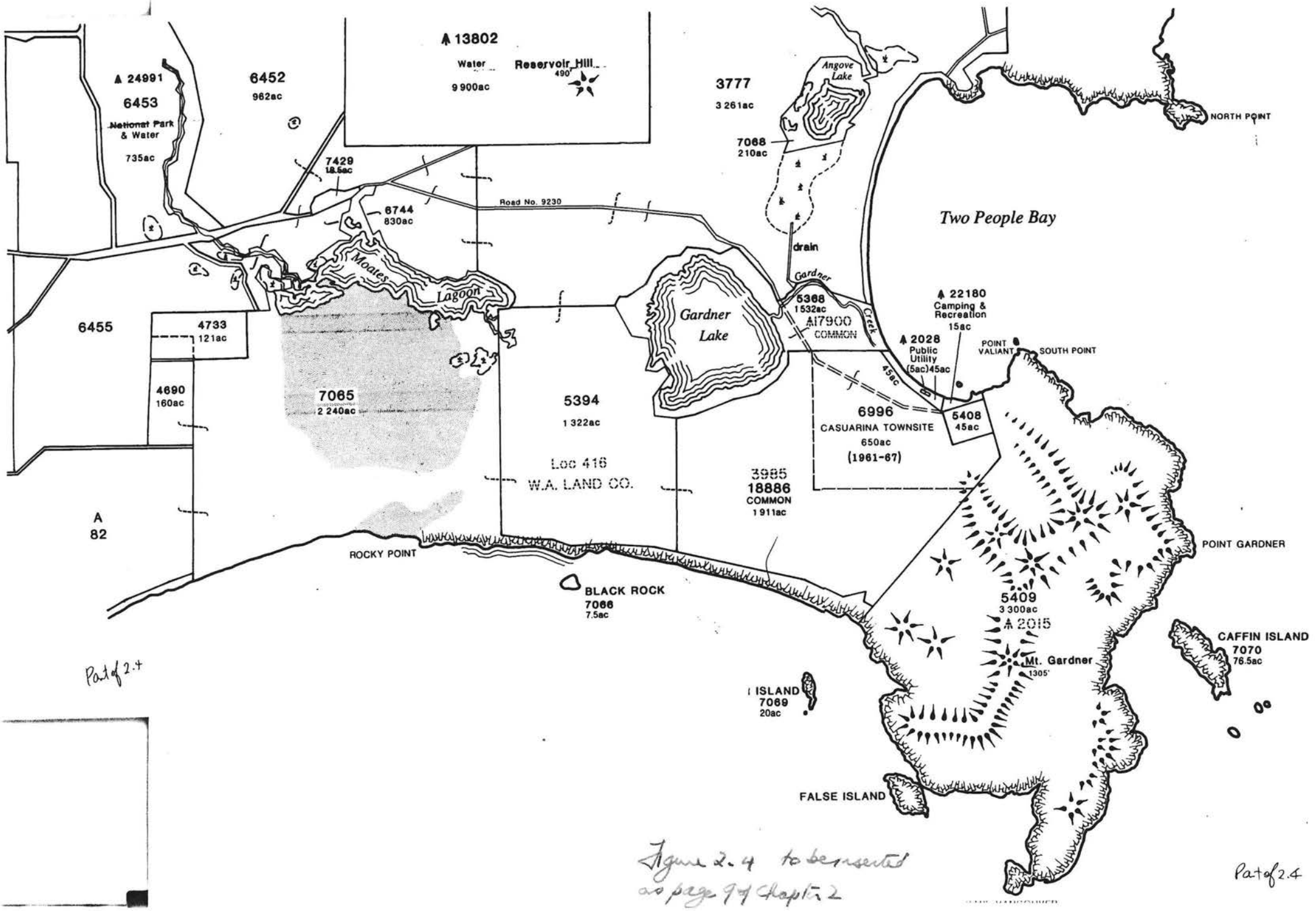


Figure 2·3 to be @ this size on page 7 of Chapter 2

Also – old Cascarena Tsimsatt was named "Collinglebut" (proposed township) in 1831.

Staff Commander W.E. Archibald R.N Hydrographer 187-

No Sand Blow Out shown x Moats in area of the 20 Fathom Range



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Part of 2.4

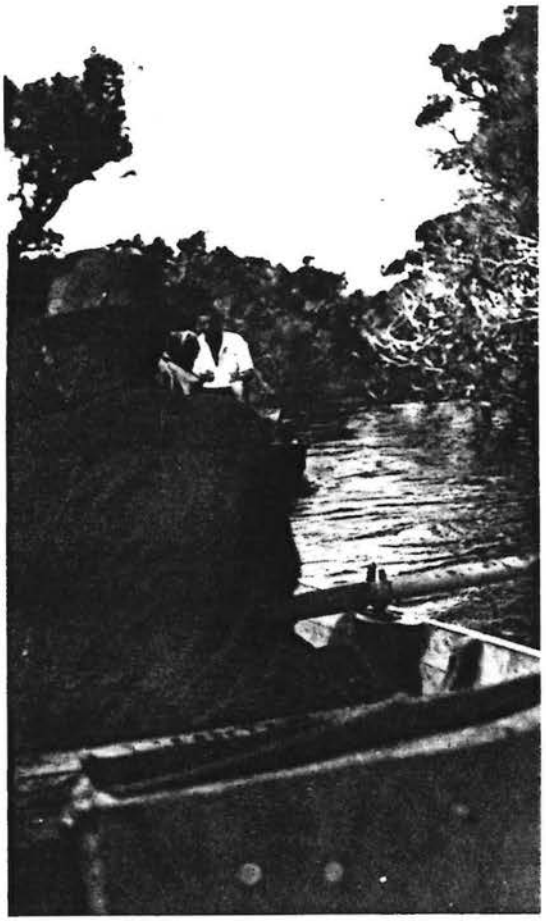

Figure 2.6
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Chapter 2

Fig 2.7 of chapter 2
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page 12 of chapter 2

Figure 2.8
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14 of Chapter 2

Fig 2.8
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Figure 2.9
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Chapter 2

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CHAPTER 3

Management of the Reserve

N.J. Coy, A.A. Burbidge, A. Danks, G.L. Folley and R.E.S. Sokolowski

INTRODUCTION

With the cancellation of the Casuarina townsite on 22 April 1966, the first 260 ha portion of the Two Peoples Bay Reserve was gazetted as Reserve No. 27956 for the purpose of Conservation of Fauna,[1] vested in the Fauna Protection Advisory Committee (FPAC).[2] The Reserve was to be administered by the then Department of Fisheries and Fauna.

Creating this sanctuary for the preservation of the rediscovered Noisy Scrub-bird (*Atrichornis clamosus*) set a precedent which was followed two months later when two reserves were gazetted in the Perth metropolitan region for the preservation of the Short-necked tortoise (*Pseudemydura umbrina*), which had been rediscovered in 1953. These benchmark wildlife sanctuaries (as nature reserves were then known) were a new concept in Western Australia at a time when the conservation ethic was still alien to most people.[3]

With the newly declared Reserve at Two Peoples Bay the Department and FPAC were inheriting a varied coastal landscape, degraded in parts by recreational access and human occupation, overgrazing by livestock and frequent fires. Parts of the Reserve had been exploited for timber by the sealers, whalers and woodcutters of the nineteenth century. During the first half of the twentieth century contract woodcutters procured sheoak from the Reserve to supply the cooperage at Albany. A limited amount of firewood was also cut from the Reserve to fire the pumping station boilers at the Angove River dam, prior to power being converted to the State Electricity Commission supply in 1953[4] (ch. 2 this publication).

The authorities also inherited a degree of resentment amongst the local community, displaced to create the Reserve, because they had anticipated their squatters' settlement would develop into a burgeoning holiday village. The public, including professional fishermen and anglers, had enjoyed access to the coastline, and Moates Lagoon (now Moates Lake) was popular for boating and catching marron (*Cherax tenuimanus*). The members of several local football clubs used the area as a pre-season training course, by running over the sand dunes after swimming across the lake.

These factors were to become important elements in managing the Reserve in a manner acceptable to the public while, at the same time, fulfilling the reason for its creation - the preservation of the Noisy Scrub-bird in its natural environment. The past quarter of a century has seen dramatic increases in rare bird numbers, regeneration of native vegetation, removal of squatters' camps and conservation of large areas of bush. Although the Reserve is still potentially threatened by both humans and natural forces, the story of its development to 1991 is in the vanguard as a model example of intelligent and determined nature conservation management.

THE FIRST TENTATIVE STEPS

At first, the Department was not in a strong position to manage the newly declared Reserve. There were only four Fauna Wardens (now known as Wildlife Officers) to cover the whole State and only one of these was based in the country. The sole, graduate fauna research officer employed by the Department was fully occupied on waterfowl conservation. The Department depended largely on advice from the FPAC because it had limited expertise and experience in managing nature conservation reserves. In 1966 an additional warden, Mr Malcolm MacDonald, was stationed at Albany to patrol an enormous area along the south coast that extended inland to Kojonup. He was also to manage the new sanctuary at Two Peoples Bay.[5]

A problem that needed early resolution was the administrative error in the gazetted description of the area set aside for the Reserve. This was ultimately

corrected on 2 June 1967 with re-gazetting of Reserve No. 27956 to increase the area to 4638 ha.[6] The boundary along the 25 km of coastline extended only to high water mark - a situation that remained unchanged until the Reserve was extended to the low water mark in 1987.

In July 1966, Fauna Officer, Mr H.B. (Harry) Shugg was sent overseas to study the organisation of nature conservation in the United Kingdom. While overseas he addressed three environ- ment-oriented conventions at Lucerne, in Switzerland, and at Cambridge and Oxford in Great Britain. As a guest speaker, Mr Shugg described work being done on the Noisy Scrub-bird and, to a lesser extent, the short-necked tortoise. Mr Shugg's visit brought further international acclaim from conservationists, as exemplified in a letter from the Secretary of the Survival Services Commission of the International Union for the Conservation of Nature and Natural Resources (IUCN) to the Minister for Lands:

> ....the Commission was greatly heartened by the wonderful news of your outstanding decision not to proceed with plans for the Casuarina township...at Two People Bay...without any doubt at all it will ever be quoted as a most memorable example of true conservation, designed to ensure the survival in perpetuity of an interesting and unique bird.[8]

Squatters Evicted

The first management problem to be addressed concerned the 16 squatters' shacks (Fig. 3.1) which had been built on the cancelled Casuarina townsite, in the vicinity of the present picnic area (ch. 2 this publication). Following FPAC's decision to exclude residential development and camping activities on the Reserve, the Department wrote to the shack owners in June 1966, directing them to remove all shacks and materials by 31 December 1966.[9] After several shack owners asked for the notices to be withdrawn, Mr J. Hall, MLA for Albany, wrote to the Minister for Fisheries and Fauna enclosing a petition signed by 22 squatters. In his covering letter dated 2 November 1966, Mr Hall stated:

> To the people who enjoy Two People Bay, that notice is a tragic blow...It could also be claimed that they live in harmony with the Noisy Scrub-bird, in fact the bird will leave the area when the children are not about and return when they come back for their holidays after school has broken up...It is my firm conviction that the Noisy Scrub Bird does like children and if denied their company will leave the area...[10]

Early in 1967 the FPAC met to consider the objections to the eviction notices and resolved to recommend to the Lands Department that one person, Mr C. Wilson, who fished the Bay professionally, be granted a lease.[11] All other pleas were rejected and the Crown Law Department was approached to give an opinion as to what action could be taken against persons who had not removed their buildings.[12] Crown Law advised that there was no power to prosecute under the Fauna Conservation Act but that the FPAC could take court action under Common Law to take possession of buildings and other materials left on the Reserve.[13] The FPAC resolved accordingly and the matter was heard in the Albany Court on 8 September 1967. Action was originally taken against sixteen persons but thirteen removed their buildings before the hearing date and actions against them were discontinued. The FPAC was granted an order for possession of the remaining three buildings.[14]

One owner was overseas at the time of the court action and, on his return late in 1967, he approached the Department to see if it was interested in buying his cottage for $1000 on a `walk-in walk-out' basis. This building was well constructed and, after obtaining a valuation, the Department agreed to purchase it.[15] The cottage, plus additions, is still in use today as the Research Station and Reserve Office (Fig. 3.2).

Management Policies Formulated

Another major management problem was dramatically highlighted on 20 December 1966 when a large tract of land west of Mt Gardner was burnt out - much of it by back-burns lit by volunteer members of the Lower Kalgan Bushfire Brigade (LKBB). Although the fire was primarily outside the cancelled Casuarina townsite reserve it burnt a considerable portion of the area then under consideration for the enlarged Reserve. Early in 1967 Departmental officers discussed fire control with the Captain of the LKBB and agreed on an initial system of bulldozed firebreaks (ch. 19 this publication).

Having overcome the immediate management problems the FPAC next considered its long-term policy for the Two Peoples Bay Reserve. In September 1967 a Sub-Committee was appointed to look at all aspects of management of the Reserve. The Sub-Committee consisted of Dr D.L. Serventy, Mr A.J. Milesi, Mr A.H. Robinson, Mr H.B. Shugg and Mr A.T. Pearce.[16] Arthur Pearce was a former rock lobster fisherman and fisheries inspector from Geraldton who had replaced Mr MacDonald as Fauna Warden at Albany.

The Sub-Committee visited the Reserve and reported back to the FPAC in October. The FPAC adopted recommendations that the Reserve should be

open to as much public use as possible without compromising the purpose of the Reserve, i.e. the protection of the Noisy Scrub-bird and other species of animals and plants. It was decided that public use should be on the basis of day visits only. Camping and the parking of caravans were not to be permitted.[17] Plans for a system of firebreaks were also adopted and it was resolved to commence a census of the flora and fauna of the Reserve. The initial bulldozed firebreaks, begun in March 1968, were later extended in an attempt to prevent fires from crossing the Reserve boundary and to provide a firebreak and fire-fighting access between Lake Gardner and the Southern Ocean (Fig. 19.3).

In October 1968, the Department appointed its first two officers to work mainly on reserve management research. One of these was Dr A.A. (Andrew) Burbidge, who was responsible for developing and administering policies at Two Peoples Bay Nature Reserve.

Research Future Assured

After publishing his reports in 1962 on the re-discovery of the Noisy Scrub-bird, the late Mr H.O. (Harley) Webster (see notes 111 and 112 in ch. 2 this publication) commenced a study on the bird's song. He was supervised by Mr F.N. (Norm) Robinson, Division of Wildlife Research, CSIRO, who had previously completed studies on the Lyre bird's song. In 1966 Mr Robinson was transferred to Perth from Canberra and began a study of the Noisy Scrub-bird under a part-time study grant from the Science and Industry Endowment Fund.[18] Automatic recording equipment was installed to measure song output and ecological and behavioural data were collected in an attempt to understand the function of the song. Fifty-five territories of singing male Noisy Scrub-birds were identified on the Mt Gardner headland, (from data collected between 1962 and 1965), and the bird population (ch. 16 this publication) appeared to be reasonably viable in its limited environment.[19]

In August 1968 the Western Australian Wildlife Authority, which had replaced the FPAC, requested a report from Robinson for the development of a management program. Information on the history of the Reserve, particularly relating to fire, was also sought from Webster (ch. 19 this publication). Robinson's report concluded that it was not possible for him to make suggestions on a long-term management program but he was sure that the survival of the rare birds had been `entirely due to the relative protection of the small promontary of Mt Gardener [sic] from perennial firing by man.'. Both reports stipulated a total ban on fires and the closure of tracks, especially those eroding badly on steep terrain.[20] Robinson also advocated sign-posted walking tracks and a few shelter sheds, especially in the Mt Gardner area: `The flora and scenic views on the seaward side of Mt Gardner...are amongst the finest in the world...[but] have been seen by very few people'.[21]

These reports reinforced the opinion that before an effective management plan could be developed for the Reserve a great deal of information would be needed on the biology of the Noisy Scrub-bird and the other rare species occurring there. Departmental staff were fully committed so the Wildlife Authority decided to ask the CSIRO Division of Wildlife Research to expand its work on the Reserve.[22] In April 1969, Dr H.J. Frith, Chief of the Division, stated in his reply that the part-time study (of Robinson and Webster) had created a reasonable basis on which future work could be planned. Dr Frith and Dr S.J.J.F. Davies (Officer-in-Charge, Perth Laboratory of CSIRO Division of Wildlife Research) proposed a change in direction by broadening the terms of reference for a wider study:

> We should suggest that although the central work would be around the Noisy Scrub-bird the behavioural and other inter-relations that exist with the Western Whip-bird, Heath Wren, Bristle Bird and Emu Wren should also be used to provide background and depth to the work. We would hope that the work would demonstrate the value of the behavioural and other population control mechanisms that operate in that specialised environment. The study would also be expected to give some insight into the management of a relatively small and isolated reserve.[23]

The Wildlife Authority met in June 1969 and resolved to accept the broad-based research program outlined by Dr Frith who then approached the CSIRO Executive with a definite proposition.[24] This proposal was approved and Research Scientist, Dr G.T. (Graeme) Smith commenced work in April 1970.[25] In the summer of 1970/71 an A-frame research station (Fig. 3.3) was built adjacent to the small shed on Tick Flat that had been built by CSIRO personnel in 1966.[26] The research station was named `Jeemuluk' - an Aboriginal word for the Noisy Scrub-bird.[27]

Just prior to Dr Smith's appointment a biological survey of the vertebrate fauna (excluding birds) on the Reserve, was carried out by Dr J.L. Bannister of the Western Australian Museum (ch. 15 this publication).

GATHERING MOMENTUM

Administration Upgraded

The early 1970s heralded great changes in the development of the Reserve. Management and research policies were put in place and finances were made available to both upgrade and construct facilities, and to employ the State's first resident Reserve Officer to administer the Reserve. The need for a resident officer was further emphasised in March 1970 when two wildfires burnt out much of the Reserve area (ch. 19 this publication).

When Mr R.J. (Dick) Grayson was appointed Reserve Officer in August 1970 he had to provide hiw own accommodation. Mr Grayson, an ex-police officer and well-known local identity, was also an experienced part-time builder. Because the cottage purchased early in 1968 was not suitable for a family to inhabit year-round, Mr Grayson set to work to improve it. Two rooms and a toilet were added, a bore was sunk to provide a reliable water supply and a 240 volt alternator was installed to replace the old 32 volt DC supply. He also constructed a public toilet block at the picnic area.[28]

The Reserve's first Draft Management Plan to promote the conservation of flora and fauna was developed by A.A. Burbidge and T. Evans in 1970. It aimed at the management of the three main problems at that time - fire, public use and the proliferation of vehicle tracks. The Management Plan was adopted by the Wildlife Authority in January 1971. The final plan excluded a section recommending the Reserve be declared a éFire Protected Areaé under Section 16 of the Bushfires Act in the belief that fires on adjacent land could be better managed by co-operation than with rules.[29]

The Plan was approved by the then Minister for Fisheries and Fauna, the Hon. Ron Davies, MLA, and the classification of parts of the Reserve into éProhibited Areaé, éLimited Access Areaé and éUnlimited Access Areaé was published in the Government Gazette on 25 June 1971 (see Appendix 3.1 at end of chapter and Fig. 1.3 this publication).

Roads proposed in the Plan were upgraded from rough sand tracks into gravel roads by the Shire of Albany in October and November 1971, financed by funds for tourist roads. The original tracks were re-routed in several places to improve access for amateur anglers and to direct traffic away from the environmentally sensitive Mt Gardner area. The Shire of Albany agreed to the imposition of a 40 km/h (then 25 miles per hour) speed limit on these roads in order to increase safety and reduce road maintenance costs.[30]

Other occurrences of note during this period included the allocation of a small lease, Plantagenet Location 7132 (Fig. 2.4 this publication) to professional salmon fisherman, Charles Wilson.[31] In 1972, Mr Wilson was also given permission to construct a small wooden bridge over Gardner Creek to provide access to three huts on his beachfront lease.[32] Although the lease was cancelled in 1986 the bridge remains to this day, about 100 metres upstream from the creek mouth.

On 26 January 1972 the Two Peoples Bay Fauna Reserve was officially declared a Wildlife Sanctuary. (This terminology was later changed when the Fauna Conservation Act (1950-1970) was replaced by the Wildlife Conservation Act (1950-1975) and gazetted on 5 December 1975. The Department of Fisheries and Fauna was renamed Fisheries and Wildlife and former Wildlife Sanctuaries were renamed Nature Reserves.)[33]

Change of Personnel

In 1972 Mr Grayson was promoted to the position of Fauna Warden at Albany, where he replaced Mr Pearce. Local farmer, R.E.S. Sokolowski was appointed as Reserve Officer at the Two Peoples Bay Wildlife Sanctuary in August 1972. Ron Sokolowski was to become well-known through his rapport with visitors to the Reserve. During his six years there he also provided assistance to the Noisy Scrub-bird research program as he had special interests in ornithology and herbarium collections. He established biological and botanical study areas within the Reserve and at Gull Rock National Park, for students from the Albany Senior High School.

Public facilities were further upgraded in 1973 when direction and courtesy signs were erected in the Reserve. In the picnic area the changeroom block, with fresh water showers, and three wood-fired barbecues were built. A display board featuring Noisy Scrub-bird biology (Fig. 3.4) was installed. This display included a tape recording of Noisy Scrub-bird song, with a commentary by Dr Smith. The recording, a visitor-operated, battery tape-deck, was designed for educational use by visitors, but it sometimes stimulated territorial song from a Noisy Scrub-bird in the swamp adjacent to the picnic area.

Later in 1973, American lawyer Mr L. Milgraum purchased `Tandara' from the Webb family who had farmed the property since 1949, when they bought the farm from H.C. Poole.[34] Mr Milgraum expressed an early interest in the welfare of the Reserve and conservation in general. He also purchased the

farming land west of the Reserve through to Nanarup at a later date.

Prince Philip's visit to the Reserve

A highlight of the Two Peoples Bay Nature Reserve's history was the visit of His Royal Highness Prince Philip, the Duke of Edinburgh. Prince Philip's influence made a significant contribution toward the creation of the Reserve and he had a special interest in the Noisy Scrub-bird (ch. 2 this publication).

On the afternoon of 6 March 1974, Prince Philip officially opened the Western Australian Wildlife Research Centre at Woodvale in the Perth metropolitan area. That evening he was flown to Albany and the following morning his royal entourage drove through rain in the the pre-dawn darkness to Two Peoples Bay from their Albany hotel - quite a change after sweltering in 42°C heat at Woodvale the previous day.

The Royal Party was met at the reception area on the beachfront by Departmental and CSIRO personnel after which Prince Philip was driven by Dr Smith, accompanied by Dr Burbidge and Prince Philip's Aide-de-Camp, to the CSIRO station on Tick Flat to inspect a display inside the hut.[35] At 0700 h he set off on foot with Dr Smith, who was equipped with a tape recording of the male Noisy Scrub-bird's territorial song. Prince Philip and Dr Smith heard bird calls from four different observation points and in one instance a male bird was singing within one metre of Prince Philip but remained hidden in the thick scrub.[36]

After driving down from the mist-enshrouded Mt Gardner the party was treated to morning tea prepared by the Lower Kalgan Branch of the Country Women's Association. The ladies proudly provided their finest crockery and silverware for this very auspicious occasion, underneath a large canopy set up outside the Ranger's residence. Prince Philip met a number of local dignitaries, Reserve neighbours and other persons associated with the Reserve.

Although a little disappointed at not seeing a Noisy Scrub-bird in the incessant rain, Prince Philip was very enthusiastic about the experience and the overall concept of the Reserve. His symbolic visit to the home of the Noisy Scrub-bird gave much credibility to the Reserve and the conservation ideals it represents.[37]

SETBACKS AND ADJUSTMENTS

At Odds with the Shire

In response to repeated requests from the public to have the Two Peoples Bay Road bituminised, the Albany Shire Council passed a resolution in January 1975 to seal the road from the Nanarup turn-off to the Reserve boundary. Discussions in April, between representatives from the Wildlife Authority and the Shire, resulted in a reversal of the decision on the basis that the expected increase in visitors to the Reserve would overtax the available facilities.[38] The Shire also vigorously challenged the lack of prescribed burning and the Shire President complained to the Minister for Lands, Mr Ridge, MLA, that he regarded the Reserve as a fire hazard over which the Shire had no control.[39] This matter was resolved in November when Mr Sokolowski addressed the Shire Council to explain the revised fire control policies designed to protect the special needs of the rare fauna on the Reserve.[40]

Improving Management and Facilities

As the Reserve gathered popularity with visitors there was a pressing need to improve facilities for administrative, research and public purposes.

In 1975 a house was purchased from the Education Department and transported in three sections on the back of a low-loader truck, from the Albany Primary School to the Reserve, to become the permanent residence for the Reserve Officer and his family. The former beach shack, which had previously doubled as the Reserve Officer's residence and office, was refurbished as a research station and office for use by *bona fide* research and management personnel.

With the ever-increasing number of cars and people entering the Reserve, facilities became severely taxed. During 1976, for example, visiting groups included 32 tourist buses, 830 school students on organised outings and eight social club picnics involving a total of 850 persons. This naturally led to requests for the parking areas, toilets and change-rooms to be extended. However, these were not accepted by management as desirable additions, in keeping with the management objectives.[41]

Further upgrading of the firebreak system created a strategic, fuel-reduced zone between the Mt Gardner headland and the rest of the Reserve. The

first two segments of this twelve section firebreak were burnt in September 1976 (ch. 19 this publication).

Cyclone Alby

On the night of 4 April 1978 Cyclone Alby brought havoc and destruction to the south coast. Fortunately, there was not too much damage at Two Peoples Bay. Anemographic records from the Albany Airport show that at 1710 h the 10-35 km/h easterly wind suddenly swung to the north and increased dramatically with gusts to 85 km/h. The gale force winds increased to 130 km/h for ten minutes, then intensified to hurricane force at 150 km/h as the eye of the cyclone passed to the south-west. Half an hour after midnight the south-westerly suddenly abated to 50 km/h and, by dawn, a comparatively gentle 20-35 km/h breeze greeted those local inhabitants who ventured out to inspect the cyclone's damage.[42]

Part way through the storm, members of the Wilson family arrived to find waves pounding on the front door of their net shed (Fig. 3.5) and they had to tear off the rear wall to rescue their fishing gear from the besieged shed.[43] The north to south-westerly winds and the surging sea scoured beach and frontal dunes and dumped tonnes of weed on the beach. The wind from this very severe but short-lived, seven and a half hour storm, was not from a direction to severely damage the foredune at Two Peoples Bay as did the great storm of 1984.

CHANGING DIRECTION

Change in Administration

In January 1979 Mr Sokolowski was transferred by the Department to Karratha. He was replaced by Mr G.L. (Graeme) Folley as Reserve Officer at Two Peoples Bay in October 1979. A former cartographer with the Department of Mines, Mr Folley was a keen naturalist who subsequently helped to pioneer relocation of Noisy Scrub-birds to other reserves along the South Coast.

Mr Folley's seven years at Two Peoples Bay were to see great changes, during which time pressures on him as the only Reserve Officer increased tremendously. One of his early tasks was to assist in establishing the first section of the self-guiding nature trail, designed by Dr Burbidge (Fig. 3.6). As originally planned this was later extended to its present circuit route.[44] In 1980 Mr Folley designed new gas barbecues which were installed to replace the wood-fired ones in the picnic area and the Shire of Albany subsequently adopted the design for other reserves in the region.[45] He also initiated biology camps for secondary school students who camped on a nearby farm and commuted to the Reserve each day.

Reserve Under Threat

Two Reserve-threatening problems emerged in 1980 when the pathogenic fungus *Phytophthora cinnamomi* was positively identified on the Reserve and a resort development was proposed on adjoining farmland to the west.

The long-term problem of *P. cinnamomi* was identified in December 1980 when Mr A.J.M. (Angas) Hopkins, who had been researching fire ecology in the Reserve since 1976, and Mr Folley gathered soil samples from around dying banksias near the access track to Moates Lake.[46] When tested by the Department of Agriculture these samples proved to contain *P. cinnamomi*, thereby confirming fears that the dreaded `jarrah dieback' was established in the Reserve (ch. 21 this publication). This discovery resulted in the western third of the Reserve, which was largely free of the fungus, being gazetted as a éLimited Access Areaé on 4 December 1981 (Fig. 1.3 this publication). Because vehicles are the main cause of spreading *P. cinnamomi*, vehicular access to Moates Lake was banned, although marron-fishers and other members of the public were still permitted pedestrian access around the shores of Moates Lake and the sand dunes to the south.[47]

In June 1980 the Milgraum family applied to the Albany Shire Council for an 850 ha resort and settlement complex for Nanarup. The proposal included the establishment of several wetland reserves and a flora and fauna reserve of 169 ha abutting the western boundary of the Two Peoples Bay Nature Reserve. The resort was to include holiday cottages, townhouses, community and recreation centre, a possible convention centre, residential and rural lots, and an 18-hole golf course.[48] The Department expressed concern about the resort on the grounds that wetlands could be polluted within the Reserve; there would be problems of sewerage disposal; further spreading of *P. cinnamomi* could occur; and such an increase in the number of people in close proximity could lead to other unmanageable problems for the Reserve. The development did not proceed.[49]

Research Extended on the Reserve

During the early 1980s, research into many of the biogeographical aspects of the Reserve was actively encouraged by the Department to complement preliminary field studies on fire ecology begun by Mr Hopkins in 1976. Much of the data collected from this research formed the basis for this

publication, thereby fulfilling the guidelines agreed to by the Wildlife Authority and CSIRO when the broad-based research program was outlined in 1969.[50]

Scientific research teams from government departments, academic institutions and several private consultants were invited to participate in the detailed surveys and gathering of data on the Reserve. These included the Department's Western Australian Wildlife Research Centre, CSIRO, Department of Mines, and the University of Western Australia. Extensive assistance was given by Mr Folley, as recognised by his co-authorship of a number of chapters in this publication.[51]

In the early 1980s the CSIRO's Dr Smith continued his research at Two Peoples Bay. His work mainly involved annual censuses and captive breeding research, after his initial biological research on the Noisy Scrub-bird had concluded in 1976. However, further studies were being made on the Western Whipbird and the Bristlebird[52] and these were being aided by observations of a volunteer, Mrs Lesley Harrison.[53] Other volunteers also proved invaluable in assisting research teams and on the Noisy Scrub-bird translocation program.

Translocation of the Noisy Scrub-bird

By 1983 the number of identifiable Noisy Scrub-bird territories within the Reserve had increased to 138, a threefold increase since 1970 (ch. 16 this publication), and it appeared that the fire exclusion policy of the seventies had been successful. The amount of habitat for Scrub-birds at Two Peoples Bay, however, is limited and the population could never be expected to be really large. Therefore a decision was made to establish Scrub-bird colonies in other localities, or else they would remain vulnerable as a single, isolated population.[54]

Successful but time-consuming and expensive experiments on captive breeding by the CSIRO at Helena Valley, proved that this method was possible if ever needed.[55] Meanwhile, the Department decided to capture birds from the Mt Gardner area and transfer them to new sites (ch. 18 this publication). Towards this end the Department sought and obtained the services of Mr D.W. (Don) Merton, a world-renowned expert on the translocation of endangered birds. He was seconded from the New Zealand Wildlife Service (NZWS) to Two Peoples Bay for two months in 1983. Techniques for transferring threatened species had been pioneered and developed by NZWS over many years and these techniques proved applicable, with some modifications, to Noisy Scrub-birds. Capturing these elusive and secretive birds was more difficult and required many weeks of trial and error by the translocation team with some advice from the CSIRO's Dr Smith before reliable methods evolved.[56]

In the winter of 1983 ten male and four female birds were released in two valleys on the north-west slopes of Mt Manypeaks, 15 km north-east of Mt Gardner across Two Peoples Bay, in an area first recommended for translocation by Dr Smith in 1975.[57] In the summer of the same year two more females were translocated. By the spring of the following year six males were defending territories on Mt Manypeaks and the successful colonization of the mountain range had begun.[58]

THE HUNDRED YEAR STORM

In early August 1984 a very severe storm wreaked considerable damage along the south coast, especially in the Albany District. The storm's severity can be gauged by local people referring to it as `The Hundred Year Storm'. Large Norfolk Island pines were washed out of the ground at Albany's Middleton Beach and beachcombers picked up live crayfish among hundreds of other marine animals that had been washed in from offshore reefs.[59]

On 2 August a dual-centered, low pressure meteorological system developed; one centered near Albany and the other to the south, with a cold front stretching from Carnarvon to Albany and extending further south to the southern low. A slow moving, complex cut-off low developed and was centred in the western portion of the Great Australian Bight. A tightening of the pressure gradients late in the day caused gale force southerly winds throughout 3-4 August (see synoptic charts, Fig. 3.7).[60]

Pre-frontal north-west winds throughout the morning of 2 August dramatically increased to 74 km/h at 1710 h as the gale approached from the south. The peak of this prolonged storm continued with gusts to 110 km/h until 0130 hours of 3 August, before easing slightly to a gusty 40-90 km/h gale which continued unabated from the south-south-east, until it eased and turned westerly at about 1700 h on 4 August.[61] The storm kept Two Peoples Bay under constant bombardment from pounding waves and driving wind for 48 hours, with the swell driving almost directly into the Bay.

When relieving Reserve Officer Alan Danks looked along the Bay on the morning of 3 August the beach had virtually disappeared and, out in the Bay, the wave action had torn big gaps in the sea grass

beds. By the time the storm was over the beach along the southern quarter of the Bay was clogged with torn and uprooted sea grass to a depth of about 3 m (Fig. 3.8). This `weed rack' banked up the water of Gardner Creek and created a spongy morass that prevented any access to the Bay.[62]

Along the beach itself the storm had moved thousands of tonnes of sand out into the Bay. In his later report Mr Folley stated: `...the entire beach, foredune and half of the vegetated (stable) dune was eroded' (Figs. 3.9 and 3.10). Of the pocket beaches to the south of the main beach many of the stable slopes had been eroded and, at Waterfall Beach, virtually all the sand had been swept out to sea.[63] The fringing woodland and swamp near the tidal pool, that had been home to a Noisy Scrub-bird since 1982, was destroyed by wave action and salt water, which had swept over the rocks and across the pool.[64]

As the forces of nature, aided by the high spring tides of the Equinox, had failed to restore the beach by the time the tourist season began[65] there were numerous complaints from visitors and fishermen, and vehement attacks on the Department by the local news media.[66] The boat launching area was eventually re-opened in April after the Department sought advice from the Public Works Department and $4000 was allocated to remove the weed and restructure the area.[67] Part of the restructuring included work by Mr Folley who, with a tractor, reshaped the southern end of the Bay by redistributing weed to form a sand trap for further stabilising of the beach.

Other pressures on the Reserve during this era included further requests by the Shire and the Public Works Department to seal and realign the road and to build a two-lane bridge over Gardner Creek.[68] The prolonged debates on both these issues reflected the continuing conflict of attitudes between the Department and some other authorities on the amount of public use that was desirable in the Reserve.

THE BLACKWELL REPORT

Late in 1984 the Department contracted biological and landscape consultant Mrs M.I. (Marion) Blackwell to compile a report on `Recreation Management and Interpretive Strategy' for the Reserve.

Mrs Blackwell studied public usage of the Reserve based on information provided by Mr Folley and noted in particular the excessive numbers of people using the limited facilities at peak times of the year. On holiday weekends, in the period December - March, more than 200 vehicles (600 people) were often in the Reserve at one time. This number was nearly four times the capacity of the main carparks. Other statistics from vehicle counts between October 1977 and May 1985 included: 481 vehicles entered the Reserve on New Years Day 1982; 566 vehicles entered the Reserve on the four day Easter weekend of 1985; an average of 2188 vehicles entered the Reserve in January, and 4462 during the summer months December-February; 2802 vehicles in autumn (March-May); 1529 in winter (June-August); and an average of 2525 vehicles entered the Reserve during the spring (September-November). Most of the 35 000 people visiting each year focussed on the picnic area whereas, for instance, only 400-500 visited Rocky Point and only a few hundred marroners fished at Moates Lake. An estimated 1000 people, mostly from interstate or overseas, came especially for bird watching, drawn by the success of the Noisy Scrub-bird conservation program and the presence of other rare birds.

A survey of visitors carried out over the three-day holiday weekend in March 1985 showed that, at that time of the year, 50 per cent lived in Albany, about 25 per cent in Perth, 15 per cent were from nearby country towns and `other visitors' constituted about ten per cent. Casuals who regarded the picnic area as `just another place to go' formed the largest proportion of visitors. The report considered that these people could be better catered for at a number of other recreational sites in the vicinity of Albany. The report also stated that:

> ...there is increasing pressure to accommodate larger numbers of visitors, many of whom come for general recreation rather than the Reserve's *raison d'etre*... When such recreation pressure is considered in the light of the Reserve's primary function of wildlife conservation...it becomes evident that detailed planning and remedial management initiatives are urgently needed... There is the opportunity to develop a `model reserve' to generate public interest in conservation with comparisons to other parts of the world.

Mrs Blackwell's major recommendation for interpretation and recreation at Two Peoples Bay Nature Reserve was:

> That this area be treated primarily as an Education and Conservation resource (as is the purpose for the setting aside of Nature Reserves), and that measures be taken to convey this function (as well as its value) to the public.

Among many specific recommendations the report emphasised that *pertinent* usage be encouraged and that future development should focus on interpretive presentation of the Reserve for educational purposes and to help change the present public use of the area.

The specific recommendations included: the promotion of other coastal recreation areas of the Albany Region to assist in providing a regional perspective for the Two Peoples Bay Nature Reserve; a review of the positioning and design of an administration complex, allied to the future possibility of setting up a display centre; and protection of the Reserve by including the land between low and high water marks.[69]

MANAGEMENT UNDER CALM

In March 1985 the Wildlife part of the former Department of Fisheries and Wildlife was incorporated into the newly created Department of Conservation and Land Management (CALM) and the Reserve was vested in the new National Parks and Nature Conservation Authority.

At Two Peoples Bay several inconvenient changes caused by the 1984 storm were still creating problems and other emerging uncertainties needed resolution. These included debates on whether or not the Gardner Creek bridge should be realigned and widened[70] and the possibility of amalgamating the Goodga River and Gull Rock National Park reserves within the Two Peoples Bay Nature Reserve.[71] Other points of concern included the probable spread of dieback in the district by wildflower pickers;[72] uncertainties about professional fishermen using the Bay as their base;[73] the probability that off-road vehicles would increase pressure on normal beach activities, as the Shire of Albany intended upgrading the road to the northern end of the Bay and developing a camping area there;[74] and urgency in formulating new management plans.[75]

These problems, combined with the restructuring of procedures and personnel within the new Department, and the pressure of implementing the Noisy Scrub-bird translocation program, culminated in very demanding times at Two Peoples Bay. Following on from bird census work in April 1985 the first concerted translocation program released eight male and eight female birds between June and August, to add to those previously released on Mt Manypeaks.[76]

Reserve Management Officer

In early January 1986 Reserve Officer Graeme Folley expressed his intention to resign at the end of April.[77] The Department realised they were losing a very valuable officer who had been 'burnt out' by his work on the Reserve. There was a general realisation 'that no one man should be asked to carry the load of implementing the Noisy Scrub-bird program and managing the Reserve'.[79] In April both Mr Folley and his assistant Andrej Molan left the Reserve.

Mr A. (Alan) Danks, a naturalist living near Nannup, had been Relieving Officer at Two Peoples Bay Nature Reserve since 1980 - taking charge each year when Mr Folley was on annual leave. He had participated in the translocation work in 1983 with Mr Merton and Mr Folley and also on the 1985 project. At the time of Folley's resignation Danks was a Technical Officer at the Wildlife Research Centre at Woodvale. After carrying out the 1986 translocation project while based at Woodvale, Mr Danks commenced duties in the newly-created position of Reserve Management Officer (RMO) in September. He was initially assisted by National Park Ranger Mr N. (Neil) Scott, who had taken care of the Reserve since April.

Further Changes to the Status Quo

Mr Folley's resignation had underlined the urgency for completing management plans as it was important to incorporate his knowledge into future plans for the Reserve. In March, planning consultant Mr R. McKellar, who had previously acted as a relief officer on the Reserve, was contracted to prepare a first draft for a new Reserve Management Plan.[80]

In January 1986 the salmon fishing lease on Plantagenet Location 7132 was cancelled and the huts removed from the beach front the following November.[81] This resumption was made possible by the Wilson brothers' transfer of their salmon fishing license to Bremer Bay.[82] (They had taken over the Two Peoples Bay lease following their father's death in 1981.) The Bay, however, remained a `Fishing Zone' as proclaimed under the Fisheries Act in 1975.[83] Since 1986 pilchard fishing boats have been based in the Bay and as many as eight boats operate out of Two Peoples Bay, using the beach for launching boats, parking trucks and vehicles, and off-loading catches.

Upon the resumption of Location 7132, the Department applied to extend the Reserve boundary to the low water mark.[84] When proclaimed in the Government Gazette on 13 November 1987, the additional land and the inclusion of Rock Dunder extended the Reserve area to 4744.6618 ha,[85] an increase of about 100 ha, as a few small areas, created by road realignments, had previously been added. (The area reserved in June 1967 was 4638 ha). Extending the Reserve to low water mark allowed the Department to restrict vehicle access along the beach. A ban on off-road vehicles was also extended to the

Rocky Point track that had been badly damaged in places by off-road vehicles, which were also creating *ad hoc* tracks to fishing spots.[86]

The debate on the Gardner Creek bridge was temporarily resolved in 1987 when the Main Roads Department reinforced and raised the bridge 30 cm and erected wooden rails in keeping with the aesthetic setting of the bridge (Fig. 3.11). More debate concerning Two Peoples Bay Road arose in April 1987 when a 323-signature petition, supported by the Albany Tourist Bureau, was submitted to support the Shire Council's quest to gain Government funding to bituminise the road.[87] The Department has since accepted that sealing of the road will eventually occur, though there will likely be serious implications for the management of the Reserve.

Tandara for Sale

Early in 1988 the Milgraum family placed Tandara on the market[88] and a full colour glossy brochure advertised the property as `Paradise Down Under':

> ...The rare opportunity to own a freehold investment of 3261 acres (1319 ha), which provides two miles of ocean frontage. The serene Two Peoples Bay has a protected panorama of white beach which "rests at the feet" of the two protecting mountains which overlook the tranquillity of this southern hide-away...Tandara in Western Australia is indeed a paradise where beauty has a new meaning. "Tandara" unfolds its secrets daily as the seasons change, and nature provides an endless parade of wonderment. - $US 10 million.[89]

Although the farm is still owned by the Milgraum family in 1990 the asking price is perhaps an indication of what kind of values would be placed on the Two Peoples Bay area at an international level.

Noisy Scrub-bird Management Program

In 1986 the Noisy Scrub-bird Management Program was formulated by Dr Burbidge, Dr Smith and Mr Folley and published by the Department of CALM. The aim of the program was to establish and maintain at least four viable populations of the Noisy Scrub-bird. But, in order to maintain four viable populations at any given point in time, it was considered necessary to establish six to eight populations, during the ten years of the program, to allow a safety margin in case some areas are burnt.[90]

Through the late 1980s and into the 1990s the work of translocating Noisy Scrub-birds has continued in accordance with the Management Program and birds have also been released at two locations west of Albany. Selecting and monitoring release sites, preparing for and carrying out capture and release work, now occupies the major part of the RMO's time (see ch. 18 this publication). Volunteers have assisted with the capture and release projects since 1985 and supply a large part of the labour force required to do this work. Many of these people return regularly to participate in the project and their enthusiasm and dedication are essential ingredients in successful Scrub-bird translocation.

These projects have also been valuable training grounds for Departmental staff whose interests and professional work involve wildlife management and research. A Nature Reserve Assistant (NRA) was appointed in 1988 after several National Park Rangers had been temporary assistants since 1985. In December 1988 a link with the past was reforged when Dave Wilson took up the NRA position. He is the youngest of the three Wilson brothers who had fished the Bay professionally with their father and Dave subsequently spent much of his childhood at Two Peoples Bay.

CONCLUSION

In concluding this chapter on the history of Two Peoples Bay Nature Reserve it seems appropriate to reflect on two coincidences that occurred in 1989. The first took place in May when timbers, probably from the old whaling ship *Avis*, were washed up on the beach 100 m north of the mouth of Gardner Creek.[91] The *Avis* was wrecked in a severe south-easterly storm on 28 August 1842 (ch. 2 this publication), just a few weeks before John Gilbert `discovered' the Noisy Scrub-bird at Drakesbrook,[92] near modern-day Waroona (ch. 16 this publication).

The second event occurred later in 1989 when Dave Wilson single-handedly rescued a Minke Whale (Fig. 3.12) that had stranded itself on the beach at Two Peoples Bay[93] - a reflection on the changing attitudes of society to nature conservation. Other reminders of the attitudes of the past can be seen in the remains of the old try works in `Whalers Cove' and a circular stone enclosure on the middle of Coffin Island, that may be a legacy from the old sealing days.[94]

The sequence of events leading up to the present day, as described in this chapter and chapter 2 of this publication, should allow an appreciation of the fortuitous circumstances that have allowed the Noisy Scrub-bird to make a comeback from the verge of extinction. Since then, the course of events have required courageous decisions, and much hard work and determination by many people, to bring the

species back to a position of greater security than at any time in the past 100 years.

Much remains to be done and there are many challenges ahead, not least of which is the continuance of a high standard of management in times of dwindling resources. A revised Two Peoples Bay Management Plan, based on the information in this publication, will be formulated to address the new challenges and set out a path for the following ten years.

ACKNOWLEDGEMENTS

We wish to thank a number of people who have been most helpful in providing information vital to the authenticity of this chapter. Firstly, thanks to Dave Wilson for his first hand knowledge of Two Peoples Bay, and Mr and Mrs Dunstan West for their extensive historical knowledge of the Albany area, and Harry Shugg for his historical perspective. Ian Elliot and Brian Goodchild, of the Geographic Names Section of the Department of Land Administration, provided critical information on several facets. Librarians at both the Western Australian Wildlife Research Centre at Woodvale, and Battye Library were also most helpful. Angas Hopkins, Harry Shugg, Graeme Smith and Dunstan West made valuable comments on the text.

ABBREVIATIONS

CALM : Department of Conservation and Land Management

Department of Conservation and Land Management Files appertaining to the Two Peoples Bay Nature Reserve:

Tenure 1: CALM 015749F3102 (Tenure vol. 1)
Tenure 2: CALM 015750F3102 (Tenure vol. 2)
Tenure 3: CALM 015751F3102 (Tenure vol. 3)
Tenure 4: CALM 015752F3102 (Tenure vol. 4)
Tenure 5: CALM 015753F3102 (Tenure vol. 5)
Management 1: CALM 016178F3102 (Management vol. 1)

CSIRO : Commonwealth Scientific and Industrial Research Organisation

DOLA : Department of Land Administration

LKBB : Lower Kalgan Bushfire Brigade

MLA : Member of Legislative Assembly

WAM : Western Australian Museum

NOTES

1 Government Gazette, 22 April 1966 `Cancellation of Casuarina Townsite'. (The locality was known as Two People Bay prior to an official nomenclature change to Two Peoples Bay in 1978). Department of Conservation and Land Management, Two Peoples Bay Nature Reserve, File No. 015749F3102 (Tenure 1). Tenure 1, p.9.

2 Under-Secretary of Lands to Director of Fisheries and Fauna, 28 April 1966. Tenure 1, p.12; The Fauna Protection Advisory Committee during that era comprised: Mr A.J. Fraser, Chairman (Director, Department of Fisheries and Fauna); Dr A.R. Main (Zoology Department, University of Western Australia); Dr W.D.L. Ride (Director, Western Australian Museum (WAM)); Dr G.M. Storr (WAM); Mr J.B. Higham; Mr A.R. Tomlinson (Agriculture Protection Board of Western Australia); Mr A. Milesi (Forests Department of Western Australia); Dr D.L. Serventy (Division of Wildlife Research, CSIRO) and Mr H.B. Shugg, Secretary, (Fauna Officer, Fisheries and Fauna Department). Extracts from Fauna Protection Advisory Committee minutes (1966-1968), In Tenure 1.

3 H.B. Shugg, personal communication; Government Gazette, 30 September 1966. Declaration of the Ellen Brook and Twin Swamps reserves for the preservation of the Short-necked Tortoise (*Pseudemydura umbrina*).

4 D. Wilson, personal communication.

5 H.B. Shugg, personal communication.

6 *Government Gazette*, 2 June 1967.

7 H.B. Shugg, personal communication.

8 Letter of Minister for Lands and Forests from Colonel J. Vincent, Survival Service Commission, International Union for Conservation of Nature and Natural Resources, 14 September 1966. Tenure 1, pp.46-7.

9 Director of Fisheries and Fauna to owners of dwellings at Two Peoples Bay. Copies sent to C.H. Johnson, W.W. Haddleton, Mrs C. Evans, J. Martin, Mrs M. Parkin, A.D. Wilson, W.T. Clark, K. McCusker, C.E. Rule, E.M. Gray, A. Kleeman, L.H. Jones, K.E. Western, N.O. Reeves, L. Fitzpatrick. Tenure 1, p.24; Sketch plan of squatters' settlement. Tenure 1, p.119.

10 Mr J. Hall, MLA for Albany, to Minister for Fisheries and Fauna, 2 November 1966. Tenure 1, pp.52-3.

11 Director of Fisheries and Fauna to Under Secretary for Law, 5 April 1967. Tenure 1, p.76.

12 Crown Law Department to Director of Fisheries and Fauna; and copy of legal opinion to Fauna Protection Advisory Committee. Tenure 1, pp.77-80.

13 J.M. Forrest, Crown Law Department, to Director of Fisheries and Fauna, 21 April 1967. Eviction of squatters. Tenure 1, p.77.

14 State Crown Solicitor to Director of Fisheries and Fauna, 15 September 1967. Tenure 1, p.129.

15 A. Pearce to H.G. Shugg, 28 November 1967, Tenure 1, p.144; State Government Insurance Office to Director of Fisheries and Fauna 13 February 1968, Tenure 1, p.163; A.A. Burbidge and G.L. Folley (1984). Unpublished version of this chapter on Management and Recreation at Two Peoples Bay Nature Reserve.

16 Fauna Protection Advisory Committee minutes, 1 September 1967. Tenure 1, p.140.

17 Fauna Protection Advisory Committee minutes, 1 September 1967. Tenure 1, p.131.

18 F.N. Robinson, (1968) Unpublished Report to Fauna Protection Advisory Committee. Tenure 1, pp.197-204.

19 Robinson 1968.

20 Robinson and H.O. Webster, Reports to FPAC 1968. Tenure 2, pp.1-3.

21 Robinson, 1968.

22 H.B. Shugg to J.H. Frith, CSIRO, Canberra, 21 January 1969. CALM File No. 015750F3102, Tenure 2, pp.14-15.

23 H.J. Frith to H.B. Shugg, 30 April 1969. Tenure 2, pp.24-5.

24 Western Australian Wildlife Authority, minutes 24 June 1969. Tenure 2, p.36; H.J. Frith to H.B. Shugg; proposal for CSIRO, 1 August 1969. Tenure 2, p.39.

25 G.T. Smith, personal communication.

26 Smith, personal communication.

27 D.L. Serventy & H.M. Whittell *Birds of Western Australia* 5th edition, (University of Western Australia Press, Perth, 1976). p.314.

28 Burbidge and Folley (1984).

29 Burbidge and Folley.

30 Imposing 25 mph (40 km/h) speed limit within the Nature Reserve. Crown Law advised Department could not impose speed limits. Management CALM File No. 016178F3102, 1, pp.59-61. Department then contacted Shire of Albany which applied to Minister for Transport who granted permission for the speed limit. The Department then purchased and erected the signs. Management 1, pp.165-7.

31 *Government Gazette*, 23 January 1970. An area of 2 roods 16 perches excluded from the Reserve; identified as Plantagenet Location 7132. Plan 451C/40 DOLA. Tenure 2, p.48.

32 B.K. Bowen to Harbour and Lights Department 25 February 1971. Tenure 2, p.83; reply Tenure 2, p.85.

33 *Government Gazette*, 26 January 1972. Naming of Two Peoples Bay Wildlife Sanctuary. Tenure 2, pp.94-5; Government Gazette, 5 December 1975. Legislation of the Wildlife Conservation Act (1950-1975).

34 Mr and Mrs D.A.P. West, personal communication.

35 Details of schedule for the Tour of Inspection by His Royal Highness, the Prince Philip, Duke of Edinburgh. Tenure 3, pp.68-74.

36 Smith, personal communication.

37 Smith, personal communcation.

38 R.E.S. Sokolowski to A.A. Burbidge. Sealing of road. CALM File No. 015751F3102 Tenure 3, p.83; W.A. Wildlife Authority minutes 17 March 1975 and 21 April 1975. Tenure 3, pp.90-1.

39 R.E.S. Sokolowski to A.A. Burbidge, 21 March 1976; Under-Secretary of Lands to B.K. Bowen, 21 March 1976. Tenure 3, p.108; pp.112-25.

40 R.E.S. Sokolowski to A.A. Burbidge, 11 November 1976. Tenure 3, p.123.

41 W.P. Norman, Secretary of the Lower Kalgan Progress Association to Department of Fisheries and Wildlife, 27 April 1979. Lack of parking space of picnic area. Tenure 3, p.169; Hon. R.J. O'Connor, Minister for Fisheries to W.P. Norman, 8 August 1979. Tenure 3, p.174. B.K. Bowen to Minister of Fisheries and Wildlife, 7 December 1978. Tenure 3, p.154; W.A. Wildlife Authority minutes 29 February 1979. Tenure 3, pp.164-73.

42 Australia. Bureau of Meteorology, Monthly weather review: Western Australia, 1-30 April 1978, (Department of Science, Canberra, 1978). Daily weather maps 1000k (00GMT), 4-5 April 1978; Chart daily for Dines anemograph: station Albany, 0830 h, 4 April 1978 - 0830 h, 5 April 1978; Summary of cyclone No. 5: Class I: "Alby", pp. 25-35, and Fig. 5.1, tracing route of Tropical Cyclone "Alby", 27 March - 4 April 1978.

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PERSONAL COMMUNICATIONS

Smith, G.T., Senior Research Scientist, CSIRO, Division of Wildlife and Ecology, Helena Valley, WA.

Shugg, H.B., former Chief Warden of Fauna with Department of Fisheries and Fauna, and later Conservator of Wildlife, prior to his retirement from the Department of Fisheries and Wildlife in 1979.

West, D.A.P., author and local historian, Mt Barker, WA.

Wilson, D., youngest of the three Wilson brothers who, with their father, fished Two Peoples Bay professionally for many years. Now the Reserve Management Assistant at the Two Peoples Bay Nature Reserve.

July 91

Appendix 3.1

The Two Peoples Bay Management Plan of June 1971. As presented in S.W.A.N.S. vol. 2, No. 3.

TWO PEOPLES BAY MANAGEMENT PLAN (JUNE 1971)

Introduction

Two Peoples Bay Reserve is situated approximately 15 miles east of Albany and is vested in the Western Australian Wildlife Authority. It was set aside for the purpose of "Conservation of Fauna" in April 1966 following the rediscovery of the Noisy Scrub Bird (*Atrichornis clamosus*) in the area in 1961. subsequently a number of other interesting and rare species have been found to occur there, and these include the Western Whip Bird, the Bristle Bird, the Southern Emu-Wren, the Quokka, the Honey Possum, the Ringtail Possum, the Yellow-footed Marsupial Mouse and the Water Rat.

C.S.I.R.O. officers commenced research on the Noisy Scrub Bird in 1963, and studies have been made firstly of the bird's song, and more recently of its ecology and behaviour. A field station is being erected to facilitate further research work.

While the main value of the Reserve is the rare fauna it contains, it is also very attractive to tourists because of its fame as the locality of the Noisy Scrub Bird, the scenery and the excellent fishing facilities. The high degree of public usage led to the appointment of a ranger in August 1970 who is housed in a cottage near the main beach and picnic area.

The danger of fire is the greatest problem for management personnel. The Noisy Scrub Bird probably remains in the locality because of the lack of frequent fires in the Mount Gardner area, which is protected from prevailing winds from the south-west and east; but fire in the reserve as a whole has been relatively common over the past four years, and the heathland burns easily at almost any time, even immediately after heavy rain. Heath will carry a fire again after only three years regrowth and other types of vegetation are probably similar in this respect.

Another management problem is the continual multiplication of vehicle tracks on the sanctuary. Much of the area is sandy and when a track becomes boggy it is relatively easy to drive across the heath and another track soon results. This problem will continue while there are no good roads on the Reserve.

Aims of the Management Plan

The primary aim of any plan for the Two Peoples Bay Wildlife Sanctuary must be to protect and conserve the Noisy Scrub Bird and all other native flora and fauna. Secondly, the plan should allow controlled public usage and provide facilities in such a way that the primary aim of conservation is not compromised. Thirdly, the plan should provide for continuing research to be carried out into the requirements of the fauna, the regeneration of the flora after fire, the effects of fire on the fauna, fire control methods and the impact of human usage on the area.

Management Plan

The following recommendations have been made by the Western Australian Wildlife Authority, and approved by the Hon. Minister for Fisheries and Fauna.

1. That roads be constructed from the bridge over Lake Gardner Creek through the reserve, roughly as shown on the map. Parking areas to be constructed at the end of the roads as shown.

2. That apart from these roads, only those tracks which are indicated on the map remain open to public use. No vehicle may use any other track unless authorized by the Chief Warden of Fauna or the resident ranger.

3. That a limited number (approximately six) of barbecue places be constructed in the picnic area near the ranger's cottage. No fires to be lit elsewhere in the reserve.

4. That a toilet-changing room block be built near the picnic area and main beach.

5. That the firebreak system be progressively enlarged so that the perimeter breaks exist on all boundaries, and further internal breaks to be created by use of a topper instead of a bull-dozer.

6. That walking tracks be marked out from the area below "Tick Flat" to Mt Gardner and Cape Vancouver.

7. That research be continued or carried out into

(a) the ecology of the Noisy Scrub Bird and methods of management to ensure its persistence;

(b) the effect of fire on the fauna and flora;

(c) the number of animals and plants occurring in the reserve.

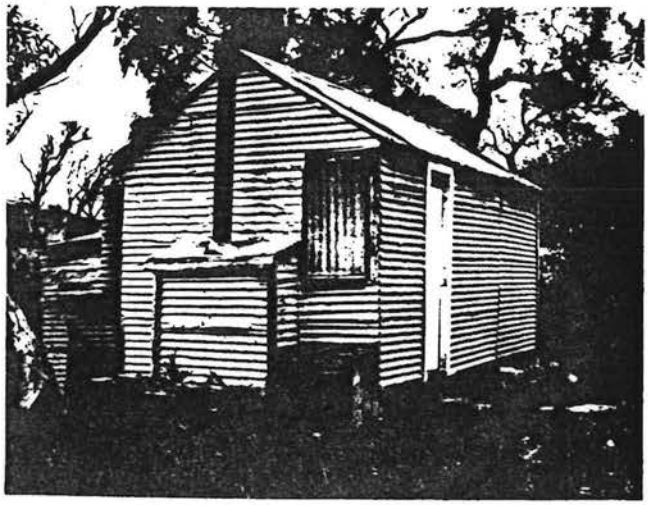
(d) Any other factor which the Officer-in-Charge of Reserve Management deems necessary and practical.

8. That notices be erected on the reserve advertising this plan and the regulations. That a brochure be printed giving details of the reserve and usage of the area.

Following acceptance of this Management Plan the two areas shown on the map were classified as prohibited and limited access areas. Notice of this classification appeared in the *Government Gazette* on June 25, 1971.

On 7 December 1978 another recommendation was added to the management plan:

9. That a small self-guiding nature trail be established. This trail to run from the present picnic area, along existing tracks to a thick area of bullich, woodland and swamp. Thence through an adjoining area of heath.



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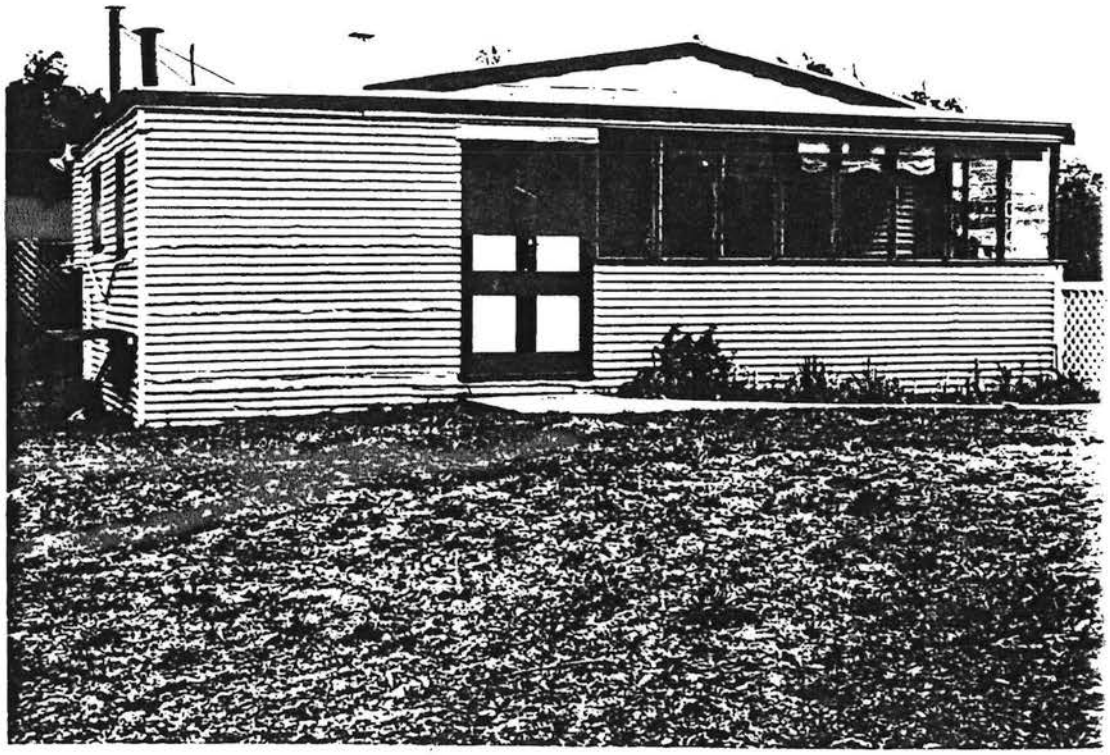

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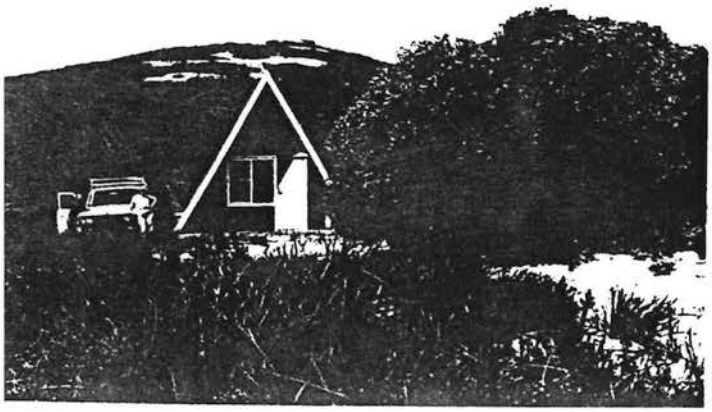

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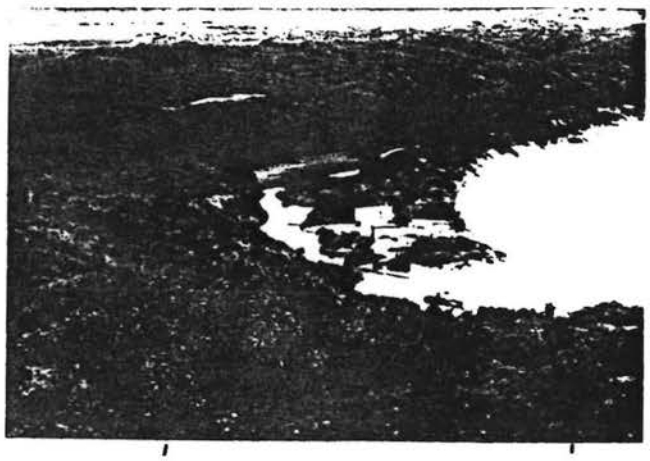

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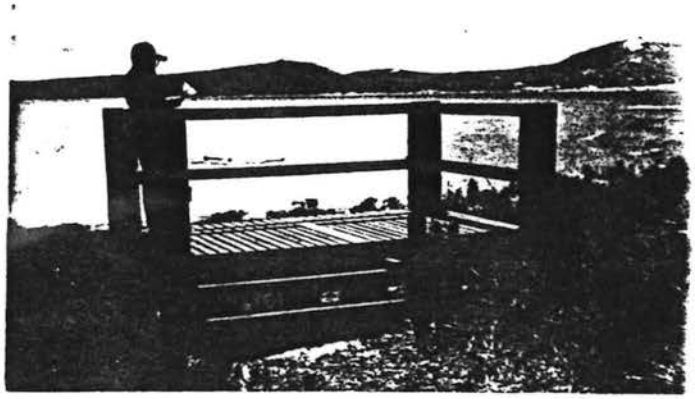

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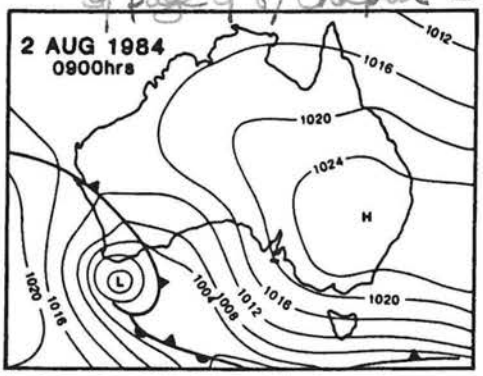

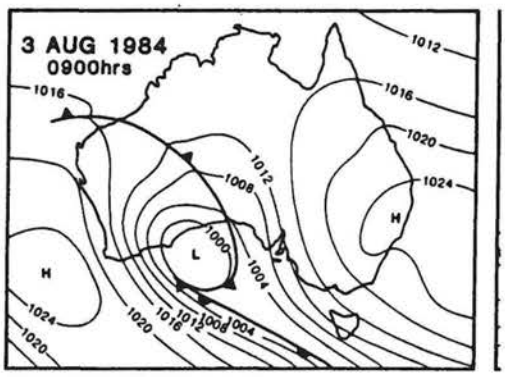

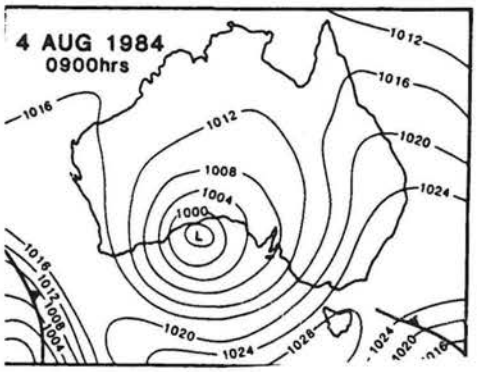

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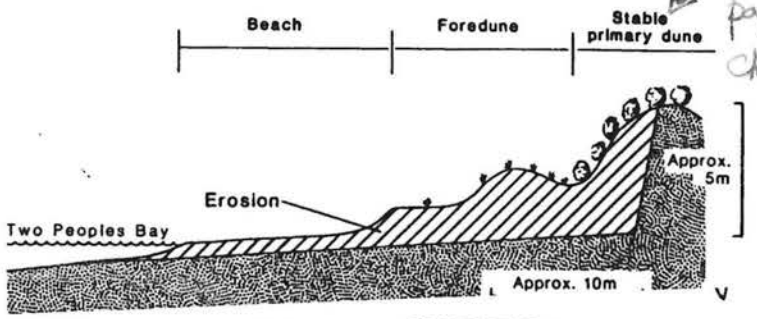

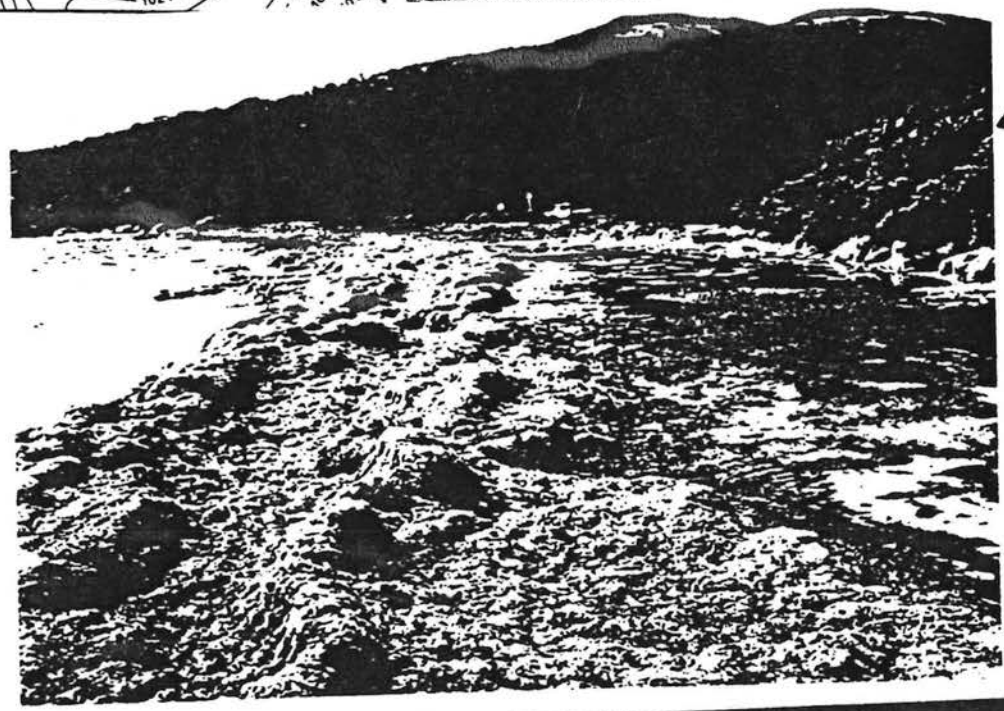

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View South

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CHAPTER 4

Geology of Two Peoples Bay Nature Reserve

Phillip E. Playford

INTRODUCTION

The Two Peoples Bay Nature Reserve lies within the Albany Mobile Belt of the Albany-Fraser Province, a belt of Pre-cambrian (Proterozoic) granite and high-grade metamorphic rocks, which is on-lapped by sedimentary rocks of the Cainozoic Bremer Basin (Doepel 1975; Beeson *et al.* 1988). The most recent geological account of the area is by Muhling and Brakel (1985).

The geology of the Two Peoples Bay Nature Reserve was studied for this project during a visit to the area from 26 January to 1 February 1982. Mapping was done using 1:40 000 colour air photos taken in 1981 for the Australian Survey Office. This chapter sets out the results of that work.

GEOMORPHOLOGY

The Two Peoples Bay area is dominated by Mt Gardner, a mass of granite which rises some 408 m above sea level. The granite coastline flanking the east, north and south sides of Mt Gardner is very steep, with deeply incised streams descending to the sea. It is a typical drowned shoreline, with indentations on the coast controlled by the inundated stream valleys, and small offshore islands marking the crests of drowned hills. A similar coastal topography is found in the North Point area, north of Two Peoples Bay.

The main granite mass around Mt Gardner is believed to have formed an island during part of the Pleistocene, and it was 'tied' to the mainland during the late Pleistocene by the accumulation of sand shoals and dune sands, now largely lithified as calcareous sandstone. The Mt Gardner area is also thought to have been an island during the Eocene, while sediments of the Plantagenet Group were being deposited in adjoining topographically lower areas.

Two Peoples Bay itself is bounded to the west by a wide beach, backed by beach ridges, dune sands, and some intervening swamps. Angove, Gardner, and Moates Lakes have been dammed behind Pleistocene and modern dunes. The lakes are fringed by peaty sands marking earlier extensions of the lakes and their associated swamps. Most of the Holocene sand dunes are now stabilised by vegetation, but there is a large blowout with mobile dunes south of Moates Lake, and some coastal dunes are active near Rocky Point.

The coastline west of the Mt Gardner granite mass is backed by cliffs up to 50 m high, composed of calcareous quartz sandstone, a lithified Pleistocene aeolianite deposit. West of Rocky Point the cliff is fronted by a sandy beach, whereas at Sinker Reef there is little beach sand and the cliff is fronted by an elevated shoreline platform that is about 3.5 m above the adjoining modern platform. The elevated platform is relatively little eroded and is presumably of Holocene age. It is not known whether emergence of this platform is a result of tectonic uplift or fall in sea level. Overall, the coast is characterized by submergence since the Eocene, associated with downwarping of the Ravensthorpe Ramp (Cope 1975). However, the relative uplift evidenced by the raised platform at Sinker Reef would indicate a recent minor reversal of this overall trend. W.M. McArthur[1] (written communication, 1990) reports having observed a similar bench at various localities along the south coast between Point D'Entrecasteaux and Esperance, and it seems possible that this correlates with the 2.4 m elevated platform at Rottnest Island, which emerged (through uplift of the land or fall of sea level) some 4800 years ago (Playford 1988).

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1 W.M. McArthur, CSIRO, Wembley WA.

Residual sands formed by leaching of the Pleistocene aeolian calcareous quartz sandstones overlie the Proterozoic granite on the flanks of Mt Gardner. These are effective reservoirs for groundwater, feeding small permanent springs and seepages. Consequently, many of the creeks draining Mt Gardner flow throughout the year, although the rate of flow is generally very small during the summer. The presence of this permanent water, with consequent dense vegetation, is perhaps one of the reasons why the Noisy Scrub-bird was able to survive in this small area.

GEOLOGY

Rocks exposed in the area on and surrounding the Two Peoples Bay Nature Reserve are Precambrian (Proterozoic) granitic and gneissic rocks and Cainozoic (Tertiary, Pleistocene, and Holocene) sediments (Fig. 4.1).

Proterozoic

Proterozoic granite (a monzogranite or adamellite; Stephenson 1973) outcrops prominently in elevated parts of the area. The rock is porphyritic, with prominent megacrysts of microcline in a groundmass of quartz, microcline, plagioclase (oligoclase/ande-sine) and biotite. Most of the granitic rocks are homogeneous, without layering, but there is also some granitic gneiss, intruded by granite or occurring as rafts within granite. Some minor pegmatite and quartz veins and microgranite dykes intrude the granite at a few localities (Stephenson 1973).

The granites are cut by a number of well-developed fracture zones, which may have formed in association with early wrench-fault movements along the Darling Fault, some 200 km to the west (L.B. Harris, written communication, 1990).[2]

Tertiary

The only positively dated Tertiary rocks exposed in the area belong to the Eocene Plantagenet Group. However, some of the sandy soils overlying these rocks are lateritized and they are probably at least partly Tertiary. The laterites themselves may range from Oligocene to Pleistocene in age.

The Plantagenet Group in this area consists of the Pallinup Siltstone and Werrilup Formation.

The *Werrilup Formation* is exposed above Herring Bay, where it overlies Proterozoic granite and is overlain by the Pallinup Siltstone. The contact with the granite is strongly irregular, with local relief of about 3 m, although the total relief in the vicinity is at least 30 m. The Werrilup Formation at Herring Bay consists of grey to dark-brown, strongly cross-bedded, medium-grained quartz sandstone, which is partly siliceous or ferruginous. The thickness of the exposed unit is 13.5 m. The Werrilup Formation is also exposed in road cuts on the road to Albany immediately west of the mapped area.

The *Pallinup Siltstone* is well exposed at Herring Bay, overlying the *Werrilup Formation*, and overlain by laterized sandy soil. It is about 14 m thick, consisting of orange, yellow, and whitish, bedded spongolite which is clayey in part. It contains prominent silicified 'stick' sponges and some poorly preserved bivalves, echinoid spines, and bryozoans. Strong bioturbation is visible in some horizons.

The *Pallinup Siltstone* is also exposed in two dams near Tandara homestead, west of Angove Lake.

Laterite in the area is massive to pisolitic, sandy, and ferruginous. It is exposed principally in the north-eastern part of the map area, overlying Proterozoic granite and sandy soils. Much of this laterite is presumed to be Tertiary (?Oligocene, Miocene, or younger), but part must be Pleistocene or Holocene, as it occurs within the Pleistocene dune sandstones in the south-western part of the Reserve.

Quaternary

Calcareous quartz sandstone of Pleistocene to perhaps Holocene age outcrops prominently along the coast from Sinker Reef to west of Rocky Point and in a few other places that are too small to map separately. It is an aeolian deposit, strongly cross bedded, and is equivalent to the Tamala Limestone of the Perth Basin (Playford *et al.* 1976). The unit includes many root structures (rhizoliths) formed by calcification around roots of trees and shrubs that grew on the original dunes. Fossil land snails (*Bothriembryon*) are common in the sandstone.

The maximum exposed thickness of the unit is about 60 m at the eastern end of the Sinker Reef cliff. Here the sandstone can be seen to abut a steeply sloping unconformity on the granite of Mt Gardner. The sandstone extends below sea level, so that its total thickness in unknown.

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2 Dr L.B. Harris, The University of Western Australia.

Residual quartz sand of Holocene to perhaps late Pleistocene age overlies the calcareous sandstone over a large part of the area west of Mt Gardner, extending along valleys in the granite to elevations of up to 200 m. The sand is believed to be a product of decalcification through weathering of the Pleistocene calcareous sandstone. Small patches of the original sandstone can still be seen in places below the sand (e.g. in the valley behind Waterfall Beach).

Several Holocene deposits have been mapped; beach sand, beach ridges, mobile and fixed dune sand and lake and swamp deposits. Most consist of calcareous quartz sands, with the exception of some swamp and lake deposits which are commonly peaty and non calcareous.

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CHAPTER 5

Landforms and Soils

W.M. McArthur and G.A. Bartle

INTRODUCTION

In the south coastal area of Western Australia the variations in landscape features are clearly related to geological events and processes (Churchward *et al.* 1988). This relationship is exemplified in and around the Two Peoples Bay Nature Reserve where many of the elements of the Albany coastal region are represented. The relationship is described in this chapter.

LANDSCAPE DEVELOPMENT

The history of this area extends back to Pre-Cambrian times, about 1.3 x 10^9 years Before Present (BP), when Australia formed part of the super-continent Gondwanaland. This land mass existed until late Mesozoic times (about 100 million years BP) when India drifted away to the north-west thus forming the western coast of Australia. Then, in the Eocene (about 40 million years BP), Antarctica drifted southward and the gross shape of the Australian continent was established. The present coastal area was submerged with only the higher granite hills projecting as islands and reefs. The ocean was probably about 100 m deeper than present and, during this period of submergence, the sediments of the Plantagenet Group were laid down. These were firstly limestone and sandstone and finally siltstone. These sediments are not well shown in the Reserve but there is an excellent exposure in a cliff at Herring Bay.

Then, towards the end of the Tertiary (possibly about 20 million years BP), this entire mass emerged from the ocean so that the granite basement with its prominent hills and associated marine sediments became part of the Australian continent, when the approximate position of the coastal zone was established.

The remainder of the Tertiary, and perhaps into early Pleistocene times (about one million years BP), was a period of landscape stability during which sediments and granite alike were subjected to intense weathering, with the end result being a surface mantle of weathered material capped by lateritic duricrust. Only the higher parts of the granite hills projected above the laterite surface. Also during this period, the Plantagenet sediments were eroded by wave action so that the shoreline consisted of a low scarp interrupted by granite hills and headlands, with near-shore granite islands. The end of this period saw the development of a narrow, low-lying coastal plain which possibly reconnected Mt Gardner to the mainland.

In the Quaternary Period, especially during the time since the middle Pleistocene, the details of the the present landscape were developed. Firstly, during times of low sea level (ice ages or glacial phases), calcareous detritus was blown from the continental shelf to form huge transgressive dunes; this process occurred several times with each phase overlying the previous dune surface. This material quickly became lithified by solution and redisposition of lime to form a soft limestone (equivalent to Tamala Limestone) which effectively linked the granite headlands.

Sea-level rose to just above its present position towards the close of the Pleistocene and this is manifest in the near-shore environment. The limestone was readily eroded by wave action and so the shoreline gradually took on the familiar form of granite headlands linked by smooth, curved limestone barriers with a steep scarp to seaward. Another effect was that the low-lying land in the corridor may have been inundated by shallow water, or perhaps consisted of a series of shallow, swampy inlets.

At about 5500 years BP, sea level fell by about 3 m to its present position (Playford and Leech 1977). Thus the wave-cut bench formed at the higher level was stranded and it remains as important evidence of sea-level changes; it is well expressed along the coast

between Sinker Reef and Rocky Point (Fig. 5.2). Similar benches occur below sea level. At the same time land in the corridor emerged to be just above sea-level and there were probably two inlets and associated flat, swampy land. The most westerly inlet, which probably included the present Moates and Gardner Lakes, possibly entered the ocean near Rocky Point; the other, Angove Lake, was probably much the same as it is now. Also, at about the beginning of the Holocene, there were apparently periods of landscape instability when sand from various sources was re-worked by wind to form sand sheets, dunes and hummocks.

Finally, during the Holocene, a complex system of parabolic coastal dunes was blown inland partially covering prior land surfaces to produce the present coastal landscape.

The landscape features mentioned above have been studied, both in the field and from aerial photographs, and classified to form a system of landform-soil mapping units. Thus Mt Gardner and Boulder Hill, with the associated sand deposits, are referred to as the *Gardner* unit (Fig. 5.1); Reservoir Hill, which was subjected to laterite formation, is mapped as the *Barrow* unit. The Plantagenet Group of sediments, with the lateritic surface and showing erosional modifications, is known as the *Dempster* unit. The *Meerup* system of parabolic dunes, with four phases of activity, occur as a partial cover over the *Gardner* and *Dempster* units and almost completely obscure the Tamala Limestone. The swampy country associated with Gardner and Angove Lakes is mapped as the *Owingup* unit while the sandy plain between the lakes is separated as the *Blackwater* unit; these last two units are partially obscured by the latest phase of the Meerup dunes. Figure 5.1 shows the distribution of the landform-soil mapping units.

DESCRIPTION OF THE MAPPING UNITS

Gardner (G).

This is a landscape of rocky hills, with greater than 60 m relief, partially blanketed by sand; the incidence of sand is the main basis for subdivision. The crests and upper slopes (Gg) are dominated by granite outcrop and boulders. These are represented in the Reserve by Mt Gardner and Tor Hill. On gentler slopes there may be a shallow soil of gritty loam over gritty clay with granite at 15-20 cm, or shallow peaty sands in some hollows (Fig. 5.3).

Gardner Sand (Gs) occurs as a smooth landscape between the granite crests and extends down on the gentler slopes. The localities known as Tick Flat, Pizzy Gully and The Moors are parts of the Gs unit. The upper parts of the Gs unit, between the granite crests, are poorly drained and this is reflected by the humus podzol profile. The surface is very dark and there is an iron-organic hard pan at 1-1.5 m; granitic detritus commonly occurs in the lower layers. On the flanks of Mt Gardner the sandy landscape is well drained and the soil is an iron podzol with a grey sandy surface, a light grey sub-surface, and a bright yellow-brown sandy subsoil which is often indurated. On the northern flank of Robinson Gully is an exposure of indurated yellow-brown sand, about 5 m thick, which is probably a remnant of such a profile.

Run-off from the granite peaks is very high and this has resulted in the formation of spectacular erosion gullies (Gr). Many of these have been identified because they are the favoured habitat of the Noisy Scrub-bird; the local names are shown on Figure 1.4 (this publication). The gullies usually have steep, sandy slopes with granite outcropping in the floors. Many of the gullies are aligned NW-SE possibly in response to a jointing pattern in the granite basement.

Barrow (BA).

This unit comprises hills and ridges, often with irregular crests and upper slopes dominated by granitic pavements, domes, pinnacles, and tors. Local relief is in excess of 60 m and frequently more than 100 m. This unit occurs only on Reservoir Hill to the north of the Reserve. Granitic rocks outcrop on the crests and upper slopes while on the lower slopes these rocks are deeply weathered and may be overlain by a sandy mantle. Some Plantagenet sediments may be present on the lower slopes. Yellow duplex soils are dominant but there are some gritty loams. Two subdivisions have been recognized, mainly based on the incidence of granite outcrop.

BAg represents crests and upper slopes dominated by granitic rock outcrops; some shallow brown, gritty loamy soils are on the fringes of granitic outcrop, along with some pockets of gritty yellow duplex soils.

BAf comprises the smooth, gently-sloping, middle and lower slopes that are dominated by yellow duplex soils having sandy A horizons and pale yellow and brown mottled clay B horizons. A_2 horizons are present, often with lateritic gravel, but they are not usually bleached. The surface may have a scattering of lateritic duricrust boulders. Extensive areas of

deep sands (yellow or grey) occur on the lower slopes.

Dempster (D).

This landscape, formed on the sediments of the Plantagenet Group, consists of low spurs separated by narrow swampy drainage lines. Subdivision is based on topography. The tops of the spurs (Dl) are generally mantled by laterite duricrust and ferruginous gravels; at the edges of the spurs the soil consists of sandy gravelly surface over a reddish-brown clay. Associated with the laterite on some spurs are areas of deep gritty sand (Ds) which occur as saddles. The flanks of the spurs (Dr) are generally occupied by sand which , on upper slopes, may overlie duricrust at shallow depth; the sand becomes deeper down slope and may be more than 1 m deep in mid-slope. In lower positions, where the slope decreases, the land becomes swampy and the soil is a humus podzol profile (Fig. 5.4). In the Goodga River valley the floor is interrupted by sandy hummocks; also the floor is dissected to form a deep narrow channel. Associated with the Dempster units is a series of linear dunes and hummocks occurring in all landscape positions. In some instances the sand apparently occurs as outwash fans (Dd) which have later been remodelled by wind action.

Meerup (M)

This system of parabolic dunes is represented by four phases of activity. The oldest (Ms) is represented as a pattern of very subdued ridges extending over the old limestone, leaving much of the substrate exposed, and continuing onto the western flank of Mt Gardner. The material is siliceous throughout and has a podzol soil profile with a brown or yellow-brown B horizon at about 1 m. There may be soft ferruginous concretions in lower layers. On Mt Gardner this unit overlies the Gardner sand.

The next phase (Mp) of the Meerup system consists of low parabolic dune ridges which extend from the south coast, over the limestone, almost to Two Peoples Bay. The soil profile is characterised by a weak podzol developed in the surface and calcareous sand at about 1.5 m. The pattern of distribution of the Mp unit is difficult to explain. The main system has come from the south coast and clearly extends to the main road. However, another small area east of the road appears to have come from Two Peoples Bay. This is unlikely because the present dunes (Me) coming from the east are siliceous throughout. Therefore it is possible that this small group of parabolic dunes represents a re-worked deposit which came originally from the south coast. Similarly, the dune fringing the southern corner of Two Peoples Bay possibly came from the south coast, and was then re-directed. The Mp unit appears to overlie the Ms unit although no proof of this relationship was seen. The age of the Two Peoples Bay Me dunes in relation to other Meerup dunes is not known. On the basis of dune morphology there are at least two phases present but, since the sand has little or no carbonate content, no direct comparison can be made. The dunes show little soil profile development and so may be relatively young.

The next phase (Mc) differs markedly from older phases in that it shows moderate relief with fairly steep, irregular dune ridges. It extends from the south coast over a low barrier of limestone, partially covers spurs of the Plantagenet beds, and continues inland over the coastal plain where it was probably effective in cutting off Moates Lake. Soil profile development is minimal; the surface is organic stained and is siliceous or only faintly calcareous, but is strongly calcareous at about 10 cm. The youngest phase (My) has been separated on the basis that there is no organic staining in the surface and the very loose material is highly calcareous throughout. Also, the My unit shows high relief with a very irregular outline and much evidence of recent modifications by wind. The My unit has come in from the south coast, over the low limestone barrier and the coastal plain, and onto a spur of the Plantagenet beds where it has effectively cut off Moates Lake from Gardner Lake. The areas of unstable sand (Mu) are mainly associated with the My and Mc units and the inference is that they are more prone than other phases to become unstable when disturbed (Fig. 5.5).

Within the Meerup system there are small, flat or gently undulating areas (Mf) which have been enclosed by dune ridges. These vary greatly in their composition, depending on the nature of the substrate and the manner in which the dunes have moved over the land. Generally, the dune sand has blanketed the Mf unit, so that the soil is similar to that in the adjacent dunes. However, as the unrelated substrate is sometimes exposed, this may be a sand or rock surface. In the Reserve the Mf units enclosed by the younger dune phases are mostly very swampy areas which probably were originally part of an inlet linking Moates Lake and Gardner Lake. Where the Mp dunes have extended onto the plain near the main road, the Mf unit has the same profile as the dunes.

Owingup (O)

The lakes are fringed by the Owingup unit, consisting of low ridges and intervening swales, forming a landscape at about 1 m above water

level. The soils are very young and reflect the poorly drained conditions; they consist of layers of organic loam, sand, estuarine shells and clay. Included are some low benches fringing the ocean in protected situations. These are very wet areas, about 1-2 m above sea level, which are probably watered by springs coming from the adjacent hills. The soil consists of layers of material including organic loam, grey sand, and bluish-grey clay.

Blackwater (Bw)

This unit occurs near Angove Lake, as a flat landscape composed of sand, 1-2 m above sea level. The water table is at about 1 m and the soil profile is a humus podzol; peaty sands also occur. A small area immediately south of the Gardner Creek has a siliceous surface overlying indurated calcareous clay. This has possibly formed from carbonates dissolving from the adjacent dunes and precipitating on the plain.

Islands

Four islands - Coffin Island, Inner Island, Rock Dunder and Black Rock - are also included in the Reserve. These were not visited but, from air photo interpretation, Coffin Island appears to be the only one with substantial vegetation (see also Smith and Kolichis 1980). It has a flat, gently sloping surface, with shallow granitic soils which support a dense low vegetation (Fig. 5.6). Inner Island may have a small area of low vegetation but the other two appear to be completely barren.

CONCLUSION

The Reserve has been shown to have variation in topography and soils and these are seen to be orderly when considered in a geological and geomorphological framework. The detail shown on the map is by no means the ultimate, as most units are known to vary in terms of colour and thickness of horizons of soils, and incidence of rock outcrop.

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Smith, GT and Kolichis, N. (1980). The flora and fauna of Coffin Island. *Western Australian Naturalist* **14**, 225-8.

FIGURE 5:1 LEGEND

Gardner (G) - Coastal headlands; >60 m relief; steep irregular rocky crests and upper slopes separated by smooth sandy tracts; deep erosion ravines.

Gg - Granite outcrop and shallow gritty soils.

Gs - Leached sands and pozols.

Gr - Erosion ravines with sandy slopes and granite exposed in channels.

Barrow (BA) - Hills and ridges >60 m relief; granite outcrop on crests; gently sloping flanks:

BAg - Granite outcrop and boulders

BAf - Lateritic duricrust and gravelly yellow duplex soils.

BAs - Grey leached sands or iron podzols.

Dempster (D) - Broad ridge crests and intervening swampy drainage lines.

Dl - Lateritic duricrust and gravelly duplex soils and spurs.

Ds - Leached sands and podzols on spurs.

Dr - Sandy valley slopes with iron podzols.

Df - Valley floor with humus podzols.

Dd - Dunes and Hummocks; iron podzols.

Meerup (M) - Parabolic coastal dunes and interdunal flats overlying various substrata:

Ms - Parabolic dune ridges, of very low relief, making up the oldest member of the Meerup dune system. The soil is an iron podzol with white sand over a B horizon of yellow-brown sand at about 1.5 m; soft ferruginous concentration may occur at lower levels.

Mp - Parabolic dune ridges, of moderate relief, forming the next member of the Meerup Dunes. The soil is a weakly developed podzol with white sand over a light yellow brown B horizon at about 1 m and then passing into calcareous sand at about 1.5 m.

Mc - Parabolic dune ridges of high relief forming the next member of the Meerup Dunes. The material shows slight soil development with a faintly calcareous organic stained surface overlying strongly calcareous sand.

My - Small parabolic dunes of high relief, fringing the present coastline, representing the youngest phase of the Meerup system. The sand is calcareous to the surface and is characteristically loose and unstable.

Mu - Presently unstable sand.

Me - Small parabolic dunes of high relief, which have originated as a fringe along Two Peoples Bay from an easterly wind. They are siliceous throughout the profile and show little soil development.

Mf - Flat or gently undulating land enclosed within parabolic dune ridges. The soils are generally sandy, sometimes swampy and reflect the character of materials in adjacent ridges and the substrate.

Blackwater (BW): - Coastal plain of very low relief, generally mantled by sand. Soils recognized are deep siliceous sands, peaty sands, and shallow siliceous sands over calcareous clay.

Owingup (OW): - Lacustrine deposits, consisting of low ridges and intervening swales, fringing the lakes. The materials show layering and consist of organic loam, sand, and estuarine shell deposits; seasonally flooded.

Substrates

General dunes

Limestone

Plantagenet

Granite

Limestone Scarp

fig 5-1 is the soils/landforms map

Fig 5.2
Photo of limestone platform @ Sunken reef
to be inserted top LH corner of page 2 of chapter 5

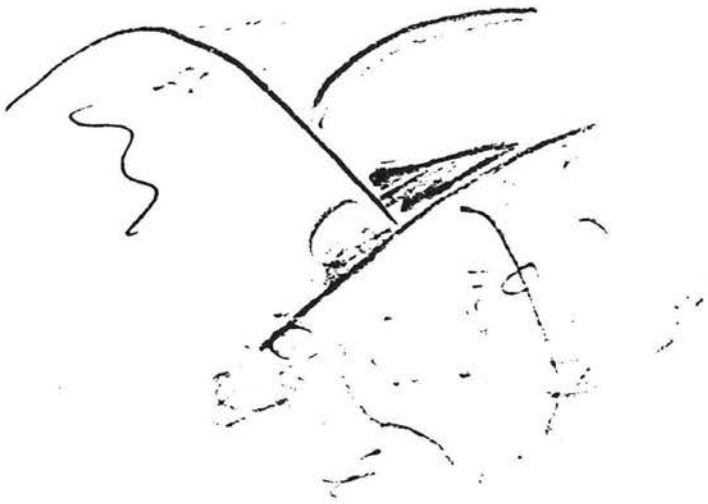

Fig 5.3
photo of Mt Gardner scarp
to be inserted mid RH of page 2 of chapter 5

Fig 5.4.
photo of soil profile at Moates
to be inserted top RH page 3 of chapter 5

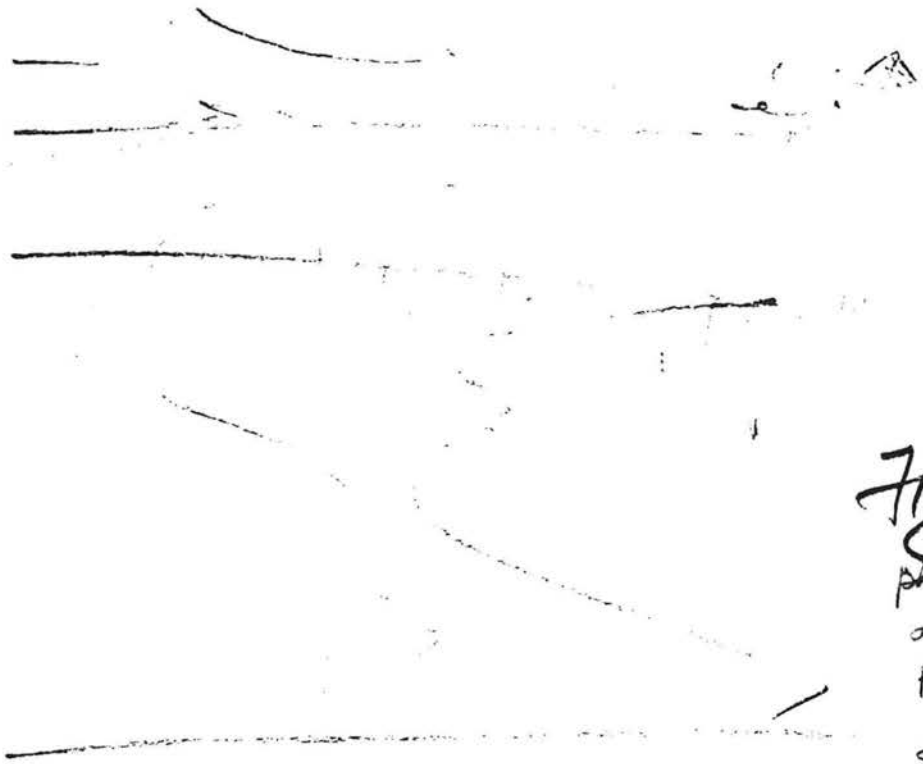

Fig 5.5
photo of dune across Moales to be positioned bottom of p 4 of chapter 5

Fig 5.6
Photo of Coffin Island to be inserted lower middle, page 5 of Chapter 5

EXPOSED PLANTAGENET SEDIMENTS

Substrates:-
2 — — — Limestone
3 — · — · — Plantagenet Sediments
4 — • — • — Granite

'DFORMS

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CHAPTER 6

Beach and Coastal Dune Systems

P.A. Hesp

INTRODUCTION

The Two Peoples Bay - Nanarup area comprises a range of beach-dune environments. These display a high variability in their Quaternary geological history, their geomorphological evolution, current geomorphological processes and attendant ecological and pedological processes. Preservation and conservation of these beaches, dunes and barrier systems in the Reserve is thus a priority, as they represent fine examples of natural coastal ecosystems in south-west Australia.

TWO PEOPLES BAY

The Two Peoples Bay beach-surfzone system is a modally intermediate type system (rhythmic bar and beach; Short 1983). It is fine grained and siliceous, and the surfzone is typically characterised by a shore-parallel, crescentic bar and trough system with rips. The overall beach-surfzone gradient is low because of the presence of fine sand.

The Bay faces east and is not exposed to the dominant south-west swell. Refracted wave energy is thus moderate and may be low for extensive periods particularly in summer. Wave energy is greatest in the north and declines to the south, which is sheltered and therefore less exposed. This trend is reflected in the distribution of sea grasses. At the northern end of the Bay the outer seagrass boundary is 100 m offshore, while at the southern end seagrass extends to 20-30 m offshore. This boundary provides a good indication of the position of wave base in the Bay (see Frontispiece this publication).

Foredune

The beach foredune is severely eroded during winter storms, which are mostly from the north-west to south-west with the storm waves being refracted into the Bay. The established foredune is significantly scarped during rare south-easterly storm events. Major erosion has occurred in recent years (e.g. 1984) leaving a large (3-4 m) scarp along the seaward face of the established foredune, and removing the incipient (or newly forming) foredune (see Figs 3.9 and 3.10 this publication).

Aeolian (wind-blown) sand transport is low to moderate on this beach because there is little sediment delivery by waves and exposure to strong winds is limited. Post-storm recovery (i.e. rebuilding of the dunes) is therefore slow.

Holocene Dunes

The Holocene (0-10 000 years Before Present (B.P.)) sand dunes backing Two Peoples Bay are well-vegetated, stable parabolic dunes. They are limited in area, height and volume and are best developed in the northern and central sections, diminishing to the south where they are eventually replaced by relict foredunes and wetlands. This trend is also reflected in the distribution of wave and wind energy noted above. Decreasing wave energy results in a decrease in the transport of onshore, wave-induced sediment and thus the net volume of sand delivered to the beach for dune-building decreases (Short and Hesp 1982).

The decrease in wave energy and surfzone width also has a marked effect on the foredune vegetation zonation and structure (Hesp 1988, 1990). As wave energy decreases, the degree of local salt spray decreases and many salt-intolerant species can therefore grow closer to the beach. Thus, there is also a gradient in vegetation species zonation and structure. The pioneer and successive zones are widely separated and of limited richness in the northern and central areas, and closely spaced, richer and more diverse in the southern section.

NANARUP BEACH TO ROCKY POINT

Nanarup beach receives much higher energy waves than other beaches on the Reserve and is modally an intermediate (longshore bar-trough) type 'b' or dissipative (linear, parallel bars and troughs) type 'a' surfzone system.[1] The bay east of Nanarup faces into the prevailing south and south-west swell and breaker wave heights commonly exceed 3-4 m during storms.

The surfzone is wide, and waves may break on the linear, carbonate reef lines which trend alongshore in the outer surfzone/nearshore zone (Fig. 6.1). Beach mobility (the degree of erosion and accretion) is high, and both wave-induced and wind-induced sediment transport is high.

Foredunes

Foredunes are formed during periods of accretion and low-moderate wave activity, but are eroded fairly quickly and regularly during storms. The erosion scarps are prone to wind attack and sand blowouts are common along the seaward edge of the dunes. Sand transport and salt spray inundation are much greater on this beach than on Two Peoples Bay and the vegetation zonation is generally wide, the pioneer zone being dominated by *Spinifex*. The vegetation zones are truncated by scarping, and in places locally disrupted because of blowout and gully development (Fig. 6.2)

Holocene Dunes

The Holocene dunes are extensive transient dune fields overlying bedrock and Pleistocene (10 000 - 1.8 million years B.P.) terrain. They are dominated by massive, vegetated transgressive dunes, and one large, unvegetated, mobile sand sheet which abuts Moates Lake (Figs 6.3 and 5.5 this publication).

The sinuous ridge pattern prevalent on the vegetated dune results from in-place stabilization by vegetation of the edges of active dune sheets (Hesp and Thom 1990). Just west of Rocky Point individual transverse dune ridges have been stabilized in place by vegetation. These dunes were probably forming as the Postglacial rise in sea level or Transgression, which began 18 000 years B.P. and reached the present level 6500-7000 years B.P., was still in progress (Thom and Roy 1983). The landward-most dunes, assuming no reactivation, may be in the order of 10 000 years old.

The Holocene dunes overlie a formerly extensive lake and estuarine system. Although Moates Lake, Gardner Lake and Angove Lake may not have been estuaries in the Holocene, they were almost certainly linked together to form an extensive estuary during the last Interglacial (~120 000 years B.P). when sea level was around 5 m higher than present. The entrance of this Pleistocene estuary may have been located near the centre of the bay close to the present boundary between the Holocene and Pleistocene dunes (Fig. 6.1).

Pleistocene Dunes

The Pleistocene dunes have been lithified to form aeolian calcarenites, which have been eroded to form cliffs along the seaward edge of the bay east of Rocky Point. They were also formed as transgressive dune fields both during low and high sea level phases.

The present cliff provides a strong indication that much of the surface terrain was formed during periods when sea level was lower than at present. Surface dune forms extend to the cliff edge, dune sequences and palaesols are visible in cliff exposures, and these appear to extend below present sea level.

THE POCKET BEACHES

Three 'pocket' beaches are present within or near the Reserve. Two lie immediately south-west of South Point (Little Beach and Waterfall Beach) and one immediately east of the northern end of Two Peoples Bay (Herring Bay). These beaches are reflective beaches. That is, the surfzone is very narrow, and plunging to surging breakers break near the base of the beach, surge up the beach as accentuated swash and the return swash is reflected off the beachface back out to sea (Fig. 6.4).

The beaches have moderately steep gradients and display limited aeolian sand transport. Dune formation is restricted to minor incipient foredunes which are occasionally scarped by storm waves.

CONCLUSION

The beaches and barrier systems comprise a major geomorphic element of the Two Peoples Bay Nature Reserve. They range in type from relatively high to low energy systems and include all the major dune types present along the W.A. coast. They also represent a Quaternary sequence

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1 P.A. Hesp, unpublished data

extending from Last Interglacial (120 000 B.P.) transgressive dunes, Last Glacial (40 000 - 10 000 B.P.) cliff top parabolic and transgressive dunes, to Holocene (10 000 B.P.) parabolic, and transgressive dunes and foredunes. The beach and barrier systems are both dynamic and fragile and warrant sensitive management.

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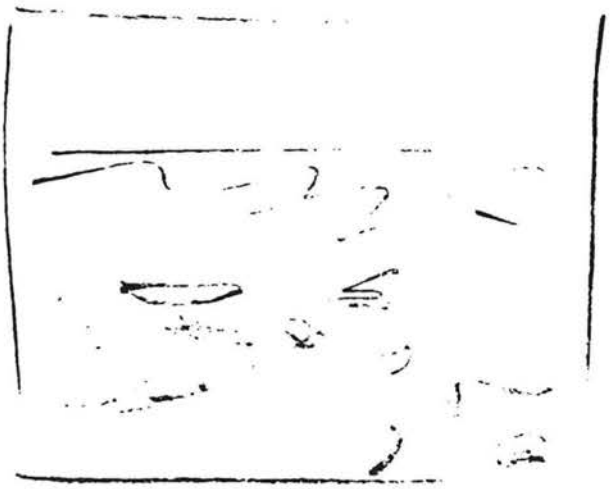


Fig 6.3

Photo of dunes & swales south of Moates — to be inserted top RH of page 2 of chapter 6

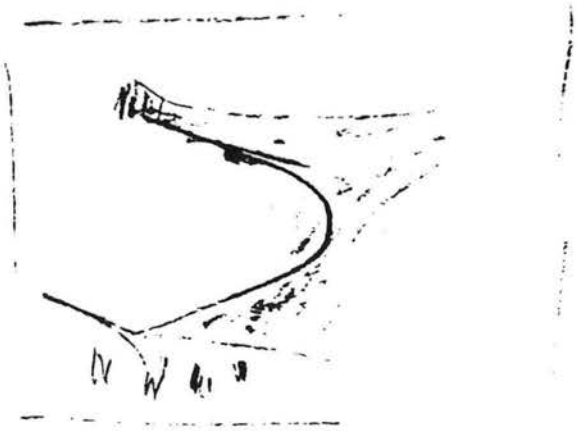


Fig 6.2

Photo of coastline dunes to be inserted bottom LH on page 2 of chapter 6

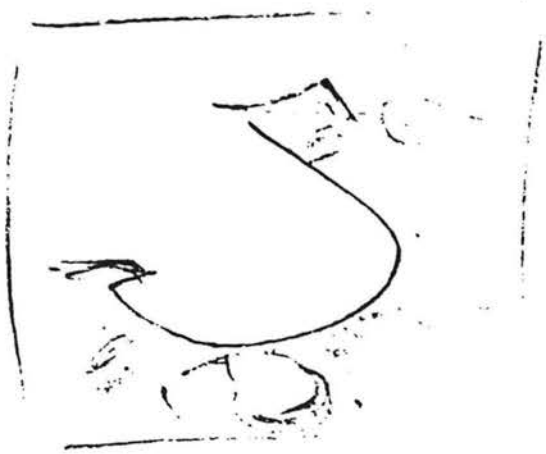
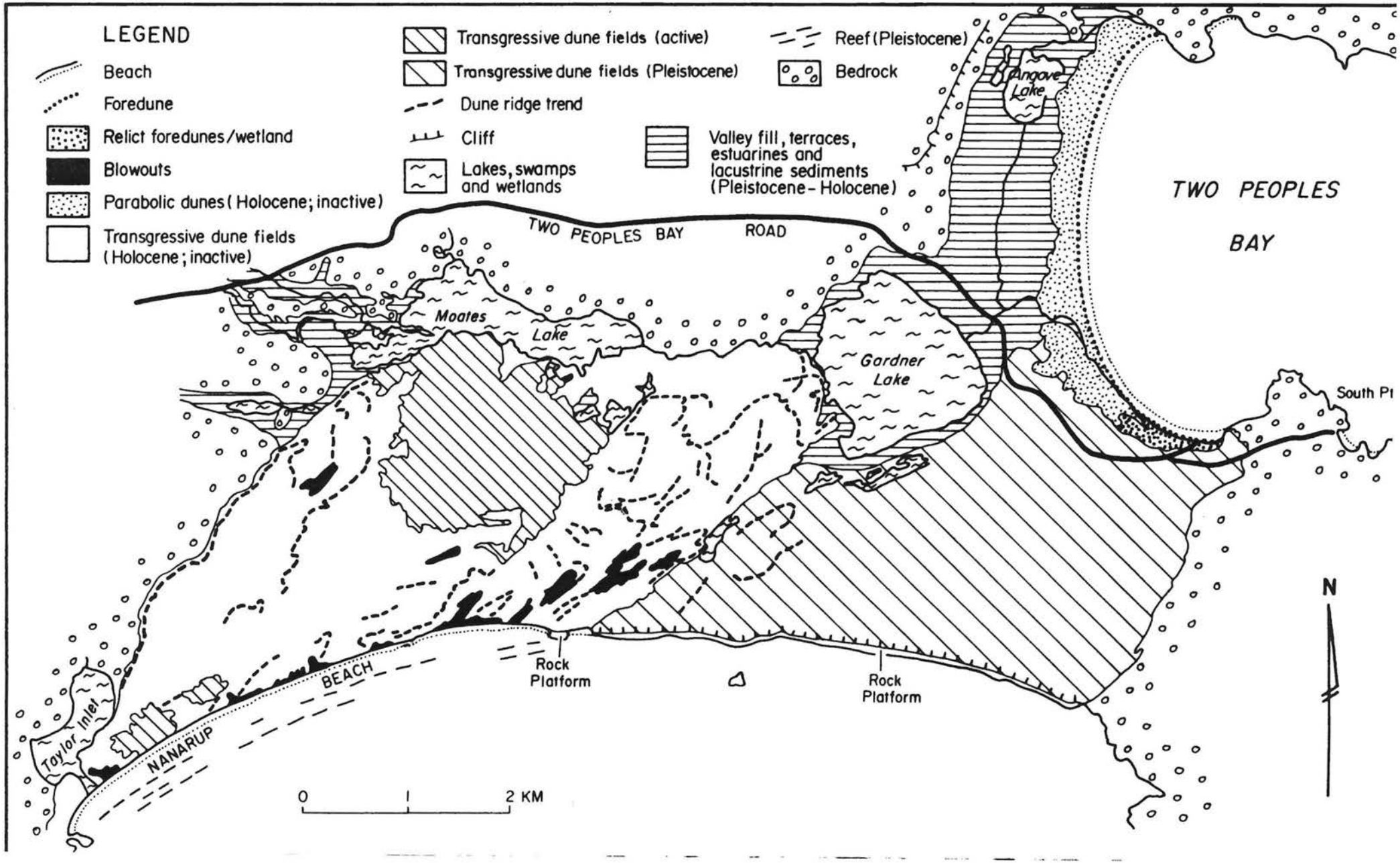


Fig 6.4

Photo of Little Beach & headland to be inserted bottom page 3 of chapter 6


LEGEND
Beach
Foredune
Relict foredunes/wetland
Blowouts
Parabolic dunes (Holocene; inactive)
Transgressive dune fields (Holocene; inactive)
Transgressive dune fields (active)
Transgressive dune fields (Pleistocene)
Dune ridge trend
Cliff
Lakes, swamps and wetlands
Valley fill, terraces, estuarines and lacustrine sediments (Pleistocene - Holocene)
Reef (Pleistocene)
Bedrock
TWO PEOPLES BAY ROAD
Moates Lake
Gardner Lake
Mangrove Lake
TWO PEOPLES BAY
South Pt
Rock Platform
Rock Platform
BEACH
NANARUP
Taylor Inlet
0 1 2 KM
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CHAPTER 7

Climate

A.J.M. Hopkins, W.M. McArthur and G.A. Bartle

INTRODUCTION

The climate patterns experienced within the Two Peoples Bay Nature Reserve have important influences on all biotic and abiotic components of the Reserve. For example, climate affects rates of weathering of rocks and soil formation, as well as factors such as erosion, the distribution of plant and animal species over the landscape and their seasonal behaviour, and processes like fire behaviour. This chapter provides an overview of aspects of climate that are relevant to understanding the resources of the Reserve and their management.

RAINFALL AND TEMPERATURE

There are several meteorological stations in the vicinity of Albany. The main meteorological office is located at the Albany airport, 13 km to the north of Albany township. This has been in operation only since 1965, whereas there are rainfall records from Albany townsite going back to 1877.

Table 7.1 summarises climate data for those stations for which reliable data are available. We include in this Table rainfall data from Eclipse Island, 20 km south of Albany, for the years 1926-1973; from 'Tandara', the property immediately adjacent to Two Peoples Bay Nature Reserve, for the years 1951-1972; and from the Reserve itself (1974-1989). The figures show a trend of diminishing rainfall with distance inland from the coast and also moving eastwards of Albany. This trend is more accurately portrayed in a comparison of rainfall for various stations over similar time intervals. For example, during the period 1964-1987 there are 13 years for which complete rainfall records are available for Albany Meteorological Office, Albany Town and Mt Manypeaks. Mean annual rainfall records for each of those stations for those 13 years are 811, 861 and 653 mm respectively (Table 7.1).

Annual rainfall for Mt Manypeaks for the period 1951-1971 averaged 694 mm: 27 mm lower than the long-term average for that station and 128 mm lower than the average for Tandara for the corresponding period.

Taken as a whole, the rainfall data suggest that the historical long-term annual mean for Two Peoples Bay is likely to be about 850 mm. Ten of the past 16 years, however, have been below this average during a period when rainfall has generally been low in the Albany district (Table 7.2).

It is likely that Mt Gardner has an orographic effect on local weather patterns, as the peak is often shrouded in cloud; however, data to support such a contention are scarce. There was a rain gauge on the slope near the CSIRO research station (Tick Flat) from 1972 to 1977, and data from this gauge can be compared with records from the gauge at the Reserve office for only three years. In 1974, Tick Flat received 804 mm of rainfall compared with the 787 mm recorded at the Reserve office. Figures for 1975 are 809 mm compared with 802 mm and for 1976, 873 mm compared with 932 mm.

Annual evaporation for Albany, as estimated from Bureau of Meteorology (1962), is around 1415 mm but the value for the Reserve may be considerably less because of the moderating influence of the sea. Any orographic effect of Mt Gardner would further ameliorate evaporation.

Temperatures are mild with mean values of 12°C for winter and 19°C for summer (Bureau of Meteorology 1962). Mean temperature for the hottest month, February, is 24°C mean maximum and for the coldest month, July, 8°C mean minimum.

The ombrothermic diagram (Fig. 7.1) when compared with those given in UNESCO-FAO (1963) shows the climate pattern of the Reserve to be mesomediterranean attenuated (with a short dry

season of about 4 months). Irregularities in the rainfall curve (low September rainfall, high January/February rainfall) are probably a result of the short-term nature of the records for the Albany Meteorological Office and the Reserve, since these patterns are not obvious in the Albany town record.

Beard (1981) used the scheme of Bagnouls and Gaussen (1957) to describe the climates of south-western Australia; according to this scheme the Reserve has a moderate mediterranean climate. Dick (1975) has mapped the climate patterns for Australia using up-to-date data and the Köppen scheme and shows the Reserve as CSb - a humid mild-winter climate with cool dry summers and wet winters.

WIND

The Reserve forms part of the coastal zone and therefore is at the interface between the land, the ocean and the atmosphere. It is a very dynamic environment and one of the most effective elements is the wind. It has been shown that, in the past, movement of materials by wind has been a major factor in landscape modelling (chs 4, 5 and 6 of this publication). It is evident that wind is still having a significant effect in redistributing detritus in the Reserve. Wind also has an effect on other management considerations, such as provision of access to beaches, location and orientation of tracks and firebreaks, and in relation to fire generally.

The nearest wind recording stations are on Eclipse Island, about 8 km offshore (Fig. 1.2 this publication), and at Albany Airport, about 13 km inland, and Albany town (1960-1963). Although conditions on the Reserve would not be identical to these three locations the wind pattern would probably be similar. Wind is expressed by four independent parameters - direction, speed, frequency, and duration - which are not fully shown by the 0900 h and 1500 h recordings. Figure 7.2 shows three of these parameters for the Eclipse Island station for four separate months; representing summer, autumn, winter and spring.

The wind speed required to move sand varies with the nature of the surface and the atmospheric conditions, but it can be assumed that under conditions on the Reserve any wind of 20 km/h or higher would move sand grains. The efficiency of wind in sand movement increases as the cube of the speed. This has importance because, apart from the high speeds which may be recorded, there are sometimes very strong gusts. These may be of short duration but may initiate sand movement or cause structural damage to vegetation. (See details on storm damage in ch. 3.)

In summer the days are dominated by easterly winds, evidently at high speeds for much of the time, because of the position of the belt of high pressure systems. This wind has influence on sand movement in the east-facing bays. In the afternoons there is a significant component of onshore winds from the southerly quadrant. The south-westerly wind has a high percentage of winds greater than 20 km/h and some higher than 51 km/h. (This is when the sea-breeze coincides with the system wind at the eastern end of a high pressure pattern.)

In April the pattern changes with mornings having no clearly defined dominant wind but, probably because of the high ridge axis shifting to the north, there is a significant north-westerly component. In the afternoons the south-westerly wind is dominant, with easterlies still present at times.

This pattern continues into July with the north-west wind even more dominant in the mornings, mostly at very high speeds, and continuing in the afternoon. The afternoons also have a strong south-west component at consistently high speeds. For example, of the 21 per cent of recordings from the south-west, 14 per cent exceed 20 km/h and 6 per cent exceed 51 km/h. In October the south-westerly component is dominant in both morning and afternoon but with easterly winds beginning to be significant. Thus, there are two major wind influences which change seasonally: the easterly dominates the pattern during the summer but the south-westerly, which is significant throughout the year, becomes dominant and very strong during the winter months.

These comments are based on the Eclipse Island record. Examination of the Esperance and Albany records shows that the summer is dominated by south-east winds with south-westerlies becoming dominant in winter. However, in no instance does the speed reach the same level as at Eclipse Island, therefore the Reserve may be in a zone of change between these two regimes.

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Table 7.2.

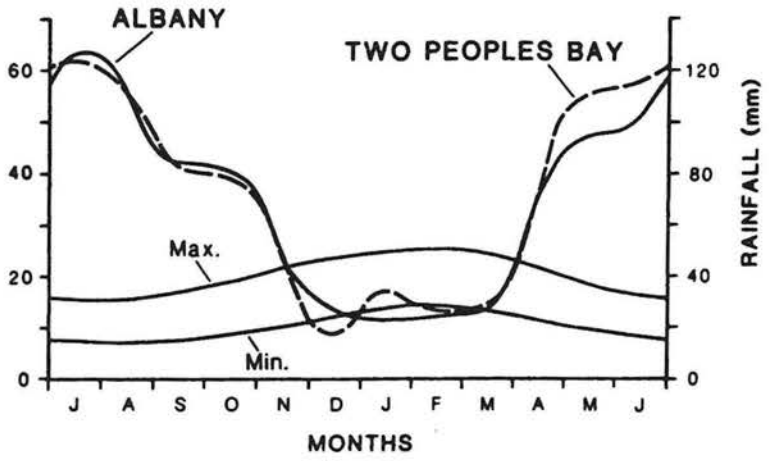
Rainfall and number of Rain Days at Two Peoples Bay Research Station

YEAR	JAN	FEB	MAR	APR	MAY	JNE	JLY	AUG	SEP	OCT	NOV	DEC	TOTAL
1974 (mm)	14.5	24.0	31.0	81.5	107.5	92.0	98.5	132.5	73.0	65.6	46.5	15.5	782.0
(days)	(5)	(5)	(4)	(7)	(5)	(6)	(9)	(8)	(8)	(7)	(6)	(3)	(73)
1975	21.8	8.5	4.5	100.5	129.1	78.1	83.7	146.5	60.5	109.8	56.5	2.5	802.0
	(5)	(3)	(2)	(10)	(15)	(10)	(14)	(10)	(10)	(12)	(6)	(1)	(98)
1976	70.0	28.5	12.0	101.0	91.0	98.1	105.0	95.0	88.5	152.0	83.5	7.0	931.6
	(5)	(4)	(2)	(9)	(8)	(8)	(15)	(16)	(14)	(15)	(7)	(2)	(105)
1977	8.0	13.7	13.5	31.5	118.0	63.5	87.0	145.0	85.3	141.0	26.0	51.0	783.5
	(2)	(3)	(4)	(5)	(15)	(12)	(16)	(17)	(12)	(9)	(5)	(4)	(104)
1978	47.5	56.0	13.0	58.5	153.0	261.0	186.0	69.5	140.5	39.5	27.0	26.5	1078.0
	(3)	(5)	(5)	(9)	(18)	(24)	(21)	(16)	(20)	(10)	(4)	(9)	(144)
1979	13.0	74.0	35.0	44.0	117.5	119.5	95.5	209.0	101.5	70.5	50.0	9.7	939.2
	(6)	(10)	(14)	(12)	(14)	(23)	(19)	(20)	(16)	(11)	(13)	(6)	(164)
1980	7.2	34.5	9.0	100.5	40.5	110.5	95.5	79.5	49.5	110.5	49.0	15.3	701.5
	(5)	(6)	(5)	(10)	(10)	(18)	(19)	(16)	(9)	(19)	(12)	(4)	(133)
1981	11.0	11.2	13.5	61.5	153.8	174.0	125.5	118.5	57.3	46.0	48.3	4.0	824.7
	(6)	(6)	(7)	(15)	(18)	(22)	(20)	(20)	(11)	(9)	(14)	(2)	(150)
1982	149.2	24.3	53.8	34.3	71.6	134.5	108.6	68.3	51.3	25.5	44.3	14.3	780.0
	(13)	(7)	(7)	(11)	(16)	(18)	(14)	(18)	(15)	(9)	(9)	(4)	(141)
1983	8.0	22.0	20.0	47.7	50.0	141.7	92.5	79.5	83.7	86.2	40.0	32.5	703.8
	(6)	(9)	(10)	(11)	(14)	(14)	(13)	(21)	(17)	(12)	(13)	(8)	(148)
1984	3.3	23.8	23.8	36.8	73.5	73.8	143.0	158.0	95.3	48.0	67.3	20.8	767.4
	(5)	(10)	(13)	(6)	(16)	(13)	(21)	(23)	(22)	(15)	(13)	(8)	(165)
1985	42.5	3.0	66.3	105.5	72.3	61.3	201.5	114.8	54.3	76.3	45.2	31.3	874.3
	(8)	(4)	(11)	(12)	(13)	(19)	(15)	(24)	(11)	(17)	(12)	(7)	(153)
1986	7.5	53.0	37.3	17.0	105.8	52.3	148.0	98.3	144.3	79.3	55.0	26.0	826.8
	(2)	(10)	(11)	(11)	(14)	(20)	(22)	(22)	(23)	(16)	(11)	(5)	(167)
1987	11.0	1.5	35.0	61.5	87.5	78.5	115.0	73.0	66.5	47.0	83.5	11.0	671.0
	(4)	(2)	(11)	(14)	(12)	(13)	(16)	(11)	(12)	(8)	(9)	(5)	(117)
1988	20.5	2.0	39.5	27.5	241.3	200.0	128.9	104.4	87.1	61.0	32.5	11.5	956.2
	(6)	(2)	(9)	(8)	(22)	(19)	(15)	(20)	(16)	(14)	(9)	(9)	(149)
1989	113.2	28.5	12.0	107.0	132.5	95.7	135.0	111.0	90.5	116.5	22.0	8.0	972.0
	(12)	(10)	(9)	(14)	(18)	(20)	(16)	(10)	(16)	(15)	(6)	(3)	(155)
MEAN	34.3	25.5	26.2	63.5	109.0	114.6	121.8	112.7	83.1	79.7	48.5	17.9	837.0
(1974-89)	(6)	(5.8)	(7.7)	(10.3)	(14.2)	(16.5)	(16.6)	(17)	(14.5)	(12.4)	(9.4)	(5)	(135)

Table 7.1.

Summary of Climatic Data for Two Peoples Bay and Adjacent Stations

	RECORD (years)	JAN	FEB	MAR	APR	MAY	JNE	JLY	AUG	SEP	OCT	NOV	DEC	YEAR
Albany Met. Office (Airport) **(1965-1988)**														
(34°56'S, 117°48'E, 71m Elev)														
Av Rainfall (mm)	23	23	25	27	65	94	100	125	109	83	81	47	26	805
Av Raindays (No.)	23	7	9	11	14	18	19	21	21	19	15	13	10	177
Mean Daily Max Temp (°C)	21	25.4	25.1	24.2	21.5	18.7	16.5	15.8	16.0	17.2	18.9	20.9	23.7	
Mean Daily Min Temp (°C)	21	13.6	14.4	13.1	11.5	9.7	8.1	7.6	7.4	7.8	9.0	10.7	12.4	
0900h Mean Rel. Humidity (%)	21	62	65	68	77	82	84	82	80	77	72	69	62	73
1500h Mean Rel. Humidity (%)	21	52	54	56	60	64	67	69	67	66	64	63	56	62
Albany Town (1877-1989)														
(35°01'S, 117°53'E, 13m Elev)														
Av Rainfall (mm)	103	24	23	38	72	121	134	146	127	101	81	42	30	939
Av Raindays (No.)	103	8	8	11	14	19	20	22	21	18	17	12	10	180
Manypeaks Townsite (1947-1989)														
(34°50'S, 118°10'E, 220m Elev)														
Av Rainfall (mm)	42	22	24	39	62	83	94	101	86	77	66	39	31	724
Av Raindays (No.)	42	5	6	7	11	13	15	16	16	14	12	8	6	129
Tandara (not Met. Bureau) **(1951-1972)**														
(34°57'S, 118°9'E, 35m Elev)														
Av Rainfall (mm)	21	19	30	43	78	95	112	114	101	86	72	42	32	820
Two Peoples Bay (not Met. Bureau) **(1974-1989)**														
(34°59'S, 118°11'E, 5m Elev)														
Av Rainfall (mm)	16	34	26	26	63	109	115	122	117	83	80	48	18	837
Av Raindays (No.)	16	6	6	8	10	14	16	17	17	14	12	10	5	135
Eclipse Island (1926-1972)														
(35°11'S, 117°53E, 103.m Elev)														
Av Rainfall (mm)	47	23	16	33	69	119	149	169	134	100	71	39	28	950
Av Raindays (No.)	47	8	6	11	15	20	21	23	22	19	17	12	9	183



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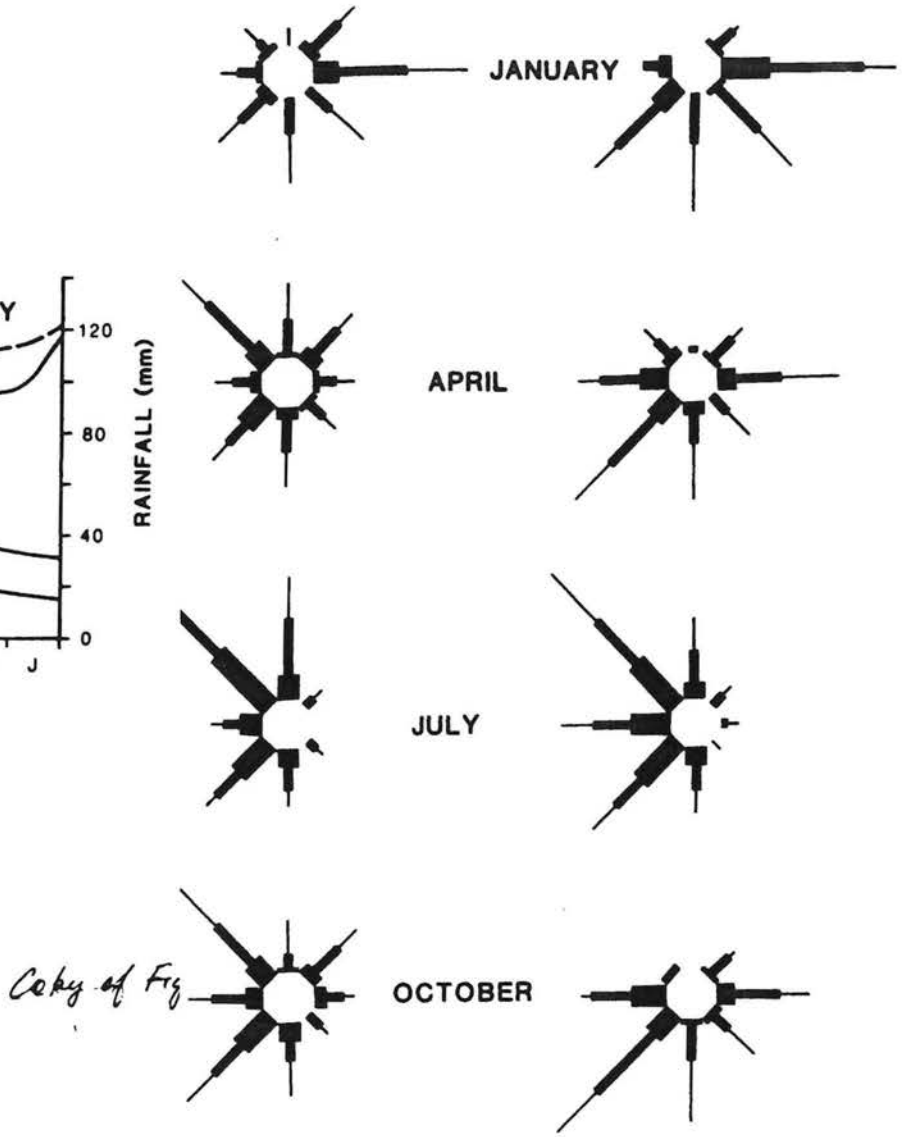

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CHAPTER 8

The Larger Fungi of Two Peoples Bay Nature Reserve

R.N. Hilton

INTRODUCTION

The first recorded collections from the Reserve were made by Dr. Graeme Smith in the autumn of 1974 and 1975. The fungi were chilled and despatched as fresh specimens to the Botany Department, University of Western Australia, where it was possible to make a number of positive identifications. It was evident that the Reserve was rich in larger fungi. This led to brief visits in May 1976 by Dr. Derek Reid from the Royal Botanic Gardens, Kew, and in September 1981 by Professor Orson K. Miller Jr., of Blacksburg, Virginia, both eminent specialists in larger fungi. Neither visit was at the height of the season (June/July). Nevertheless, a number of interesting finds were made, some of which are incorporated into the list below. The author spent a week collecting in the Reserve in late May 1982.

This paper provides details of all the larger fungi so far recorded for the Two Peoples Bay Nature Reserve. The list follows the classification of Ainsworth *et al.* (1973) and includes comments on the known distribution within the Reserve.

ANNOTATED LIST

Subdivision ASCOMYCETES
Class DISCOMYCETES - disk and flask fungi.

Peziza austrogeaster (Rodway) Rifai - found on Pitcher Flat, also common in the heath and gullies on Tick Flat and Robinson Gully, West Gully and on the sea shore.

Peziza vesiculosa Bull. ex St. Am. - collected among sandy open scrub on Pitcher Flat.

Subdivision BASIDIOMYCETES
Class HYMENOMYCETES

Subclass PHRAGMOBASIDIOMYCETIDAE - a group of jelly fungi and their allies related to the rusts and smuts.
Order TREMELLALES

Exidia sp. - witches butter - abundant on dead branches throughout the wooded areas.

Tremella mesenterica Fr. - common on dead wood in the gullies of the Mt Gardner area.

Subclass HOLOBASIDIOMYCETIDAE
Order AGARICALES - the mushrooms and toadstools.

Family AGARICACEAE

Agaricus arvensis Schaeff. ex Secretan - the horse mushroom has a similar distribution to the common field mushroom.

Agaricus campestris L. ex Fr. - the common field mushroom was found in the picnic area and adjacent to farmlands.

Agaricus langei (Moller) Moller = *Agaricus vinaceus* Cleland.

Agaricus silvaticus Schaef. ex Vitt. - the woodland mushroom.

Family AMANITACEAE

Amanita dumosorum Reid - type locality. Found in heath communities (Reid 1978, 1980).

Amanita grisella Gilbert & Cleland.

Amanita griselloides Reid - the type locality is near Walpole. Found in heath communities on the Reserve (Reid 1980).

Amanita ochroterrea Gentilli ex. Bas. - a remarkable green variety of this species. This is a rare fungus found only in the heath areas around Mt Gardner.

Amanita preissii (Fr.) Sacc.

Amanita subalbida Cleland - found in heath, also recorded in South Australia and Queensland (Reid 1980).

Amanita umbrinella Gilbert & Cleland.

Amanita virgineoides Bas. aff.

Amanita xanthocephala (Berk.) Reid & Hilton [= *A. pulchella* (Cooke & Massee) Gilbert] - common in the Mt Gardner area.

Family BOLBITIACEAE

Bolbitius vitellinus Fr. - common in grassy areas.

Family BOLETACEAE

Austroboletus occidentalis Watling.

Boletellus obscure-coccineus (Hoehn.) Singer - common in heath areas and gullies around Mt Gardner.

Phylloporus hyperion (Cooke & Massee) Singer.

A number of other boletes have been rendered unrecognisable by attack by the mould *Sepedonium* sp.

Family CANTHARELLACEAE

Cantharellus lilacinus Cleland & Cheel - characteristic fungus of the karri forest. Found in the forested gullies around Mt Gardner.

Family COPRINACEAE

Coprinus comatus (Muller ex Fr.) Gray - common in the picnic area and areas adjacent to farmland.

Coprinus disseminatus (Pers. ex Fr.) Gray.

Coprinus micaceus (Bull. ex Fr.) Fr.

Panaeolus campanulatus (Fr.) Quél.

Family CORTINARIACEAE

Cortinarius, the genus after which this family is named, is represented by a number of species, all mycorrhizal with native plants, but still awaiting specific identification.

Crepidotus uber (Berk. & Curtis) Sacc. - collected on bark of bullich (*E. megacarpa*); common throughout the Reserve on a number of other woody species.

Gymnopilus penetrans (Fr.ex Fr.) Murrill - common in gullies around Mt Gardner.

Gymnopilus purpuratus (Cooke & Massee) Singer.

Family ENTOLOMATACEAE (= RHODOPHYLLACEAE)

Entoloma and *Leptonia* species are common but identifications for most specimens await Dr E. Horak's descriptions of Western Australian members of this family.

Entoloma sericellum (Fr.) Kummer.

Leptonia incana (Fr.) Gillet.

Leptonia lampropa (Fr.) Gillet.

Family HYGROPHORACEAE

Hygrocybe coccinea (Fr.) Kummer - collected at the foot of the sand dune at the edge of Moates Lake. Common in the deeper gullies in the Mt Gardner area.

Family LEPIOTACEAE

Lepiota cristata (Fr.) Kummer - collected in heath on Tick Flat.

Lepiota konradii P.D. Orton - collected in heath on Tick Flat.

Family PAXILLACEAE

Paxillus muelleri (Berk.) Sacc. - common fungus throughout the wooded part of the Reserve.

Family PLUTEACEAE (=VOLVARIACEAE)

Pluteus spp. have been collected from decaying wood but not identified to species.

Volvariella speciosa (Fr. ex Fr.) Singer - found in grassy areas.

Family RUSSULACEAE

Russula clelandii Miller & Hilton.

Russula delica Fr. - common in wooded areas.

Russula flocktonae Cleland & Cheel - common in wooded areas.

Family STROPHARIACEAE

Stropharia semiglobata (Fr.) Sacc. - found on dung of the Western Grey kangaroo (*Macropus fuliginosus*).

Naematoloma fasciculare (Huds ex Fr.) Kummer - sulphur tuft. Found on dead wood.

Family TRICHOLOMATACEAE

Anthracophyllum archeri (Berk.) Pegler - abundant in heavy, woody undergrowth. Collected from dead *Melaleuca* sp. 1 on Mt Gardner.

Armillaria luteo-bubalina Watling & Kile - common.

Collybia butyracea Fr.

Laccaria laccata (Scop. ex Fr.) Berk. & Broome - on litter and roots in gullies around Mt Gardner.

Lentinus lepideus (Fr. ex Fr.) Fr.

Mycena subgalericulata Cleland.

Oudemansiella radicata (Relhan ex Fr.) Singer.

Pleurotus nidiformis (Berk.) Sacc. - the ghost fungus - has been found on *Eucalyptus marginata*, *Agonis flexuosa*, *Melaleuca thymoides*, and *Banksia grandis*.

Resupinatus applicatus (Batsch ex Fr.) - S.F. Gray - abundant in heavy woody undergrowth.

Tricholoma is represented, but the species have not been determined.

Order APHYLLOPHORALES - the bracket fungi and their allies.

Family HYMENOCHAETACEAE

Coltricia cinnamomea (Pers.) Murrill - grows in troupes from detritus buried in the ground.

Family FISTULINACEAE

Fistulina hepatica Fr. - the beef steak fungus - recorded once.

Family GANODERMATACEAE

Ganoderma applanatum (Gray) Pat. - rarely found; on rotten wood.

Family HYDNACEAE

Hydnum repandum L. ex Fr. - a spine fungus, sporadic in its distribution.

Phellinus gilvus (Schwein.) Pat.

Phellinus rimosus (Berk.) Pilat - common in gullies around Mt Gardner.

Family POLYPORACEAE

Piptoporus australiensis (Wakef.) G. Cunn- curry punk - found in Robinson Gully.

Piptoporus portentosus (Berk.) G. Cunn - giant punk - has been found on marri (*E. calophylla*) and bullich (*E. megacarpa*).

Pycnoporus coccineus (Fr.) Bond & Singer - scarlet bracket fungus - common throughout the Reserve.

Trametes lilacino-gilva complex.

Family CONIOPHORACEAE

Podoserpula pusio (Berk.) Reid - The many-tiered pagoda fungus - remarkable member of this group, found in wetter parts of the Reserve, e.g. growing on dead branches on *Melaleuca* sp. 1 in Coffin Gully. Also found in *Nothofagus* forests in the Otway Ranges in southern Victoria, in Tasmania and South America.

Family CLAVARIACEAE

Ramaria sinapicolor Cleland - coral fungus - common in gullies around Mt Gardner.

Family STEREACEAE

Stereum hirsutum (Wild.) Pers. ex Gray - common on rotten wood, e.g. *Gastrolobium bilobum*.

Order DACRYMYCETALES - jelly fungi related to the mushrooms and toadstools

Family DACRYMYCETACEAE

Calocera guepinioides Berk - abundant on dead *Banksia littoralis* on the shore of Moates Lake.

Heterotextus peziziformis (Berk.) Lloyd - abundant on living and dead *Banksia littoralis* trunks on the shores of Moates Lake.

Class GASTEROMYCETES - puffballs, earth-stars, stink-horns and their allies.
Order LYCOPERDALES

Family GEASTRACEAE

Geastrum triplex Jungh. - earth star - common throughout the Reserve.

Order SCLERODERMATALES

Family SCLERODERMATACEAE

Pisolithus tinctorius (Mich. ex Pers.) Coker & Couch.

Scleroderma verrucosum Pers. - earth ball - common.

CONCLUSION

The species of large fungi so far recorded are only a fraction of what must be present and further studies are in hand to identify this large and varied flora of the Reserve. Further information on the distribution of the fungi recorded above is given in Hilton (1982, 1988).

Fungi are dependent for their survival on organic matter that is either dead or a part of living organisms. If the latter, they are parasitic or, as is much more usual with the larger fungi, symbiotic. Consequently, any management policy that encourages tree growth, and favours the accumulation of organic matter in and on the soil will maintain a rich fungus flora. Exclusion of burning is the most important factor. This has been a policy in parts of the Reserve in the interests of the Noisy Scrub-bird. Not only do such unburnt areas reveal a rich fungus flora but they act as a centre from which burnt areas can be re-colonised. It is desirable to have more areas protected from fire that can form a chain of isolated reserves from Two Peoples Bay west to Augusta.

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CHAPTER 9

Bryophytes

R. Wyatt, A. Stoneburner and S.D. Hopper

INTRODUCTION

There is a general lack of knowledge of the bryophyte flora of Western Australia. According to Ramsay (1977), the flora is thought to be depauperate with only about 100 species compared with over 1200 species for the rest of Australia. Ramsay (1977) also notes a lack of endemism in the bryophyte flora compared with the high degree of endemism found among flowering plants (Beard 1981). She suggests that the low incidence of rainforest habitat may account for the lack of a rich and diverse bryophyte flora. From our own experience in south-west Western Australia, it appears that the presumed lack of species is attributable to a lack of bryophyte collecting. We are preparing a checklist of Western Australian mosses, which includes nearly 200 species, in collaboration with David Catcheside of the University of Adelaide. The majority of collections were made in the South-West Botanical Province.

Bryophytes can be considered part of the natural assemblage of whole floras acted upon by the same geological, climatic, and ecological conditions that shape the evolution of the vascular members of that flora (Crum 1972). It is therefore likely that further study will reveal that the bryophyte flora of the State is more diverse than previously supposed.

At Two Peoples Bay Nature Reserve, the moderate mediterranean climate with wet, mild winters and cool, dry summers provides favourable conditions for the establishment and growth of bryophyte colonies. However, the relative youth of much of the landmass of the Reserve may have hindered development of a diverse bryophyte flora as the Mt Gardner headland apparently emerged from the sea during the mid-Pleistocene and the sands of the isthmus and lakes areas have accumulated since that time (chs 4 and 5 of this publication). For most species, long-range dispersal by spores or plant fragments is not common (Crum 1972). However, wind is an important component in the environment of the Reserve (ch. 7) and may play a larger role in dispersal here than expected.

MATERIALS AND METHODS

During the period April-September 1984, seven sites were visited in the Reserve and 105 collections of mosses and 19 of liverworts were made. Voucher specimens of all collections have been deposited in the Western Australian Herbarium (PERTH). Prior to this survey only one specimen from the Two Peoples Bay Nature Reserve (*Campylopus bicolor* from Mt Gardner) was available for study (PERTH). A limited number of collections made subsequent to the survey have been reported to us. These reports are included in Table 9.1 under the heading 'Other Collections'. T9.1

This survey should be considered a preliminary one. An attempt was made to visit different kinds of habitats in the relatively short time available. More time will be required in future to study in detail mesic habitats, especially the gullies and sclerophyll woodlands.

Mosses were identified using the manuals of Catcheside (1980) and Scott and Stone (1976) and by comparison with specimens from PERTH and the Herbarium of the University of Western Australia (UWA). Geographical distributions of the species were noted and compared for provinces within Western Australia, using Beard's (1980) classification, and within Australia and the rest of the world, as described in the aforementioned manuals and *Index Muscorum* (Wijk *et al.* 1959-1969). Liverworts were identified using keys made available and subsequently published by Scott (1985). Members of the genus *Riccardia* were identified using Hewson's (1970) keys and descriptions.

RESULTS

Mosses

The 37 species of mosses listed in Table 9.1 represent 20 genera from 13 families. Two species are reported as new for Western Australia : *Bryum inclinatum* and *Tortella dakinii*. Three of the taxa inventoried here are new to science in the genera *Bryum, Pleurophascum* and *Tortella*. Descriptions of the new species will be published elsewhere. The Pottiaceae is the largest family represented with six genera and eleven species.

The habitats occupied by these taxa are not narrowly specific. Most are found on soil at the bases of trees or boulders or on rocks in protected crevices or fissures. In more mesic sites, bryophytes grow on fallen logs or on the trunks and branches of trees and shrubs. Numerous species, while not strictly acidophilic, calciphilic or epiphytic, appear to favour particular habitats over others. Accordingly, granitic sites like Robinson Gully support a different set of bryophytes when compared with Sinker Reef, which is largely limestone. More than one-half of our collections came from just two of the seven sites - Robinson Gully and the forests adjacent to the picnic area.

The majority of moss and liverwort species collected at Two Peoples Bay Nature Reserve are found elsewhere in the South-West Botanical Province of Beard (1980), notably from the Darling Botanical District. Except for the three new taxa, all of the species have been reported from elsewhere in Australia or New Zealand. The bryophyte flora of South Australia is especially similar to that of south-west Western Australia. The greatest number of species (46 per cent) are endemic to Australia and/or New Zealand; 24 per cent demonstrate a Gondwanaland distribution; 27 per cent can be described as nearly cosmopolitan; and only one species (*Sematophyllum homomallum*) shows an Australasian distribution (i.e., it occurs in Australia, New Zealand and parts of Asia).

Liverworts

T.9.2

Table 9.2 lists 11 species of liverworts, with site notes. As with mosses, Robinson Gully supported the most abundant and diverse flora.

DISCUSSION

Worldwide there are about 14 000 species of mosses and liverworts. Their origin is thought to be more ancient than that of vascular plants. With the exception of fairly local colonizations of newly available or disturbed sites, their present distributional patterns probably antedate the origin of flowering plants and the breakup of Gondwanaland in the Cretaceous (Crum 1972). A rich and diverse bryophyte flora would not be expected along that portion of the south-west coast that is of geologically recent exposure. The genus : species ratio, 1:1.85, is similar to that of mosses of the Hawaiian Islands (1:1.80), another landmass of geologically recent origin (Crum 1972).

The Pottiaceae, the most common family occurring in the Reserve, forms a highly polymorphic group. Many of its members are adapted to semi-arid to arid conditions and are commonly thought of as small, tufted mosses of soil and rocks.

Regardless of family relationships, nearly one-half of the species collected in the Reserve have the capacity to occupy open, relatively dry habitats. The morphological adaptations to drought of several of these species are described in detail by Scott (1982). Those sites with the greatest diversity and cover of bryophytes are the most mesic, especially Robinson Gully and the sclerophyll forests adjacent to the picnic area. The driest sites have a distinctly depauperate bryophyte flora, particularly 'Rock Island' , the shores of Gardner Lake, and Sheoak Ridge.

The bryophyte flora of the Reserve is, as expected, similar to that of adjacent regions. Only three species (*Campylopus pallidus, Barbula crinita*, and *Funaria salsicola*) had not been collected previously from the Darling District, although they are known from other districts in the South-West Province. The majority of all other collections of the Two Peoples Bay Nature Reserve species are also recorded in the Darling District. The Eyre and Avon Districts appear to have a decidedly lesser influence on the flora, and the Irwin and Roe the least.

The flora of south-west Western Australia and South Australia appear very similar, thereby making *Mosses of South Australia* (Catcheside 1980) an invaluable manual for collectors in W.A. The most commonly collected species (collected at five or more sites) show the following geographical affinities: *Rhacopilum convolutaceum* is an Australian-New Zealand endemic; *Tortella calycina* and *Campylopus bicolor* have a Gondwanaland distribution; *Campylopus introflexus* is cosmopolitan; and *Sematophyllum homomallum* is found in Australia, New Zealand and parts of Asia.

Although the majority of species collected from the Reserve were not unexpected, several collections support the importance of continuing the bryophyte survey: *Bryum inclinatum* and *Tortella dakinii* had not been reported previously from Western Australia, and three species appear to be new to science. Two of the taxa reported as new belong to genera which are notorious for blurred species boundaries (*Bryum* and *Tortella*). With further study these taxa may be treated as conspecific with species as yet unknown from Australia. *Pleurophascum occidentale*, however, differs distinctly from the one described species of genus, *P. grandiglobum* and represents a striking geographical disjunction from Tasmania and New Zealand, where the latter occurs (Wyatt and Stoneburner 1989). It is important to continue floristic investigations in south-west Western Australia, a region unique in its geographical diversity and ecological amplitude.

The hepatic flora of Australia is even less studied than the moss flora. A recent manual by Scott (1985) has done much to remedy that situation for southern Australia. Scott (1985), however, does not consider his manual exhaustive nor intensive in scope. Distributional information available for Australian liverworts is especially incomplete. The list of species reported here should not be considered definitive, but rather an indication of the orders, families, and genera likely to be most common in the Reserve. For southern Australia, Scott (1985) lists 80 genera in five orders and 33 families.

Bryophytes play an important role in soil conservation (Moul and Buell 1955; Golding and Stanton 1972), vegetation development (Thieret 1956) and nutrient cycling (Brown 1982). A well developed colony of a moss or liverwort may be decades in the making. It is well to remember 'that mosses are vulnerable ... and that indiscriminate or wasteful collecting is unethical, immoral and altogether to be deplored' (Scott and Stone 1976). Management policy at Two Peoples Bay Nature Reserve should continue with protection of the flora and fauna as its number one priority.

ACKNOWLEDGEMENTS

Valerie Hobbs and Graeme Smith collected additional specimens after our survey and communicated their identifications to us. Various specimens were referred to David Catcheside and G.A.M. Scott, who were most helpful in solving troublesome problems. We thank G.G. Smith and John Green, former curators of the herbariums at UWA and PERTH, respectively, for their assistance with herbarium specimens, and Neville Marchant and Marion Blackwell for comments on the manuscript.

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Table 9.1
List of species of moss collected at Two Peoples Bay Nature Reserve

SPECIES	SITE*							
	RG	RO	WB	SRf	RI	SRd	LG	Other collections
Barbula crinita Schultz		x						
Barbula torquata Tayl.		x						
Bryum albo-limbatum (Hampe) Jaeg.	x	x			x			
Bryum billardieri Schwaegr.		x						x
Bryum campylothecium Tayl.			x					
Bryum chrysoneuron G. Mull.		x						
Bryum inclinatum (Brid.) Bland		x						
Bryum sp. nov.	x	x						
Campylopus australis Catche. & Frahm		x						x
Campylopus bicolor (C. Muell.) Hook. f. & Wils.	x		x					x
Campylopus introflexus (Hedw.) Brid.	x	x						x
Campylopus pallidus Hook. f. & Wils.								x
Dicranoloma diaphanonerum (Hampe & C. Muell.) Par.	x							
Fissidens tenellus Hook. f. & Wils.	x		x					
Funaria hygrometrica Hedw.		x						
Funaria salsicola C. Mull.				x				
Grimmia laevigata (Brid.) Brid.								x
Gymnostomum calcareum Nees & Hornsch.			x	x				
Hypnum cupressiforme Hedw.								x
Orthodontium inflatum (Mitt.) Par.	x							
Pleurophascum occidentale	x					x		
Rhacocarpus purpurascens (Brid.) Par.	x							
Rhacopilum convolutaceum (C. Muell.) Reichdt.	x	x			x		x	x
Sematophyllum amoenum (Hedw.) Mitt.	x						x	
Sematophyllum contiguum (Mitt.) Mitt.	x		x					x
Sematophyllum homomallum (Hampe) Broth.	x	x	x		x		x	x
Thuidium furfurosum (Hook. f. & Wils.) Reichdt.	x				x			
Thuidium laeviusculum (Mitt.) Jaeg.	x	x						
Tortella calycina (Schwaegr.) Dix.	x	x	x					x
Tortella dakinii Willis	x							
Tortella rubripes (Mitt.) Broth.				x				
Tortella sp. nov.				x				
Tortula muralis Hedw.		x						
Tortula princeps De Not.		x		x		x		
Trichostomopsis australasiae (Hook. & Grev.) Robins.		x		x				
Triquetrella paillata (Hook. f. & Wils.) Broth.		x	x			x		
Zygodon menziesii (Schwaegr.) Arnott		x						

*Robinson Gully (RG), forest at Reserve Office (RO), Waterfall Beach (WB) Sinker Reef (SRf), 'Rock Island' (RI), Sheoak Ridge (SRd), and margins of Lake Gardner (LG).

Table 9.2
List of liverwort species collected at Two Peoples Bay Nature Reserve

SPECIES	SITE*						
	RG	RO	WB	SRf	RI	SRd	LG
METZGERIALES							
Aneuraceae							
Riccardia crassa (Schwaegr.) Carring. & Pears.	x		x				
Riccardia rupicola (Steph.) Hewson			x				
Riccardia sp. nov.	x						
Pallaviciniaceae							
Symphyogyna interrupta Carring. & Pears.	x		x				
JUNGERMANNIALES							
Cephaloziellaceae							
Cephaloziella exiliflora (Tayl.) Douin		x					
Frullaniaceae							
Frullania prosbosciphora Tayl.			x		x		
Geocalycaceae							
Lophocolea planiuscula (Hook. f. & Tayl.) Gott., Lindenb. & Nees	x						
Lophocolea semiteres (Lehm. & Lindenb.) Mitt.	x	x			x		
Lepidoziaceae							
Hyalolepidozia longiscypha (Tayl.) Grolle	x		x				
Telaranea dispar (Mont.) A. Hodgs.							x
Telaranea tetradactyle (Hook. f. & Tayl.) A. Hodgs.	x		x				

*Robinson Gully (RG), forest at Reserve Office (RO), Waterfall Beach (WB) Sinker Reef (SRf), 'Rock Island' (RI), Sheoak Ridge (SRd), and margins of Lake Gardner (LG).

3 July 91 ✓
Clarke

CHAPTER 10

The Vascular Flora

J.M. Harvey, A.J.M. Hopkins, L.A. Moore and G.T. Smith

INTRODUCTION

The area encompassed by the Two Peoples Bay Nature Reserve is of considerable historic, as well as present-day botanical, interest. Because of the fine anchorage nearby and its proximity to Albany, the area has long been accessible to scientists. Consequently a number of botanical collections have been made since the time of the first exploration. The studies which began with the creation of the Reserve inevitably involved the collection of botanical data. We have collated details of all past collections in the preparation of this paper and here present a list of all vascular plants found on the Reserve together with a brief ecological and biogeographical analysis of the data.

HISTORY OF BOTANICAL COLLECTIONS

As Chatfield (ch. 2 of this publication) has already outlined, the natural resources of the south-western part of the Australian continent attracted the interest of sea-borne explorers. These men primarily sought safe anchorages, fresh water and food. Few could afford the luxury of detailed investigations of the coastline but those who did invariably made collections of the plants. The first such detailed survey of the Two Peoples Bay area was made between 20 and 27 February 1803 by Midshipman Ransonnet under orders from Captain Baudin (in the *Geographe*). Ransonnet went by long boat from King George Sound around into Two Peoples Bay. He climbed Mt Gardner, explored the inlets to the east and took a boat up a small creek into the waterbody now called Gardner Lake. He `...could make out another lake which joined this one (and) wanted to follow it but it was impossible to combat the obstacle made by the thick shrubs settled on the sand dunes.' (Ransonnet 1803). During the same few days another party, including the geographer Faure, was exploring the coast from Oyster Harbour in the west to Mt Gardner (Baudin 1947). It is probable that they both made collections from the Reserve area as all Baudin's expeditions were instructed to collect plants when on land. However, specimens collected from Two Peoples Bay could be few in number as King George Sound was extensively surveyed during the time of Baudin's visit and duplicates may not have been kept.

The entire collection made on the 1803 voyage of the *Geographe* from Sydney to the Bonaparte Archipelago, via the South Australian gulfs, Ceduna, King George Sound, Geographe Bay and Shark Bay (L.R. Marchant 1982), is lodged at either the Museum National d'Histoire Naturelle at the Jardin de Plante or the Museum d'Histoire Naturelle, Le Havre. It would appear that, after the *Geographe* returned to France, the plants were sorted and classified according to the pre-Linnean System that was then in use. Subsequently they received little attention (L.R. Marchant,[1] personal communication 1982).

In June 1831 the colonial surgeon at Albany, Alexander Collie, accompanied a band of sealers on a visit to Coffin Island. He then crossed to the mainland and climbed to the summit of Mt Gardner where he made some general observations on the soils and vegetation on much of the Reserve. It is not known whether Collie collected any plants during this visit but he did add some: he planted almond seeds in a patch of brown loam near the top of Mt Gardner. He had previously planted almond, castor oil and other species, and one of the sealers planted flower seeds on Coffin Island (Collie 1833). No evidence of any plantings has been seen during the thorough surveys of the past decade.

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Johann August Ludwig Priess, a German botanist, made numerous collections as he travelled on foot from Torbay to Cape Riche late in 1840. Although he is thought to have travelled north of the Reserve area (N.G. Marchant,[2] personal communication 1981) his collections included six specimens labelled Two Peoples Bay 23, 24 November 1840 (Lehmann 1844-47). The species collected were *Jacksonia spinosa*, *Isopogon longifolius*, *Leucopogon corynocarpus*, *Pimelia sylvestris*, *Microcorys selaginiodes* (?), and *Scaevola revoluta*. Only the first two species have been collected on the Reserve subsequently. *S. revoluta* has only been collected in the north of Western Australia and no record of the species of *Microcorys* can be found.

Following the regazetting of the Two Peoples Bay Nature Reserve in June 1967 (chs 2 and 3 this publication), the public interest in the area, especially in the Noisy Scrub-bird, provided impetus for detailed studies of the biota. Early studies focussed on the rare birds found on the Reserve and plant collections were made mainly to identify the species important in the habitats of these birds. This work was carried out by the staff from the CSIRO Division of Wildlife and Ecology. Later research, dealing more specifically with the flora and vegetation of the Reserve, was conducted by the staff from CSIRO, the Department of Fisheries and Wildlife (now Conservation and Land Management), the University of Western Australia and various herbaria.

In the compilation of a flora list, plant collections or lists of plant collections made by the following people at locations shown in Figure 1.4 (this publication) have been examined: L.A. Moore & G.T. Smith (1974-82 , CSIRO plant study transects, locations 1, 2, 3 and 6); M.C. Ellis, L.A. Moore, F.N. Robinson and G.T. Smith (1969-82, Noisy Scrub-bird study areas, locations 4 and 5); R.E.S. Sokolowski (1976, location 7); I. Abbott (1980, locations 7,8 and 9); N. Kolichis and G.T. Smith (1980, location 7); E.M. Gude (1990, wetlands in locations 2,3,4, and 13). Collections in the more general regions 10-12 were made by A.J.M. Hopkins (1975-87), L.A. Moore and G.T. Smith (1974-82), A.A. Burbidge (1970-71), R.E.S. Sokolowski (1971-78), G. Folley (1978-82) and S.D. Hopper (1979-81). Other collections for which no specific locality data were given have been incorporated without annotation. These collections result from visits to the Reserve by N.T. Burbidge from the Herbarium Australiense (1973), J. Powell from the National Herbarium in Sydney (1980), A.S. George (1964, 1967 and 1971), N.G. Marchant (1971) and S. Paust (1971) from the Western Australian Herbarium.

The large number of collectors and collections of Two Peoples Bay material has posed species problems in the compilation of a flora for the Reserve. Many of the identifications are not supported by voucher specimens and some specimens are in distant herbaria. However, we now have a substantial, though incomplete, collection located at the Western Australian Herbarium (PERTH) and the Helena Valley Laboratories of CSIRO Division of Wildlife and Ecology. Field herbaria are located at CALM's Wildlife Research Centre, Woodvale and at the Two Peoples Bay Research Station. As far as possible, specimens incorporated in these herbaria are consistently named (nomenclature of Green 1985).

THE VASCULAR FLORA

A total of 622 vascular plant species have been recorded as occurring on Two Peoples Bay Nature Reserve; these are listed in Table 10.1, together with location and phenology data. Of this total 352 species (55 per cent) belong to nine major families: Papilionaceae (48 species), Proteaceae (58), Orchidaceae (55), Myrtaceae (51), Epacridaceae (36), Asteraceae (34), Cyperaceae (31), Stylidiaceae (20), Poaceae (19). The most diverse genera are *Stylidium* (18), *Leucopogon* (17), *Acacia* (14), *Caladenia* (14) *and Hakea* (13).

The 51 introduced species found on the Reserve are denoted in Table 10.1 by asterisks.

CONSERVATION STATUS

Three species of vascular plants occurring on the Two Peoples Bay Nature Reserve are gazetted as rare flora, under Section 23 of the Wildlife Conservation Act 1950-1984. They are *Adenanthos cunninghamii* (Plate 10 this publication), *Banksia verticillata* and *Stylidium plantagineum* (Fig. 10.1) (Government Gazette 25 June 1990). *Melaleuca baxteri* was declared on 14 November 1980 but was deleted from the list in a subsequent notice (12 March 1982), as the type species had recently been equated with *Agonis spathulata* and the species at Two Peoples Bay is now believed to be an undescribed *Melaleuca*. It is referred to in this publication as *Melaleuca* sp. 1. (Fig. 10.2). It was

2 Dr N.G. Marchant (CALM), Western Australian Herbarium, Como, WA.

previously thought to be restricted to Gardner Creek but was found to be common in the gullies around Mt Gardner. Table 10.2 lists ten species of special interest extracted from priority lists compiled by CALM in June 1990.

THE PITCHER PLANT

One species of particular interest occurring at Two Peoples Bay is the Albany or Western Australian Pitcher Plant, *Cephalotus follicularis* (Plate 8 this publication). The species is endemic to the south-west of Western Australia where it occurs between Busselton and Mt Manypeaks. It is probably best known from the Albany district. On the Reserve, *Cephalotus* can be found in the peaty swamps around Gardner and Moates Lakes. It is in a monotypic family, Cephalotaceae, which is most closely related to the families Crassulaceae and Saxifragaceae. The ecology of the species has been studied by Sally Clarke of the Department of Zoology, University of Western Australia. The following information was supplied by her (personal communication 1982).

The plant form is a rosette, ranging in size from a single pitcher or a few unmodified leaves to as many as 200 pitchers and unmodified leaves. Growth occurs from November to February, when new, modified leaves (pitchers), unmodified leaves and flower buds appear and mature. New plants may also develop, apparently from underground stems. Plants which live in the shade are green and are a larger size than those growing in sunlight. The maximum pitcher length is about 25 mm in the shade and 18 mm in direct sunlight, but more common sizes are 20 mm and 12-15 mm respectively. Pitchers growing in direct or partial sunlight have varying degrees of red colouration caused by the development of anthocyanin pigments in sunlight; in full sunlight they are completely dark red while those in partial sunlight have red or pink patches and those that live in the shade are green. The plant may live for many years, each year recruiting new, modified and unmodified leaves. Pitchers in full sun die within the first year while those in the shade die in their second year. The white flowers are borne on 30-60 cm stalks in late summer.

When fully grown the pitchers open and are about 75 per cent filled with a fluid which is secreted by the plant. This fluid traps insects and also acts as the digestive medium. Observations have indicated that only about 10 per cent of the ants visiting the pitcher are trapped. Other invertebrates commonly captured include dipterans and mites and, more rarely, coleopteran larvae and millipedes. The pitcher provides suitable habitat for a community of invertebrate species including protozoa, rotifers, oligochaets, nematodes, ceratopogonid larvae, harpacticoid copeopod crustaceans and aquatic mites. Caging experiments have shown that these invertebrates are transported by the wind (most likely as cysts) or splash from rain, or are brought on the insects which visit and perhaps fall prey to the pitcher.

The pitchers' microfauna are also found in adjacent, small pools but since the pitcher provides a rich food source of small bacteria and trapped arthropods, it is therefore able to support denser populations. The pools often contain species of micro-organism related to those found in the pitchers but precluded from occurring in the pitchers because they are too large.

PHENOLOGY

Observations of flowering and fruiting were recorded for four plant transects (Table 10.1, locations 1, 2, 3 and 6) over the period 1975-82. Transects were visited at the following times: 1975; May (locations 1 and 3), June (2), July (1, 2, 3 and 6), September (1, 2, 3 and 6) and October (1, 2, 3 and 6), 1976; January (1), February (1 and 2), March (1 and 6), April (1), May (1, 2 and 6), June (6), 1982; January (1, 2, 3 and 6).

These observations provided phenological data for 425 species (Table 10.1). The observations were not systematic so we have assumed continuous flowering through any month where no traverse was made but for which both preceding and subsequent months have positive records. Results are expressed as a proportion of total observed flora. The phenological data are summarized in Figure 10.3, where the number of species in flower in each month is expressed as a percentage of the 425 species for which observations were recorded.

On the Reserve there is a seasonal peak of flowering in October, followed by a steady decline to a minimum in March and April; thereafter the proportion of species flowering increases again. Apparently most species take advantage of the abundant soil moisture and rising temperatures in spring whereas few cope with the relatively dry conditions in autumn. The onset of rains in April appears to stimulate an increasing number of species to flower despite the falling temperatures. The low level of records in December results from no transect collections in that month.

The general shape of the phenology graph (Fig. 10.3) accords well with that for Tutanning Nature Reserve in the wheatbelt (Specht *et al.* 1981) although there is a higher overall level of flowering at Two Peoples Bay for all seasons except early spring. It is worth noting that many species in the Myrtaceae and Proteaceae (*Agonis, Beaufortia, Eucalyptus, Melaleuca, Adenanthos, Banksia, Dryandra* and *Hakea*), that are important components of the vegetation, flower through late summer-autumn. Species in these taxa are important nectar producers; thus, continuity of food resources for the many nectivorous birds, mammals and insects is assured.

DIVERSITY AND PHYTOGEOGRAPHY

The compilation of the flora of the Two Peoples Bay Nature Reserve provides the opportunity to systematically examine the basis of some of the diversity and biogeographic relationships of the flora within the South West Botanical Province. Comprehensive lists are available for the Stirling Range National Park (G.J. Keighery,[3] personal communication) and the Porongurup Range National Park (Abbott 1982), both north of Two Peoples Bay, and a coastal area to the east which includes Cape Riche and the Fitzgerald River National Park (Newbey 1979).

The total numbers of plant species recorded for each of the four areas are given in Table 10.3. Figures show the areas to be quite rich in species - this is to be expected since the south-west as a whole has long been known as an area of great floristic richness (eg. Marchant 1973).

In a study of species richness of several large areas of natural vegetation in Cape Province, South Africa, Kruger and Taylor (1979) derived a relation between richness and area of Log S = 2.69 + 0.25 log A (where 'S' is total number of species present in a landscape unit of area 'A' km^2). These South African areas supported fynbos, a vegetation type very similar to the sclerophyllous shrublands (kwongan) of south-western Australia. S values calculated using the A values for the four south-western Australian areas using this equation are between two and three times the observed values. That is, these large reserves in Western Australia are not as rich as similarly sized areas in the Cape would be. The higher floristic richness in the Cape is probably a reflection of the greater topographic variety there, when compared with the subdued topography of south-western Australia (Lamont *et al.* 1984).

The species list for the Reserve was compared with those for the three other areas. We found that 30 per cent, 41 per cent and 60 per cent of the species recorded for the Reserve were common to the Porongurups, Stirling Range and Fitzgerald River areas respectively. These values are influenced by the different sizes of the areas and hence the total numbers of species. The calculated Sorensen's similarity indices (Mueller-Dombois and Ellenberg 1974, pp. 214-15) take these size differences into account (Table 10.3). The low values indicate a high turnover in flora from one major landscape area to another, or high gamma diversity. Values are comparable with those calculated for the Cape Fynbos (Kruger and Taylor 1979).

The Sorensen's Index values indicate that the Reserve has roughly equivalent floristic relationships with each of the other three areas. These results provide some limited support for the phytogeographic divisions proposed by Beard (1979). Beard placed the forested area in the north-west of the Reserve within the Menzies subdistrict of the Darling Botanical District whereas the lakes and coastal shrublands on and around Mt Gardner were included within the Bremer Vegetation System of the Eyre Botanical District. The Porongurups fall within the Menzies subdistrict. Both the Stirling Range and the Fitzgerald River area are within the Eyre District, although the Stirling Range has floristic affinities with the Avon and Darling Districts. Phytogeographic relationships between Two Peoples Bay and Newbey's (1979) Fitzgerald River area are probably enhanced because the latter includes a substantial length of coastline, some of which is physiographically similar to the Two Peoples Bay area.

Detailed floristic comparisons at the family level were made. Two Peoples Bay is rich in species of Orchidaceae and Liliaceae relative to the other three areas. Data of Keighery (1981, 1982) suggest that both these families are best developed in the high rainfall (800 mm per annum) zone although Liliaceae are somewhat reduced at very high rainfall (1200 mm per annum) sites. Fitzgerald River is rich in *Acacia*, relative to Two Peoples Bay. This accords closely with findings of Hopper and Maslin (1978) who located a node of *Acacia* richness in the grid cell which includes much of Fitzgerald River National Park.

3 G.J. Keighery, Senior Research Scientist (CALM), Western Australian Wildlife Research Centre, Woodvale, WA.

CONCLUSIONS

The Two Peoples Bay Nature Reserve has a rich and varied flora reflecting the wide range of plant habitats represented within its boundary. These include forest, woodland and shrubland associations as well as dune, swamp, coastal and island communities.

The Reserve contains populations of three species of gazetted rare flora and may well have a fourth species. The area also provides a safe refuge for some geographically restricted species and these should be considered when management plans are drawn up.

While the flora has received considerable attention over the last decade, there is still much to be learned about it, particularly in terms of the distribution and phenological patterns and the role of various ecological and evolutionary factors in contributing to these patterns.

ACKNOWLEDGEMENTS

We thank Dr Neville Marchant for access to his early collections from Two Peoples Bay and his advice on historical collections. Mr Greg Keighery checked the flora list and provided his unpublished data on the Stirling Range National Park. Mr Keighery and Mr Arthur Weston made useful comments on the manuscript.

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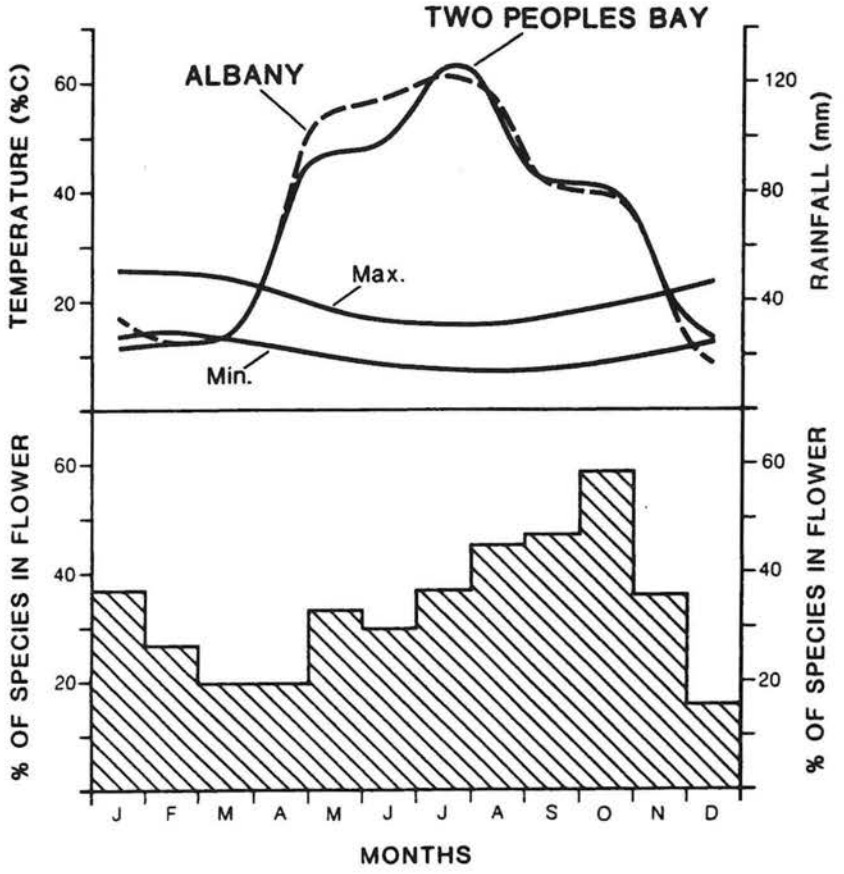


Figure 10.3 to be inserted in text after page 3 of Chapter 10.

Fig 10.1 photo of ~~Stylidium~~ plantagineum

Fig 10.2 photo of Melaleuca sp (baxteri).

4 other plant spec. to be included as colour plates in centre

Fig. 10.1

Table 10.1

THE FLORA OF TWO PEOPLES BAY NATURE RESERVE (SEPTEMBER 1990)

Key to Annotations

(a) Flora

- \+ Species included on historical lists, no specimen sighted but it occurs in the general area.
- # Species included on historical lists, no specimen sighted and it does not occur in the general area (I. Abbott's specimens not sighted)
- * Introduced Species
- ? Uncertain identification

(b) Collectors and Location of Plant Species (see Fig. 1.4 this publication)

1. CSIRO Western boundary area
2. CSIRO/CALM Between the lakes area
3. CSIRO Moates traverse
4. CSIRO Robinson Valley
5. CSIRO Tick Flat
6. CSIRO Bat & Obat transects
7. CSIRO, I. Abbott and CALM Coffin Island
8. I. Abbott Cape Vancouver
9. I. Abbott False Island
10. CALM Plateau and lakes areas
11. CALM Isthmus area
12. CALM Mt Gardner headland area
13. CALM Lake Angove

(c) Phenology

- x in flower
- o in fruit

FLORA (a)	LOCATION (b)	PHENOLOGY (c) J	F	M	A	M	J	J	A	S	O	N	D
LYCOPODIACEAE													
Phylloglossum drummondii Kunze	12									o			
SCHIZAECEAE													
Schizaea fistulosa Labill.	+												
ADIANTACEAE													
Anogramma leptophylla (L.) Link	12									o			
DENNSTAEDTIACEAE													
Pteridium esculentum (G.Forster) Cockayne	10,13												
LINDSAEACEAE													
Lindsaea linearis Swartz	3,4								o		o		
ASPLENIACEAE													
**Asplenium trichomanes* L.	12												
PODOCARPACEAE													
Podocarpus drouynianus F.Muell.	3	x											

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c) J	F	M	A	M	J	J	A	S	O	N	D
TYPHACEAE													
Typha domingensis Pers.	2,11	x	x				x						
JUNCAGINACEAE													
Triglochin procera R. Br.	1,2,9,10,13	x						x		x	x		
Triglochin striata Ruiz Lopez & Pavon	3	x											
POACEAE													
Agrostis avenacea J. Gmelin	2,9		o										
**Aira caryophyllea* L.	6,7,11,12												
Amphipogon laguroides R. Br.	3,11	x											
Amphipogon turbinatus R. Br.	5,11						o	o					
**Anthoxanthum odoratum* L.	1										x		
**Briza maxima* L.	7												
**Bromus diandrus* Roth	7,8,9												
Danthonia caespitosa Gaudich	2,6,11									o			ox
**Ehrharta longiflora* Smith	7												
**Holcus lanatus* L.	11,13			x									
**Lagurus ovatus* L.	11	o											
**Parapholis incurva* (L.) C.E. Hubb.	2		o										
Poa drummondiana Nees	2,6,10,11	x	x					o			o	o	
Poa poiformis (Labill.) Druce	7,8,9,11												
Spinifex hirsutus Labill.	10,11												
Sporobolus virginicus (L.) Kunth	7,8,9												
Stipa compressa R. Br.	2,5,6,10										o	o	
Stipa elegantissima Labill.	+												
Stipa flavescens Labill.	8												
CYPERACEAE													
Baumea articulata (R. Br.) S.T. Blake	1,2,3,13					o							
Baumea juncea (R. Br.) Palla	1,3,12												
Baumea preisii Nees	13												
Cyathochaeta clandestina (R. Br.) Benth.	2,11	x											
Cyperus tenuiflorus Rottb.	1,11					x							
Evandra aristata R. Br.	1,3	x	x			o		o		o	o		
Gahnia lanigera (R. Br.) Benth.	11												
Gahnia trifida Labill.	2,3,8	x						o					
Isolepis cernua (M.Vahl) Roemer & Schultes	9												
Isolepis marginata (Thunb.) A. Dietr.	1												
Isolepis nodosa (Rottb.) R. Br.	1,2,7,8,9,11,13	x	x			x	x	o			o		
Isolepis prolifer (Rottb.) R. Br.	13												
Lepidosperma angustatum R. Br.	1,3,4,8	o	o	x		x		x					
Lepidosperma brunonianum Nees.	1,3,5,6,11				o			o					
Lepidosperma effusum Benth.	2	o	o	o		o	o				o		
Lepidosperma gladiatum Labill.	1,2,4,5,8,9,11,12	o				o	o		x		o		
Lepidosperma longitudinale Labill.	1									x			
Lepidosperma striatum R. Br.	1,3	o						o					
Lepidosperma tetraquetrum Nees									o				
Lepidosperma sp. indet (CSIRO 353A)	1					o							
Mesomelaena tetragona (R. Br.) Benth.	1,3,8		x	x	x	x		x					
Mesomelaena stygia (R. Br.) Nees	1,3,8												
Mesomelaena sp. aff. *stygia* (CSIRO 384)	1							x		x			
Schoenus brevifolius R. Br.	2,3,8	x					o	o	o	o	o	x	
Schoenus caespititius W. Fitzg.	6,11,12				o								
Schoenus curvifolius (R. Br.) Benth.	10,11								x		x	x	x

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c)											
		J	F	M	A	M	J	J	A	S	O	N	D
Schoenus grandiflorus (Nees) F.Muell.	12					o			o				x
Schoenus hexandrus F.Muell. & Tate	11												
Schoenus rigens S.T. Blake	2,4		o		x	x							
Schoenus subbulbosus Benth.	5,8												
Schoenus subflavus Kuek.	11												
RESTIONACEAE													
Anarthria gracilis R. Br.	1,3,8									o	x		
Anarthria prolifera R. Br.	1,2,3,5,6,8,11	x		o		x	o	x	o	o	x		
Anarthria scabra R. Br.	1,3,5,8,12	x				x		x	x	x	x	x	x
Hypolaena exsulca R. Br.	1,3,5,11	x				o		o			o	o	
Leptocarpus coangustatus Nees	1,3,10,11												
Leptocarpus scariosus R. Br.	1,3,6,10,13	x	x	o		x		o	o		x		o
Lepyrodia drummondiana Steudel	8												
Lepyrodia sp. 1	8												
Loxocarya fasciculata (R. Br.) Benth.	3,8	x											
Loxocarya flexuosa (R. Br.) Benth.	1,2,5,6,11	x	ox	x	o	o				o	o	ox	
Loxocarya pubescens (R. Br.) Benth.	2,8,10						o			o	o	o	
Lyginia barbata R. Br.	1,2,5,6,11	o	ox					x		x	x	o	
Restio megalotheca F.Muell.	2,3,4				x	o		o	o	x	o		
CENTROLEPIDACEAE													
Centrolepis aristata (R. Br.) Roemer & Schultes	8												
Centrolepis polygyna (R. Br.) Hieron.	8,9												
Centrolepis strigosa (R. Br.) Roemer & Schultes	7,8,9												
XYRIDACEAE													
Xyris lanata R. Br.	1,3	x								x	x		
JUNCACEAE													
Juncus capitatus Weigel	13			x									
Juncus kraussii Hochst.	2,11,13	x		x	x								
Juncus pallidus R. Br.	13			x									
DASYPOGONACEAE													
Calectasia cyanea R. Br.	2,5	x						x	x		x		
Dasypogon bromeliifolius R. Br.	1,3,5	x				x		x		x	x	x	
Kingia australis R. Br.	10												
Lomandra nigricans T.D. Macfarlane	1,2,3,5,11					x		x		x			
Lomandra rigida Labill.	3	x										o	
Lomandra sonderi (F.Muell.) Ewart	3							x					
XANTHORRHOEACEAE													
Xanthorrhoea platyphylla D.J. Bedford	10,12												
PHORMIACEAE													
Dianella revoluta R. Br.	7,8,9												
Stypandra grandiflora Lindley	7,9												
ANTHERICACEAE													
Agrostocrinum scabrum (R. Br.) Baillon	1,3,5	x						x			x	x	
Borya nitida Labill.	8,12								x	x			
Chamaescilla corymbosa (R. Br.) F.Muell. ex Benth.	3								x				
Johnsonia lupulina R. Br.	1,3,4	x	x			x		x		x	x	x	x

Table 10.1 *(continued)*

FLORA (a)	LOCATION (b)	PHENOLOGY (c)											
		J	F	M	A	M	J	J	A	S	O	N	D
Thysanotus asper Lindley	1,2	x	x					x					
Thysanotus glaucifolius N.H.Brittan	3,10	x											
Thysanotus gracilis R. Br.	2,10,11			x	x								
Thysanotus multiflorus R. Br.	3	x											
Thysanotus patersonii R. Br.	1,2									x	x		
Thysanotus tenellus Endl.	3,5	x											x
Thysanotus thyrsoideus Baker	2										x		
ALLIACEAE													
**Allium triquetrum* L.	10												
COLCHICACEAE													
Burchardia umbellata R. Br.	1,3,5,11	x	x							x	x		
HAEMODORACEAE													
Anigozanthos flavidus Redoute & DC.	2,3	x	x			x				x	x		
Anigozanthos preissii Endl.	1,3									x	x		
Conostylis aculeata R. Br. ssp. *aculeata*	2,6,8,11									x	x	x	
Conostylis serrulata R. Br.	1,4,5,6								x	x	x	x	
Conostylis setigera R. Br.	2,3									x	x		
Haemodorum spicatum R. Br.	3,11	x											
Tribonanthes violacea Endl.	12					x		x					
IRIDACEAE													
**Crocosmia crocosmiiflora* (Lemoine) N.E.Br.	11			x									
**Homeria flaccida* Sweet	11												
Patersonia occidentalis R. Br.	2,8,10										x		
Patersonia umbrosa Endl.	1,3,5										x		
**Romulea rosea* (L.) Ecklor var. *rosea*	11							x					
ORCHIDACEAE													
Caladenia aphylla Benth.	10												
Caladenia cairnsiana F. Muell.	+												
Caladenia corynephora A.S. George	2,10	x										x	
Caladenia deformis R. Br.	6							x					
Caladenia x *ericksonae* Nicholls	1												
Caladenia denticulata Lindley	3,11								x	x			
Caladenia flava R. Br.	1,2,3,6,10,11								x	x			
Caladenia gemmata Lindley	10,11										x		
Caladenia aff. *infundibularis* A.S. George ('*granitora*')	12											x	
Caladenia latifolia R. Br.	1,2,9,11					x				x	x		
Caladenia longicauda Lindley	+												
Caladenia longicauda x pectinata	2,6										x		
Caladenia pectinata R.S. Rogers	1,3,6,10,11,12									x	x		
Caladenia sericea Lindley	3									x			
Calochilus robertsonii Benth.	12										x		
Corybas despectans D.L.Jones	+												
Corybas dilatatus Rupp & Nicholls ex Rupp	12							x					
Cryptostylis ovata R. Br.	11												x
Cyrtostylis robusta D. Jones & Mclements	1,2						x	x	x	x	x		
Diuris emarginata R. Br. var. *pauciflora*	10	x											
Diuris laevis Fitzg.	2										x		
Diuris laxiflora Lindley	+												
Diuris longifolia R. Br.	3,11								x		x		

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c)											
		J	F	M	A	M	J	J	A	S	O	N	D
Elythranthera brunonis (Endl.) A.S. George	1,3,8,12										x		
Elythranthera emarginata (Lindley) A.S. George	11												
Epiblema grandiflorum R. Br.	3	x											
Eriochilus dilatatus Lindley	1,3			x	x	x							
Eriochilus scaber Lindley									x				
Leporella fimbriata (Lindley) A.S. George	+												
Leptoceras menziesii R. Br.	10									x			
Lyperanthus nigricans R. Br.	10,11							x		x			
Lyperanthus serratus Lindley	1,11,12									x			
Microtis alba R. Br.	1,2,4		x								x	x	
Microtis unifolia (G. Forster) H.G. Reichb.	2,3	x											
**Monadenia bracteata* (Sw.) T. Durand & Schinz	12										x		
Paracaleana nigrita (Lindley) Blaxell	12										x		
Prasophyllum elatum R. Br.	3									x			
Prasophyllum fimbria H. Reichb.	10,12							x		x			
Prasophyllum hians H. Reichb.	3,10									x			
Prasophyllum parvifolium Lindley	1,2,3,6,12		x			x	x	x	x	x	x		
Prasophyllum regium R.S. Rogers	3								x				
Pterostylis barbata Lindley	12							x			x		
Pterostylis aff. *nana* R. Br.	1,4,10,11						x		x	x			
Pterostylis plumosa L.Cady	10,11										x		
Pterostylis rogersii E.Coleman	1,2,11	x				x		x					
Pterostylis vittata Lindley	1,11,12					x	x						
Thelymitra antennifera (Lindley) J.D.Hook.	12										x		
Thelymitra campanulata Lindley	1										x		
Thelymitra canaliculata R. Br.	1,2										x		
Thelymitra crinita Lindley	1,3,6,12									x	x		
Thelymitra flexuosa Endl.	12										x		
Thelymitra fuscolutea R. Br.	1										x		
Thelymitra nuda R. Br.	12										x		
Thelymitra pauciflora R. Br.	1,2										x		
Thelymitra tigrina R. Br.	+												
CASUARINACEAE													
Allocasuarina fraseriana (Miq.) L.Johnson	10												
Allocasuarina humilis (Otto & Dietr.) L.Johnson	2,6,8,11,12		x	x	x		x	x	x	x	x	x	x
Allocasuarina lehmanniana (Miq.) L. Johnson	10												
Allocasuarina trichodon (Miq.) L.Johnson	2,4,8	x		x					o				
URTICACEAE													
Parietaria debilis G. Forster	2,7,8										x		
PROTEACEAE													
Adenanthos cuneatus Labill.	1,2,3,6,8,11	x	x	x	x	x	x	x	x	x	x	x	x
Adenanthos cunninghamii Meissner	10,11									x	x		
Adenanthos obovatus Labill.	1,3,4	x	x	x	x	x	x	x	x	x	x		x
Adenanthos sericeus Labill.	1,2,4,8,12	x	x	x	x	x	x	x	x	x	x		
Banksia attenuata R. Br.	3,8,10,11,12	x								x	x		
Banksia coccinea R. Br.	1,10,12						x	x	x	x	x		
Banksia dryandroides Baxter ex Sweet	12												
Banksia gardneri A.S.George var. *gardneri*	3,11	x									x	x	
Banksia grandis Willd.	3,10,11,12	x	x								x		
Banksia ilicifolia R. Br.	3,10	x											
Banksia littoralis R. Br.	1,3,10,11,12					x							
Banksia nutans A.S. George var. *cernuella*	10			x									

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c)											
		J	F	M	A	M	J	J	A	S	O	N	D
Banksia occidentalis R. Br. var. *occidentalis*	1,10			x	x	x	x				x		
Banksia praemorsa Andrews	1,8,10,11,12					x		x			x		
Banksia quercifolia R. Br.	1,10		x	x	x	x		x			x		
Banksia seminuda (A.S. George) B.L. Rye	1,10					x							
Banksia verticillata R. Br.	1,12	x	x		x	x	x	x					
Conospermum caeruleum R. Br.	3,8,12					x		x	x	x	x	x	x
Conospermum petiolare R. Br.	1,3	x											
Conospermum teretifolium R. Br.	4,5	x											x
Dryandra armata R. Br.	5					x		x	x			x	
Dryandra formosa R. Br.	3,5,8,12	x		x		x	x	x	x	x	x		
Dryandra nivea (Labill.) R. Br.	2,5,6,8,11					x			x	x	x		
Dryandra pteridifolia R. Br.	4,5,8,11							x	x				
Dryandra serra R. Br.	10											x	
Dryandra sessilis (Knight) Domin	1,2,6,8,11,12		x	x		x	x	x	x	x	x		
Franklandia fucifolia R. Br.	5,12	x			x								
Grevillea brownii Meissner	+												
Grevillea fasciculata R. Br.	+												
Grevillea pulchella (R. Br.) Meissner	2,3,12	x	x					x		x	x		
Grevillea trifida (R. Br.) Meissner	1,3,10					x							
Hakea amplexicaulis R. Br.	+												
Hakea ceratophylla (Smith) R. Br.	3,8,12	x				x		x		x			
Hakea corymbosa R. Br.	8							x	x				
Hakea cucullata R. Br.	12							x					
Hakea dolichostyla Diels	1,3				x	x		x		x			
Hakea elliptica (Smith) R. Br.	1,4,8,12											o	
Hakea linearis R. Br.	1,5							o					
Hakea oleifolia (Smith) R. Br.	1,3,6					x		x	x	x	x		
Hakea prostrata R. Br.	1,2,6,11		x				x	x	x	x	x	x	
Hakea ruscifolia Labill.	2,3,6,11		x	x	x	x	x	x			x		
Hakea suaveolens R. Br.	8,9,#												
Hakea trifurcata (Smith) R. Br.	1,4,8			x		x	x	x	x			x	
Hakea varia R. Br.	1,2,5	x	x	x		x		x		x			x
Isopogon attenuatus R. Br.	5												o
Isopogon cuneatus R. Br.	+												
Isopogon formosus R. Br.	1,3,4,5					x		x	x	x	x		
Isopogon longifolius R. Br.	3,4	x											
Lambertia uniflora R. Br.	5	x		x		x	x	x	x			x	
Petrophile diversifolia R. Br.	1,3,10	x								x	x		
Petrophile longifolia R. Br.	1					x				x	x		
Petrophile rigida R. Br.	5,8										x	x	
Petrophile squamata R. Br.	1,4,5,12					x	x	x	x	x	x		
Stirlingia latifolia (R. Br.) Steudal	3	o				x		x		x			
Stirlingia tenuifolia (R. Br.) Steudal	2,12									x	x		o
Synaphea favosa R.Br.							x			x			
Synaphea petiolaris R. Br.	+												
Synaphea polymorpha R. Br.	5					x		x	x	x	x	x	
SANTALACEAE													
Exocarpos sparteus R. Br.	1					x							
Leptomeria pauciflora R. Br.	3					x				x			
Leptomeria squarrulosa R. Br.	2		o			o	o	x		o	x		
OLACACEAE													
Olax phyllanthi (Labill.) R. Br.	1,2,3,6,8		x	x	x	x	x	x	x	x	x		

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c) J	F	M	A	M	J	J	A	S	O	N	D
LORANTHACEAE													
Nuytsia floribunda (Labill.) R. Br. ex Fenzl	5			x									
POLYGONACEAE													
Muehlenbeckia adpressa (Labill.) Meissner	8,9												
CHENOPODIACEAE													
Atriplex isatidea Moq.	7,8,11												
Atriplex prostrata M. Boucher ex DC	3				o								
Maireana oppositifolia (F.Muell.) Paul G.Wilson	9												
Rhagodia baccata (Labill.) Moq.	2,7,8,9	x				x	x						
Rumex acetosella L.	13												
Sarcocornia blackiana (Ulbr.) A.J.Scott	8												
Threlkeldia diffusa R. Br.	8												
GYROSTEMONACEAE													
Gyrostemon sheathii W. Fitzg.	2,8,11	x				x		x		x	x		
Gyrostemon thesioides (J.D.Hook.) A.S. George	2,10,11									x			
PHYTOLACCACEAE													
**Phytolacca octandra* L.	3		x										
AIZOACEAE													
**Carpobrotus aequilaterus* (Haw.) N.E.Br.	1,11					x		x			x		
Carpobrotus virescens (Haw.) Schwantes	2,6,7,8,9	o								x	x	x	
Disphyma crassifolium (L.) L.Bolus	8,9												
**Tetragonia decumbens* Miller	8												
Tetragonia implexicoma (Miq.) J.D. Hook.	2,8									x			
PORTULACACEAE													
Calandrinia brevipedata F.Muell.	1,2									x	x		
Calandrinia calyptrata J.D.Hook.	7,8												
Calandrinia eremaea Ewart	2										x		
Calandrinia polypetala Fenzl	2										x		
CARYOPHYLLACEAE													
**Sagina apetala* Ard.	7												
RANUNCULACEAE													
Clematis microphylla DC.	#												
Clematis pubescens Huegel ex Endl.	1,2,9,11			x	x	x	x	x		x			
LAURACEAE													
Cassytha glabella R. Br.	1,2,3,6,8	x	x	x		x	x	x	x		x	x	
Cassytha racemosa Nees	2,3	x											
FUMARIACEAE													
**Fumaria muralis* Sonder ex Koch	11										x		
BRASSICACEAE													
**Cakile maritima* Scop.	8,11												
**Heliophila pusilla* L.	5,6												
Lepidium foliosum Desv.	7												
Lepidium rotundum (Desv.) DC.	2										x		

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c)											
		J	F	M	A	M	J	J	A	S	O	N	D
DROSERACEAE													
Drosera erythrorhiza Lindley	3,11,12							x	x	x			
Drosera glanduligera Lehm.	3									x	x		
Drosera huegelii Endl.	1,3,11,12							x	x	x			
Drosera macrantha Endl.	1,4							x		x			
Drosera menziesii R. Br.	6										x		
Drosera microphylla Endl.	5								x				
Drosera modesta Diels	3										x		
Drosera neesii Lehm. ssp. *neesii*	+												
Drosera paleacea DC.	3												
Drosera pallida Lindley	1,2,3,6					x		x	x	x	x	x	
Drosera platypoda Turcz.	3									x	x		
Drosera pulchella Lehm.	3	x											
Drosera stolonifera Endl.	3,11									x	x		
CRASSULACEAE													
Crassula colorata (Nees) Ostenf.	11												
Crassula decumbens Thunb.	7,8,9,11												
CEPHALOTACEAE													
Cephalotus follicularis Labill.	10	x	x										
PITTOSPORACEAE													
Billardiera laxiflora (Benth.) E.M. Bennett	1,3,4,5		x	x	x	x					x		
Billardiera variifolia DC.	1,2,3	x	x	x	x	x							
Pronaya fraseri (Hook.) E.M. Bennett	3	x		x									
Sollya heterophylla Lindley	1,2,3,4,9,10,13	x	x	x	x			x			x	x	
MIMOSACEAE													
Acacia browniana H.L. Wendl. var. *browniana*	1,3	x	x					x					
Acacia cochlearis (Labill.) H.L. Wendl.	1,2,6,11	x	x										
Acacia cyclops Cunn. ex Don	2,3,11	x											
Acacia varia Maslin var. *varia*	+												
Acacia leioderma Maslin	1,3,5,8,12					x		x	x	x	x		
Acacia littorea Maslin	1,2,3,8	x	x			x	x	x	x	x	x		
Acacia luteola Maslin	3					x		x	x	x	x		
Acacia myrtifolia (Smith) Willd.	1,3,4,8,9					x		x	x	x	x		
Acacia myrtifolia (Smith) Willd. var. *angustifolia*	3										x		
Acacia pulchella R. Br.	3		x	x	x	x				x	x		
Acacia pulchella R. Br. var. *goadbyi*	12							x					
Acacia robinae Maslin	3					x							
Acacia sulcata R. Br.	8,12					x		x		x	x		
Acacia willdenowiana H.L. Wendl.	3									x	x		
Paraserianthes lophantha (Willd.) I. Nielsen	8												
PAPILIONACEAE													
Aotus intermedia Meissner	1,3	x	x							x			
Bossiaea dentata (R. Br.) Benth.	4			x		x	x	x	x	x	x	x	
Bossiaea linophylla R. Br.	1,2,3,5,11							x	ox	x	x		
Bossiaea rufa R. Br.	3,5								x	x		x	
Burtonia asperula S. Moore													
Burtonia conferta DC.	2,3,6,8,10,11	x	x	x		x					x	x	x
Burtonia scabra (Smith) R. Br.	3,12			x		x				x	x	x	x
Chorizema glycinifolium (Smith) Druce	2,3,5,6,11					x		x	x	x	x		
Chorizema ilicifolium Labill.	1,2,6						x	x	x	x	x	x	

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c)											
		J	F	M	A	M	J	J	A	S	O	N	D
Chorizema reticulatum Meissner	3												
Chorizema rhombeum R. Br.	3								x		x	x	
Daviesia benthamii Meissner	1,2,3,4,5,6,11	x				x		x	x	x	x	x	x
Daviesia decurrens Meissner	8												
Daviesia flexuosa Benth.	11												
Eutaxia obovata (Labill.) C. Gardner	5,8,9,11								x	x	x	x	
Gastrolobium bilobum R. Br.	8,9,12			x					x	x	x	x	x
Gompholobium amplexicaule Meissner	+												
Gompholobium aristatum Benth.	3	x											
Gompholobium knightianum Lindley	3,5,11	x				x		x		x	x		
Gompholobium polymorphum R. Br.	3,5,11,12	x									x	x	
Gompholobium tomentosum Labill.	2,6								x		x	x	x
Gompholobium venustum R. Br.	10												
Hardenbergia comptoniana (Andrews) Benth.	1,2,12					x		x	x	x			
Hovea chorizemifolia (Sweet) DC.	3,12							x					
Hovea elliptica (Smith) DC.	+												
Hovea trisperma Benth.	4,5								x				
Isotropis cuneifolia (Smith) Benth. ex B.D. Jackson	2,6,10,11								x	x	x		
Jacksonia furcellata (Bonpl.) DC.	+												
Jacksonia horrida DC.	2,3,4,6,8,11,12	x	x	x	x	x	x	x	x	x	x	x	x
Jacksonia spinosa (Labill.) R. Br.	1,3,4,5,12	x		x	x	x	x	x	x	x	x	x	x
Kennedia coccinea Vent.	1,2,3,6,10,11								x	x	x	x	
Latrobea genistoides (Meissner) Meissner	1,3									x	x		
Latrobea hirtella (Turcz.) Benth.	1,3		x								x		
**Lotus* ? *angustissimus* L.	3										x		
Oxylobium coriaceum (Smith) C. Gardner	3,5,10									x	x		
Oxylobium lanceolatum (Vent.) Druce	2,3,5,7,8,9,13	x									x	x	x
Oxylobium obovatum Benth.	12												
**Psoralea pinnata* L.	13		x										
Pultenaea barbata C.R.P. Andrews	1,3,13		x			x		x		x	x		
Pultenaea obcordata (R. Br.) Benth.	2,12								x	x			
Pultenaea reticulata (Smith) Benth.	1,4			x		x		x	x	x	x		x
Sphaerolobium alatum Benth.	3,5,8					x		o		x	x		
Sphaerolobium grandiflorum (R. Br.) Benth.	1,3										x		
Sphaerolobium linophyllum (Huegel) Benth.	2		x										x
Sphaerolobium vimineum Smith	1,2,3									x	x		
Templetonia retusa (Vent.) R. Br.	8												
**Trifolium dubium* Sibth.	3										x		
**Ulex europaeus* L.	10									x			
GERANIACEAE													
**Erodium botrys* (Cav.) Bertol.	3										x		
**Geranium molle* L.	11												
Pelargonium australe Willd.	7,8												
**Pelargonium capitatum* (L.) L'Her.	2,11	x									x		
Pelargonium havlasae Domin	2,10										x		
RUTACEAE													
Boronia alata Smith	12												
Boronia albiflora R. Br. ex Benth.	8,12							x					
Boronia crenulata Smith	1,4,5,12			x		x		x	x	x	x	x	
Boronia denticulata Smith	1,2,3	x											
Boronia sp. aff. *denticulata* Smith (CSIRO 355A)	1,2		x			x							
Boronia gracilipes F. Muell.	12,13						x	x	x	x			

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c)											
		J	F	M	A	M	J	J	A	S	O	N	D
Boronia spathulata Lindley	1,2,3,4,12	x	x	x	x	x		x		x	x	x	x
Boronia tetrandra Labill.	12							x	x		x		
Chorilaena quercifolia Endl.	1,4,8,9,12							x	x	x	x		
Crowea angustifolia Smith var. *dentata*	3,4,12		x			x				x			
Phebalium anceps DC.	1,2,4,11	x	x	x		x	x	x	x	x	x	x	x
Phebalium rude Bartlling	8		x										
TREMANDRACEAE													
Tetratheca setigera Endl.	3,5,12	x				x		x	x	x	x	x	
Tremandra stelligera R. Br. ex DC.	7,11							x	x		x		
POLYGALACEAE													
Comesperma calymega Labill.	1,2,3,6	x	x	x							x	x	x
Comesperma confertum Labill.	1,2,3,6,10	x	x								x	x	x
Comesperma flavum DC.	3	x											
Comesperma nudiusculum DC.	1,2					x							
Comesperma virgatum Labill.	2,3,5,6,11		x							x	x	x	
EUPHORBIACEAE													
Amperea ericoides Adr.Juss.	5,11										x		
**Euphorbia paralias* L.	8,11												
Phyllanthus calycinus Labill.	1,2,5,6,10,11	o			x		x	x	x	x	x	x	x
Poranthera huegelii Klotzsch	3	x									x		
Poranthera microphylla Brongn.	6,10										x		
Ricinocarpos glaucus Endl.	4,12								x		x		
Ricinocarpos tuberculatus Muell. Arg.	8												
STACKHOUSIACEAE													
Stackhousia huegelii Endl.	11												
Stackhousia pubescens A. Rich.	4										x	x	
SAPINDACEAE													
Dodonaea ceratocarpa Endl.	8,9,12												
RHAMNACEAE													
Spyridium globulosum (Labill.) Benth.	1,2	x				x	x	x		x	x		
Spyridium spadiceum (Fenzl) Benth.	1,2,6,8	x	x	x	x	x		x		x			
Trymalium floribundum Steudel	4,8,12							x	x		x		
Trymalium ledifolium Fenzl	1,2,11	x	x			x				x			
MALVACEAE													
**Lavatera plebeia* Sims	7												
STERCULIACEAE													
Thomasia discolor Steudel	+												
Thomasia aff. *foliosa* Gay.	+												
Thomasia purpurea (Aiton) Gay	4,5,12										x	x	x
DILLENIACEAE													
Hibbertia cuneiformis (Labill.) Smith	1,2,7,8,11	x			x	x		x		x	x		
Hibbertia cunninghamii W.T. Aiton ex Hook.	2,3,8,11,12							x	x	x	x	x	
Hibbertia depressa Steudel	10												
Hibbertia desmophylla (Benth.) F.Muell.	3	x											
Hibbertia enervia (DC.) Hoogl.	11												

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c)											
		J	F	M	A	M	J	J	A	S	O	N	D
Hibbertia furfuracea (R. Br. ex DC.) Benth.	5,8,10			x		x		x	x	x	x	x	x
Hibbertia grossulariifolia (Salisb.) Salisb.	11								x				
Hibbertia microphylla Steudel	12									x	x		
Hibbertia pulchra Osteni.	3,5	x		x	x	x	x	x			x		
Hibbertia racemosa (Endl.) Gilg.	1,2,6,8,11	x	x	x		x	x	x	x	x	x	x	x
Hibbertia verrucosa (Turcz.) Benth.	12					x		x	x				
THYMELAEACEAE													
Pimelea clavata Labill.	1	x						x		x	x		
Pimelea ferruginea Labill.	6,8,11								x				x
Pimelea hispida R. Br.	12							x	x		x	x	
Pimelea longiflora R. Br.	1,3,5,8,11	x	x			x		x	x	x	x	x	x
Pimelea preissii Meissner	5,11,12									x	x		
Pimelea rosea R. Br.	1,2,6,8,11	x				x	x	x	x	x	x	x	x
Pimelea suaveolens Meissner	#												
Pimelea sylvestris R. Br.	+												
MYRTACEAE													
Actinodium cunninghamii Schauer	3	x						x		x	x		
Agonis flexuosa (Sprengel) Schauer	2,6,8,9,11	x		x		x		x			x	x	x
Agonis hypericifolia Schauer	1,3	x		x							x	x	
Agonis juniperina Schauer	1,2,3,5,13	x	x	x	x	x	x	x	x	x	x	x	x
Agonis linearifolia (DC.) Schauer	3,8,13	x		x		x							
Agonis marginata (Labill.) Schauer	5,8,9,12			x	x	x	x	x			x		
Agonis parviceps Schauer	1,2,3,5,12	x	x	x		x		x	x	x	x	x	
Astartea fascicularis (Labill.) DC.	1,3,8,13	x	x			x							
Baeckea schollerifolia Lehm.	3,10							x			x	x	
Beaufortia anisandra Schauer	1,3	x	x	x	x	x		x					
Beaufortia decussata R. Br.	1,3,4,5	x		x	x	x	x	x	x	x			
Callistemon speciosus (Sims) DC.	1				x	x							
Calothamnus sanguineus Labill.	#												
Calytrix asperula (Schauer) Benth.	3	x	x										
Calytrix leschenaultii (Schauer) Benth.	4								x				
Chamelaucium forrestii (F.Muell) Marchant & Keighery	8										x		
Darwinia citriodora (Endl.) Benth.	12								x				
Darwinia diosmoides (DC.) Benth.	8												
Darwinia oederoides (Turcz.) Benth.	10												
Darwinia vestita (Endl.) Benth.	1,2,3,4,5,8,12							x	x	x	x	x	
Eucalyptus angulosa Schauer	4,8,11,12	x		x					o		x		
Eucalyptus calophylla Lindley	3,4,10,11,12	x	x	x									
Eucalyptus conferruminata D.J. & S.G.M. Carr	4,12		x			x			x	x			
Eucalyptus cornuta Labill.	8,11,12			x									
Eucalyptus goniantha Turcz.	3,5,11,12		x						x				
Eucalyptus marginata Donn ex Smith	3,4,10,11,12	x		x			x	x		x	x		
Eucalyptus megacarpa F. Muell.	4,10,11,12			x		x	x		x		x		
Eucalyptus missilis Brooker & Hopper (med)	12												
Eucalyptus staeri (Maiden) Kessel & C.Gardner	3,10,12	x											
Homalospermum firmum Schauer	1,3,10,12	x						o					
Hypocalymma angustifolium Endl.	1									x	x		
Hypocalymma cordifolium (Lehm.) Schauer	3,4,8	x				x		x	x	x	x		
Hypocalymma strictum Schauer	1,3,8,12		x	x		x							
Kunzea recurva Schauer var. *melaleucoides*	1										x		
Kunzea ericifolia (Smith) Heynh.	1,3,10,13	o			o					x	x		
**Leptospermum laevigatum* (Gaertner) F.Muell.	+												

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c)											
		J	F	M	A	M	J	J	A	S	O	N	D
Lhotskya ericoides Schauer	10,11												
Melaleuca cuticularis Labill.	10,11,13									x			
Melaleuca densa R. Br.													
Melaleuca diosmifolia Andrews	8,12									x			
Melaleuca nesophila F. Muell.	#												
Melaleuca pentagona Labill.	1,2,6	x											x
Melaleuca preissiana Schauer	10,11	x											
Melaleuca rhaphiophylla Schauer	10,11											x	
Melaleuca striata Labill.	1,2,3,4,5,8,10	x		x	x	x	x	x			x	x	x
Melaleuca thymoides Labill.	1,2,3,6,8,11,12,13	x		x	x	x	x	x	x	x	x	x	x
Melaleuca sp. 1 (formally regarded as *M. baxteri*).	10,12,13											x	
Melaleuca sp. 2 (I. Abbott)	8												
Pericalymma ellipticum (Endl.) Schauer	3										x		
Thryptomene saxicola (Cunn. ex Hook.) Schauer	5						x	x	x	x			
Verticordia plumosa (Desf.) Druce	5,8							x	x	x		x	
ONAGRACEAE													
Epilobium billardierianum Ser.	2		x										
HALORAGACEAE													
Glischrocaryon aureum (Lindley) Orch.													
Haloragis brownii (J.D. Hook.) Schindler	2	x	x					x			x		
APIACEAE													
Actinotus glomeratus Benth.	1					x							
Actinotus omnifertilis (F. Muell.) Benth.	1,3	x	x		x	x							
Apium prostratum Labill. ex Vent.	7,8,9,11												
Centella asiatica (L.) Urban	2												
Homalosciadium homalocarpum (F. Muell.) H.Eichler	11												
Hydrocotyle diantha DC.	8,9												
Platysace compressa (Labill.) Norman	1,2,3,6,10,11	x	x	x	x	x	x	x	x	x	x	x	x
Trachymene cyanopetala (F. Muell.) Benth.	1,3												
Trachymene pilosa Smith	2,6,10,11									ox	x	x	
Xanthosia huegelii (Benth.) Steudel	11										x		
Xanthosia pusilla Bunge	6,11											x	
Xanthosia rotundifolia DC.	1,3,4,8,12	x	x	x	x	x	x	x	x	x	x	x	x
EPACRIDACEAE													
Acrotriche cordata (Labill.) R. Br.	2,8						x						
Andersonia caerulea R. Br.	1,3,6,11,12		x			x	x	x	x	x	x	x	
Andersonia micrantha R. Br.	12												
Andersonia simplex (Stschegl.) Druce	3									x			
Andersonia sprengelioides R. Br.	8,11												
Astroloma baxteri DC.	1,3,5	x	x	x	x	x		x					
Astroloma ciliatum (Lindley) Druce	5					x							
Astroloma microcalyx Sonder	1,6					x		x					
Astroloma pallidum R. Br.	3,5								x	x	x		
Cosmelia rubra R. Br.	3,12	x	x						x	x			
Leucopogon sp. aff. *australis* R. Br. (CSIRO 128)	1,12		x	x	x			x	x		x		
Leucopogon capitellatus DC.	3,4				x	x	x	x	x	x	x	x	x
Leucopogon carinatus R. Br.	1,3,4,6,8				x								
Leucopogon corynocarpus Sonder	+												
Leucopogon distans R. Br.	1,3	x	x	x	x	x		x		x	x		

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c)											
		J	F	M	A	M	J	J	A	S	O	N	D
Leucopogon elegans Sonder	3	x											
Leucopogon flavescens Sonder	3,10	x											
Leucopogon glabellus R. Br.	3	x											
Leucopogon obovatus (Labill.) R. Br.	2,3,6,7,8,9,11					x	x	x	x	x	x	x	x
Leucopogon oxycedrus Sonder	2,12	x			x						x		
Leucopogon parviflorus (Andrews) Lindley	1,2,3,5,6		x			x	x	x	x	x	x		
Leucopogon pendulus R. Br.	11			x					x				
Leucopogon propinquus R. Br.	1,3,5		x	x	x	x		x					
Leucopogon reflexus R. Br.	1,5,8							x	x	x	x		
Leucopogon strictus Benth.	3,5		x	x				x	x		o		
Leucopogon verticillatus R. Br.	3,10	x				x		x	x	x	x		
Leucopogon sp. indet (CSIRO 118B)	6												
Leucopogon sp. indet (CSIRO 415)	3					x							
Lysinema ciliatum R. Br.	1,2,3,5,6	x	x	x	x	x	x	x	x	x	x	x	x
Lysinema conspicuum R. Br.	1,3,10	x		x	x	x				x	x		
Needhamiella pumilio (R. Br.) L. Watson	1		x							x			
Oligarrhena micrantha R. Br.	12					x		x			x		
Sphenotoma capitatum (R. Br.) Lindley	3,4												x
Sphenotoma dracophylloides Sonder	5,12										x	x	x
Sphenotoma gracile (R. Br.) Sweet	1,3,10,12	x								x	x		
Styphelia melaleucoides F. Muell.	+												
PRIMULACEAE													
Anagallis arvensis L. var. *arvensis*	1,5							x					x
Anagallis arvensis L. var. *caerulea*	8												
Samolus repens (Forster & G. Forster) Pers.	8												
LOGANIACEAE													
Logania fasciculata R. Br.	6					x	x	x	x			x	
Logania serpyllifolia R. Br.	2,3,5,6,8,10,11	x				x		x		x	x	x	x
Logania vaginalis (Labill.) F. Muell.	1,2	x					x			x	x		
Mitrasacme paradoxa R. Br.	2,5,6,8,9,11										x	x	
GENTIANACEAE													
**Centaurium erythraea* Rafn	8,9												
**Centaurium spicatum* (L.) Fritsch ex Janchen	1				x								
MENYANTHACEAE													
Villarsia lasiosperma F. Muell.	1,2,3									x	x		
Villarsia parnassifolia (Labill.) R. Br.	2,3,10	x	x								x		
LAMIACEAE													
Hemigenia podalyrina F.Muell	12								x				
Hemigenia sp. aff. *sericea* Benth. (CSIRO 584)	3	x											
Microcorys barbata R. Br.	4	x						x		x	x	x	
Microcorys virgata R. Br.	12				x								
Westringia dampieri R. Br.	1,4,8,9,12								x	x	x		
SOLANACEAE													
Anthocercis littorea Labill.	2,10,12							x	x	x	x	x	
Anthocercis viscosa R. Br.	1,7,8,9,12					x		x	x		x	x	
**Solanum nigrum* L.	1,2,3	ox				x		x					
Solanum symonii H. Eichler										x			

Table 10.1 *(continued)*

FLORA (a)	LOCATION (b)	PHENOLOGY (c) J	F	M	A	M	J	J	A	S	O	N	D
SCROPHULARIACEAE													
**Bellardia trixago* (L.) All.	11												
**Dischisma arenarium* E. Meyer	2									x	x		
Euphrasia collina R. Br.	2												
Gratiola peruviana L.	2,13		x										
**Parentucellia latifolia* (L.) Caruel	6,11										x		
LENTIBULARIACEAE													
Utricularia menziesii R. Br.								x					
MYOPORACEAE													
Myoporum caprarioides Benth.	2										x		
Myoporum oppositifolium R. Br.	2		x				x	x		x			
RUBIACEAE													
Opercularia hispidula Endl.	2,3,10	x								x	x		
Opercularia vaginata Labill.	2,6		x							x	x	x	
CAMPANULACEAE													
Wahlenbergia gracilenta Loth.	11										x		
**Wahlenbergia capensis* (L.) DC.	11										x		
LOBELIACEAE													
Isotoma hypocrateriformis (R. Br.) Druce	3,6,11		x								x	x	x
Isotoma scapigera (R. Br.) Don	11												
Lobelia alata Labill.	1,2,7,8,9,13	x	x	x	x	x							
Lobelia gibbosa Labill.	2,6		x	x									
Lobelia heterophylla Labill.	1,2,3,6	x	x	x							x		
Lobelia rarifolia F.Wimmer	3	x											
Lobelia rhombifolia Vriese	3										x		
GOODENIACEAE													
Dampiera fasciculata R. Br.	1,3,4,5							x	x		x	x	x
Dampiera leptoclada Benth.	4,5							x		x	x		
Dampiera linearis R. Br.	1,3,4,8,12	x				x		x		x	x	x	
Dampiera prostrata Vriese	8										x		
Diaspasis filifolia R. Br.	1,3		x	x	x	x				x	x		
Goodenia caerulea R. Br.	3	x											
Goodenia filiformis R. Br.	+												
Lechenaultia tubiflora R. Br.	3,4,5,11,12							x	x		x	x	
Scaevola globulifera Labill.	2,6,11									x	x	x	x
Scaevola nitida R. Br.	1,2,3,8,11	x		x						x	x		
Scaevola phlebopetala F.Muell.	3	x											
Scaevola revoluta R. Br.	#												
Scaevola striata R. Br.	3,4,5,10								x		x	x	x
Velleia trinervis Labill.	2,4,5,6,8,11,12							x	x		x	x	x
STYLIDIACEAE													
Levenhookia pauciflora Benth.	5,11										x		
Levenhookia pusilla R. Br.	1,4,12										x	x	
Stylidium adnatum R. Br.	2,4,6,10,11										x	x	
Stylidium amoenum R. Br.	8				x							x	
Stylidium assimile R. Br.	3	x											
Stylidium corymbosum R. Br.	8												
Stylidium diversifolium R. Br.	3,4,11	x										x	

Table 10.1 (*continued*)

FLORA (a)	LOCATION (b)	PHENOLOGY (c)											
		J	F	M	A	M	J	J	A	S	O	N	D
Stylidium fasciculatum R. Br.	6,8											x	
Stylidium glaucum Labill.	3		x	x				x		x	x		
Stylidium hirsutum R. Br.	10	x										x	
Stylidium imbricatum Benth.	3					x							
Stylidium junceum R. Br.		x											
Stylidium luteum R. Br.	1,3	x									x		
Stylidium piliferum R. Br.	3,11										x		
Stylidium plantagineum Sonder	10											x	
Stylidium repens R. Br.	1		x			x							
Stylidium scandens R. Br.	1,3	x	x		x	x		x		x	x		
Stylidium schoenoides DC.	1,3,11										x		
Stylidium spathulatum R. Br.	4,5							x	x	x	x	x	
Stylidium violaceum R. Br.	3	x											
ASTERACEAE													
Actites megalocarpa (J.D. Hook) N.S. Lander	11												
**Arctotheca calendula* (L.) Levyns	1,3,5	x				x				x	x		x
**Arctotheca populifolia* (F.Bergius) Norlindh	11,12												
Asteridea asteroides (Turcz.) G. Kroner	10										x		
Asteridea nivea (Steetz) G. Kroner	8												
Brachycome iberidifolia Benth.													
Brachycome pusilla Steetz	6								x	x	x		
Calocephalus brownii (Cass.) F.Muell.	7,8												
Cotula coronopifolia L.	13		x										
Craspedia pleiocephala F.Muell.	+												
**Gnaphalium gymnocephalum* DC.	7,13		x										
Helichrysum cordatum DC.	1,2	x	x		x	x							
**Hypochaeris glabra* L.	1,3,7,9,11	x	x			x							
Ixiolaena viscosa Benth.	2	x											
Lagenifera huegelii Benth.	6,10										x		
Leptorhynchos medius Cunn. ex DC.	2,6,10,12										x	x	x
Millotia tenuifolia Cass.	3										x		
Olearia axillaris (DC.) F.Muell. ex Benth.	8,11				x								
Olearia ciliata (Benth.) F.Muell. ex Benth.	5											x	x
Podolepis canescens Cunn. ex DC.	2	x	x			x	x			x			
Podolepis rugata Labill.	6										x	x	x
Podotheca angustifolia (Labill.) Less.	2,6,10,11										x	x	
Quinetia urvillei Cass.	6,8,9,11												
Senecio elegans L.	1,6,11										x		
Senecio lautus G. Forster	1,2,6,7,8,10,11	x						x	x	x	x	x	x
Senecio ramosissimus DC.	1,2	x									x		
Siloxerus humifusus Labill.	8												
**Sonchus asper* Hill	1,3,13							x			x		x
**Sonchus oleraceus* L.	2,7,8,9	x	x										
Trichocline spathulata (Cunn. ex DC.) J.H.Willis	7												
**Ursinia anthemoides* (L.) Poiret	+												
**Vellereophyton dealbatum* (Thunb.) Hilliard & B.L.Burtt	1,3,13		x			x					x		
Waitzia citrina (Benth.) Steetz	1,2,3,6,11									x	x		
Waitzia suaveolens (Benth.) Druce	2,6,10,11	x	x	x	x								

Fig 11.2 (c)

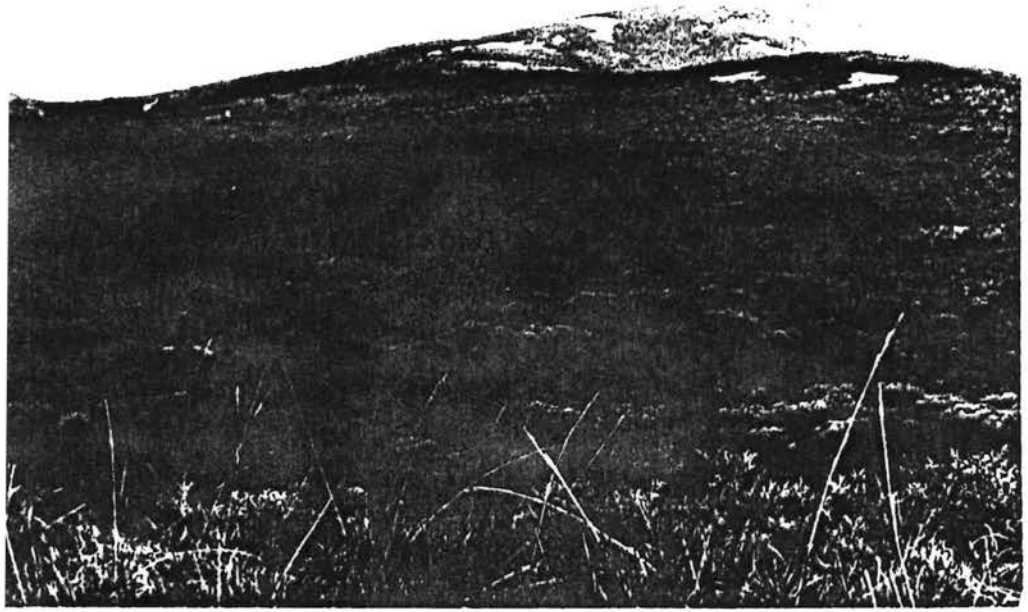
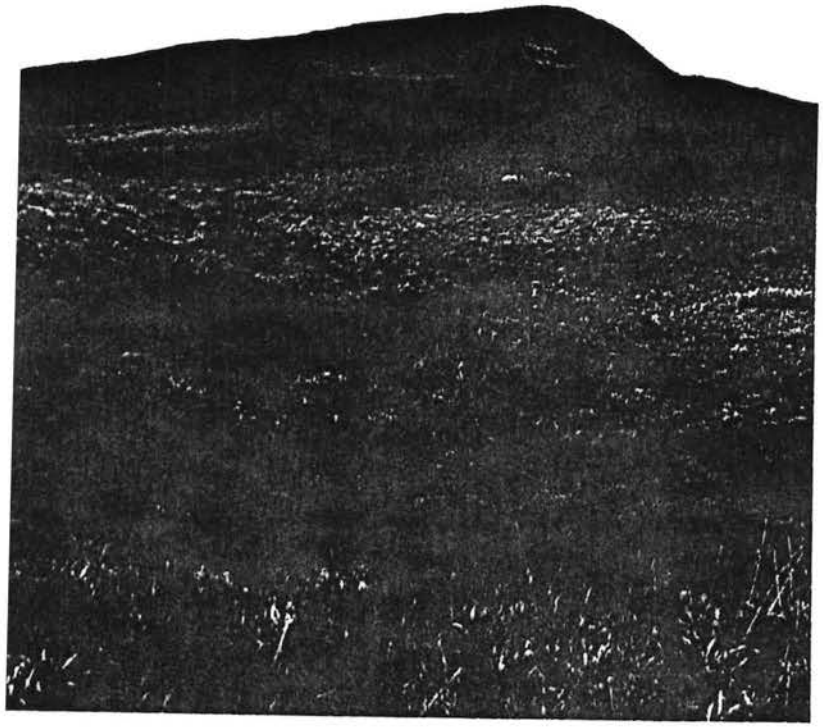
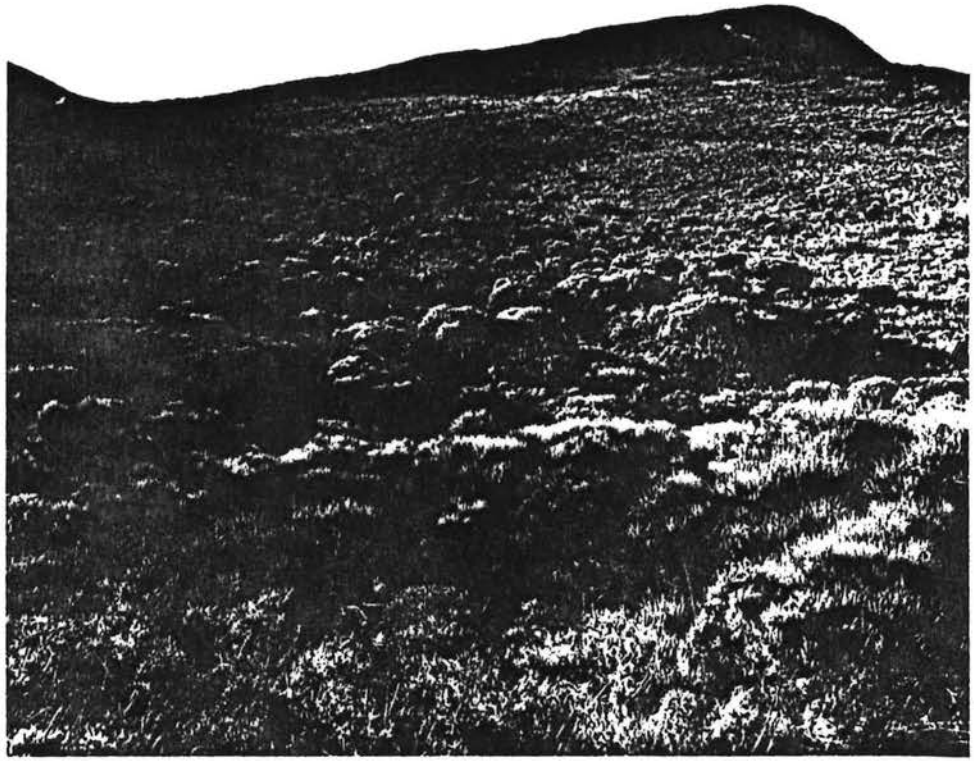


Fig 11.3 (c)





ig 11·3

Fig 11·3b

Fig 11·3

Fig 11·3(a)

Fig 11.4 (b)

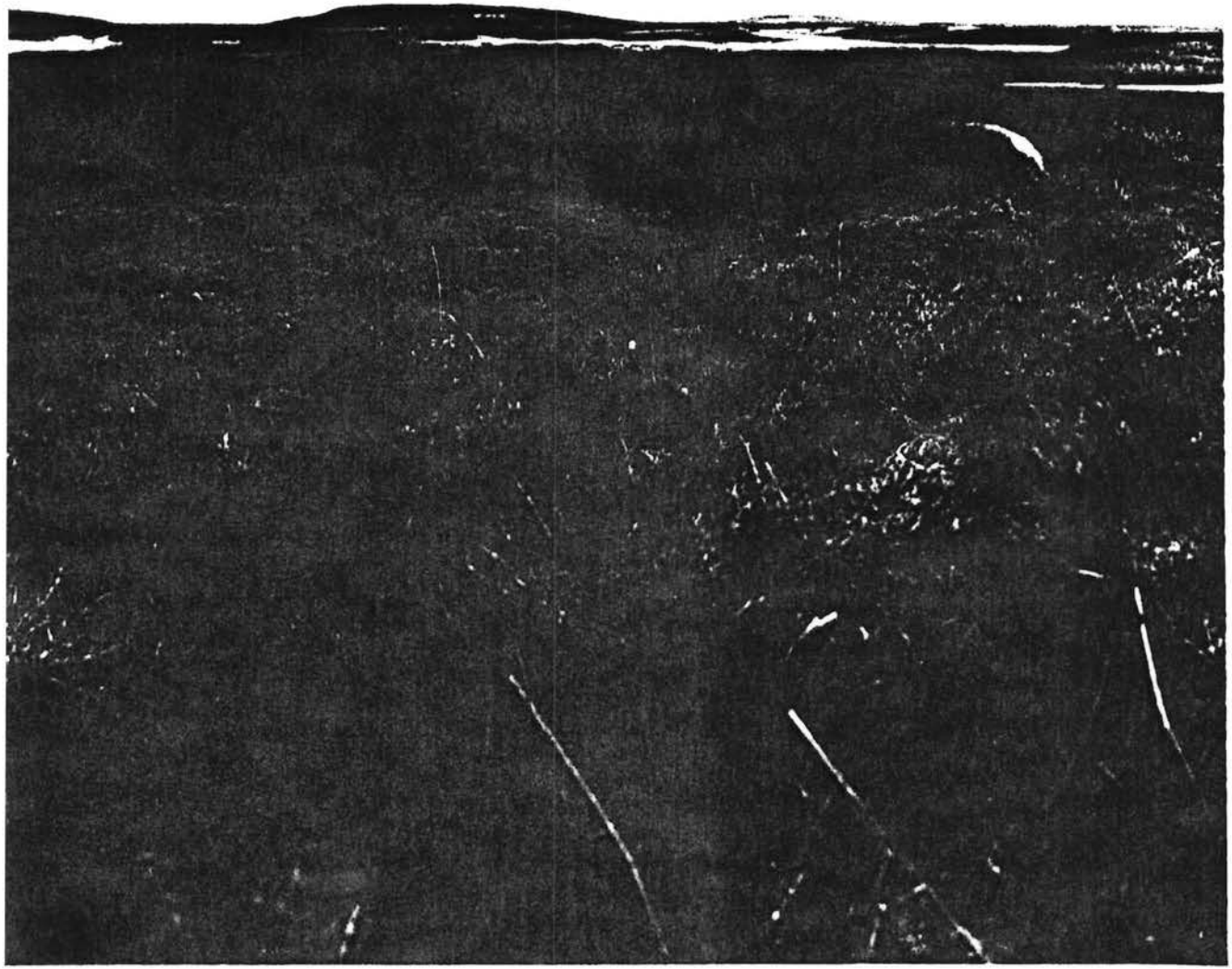


Fig 11.4 (a)

Fig 11.4 (c)

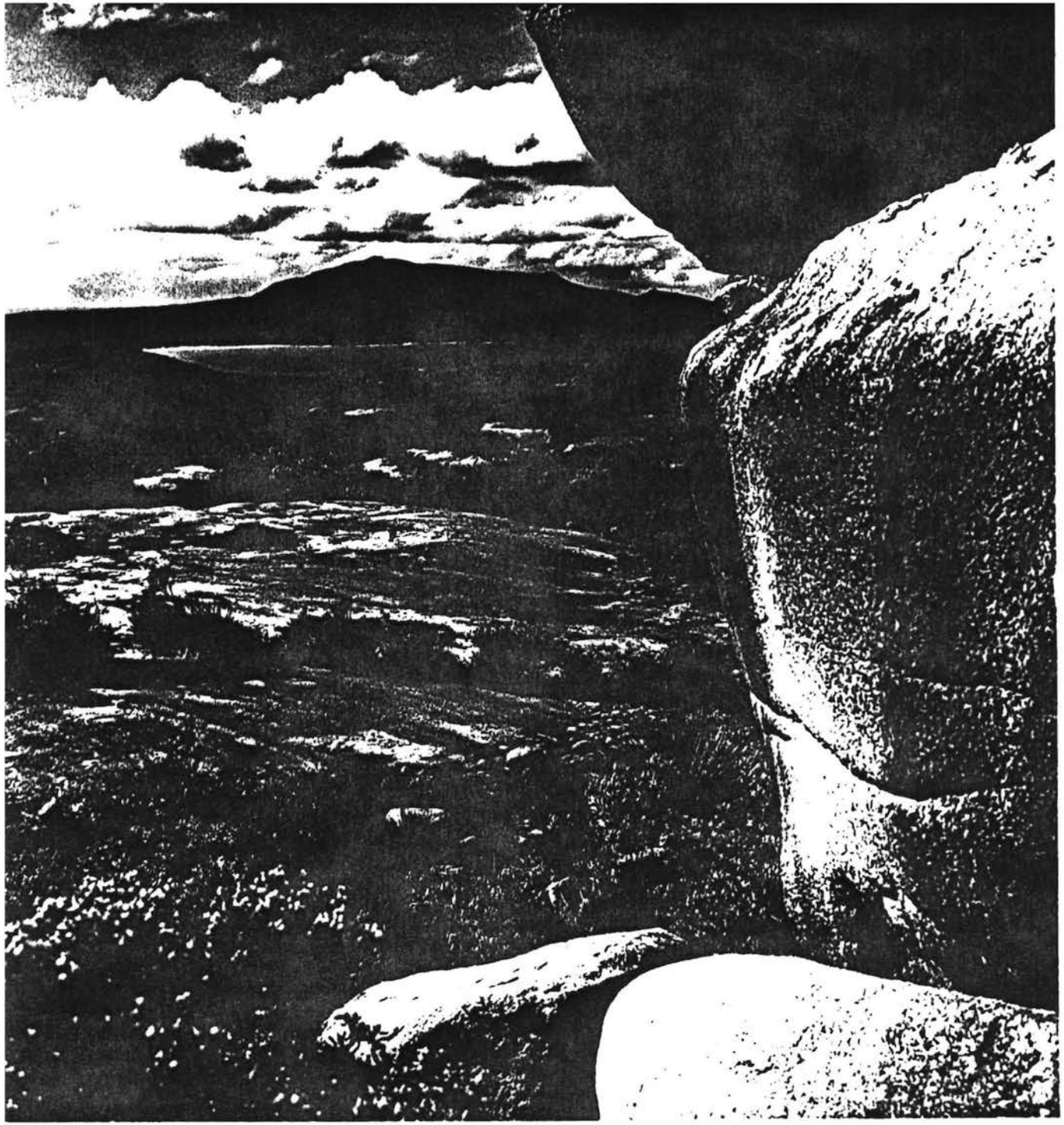


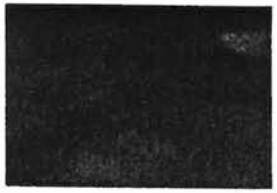
Fig 11.5(a)

Fig 11.5(b)

VEGETATION TYPES

* B+W

(11.6)

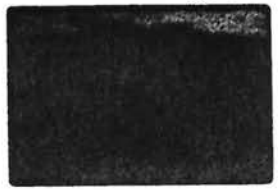


Agonis juniperina
Low Forest T1 AD

(11.7)

T6 Jarrah/Allocasuarina Low Forest

(11.8)

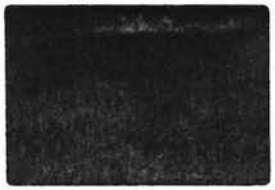


T111

(11.9)

S2 Gully thicket

(11.11)



S7 Isthmus Mixed Dense Low Heath AJMH

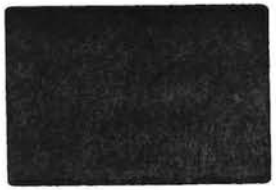
(11.12)

S8 Heathland Heath

(11.10)

GTSmith
S4 Coastal Dune Scrub

(11.13)



S12 Grandelpark complex

Fen between the lakes Two Peoples Bay Feb. 1990 (11.14)

V3 Baumea/Juncea Tall Sedge Swamp

(11) Alternative to one above

T6 Jarrah

July 91 cleared ✓

CHAPTER 11

The Vegetation

A.J.M. Hopkins, A.A.E. Williams and J.M. Harvey

INTRODUCTION

This chapter provides a detailed description and a 1:25 000 scale map of the vegetation of the Two Peoples Bay Nature Reserve. The level of detail in the present work reflects two general features of vegetation mapping:

(1) that vegetation mapping is an iterative process. This map is more detailed than any previous map but as knowledge increases then further improvements and refinements can be expected; and,

(2) that the scale and level of detail selected is appropriate to the purpose for which the map is to be used. This document is oriented towards management, particularly in relation to fire. Thus an attempt has been made to determine vegetation boundaries of relevance to fire behaviour as well a those of ecological significance.

PREVIOUS WORK

As indicated by other contributors to this publication, the vegetation and flora of the Albany - Stirling Range - Cape Riche triangle (Fig. 1.1 this publication) have received considerable attention since *c.* 1800. The many collectors and naturalists invariably provided some description of the landforms and vegetation types which they observed on their travels, but it was not until 1906 when the work of the eminent German botanist Emil Ludwig Friedrich Diels was published that the vegetation was formally classified. In particular, Diels described a number of shrub formations of which Sklerophyll Gebüsche (sclerophyllous bush) was the one he considered to make the greatest contribution to the floristic richness of south-western Australia (Diels 1906). Diels specifically described the sclerophyllous bush vegetation around King George Sound and on the Stirling Range and suggested that it would continue eastwards along the coast as far as Esperance.

The extent and importance of shrublands in the Albany area and the variety of other vegetation types there was confirmed in 1979 when J.S. Beard published his 1:250 000 vegetation map (Albany-Mt Barker sheet) (Beard 1979). He showed four principal vegetation types on the Two Peoples Bay Nature Reserve:

(1) Heath of mixed composition at the end of the peninsula between Mt Gardner and Cape Vancouver.

(2) *Agonis flexuosa* scrub heath over the areas west of the granitic outcrops and south of Moates and Gardner Lakes.

(3) *Eucalyptus marginata* (jarrah), *E. staeri*, *Allocasuarina fraseriana* low forest to the north of Moates Lake.

(4) Reeds (sedges, Restionaceae and heath shrubs) north of Gardner Lake and around Angove Lake.

Beard used the eastern limit of the tree form of jarrah to define the boundary between the Darling Botanical District and the Eyre District. He thus included the forested area north of Moates Lake in the East Kalgan Vegetation System, a part of the first of these two phytogeographic districts. The remainder of the Reserve was described as part of the Bremer Vegetation System of the Eyre Botanical District, a system that includes the granitic uplands and coastal dune complexes to the east as far as Cape Riche. (Some of Beard's maps show a Manypeaks Vegetation System but this was incorporated into the Bremer System at a late stage of drafting - J.S. Beard[1], personal communication.)

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1 Dr J.S. Beard, 6 Fraser Road, Applecross, WA.

A more detailed description of the vegetation of the Two Peoples Bay Nature Reserve was provided by Hopper (1981), who recognised seven generalised physiographic units and described the vegetation associated with them:

(1) The granitic headland with areas of overlying sand and some limestone supporting dense low heaths, dense thickets and with eucalypt and *Melaleuca* dense low forests in the gullies and on the margins of the granite.

(2) The dunes, limestone cliffs and ridges of the isthmus with dense low heath with scattered emergents of *Agonis flexuosa*, *Banksia attenuata*, *B. littoralis* var. *littoralis*, thickets of *Dryandra sessilis* and scattered eucalypt mallees with *Adenanthos sericea* thickets on coastal dunes.

(3) The wetlands fringed by sedgelands with a backing of low woodland and forests of *Agonis juniperina*, *Banksia littoralis*, *Melaleuca* sp. 1, *M. cuticularis*, *M. preissiana* and *M. raphiophylla*.

(4) The area between Moates and Gardner Lakes, and southwards to the coast, is a complex of dunes and swales. The dunes are well-vegetated with *Agonis flexuosa*, *Adenanthos sericea* thickets and the swales are composed of swamp, sedgelands, and low forests and low woodlands of *Banksia littoralis*.

(5) The coastal dunes and swales in the south-western corner of the Reserve with a gradation of vegetation from heaths and thickets near the coast to *Agonis flexuosa*, *Banksia praemorsa* woodlands further inland (including a small *Banksia*-rich sandpatch).

(6) The lateritic and sandy-lateritic hills in the north and north-west supporting low forests and open woodlands of *Eucalyptus marginata*, *E. staeri*, *E. calophylla* and *Allocasuarina fraseriana*.

(7) The offshore islands with dense low heath.

In this present work we have further subdivided these categories while at the same time maintaining reference to the close links between landform (and soils) and vegetation.

Readers with an interest in other areas of natural vegetation within the Albany - Stirling Range - Cape Riche triangle are referred to the work of Beard (1979, 1:250 000 vegetation map, and an unpublished vegetation map of the Stirling Range), Enright (1978, a study of vegetation of Torndirrup National Park, south of Albany), Storr (1965, a vegetation map and description of Bald Island) and Newbey (1979, vegetation maps and descriptions of the coastal area from Cape Riche east to the Fitzgerald River National Park).

METHODS USED IN PREPARING THE VEGETATION MAP

The vegetation map was produced by stereo interpretation of aerial photographs using the methods generally outlined by Küchler (1967). The following photography was utilised during the project:

Coastline: Kalbarri-Israelite Bay Project E51 (Public Works Department); 1:16 000 Black and White. Flown 11 December 1965 (incomplete coverage of the Reserve).

Noisy Scrub Bird: Project K63 (Department of Fisheries and Wildlife) CALM; 1:16 000 Black and White and Infrared. Flown 28 May 1970 (incomplete coverage).

Mt Barker 1:250 000 Sheet: Project M26 (Lands and Surveys Department) Department of Land Administration; 1:40 000 Black and White. Flown 7 February 1973.

Two Peoples Bay Wildlife Sanctuary: Project N74 (Department of Fisheries and Wildlife) CALM; 1:40 000 Black and White. Flown 15 February 1973.

Bunbury to Israelite Bay: Job 770049 Department of Marine and Harbours; 1:25 000 Colour. Flown 15 July 1977 (incomplete coverage).

Albany and Environs, W.A.: 035-049 Water Authority of Western Australia 1:40 000 Colour. Flown 17 April 1981.

Features identified by photo-interpretation were confirmed by ground survey. Much of the field work was performed in December 1981-January 1982. However, a considerable proportion of the ground verification was based on previous field experience within the Reserve by many of the contributors to this publication. We gratefully acknowledge this assistance.

Vegetation was classified according to the scheme of Muir (1977) developed for biological surveys of Western Australian wheatbelt.

The accuracy of the vegetation maps reflects, in large part, the skill of Mr Alan Miller who revised the original maps using a photogrammetric plotter. The colour positives were supplied by the Australian Surveys Office.

of more open vegetation (Associations S5 and V3) in their centres.

T5. *Agonis flexuosa* Low Forest A/Low Woodland A (LAc-i)

The dunes between the lakes support 5-8 m tall *Agonis flexuosa* with a very sparse shrub storey which includes such species as *Acacia littorea, Dryandra sessilis, Adenanthos sericea* and *Hibbertia cuneiformis. Loxocarya flexuosa* is usually present as a sparse ground cover.

T6. Jarrah/Allocasuarina Low Forest A (LA/LBi)

The lateritic soils in the northern section of the Reserve are heavily vegetated with jarrah (*Eucalyptus marginata*) and *Allocasuarina fraseriana* forest, 10-15 m tall. Occasional trees of marri (*E. calophylla*) and *Banksia grandis* are also present. The dense to mid-dense shrub storey to 2 m tall contains species such as *Xanthorrhoea preissii, Bossiaea linophylla, Agonis hypericifolia, Beaufortia decussata, Acacia leioderma* and *Leucopogon verticillatus* (Fig. 11.7).

T7. Mixed Low Forest A (LAc)

The area near the Reserve office and including the present picnic ground is dominated by trees 10-15 m tall of *Agonis flexuosa, Eucalyptus megacarpa* (bullich) and *E. cornuta* (yate). Except for the grassed picnic area, this forest has a dense understorey 2-4 m tall dominated by *Bossiaea linophylla, Acacia cyclops, Phebalium anceps* and *Acacia littorea*. Towards the eastern part of this stand, the low forest is composed almost entirely of *Agonis flexuosa*. A similar forest type occurs along the margins of the Angove River. The Angove River stands have been badly burnt and most trees are coppicing. Those stands include low trees of *Melaleuca cuticularis* and understorey shrubs and include *Pultenaea reticulata, Boronia crenulata, B. gracilipes* and *Hypocalymma cordifolium*.

T8. Mixed Jarrah/Marri/Bullich Low Forest A (LAc)

A small stand of this forest type occurs on sands overlying a podzol material on granite at the headwaters of Firebreak Gully. Trees 7-10 m tall of *Eucalyptus marginata, E. calophylla, E. megacarpa* with occasional *Allocasuarina fraseriana* occur over a mixed dense shrub stratum in which *Xanthorrhoea preissii, Pteridium esculentum* (bracken), *Hibbertia furfuracea, Acacia leioderma, Agonis parviceps* and *Boronia spathulatum* are common. This unit grades into *Allocasuarina* Low Forest (T9) downslope along the gully.

T9. *Allocasuarina fraseriana* Low Forest A/Low Woodland (LAc/i)

This forest type is found downslope from the previous type and below the granite outcrops on either side of Firebreak Gully. *Allocasuarina fraseriana* attains a height of 6-10 m and occasional *Eucalyptus marginata, E. megacarpa* and *Agonis flexuosa* also contribute to the tree canopy. The mid-dense shrub stratum (Heath A/B) is dominated by *Melaleuca thymoides, Bossiaea linophylla* and *Adenanthos cuneata*. The sedge *Cyathochaeta clandestina* and *Anarthria scabra* are also important components of the understorey.

T10. Gully Mixed Dense Low Forest (LA/LB d)

Some of the well-watered gullies of the Mt Gardner area have a dense forest vegetation 4-8 m tall in which *Eucalyptus cornuta, E. conferruminata, E. calophylla, Hakea elliptica* and *Oxylobium cuneatum* are important species.

T11. South-west Peppermint Low Forest A over Scrub (LAc)

This association is confined to areas of consolidated sands in the south-western part of the Reserve, to the west of the sand-dune. The upper canopy consists of *Agonis flexuosa* 5-8 m tall with occasional *Banksia littoralis*. There is a prominent shrub component that includes *Acacia littorea* and *Bossiaea linophylla* at most sites while the tall shrubs (2-4 m tall) *Adenanthos sericea, Allocasuarina lehmanniana* and *Dryandra sessilis* are less widespread. This association is floristically similar to that found to the east of the dune on the sand ridges (T5). Towards the south coast it becomes lower in height and grades into coastal dune scrub/thicket (S4). Adjacent to the track into the large and mobile sand dune there is an area of this association that may have been burnt more recently than the remainder; it is both lower and more open but otherwise floristically similar to T11. It is labelled T11/S4 to indicate its scrub/open scrub classification.

T12. Mixed Low Forest A on Limestone (LAc)

This association is of limited areal extent in the Reserve, being confined to two small areas in the south-west of the Reserve. Along the western boundary, the shallow aeolian sands overlie a pavement of limestone with some iron enrichment; this limestone improves the water retention properties of the soil. The association comprises scattered mature paperbarks (*Melaleuca cuticularis*)

VEGETATION CHANGE OVER TIME

Some important, recent changes in vegetation of parts of the Two Peoples Bay Nature Reserve became evident during the vegetation mapping project. The time-series of aerial photographs spanned some 16 years. In addition, photographs of a number of identifiable sites around the Reserve were available for comparison with present-day situations. Some early reports and verbal impressions were also supplied by people with long associations with the area.

The principal change in vegetation reflected continuing growth and development by an increase in height and cover. For example, in the dune and swale complex south-west of Gardner Lake, an area that was burnt in 1970, the swale vegetation expanded outwards and up the dune slopes in the ensuing 12 fire-free years. In the isthmus area dominated by heath, the emergents *Agonis flexuosa* and *Dryandra sessilis* have become more prominent in recent years. Some photographs showing this change are presented here (Figs 11.2(a,b), 11.3(a,b,c), 11.4(a.b.c), and 11.5(a,b)). The original photographs were taken by CSIRO photographer Mr Ed Slater in 1960. Sites were identified and rephotographed in May 1982 by Messrs L.A. Moore and G. Chapman of CSIRO Division of Wildlife and Ecology, and again in April 1990 by N.J. Coy.

It is likely that some of these changes resulted from the policy of fire exclusion and containment practised since the Reserve was created. This policy was considered important for protection of the Noisy Scrub-bird. As indicated elsewhere in this publication, the policy has probably contributed to the increase in bird numbers in recent years. However, the more general implications have yet to be assessed. In our mapping we have accurately delineated boundaries as they were in the 1981 photography so that future workers may address questions of change with a reliable reference point.

THE VEGETATION

The following descriptions of plant associations are to be read in conjunction with the vegetation map, Figure 11.1 (Foldout inside back cover of this publication). It should be noted that each unit mapped at the 1:25 000 scale will incorporate a degree of physiognomic and floristic variability, so both the boundaries and the descriptions represent generalisations. Further, important floristic boundaries are often not coincident with physiognomic boundaries; these latter boundaries generally reflect limits of distribution of a few large species rather than limits of floristic assemblages. It is anticipated that, as the Reserve becomes better known, more precise and detailed vegetation maps will be developed.

A total of 33 associations have been recognised for the Reserve. These include a number that appear to be closely related floristically. Together they comprise about 15 formations but, because of the variability from place to place within each association, no attempt is made to develop this hierarchy.

Tree-dominated Communities

T1. *Agonis juniperina* Forest/Dense Forest (Mc/Md of Muir 1977)

Small patches of this forest type exist on the edges of both Moates and Gardner Lakes and in low-lying areas with sandy soils between the lakes. The *Agonis* may achieve heights of 17 m. In some cases this upper stratum has collapsed and in other cases the stand has been burnt and there is prolific regeneration from seed. A dense to mid-dense understorey of sedges and shrubs such as *Phebalium anceps, P. rude, Logania vaginalis* and *Myoporum caparioides* may be present (Fig. 11.6).

T2. *Agonis juniperina* Low Forest/Scrub/Thicket (LA/S)

Areas of lower *Agonis* vegetation, between 3-8 m in height, can be found around the lakes. At the western end of Moates Lake, dense sedges to 0.75 m tall form an understorey. Around the southern margins of Gardner Lake the *Agonis* may be associated with *Banksia littoralis*.

T3. *Agonis juniperina* Dense Low Forest (LA/d)

At the south-eastern end of Two Peoples Bay, immediately behind a small gently sloping beach, is a small area of *Agonis* forest to 10 m tall with a mid-stratum (2-4 m tall) of *Oxylobium lanceolatum* and a lower stratum of tall sedges (to 2 m tall) including *Lepidosperma gladiatum* and *Isolepis nodosus*.

T4. *Banksia littoralis* Low Woodland A/Open Low Forest (LAc-r)

This association, dominated by *B. littoralis*, is developed in the swales of the dune system, between the lakes and towards the coast. These swales are probably not seasonally waterlogged to the same extent as those which support *Agonis juniperina*. This association has an understorey of shrubs (*Acacia littorea*) and sedges (*Lepidosperma gladiatum*). Some of the swales contain small areas

Agonis flexuosa (to 5 m tall) and *Adenanthos sericea* (to 3 m) interspersed with shrubs to 2 m of *Spyridium globulosum, Hibbertia cuneiformis, Acacia littorea, A. cyclops, A. cochlearis, Scaevola crassifolia* and *Olearia axillaris*. A sparse ground cover of *Loxocarya flexuosa* is often present. Plants of *Spinifex hirsutus, Euphorbia paralias* and *Cackile maritima* are prominent on the seaward margins of the dunes.

S4. Coastal Dune Scrub (Si)

The recent dunes west of Rocky Point have a scrub vegetation that intergrades with the peppermint forest (T11) further inland. *Banksia praemorsa* forms a sparse to very sparse upper stratum up to 6 m tall. *Dryandra sessilis* (to 3 m) and shrubs (to 2 m) of *Acacia littorea, Spyridium globulosum* and *Adenanthos sericea* form much of the understorey. This association is also found behind Little Beach where aeolian limestone and calcareous sands occur (Fig. 11.10).

S5. *Phebalium* Thicket/Scrub (Sc/i)

The large swale, centered about 300 m west-north-west of the Reserve office, consists of a mid-dense thicket of *Phebalium anceps* of around 3 m in height with the sword sedge (*Lepidosperma gladiatum*) over dense *Scaevola crassifolia, Acacia littorea* and sedges. Trees of *Banksia littoralis* 4-5 m tall are scattered throughout the swale. In some of the swales between the dune and Gardner Lake there is a similar association with *Phebalium anceps, P. rude, Logania vaginalis, Allocasuarina lehmannianae, Hakea varia, Spyridium globulosum* and stunted *Agonis flexuosa*. A dense ground cover of *Loxocarya* may be associated with those shrub associations.

S6. Swamp Margin Thicket (Sc)

On the northern margins of Gardner Lake there is a broad band of thicket vegetation that includes dense stands of *Homalospermum firmum* to 2.5 m tall. Associated species include *Astartea fascicularis, Kunzea ericifolia* and *Jacksonia spinosa*. This association intergrades with *Agonis juniperina* scrub (T2) and can also have tall *Oxylobium lanceolatum* stands. The peaty soils often support populations of *Cephalotus follicularis*. The western edges of Angove Lake are steeper than the edges of Gardner Lake; there the fringing thicket is narrow and it intergrades with *Eucalyptus staeri/Allocasuarina fraseriana* woodland (T15).

S7. Isthmus Mixed Dense Low Heath (SCd)

The area of consolidated, well drained, calcareous sand-dunes between Gardner Lake and the granitic outcrops of Mt Gardner consists mainly of a dense low heath (shrubs to 1 m). Shrubs include *Acacia cochlearis, Melaleuca thymoides, Jacksonia horrida, Allocasuarina humilis, Adenanthos cuneata, Leucopogon revolutus* and other epacrids. The tussock sedge *Cyathachaeta clandestina* is very prominent. Scattered emergent tall shrubs of *Agonis flexuosa* and some mallee *Eucalyptus angulosa* occur in clumps. *Banksia littoralis* and *B. attenuata* trees may be present. Stands of emergent *Dryandra sessilis* are generally associated with outcrops of the coastal limestone (Fig. 11.11).

S8. Headland Mixed Dense Low Heath (SCd)

The sandy soils associated with the granitic outcrops of the Mt Gardner headland are generally non-calcareous and, as a result, *Dryandra sessilis* is uncommon. The heath vegetation is otherwise floristically very similar to that on the isthmus. Prominent species include *Melaleuca thymoides, M. striata, Leucopogon spp., Cyathachaete clandestina, Anarthria scabra* and *Dasypogon bromeliifolius*. Emergents include *Allocasuarina fraseriana, Nuytsia floribunda, Agonis flexuosa* and some mallee eucalypts (Fig. 11.12).

S9. Moors Low Heath (SC/D c)

In the area referred to as The Moors (Fig. 1.4 this publication) near Cape Vancouver, limestone overlies the granite and soils are calcareous and skeletal. The vegetation in this exposed site is severely wind-pruned and open. Shrubs are generally less than 0.5 m in height.

S10. Limestone Cliff Heath (SB c/d)

The steep limestone cliffs above Sinker Reef support a heath that is characterised by the presence of *Banksia praemorsa, Adenanthos* spp. and *Olearia axillaris* to 1.5 m tall. Shrubs include *Acacia littorea, Scaevola crassifolia, Melaleuca ?pentagona* var. *subulifolia, Pimelea ferruginea, Spyridium globulosum* and *Leucopogon parviflorus*.

S11. Island Heath (SDc)

The islands off the coast that are included within the Reserve have a species-poor heath vegetation that is confined to the limited areas where some soil has developed. Vegetation on Coffin Island consists of a dense shrub layer of *Rhagodia baccata* (1 m tall and up to 2 m tall in depressions) with scattered clumps of *Anthocercis viscosa*. This

to 10 m tall mixed with *Banksia seminuda*, *Eucalyptus staeri*, and *Agonis flexuosa* 6-9 m tall. A mid-storey thicket (to 4 m tall) includes *Hakea elliptica*, *Dryandra sessilis*, *Allocasuarina lehmanniana* and *Agonis flexuosa*. Sparse low shrubs (including *Leucopogon revolutus*) and sedges are present.

T13. *Melaleuca* Low Forest A/Dense Low Forest A (LAd/c)

The area adjacent to where Gardner Creek flows from Gardner Lake supports a forest 6-10 m in height dominated by *Melaleuca* sp. 1, *M. cuticularis*, *M.* sp. *raphiophylla* and *M. preissiana* with some *Agonis flexuosa*. The sparse shrub storey includes *Hibbertia furfuraceae* 1-2 m tall and low sedges are present. The margins of the Gardner Creek are fringed by a narrow band of *Melaleuca cuticularis* 3-5 m tall with dense sedges to 2 m tall. *M. preissiana* (trees to 4 m) also occurs in a swamp south of the Goodga River in the western boundary area.

T14. *Eucalyptus staeri* Low Woodland B (LBi)

The sandy slopes away from the lateritic uplands in the areas to the north of Moates Lake are vegetated with very sparse trees of *Eucalyptus staeri*, *Allocasuarina fraseriana*, *Banksia attenuata* and *B. coccinea* to 10 m in height. A mid-dense heath containing species such as *Beaufortia anisandra*, *Melaleuca striata*, *Adenanthos cuneata*, *Calytrix asperula* and *Dasypogon bromeliifolius* underlies the trees (Fig. 11.8).

T15. *Eucalyptus staeri/Allocasuarina fraseriana* Open Low Woodland (LBr)

Towards the western boundary of the Reserve there is a series of dunes where the tree stratum is exceedingly sparse and the vegetation might be better described as a low heath, with emergent *Banksia coccinea*. Important components of the shrub stratum include *Beaufortia decussata*, *Melaleuca thymoides*, *Agonis marginata*, *Adenanthos cuneata*, *Jacksonia spinosa*, *Dasypogon bromeliifolius* and *Xanthosia rotundifolia*.

Much of this vegetation type has been affected by *Phytophthora cinnamomi* and has, as a result, become more open and changed in floristic composition. *Banksia coccinea*, *Leucopogon flavescens* and *Jacksonia spinosa* are nearly eliminated.

T16. *Banksia* Open Low Woodland B (LBr)

The aerial photographs reveal a conspicuous, sandy, almost bare, patch along the western boundary track. It is not clear whether this is a very old sand blowout or a revegetating infilled swamp. It is characterised by a wealth of *Banksia*. The upper stratum is composed mainly of *Agonis juniperina*, *Banksia attenuata*, *B. coccinea*, *B. grandis*, *B. littoralis*, *B. quercifolia*, *B. occidentalis*, *Agonis flexuosa* and *Adenanthos sericea*. The understorey is very sparse but includes *Bossiaea linophylla*, *Astroloma ciliatum*, *Isopogon formosus* and *Latrobea hirtella*. The lowest stratum includes *Conostylis setigera*, sedges, and the Albany Pitcher Plant, *Cephalotus follicularis*.

Mallee-dominated communities

M1. Mixed Mallee Shrublands (KS)

Patches of mallee vegetation are spread throughout the Mt Gardner headland where they are often indistinguishable on the aerial photography from the Mt Gardner Thicket (S1). Species include *Eucalyptus angulosa*, *E. cornuta* and *E. goniantha*. In addition, small clumps of mallee occur in areas of heath such as that on Tick Flat.

Shrub-dominated communities

S1. Mt Gardner Thicket (Sd/c)

Fringing the exposed granitic outcrops of the Mt Gardner headland is a dense to mid-dense thicket 2-4 m in height and dominated by such species as *Hakea elliptica*, *H. trifurcata*, *Allocasuarina trichodon*, *Oxylobium cuneatum*, *Dryandra formosa*, *Agonis marginata* and *A. parviceps*. In some areas, tall *Xanthorrhoea preissii* are conspicuous.

S2. Gully Thicket (Sc/d)

Many of the gullies that do not support forest have a thicket vegetation to 3 m tall that may be dominated by *Gastrolobium bilobum* and *Oxylobium cuneatum* with some *O. lanceolatum* and *Chorilaena quercifolia* sp., *Melaleuca* sp. 1 may be present. Stunted mallees of *Eucalyptus marginata* and *E. calophylla* are also present. The gully at the eastern end of the limestone cliff heath has *Adenanthos cygnorum* and *Dryandra sessilis* with *Agonis flexuosa* thickets further up the gully (Fig. 11.9).

S3. Sand Dune Thicket/Scrub (Sc/i).

The steep dunes fronting Two Peoples Bay and dissected by Gardner Creek have a thicket of

Legend

Vegetation units described for the Two Peoples Bay Nature Reserve. The distribution of these units is shown on Map 11.1 (in pocket inside back cover). Terminology follows Muir (1977).

T. Tree Dominated Communities

T1 *Agonis juniperina* Forest/Dense Forest

T2 *Agonis juniperina* Low Forest/Scrub/Thicket

T3 *Agonis juniperina* Dense Low Forest

T4 *Banksia littoralis* Low Woodland A/Open Low Forest

T5 *Agonis flexuosa* Low Forest A/Low Woodland

T6 Jarrah/*Allocasuarina* Low Forest A

T7 Mixed Low Forest A

T8 Mixed Jarrah/Marri/Bullich Low Forest A

T9 *Allocasuarina fraserina* Low Forest A/Low Woodland

T10 Gully Mixed Dense Low Forest

T11 South-west Peppermint Low Forest A over Scrub

T12 Mixed Low Forest A on Limestone

T13 *Melaleuca* Low Forest A/Dense Low Forest A

T14 *Eucalyptus staeri* Low Woodland B

T15 *Eucalyptus staeri/Allocasuarina fraseriana* Open Low Woodland

T16 *Banksia* Open Low Woodland

M. Mallee Dominated Communities

M1 Mixed Mallee Shrublands

S. Shrub Dominated Communities

S1 Mt Gardner Thicket

S2 Gully Thicket

S3 Sand Dune Thicket/Scrub

S4 Coastal Dune Scrub

S5 *Phebalium* Thicket/Scrub

S6 Swamp Margin Thicket

S7 Isthmus Mixed Dense Low Heath

S8 Headland Mixed Dense Low Heath

S9 Moors Low Heath

S10 Limestone Cliff Heath

S11 Island Heath

S12 Granite Rock Complex

S13 Wet Heath

V Sedge Dominated Communities

V1 *Evandra* Dense Tall Sedge Swamp

V2 *Lepidosperma* Dense Tall Sedge Swamp

V3 *Baumea/Juncus* Tall Sedge Swamp

This is the Legend for Fig 11.1 which is the vegetation map of the whole reserve. It is intended that Fig 11.1 should be a foldout contained in a pocket inside the back cover. The Legend may be included on the foldout.

is fringed by *Carporbotus virescens, Poa poiformis* and *Lomandra rigida.*

S12. Granite Rock Complex (SDi/Pi/Xi)

Exposed sheets and boulders of granite on the Mt Gardner headland support varied vegetation in pockets of shallow soil. Prominent species include *Agonis marginata, Anthocercis viscosa, Verticordia plumosa* and *Andersonia simplex. Borya nitida,* mosses and orchids are also important. There is a conspicuous rock supporting this complex beside the main road and just east of the bridge over Gardner Creek (`Rock Island' on Fig. 1.4 this publication) - (Fig. 11.13).

S13. Wet Heath (SC d/c)

To the north and west of Moates Lake there are numerous patches of variable low heath to 1 m tall in areas that may be seasonally waterlogged. Some sites contain emergent *Callistemon speciosus* to 2 m tall. The low shrub stratum comprises such species as *Actinodium cunninghamii, Andersonia simplex, Sphenotoma gracile* and *Banksia nutans.*

Sedge-dominated Communities

V1. *Evandra* Dense Tall Sedge-Swamp (VTd)

The low-lying swampy areas to the north and west of Moates Lake and along the Goodga River are densely vegetated with *Evandra aristata* to 1 m tall. The shrub species *Leucopogon distans* and *Melaleuca thymoides* may be conspicuous. Areas of *Xyris lantana, Leptocarpus scariosus* and *Hypolaena exsulca* are included in this unit.

V2. *Lepidosperma* Dense Tall Sedge Swamp (VTd)

The swamp around the picnic ground is dominated by *Lepidosperma gladiatum* to 2 m tall. In some areas *Typha domingensis* has invaded. The swamp margins may contain *Ghania* spp, *Lepidosperma tenu* and *Isolepis nodosus.*

V3. *Baumea/Juncus* Tall Sedge Swamp (VTc/i)

Extensive areas of *Baumea articulata* with some *Juncus kraussii* occurs at Angove Lake and also fringe Gardner and Moates Lakes. In some areas these sedge swamps intergrade with the fringing *Leptocarpus scariosus* and *Hypolaena exsulca* sedges. A similar association can be found in seasonally waterlogged swale areas between the dune and Gardner Lake. *Baumea juncea* and *Schoenus grandiflorus* are prominent in these swamps (Fig. 11.14).

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CHAPTER 12

Banksias and Eucalypts - A Pilot Study of the Distribution and Habitats of Flora on Two Peoples Bay Nature Reserve

S. D. Hopper and G. L. Folley

INTRODUCTION

This paper summarizes results of a systematic survey of Two Peoples Bay Nature Reserve for species of *Banksia* (Proteaceae) and *Eucalyptus* (Myrtaceae). It provides an atlas, line drawings and ecological notes for the 13 banksias and nine eucalypts known on the Reserve.

The study was aimed at understanding the logistic problems associated with survey work in topographically diverse terrain. It attempted to assess whether information of value to management planning and biological studies could be obtained for these genera within a reasonable survey period.

The work reported here also served as a useful precursor to *The Banksia Atlas* (Taylor and Hopper 1988), a national computer mapping project involving volunteer contributors. Experience gained at Two Peoples Bay was invaluable for designing sight record data sheets for *The Banksia Atlas*.

It is hoped that the maps and line drawings will assist future managers and visitors to the Reserve in the identification, study and management of these conspicuous and important components of the flora of the Reserve.

MATERIALS AND METHODS

A map of Two Peoples Bay Nature Reserve was divided into 500 m grids using Australian Map Grid coordinates (Fig. 12.1). The grid system was then redrawn on 1:25 000 aerial photographs to ensure accurate field location. A 500 m grid size was chosen because it was small enough to allow for discrimination between major landforms and vegetation types, while still large enough to enable all grid cells (247 in total) to be inspected at least once within a three-week survey period.

Banksias and eucalypts were chosen for the survey because most species are trees or large shrubs that can be recognised from distances of up to several hundred metres with the aid of binoculars. Species were identified using standard reference works (Chippendale 1973; Holliday and Watton 1975; George 1981) and through comparisons with specimens housed in the Western Australian Herbarium (PERTH). Preliminary observations were made in 1979 before grid maps were available, and the main survey was undertaken over the periods 2-9 February 1980 and 2-9 and 18-20 February 1981.

The last four grids inspected (near Angove Lake) were visited on 8 March 1981. Grids were visited using four-wheel-drive vehicle, canoe (Moates Lake area), or by foot. The few grids that were not reached were inspected through binoculars, from suitable vantage points no more than 500 m beyond their boundaries. Such binocular inspections enabled the successful identification of all banksias except for the small shrubs *B. dryandroides*, *B. gardneri*, and *B. nutans*, all three of which could be easily overlooked. Only eucalypts with large recognisable fruits (i.e. *E. conferruminata*, *E. calophylla* and *E. megacarpa*) could be identified using binoculars.

A combination of ease of access, visibility of vegetation, and habitat diversity influenced the completeness of the survey of each grid. In general, grids in the rugged eastern Mt Gardner headland area could be examined only where tracks had been made through patches of dense vegetation for Noisy Scrub-bird census work. Consequently, only a small proportion of the area of these grids was examined, and some species may have been overlooked. Grids

TWO PEOPLES BAY NATURE RESERVE
SYMBOLS
Reserve boundary
Road
Track / firebreak
Foot traverse
Swamp
Goodga River
Moates Lake
Sand dunes
Rocky Point
Black Rock
Inner Island
Mt Gardner
Coffin Island
Gardners Lake
Angove Lake
Mettler Beach
Rock Dunder
Cape Vancouver
TWO PEOPLES BAY
PERTH
Esperance
TWO PEOPLES BAY
115°
120°
125°
35°
30°

Table 12.1
Statistics on estimated maximum heights (m) of banksias and eucalypts on Two Peoples Bay Nature Reserve.

Species	Mean ± S.E.	Range	N
Banksia			
attentuata	2.3 ± 0.2	0.5-6	77
coccinea	2.7 ± 0.2	1.0-6	50
dryandroides	0.5 ± 0.0	0.5-1.0	16
gardneri	0.3	-	1
grandis	2.4 ± 0.2	0.5-5	62
ilicifolia	4.6 ± 0.7	3.0-8	7
littoralis	6.1 ± 0.3	1.5-10	78
nutans var. *cernuella*	1.1 ± 0.1	0.5-1.5	8
occidentalis	3.0	-	1
praemorsa	2.7 ± 0.3	1.0-5	32
quercifolia	2.1 ± 0.2	1.0-2.5	6
seminuda	7.7 ± 1.5	5-10	3
verticillata	1.8 ± 0.8	1.0-2.5	2
Eucalyptus			
angulosa	2.1 ± 0.2	0.5-8	29
calophylla	5.3 ± 0.5	1.0-18	67
conferruminata	2.6 ± 0.3	1.0-8	34
cornuta	5.3 ± 0.6	1.0-15	33
goniantha off. *falcata*	3.7 ± 0.5	2.0-7	10
marginata	4.1 ± 0.4	1.0-13	88
megacarpa	4.5 ± 0.4	1.0-15	57
missilis	3.7 ± 0.5	2.0-7	10
staeri	6.0 ± 0.5	2.5-10	26

S.E. = Standard of the Mean. N = Sample Size.

Table 12.2
Statistics on estimated maximum heights (m) for Mt Gardner headland populations compared with the rest of the Reserve in three banksias and two eucalypts on Two Peoples Bay Nature Reserve.

Species	Population	Mean ± S.E.	Range	N
Banksia				
attenuata	headland	1.5 ± 0.1	1.0-4	37
	rest	3.0 ± 0.3	0.5-6	36
coccinea	headland	2.0 ± 0.1	1.03.0	29
	rest	3.5 ± 0.3	1.0-6	22
grandis	headland	1.4 ± 0.1	0.5-2.5	33
	rest	3.5 ± 0.2	1.0-5	29
Eucalyptus				
calophylla	headland	3.1 ± 0.3	1.0-8	46
	rest	10.7 ± 0.8	2.5-18	20
marginata	headland	1.9 ± 0.1	1.0-5	50
	rest	7.2 ± 0.5	1.0-13	36

S.E. = Standard of the Mean. N = Sample Size.

on the isthmus were very easy to survey, whereas those in the western part of the Reserve were of variable difficulty.

Whenever a banksia or a eucalypt species was first encountered in a grid, the following data were collected: maximum height was estimated to the nearest half-metre, vegetation structure (using the classification of Muir 1977), associated dominant species, landform and soil. (Soil type was inferred from vegetation attributes for those few grids that were inspected at a distance with binoculars.) This information gave quantitative data on the habitats favoured by each species. Because of the large amount of habitat information obtained, only major features are presented in the annotated species list. The sequence in which vegetation structure, landforms, soils and associated species are listed reflects their relative frequencies in the habitat tabulations.

RESULTS

Data from this study are summarized in distribution maps (Figs. 12.4-12.25) and in the annotated species list below. The survey found 13 banksias and nine eucalypts on the Reserve. Among the most significant additions to the species inventory were *Banksia verticillata*, *Eucalyptus missilis* and *E. goniantha*. These rare plants occurred in small populations that may have escaped detection had the survey not been based on a systematic sampling of grids.

The inset maps of south-west Western Australia in Figures 12.4-12.25 show that Two Peoples Bay Nature Reserve has geographically important populations of 12 of the species surveyed. Plants from high rainfall regions of the south-west that reach their south-eastern limit on or near the Reserve include *Eucalyptus megacarpa*, *Banksia littoralis*, *B. ilicifolia* (Fig. 12.2), *B. quercifolia*, *B verticillata* and *B. seminuda*. Species from semi-arid coastal areas that reach their western limit on or near the reserve include *B. dryandroides*, *B. nutans* var. *cernuella* (Plate 9 this publication), *E. conferruminata* (Fig. 12.3) and *E. goniantha*. Uncommon species with significant populations on the Reserve include *B. praemorsa* and *B. occidentalis*.

Banksia species were found in 165 (67 per cent) of the 247 grids. Areas rich in species were the western boundary (up to eight species per grid cell), slopes to the north of Moates Lake (five species per grid) and near coastal slopes and ridges north-east of Mt Gardner and north-west of Little Beach (five species). *Banksia* was absent on the four islands of the Nature Reserve, on sections of the coastline with exposed granite or where limestone was absent and on the bare dunes south of Moates Lake.

Eucalypt species covered less of the Reserve than did the banksias, being found in 126 (51 per cent) of the grids. The headland, dominated by Mt Gardner and associated granite ridges and slopes, was the area richest in species, with up to six per grid cell. The north-western corner of the Reserve was a secondary node of species richness (up to three per grid cell), while the genus was absent from the extensive swamp, dune and coastal systems between these two nodes and from all four near-coastal islands.

Estimated maximum heights (Table 12.1) were uniformly lower than those reported in the literature (George 1981; Hall *et al.* 1970) for populations from high rainfall regions of the south-west in such species as *Banksia attenuata*, *B. grandis*, *B. littoralis*, *B. seminuda*, *Eucalyptus calophylla*, *E. marginata* and *E. megacarpa*. Additionally, the maximum height of four banksias and two eucalypts is greater in the western node than on the eastern headland (Table 12.2).

DISCUSSION

This investigation has demonstrated that certain species of woody perennial shrubs and trees can be profitably surveyed on Two Peoples Bay Nature Reserve over a three-week period using 500 m grids. Banksias and eucalypts were favourable groups for such a survey because most species had large distinctive leaves, flowers and a habit permitting identification using binoculars over distances of up to 1 km. Only the small shrubs *B. dryandroides*, *B. gardneri* and *B. nutans* proved difficult to locate and identify over distances greater than 30 m. The eucalypts were less amenable to medium distance identification, although this was possible for species with relatively large nuts such as *E. calophylla*, *E. conferruminata* and *E. megacarpa*.

The nature of the terrain and vegetation structure also placed limitations on the survey. For example, the gently undulating topography of the isthmus north of Sinker Reef, with its cover of dense low heath, gave uninterrupted views of more than 1 km. At the other extreme, dense thickets on the slopes of Mt Gardner restricted visibility down to a few metres in some places. However, suitable vantage points were found throughout the Reserve to inspect relatively inaccessible areas on the majority of grids using binoculars.

As Figure 12.1 indicates, 101 (41 per cent) of the 247 grids covering the Reserve are traversed by roads, tracks or firebreaks accessible to four-wheel-drive vehicles. This necessitated a considerable amount of survey work on foot to cover most of the remaining grids. A small number of grids located in the swamps between Moates Lake and Gardner Lake, and in the rugged gullies of the Mt Gardner headland were too difficult to access on foot within the three-week survey period and had to be inspected at a distance using binoculars. It is likely that some species (particularly eucalypts) were not recorded in the few peninsula grids in which they occur, as a consequence of this problem.

With these limitations in mind, the maps presented in Figures 12.4-12.25 should be regarded as provisional for some species. In a few cases future work may significantly alter the distributions presented, but we are confident that for most species the true limits of their distribution on the Reserve have now been defined.

The survey provided data for management of the Nature Reserve and contributed to an understanding of the biology of the plants studied. Firstly, a number of additions to the species inventory for the Reserve were made (i.e. *Eucalyptus goniantha, E. missilis, Banksia verticillata, B. gardneri, B. seminuda*). The Reserve occupies a transitional floristic region between the high-rainfall forests of the south-west and the semi-arid mallee and heathland belt of the southern sandplains. As a consequence it contains a number of species at the limits of the geographical distributions (e.g. *Banksia dryandroides, Eucalyptus megacarpa).* It also has populations of species endemic to the Albany region, such as *Banksia praemorsa*. Of particular interest was the location of the rare species *E. missilis* and *B. verticillata* on the Reserve. At the time of the survey, the small clumps of *E. missilis* represented only the fourth recorded population of this plant and this was the largest known. A fifth population found in 1987 in West Cape Howe National Park, just to the west of Albany, is bigger. Having established the location of such rare taxa within 500 m grids, the survey now provides management personnel with an aid for future planning of fire break construction, control burning, *Phytophthora* control or other activities that may involve the destruction of vegetation. It seems probable that mapping other components of the flora will similarly reveal the location of rare species and thus contribute to an informed management program for the Reserve.

Other benefits for management arising from the survey derive from the fact that maps of some of the dominant plants on the Reserve are now available in a systematically recorded form. These maps could be used as guides to the distribution of major vegetation formations and habitats on the Reserve. For example *Banksia littoralis* is an indicator of communities occupying seasonally waterlogged depressions, flats and swamps on deep peaty sands. *Banksia praemorsa* is an indicator of heath and scrub communities occupying soils where massive limestone is on or near the soil surface. *Eucalyptus staeri* characterises low woodlands on sandy hillslopes. A knowledge of the ecological characteristics of the species mapped may be used to predict the location of associated plants and animals. The maps may also be utilised for predicting fire behaviour, for planning recreational uses on the Reserve, and for other purposes requiring a knowledge of the distribution of plant communities and their dominant species.

Already, some of the data in the maps constitute historical records because of the death of banksias caused by the spread of dieback disease (ch. 19 this publication). Thus, the maps may provide a useful benchmark for documenting future changes in the distribution of plants on this important nature reserve.

ACKNOWLEDGEMENTS

We are grateful to T.J. Fetherstonhaugh, C.G. Hopper and W. Porter for assistance in the field; to P. Coleman for drawing the base grid map; to the W.A. Department of Land Administration for the provision of aerial photography; to the Curator, Western Australian Herbarium for permission to examine specimens under his care and to B. Dell, A.J.M. Hopkins, A. Kelly and G.T. Smith for helpful comments on the manuscript.

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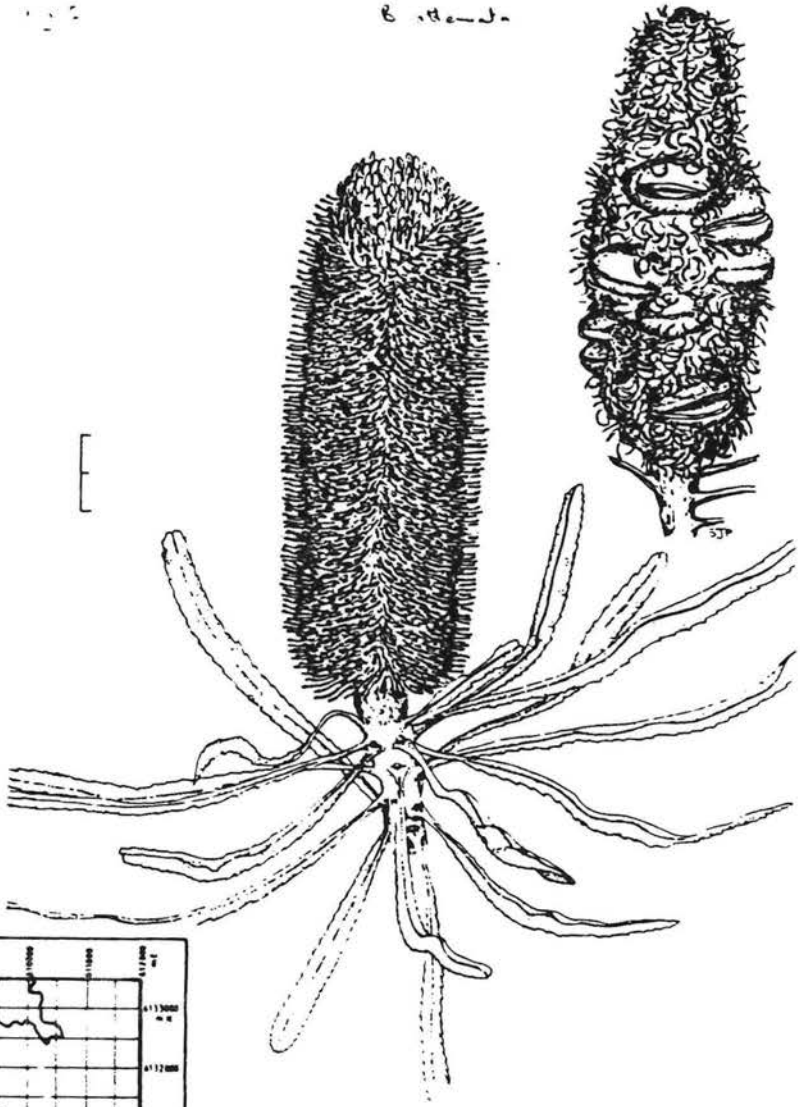
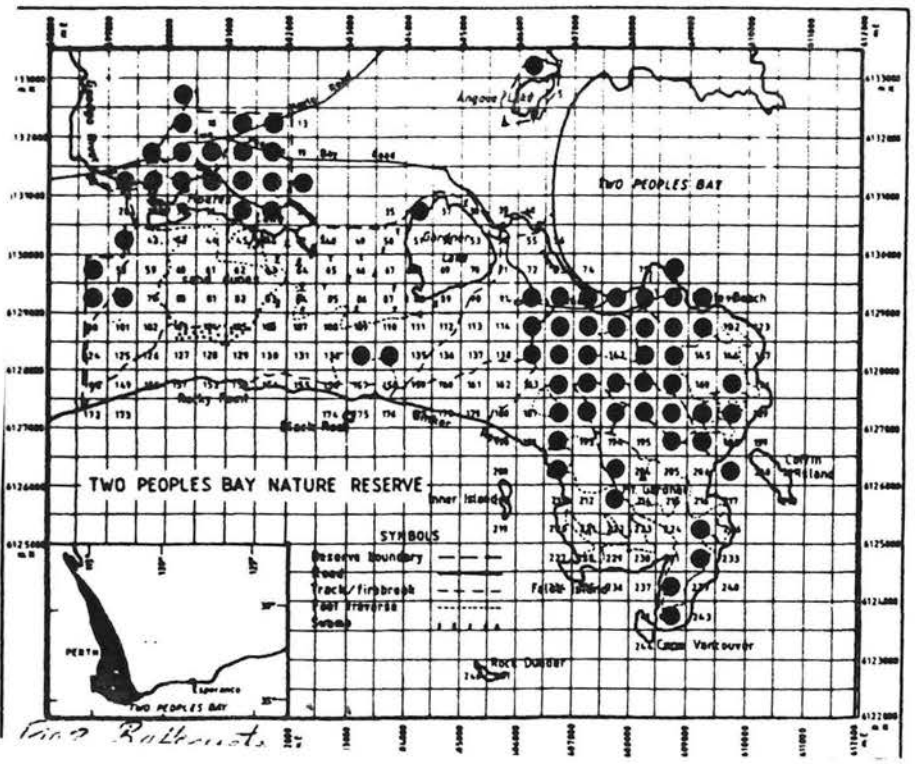
ANKSIA ATTENUATA R.Br.
andlestick Banksia

This species occurred in 71 (29%) grids. It was widespread on the Mt. Gardner Headland and its western slopes and, north and west of Moates Lake. It was absent in the intervening terrain across the centre of the reserve except for two small populations high on a ridge north of Black Rock, and a further two in narrow strips of hillslope vegetation bordered by cleared paddocks to the north of Gardner and Angove Lakes.

Headland populations of *B. attenuata* averaged 1.5 m in height and occurred predominantly as scattered emergents in dense low heathlands on sandy hillslopes and ridges of varying aspect. Common associated dominants included *B. grandis, E. marginata, B. coccinea, Agonis flexuosa, E. megacarpa* and *E. calophylla*.

Western populations were taller (3.0 m on average), and occurred as a dispersed understorey component principally in open low woodlands, low woodlands and low forests. Again, sands on gradual hillslopes were overwhelmingly the preferred soil type and landform. *B. coccinea, E. marginata, E. staeri, Allocasuarina fraseriana, B. grandis* and *B. ilicifolia* were the most common associated dominants in this part of the reserve.



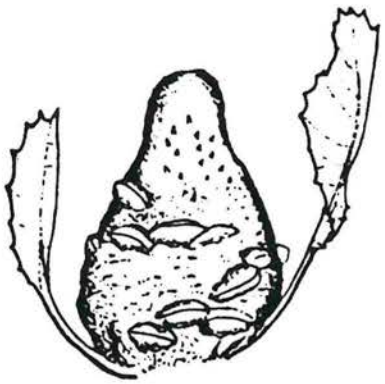


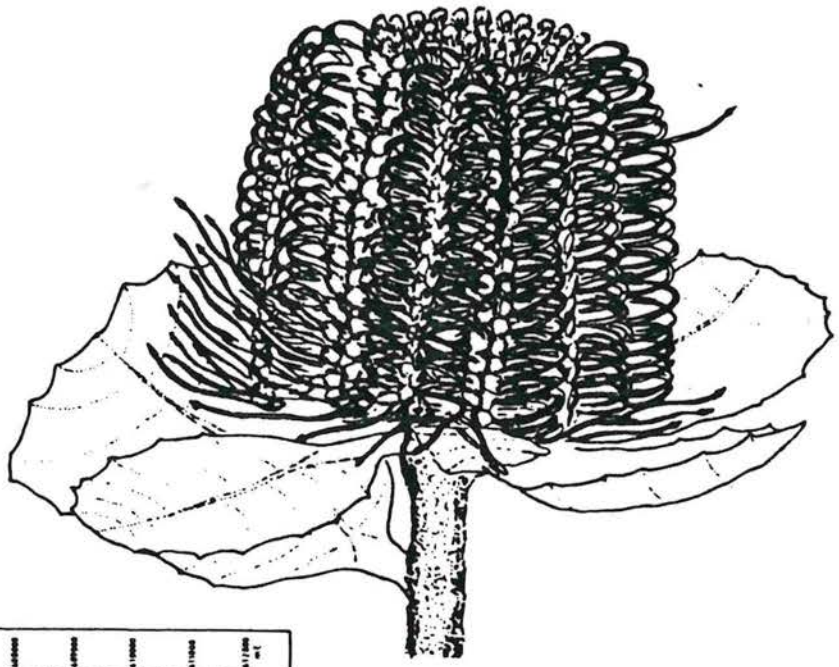
BANKSIA COCCINEA R.Br.
Scarlet Banksia

B. coccinea was found in 46 (19%) of the grids. Its distribution closely paralleled that of *B. attenuata* with two disjunct populations, one on the Mt Gardner Headland and the other north-west of Moates Lake. Two small isolated populations occurred on the northern margins of Gardner and Angove Lakes.

Populations of *B. coccinea* on the Mt. Gardner Headland were small in stature (2.0 m), but were prominent emergents in the dense low heaths on sandy slopes and hill tops, where they were most frequently observed. Associated dominants or emergents included *B. grandis*, *B. attenuata* and *E. marginata*.

Stands to the north and west of Moates Lake were taller (3.5 m), often forming dense clumps in the most preferred habitat of open low woodlands on sandy gradual slopes. Here, *B. coccinea* was recorded with dominants including *E. staeri*, *E. marginata*, *B. attenuata*, *Allocasuarina fraseriana*, *B. grandis* and *B. ilicifolia*.





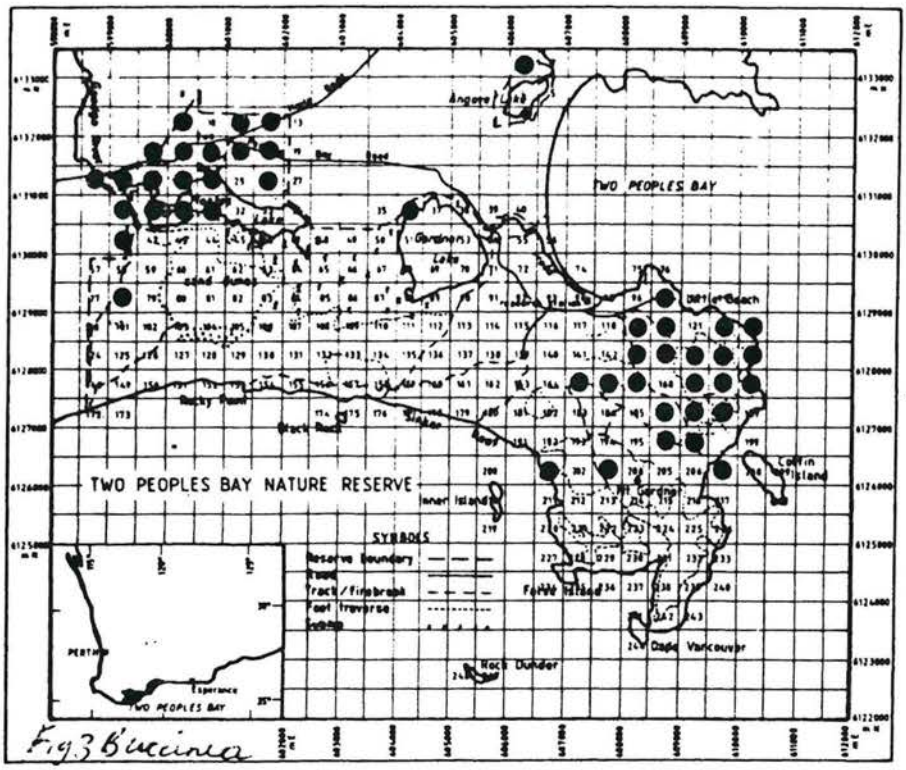
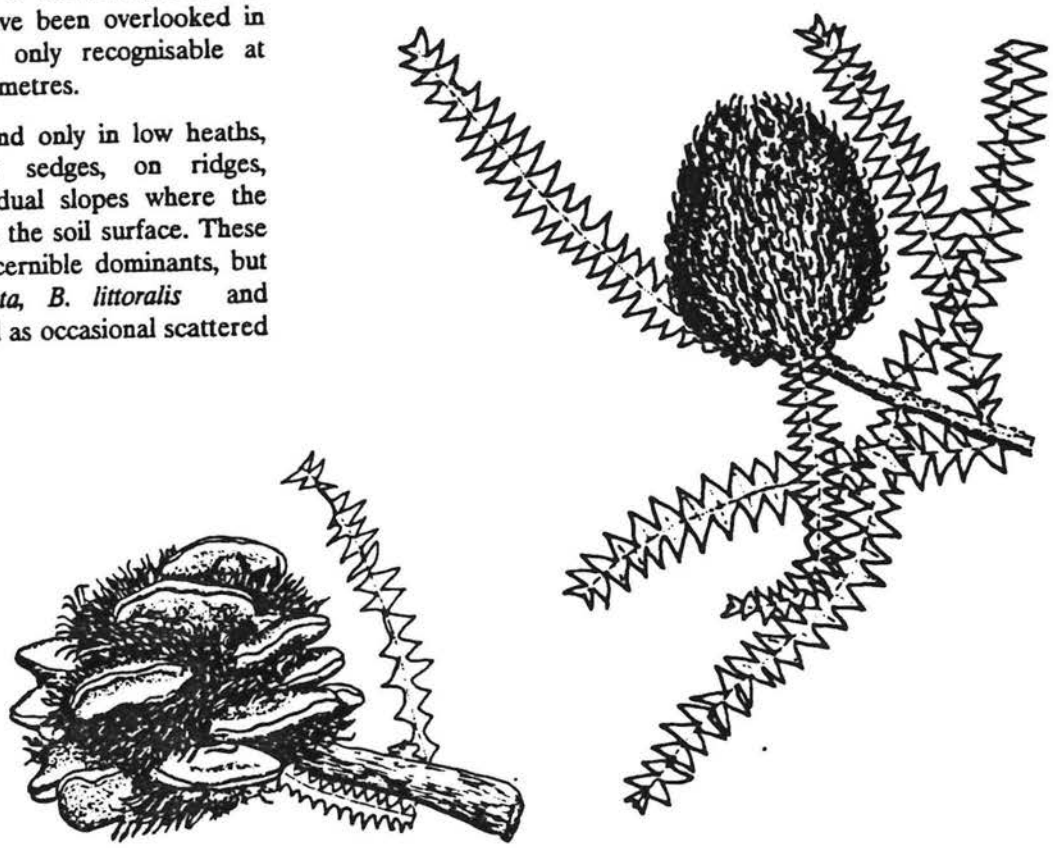


Fig 3 B. coccinea

ANKSIA DRYANDROIDES Baxter ex
weet
)ryandra-leaved Banksia

This compact shrub was confined to the Mt. Gardner Headland. It was recorded in 16 (7%) grids, but may have been overlooked in others because it was only recognisable at distances of less than 10 metres.

B. dryandroides was found only in low heaths, often with prominant sedges, on ridges, winter-wet flats or gradual slopes where the water table was close to the soil surface. These low heaths had few discernible dominants, but *B. grandis, B. attenuata, B. littoralis* and *E. calophylla* were noted as occasional scattered emergents.



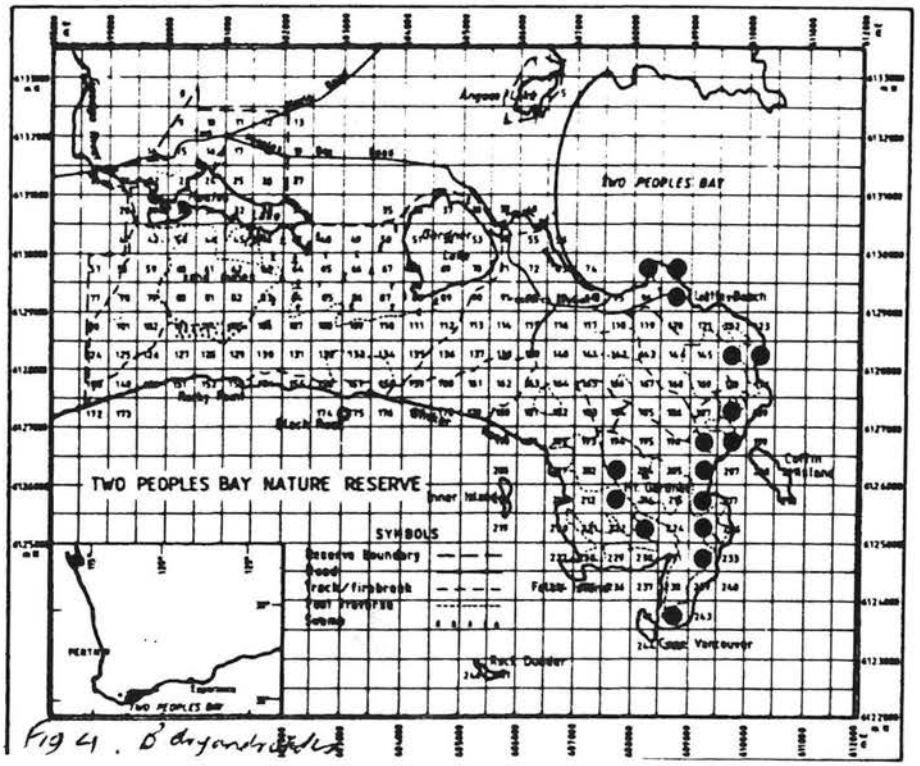
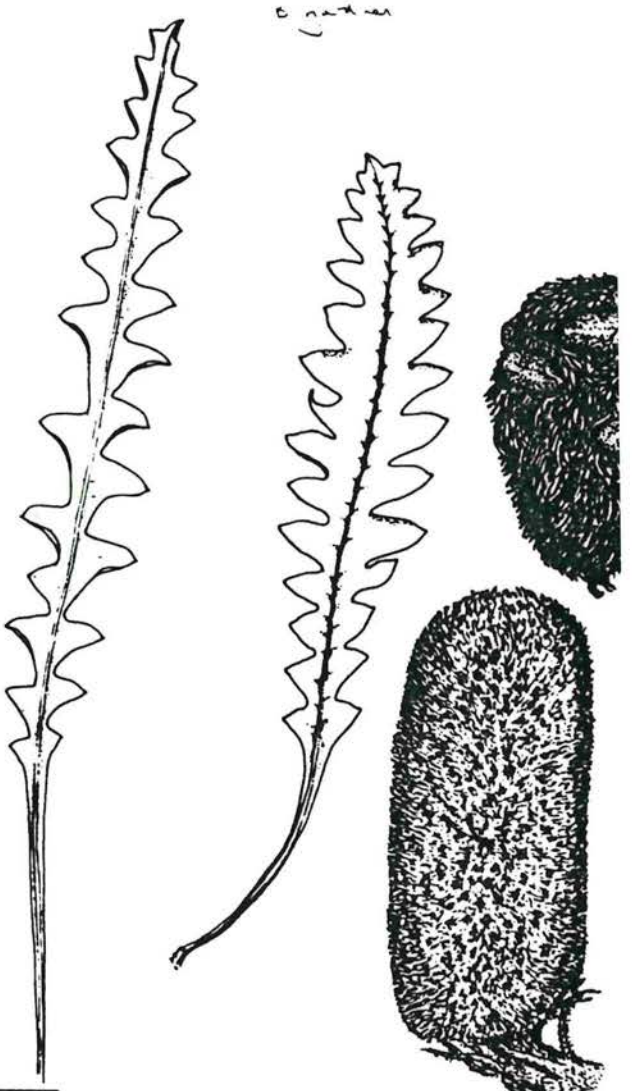
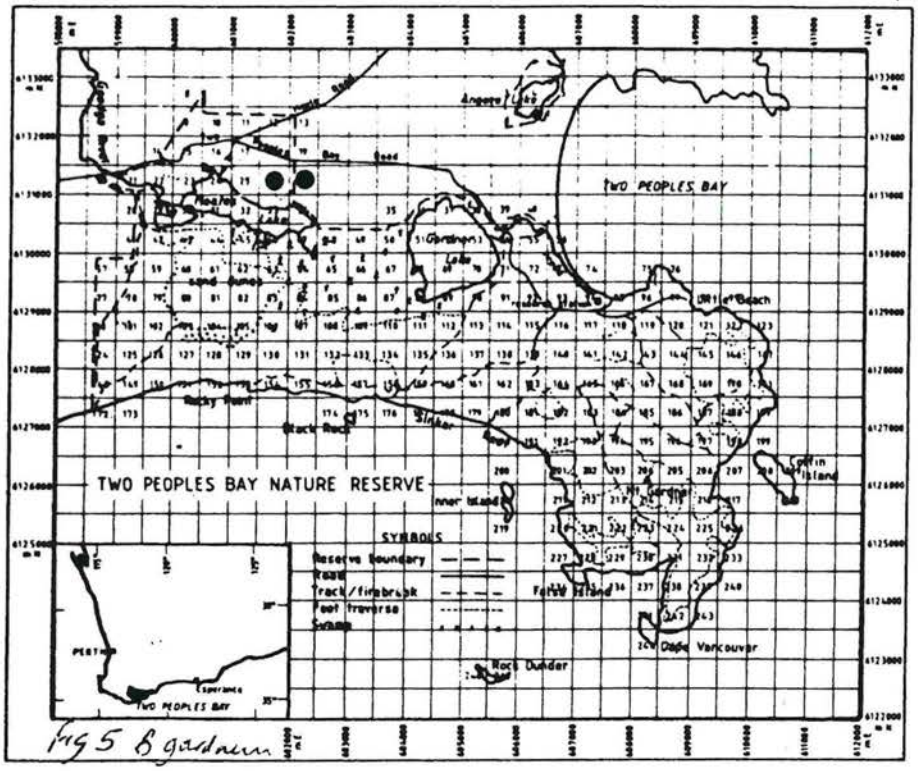


Fig 4. B dryandroides

BANKSIA GARDNERI A.S. George var. **GARDNERI**
Prostrate Banksia
(Fig. 12.7)

This low-growing species escaped detection during the main survey. It was found in the spring of 1981 growing in two grids on the sandy slopes to the north of Moates Lake. The vegetation was a low woodland over dense low heath and open low sedges dominated by *Eucalyptus staeri* and *Allocasuarina fraseriana*. Common understorey species included *Dasypogon bromeliifolius, Adenanthos cuneata, Beaufortia anisandra, Melaleuca thymoides* and *Leucopogon distans*.

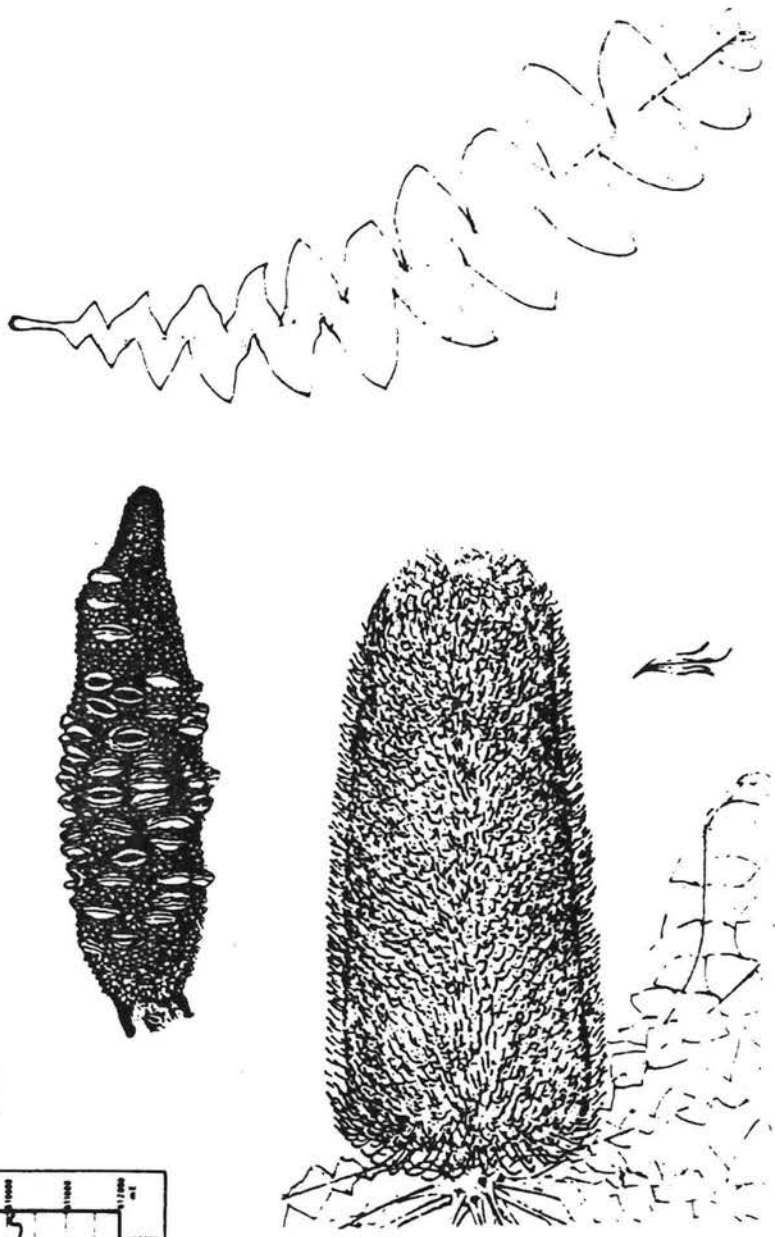




BANKSIA GRANDIS Willd.
Bull Banksia
(Fig. 12.8)

B. grandis was a third species found at the eastern and western ends of the Reserve. It occupied 59 (24 per cent) grids. Only four of these were in the central region, all on the north boundary near Lake Gardner.

As in *B. attenuata* and *B. coccinea*, the Mt Gardner headland populations of *B. grandis* were stunted, averaging 1.4 m estimated maximum height. Dense heaths, dense low heaths or dense low sedgelands were favoured on sandy gradual slopes and ridges. Co-dominant emergents from the heaths were *B. attenuata, B. coccinea, Eucalyptus marginata* and *E. megacarpa*. The taller (3.5 m) north-western populations differed from those of *B. attenuata* and *B. coccinea* in occurring mostly as an understorey component in low forests rather than in open low woodlands. Here, *B. grandis* occurred on either sand gravel duplexes, hilltops or pure sand on gradual slopes. *E. marginata* and *E. calophylla* were its most common associated dominants in these low forests. Other less frequently recorded associates included, *Allocasuarina fraseriana, B. attenuata, B. coccinea* and *E. staeri*.



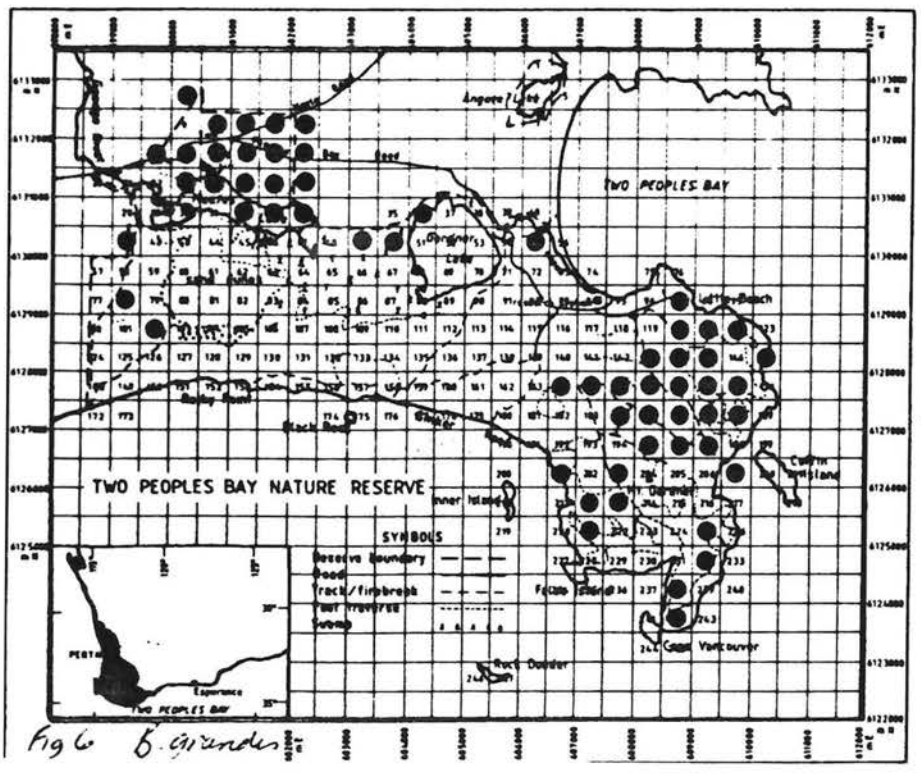
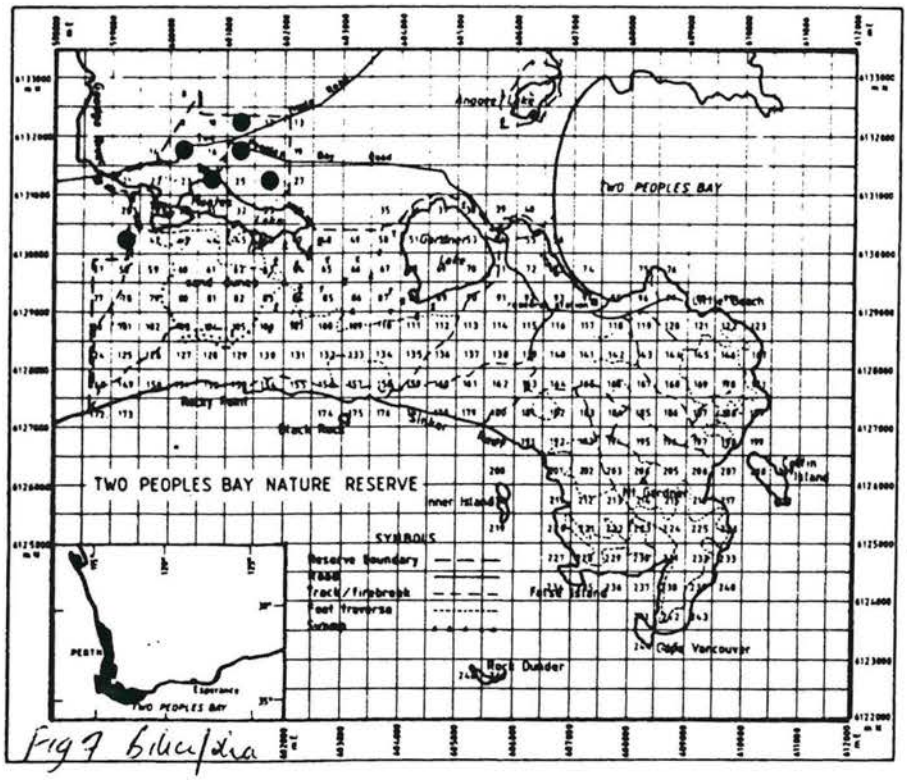


Fig 6 B. grandis

BANKSIA ILICIFOLIA R.Br.
Holly-leaved Banksia
(Fig. 12.9)

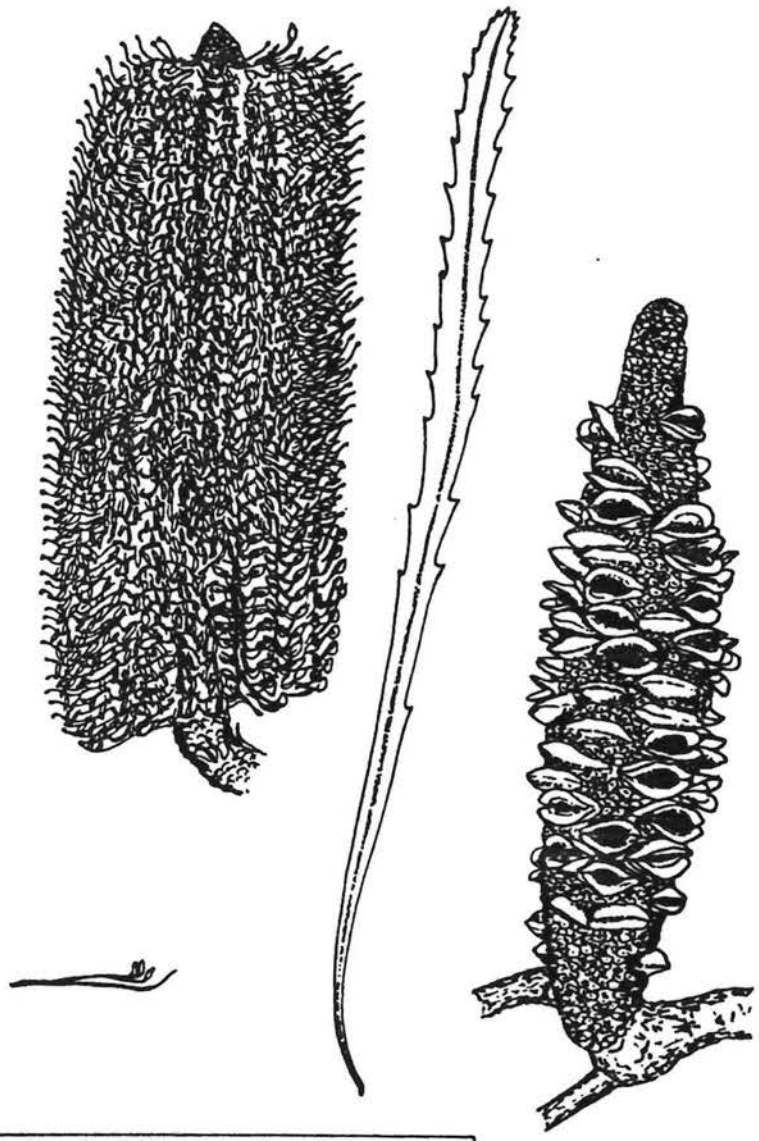
This tree was found in only five grids (2 per cent), all to the north and west of Moates Lake. There it occurred in open low woodlands or low forests on sandy gradual slopes. *Eucalyptus staeri, B. coccinea, B. attenuata, B. grandis, Allocasuarina fraseriana* and *E. marginata* were its recorded dominants or co-dominants.



NKSIA LITTORALIS R.Br.
ımp Banksia

The most frequently recorded *Banksia*, this small tree of wetland habitats was located in 81 (32%) of the grids. It ranged from the western boundary across the central mainland region through to South Point on the Mt Gardner Headland. A small outlying population was located on a ridge north-east of Mt Gardner.

B. littoralis typically occurred in dense low forests or low woodlands in peaty sand on the margins of lakes or in winter-wet swamps and swales. *Agonis flexuosa* and *A. juniperina* were its most frequently recorded dominants. Occasional co-dominants included *Melaleuca cuticularis, Oxylobium lanceolatum, Eucalyptus megacarpa* and *Adenanthos sericea*.



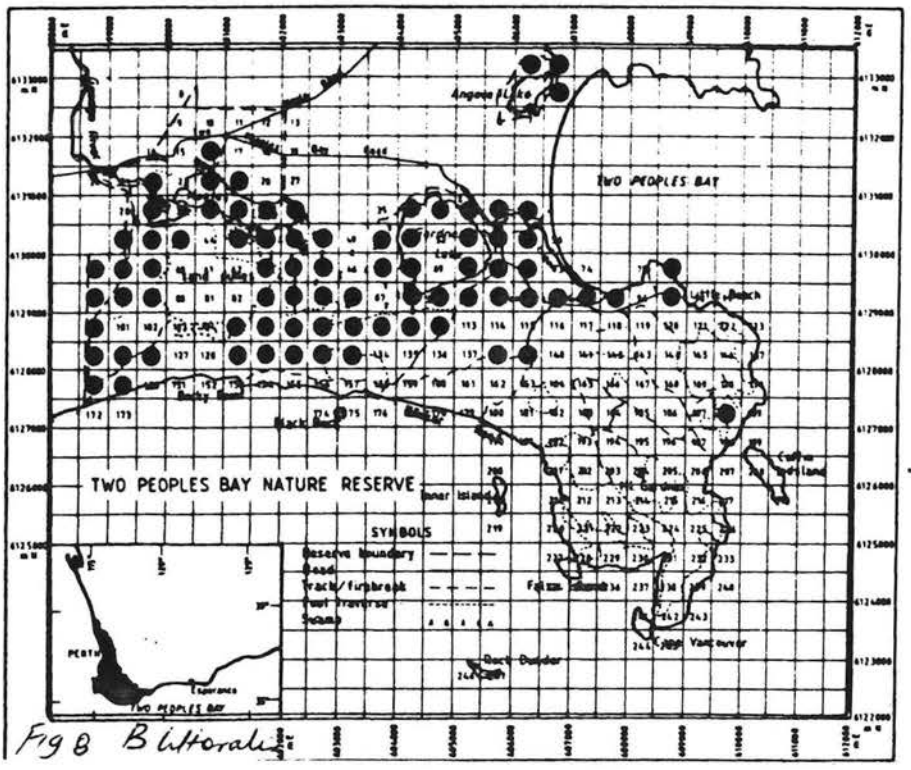
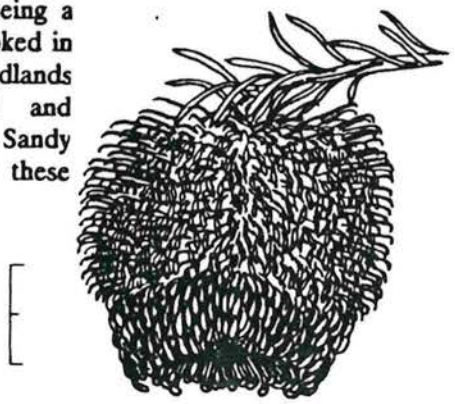


Fig 8 B littoralis

NKSIA NUTANS R.Br. var.
RNUELLA A.S. George
dding Banksia

B. nutans was recorded in eight grids (3%) to the west and north of Moates Lake. Being a compact shrub, it may have been overlooked in some adjoining grids. Open low woodlands dominated by *E. marginata, E. staeri* and *B. coccinea* were favoured by *B. nutans*. Sandy soils on gradual slopes supported these populations.



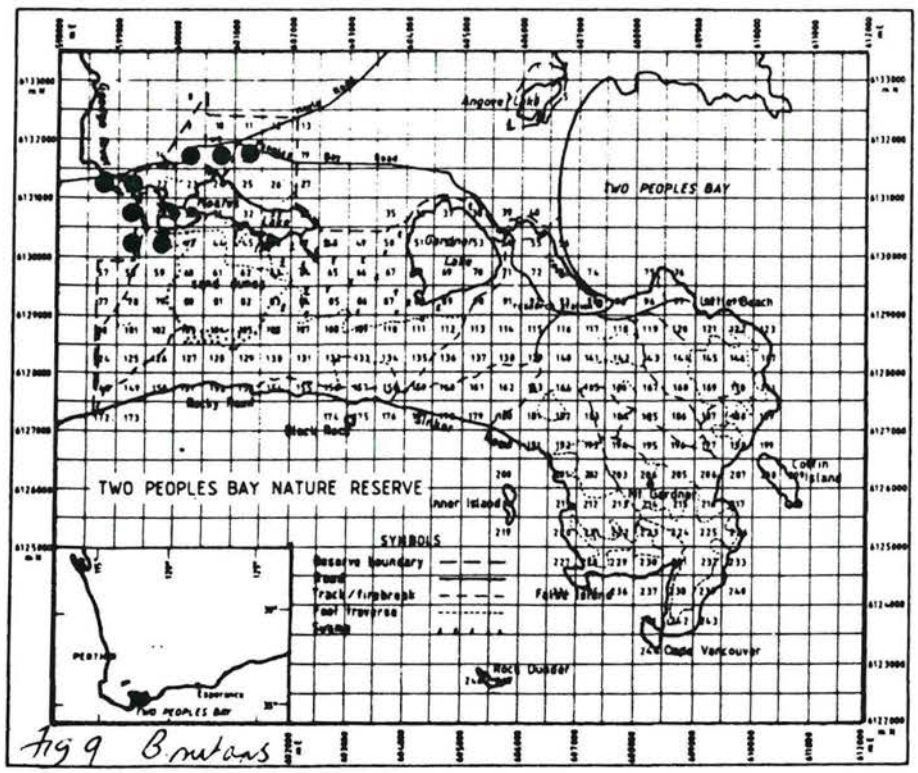
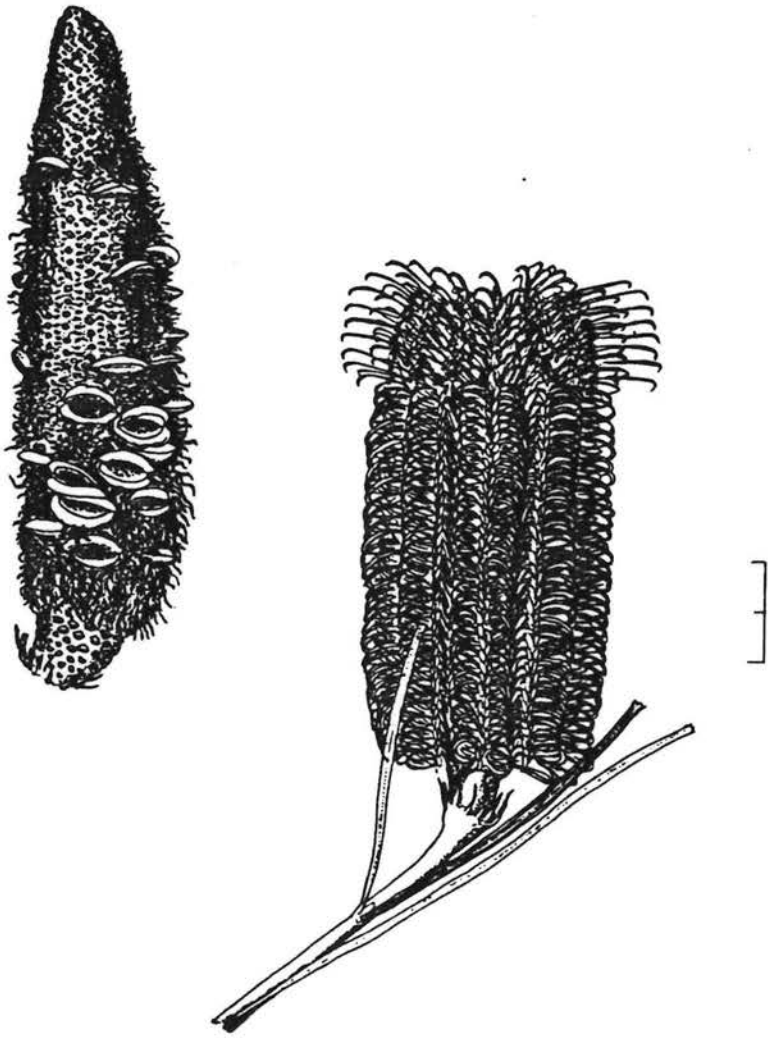


fig 9 B nutans

ANKSIA OCCIDENTALIS R.Br. subsp. CCIDENTALIS
ed Swamp Banksia



B. occidentalis was second only to *B. verticillata* in rarity on the reserve. A handful of plants were located in one grid (0.4%) near the western boundary. Here the species occurred in a low woodland co-dominated by *B. praemorsa*, *B. quercifolia*, *B. littoralis*, *B. seminuda*, *B. coccinea* and *Adenanthos sericea*. A sandy swale between subdued stabilized dunes supported this low woodland.

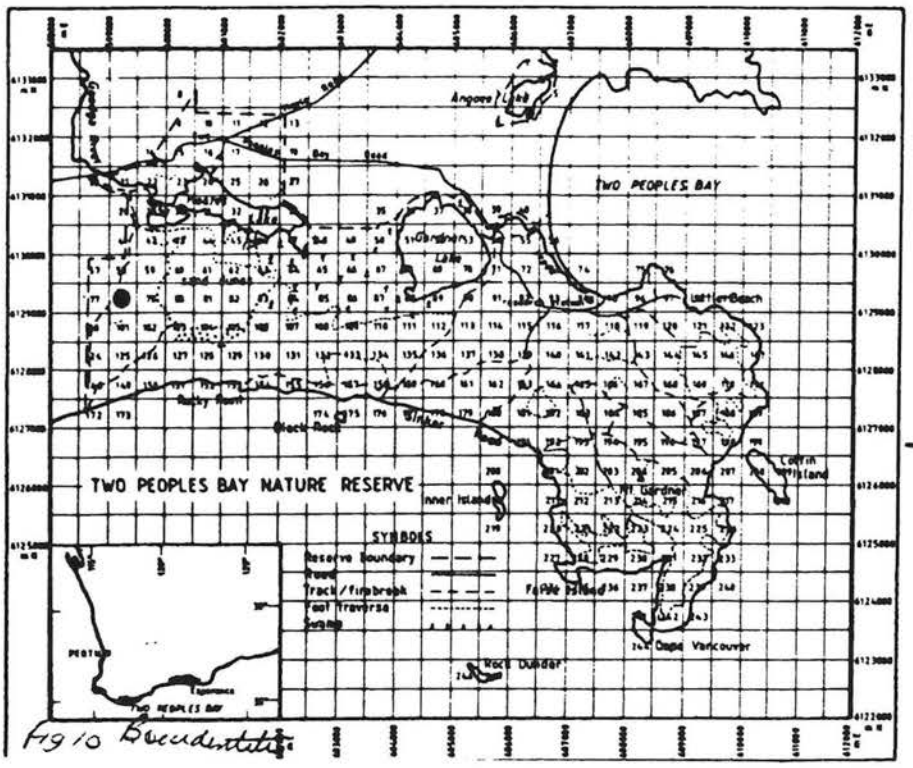
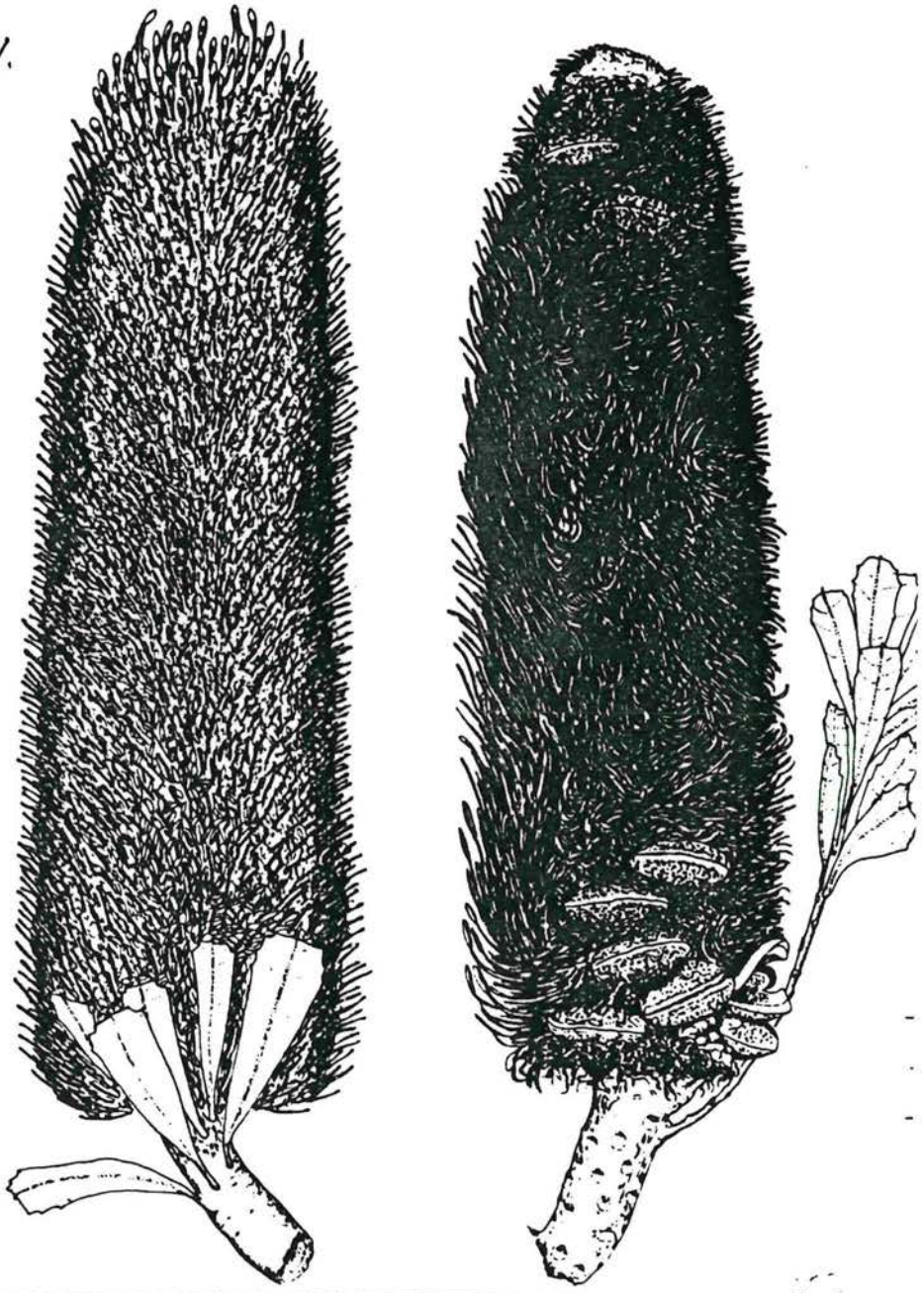
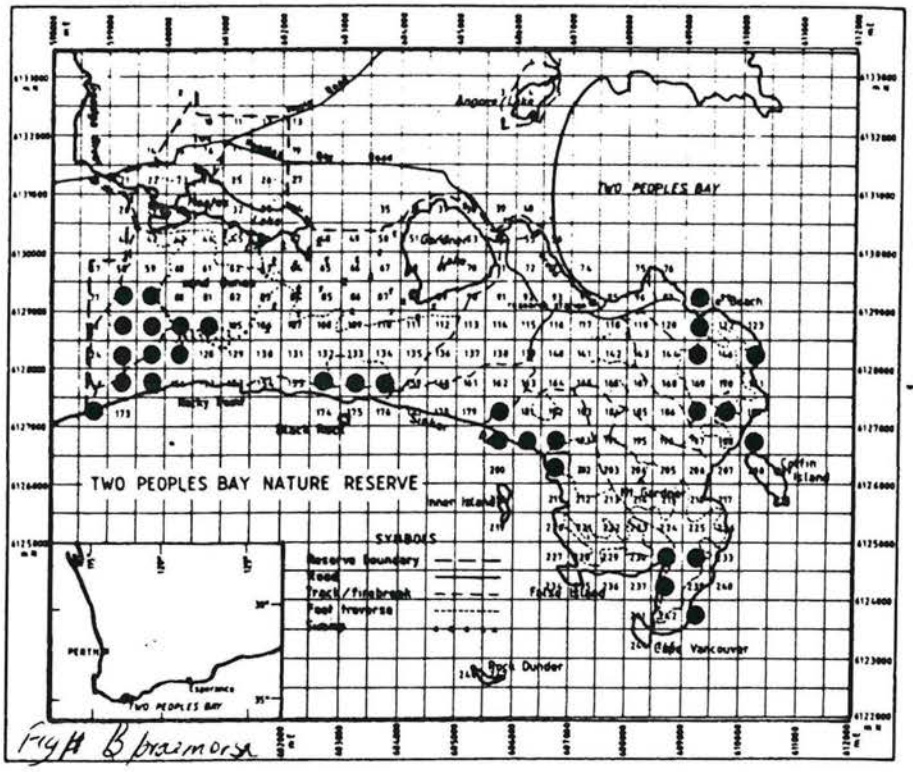


Fig 10 B occidentalis

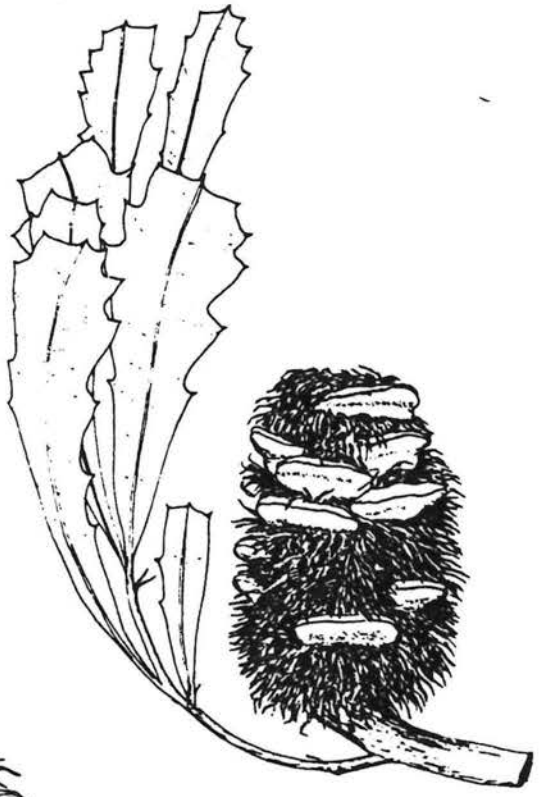
BANKSIA PRAEMORSA Andrews
Cut-leaf Banksia



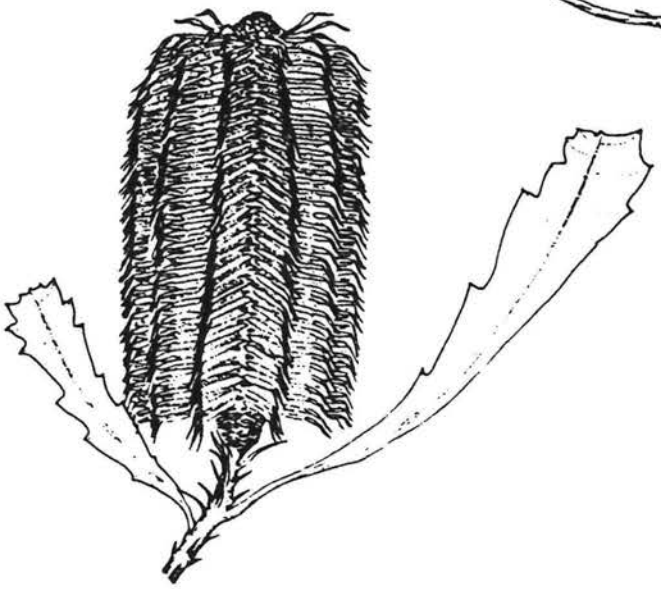
This sprawling shrub or small tree occurred in five disjunct areas along the coastline of the reserve, occupying 32 (13%) grids. Near the western boundary it penetrated up to 2 km inland as a coloniser of recently stabilized dunes. However, it usually was confined to coastal ridges and slopes where sands overlay limestone rock. Heathlands of varying density were found typically in these landforms. Frequently recorded co-dominants of *B. praemorsa* included *Dryandra sessilis*, *E. angulosa* and *Adenanthos sericea*.



NKSIA QUERCIFOLIA R.Br.
:-leaved Banksia



A series of disjunct stands of this shrub were located in six grids (2%), three down the western boundary, and three east of Lake Gardner. They were found in dense thickets, sometimes as an understorey in dense low forests or in open low woodlands. A diversity of landforms was occupied, including the margins of lakes, rivers, seasonally waterlogged flats and interdunal swales. *B. littoralis, Agonis juniperina, A. flexuosa* and *B. coccinea* were common associated dominants.



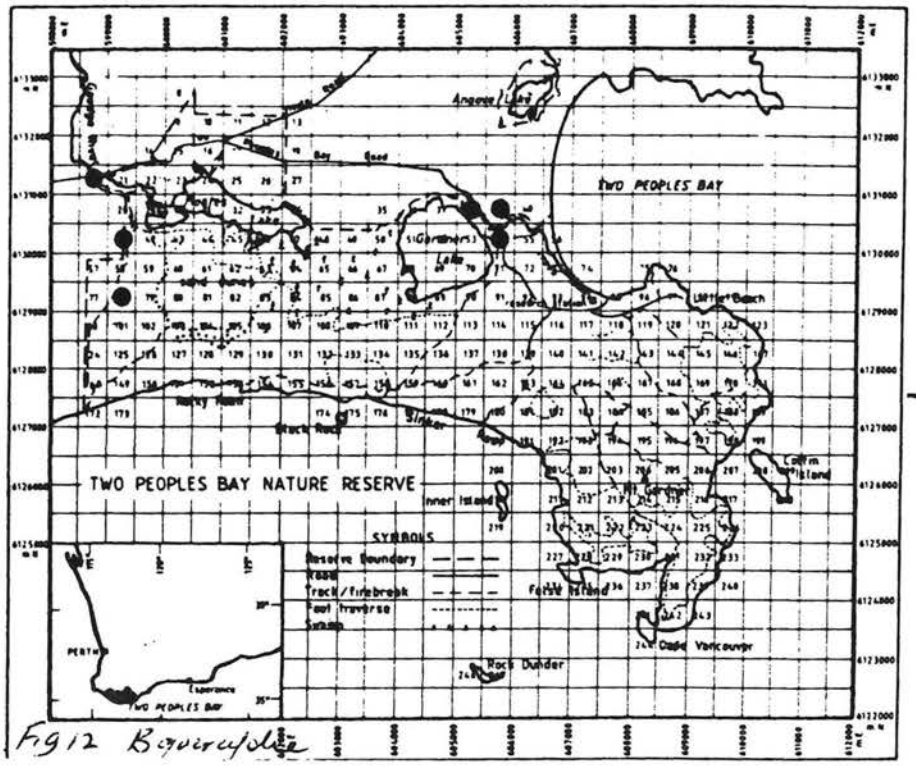
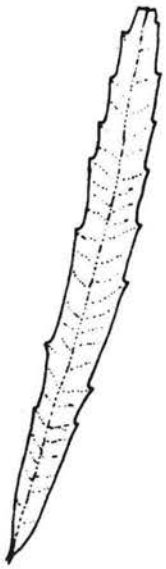


Fig 12 Bquercifolia

BANKSIA SEMINUDA (A.S. George)
B.L. Rye
River Banksia



This species occurred in only two grids (1%) on the western boundary of the reserve. It co-dominated low forests and low woodlands with *B. littoralis* and *Agonis flexuosa*, favouring sands on seasonally inundated flats and swales.

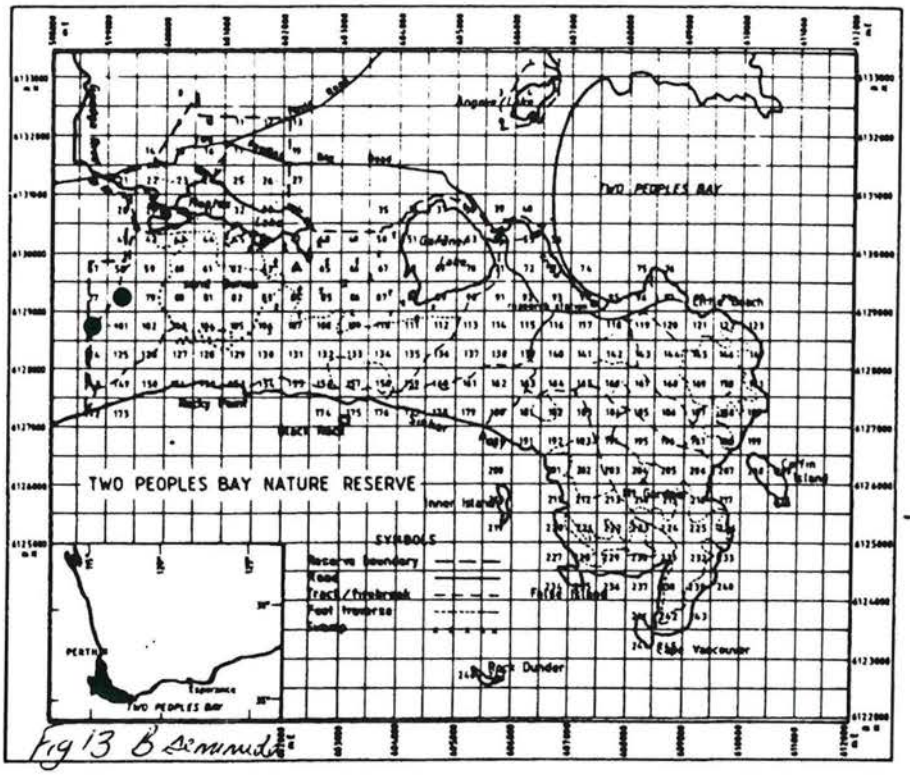
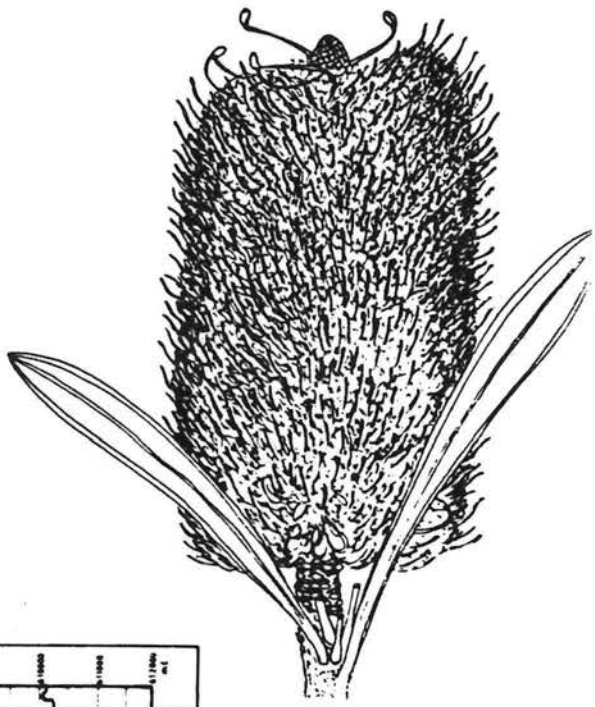


Fig 13 B. seminuda

ANKSIA VERTICILLATA R.Br.
Granite Banksia



This species was first located on the reserve only as isolated dead trunks with decaying fruits at their bases on the north-eastern slopes of Mt Gardner. Consequently, particular attention was paid to locating live specimens of *B. verticillata* during foot traverses across the rugged terrain of the peninsula. Two specimens were eventually located. The first was a small tree 2.5 m tall at the edge of a small exposure of granite at the base of a steep sided gully (Rocky Gully) some 200 m inland from the sea. Associated plants in the dense heath of this site included *E. megacarpa* and *Agonis marginata*. The second individual occurred higher up on a ridge. It was sterile and only 1 m tall, presumably because it grew in a very narrow cleft on a massive sheet of outcropping granite.

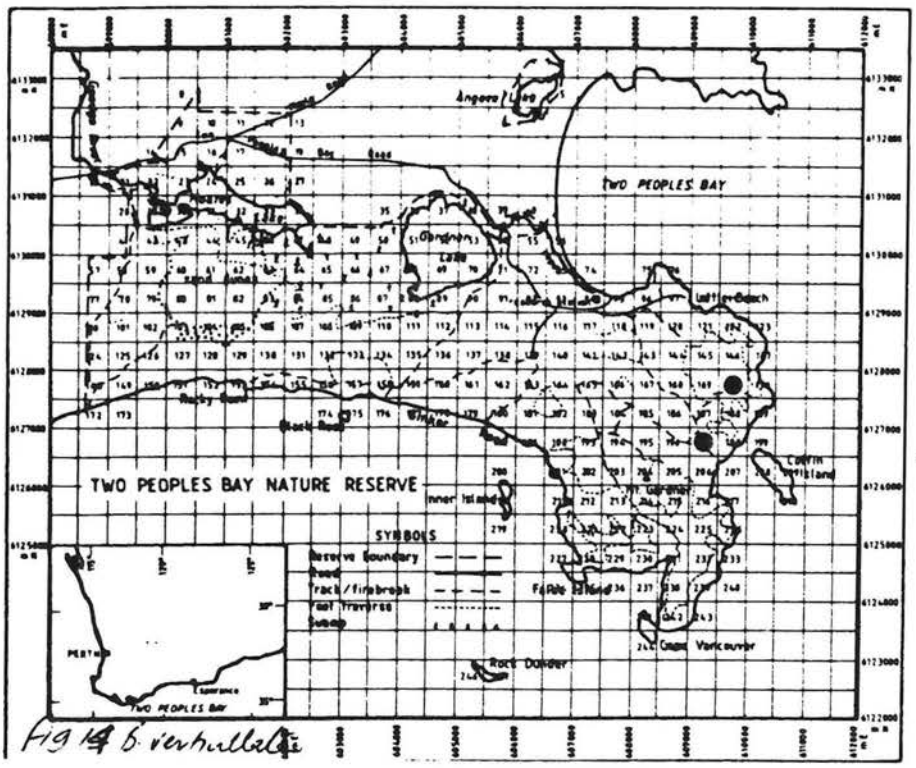
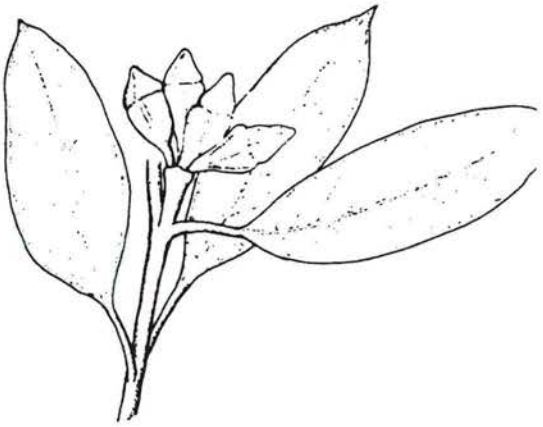
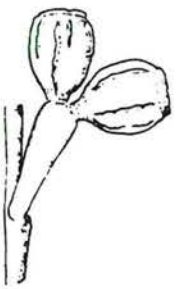


Fig 14 B. verticillata

:UCALYPTUS ANGULOSA Schauer
:idge-fruited Mallee

E. angulosa occurred in disjunct populations on the eastern and southern coastlines of Mt Gardner Headland in 28 (11%) grids. It also extended a short distance westwards towards Sinker Reef along the south side of the Isthmus, with an outlier south of Gardner Lake. Usually it was a scattered emergent from dense low heaths, but occassionally it clumped to form dense shrub mallee vegetation. Sands over limestone or at the edge of granite rock were favoured in varied landscape positions including ridges, gradual slopes and swales. It was associated frequently with *E. conferruminata, B. praemorsa, Agonis flexuosa, B. attenuata* and *Dryandra sessilis*.





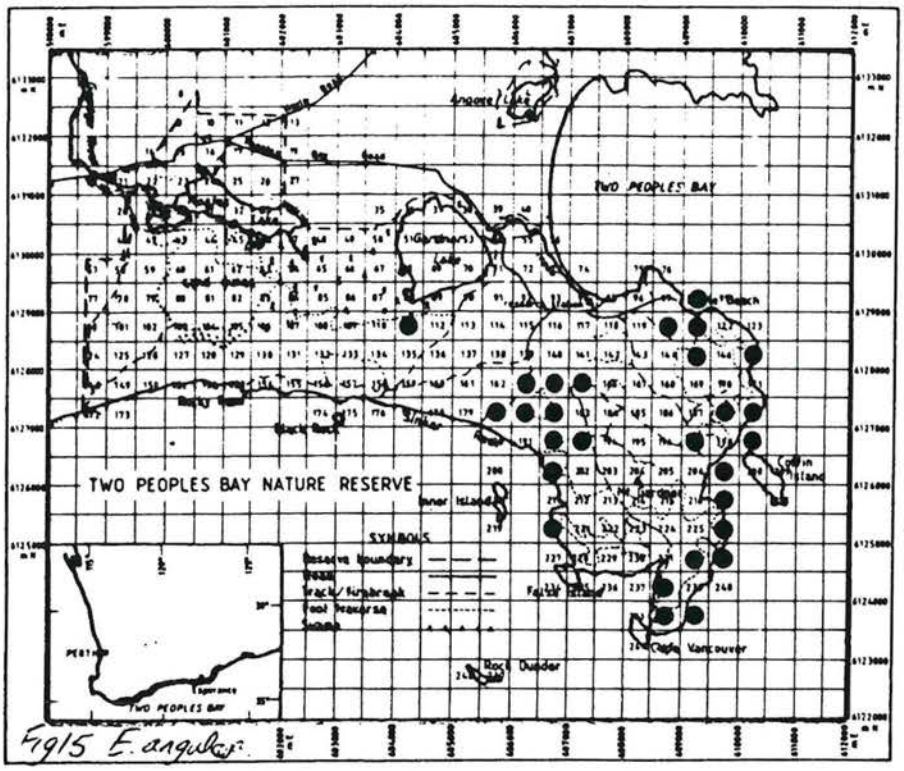


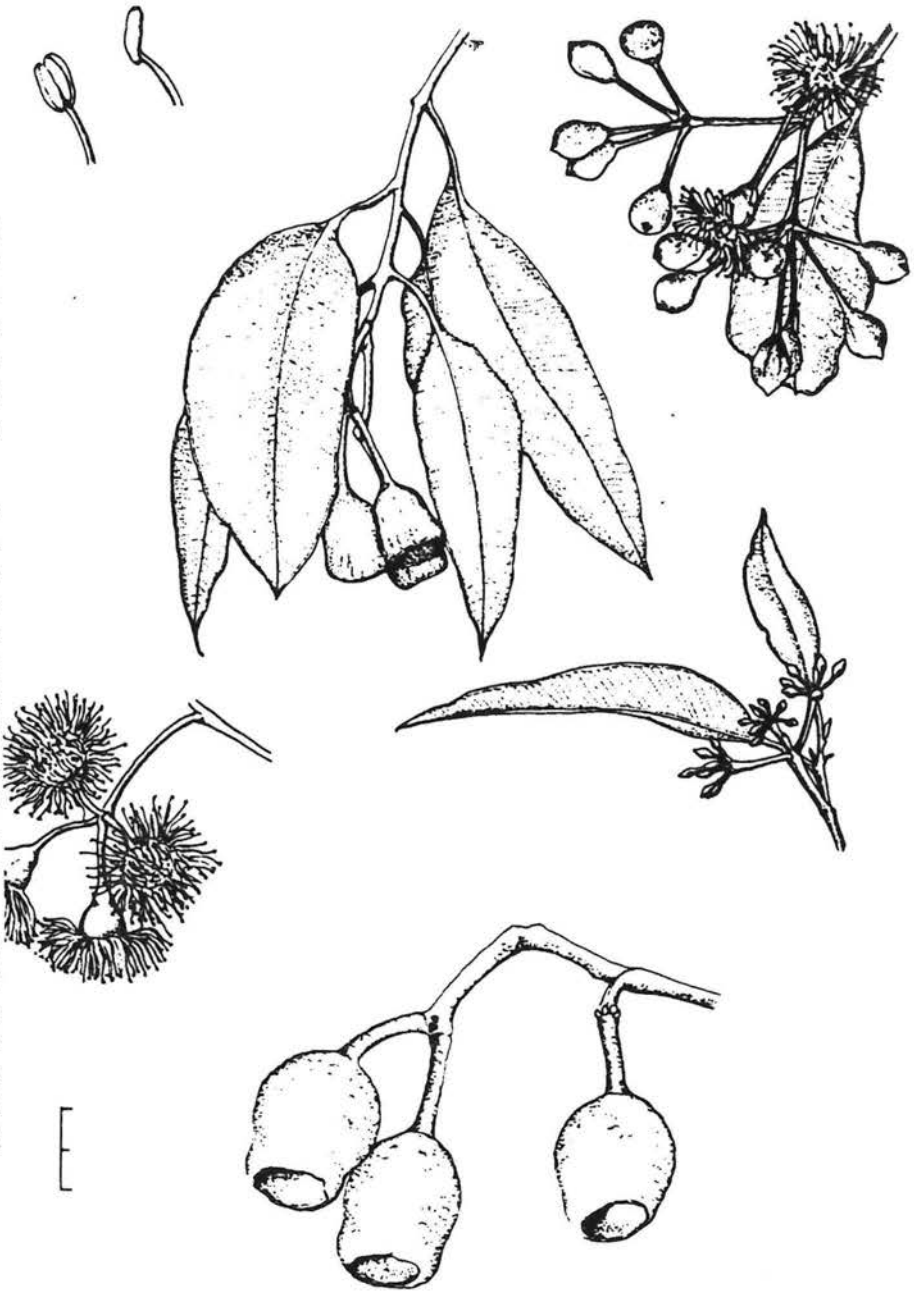
Fig 15 E. angulosa

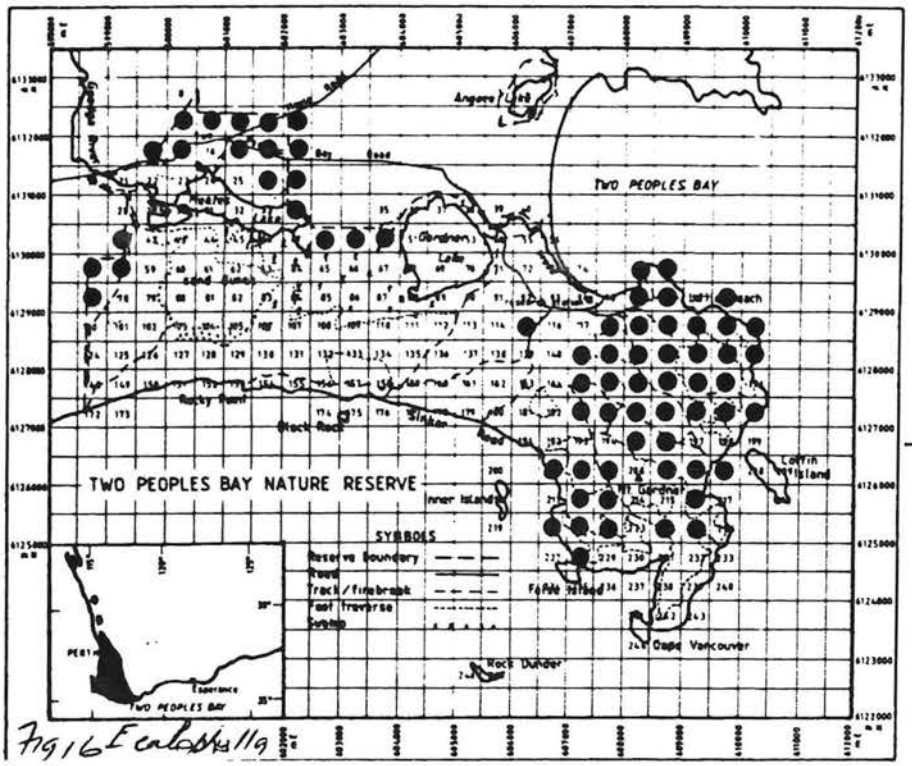
:UCALYPTUS CALOPHYLLA Lindley
Aarri

The distribution of *E. calophylla* parallelled those of *E. marginata, B. attenuata, B. coccinea* and *B. grandis*, with abundant populations on the Mt Gardner Headland and north and west of Moates Lake, but no major occurrences in the central mainland and southern coastal regions of the reserve. The species was recorded in 69 (28%) grids.

A dwarfing effect was evident in the Mt Gardner populations (3.1 m average height), but the species was nonetheless visible as an emergent in dense heaths or thickets. It also dominated dense low forests in certain favourable sites, particularly at the well-watered edges of massive granite where it was most frequently located. Sand, slopes and ridges of varying steepness were also occupied. The associated co-dominants of *E. calophylla* here included *E. marginata, E. megacarpa, E. conferruminata, E. cornuta, B. attenuata* and *B. grandis*.

The north-western populations were taller (10.7 m average). They co-dominated low forests and open low woodlands with *E. marginata* and had *B. grandis, Allocasuarina fraseriana* and *B. attenuata* prominent in the understorey. Sand mixed with lateritic gravel was the favoured soil, usually on the tops and upper slopes of undulating hills.

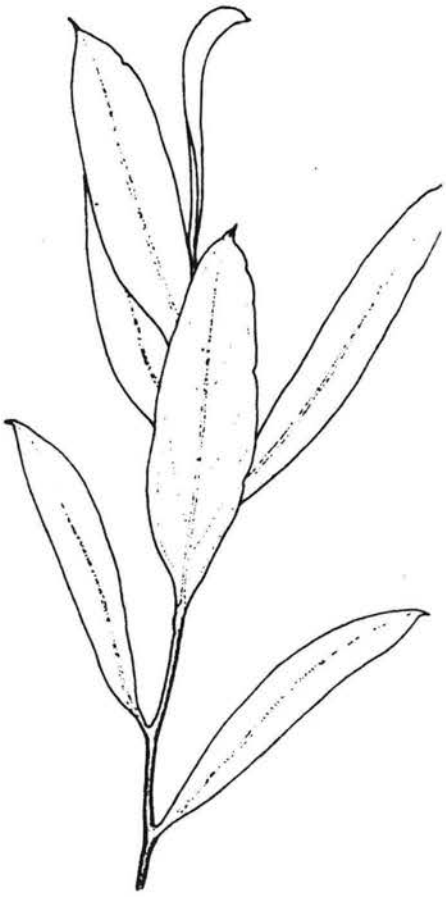




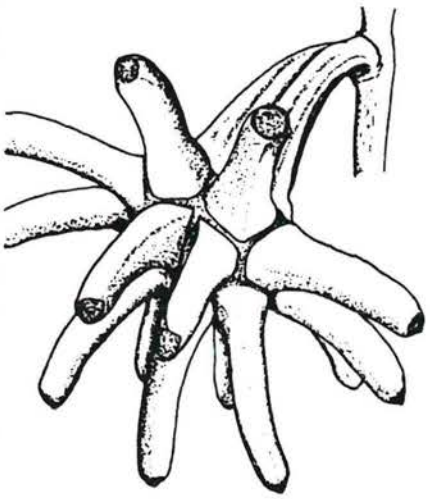
:UCALYPTUS CONFERRUMINATA

)J. Carr & S.G.M. Carr

3ald Island Marlock

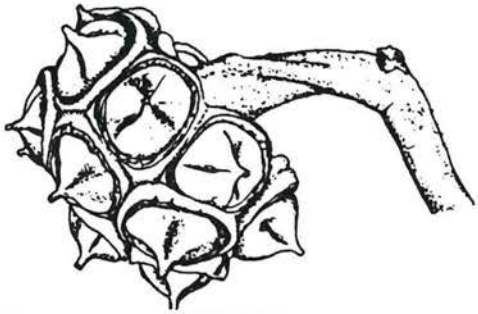


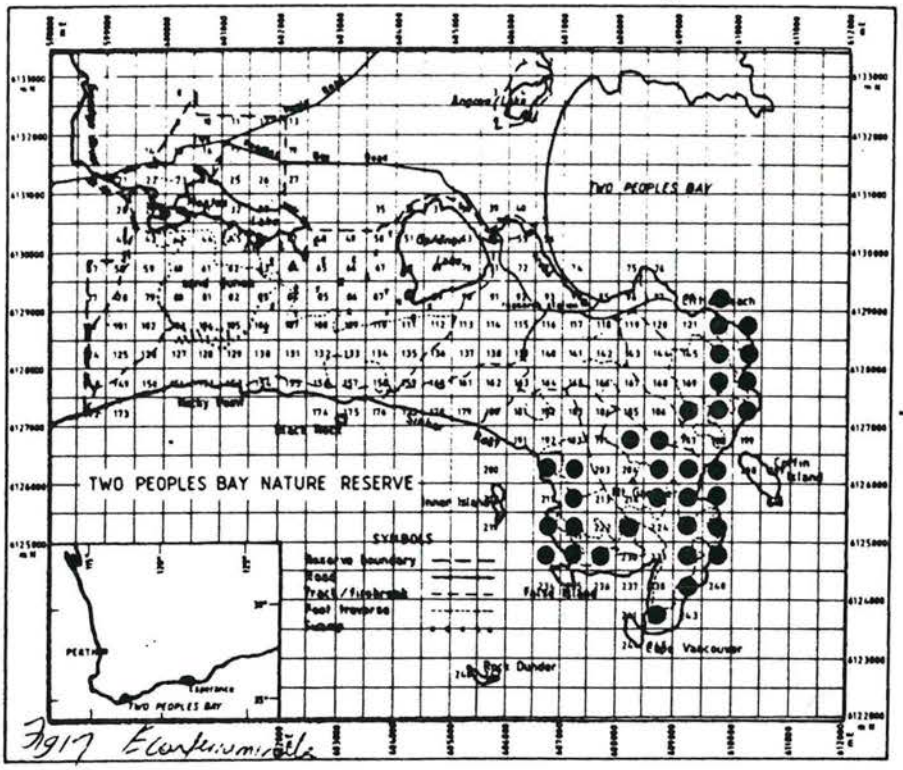
E. conferruminata was recently described by Carr and Carr (1980). Previously, it was known and referred to as a robust form of *E. lehmanii* (e.g., Chippendale 1973).



Thirty three grids in the eastern and southern sectors of the Mt Gardner Headland were occupied by this species. It occurred in dense shrub mallee, dense heath or dense low forest predominantly at the edges of massive granite on coastal slopes. *E. megacarpa, E. calophylla* and *E. angulosa* were frequent associates.

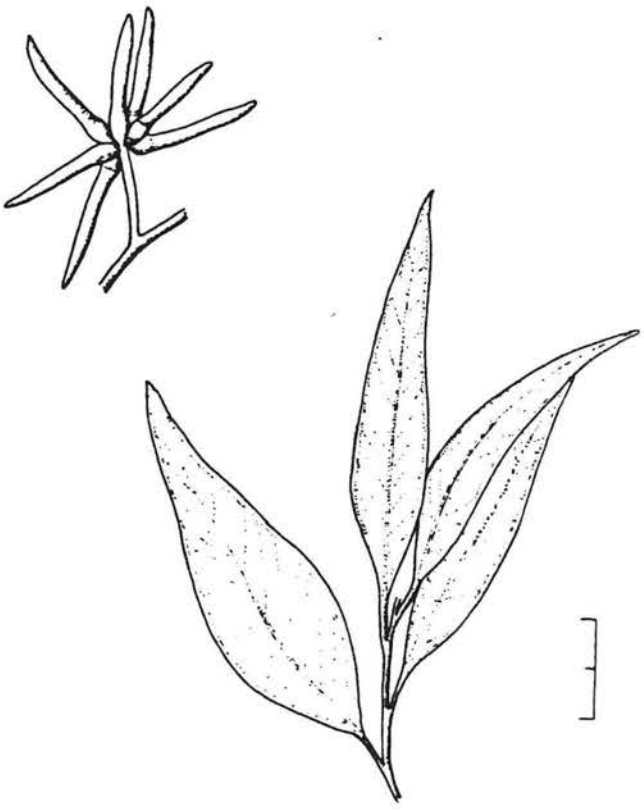
Apparent hybrids between *E. conferruminata* and *E. comuta* were observed at several locations on Mt Gardner.

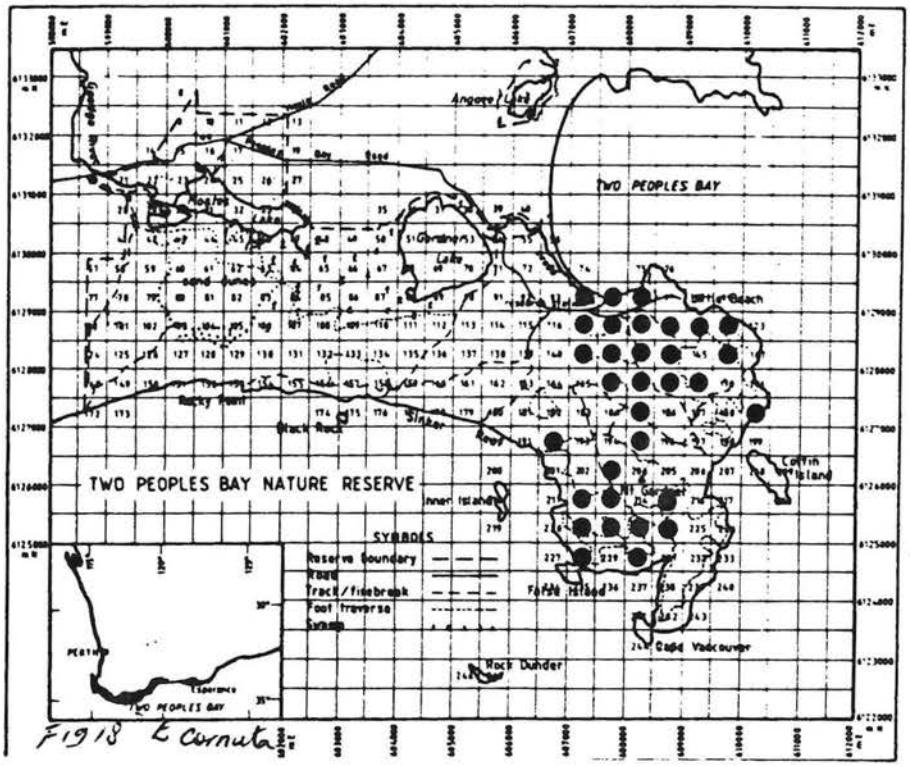




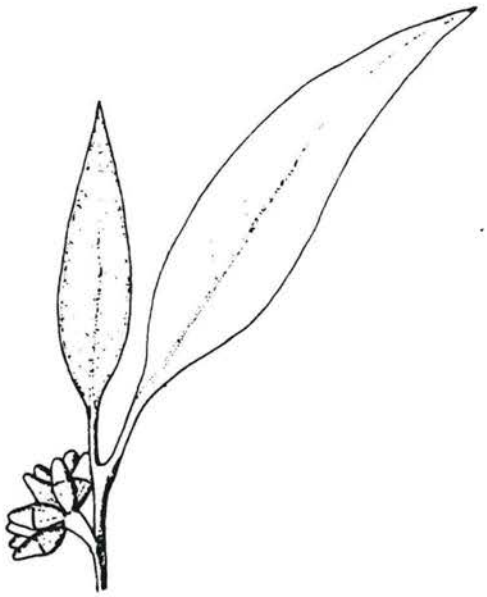
CALYPTUS CORNUTA Labill.
te

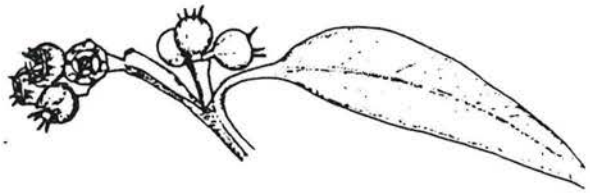
This species was found in 32 grids (13%), all on the Mt Gardner Headland. It usually formed dense low forests or dense thickets at the edge of massive granite outcrops, but also occurred as a scattered tree in open low woodlands on the sandy lower slopes to the north of Mt Gardner. Ocassionally, as around the research station and picnic ground on Two Peoples Bay, it occurred in low forests as a codominant with *E. megacarpa*. Other associates included *E. calophylla, Agonis flexuosa, E. marginata, B. attenuata* and *Melaleuca* sp. 1.



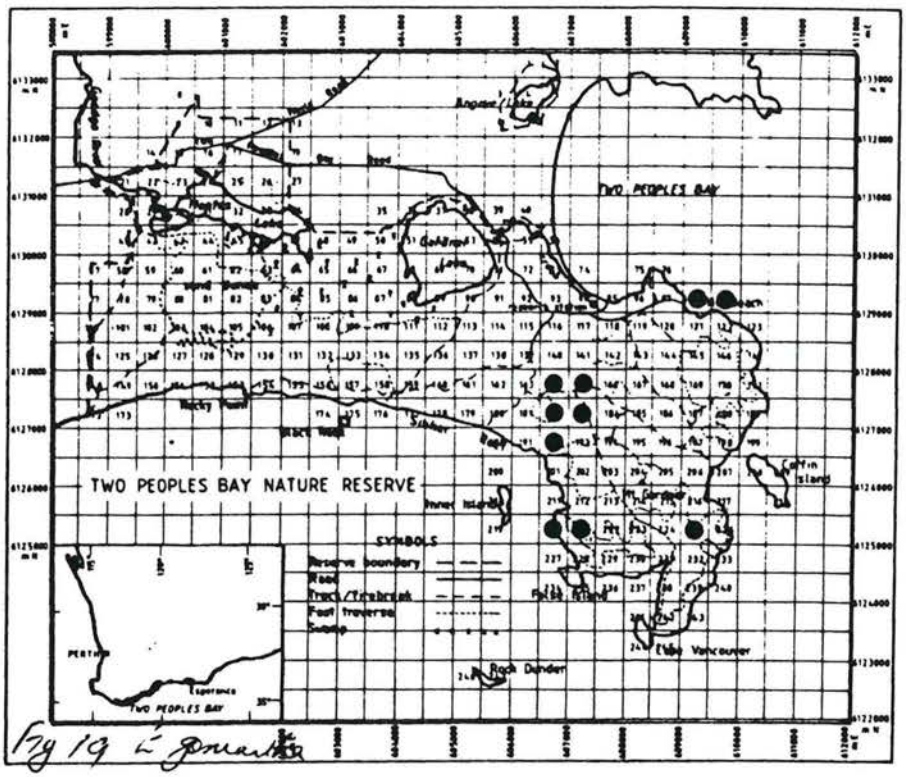


EUCALYPTUS GONIANTHA Turcz.





Although the identify of this taxon was not clear at the time of the survey, it is now recognised as an unnamed coastal subspecies of *E. goniantha* that ranges from Two Peoples Bay east to Esperance. It resembles *E. falcata* but lacks peduncles on the buds and fruits and has larger coarser leaves. It occurred in 10 grids (4%) scattered in four disjunct areas on the Mt Gardner Headland. It often grew clumped to form dense low forests or stands of shrub mallee with *E. angulosa, E. megacarpa* and *E. calophylla*. Occasionally, it was a scattered emergent from dense heath growing with *Agonis fluxuosa* and *B. attenuata*. Sand or sand over limestone on slopes or in swales were favoured by it.



CALYPTUS MARGINATA Donn ex
ith
rah

E. *marginata* was the most widespread eucalypt recorded (85 grids, 34%). It was widespread on he Mt. Gardner headland and north and west of Moates Lake. The intervening areas were devoid of *E. marginata*, but narrow extensions down the western and northern boundaries occurred from the main north-western stands, and a few plants occupied the north-western margin of Angove Lake.

The peninsula populations generally were stunted (1.9 m average height). The species most frequently occurred as scattered emergents from dense low heaths or thickets on sandy slopes or at the edges of sheet granite. Common associates were *E. calophylla*, *B. attenuata*, *B. grandis*, *E. megacarpa*, *B. coccinea*, *Hakea elliptica* and *Agonis flexuosa*.

The taller north-western populations (7.2 m average height) were co-dominant in low forests or open low woodlands with *E. calophylla*, *B. grandis*, *Allocasuarina fraseriana*, *B. attenuata*, *B. coccinea* and *E. staeri*. Sands or sands mixed with lateritic gravel on gradual slopes usually supported *E. marginata*.

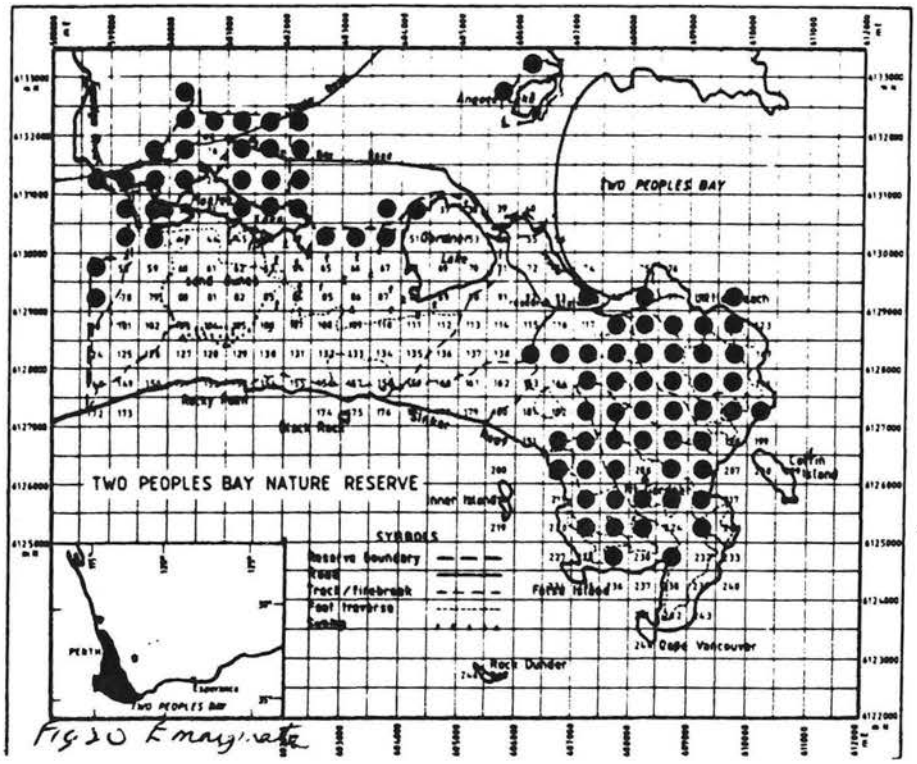
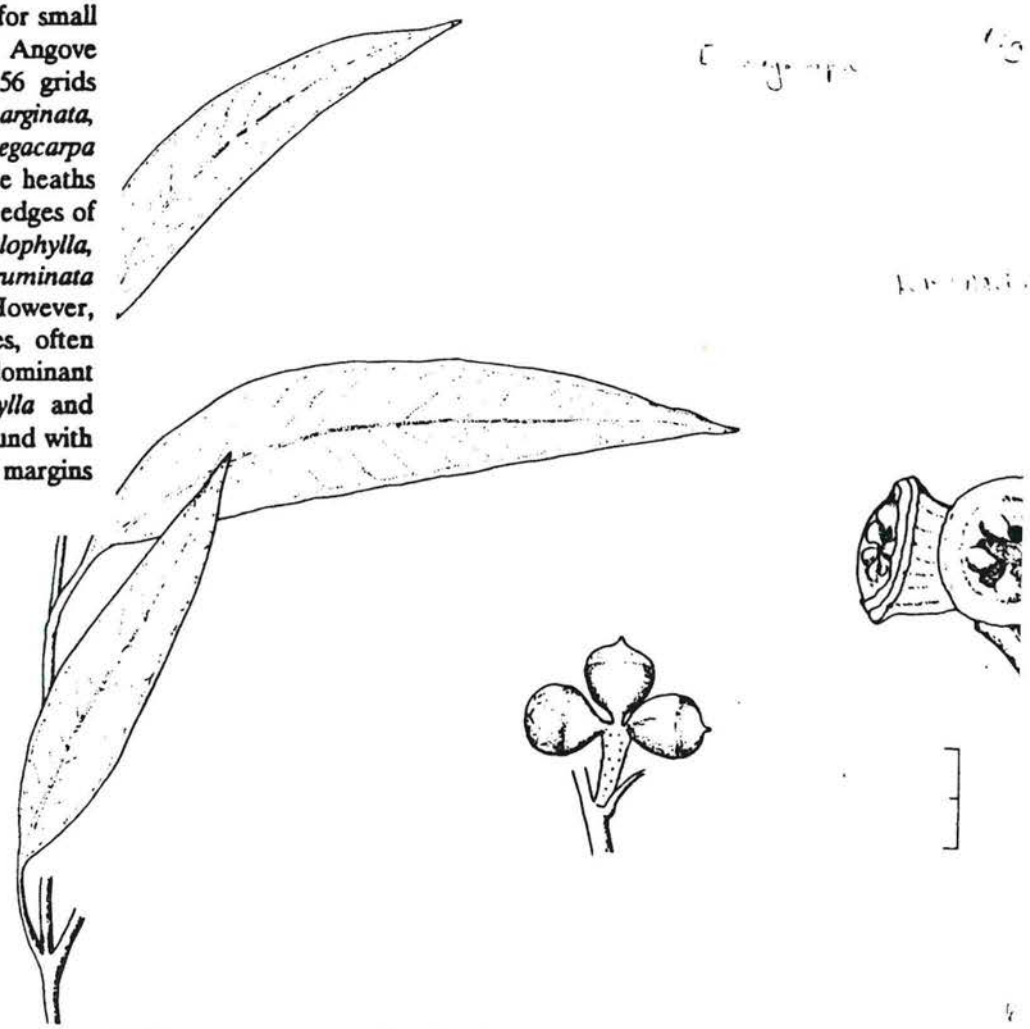


Fig 20 E marginata

:UCALYPTUS MEGACARPA F. Muell.
:ullich

This species was widespread on the Mt Gardner Headland but absent elsewhere except for small outlying populations bordering Lake Angove and the Goodga River. It occupied 56 grids (23% of the total). Like *E. marginata*, *E. calophylla* and some banksias, *E. megacarpa* occurred as stunted individuals in dense heaths and thickets on exposed slopes and the edges of sheet granite. *E. marginata*, *E. calophylla*, *B. grandis*, *B. attenuata* and *E. conferruminata* were its associates in these situations. However, it also occurred in well-watered gullies, often forming dense low forests in codominant associations with *E. cornuta*, *E. calophylla* and *Melaleuca* sp. 1.. Occasionally, it was found with *B. littoralis* in dense low forests on the margins of lakes, rivers or in coastal swamps.



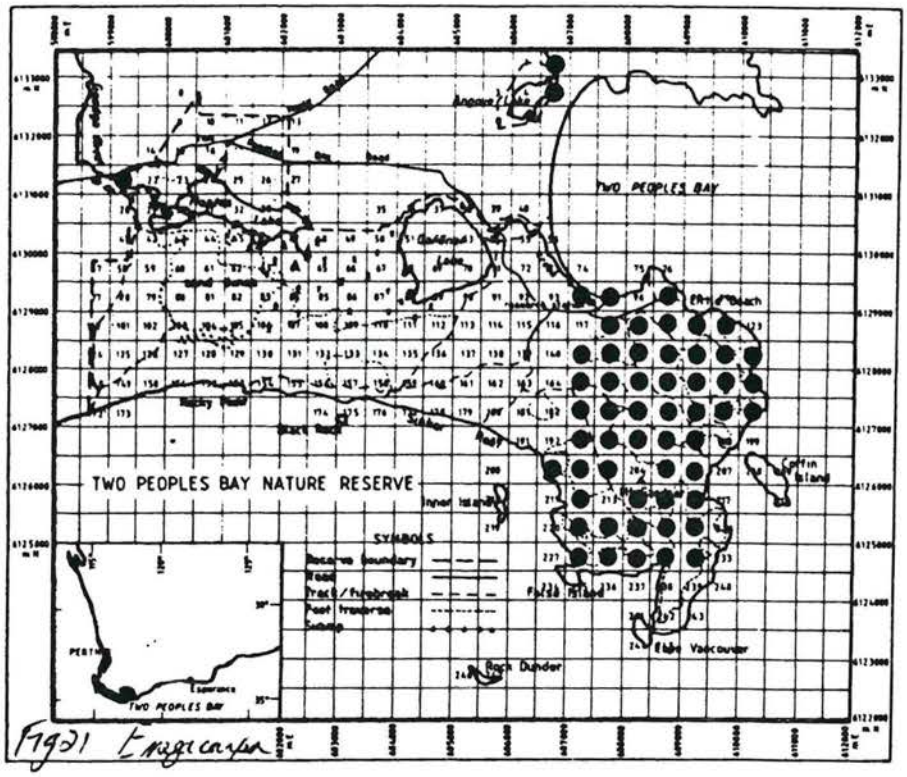
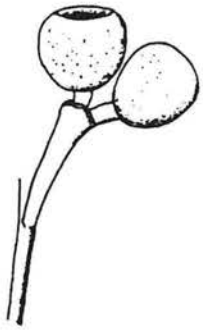
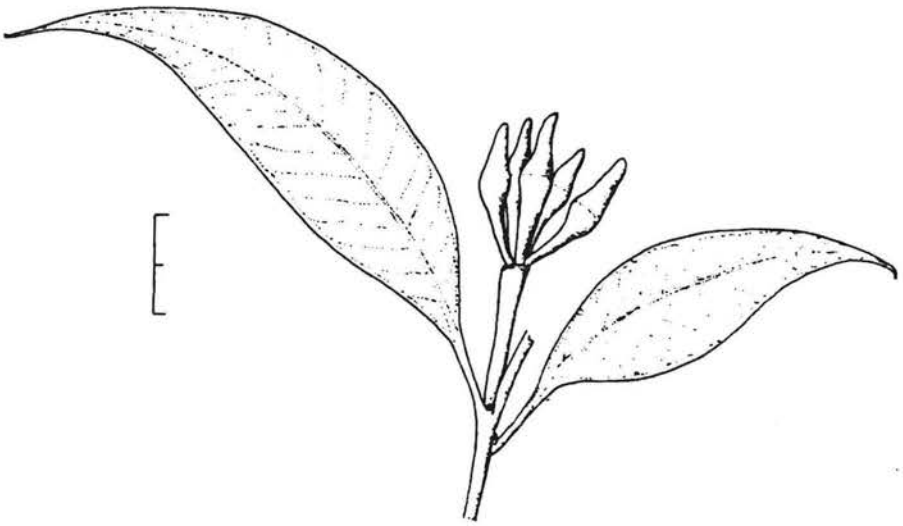


Fig 21 E megacarpa

UCALYPTUS STAERI (Maiden)
essell & C. Gardner
lbany Blackbutt



E. staeri was located in 27 grids (11%). It occurred predominantly north and west of Moates Lake, but small outlying populations were located north-west of Mt Gardner and on the west bank of Lake Angove. Open low woodlands on sandy gradual slopes or valley bottoms were the preferred habitat of *E. staeri*. Co-dominants included *B. coccinea*, *B. attenuata*, *Allocasuarina fraseriana*, *E. marginata* and *B. grandis*.



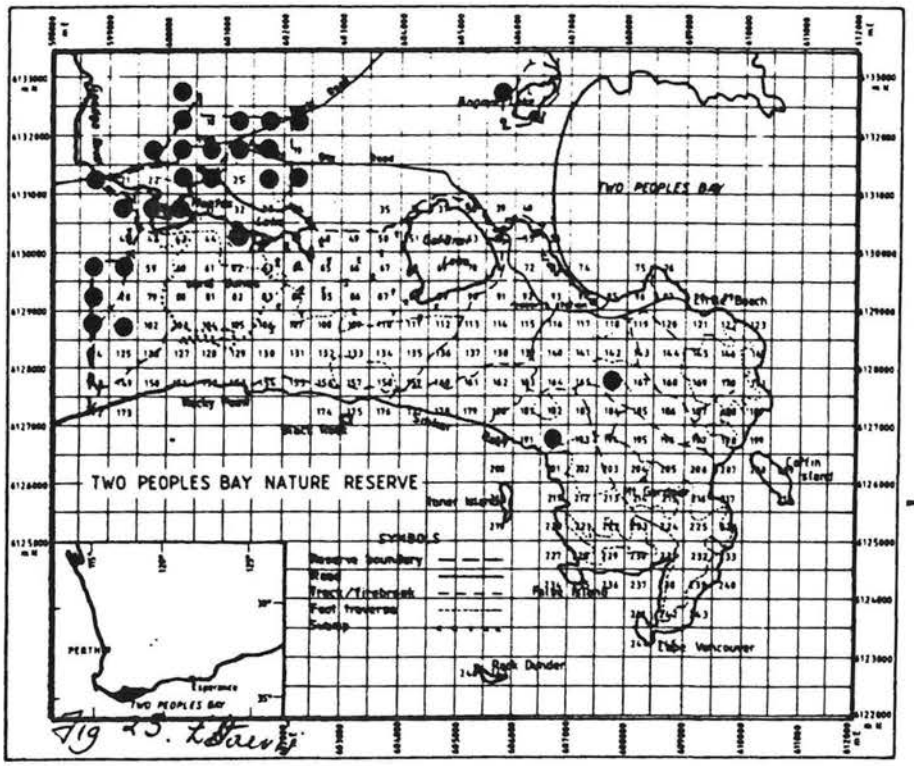
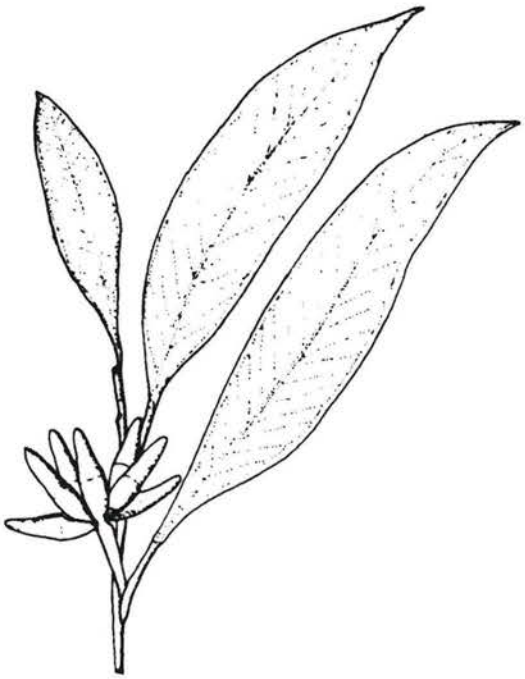


Fig 25. L Staeri

EUCALYPTUS MISSILIS Brooker & Hopper (ined.)
Bullet Bush

This was the rarest eucalypt located (2 grids, 1%). Its affinities were not clear at the time of the survey, but it now appears to be a stabilised hybrid of *E. angulosa* and *E. cornuta* found between West Cape Howe and Cape Le Grand in disjunct small populations. It occurred in a stand of open shrub mallee over dense low heath as a scattered emergent with *E. angulosa*, *E. goniantha*, *Agonis flexuosa* and *B. attenuata*. Sand or sand over limestone on a ridge and associated gradual slopes supported this vegetation.



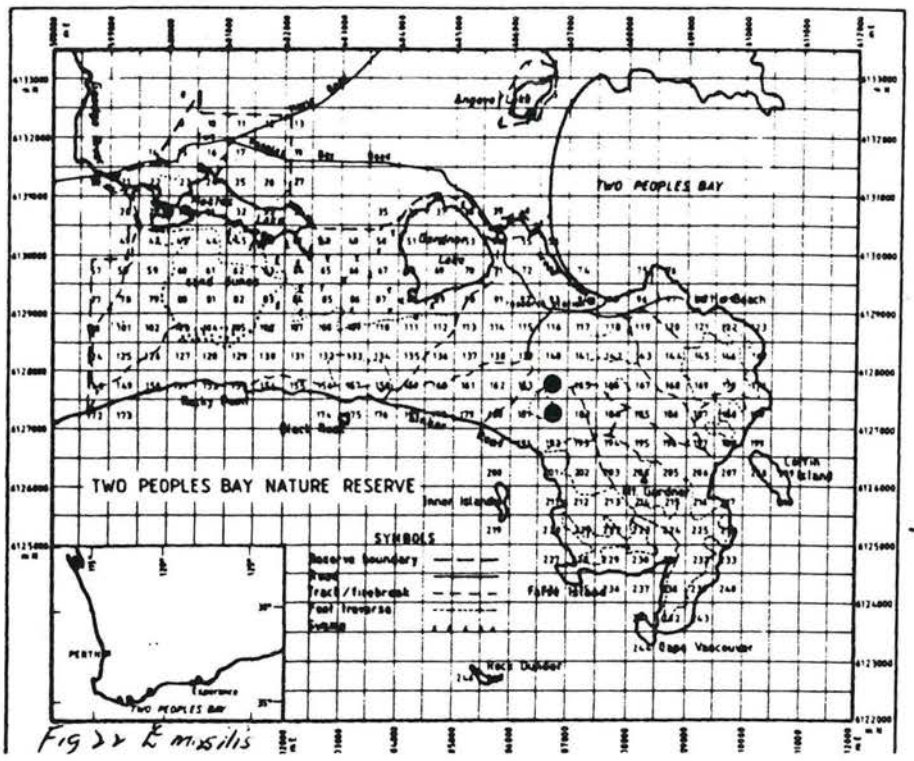


Fig 22 E. missilis

CHAPTER 13

Terrestrial Invertebrate Fauna

G.T. Smith

INTRODUCTION

The floristic richness and topographic diversity of the Two Peoples Bay Nature Reserve suggest that there should be a rich invertebrate fauna. However, as with most conservation areas in Western Australia, there have been no systematic collections of invertebrates and little attempt to study the biology of any species.

The data presented below are mainly from collections made during the period 1970 to 1977 and to a lesser extent from 1978 to 1982. The collections are biased in that they were made for studies on the prey of the Noisy Scrub-bird (*Atrichornis clamosus*), and scorpions. J. Springett[1] has collected the taxa found in the litter and soil in an area of bullich (*Eucalyptus megacarpa*) and Smith and Calver (1984) list the taxa found in the litter in an area of marri (*E. calophylla.*) Both collections were made in Tick Flat (Fig. 1.4 this publication)).

Additional collections have been made of invertebrate groups of interest to particular scientists. The names of colleagues who identified species and made comments on distribution are given at the start of each group. Most specimens were collected from hand sorted litter or were collected from under rocks on the granite outcrops. Gastropods and spiders were collected opportunistically.

ANNOTATED SPECIES LIST

AMPHIPODA (J.A. Friend)

Austrotroides pectinalis Friend, 1982

Found in litter in the forested gullies and soakage lines on the Mt Gardner headland. Common in the forests of the south-west of Western Australia. The distribution is from Two Peoples Bay to Cape Naturaliste and inland as far as the Perup River (Friend 1982).

Agilestia sp.

Most common in the litter in the damper gullies of the Mt Gardner headland. Found on the south coast from Walpole to Two Peoples Bay and inland to the Stirling and Porongurup Ranges. This is an undescribed species belonging to the genus *Agilestia*, established by Friend in 1982. This genus is also known from Tasmania.

CHILOPODA (L.E. Koch)

Scolopendridae: Scolopendrinae

Cormocephalus hartmeyeri Kraepelin, 1908

Common in the south-west of Western Australia.

Cormocephalus michaelseni Kraepelin, 1908

Found in coastal districts from Margaret River to Esperance.

Arthrorhabdus mjobergi Pocock, 1891

Uncommon, found under rock litter on granite outcrops.

Cryptopidae

Specimens of this family have been collected from marri litter on Tick Flat.

Geophilidae

Specimens of this family have been collected from marri litter on Tick Flat.

1 J.A. Springett, (unpublished manuscript) Survey of soil fauna 1971-72.

GASTROPODA (S. Slack-Smith)

Bothriembryon kingii (Gray, 1825)

Confined to coastal regions from Albany to Cape Riche. In the Reserve it has been recorded from coastal dunes and Coffin Island. Dead specimens collected in a sand blowout near Rocky Point show traces of concentric sculpture and so appear to be intermediate between the typical *B. kingii* and the typical *B. brazieri* Angas. They resembled fairly closely the form Pilsbry (1900) called *humilis*. It appears that these two forms are closely related.

Bothriembryon melo (Quoy & Gaimard, 1832)

Found in the coastal regions from Torbay to the Fitzgerald River, but extends further inland than *B. kingii*. Has been recorded throughout the Reserve; some specimens have been found under rocks on the granite outcrops around Mt Gardner. On 25 March 1982 this species was found to be abundant in the sand dunes around Moates Lake where it was feeding on dead plant material on the ground.

Bothriembryon brazieri (Angas, 1871)

The range is from Torbay to Two Peoples Bay and inland to the Stirling Range. It is most commonly found in forest areas. On 25 March 1982, a few specimens were found on *Agonis flexuosa* branches 2 m above the ground and on the stems of *Acacia decipiens* in sand dunes near Moates Lake. Much less common in this area than *B. melo*. On the Mt Gardner headland it has also been recorded (dead) under rock litter on the granite outcrops.

Physastra georgiana (Quoy & Gaimard, 1832)

This species is common throughout the south-west of the State. In the Reserve it has been recorded in a swamp between Gardner Lake and the sea.

SCORPIONIDA

Only two species of scorpion have been recorded from the Reserve, *Cercophonius squama* and *Urodacus novaehollandiae*. The distribution maps in Koch (1977) indicate that the only additional scorpion that may be found is *Lychas marmoreus* (Koch, 1845).

Bothriuridae

Cercophonius squama (Gervais, 1844)

This species is widespread in the wetter, temperate areas of southern Australia; however, there are relict populations in cooler, moister microhabitats in the more arid regions, for example, the south-side of Ayers Rock, in the Northern Territory (Smith 1983).

In the Reserve it has been found in litter in the forested gullies and soakage lines, in grass tussocks on stony ridges and under rocks around the bare granite outcrops on the Mt Gardner headland for one or two months after the start of the winter rains.

Little is known of its biology. In captivity it will dig a burrow even if shelter is provided. These burrows may be excavated each night, or the animal may seal itself in and remain there for up to four months. One female is known to have given birth while sealed in her burrow (Smith 1983).

As with most scorpions, its food is a range of invertebrates. On the Reserve observed prey items have been ants, crickets, centipedes, moths, weevils and slaters. Its main hunting strategy appears to consist of climbing into a shrub or sedge clump up to 1 m above the ground and waiting head down with the pedipalps extended. The prey is eaten *in situ*, the scorpion then climbs down and finds shelter, often in the base of the sedge clump it has foraged in.

Scorpionidae (G.T. Smith)

Urodacus novaehollandiae Peters, 1861

U. novaehollandiae is widely distributed in south-west Western Australia extending east in coastal districts to the Flinders Range in South Australia (Koch 1977). On the Reserve it is widely distributed on the rocky outcrops on the Mt Gardner headland and also in the sandy soils on the isthmus area.

On the Mt Gardner headland, *U. novaehollandiae* is found mainly under rocks on the edges of the granite outcrops. Only two vagrant adult males have been found away from these areas. In the sandy soils of the isthmus area, burrows of this species are widely dispersed and the population density appears to be less than that around the outcrops.

Under rocks, the species digs a shallow, twisting burrow up to 9 cm deep. Adult females appear to use the same burrows for a number of years - one marked female used the same burrow for five years. On the other hand, adult males rarely use a burrow for more than a few months and are commonly found moving around on the surface at night, whereas, adult females are infrequently found on the surface. Of 46 adults caught in pitfall traps near Mt Manypeaks (north-east of the Reserve) only seven were females. Populations are larger around outcrops with fine-grained granite than those with coarse granite. There also appears to be a preference for outcrops facing west.

Females give birth to 12 to 26 young in February. The young undergo their first moult one or two weeks later and then start leaving their mother's back and slowly dispersing away from their natal rock. Young usually move only a few metres before finding a rock and digging their own burrow. Some young may spend the winter under their natal rock.

In the smaller, closely related, *U. manicatus*, adult size is reached after five moults which take 18 to 25 months to complete (*U. abruptus* in Smith 1966). The larger *U. yaschenkoi* takes five years to complete the five moults required to reach adult size (Shorthouse and Marples 1982). *U. novaehollandiae* probably also takes five moults to reach adult size, however, the time taken is not known, but is probably greater than two years.

Females mate in the first spring after reaching adult size. Observations of two marked females suggest that parturition takes 16 to 18 months. Females may produce up to four litters during their life which indicates a maximum life span in excess of 10 years. The longevity of males is unknown.

U. novaehollandiae prey on a wide variety of invertebrates, particularly species that also live under rocks. They use a 'wait and see' hunting strategy, waiting at the entrance of the burrow for a potential prey to come within reach in the channel they dig from the edge of the rock to the burrow entrance. The more mobile males may also hunt while on the surface. Known predators of *U. novaehollandiae* include centipedes, the goanna (*Varanus rosenbergi*) which occasionally digs out scorpion burrows, the Kookaburra (*Dacelo novaeguineae*) and the Tawny Frogmouth (*Podargus stringoides*).

ARANEIDA (Barbara York Main)

Mygalomorphae

Ctenizidae

Eucyrtops Pocock sp. nov.

The species is a member of the *E. 'latior'* species group which is confined to south-west Western Australia. This undescribed species is probably confined to the south coast, i.e. south of the Stirling Range region.

Nemesiidae

Chenistonia tepperi Hogg, 1902

Widespread distribution from Mt Lofty in South Australia to the west coast. A common species found in many habitats. Females usually found in a silk-lined trench under rock on a granite outcrop. One female was found in a 15 cm long burrow in a sandy bank in Robinson Gully.

Araneomorphae

Amaurobiidae

Badumna Thorell, 1890 sp.

Found on leaves of *Hakea elliptica*. *Badumna* is a common lace-web spider.

Anapidae

Pseudanapis Simon, 1905 sp.

'Midget' lungless spiders confined to permanently damp or humid litter. Common in rainforests of eastern Australia. Not previously recorded in literature from Western Australia.

Araneidae - Orbweavers

Arachnura higginsi (L. Koch, 1872)

Widespread in southern Australia, especially humid and coastal localities.

Argiope trifasciata (Forskoel, 1775)

Cosmotropical and Australia-wide distribution.

Eriophora biapicata (L. Koch, 1871)

Formerly misidentified as *Araneus* (or *Eriophora transmarinus*). Distributed from the

west coast to west of the Dividing Range in southern part of continent.

Tetragnatha Latreille, 1804 sp.

Widespread genus especially near water.

Clubionidae

Chiracanthium C.L. Koch, 1839 sp.

Cosmopolitan genus.

Supunna Simon, 1897 sp.

Common, also to west of Albany.

Molycria Simon, 1887 sp.

Litter genus, common in south-west forests, but rarely recorded.

Zoridae

A juvenile found under rock, on a granite outcrop could not be identified further.

Dictynidae (=Amurodiidae)

Forsterina Lehtinen, 1967 sp.

(specimen damaged).

Gnaphosidae

Lampona Thorell, 1870 sp.

Common litter genus with a widespread distribution.

Unidentified genus that B. York Main has not seen before.

Hahniidae

Unidentified specimen from marri litter near Mt Gardner. Family is uncommon in forests in the south-west of Western Australia being found only in permanently wet, undisturbed litter as in karri (*E. diversicolor*). Common in rainforests of eastern Australia but a relic in south-west of Western Australia from where there are only two records.

Lycosidae

Trochosa oraria (L. Koch, 1876)

Found on Little Beach, also common in litter. Widely distributed on beaches from Albany to Geraldton.

Lycosa sp A

Found under rock with juveniles - 17 December 1975.

Lycosa sp B

Found under rock with egg sac - 21 December 1972.

Geolycosa serrata (L. Koch, 1877)

Common species with a widespread distribution in the south-west of Western Australia.

Miturgidae

Miturga Thorell, 1870 sp.

Common genus across southern Australia.

Nicodamiidae

Nicodamus Simon, 1887 sp.

Pisauridae

Dolomedes Latreille, 1804 sp.

This unidentified species is common west of Albany and on Bald Island.

Salticidae

Unidentified species.

Selenopidae

Selenops australiensis L. Koch, 1875

Widespread distribution in the forests of southern Australia - not common.

Sparassidae (= Heteropodiae)

Isopoda leishmanni Hogg, 1903

Distribution confined to the south-west corner of Western Australia. Specimen found on Coffin Island.

Thomisidae

Sidymella Strand, 1942 sp.

Diaea Thorell, 1870 or *Thomisus* Walckenaer 1805.

Zodariidae

Storena Walckenaer 1805 sp.

ACARINA

Amblyomma albolimbatum Neumann

Recorded on specimen of *Tiliqua rugosa* in the Mt Gardner area (Bull and King 1981). This species is the common reptile tick in the south-west of Western Australia.

OPILIONES (=Phalangida)

Nunciella sp

Widespread distribution in south-west of Western Australia.

DIPLOPODA (J. Springett)

Podykipus collinus Attems

Atelomastix sp.

Rhinotus sp.

Akamptogonus novarae (Humbert & Saussure)

ISOPODA (J. Springett)

Porcellio sp. (not *laevis*)

Philoscia (*sens. lat.*) sp.

Amphisopus lintoni (Nicholls)

Widespread distribution, mostly in water-bodies and in forest, but never in permanent streams. Has been recorded in pitcher plants (*Cephalotus follicularis*) and in pools on the wharf at Albany.

ONYCHOPHORA (J. Springett)

Peripatoides occidentalis

CONCLUSION

The terrestrial invertebrates identified in this chapter represent only a small sample of the fauna on the Reserve. Smith and Calver (1984) found that Noisy Scrub-bird (*Atrichornis clamosus*) nestlings were fed species from 12 invertebrate families, nine of which were not included in the above list. A further collection of about 100 not fully identified species from 16 families were recorded from the litter under *Eucalyptus calophylla*. Considerable work is needed to fully document the invertebrate fauna on the Reserve, however this will be dependent on available taxonomic expertise. Therefore the present list reflects the availability of taxanomic information rather than the availability of specimens.

ACKNOWLEDGEMENTS

I thank Mike Ellis and Les Moore for help in collecting the specimens, and for their identifications and comments. Many thanks also to the contributing authors and to Tony Friend and Barbara York Main for their useful comments on the text.

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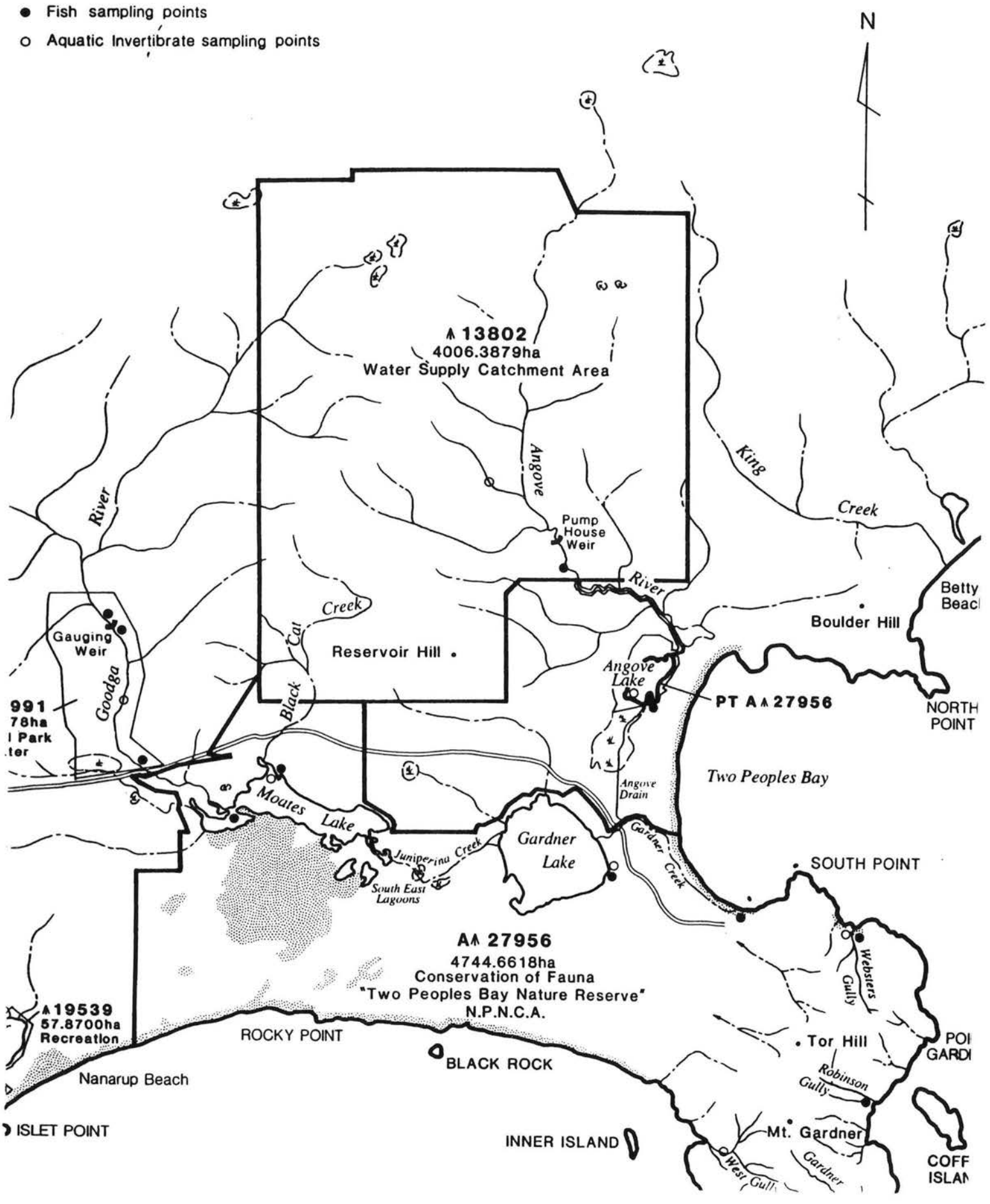
Fig. 14.1


Fish sampling points
Aquatic Invertibrate sampling points
N
A 13802
4006.3879ha
Water Supply Catchment Area
Angove
King
Creek
River
Pump
House
Weir
River
Betty
Beach
Boulder Hill
Gauging
Weir
Goodga
River
Creek
Cat
Reservoir Hill
Angove
Lake
PT A 27956
NORTH
POINT
Black
991
78ha
Park
ter
Two Peoples Bay
Angove
Drain
Moates Lake
Juniperina Creek
South East
Lagoons
Gardner
Lake
Gardner Creek
SOUTH POINT
A 27956
4744.6618ha
Conservation of Fauna
"Two Peoples Bay Nature Reserve"
N.P.N.C.A.
Websters
Gully
A 19539
57.8700ha
Recreation
ROCKY POINT
Tor Hill
BLACK ROCK
Robinson
Gully
Nanarup Beach
ISLET POINT
INNER ISLAND
Mt. Gardner
West Gully
Gardner

CHAPTER 14

Aquatic Ecosystems

N.J.Coy, S.A.Halse and A.W.Storey

INTRODUCTION

Wetlands are prominent features of the Two Peoples Bay Nature Reserve. Three distinct drainage systems occur there: the Goodga system, Angove system and the upland streams of the Mt Gardner headland (Fig. 14.1). Two of the systems (Angove and Goodga) arise outside the Nature Reserve and are influenced by external land practices (Table 14.1). This chapter describes each system in its entirety because land practices adjacent to the upper parts of a river affect all downstream sections (Hynes 1975).

Although data on depth, salinity and discharge of the Goodga and Angove systems have been recorded for a number of years (Lane and Munro 1983; Anon. 1984), the aquatic vertebrate and invertebrate fauna have been poorly documented. This chapter describes the physicochemical characteristics and vegetation (emergent and riparian) of the aquatic ecosystems of the Two Peoples Bay area and specifically reports the results of a series of waterbird surveys and a small number of surveys of the fish and aquatic invertebrate faunas.

GOODGA DRAINAGE SYSTEM

Sequentially from headwaters to river mouth, the major elements of the Goodga drainage system, which is 21 km long, are the Goodga River, Moates Lake, Juniperina Creek, Gardner Lake and Gardner Creek. Physicochemical data on the Goodga River are summarised in Table 14.1; data on Moates and Gardner Lakes are given in Figure 14.2.

Goodga River

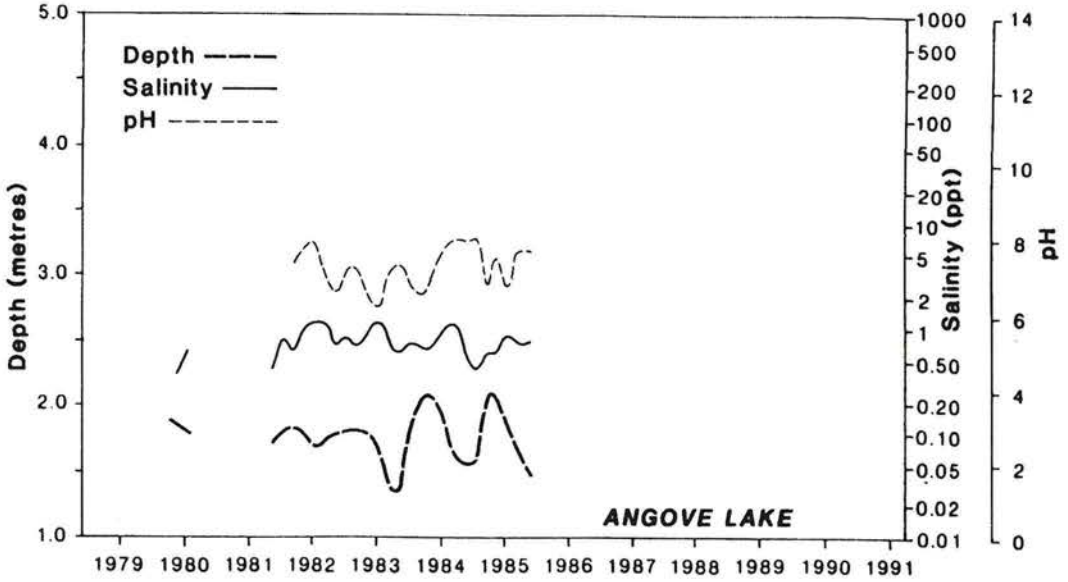
The Goodga River is the upper portion of the drainage system. The river arises c. 80 m above sea level (a.s.l.) in Water Catchment Reserve No. 13802, which currently has an area of 4006 ha. This reserve was first gazetted on 27 October 1911 with an area of 20 000 ha, then gazetted to its present size in 1953 and vested in the Department of Lands and Surveys (now Department of Land Administration (DOLA)).

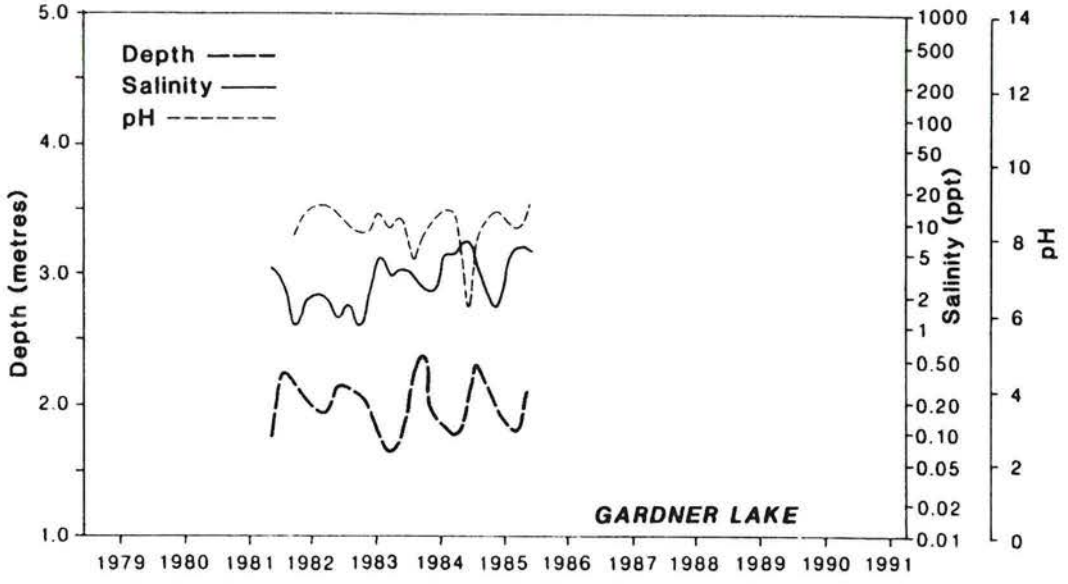
Water from the headwater swamps descends 30 m in the first 2 km as it passes between low granite hills. It then flows 6 km in a broad, swampy valley through cleared farmland (Anon. 1984; Churchward *et al.* 1988) before being joined by a smaller tributary from the west. One kilometre downstream from this confluence the river enters National Park/Water Reserve No. 24991, which was gazetted and vested in the Department of Lands and Surveys on 16 May 1958.

Throughout Reserve No. 24991 the river is slightly acidic (Table 14.1) and is characterized by a series of long, highly coloured pools that have substrates of black silt and mud and are connected by riffles that flow over laterized rock. Wetland plants along the watercourse include *Triglochin procera*, *Baumea juncea*, *Leptocarpus scariosus*, *Juncus holoschoenus* and *Lepyrodia monoica*.[1] The Water Authority of Western Australia maintains a V-notch gauging weir 2.5 km upstream from the Two Peoples Bay Road (Fig. 14.1).

As the river nears Moates Lake, in the Two Peoples Bay Nature Reserve, it emerges from Low Woodland (T14, Fig. 11.1 - vegetation map inside back cover, this publication) to flow through Wet Heath (S13). A series of sedge swamps occurs along the water course, with the dominant species being *Evandra aristata*, *Leptocarpus scariosus*, *Hypolaena exculca* and *Xyris lantana* (Fig. 14.3).

1 E.M. Gude, aquatic plant survey, March 1990 - an addition to plant collections reported in chapter 10 this publication.


Depth
Salinity
pH
Depth (metres)
Salinity (ppt)
pH
ANGOVE LAKE
1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991


Depth
Salinity
pH
Depth (metres)
Salinity (ppt)
pH
GARDNER LAKE
1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991

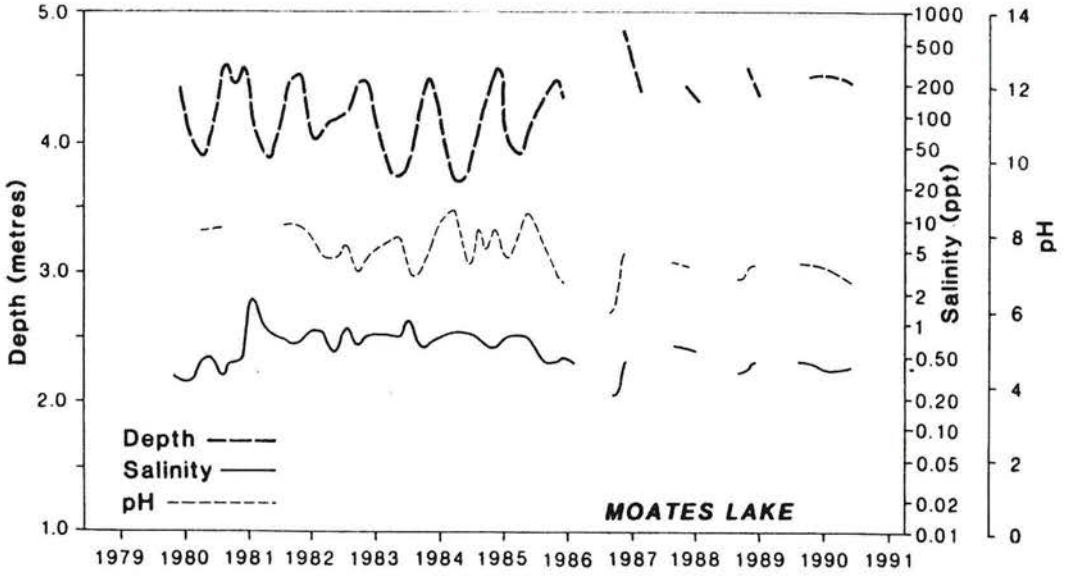

Depth
Salinity
pH
Depth (metres)
Salinity (ppt)
pH
MOATES LAKE
1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991

Fig 14.2

Moates Lake

This tannin-stained waterbody is one of the deepest natural lakes in south-western Australia, with a maximum depth of c. 5 m. Four main rivers/streams flow into the lake: from the north the Goodga River and the officially named Black Cat Creek, from the west the stream flowing through Black Cat Creek Farm and a swamp stream that originates north of Two Peoples Bay Road (Fig. 14.1). The lake has an area of about 144 ha with 124 ha being open water. Total length of the lake, from east to west, is 2.75 km with a maximum north-south measurement of 0.7 km. Elevation is c. 8 m a.s.l. with a shoreline of c. 10 km.

Moates Lake is situated in a depression between a low scarp of sandy laterite to the north and a 300 ha calcareous dune dating from the Holocene to the south (ch. 4 and Plate 2 this publication). Much of the southern shoreline is a sandy beach but apart from a few small laterite and sand beaches to the north, the remainder of the shoreline is sedge-dominated. The major species of sedge in the water are *Baumea articulata* in depths up to one metre and *B. juncea* close to the shore. *Triglochin procera* grows in sheltered areas. The marginal sedgeland includes *Evandra aristata, Leptocarpus scariosus, L. coangustatus* and *Anarthria scabra.* Behind the sedges there are low trees of *Agonis juniperina* and *A. linearifolia.*[2]

2 S.A. Halse, G.B. Pearson and S. Patrick (in prep.) Vegetation of depth-gauged wetlands in nature reserves in South-western Australia 1987-88.

Between the Lakes

The 2.5 km section of the Goodga system between Moates and Gardner Lakes has a seasonal flow that meanders between lagoons and swamps (Fig. 14.4), and through a 1.5 m deep channel to the delta marsh at the western end of Gardner Lake (Fig. 14.1). There is a fall of 6-7 m in surface level between the two lakes; the gradient varies with fluctuating lake levels. The watercourse is referred to locally as 'Juniperina Creek' and the five or six lagoons between the dunes are called the 'South-East Lagoons' (A. Danks[3], personal communication). The *Baumea/Juncus* sedgelands in the seasonally wet, interdunal swales and along the creekline are fringed by *Agonis juniperina* Dense

Gardner Lake

This slightly stained, brackish lake is fed mainly via Juniperina Creek and by the tidal flow of Gardner Creek, when this is open to the sea. Gardner Lake has about 186 ha of open water when full, within an associated winter wetland of c. 350 ha. The lake area measures 1.8 km north-south and 1.6 km east-west, with a shoreline of approximately 6 km. Because the lake bed is only c. 1.5 m a.s.l. there may be minor incursions of sea water into the lake during spring tides and storm surges, when Gardner Creek is open to the sea.

3 A. Danks, Reserve Management Officer, Two Peoples Bay Nature Reserve.

Table 14.1
Data on Angove and Goodga River Systems
(Summarised from Australian Water Resources 1982 and Anon 1984)

	ANGOVE CREEK PUMPING STATION Drainage Index No 602 187	GOODGA RIVER WEIR Drainage Index No 602 199
Period of Record	April 1963 - January 1982	June 1964 - December 1982
Catchment Area		
Catchment of Weir	29.3 km^2	46.4 km^2
Cleared Portion	20% in 1965: 30% by 1982	25% in 1965: 55% by 1982
Land Use	70% water and flora reserve and 30% cattle grazing on improved pastures.	Cattle grazing on improved pastures and a small portion in water reserve.
Downstream catchment	Angove Drain - 54.4 km^2	Moates Lake 77.7 km^2
Installation	V-notch weir for gauging. Upstream pipehead weir for extraction of water for Albany Town water supply.	V-notch weir for gauging. No water extracted from the weir.
Rainfall	770 mm/annum	800 mm/annum
Pan Evaporation	1470 mm/annum	1460 mm/annum
Water Quality		
Colour	Highly Coloured	Very Highly Coloured
Salinity (ppt TDS) (long-term average)	0.35	0.44
pH March 1990	6.8	6.4 (5.8 at main road)
Flow*		
Number of days per annum of varying flow rates (cumecs)	< .005 18.3 days .005 - .010 25.8 " .010 - .100 281.7 " .100 - 1.0 26.8 " > 1.0 1.6 " No Record 10.9 "	< .003 2.4 days .003 - .007 14.9 " .007 - .150 272.0 " .150 - 1.5 65.5 " > 1.5 3.1 " No Record 7.3 "
Minimum instantaneous	Nil/intervals Sept '77 - Feb '78	.0013 cumecs in January 1965
Maximum instantaneous	18.5 cumecs in Sept 1970	11.0 cumecs in March 1968
Minimum annual	1.00 million m^3 in 1981	2.08 million m^3 in 1965
Maximum annual	3.41 million m^3 in 1979	8.50 million m^3 in 1978
Annual extraction for Albany water supply	0.9 - 1.4 million m^3 (av. 1 million m^3)	-
Estimated mean annual	2.91 million m^3	3.93 million m^3

*(Flow figures for the weirs only, not for the downstream catchments)

Shortly after leaving the catchment reserve the river slows, flowing through an area dominated by *Melaleuca cuticularis* (T7) with an understorey that includes the shrubs *Pultenaea reticulata, Boronia crenulata, B. gracilipes* and *Hyplocalymma cordifolium*. This section of the river is in a stream reserve that is part of Two Peoples Bay Nature Reserve. Prior to the river flowing into Angove Lake, the flow and catchment area of the system are considerably increased by the contribution of four tributaries: two from the north, one flowing from Reservoir Hill in the west across cleared farmland, and a short fast-flowing stream from Boulder Hill in the east (Fig.14.1).

Angove Lake and associated lagoons

Angove Lake, which is included in the c.89 ha northern extension of the Reserve has an area of 22 ha, of which 15.6 ha is open water. It is complemented by two lagoons to the west (measuring 3 ha and 4 ha respectively), and a third lagoon of 10 ha to the north-east, inland from the dunes at the northern end of Two Peoples Bay (Fig. 14.7). The total area of swamp and inundated land around Angove Lake is c. 100 ha (estimated from vegetation map, Fig. 11.1, inside back cover).

The lake has very clear water at the end of summer. The substrate of black silt, however, is readily suspended by mechanical disturbance and settles slowly.

Angove Lake supports extensive stands of *Baumea articulata* in deeper water, with *B. preisii, Juncus pallidus, J. capitatus, Isolepis prolifera, Triglochin procera* and *Cotula coronopifolia* in shallow water and on shore. Behind the sedgeland, on the northern side of the lake, the shrubs *Agonis juniperina* and *Kunzea* aff. *ericifolia* grow, beyond which is a dense thicket of *Melaleuca thymoides*. Angove Lake has been invaded by a number of weeds, including *Rumex acetosella, Holcus lanatus, Psoralea pinnata* and *Vellereophyton dealbatum*, because the area is surrounded by farmland and livestock have used the wetland.

Fig 14.7
Angove Lake
(SDH Study)
SA Hales Study

Captain

Angove Drain

The Angove drain is an artificial channel, c. 3 km long, 1.5 m deep and 10 m wide, flowing from Angove Lake to Gardner Creek. It was originally part of a drainage system dug by hand in the late 1920s to allow summer vegetable crops to be grown on the seasonally inundated swamps of the coastal floodplain south of Angove Lake. In summer the fertile peaty ground is irrigated with underground water pumped from near Angove Lake (ch. 2). The Angove drain was enlarged and deepened to its present size by dragline in the late 1970s (D. Wilson[4], personal communication).

Where the drain leaves the lake, dense stands of *Homalospermum firmum* emerge from the water and, for much of its course through farmland, the drain is fringed by *Melaleuca* sp. 1, *Agonis linearifolia, A. juniperina* and *Kunzea vestita*. As the drainage channel nears Gardner Creek it follows a natural watercourse, fringed by *Hibbertia furfuracea* and sedges.

MT GARDNER HEADLAND STREAMS

The Mt Gardner headland is drained by 12 main streams, which are well-shaded and comparatively cool. The densely vegetated gullies, through which these streams flow, served as a refuge for the Noisy Scrub-bird when the species was locally extinct elsewhere (ch. 17 this publication). Streams on the ocean side of the headland rise at c. 200 m a.s.l. and flow to the sea with a mean gradient of about 1:7 over their 1.3-1.5 km courses. The four major streams flowing to the ocean - Gardner, Robinson, Webster's and West Gullies - hold water permanently, although they recede to pools in dry years (G.T. Smith[5] and A. Danks, personal communication).

4 D. Wilson, youngest of the three Wilson brothers who, with their father, fished Two Peoples Bay professionally for many years. Now Reserve Management Assistant at Two Peoples Bay Nature Reserve.

5 G.T. Smith, Senior Research Scientist, CSIRO, Division of Wildlife and Ecology, Helena Valley, W.A.

Much of the substrate in Gardner Lake is silt over sand and laterite. The emergent sedges around the lake are mainly *Baumea articulata*, *Juncus krausii*, *Schoenus brevifolius* and *Restio* sp. (V3). In places along the eastern shore they extend 100 m into the water when the lake is full (Fig. 14.5). The seasonally inundated margins support *Gahnia trifida*, *Lepidosperma gladiatum* and various shrubs, including *Agonis juniperina*, *Homalospermum firmum*, *Hakea* sp., *Lepyrodia* sp., *Thysanotis gracilis* and *Centella asiatica*.

Gardner Creek

Gardner Creek is a channel between Gardner Lake and the main beach at Two Peoples Bay that is closed to the sea each summer by a sandbar forming across the mouth of the creek. In early winter the water in the creek backs up on the landward side of the sandbar, which is opened by mechanical means, usually by the middle of June, to prevent flooding of the road bridge over Gardner Creek (A. Danks, personal communication).

As the 2.8 km long Gardner Creek leaves the eastern shore of Gardner Lake, it follows a north-easterly course through a grove of overhanging *Melaleuca* Low Forest (T13) with little understorey. *Melaleuca* sp. 1, *M. cuticularis*, *M. raphiophylla* and *M. preissiana* grow in this seasonally inundated area (Fig. 14.6).

The creek then turns south to follow the landward side of the dune line, through the Sand Dune Thicket association (S3). Near its mouth, at a break in the dunes adjacent to the Reserve Office, the creek flows past a dense thicket of *Phebalium anceps* over *Lepidosperma gladiatum*, with *Typha domingensis* in a disturbed backwater (V2).

ANGOVE RIVER SYSTEM

The major elements of the Angove drainage system, which is 14 km long, are the Angove River, Angove Lake and Angove Drain. The system joins the Goodga drainage system 1 km inland from the dunes of the main beach to form a common, seasonal outlet to the sea. Physicochemical data on Angove River are given in Table 14.1 and data on Angove Lake are given in Figure 14.2.

Angove River

The Angove River arises c. 90 m a.s.l. in swamps north of the uncleared Water Catchment Reserve No. 13802 (Fig. 14.1). Over the first 4 km the river descends 25 m., with a drop of 43 m over the next 4 km to a pipehead dam that was constructed in 1912-13 to provide water for the town of Albany (Table 14.1 and ch. 2 this publication). Above the dam the river flows through a gently sloping valley, with soils consisting of sand over gravels and clay. A mallee-woodland/heath grows on high ground and a woodland of jarrah and *Allocasuarina* thickets occurs on swampy land in the valley (Anon. 1984; Churchward *et al.* 1988).

Below the dam the stream flows over a sloping granite fault line, with a marked gradient of c. 15 m over 1.5 km to a V-notch gauging weir. A jarrah/*Allocasuarina* woodland grows on the valley slopes through this section.

Robinson Gully is a clear upland stream with a sloping marshland of *Schoenus grandiflorus* in its middle reaches. Webster's Gully consists of a series of gravel-bottomed, clearwater pools in its lower reaches with a 10 m drop over granite boulders onto Waterfall Beach. The vegetation of this gully is a very dense eucalypt/*Melaleuca* forest with a varied understorey that includes *Lepidospermum* sp. and *Anarthria scabra* along the stream. West Gully is a rapid stream with few pools and a dense canopy of low eucalypts along its lower reaches (Fig. 14.8).

Streams on the inland side of the headland arise at c. 180m a.s.l. and descend to the isthmus area where they seep into the dunes and swales (Fig. 14.1). These streams only flow in their upper reaches, where they are seasonal, and are more akin to drainage lines for most of their c. 2 km courses.

WETLAND AREA

The wetland area in the Two Peoples Bay Nature Reserve fluctuates seasonally between c. 400 ha (8.5 per cent of the 4745 ha reserve area) in normal summer conditions and c. 750 ha (15.8 per cent) during average winter/spring flooding in August/September. In very wet winters an estimated 830 ha (17.5 per cent) is inundated, with an additional 170 ha (3.5 per cent) of waterlogged land (areas estimated from vegetation map and aerial photography). The widespread occurence of peaty sands on the c. 860 ha. coastal plain (ch. 4 this publication) suggests this area was much wetter in previous geological times than it is now.

Extraction of water from the Angove River and construction of drains on the coastal plain are probably partly responsible for this drying.

THE FAUNA

Waterbirds

Forty-two species of waterbird were recorded from the three lakes of Two Peoples Bay Nature Reserve between 1973 and 1990 during surveys by the Royal Australasian Ornithologists Union and CALM staff (Table 14.2). This represents comparatively high species richness for wetlands of south-western Australia: Jaensch *et al.* (1988) surveyed 197 nature reserves in the south-west and ranked Two Peoples Bay twenty-fifth in terms of number of species.

The lakes showed considerable differences in waterbird usage (Table 14.2), with Angove supporting fewer species (17) than Gardner (35) and Moates (29). However, Angove was surveyed only five times and the lower number of species recorded may be partly attributed to lack of survey effort (see Jaensch *et al.* 1988, p. 19).

The lakes support only low numbers of waterbirds: Gardner was ranked eighty-third out of 285 wetlands surveyed by Jaensch *et al.* (1988) in terms of number of birds. Moates and Angove support even fewer birds (Table 14.2). The value of the lakes lies chiefly in the diversity of species that occur.

The species occurring in highest numbers are the Eurasian Coot, Pacific Black Duck, Australian Shelduck, Blue-billed Duck, Musk Duck, Red-necked Stint and Red-capped Plover (Table 14.2). The occurrence of most of these species is sporadic, however. The most frequently observed species in Moates are the Little Pied Cormorant (70 per cent of surveys), Little Black Cormorant (63 per cent) and Spotless Crake (53 per cent). The most frequently observed in Gardner are the Musk Duck (85 per cent), Black Swan (85 per cent) and White-faced Heron (70 per cent). There were too few surveys of Angove for this analysis.

The Musk Duck, Darter, Little Pied Cormorant, Pacific Black Duck, Spotless Crake and Purple Swamphen have been recorded breeding in the Reserve; Musk Ducks have bred in all three lakes (Table 14.2). Several other species, including the Little Bittern and Australasian Bittern may breed around the lakes (Jaensch *et al.* 1988). The calls of many birds that were probably Australasian Bitterns were heard by A. Danks (personal communication) in

the breeding season of 1988, which suggests that the lakes at Two Peoples Bay Nature Reserve may be an important habitat for this comparatively rare species. More fieldwork is required to confirm this.

Table 14.2

Waterbird species recorded at Angove, Gardner and Moates Lakes. (The highest number of birds recorded on a single occasion is shown for each species. Breeding species are indicated by an asterisk*.)

Scientific Name	Common Name	Angove	Gardner	Moates
Podicipedidae	**Grebes**			
Podiceps cristatus	Great Crested Grebe		6	1
Poliocephalus poliocephalus	Hoary-headed Grebe		40	4
Tachybaptus novaehollandiae	Australasian Grebe		6	7
Pelecanidae	**Pelicans**			
Pelecanus conspicillatus	Australian Pelican		2	
Anhingidae	**Darters**			
Anhinga melanogaster	Darter			*2
Phalacrocoracidae	**Cormorants**			
Phalacrocorax carbo	Great Cormorant		1	10
P. varius	Pied Cormorant		10	2
P. sulcirostris	Little Black Cormorant	1	6	8
P. melanoleucos	Little Pied Cormorant	3	9	*9
Ardeidae	**Herons and Bitterns**			
Ardea novaehollandiae	White-faced Heron	11	17	4
Egretta alba	Great Egret		2	3
Ixobrychus minutus	Little Bittern	1		1
Botaurus poiciloptilus	Australasian Bittern	1	1	1
Threskiornithidae	**Ibises and Spoonbills**			
Threskiornis aethiopica	Sacred Ibis	18	1	
T. spinicollis	Straw-necked Ibis		4	1
Platalea regis	Royal Spoonbill			3
P. flavipes	Yellow-billed Spoonbill		3	
Anatidae	**Ducks, Geese & Swans**			
Cygnus atratus	Black Swan	2	45	*10
Tadorna tadornoides	Australian Shelduck	2	54	10
Anas superciliosa	Pacific Black Duck	65	*164	13
A. gibberifrons	Grey Teal		18	2
A. rhynchotis	Australasian Shoveler		2	
Chenonetta jubata	Maned Duck	2		2
Oxyura australis	Blue-billed Duck		53	1
Biziura lobata	Musk Duck	*3	*50	*4
Accipitridae	**Hawks & Harriers**			
Circus aeruginosus	Marsh Harrier	1	1	2
Rallidae	**Rails, Coots & Gallinules**			
Porzana tabuensis	Spotless Crake	2	*1	3
Porphyrio porphyrio	Purple Swamphen	3	7	*3
Fulica atra	Eurasian Coot		216	

Table 14.2 (*continued*)

Scientific Name	Common Name	Angove	Gardner	Moates
Charadriidae	**Plovers & Dotterels**			
Pluvialis squatarola	Grey Plover		1	
Erythrogonys cinctus	Red-kneed dotterel	1		
Charadrius ruficapillus	Red-capped Plover		54	
C. melanops	Black-fronted Plover	2	5	6
Scolopacidae	**Snipe, Woodcock & Sandpipers**			
Tringa hypoleucos	Common sandpiper		1	
T. nebularia	Greenshank		6	2
Calidris ruficollis	Red-necked Stint		60	
Laridae	**Gulls & terns**			
Larus novaehollandiae	Silver Gull		23	
Chlidonias hybrida	Whiskered Tern		2	
Hydroprogne caspia	Caspian Tern		2	
Sterna bergii	Crested Tern		1	1
Muscicapidae : Sylviinae	**Old World Warblers**			
Acrocephalus stentoreus	Clamorous Reed Warbler			3
Megalurus gramineus	Little Grassbird	1		3
Number of Surveys		5	24	30
Total Number of Species		17	35	29
Number of Breeding Species[a]		1	3	5
Highest Total Count		109	420	41

[a] Additional breeding records by A. Danks have been included, hence number of breeding species cannot be related to survey effort.

Fishes

The freshwater and estuarine fish populations of the Two Peoples Bay area have not been extensively studied, although collections forwarded to the Western Australian Museum by L. Glauert in 1941, W.H. Butler (Waychinicup River) in 1964, G.R. Allen in 1976, 1980 and 1986, N.J. Cross in 1981 and N.J. Coy in 1990 provide some information (Table 14.3).

Eleven sites were sampled within the drainage systems (Fig. 14.1) in March 1990 using dip nets and a 5 m seine net. Habitats sampled included riffles and deep pools along water courses and open shallows and reed beds in the lakes.

Five species of fish were collected in the Angove and Goodga drainage systems but no fish were taken from Robinson and Webster's Gullies (Table 14.3). Additional species recorded from the previously mentioned surveys (Western Australian Museum records) and anecdotal records from several local people with a long term interest in the area are included in Table 14.3. The Swan River Goby (*Pseudogobius olorum*) and the Common Jollytail (*Galaxias maculatus*) are the most widely distributed species in the Angove and Goodga systems. Both species usually have marine stages during their life cycles.

The near-coastal sections of both river systems appear to be nurseries for several euryhaline species such as the hardyhead (*Atherinosoma wallacei*), Yellow-eye Mullet (*Alderichetta fosteri*) and Black Bream (*Mylis butcheri*) (Table 14.3). Prior to 1980 the Wilson family netted 40-60 cm long Yellow-eyed Mullet and a variety of small, unidentified `bait fish' from Gardner Lake several times each year (D. Wilson, personal communication). Black Bream have been caught in Gardner Lake and Gardner Creek by a few local anglers (D. Wilson, personal communication).

Although it has not been collected it is likely that the Pouched Lamprey (*Geotria australis*) occurs in the Angove and Goodga systems (G. Power[6], personal communication). Large spawning runs of this species usually occur each winter in nearby King Creek, Waychinicup River and the Kalgan River (Fig.1.2, this publication).

The presence of the Trout Minnow (*Galaxias truttaceus*) in a relatively landlocked situation in the Goodga River is of special significance (Plate 15 this publication), because at this time ichthyologists are unsure of its status in Western Australia (Allen 1982). Studies in the eastern states on *G. truttaceus* (Humphries 1989) and *G. maculatus* (Pollard 1973) have shown that both species can adapt to landlocked situations, although they are generally diadromous with the former being anadromous (going upstream from the sea to spawn) and the latter being catadromous (going downstream to the estuary to spawn).

Galaxias maculatus (Plate 15 this publication) is the most common minnow between Two Peoples Bay and the Duke of Orleans Bay, east of Esperance. There are old records of *G. truttaceus* from a few streams in the above area and for a land-locked population in Shark Lake, near Esperance (Western Australian Museum records). However, this species has recently been categorised as `our rarest species of native minnow' by Allen (1982), who stated that it occurs in small populations in only the Goodga and King Rivers, in the Albany district.

The Goodga River harbours the scarce Balston's Pygmy Perch (*Nannatherina balstoni*) (Allen 1982, 1989), which is also not as widespread as once thought. It was collected at only four of 120 sampling points along the south coast hinterland between the Blackwood River system, near Augusta, and the Hay River system, between Denmark and Albany by Christensen (1982).

It is possible that other endemic species occur in the Angove and Goodga drainage systems, because the dark-stained waters are difficult to fish and not all habitats have been sampled. For example, the endemic and widespread Western Minnow (*Galaxias occidentalis*), which has yet to be collected in the Angove or Goodga systems, is known to occur 10 km east in the Waychinicup River (Western Australian Museum records). In general terms the Albany District is an area of overlap for a number of Western Australian freshwater fishes. The western or eastern limit of the distribution of *Galaxias maculatus*, *Galaxias occidentalis*, *Galaxias truttaceus*, *Galaxiella munda*, *Galaxiella nigrostriata*, *Bostockia porosa* and *Nannatherina balstoni* is either Two Peoples Bay or the Albany District (Coy 1979; Allen 1982, 1989).

Comparisons with other studies of inland fish populations in south-western Australia suggest there are substantial numbers of fish in the Angove and Goodga systems. However, the collections made so far indicate the species are not atypical of the south coastal streams west of Albany (Christensen 1982), or those of the Swan Coastal Plain and northern jarrah forest in the vicinity of Perth (Sarti and Allen 1978; Pusey *et al.* 1989).

6 G. Power, Murdoch University; Research Assistant on the Lamprey Research Grant; Past President of the West Australian Trout and Freshwater Angling Association.

This table should probably face outward.

Table 14.3

Known distribution of indigenous inland fishes in the Goodga and Angove River systems, and some relevant comparisons in the near vicinity.
*Principle and Secondary species after Allen (1982). ? Possibility of these species occurring.

Scientific Name	Common Name	Kalgan River	Goodga River	Moates Lake	Gardner Lake	Angove System	Gardner Creek	Waychinicup River
	*Principle Species							
Galaxiidae	**Minnows**							
Galaxias maculatus Jenyns	Spotted Minnow or Common Jollytail		x	x	x	x	x	
Galaxias occidentalis Ogilby	Western Minnow	x						x
Galaxias truttaceus Valenciennes	Spotted Mountain Trout or Trout Minnow		x					
Percichthyidae	**Australian Perches**							
Bostokia porosa Castelnau	Nightfish	x						
Kuhliidae	**Pygmy Perches**							
Edelia vittata Castelnau	Western Pygmy Perch		x			x		x
Nannatherina balstoni Regan	Balston's Pygmy Perch		x					
	*Secondary Species							
Geotriidae	**Lampreys**							
Geotria australis (Gray)	Pouched Lamprey	x	?			?		x
Atherinidae	**Hardyheads**							
Atherinosoma wallacei Prince, Ivanstoff and Potter	Hardyhead	x			x	x	x	
Mugilidae	**Mullets**							
Aldrichetta forsteri (Valenciennes)	Yellow-eye Mullet	x			x	x	x	
Mugil cephalus Linnaeus	Sea Mullet	x			?		?	
Gobiidae	**Gobies**							
Pseudogobius olorum (Sauvage)	Swan River Goby	?	x	x	x	x	x	?
Sparidae	**Snappers**							
Mylis butcheri Munro	Black Bream	x		x	x		x	

Table 14.4
Known distribution of introduced fishes in river systems east of Albany.
(? Possibility of these species occurring.)

Scientific Name	Common Name	Kalgan River System	Goodga River System	Angove River System	King Creek	Waychinicup River
Salmonidae	**Salmon and Trout**					
Salmo trutta Linneaus	Brown Trout	x			x	
Oncorhynchus mykiss Richardson	Rainbow Trout	x	?	?	x	x
Percidae	**True Perches**					
Perca fluviatilis Linneaus	Redfin Perch	x	?			
Poccillidae	**Live Bearers**					
Gambusia affinis (Baird & Girard)	Mosquito Fish	x				

Introduced Species: Several introduced species of fish are known to occur in streams and rivers of the Albany area: Rainbow Trout (*Oncorhynchus mykiss*), Brown Trout (*Salmo trutta*), Redfin Perch (*Perca fluviatilis*) and Mosquito Fish (*Gambusia affinis*) (Table 14.4; Lenanton 1974). Both species of trout maintain self-sustaining populations in King Creek and *O. mykiss* occurs in the Waychinicup River (G. Power, personal communication). The Kalgan River contains *O. mykiss* and *P. fluviatilis* and is one of only three river systems along the south coast where *G. affinis* has been recorded (Lenanton 1974). Although there are no confirmed records of these species from the drainage systems of Two Peoples Bay, local legend claims that both trout and *P. fluviatilis* are occasionally seen breaking the surface of Moates Lake (D. Wilson and A. Annandale[7], personal communication), giving reason to believe that several of the species may occur.

Oncorhynchus mykiss were introduced to the Two Peoples Bay area in 1913 when the Acclimatization Committee of Western Australia allocated the species for waters east of Albany. In 1915 the Committee `Resolved to send English Perch to Albany to stock the stream supplying water to the town [Angove River], owing to trout being unavailable.' In July 1916 the Committee sought 500 yearling *O. mykiss* from Ballarat `...to release at Willyung and Two Peoples Bay creeks in the Albany district...'[8].

During the 1950s and 60s trout were released at regular intervals into the local streams, dams and lakes by the Albany, Denmark and Plantagenet Acclimatisation Society, which functioned between 1955 and 1964 (Coy 1979 and A. Annandale, personal communication). This practice ceased in the Angove and Goodga systems after the Reserve was gazetted in 1967 (A. Annandale, personal communication).

Aquatic Invertebrates

Qualitative samples of the aquatic invertebrate fauna of the major flowing (Angove and Goodga Rivers, West and Websters Gullies) and standing (Angove, Gardner and Moates Lakes) waterbodies in the Two Peoples Bay area were taken in early June 1990. The location of each sampling site is shown in Figure 14.1. All major habitats at each site (i.e. water column, submerged and emergent macrophytes, leaf litter, submerged wood, organic deposits, sand/gravel beds, cobbles and bedrock) were sampled by hand and with pond nets with the aim of maximising the number of taxa collected.

A total of 117 taxa of invertebrates were collected (Table 14.5). Sixty-two taxa occurred in flowing water with 49 in the two `lowland' rivers and 33 in the two headland streams. Thirty-six taxa were taken from the Angove River, with 25, 23 and 26 taxa taken from the Goodga River, West and Websters Gullies respectively. Eleven per cent of the fauna was common to all four sites while 22 per cent was recorded only from the two headland streams and 52 per cent was restricted to the two lowland rivers.

7 A. Annandale. Albany; local representative for the West Australian Trout and Freshwater Angling Association.

8 Acclimiatization Committee of Western Australia (1916), Unpublished Minute Books of Meetings, vol 2 (1903-1918). Accession 161; A/N 254/1, Battye Library, Perth.

Detailed published information on the invertebrate fauna of flowing waters of south-western Australia is restricted principally to studies from the northern jarrah forest and Swan Coastal Plain, near Perth. This limits the comparisons that may be made between the aquatic fauna of the Two Peoples Bay area and other parts of the south-west. Even so, all taxa recorded in flowing water at Two Peoples Bay, with the exception of the tipulid larva ?*Pedicia* sp. A, have been previously recorded from upland streams of the northern jarrah forest or lowland rivers of the Swan Coastal Plain (Bunn *et al.* 1986; Storey and Edward 1989; Storey *et al.* 1990).

All the known major components of the aquatic invertebrate fauna of south-western Australian flowing waters were represented in the rivers and streams of Two Peoples Bay. The absence of decapod Crustacea from the headland streams may reflect an absence of suitable habitats, since these streams were fast flowing, possessed few large pools, had small accumulations of organic matter and a coarse substratum. The lowland rivers were slow-flowing, comprised of large deep pools, exhibited large accumulations of fine organic matter and supported large populations of decapods.

Values for species richness at each site (23-36 taxa) were generally higher than reported by Bunn *et al.* (1986) for winter samples from ten perennial sites in the Wungong and North Dandalup catchments (18-26 taxa). However, the higher values may be merely the result of different sampling methods, particularly since Bunn *et al.* (1986) sampled only riffle zones, whereas the present study sampled all major habitats.

Seventy-two taxa were collected from standing water with 45 taxa occurring in Gardner Lake, 41 in Angove and 32 in Moates Lake (Table 14.5). Twenty-one per cent of the fauna was common to all three lakes.

The lakes contained high numbers of taxa compared with most freshwater wetlands in south-western Australia. Thomsons Lake, the most species-rich wetland studied on the Swan Coastal Plain, supported 60 taxa (Davis and Rolls 1987) compared with 45 taxa from Gardner Lake. The greatest number recorded in a single survey of Thomsons Lake, however, was 39[9].

Thirty taxa were recorded in one survey of Shark Lake near Esperance; 24 and 17 taxa, respectively, were recorded in single-site sampling of Lakes Wilson and Jasper, east of Augusta.[10] The only wetland from which more taxa have been recorded in one survey than Gardner Lake is Tordit-Gurrup Lagoon near Lake Muir (52 taxa in December, DeHaan 1987).

The qualitative sampling was sufficiently standardized to show that Gardner Lake contained the greatest biomass of invertebrates and Moates Lake the least, although biomass in all three lakes was low compared with many wetlands in agricultural parts of the Swan Coastal Plain.[11] None of the lakes contained many benthic animals. Chironomids and ostracods, both of which are abundant in most nutrient-enriched lakes, occurred in very low numbers.

Several species with marine affinities (e.g. *Gladioferans imparipes* and *Schizopera clandestina*) occurred in Gardner Lake, reflecting the fact that the lake is seasonally connected to the sea. The occurrence of the harpacticoid copepod *S. clandestina* is of special interest; it is the first time this west European species has been recorded in the southern hemisphere (R. Hamond[12], personal communication).

It is likely that additional taxa of freshwater invertebrates, especially beetles and chironomids, would be recorded from these systems if the survey were repeated in summer. The predictable climate of south-western Australia has resulted in the aquatic fauna of forested streams developing synchronized life-cycles (Bunn 1988), which have given rise to distinct differences between the fauna in winter/spring as opposed to summer/autumn (Storey *et al.* 1990). The pattern probably applies to most water bodies of south-western Australia.

Introduced species: According to Morrissy (1978) marron (*Cherax tenuimanus*) are not indigenous to the drainage systems of Two Peoples Bay. He reports Fisheries Inspector Goodlad stating in 1939: `There are places just outside Albany where marron have been put in by private persons...Angove Creek for instance' and was told of another translocation from waters west of Albany into Moates Lake in about 1940. Although marron are now abundant in the Goodga River and Moates Lake the average size caught by marroners

9 Davis and Rolls (1987) did not identify copepods and cladocerans beyond the level of Order, which reduced the number of taxa they recorded.

10 S.A. Halse and G.B. Pearson unpublished data.

11 A.W. Storey and S.A. Halse, unpublished data.

has been decreasing over recent years, most likely as the result of fishing pressure (N. Morrissy[13], personal communication).

The introduced yabby *Cherax destructor* is not yet evident in the waters of the Reserve but has reputedly been released into nearby farm dams (D. Wilson, personal communication). In the long term this species, with its greater fecundity and environmental tolerance, could replace the indigenous freshwater crayfishes of the Reserve (Lake and Sokol 1986; N. Morrissy, personal communication). According to Morrissy most farmers in the region are unaware of the animals' introduced status and misname it as the endemic koonac (*C. plebejus* or *C. preisii*).

CONCLUSIONS

The aquatic ecosystems of Two Peoples Bay are important natural features of the area. All three drainage systems are relatively undisturbed, especially the streams on Mt Gardner headland, and therefore provide benchmark data on water chemistry, vegetation and fauna for streams on the south coast of Western Australia, many of which are disturbed.

Angove, Gardner and Moates Lakes support a moderate diversity but low numbers of waterbirds. The lakes and streams contain relatively high numbers of species of aquatic invertebrates, although additional surveys are required to compile a complete species list. As the area is an overlap zone for freshwater fish populations further investigations are necessary to ascertain accurate boundaries of species distributions. The status of *Galaxias truttaceus* and *Nannatherina balstoni*, in particular, require clarification because the Angove and Goodga drainage systems may provide a refuge if these species are endangered in other catchments.

The greatest threat to the aquatic invertebrate and fish faunas of these drainage systems would be a reduction in water quality or quantity. At present, water quality in the Angove and Goodga Rivers appears relatively unaffected by agricultural clearing. It may decline, however, with further land clearing or intensified agricultural activities in the catchments. Agricultural development has increased salinity levels in the adjacent Kalgan River, Waychinicup River and King Creek catchments (Schofield *et al.* 1988). The downstream effect of extractions from the pipehead dam on the Angove River was not investigated.

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Table 14.5

Physicochemical data and aquatic invertebrates collected from streams, rivers and lakes of the Two Peoples Bay area on 7-8 June 1990 (see Fig. 14.1 for locations of collecting sites). Total phosphorus values are the mean of samples collected two-monthly between July 1984 and May 1985 by J.A.K. Lane and D.R. Munro.

	Angove River	Goodga River	West Gully	Websters Gully	Angove Lake	Gardner Lake	Moates Lake
A. PHYSICOCHEMICAL DATA							
Depth (m)	0.5	0.4	0.4	0.3	1.8	2.6	4.4
Salinity (ppt TDS)	0.24	0.56	0.44	0.18	0.58	0.88	0.47
pH	5.9	6.3	6.5	6.8	6.8	7.6	6.7
Temperature (°C)	13.1	11.4	10.8	11.4	13.3	10.7	11.5
Dissolved Oxygen (% sat.)	72	96	93	93	96	100*	96
Total Phosphorus (mg/l)					0.03	0.02	0.03
*23 % in flooded *Melaleuca* woodland near Gardner Creek							
B. AQUATIC INVERTEBRATES							
NEMATODA					x	x	x
MOLLUSCA							
GASTROPODA							
PULMONATA							
Ancylidae							
Ferrissia petterdi (Johnston)	x	x		x			x
Planorbidae							
Physastra sp. A						x	
ANNELIDA							
OLIGOCHAETA	x	x	x	x	x	x	x
ARTHROPODA							
ARACHNIDA							
ORIBATIDA					x	x	x
HYDRACARINA							
Oxidae							
Flabellifrontipoda sp. A	x						
Oxus sp. A					x	x	x
Unionicolidae							
Koenikea sp. A						x	
Hygrobatidae							
Corticarus sp. A		x					
Halacaridae							
Halacaridea sp. A						x	
CRUSTACEA							
CLADOCERA							
Chydoridae							
Biapertura cf. *rigidicaudis* Smirnov						x	
Biapertura cf. *affinis* (Leydig)							x
Dunhevedia crassa King						x	
cf. *Pleuroxus* sp. A					x		x
Euryalona cf. *orientalis* (Daday)					x		
Macrothricidae							
Macrothrix breviseta Smirnov					x		
Daphniidae							
Simocephalus sp. A						x	

Table 14.5 (*continued*)

	Angove River	Goodga River	West Gully	Websters Gully	Angove Lake	Gardner Lake	Moates Lake
Bosminidae							
Bosminia meridionalis Sars						x	x
?*Bosminia* sp. B						x	
OSTRACODA							
Ostracoda sp 262						x	
Cyprididae							
Cypretta sp. A				x	x		
Ilyodromus sp. A			x				
Kennethia cristata De Deckker					x	x	x
Alboa worooa DeDeckker (259)						x	
Darwinulidae							
?*Darwinula* sp. A					x		
Limnocytheridae							
Gomphodella aff. *maia* DeDeckker					x		x
Limnocythere mowbrayensis Chapman						x	
Candonidae							
Candonopsis tenuis (Brady)					x	x	
COPEPODA							
Centropagidae							
Calamoecia attenuata (Fairbridge)					x		x
Calamoecia tasmanica subattenuata (Fairbridge)					x	x	x
Gladioferens imparipes Thomson						x	
Cyclopidae							
Microcyclops sp. A					x	x	x
Mesocyclops sp. A					x	x	x
Paracyclops sp. A					x	x	x
Canthocamptidae							
Canthocamptidae sp. A					x		x
Onychocamptus chathamensis					x		x
Schizopera clandestina (Klie)						x	
Nitocra sp. A							x
DECAPODA							
Parastacidae							
Cherax plebejus (Hess)	x	x				x	
Cherax quinquecarinatus (Gray)	x				x		
Cherax tenuimanus (Smith)	x	x			x		
Palaemonidae							
Palaemonetes australis Dakin		x			x	x	x
AMPHIPODA							
Ceinidae							
Austrochiltonia subtenuis Hurley					x	x	x
Gammaridae							
Perthia branchialis (Nicholls)	x				x		
Perthia acutitelson Straskraba		x					
Uroctena setosa Nicholls			x				
Corophiidae							
cf. *Erichthonius* sp. A						x	

Table 14.5 (*continued*)

	Angove River	Goodga River	West Gully	Websters Gully	Angove Lake	Gardner Lake	Moates Lake
INSECTA							
COLLEMBOLA					x	x	x
MEGALOPTERA							
Chauliodidae							
Archichauliodes cervulus Theischinger	x						
DIPTERA							
Simuliidae							
Cnephia tonnoiri tonnoiri Drummond	x	x	x	x			
Austrosimulium furiosum (Skuse)	x	x					
Culicidae							
Aedes sp. A						x	
Culex globocoxitus Dobrotworsky						x	
Chironomidae							
Tanypodinae							
Paramerina levidensis (Skuse)			x	x		x	x
Macropelopia dalyupensis (Freeman)					x		
Macropelopia sp. V9	x						
?*Ablabesmyia* sp. V10	x						
Orthocladiinae							
Corynoneura ?scutellata Winnertz						x	
Cricotopus annuliventris (Skuse)	x	x	x	x			
Stictocladius uniserialis Freeman		x					
Nanocladius sp. VCD7							x
Thienemanniella sp. V19	x	x	x	x			
Limnophyes pullulus (Skuse)				x	x	x	x
?*Limnophyes* sp. V31	x						
Orthocladiinae sp. V11	x	x		x			
Orthocladiinae sp. VTPB1					x	x	
Orthocladiinae sp. V59	x						
Orthocladiinae sp. A					x	x	
Chironominae							
Polypedilum sp. V3	x		x	x	x		x
Polypedilum sp. V33	x			x			
Riethia sp. V4	x	x					
Riethia sp. V5	x		x				
Tanytarsus sp. V6	x	x	x	x	x		x
Stempellina ?australiensis Freeman	x		x				
?*Paratendipes* sp. V12	x						
Rheotanytarsus sp. V18		x					
Cryptochironomus griseidorsum Kieffer		x					x
Stenochironomus sp. V27	x						
Tanytarsini sp. A						x	x
Tipulidae							
Limoniinae sp. A			x	x		x	
Limoniinae sp. B			x	x			

Table 14.5 (*continued*)

	Angove River	Goodga River	West Gully	Websters Gully	Angove Lake	Gardner Lake	Moates Lake
Tipulinae sp. A			x				
?*Pedicia* sp. A			x	x			
Ceratopogonidae							
Ceratopogonidae sp. A	x		x	x			
Ceratopogonidae sp. B		x		x	x	x	x
Ceratopogonidae sp. C						x	
Ceratopogonidae sp. D							x
Stratiomyidae							
Stratiomyidae sp. A						x	
Dolichopodidae							
Dolichopodidae sp. A					x		
ODONATA							
ZYGOPTERA							
Coenagrionidae							
Ischneura sp. A					x	x	
ANISOPTERA							
Aeschnidae							
Austroaeschna anacantha Tillyard	x	x	x	x			
Cordulidae							
Cordulidae sp A (immature)	x						
Gomphidae							
Austrogomphus collaris Hagen		x					
Libellulidae							
Diplacodes haematodes (Burmeister)					x		
Synthemidae							
Synthemis macrostigma occidentalis Tillyard				x			
HEMIPTERA							
Veliidae							
Veliidae sp. A					x		
Corixidae							
Micronecta robusta Hale					x		
EPHEMEROPTERA							
Leptophlebiidae							
Nyungara bunni Dean	x						
Bibulmena kadjina Dean		x	x	x			
Caenidae							
Tasmanocoenis tillyardi (Lestage)		x			x		
PLECOPTERA							
Gripopterygidae							
Newmanoperla exigua (Kimmins)		x					
Gripopterygidae sp. A (immature)			x				
TRICHOPTERA							
Hydropsychidae							
Smicrophylax australis (Ulmer)	x	x					
Ecnomidae							
Ecnomina scindens/trulla/merga group	x						
Ecnomus pansus/turgidus complex		x	x				

Table 14.5 (*continued*)

	Angove River	Goodga River	West Gully	Websters Gully	Angove Lake	Gardner Lake	Moates Lake
Leptoceridae							
Condocerus aptus Neboiss	x			x			
Lectrides parilis Neboiss	x		x	x			
Triplectides sp. A	x						
Triplectides australis Navas					x	x	x
Hydroptilidae							
Oxyethira retracta Wells	x						
Maydenoptila ?rupina Neboiss		x					
Hydrobiosidae							
Taschorema pallescens (Banks)	x	x	x	x			
COLEOPTERA							
Dytiscidae							
Lancetes lanceolatus (Clark)					x	x	
Liodessus dispar (Sharp)						x	
Megaporus howitti (Clark)					x		
Necterosoma darwini (Babington)				x			
Rhantus suturalis (MacLeay)				x			
Sternopriscus browni Sharp							x
Helodidae							
Helodidae sp. A			x	x		x	
Number of Species	36	27	23	26	41	45	32

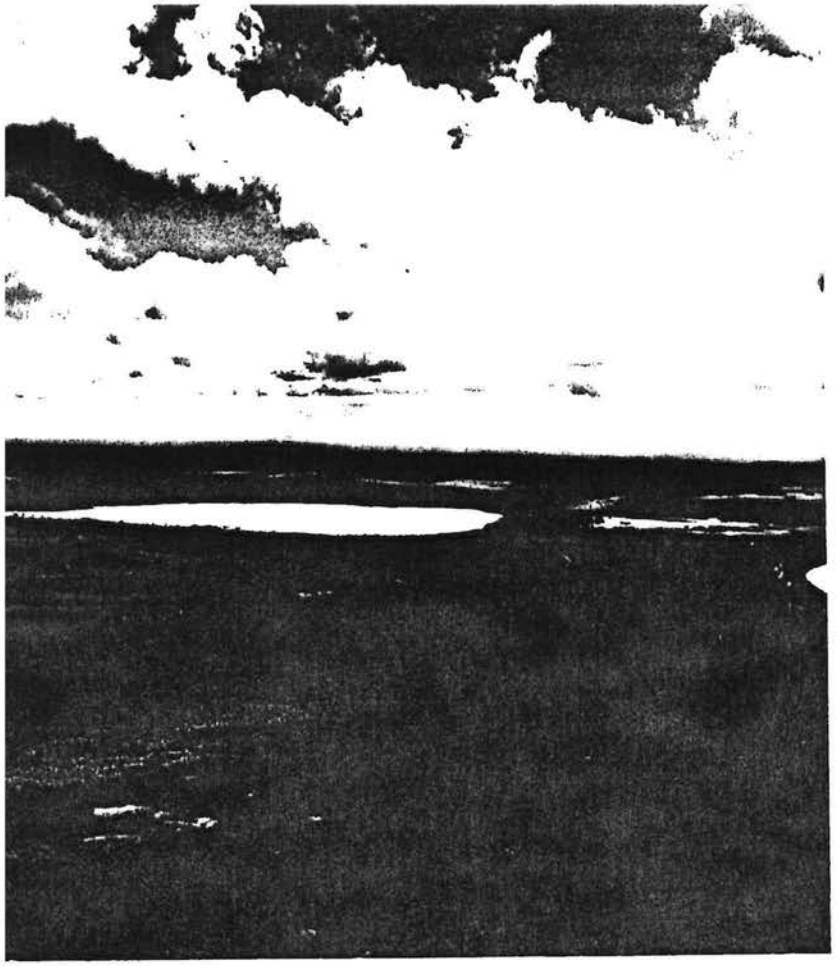

Fig 11.2(a)

Fig 11.2b.

11.2

Fig 11.2

CHAPTER 15

Terrestrial Vertebrate Fauna

G.T. Smith and L.A. Moore

INTRODUCTION

The first recorded systematic observations on the vertebrates in the Two Peoples Bay area were made by the late D.L. Serventy[1], who spent two weeks in the area in January 1935. The majority of his observations were on birds, with only a small number of observations on the other taxa; his notes were not published.

Following the creation of the Reserve in 1966, a survey party from the Western Australian Museum visited the Reserve in February 1970. Their unpublished report[2] gave an account of the vertebrates (excluding birds) found during the survey, as well as those previously recorded from the Reserve. Hopper (1981) reported the results of a pitfall trapping survey for the Honey possum (*Tarsipes rostratus*) in various areas of the Reserve, as well as updating the lists of non-avian vertebrates. The vertebrates of Coffin Island are listed by Smith and Kolichis (1980).

The aim of the present article is to present an account of the land vertebrates on the Reserve using previously published material and our own data from the period 1970 to 1988.

METHODS

The data on the vertebrates were obtained during 1000 person days spent on the Reserve in the period 1970-1983. Most of this time was spent on the Mt Gardner headland during 1970-76. Other areas (see below) were visited at least once each month at some time during the study. The swamp complexes around the lakes were the least visited areas. No systematic surveys were made on any group, however, observation on the birds were made throughout the study. Observations on the other groups were made as the opportunity arose.

Where the data are available, the habitat, distribution within the Reserve, abundance, status and breeding data are given for all species. The distribution is given in terms of the five major habitat complexes on or adjacent to the Reserve. These are:

Mt Gardner headland (area 1), isthmus area (area 2), between the lakes area and western boundary area (area 3), plateau area (area 4), and `Tandara' farm (area 5). The distribution of these areas are shown on Figure 1.4 in this publication. Detailed information on the landforms, soils and vegetation in these areas are given in chapters 5 and 10. Abundance is given in terms of very common, common, uncommon and rare. These terms are a subjective ranking of the apparent abundance of the species on the Reserve. Status is given in terms of resident (species present throughout the year), regular breeding visitor, regular visitor (non-breeding), uncommon visitor and vagrant.

ANNOTATED SPECIES LISTS

The scientific and common names used in this chapter follow Royal Australasian Ornithologists Union 1978 (Birds), Strahan 1983 (Mammals), Tyler *et al.* 1984 (Amphibians), Cogger 1986, Storr *et al.* 1981, 1983, 1986 (Reptiles).

Birds

In addition to those birds recorded during the period 1970 to 1983, the birds recorded by Serventy are marked with an asterix (*). Serventy's observations were made in the area bounded by the Two Peoples Bay beach, Mt Manypeaks, the pumping station on the Goodga

1 D.L. Serventy, Research Scientist, CSIRO, Perth WA (deceased).

2 J. Bannister, Report on a biological survey, Two Peoples Bay Nature Reserve (No. 27956), Unpublished Report, Western Australian Museum, Perth, 1970.

River, Moates Lake and Little Beach. Most of the observations were made in the vicinity of his camp at the northern end of Two Peoples Bay beach.

PODICIPEDIDAE

Podiceps cristatus Great Crested Grebe

See chapter 14 for details.

Poliocephalus poliocephalus Hoary-headed Grebe

Recorded only in April and May on Moates Lake and Gardner Lake. Status unknown.

Tachybaptus novaehollandiae Australasian Grebe

Recorded only in April and May on Moates Lake and Gardner Lake. Status unknown.

SPHENISCIDAE

Eudyptula minor Little Penguin

There is a small breeding population on Coffin Island (Smith and Kolichis 1980). Lane (1984) found eight occupied burrows with adults on eggs, small chicks and two large nestlings, during visits in October 1981 and November 1982.

Eudyptes chrysocome Rockhopper Penguin

One immature bird found on Two Peoples Bay beach on 30 August 1977 (Baker 1978).

DIOMEDEIDAE

Diomedea exulans Wandering Albatross

One observed off Cape Vancouver in December 1975.

*Diomedea melanophrys** Black-browed Albatross

A few birds seen throughout the year.

Diomedea chlororhynchos Yellow-nosed Albatross

Observed off-shore from April to October. Often seen feeding between False Island and Black Rock. About 300 birds in three rafts were seen near Inner Island at midday on 14 June 1972.

PROCELLARIIDAE

Macronectes giganteus Southern Giant Petrel

Occasional birds seen off-shore during the winter, rarely seen in summer.

Pterodroma macroptera Great-winged Petrel

A breeding bird on Coffin Island, 2000-3000 birds have been seen over the island at dusk in early winter (Smith and Kolichis 1980). Lane (1984) banded 41 nestlings on the island on 4 October 1981 and 92 nestlings on 5 November 1982.

*Puffinus carneipes** Flesh-footed Shearwater

There is a small breeding population on Coffin Island (Smith and Kolichis 1980).

Puffinus assimilis Little Shearwater

One freshly-dead adult was found on Coffin Island on 20 November 1978. On 7 October 1975 one bird was observed flying between the coast and Coffin Island (G. van Tets[3], personal communication). Lane (1984) found a large nestling, almost ready to depart on 5 November 1982.

*Puffinus tenuirostris** Short-tailed Shearwater

E.D. Kabay[4] (personal communication) found a skeleton of this species at Rocky Point.

PELECANIDAE

Pelecanus conspicillatus Australian Pelican

Single birds were seen flying across Gardner Lake in January 1975 and January 1977.

SULIDAE

Morus serrator Australasian Gannet

Single birds recorded off Cape Vancouver in July 1975 and April 1980. On 8 June 1981, A. Danks recorded 12 to 15 birds fishing close to

3 G. Van Tets, Research Scientist, CSIRO Division of Wildlife and Ecology, Canberra ACT.

4 E.D. Kabay, Scientist, Alcoa of Australia, Booragoon WA.

Little Beach (G.L. Folley,[5] personal communication).

ANHINGIDAE

Anhinga melanogaster Darter

One bird recorded on Moates Lake on 7 October 1985.

PHALACROCORACIDAE

Phalacrocorax carbo Great Cormorant

An uncommon visitor to area 3.

*Phalacrocorax varius** Pied Cormorant

Recorded by Serventy in January 1935.

Phalacrocorax sulcirostris Little Black Cormorant

An uncommon visitor to area 3.

Phalacrocorax melanoleucos Little Pied Cormorant

Lone birds seen during most months around Moates Lake and Gardner Lake. Status unknown.

ARDEIDAE

*Ardea novaehollandiae** White-faced Heron

A common visitor to the lakes and streams of area 3 and occasionally seen in the adjacent farm lands. Usually alone, but may be in groups of up to five. On one occasion 14 were seen on the edge of Gardner Lake, eight months after the fringing vegetation had been burnt in April 1970.

Egretta alba Great Egret

An uncommon visitor to the lakes and streams from January to August. Usually single birds, but occasionally in groups of two or three.

Ixobrychus minutus Little Bittern

One bird recorded in a swamp between Moates Lake and Gardner Lake on 16 September 1975. A number of birds were recorded in this area in 1988. Status unknown.

Botaurus poiciloptilus Australasian Bittern

See chapter 14 for details.

PLATALEIDAE

Threskiornis aethiopica Sacred Ibis

See chapter 14 for details.

Threskiornis spinicollis Straw-necked Ibis

See chapter 14 for details.

Platalea regia Royal Spoonbill

One bird seen in a paddock near Angove Lake on 13 August 1971.

Platalea flavipes Yellow-billed Spoonbill

See chapter 14 for details and Fig. 14.9 this publication.

ANATIDAE

Cygnus atratus Black Swan

Regular visitor, as single birds or in groups of up to 12 birds. Mainly recorded on Gardner Lake, with only a few observations on Moates Lake.

Tadorna tadornoides Australian Shelduck

An uncommon visitor to areas 3 and 5. Only recorded in February, May and August.

Anas superciliosa Pacific Black Duck

An uncommon visitor from March to September in area 3 and Two Peoples Bay beach.

Anas gibberifrons Grey Teal

Five birds recorded on the beach at the bottom of West Gully, 25 November 1971.

Anas rhynchotis Australasian Shoveler

See chapter 14 for details.

Chenonetta jubata Maned Duck

Regular breeding visitor in area 5 from May to December. Adults with young recorded in December.

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5 G.L. Folley, retired Reserve Officer, at Two Peoples Bay Nature Reserve (1978-85).

Oxyura australis Blue-billed Duck

See chapter 14 for details.

Biziura lobata Musk Duck

Regular visitor from January to July in area 3.

PANDIONIDAE

*Pandion haliaetus** Osprey

Uncommon visitor to area 1 during the winter. The one or two birds sighted were probably the breeding pair that had a nest near the bridge at Lower Kalgan during the years of the study. G.L. Folley (personal communication) reported that a pair may have taken up residence in Webster Gully in 1981.

ACCIPITRIDAE

Elanus notatus Black-shouldered Kite

Single birds were present in Tick Flat from May to September 1973 and in May and June 1976. G.L. Folley (personal communication) found a pair nesting near the homestead on Tandara (area 5) in September 1979. A pair were seen in the same area in October 1981.

Lophoictinia isura Square-tailed Kite

Single birds were recorded at Tick Flat in October 1975 and from May to October 1976 (Fig. 15.1).

Haliastur sphenurus Whistling Kite

A regular visitor in area 1.

Accipiter fasciatus Brown Goshawk

One resident pair in area 1 from 1971 to 1975.

Accipiter cirrhocephalus Collared Sparrowhawk

A bird was recorded in area 1 from May to November 1976.

Haliaeetus leucogaster White-bellied Sea-Eagle

One resident pair in area 1 from 1970 to 1980. In 1971 the pair nested in a large marri *(Eucalyptus calophylla)* in Robinson Gully. The pair were seen incubating from 22 August to 14 September. When the nest was investigated on 18 September only the remnants of broken eggs were found. The pair had a feeding site on the raised bank of a fire-break, which overlooked the nest, some 200 m away. Food items found on this bank included Crested Tern *(Sterna bergii)*, Bobtail *(Tiliqua rugosa)*, Long-necked Tortoise *(Chelodina oblonga)*, King's Skink *(Egernia kingii)* and unidentified fish remains. One bird was also observed taking a mammal, probably the Southern Brown Bandicoot *(Isoodon obesulus)* to the nest. Single birds have been sighted hunting over Gardner Lake. In 1972 the pair made a new nest in Gardner Gully, with a feeding roost in a tall eucalypt in an adjacent gully (Fisherman Gully) which overlooked the nest. This nest continued to be used until at least 1983 (Fig. 15.2).

Aquila audax Wedge-tailed Eagle

One or two adult birds, occasionally accompanied by immature birds, were regular visitors to area 1. The adult birds were often observed to fly directly towards Reservoir Hill, some 10 km to the north-west, where there was an eyrie which was still being used in 1982 (G.L. Folley, personal communication).

Hieraaetus morphnoides Little Eagle

One resident pair in area 1 from 1974 to 1977 and in 1982. Lone birds occasionally seen in areas 2 and 3.

Circus assimilis Spotted Harrier

Uncommon winter visitor in most years, although commonly seen in the farmlands to the west of the Reserve.

Circus aeruginosus Marsh Harrier

One resident pair in area 3 from 1971 to 1976 and in 1980/81. Single birds occasionally seen in area 1 and over Coffin Island (Fig. 14.10 this publication).

FALCONIDAE

Falco subniger Black Falcon

Two birds seen along road near Gardner Lake, 5 May 1976.

Falco peregrinus Peregrine Falcon

One resident pair in Webster Gully from 1970 to 1976.

Gazetted rare species (Fig. 15.3).

Falco longipennis Australian Hobby

A single bird seen occasionally in area 1 from 1970 to 1972.

*Falco berigora** Brown Falcon

One resident pair in area 1 from 1970-1976, and possibly another near the picnic area. Occasional observation of single birds have been made in area 5 from 1970 to 1982.

*Falco cenchroides** Australian Kestrel

One resident pair in Tick Flat from 1970 to 1976. Uncommon throughout the Reserve.

PHASIANIDAE

*Coturnix australis** Brown Quail

Uncommon visitor in areas of heath in areas 1 and 2 from January to September. Two adults with four young recorded in Tick Flat, 16 April 1976. G.L. Folley (personal communication) reported seeing groups of up to eight adults and young birds from February to July 1981. Status uncertain.

Coturnix novaezelandiae Stubble Quail

Uncommon visitor to the open heath areas of area 2 from February to September.

TURNICIDAE

Turnix varia Painted Button-quail

Two birds recorded in Tick Flat, in heath, 24 September 1975.

RALLIDAE

Porzana tabuensis Spotless Crake

Uncommon resident in the swamps of areas 1 and 3, status unknown.

Porphyrio porphyrio Purple Swamphen

Occasional sightings around Moates Lake, status unknown.

Fulica atra Eurasian Coot

Regularly seen on Gardner Lake, status unknown (Fig. 15.4).

HAEMATOPODIDAE

Haematopus longirostris Pied Oystercatcher

Uncommon visitor to Two Peoples Bay beach and Little Beach.

*Haematopus fuliginosus** Sooty Oystercatcher

Uncommon resident. Breeds on Coffin Island (Smith and Kolichis 1980).

CHARADRIIDAE

Vanellus tricolor Banded Lapwing

Uncommon in the adjacent farm lands from May to August. Two adults with three non-flying young recorded, 14 August 1975 (Fig. 15.5).

Pluvialis squatarola Grey Plover

See chapter 14 for details.

Erythrogonys cinctus Red-kneed Dotterel

See chapter 14 for details.

*Charadrius rubricollis** Hooded Plover

Rare on Two Peoples Bay beach from January to March. One family party seen in January 1976 and by G.L. Folley (personal communication) in February 1982. Status unknown.

Charadrius ruficapillus Red-capped Plover

Rare on Two Peoples Bay beach, status unknown.

*Charadrius melanops** Black-fronted Plover

Rare breeding visitor, seen along main road from July to November. Nests with eggs found on road in August 1971 and 1972. Pair recorded on small beach on Moates Lake on 2 March 1981 (G.L. Folley, personal communication).

Peltohyas australis Inland Dotterel

One bird recorded flying west over the picnic area, 6 September 1975.

SCOLOPACIDAE

Tringa hypoleucos Common Sandpiper

One bird recorded on Two Peoples Bay beach in January 1975 and by G.L. Folley (personal communication) on 21 November 1981.

*Tringa nebularia** Greenshank

One bird recorded by D.L. Serventy on shore of Gardner Lake in January 1935.

Calidris ruficollis Red-necked Stint

One bird recorded on Two Peoples Bay beach in January 1979.

STERCORARIIDAE

Stercorarius skua Great Skua

Uncommon visitor to surrounding sea in June and July.

LARIDAE

*Larus novaehollandiae** Silver Gull

A resident bird, breeding on Coffin Island (Smith and Kolichis 1980). On 4 October 1981, J. Lane recorded 60 adults with breeding stages varying from new nests to young that had recently left the nest (Lane 1984). Flocks of up to 60 birds have been recorded on the beaches or islands near the coast.

*Larus pacificus** Pacific Gull

Rare resident, one nest found on Coffin Island in 1979 (Smith and Kolichis 1980). Lane (1984) recorded five adults.

Larus dominicanus Kelp Gull

Two on rock stack near False Island 28 July 1983.

Chlidonias hybrida Whiskered Tern

See chapter 14 for details.

*Hydroprogne caspia** Caspian Tern

Uncommon visitor, recorded only between June and October. However, Lane (1984) found a nest with one egg on Coffin Island on 4 October 1981.

*Sterna nereis** Fairy Tern

A small flock was recorded by D.L. Serventy on the shore of Gardner Lake in January 1935.

Sterna bergii Crested Tern

Common visitor to beaches and offshore islands.

Sterna paradisaea Arctic Tern

Exhausted bird found on shore of Gardner Lake by G.L. Folley, 3 December 1984; it died the same day.

COLUMBIDAE

Phaps chalcoptera Common Bronzewing

Uncommon resident, recorded from areas 1 and 3.

Phaps elegans Brush Bronzewing

Common resident, especially in area 1. Lane (1984) found one on Coffin Island on 4 October 1981.

Ocyphaps lophotes Crested Pigeon

From August to October 1979 up to 10 birds were seen on the adjacent farm. In 1980 and 1981 two birds were seen on the farm in October and November respectively (G.L. Folley, personal communication). In 1982 small numbers were seen regularly in area 2 in the vicinity of a control burn patch.

CACATUIDAE

*Calyptorhynchus latirostris** Carnaby's Cockatoo

Regular visitor. Flocks of up to 150 birds have been seen throughout the year in area 1, where they appear to be attracted by the abundance of *Hakea elliptica*, and to a lesser extent by marri *(E. calophylla)* and *Dryandra sessilis* (Fig. 15.6).

LORIIDAE

*Glossopsitta porphyrocephala** Purple-crowned Lorikeet

Uncommon visitor to areas 1 and 3.

PLATYCERCIDAE

Purpureicephalus spurius Red-capped Parrot

Uncommon resident in areas 3 and 4 and rare visitor to area 1 and 2 in the period 1970 to 1977. In 1982 and 1983 they were commonly seen during autumn and winter in areas 1 and 2. They have been observed feeding on *Dryandra sessilis, Acacia cyclops, Hakea rustifolia* and *Oxolobium lanceolatum.*

Playtcercus icterotis Western Rosella

Uncommon resident in areas 1 and 3.

Barnardius zonarius Port Lincoln Ringneck

Vagrant, mainly observed along the main road on the boundary of the Reserve.

Neophema elegans Elegant Parrot

One bird recorded in area 1, June 1972

*Neophema petrophila** Rock Parrot

Uncommon resident. Usually only one or two birds seen, but flocks of up to 20 birds have been seen on Two Peoples Bay beach, also found in heath in areas 1 and 2 and on Coffin Island. Lane (1984) recorded about 30 on Coffin Island in October 1981 and 20 in November 1982.

CUCULIDAE

Cuculus pallidus Pallid Cuckoo

Regular winter visitor. In 1974 and 1975 the first birds were recorded on 18 June and 5 July respectively. The last bird recorded in 1975 was on 22 October.

Cuculus pyrrhophanus Fan-tailed Cuckoo

Some birds are present throughout the year, but most are found between May and November in all areas of the Reserve.

Chrysococcyx basalis Horsfield's Bronze-cuckoo

Common regular winter visitor between May and October. In 1975 and 1976 birds were present between 10 May to 22 October and 8 July to 27 October respectively.

*Chrysococcyx lucidus** Shining Bronze-cuckoo

Common regular visitor from August to November. In 1975 and 1976 birds were present from 9 August to 28 October and 11 August to 23 November respectively.

STRIGIDAE

Ninox novaeseelandiae Southern Boobook

Rarely found roosting in eucalypts in area 1. Status unknown.

Ninox connivens Barking Owl

One observed in *Hakea elliptica* patch, on Tick Flat, 26 July 1983.

TYTONIDAE

Tyto alba Barn Owl

One recorded in Tick Flat in August 1977. Status unknown.

PODARGIDAE

Podargus strigoides Tawny Frogmouth

Rare resident in areas 1 and 3. One nest found near picnic area in September 1970.

CAPRIMULGIDAE

Caprimulgus guttatus Spotted Nightjar

Uncommon, regular breeding visitor from May to January. In 1975 three nests were found on parallel ridges in area 1. All nests were small scrapes (10 x 7 cm) in gravel on the edge of bare granite outcrops. Two were under *Agonis marginata* shrubs, while the third was within 2 m of a shrub. Two of the eggs were laid in September while the third was laid in November. After hatching the juvenile birds stay with the adults near the nest site for two to three months. On two of the ridges, adults have been seen in the nest area from 1972 to 1977, and on one ridge consecutive nests were within 10 m of each other. On 21 December 1976 a bird was found incubating an egg, which it continued to do, until the egg was collected on 15 January 1977; the egg was empty. A bird killed on the Two Peoples Bay road on 5 January 1977 had a large brood patch.

APODIDAE

Apus pacificus Fork-tailed Swift

One bird recorded with a flock of Tree Martins and Welcome Swallows on 23 February 1972 in area 1. Another seen over area 1, 8 May 1984.

ALCEDINIDAE

Dacelo novaeguineae Laughing Kookaburra

An uncommon resident in area 5 and the picnic area. Lone birds are rarely seen in other areas of the Reserve, but have been common in area 2 after fires. Although present in Albany townsite in 1935 it was not recorded at Two Peoples Bay by Serventy at that time.

*Halcyon santa** Sacred Kingfisher

Uncommon regular visitor from March to October. Mainly seen along roads and firebreaks in areas 3 and 5. Only one sighting has been made in area 1. On 21 October 1975 a pair were observed cleaning out a hollow in a *Banksia littoralis* tree in area 3, in open woodland between vegetated sand dunes.

ATRICHORNITHIDAE

Atrichornis clamosus Noisy Scrub-bird

A common resident in area 1 and since 1975 it has expanded its distribution along Gardner Creek to the west end of Moates Lake. Mainly confined to the gullies and soakage lines of area 1 and the swamps and lake margins of area 3. Details on the biology are given in chapters 16 and 17. Gazetted rare species (Plate 20 this publication).

HIRUNDINIDAE

*Hirundo neoxena** Welcome Swallow

Common resident in all areas of the Reserve, seen in groups of up to 15 birds. Eggs laid from August to October (6 nests).

Cecropis nigricans Tree Martin

Uncommon visitor to areas 1, 2 and 3. Recorded from January to March and September and October. Group size ranges from 1 to 20.

MOTACILLIDAE

*Anthus novaeseelandiae** Richard's Pipit

A common resident in areas of open heath in area 2, along the road in area 5 and areas of low open heath in area 3. Invades areas of burnt heath, but becomes less common with the regrowth of the vegetation. May eventually be replaced by *Sericornis fuliginosus*.

CAMPEPHAGIDAE

*Coracina novaehollandiae** Black-faced Cuckoo-shrike

Uncommon resident in all areas, usually one or two birds, but groups of up to 12 may be seen in winter.

MUSCICAPIDAE

*Petroica multicolor** Scarlet Robin

An uncommon resident in the adjacent farmland, usually in and around the remaining patches of woodland or scrub. G.L. Folley (personal communication) recorded one male in the picnic area on 21 January 1982.

Melanodryas cucullata Hooded Robin

One bird recorded in area 2 on 26 April 1972.

Eopsaltria georgiana White-breasted Robin

A common resident in areas 1 and 3 where it lives in the gullies, drainage lines or around the margin of swamps. In area 1 most of the nests are built close to a stream and generally from 1-3 m above the ground in an open shrub or vine. The two eggs are laid from August to October with the peak in egg laying in September (eight of 13 clutches).

Mean egg sizes ($n=11$) were 20.9 x 15.6 mm (Ranges 20.3 - 21.4 x 15.0 - 16.0 mm).

*Eopsaltria griseogularis** Western Yellow Robin

Recorded by Serventy in January 1935. One bird was recorded in area 4 by A. Danks[6] on 15 July 1981 (G. Folley personal communication).

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6 A. Danks, Reserve Management Officer (CALM), Two Peoples Bay Nature Reserve.

Microeca leucophaea Jacky Winter

One bird recorded in open woodland in area 3 on 3 June 1975.

*Pachycephala pectoralis** Golden Whistler

Uncommon resident in area 1 and 3.

Colluricincla harmonica Grey Shrike-thrush

Infrequent sightings have been made from March to October in area 3. Status unknown.

Myiagra inquieta Restless Flycatcher

One bird recorded in area 2 on 7 May 1975.

*Rhipidura fuliginosa** Grey Fantail

Common resident in adjacent farmland and woodland and in all areas except area 2.

*Rhipidura leucophrys** Willie Wagtail

Uncommon resident in areas 3 and 5.

ORTHONYCHIDAE

Psophodes nigrogularis Western Whipbird

Common resident in area 1, since 1977 it has become established in areas of suitable habitat in area 2. Prefers the ecotone between the heath and the forest in the gullies or the thicket around the granite outcrops. More details are given in Chapters 16 and 17. Gazetted rare species (Plate 22).

SYLVIIDAE

*Acrocephalus stentoreus** Clamorous Reed Warbler

Recorded at Angove Lake in January 1935.

Megalurus gramineus Little Grassbird

A single bird was recorded in area 3 by H.O. Webster[7] in 1965 (personal communication). Since 1980 the species has been recorded twice in the same area. Status unknown.

MALURIDAE

Malurus splendens Splendid Fairy-wren

Rare resident in area 3.

Malurus elegans Red-winged Fairy-wren

Common resident in the forest and thickets in all areas except area 5. Nests with eggs found in September and November (Plate 19).

*Stipiturus malachurus** Southern Emu-wren

Common resident in closed heath in all areas. Nests with eggs found from September to November.

ACANTHIZIDAE

Dasyornis longirostris Western Bristlebird

A common resident in area 1 and 2. Confined to closed heath. More details are given in Chapters 16 and 17. Gazetted rare species (Plate 21).

Sericornis frontalis White-browed Scrubwren

Common resident in areas 1, 2 and 3 where they appear to prefer dense thickets and forest. Recordings of three of 18 clutches being laid in August with the remaining 15 laid in September. Clutch size two ($n=12$) or three ($n=3$). Mean egg size ($n=23$) 19.8 x 14.7 mm (ranges 18.8 - 21.3 x 14.0 - 15.7 mm). In area 1 nests have been found in the gullies close to the stream or in the soakage lines in dense shrubs.

*Sericornis fuliginosus** Calamanthus

Common resident in open heath in areas 2 and 3, in closed heath it is replaced by the Western Bristlebird.

Smicrornis brevirostris Weebill

Six birds recorded on 24 May 1975 on the edge of area 4 near Moates Lake.

*Gerygone fusca** Western Gerygone

Uncommon resident in forest in areas 3 and 4. Rarely seen in area 1.

*Acanthiza apicalis** Inland Thornbill

7 H.O. Webster, naturalist (deceased), Albany, WA.

Common resident in thickets and forest of areas 1 to 4. One nest with two eggs found on 4 October 1973.

*Acanthiza inornata** Western Thornbill

Uncommon visitor in area 3 from June to October.

*Acanthiza chrysorrhoa** Yellow-rumped Thornbill

Uncommon; sightings have been made from January to October in area 3. Status unknown.

NEOSITTIDAE

Daphoenositta chrysoptera Varied Sitella

Uncommon visitor from March to September in areas 1 and 3.

MELIPHAGIDAE

*Anthochaera carunculata** Red Wattlebird

Uncommon breeding visitor from March to November in areas 1, 2 and 3. Three nests with nestlings found in tall eucalypts in area 1 in September.

Anthochaera chrysoptera Little Wattlebird

Uncommon visitor from April to August in areas 1 and 3 in the period 1970 to 1976. In July to October 1982 and 1983 they were common in areas 1 and 2 especially where *Dryandra sessilis*, *D. formosa* and *Gastrolobium bilobum* were flowering.

Manorina flavigula Yellow-throated Miner

One bird recorded in area 3 in December 1975.

Lichenostomus virescens Singing Honeyeater

Rare visitor to areas 2 and 3.

Melithreptus brevirostris Brown-headed Honeyeater

Rare visitor, recorded only in area 1.

*Melithreptus lunatus** White-naped Honeyeater

Uncommon regular visitor from May to November in the gullies of area 1.

Lichmera indistincta Brown Honeyeater

One bird recorded in area 1 on 13 September 1973 and another in area 3 on 1 July 1975.

*Phylidonyris novaehollandiae**
New Holland Honeyeater

Very common resident in the heath and thickets of areas 1 to 3. In the period 1970 to 1976 the months in which egg-laying started was calculated for 64 nests. The number of clutches started each month from April to October were 1, 7, 20, 16, 12, 7 and 1 respectively. Thirty-five clutches had two eggs and only two had three eggs. Mean egg size (n=25) were 20.7 x 15.2 mm (range 19.0 - 22.5 x 14.6 - 16.2 mm). Nests have been found in heath, thicket and forest and never more than 2 m above the ground.

Phylidonyris nigra White-cheeked Honeyeater

Common resident in areas 1 to 3. In area 1 it favours thickets on the edge of the outcrops or in soakage lines. Clutches were laid in eight nests from May to September.

*Phylidonyris melanops**
Tawny-crowned Honeyeater

Common resident in areas 2 and 3, where it prefers areas of open heath. A rare visitor to area 1. Eggs laid from June to September (4 nests).

*Acanthorhynchus superciliosus** Western Spinebill

Common resident in the heath in areas 1 to 3. One nest with eggs found in September 1972.

EPHTHIANURIDAE

*Ephthianura albifrons** White-fronted Chat

Irregular visitor, seen along the main road from February to November in groups of up to 50 birds.

PARDALOTIDAE

*Pardalotus striatus** Striated Pardalote

One bird recorded in Robinson Valley (area 1) 19 December 1972 and another near the

western boundary of the Reserve on 1 July 1975.

ZOSTEROPIDAE

Zosterops lateralis Silvereye

Uncommon resident in all vegetation types in areas 1-3. Usually seen in small flocks of up to 15 birds. Two nests with eggs were found in September.

PLOCEIDAE

*Emblema oculata** Red-eared Firetail

Uncommon resident in thickets and forest in areas 1 and 3. Two nests with eggs found in September. In March and July 1982 it was often seen around regenerating clumps of *Agonis flexuosa* in area 2. Gazetted rare species (Plate 24 this publication).

GRALLINIDAE

Grallina cyanoleuca Australian Magpie-lark

Uncommon visitor to area 5 and the picnic area. Recorded only from July to September.

ARTAMIDAE

Artamus cinereus Black-faced Woodswallow

A flock of 30 birds was seen in area 5 on 17 October 1972.

*Artamus cyanopterus** Dusky Woodswallow

Uncommon resident in area 2 and occasionally seen in area 3. Sightings range from single birds to flocks of up to 40 birds.

CRACTICIDAE

*Cracticus torquatus** Grey Butcherbird

Uncommon resident in areas 1-3.

Gymnorhina tibicen Australian Magpie

Uncommon resident in area 5 and the picnic area. Also noted in area 2 in burnt areas up to three years after a fire.

*Strepera versicolor** Grey Currawong

Uncommon resident in areas 1-3. A nest with large young found on 23 November 1976.

CORVIDAE

Corvus coronoides Australian Raven

Uncommon resident in area 5 and around the picnic area. A flock of 10-20 birds commonly seen flying from the picnic area to south of Mt Gardner and back. The number of birds around the picnic area decreased to one resident pair, possibly a result of a more efficient garbage disposal system (G.L. Folley, personal communication 1982).

Corvus bennetti Little Crow

One bird recorded at the picnic area in January 1966 (F.N. Robinson,[8] personal communication).

Mammals

MACROPODIDAE

Macropus fuliginosus Western Grey Kangaroo

Common in areas 1 and 2 and uncommon in area 3. In area 1 the usual sighting is of one or two animals, occasionally three may be seen together. In area 2 occasional sightings of groups of up to 12 animals may be made. In recently burnt areas, groups of up to 40 animals may be seen over 0.5 km of road. Females with large pouch young have been observed from September to December.

Macropus irma Western Brush Wallaby

Uncommon in area 4, not recorded in other areas although Bannister (1970) reported a possible sighting above Little Beach on 4 February 1970.

Setonix brachyurus Quokka

Sightings of this species have been made in a number of the gullies and soakage lines in area 1, and their runs and scats have been seen in most of these areas. Bannister (1970) also recorded runs and scats at the western end of

8 F.N. Robinson, retired Research Scientist, CSIRO Division of Wildlife and Ecology, Perth WA.

Moates Lake. In June 1974 a fox was seen carrying a small quokka in West Gully. In May during the years 1971 to 1976 the remains of about 30 quokkas were found along a foot trail in the heath of Robinson Valley. The trail was used only from May to October. The condition of these remains indicated that the quokkas had been killed from a week to four months before being found. They are presumed to have been killed by foxes. A. Danks flushed a Little Eagle off the fresh carcass of a lactating female in Tick Flat on 6 August 1980 (G.L. Folley, personal communication).

PHALANGERIDAE

Trichosurus vulpecula Common Brushtail Possum

One adult of the species was recorded in Robinson Gully by Bannister (1970). No other records have been reported from the Reserve.

PETAURIDAE

Pseudocheirus peregrinus occidentalis Western Ringtail

Common in the gullies and soakage lines of area 1 and along Gardner Creek. Not recorded elsewhere, but it is undoubtedly present in area 3. Three females with pouch young were caught in July and one female in September had a three-quarter grown male young. Females carrying young were seen in May and September. On 5 July 1972 a female with two young was found in a drey (den) in Robinson Valley. One female caught on 29 May 1971 weighed 590 g. Gazetted rare species (Plate 16).

BURRAMYIDAE

Cercartetus concinnus Western Pygmy-possum

One female was collected from the Reserve in 1967 (Registration number 21297, Western Australian Museum). Several nests thought to be made by this species were found in blackboy stumps by the Museum party (Bannister 1970). Our observations suggest that they were more likely to be nests of *Antechinus flavipes*.

TARSIPEDIDAE

Tarsipes rostratus Honey-possum

Hopper (1981) found the species in areas 1 and 3. In area 1, sightings of this species have been made from August to January. Most of the observations ($n=18$) were of single animals, three were of two animals and only one of three animals. On 12 September 1971, an adult female with pouch young was disturbed from a nesting platform in a clump of *Agonis hypericifolia* under a *Dryandra formosa* bush. When she left the platform, at least one young climbed onto her back. Three animals were also seen after an area of 16 ha was burnt in September 1976 in area 2.

Nineteen feeding observations were made, eight in the two to three hours after sunrise and 11 were in the three hours before sunset. On one occasion when there was a full moon, an animal continued to feed for two hours after sunset. These animals were observed to feed on the following species of plants - *Banksia attenuata, B. grandis, Eucalyptus angulosa, Melaleuca striata, Lambertia uniflora* and *Dasypogon bromeliifolius*. All sightings were made in heath adjacent to the gullies or soakage lines or in vegetation in the soakage lines (Plate 13).

PERAMELIDAE

Isoodon obesulus Southern Brown Bandicoot

Common in areas 1 and 3. In area 1 its nests are frequently found in the drier soakage lines where there is abundant litter. Most frequently seen in closed heath adjacent to streams and soakage lines.

DASYURIDAE

Antechinus flavipes Yellow-footed Antechinus

Common in the gullies and soakage lines of area 1 and around the picnic area (Bannister 1970; G.L. Folley, personal communication). Nests have been found in dead blackboy stumps, hollows in dead trees and in old Noisy Scrub-bird nests. There is one record of this species taking over a Noisy Scrub-bird nest that

had an egg. It is unlikely that it killed the female, but it certainly ate or destroyed the egg.

Two females have been found in September, each with 8 young attached to their nipples. In October another female was found in a nest with 8 free young (Plate 17).

Parantechinus apicalis Dibbler

One sub-fossil of this species has been found in a sand dune near Moates Lake. A partial right dentory (W.A. Museum No. 7661), almost certainly of Holocene age, was found in the sand dunes to the south of Moates Lake (A. Baynes[9], personal communication). Gazetted rare species.

Sminthopsis griseoventer Common Dunnart

Hopper (1981) found the species in areas 1, 3 and 4. In September 1974 a male with a pregnant female was found in a nest in a dead blackboy stump on the slopes of Mt Gardner.

MURIDAE

Rattus fuscipes Bush Rat

Very common throughout the Reserve. In area 1 it was common in the heath and gullies. Has been observed eating the roots of *Dasypogon bromeliifolius*.

Hydromys chrysogaster Water Rat

Sightings along Gardner Creek have been made by Bannister (1970) and G. Folley (Hopper 1981) and a specimen was collected near Mt Gardner in 1975 (Kitchener and Vicker 1981). G. Folley (personal communication) found a dead animal in a swamp on the west side of Moates Lake in February 1980.

VESPERTILIONIDAE

Nyctophilus sp.

One unconfirmed sighting of a species of this genus was reported by Bannister (1970).

Eptesicus regulus King River Eptesicus

Recorded by Bannister (1970).

Chalinolobus gouldii Gould's Wattled Bat

Presence recorded by G. Folley (Hopper 1981).

MOLOSSIDAE

Tadarida australis White-striped Mastiff-bat

Calls of this species were noted near the picnic area by Bannister (1970).

OTARIIDAE

Neophoca cinerea Australian Sea-lion

Found on Coffin Island (Smith and Kolichis 1980) (Plate 18).

Arctocephalus forsteri New Zealand Fur-seal

Found on Coffin Island (Smith and Kolichis 1980). Gazetted rare species.

TACHYGLOSSIDAE

Tachyglossus aculeatus Short-beaked Echidna

The species is known to occur in the area of Mt Manypeaks (Bannister 1970), but we found no evidence of the species living on the Reserve. Dr J.A. Friend[10] (personal communication) found scratching, probably made by this species in area 4 in October 1982.

Introduced Mammals

Felis catus Feral Cat

Recorded near the picnic area, and one seen near the CSIRO hut in 1975.

Mus musculus House Mouse

Bannister (1970) found it common around the picnic area, he also recorded it at two localities in areas 1 and 2. Specimens have been trapped occasionally at the CSIRO hut and Hopper (1981) found it in the north-west end of the Reserve. G. Folley (personal communication) never saw this species in the picnic area (1978-1982).

9 A. Baynes, scientist, Western Australian Museum, Perth WA.

10 Dr J.A. Friend, Senior Research Scientist (CALM), Western Australian Wildlife Research Centre, Woodvale WA.

Rattus rattus Black Rat

A small group were trapped in the ranger's residence in 1979, the species has not been sighted since.

Vulpes vulpes Fox

Seen throughout the Reserve. In area 1 there appears to be a pair in each of the main valley systems.

Oryctolagus cuniculus Rabbit

Common, seen along the Two Peoples Bay road, and occasionally in the picnic area. A scat pile was found at West Finger Gully in 1985.

Reptiles

CHELIDAE

Chelodina oblonga Long-necked Tortoise

Occasionally seen around the edges of Gardner Lake. A common food item for the White-bellied Sea Eagle. Also found in Moates Lake (G.L. Folley, personal communication).

GEKKONIDAE

Phyllodactylus marmoratus Marbled Gecko

Cogger (1986) describes this species as arboreal, however, at Two Peoples Bay it has been found only under rocks on the outcrops in area 1. Also found on Coffin Island (Smith and Kolichis 1980). Usually only one gecko is found under a rock, but some larger slabs (1 m x 1 m) may have up to 20 geckos under them. Adult females with two eggs have been found from May, September and November and in May 1972 two adult females each had two recently hatched young. Under another rock there was a female with three eggs and three recently hatched young.

PYGOPODIDAE

Aprasia striolata

Found in areas of heath in area 1 (Hopper 1981).

Pygopus lepidopodus Common Scaly-foot

Common in area 1 in heath where it is often found basking on disused stick-ant nests or foraging under the heath. Two old ant nests that frequently had lizards basking on them had hollows or burrows inside that the lizards used when disturbed.

VARANIDAE

Varanus rosenbergi

Common in the heath in areas 1 and 2 and occasionally seen in area 4. A possible predator of Western Whipbird nestlings, and has been known to dig out the burrowing scorpion *Urodacus novaehollandiae*.

SCINCIDAE

Ctenotus catenifer

Recorded by Hopper (1981) in areas 1 and 4.

Ctenotus labillardieri

The most common skink under the exfoliations on the outcrops of area 1. Also recorded in area 4 (Hopper 1981) and Coffin Island (Smith and Kolichis 1980).

Egernia kingii King's Skink

Very common on Coffin Island (Smith and Kolichis 1980), but uncommon around the outcrops of area 1 and the swamps around the picnic area.

Egernia luctuosa Mournful Skink

Recorded by Bannister (1970).

Egernia napoleonis

Common around the outcrops of area 1 where it is often found under rocks. Occasionally seen in heath. Also recorded in area 4 by Hopper 1981.

Egernia pulchra Beautiful Skink

Recorded by Bannister (1970).

Hemiergis peronii

Uncommon under rocks around the outcrops in area 1, also recorded in areas 2, 3, and 4 (Hopper 1981) and Coffin Island (Smith and

Kolichis 1980). There is one record of it being taken by a Western Whipbird.

Leiolopisma trilineatum

Uncommon in heath and woodland areas throughout the Reserve.

Lerista microtis

Found in areas of heath in areas 1 and 4.

Morethia obscura

Found in areas of heath in area 1.

Sphenomorphus australis

Found in heath and woodland areas throughout the Reserve.

Tiliqua rugosa Bobtail

Common in heath in areas 1 and 2.

BOIDAE

Morelia spilota Carpet Python

Uncommon in the gullies and soakage lines in area 1 and the wetter areas of area 3. Gazetted rare species.

ELAPIDAE

Notechis coronatus Crowned snake

Common in area 1 where it is often seen basking on old ant nests or on the side of vehicle tracks. Occasionally found in dead blackboy stumps, and under rocks on the outcrops of area 1. Also recorded in area 2 and the western side of Moates Lake by G.L. Folley (personal communication) (Plate 14 this publication).

Notechis curtus Bardick

Common in the heath areas of areas 1 and 2 where it is often seen basking on vehicle tracks or in the adjacent vegetation.

Notechis minor Short-nosed Snake

One specimen collected in 1968 and another by A. Danks on 5 August 1984.

Notechis scutatus Tiger Snake

Uncommon in areas of heath in areas 1 and 2.

Pseudonaja affinis Dugite

Rarely seen in all areas.

Rhinoplocephalus bicolor Square-nosed Snake

Found on western boundary of Reserve in 1986, by Brad Maryan (A. Danks personal communication).

Amphibia

LEPTODACTYLIDAE

Crinia georgiana

Common in the gullies and soakage lines and adjacent heath in area 1.

Geocrinea leai

Two specimens collected on 24 March 1978.

Heleioporus eyrei Moaning Frog

Recorded around swamps in area 1, and at Angove Lake by D.L. Serventy.

Limnodynastes dorsalis Banjo Frog

Recorded around the lakes in area 3, and by G. Folley (personal communication) in the swamp near the picnic area.

Pseudophryne guentheri

Occasionally found under rocks in area 1.

Ranidella glauerti

Has been found in swampy areas of areas 1 and 3.

Ranidella subinsignifera

Common in swampy areas and along the creeks in areas 1 and 3. Occasionally found under rocks on the outcrops in area 1 in winter.

HYLIDAE

Litoria adelaidensis Slender Tree Frog

Commonly found in all areas, in forest, swamps and heath.

Litoria moorei Bull Frog

Common in swampy areas in areas 1 and 3.

DISCUSSION

A total of 210 vertebrate species have been recorded in the Reserve or the adjacent sea. The list comprises 154 birds, 23 mammals, 24 reptiles and 9 amphibians.

In 1935, D.L. Serventy recorded 49 bird species in the Two Peoples Bay area, while 140 species were recorded in the period 1970-1982. Four species recorded by Serventy - Pied Cormorant, Greenshank, Fairy Tern, and Clamorous Reed Warbler - were not found during the later survey. The first three species are likely to be uncommon or rare visitors. The absence of the Clamorous Reed Warbler probably reflects the small amount of time spent by us in areas with suitable habitat.

The most obvious change in the avifauna is the presence of the Kookaburra, Australian Magpie-lark, Australian Magpie and Australian Raven. These species were recorded in Albany but not at Two Peoples Bay by Serventy. The increased agricultural clearing between Albany and Two Peoples Bay since 1950 has allowed these species to reach the Reserve. Eight common residents not recorded by Serventy (Brush Bronzewing, Noisy Scrub-bird, White-breasted Robin, Western Whipbird, Red-winged Wren, White-browed Scrubwren, Western Bristlebird, White-cheeked Honeyeater) are more a reflection of the time of his visit (mid-summer) and the areas he visited, than any change in the species present on the Reserve. All the species are most common in area 1, which was not visited by Serventy. One further point that deserves some comment, is the apparent unsuitability of the lakes for water birds. Serventy recorded none, and our records indicate that only small numbers of a few species use the lakes. Although observers visited the lakes infrequently, comparable visits to other wetland areas in the district suggested that at Two Peoples Bay these have fewer waterbirds than other areas. A further ten species of waterbirds were recorded on the Reserve during surveys by the Royal Australasian Ornithologists Union and CALM staff, as discussed and listed in the waterbirds section of chapter 14 and Table 14.2, this publication.

The 150 species found in the present study include 12 seabirds, 13 shore birds, 29 freshwater birds and 96 land birds. Fifty-six species may be considered resident, 12 are regular breeding visitors, 13 are regular visitors while 73 are uncommon or rare visitors.

Considering the small area of the Reserve, the number of species recorded is high when compared with other larger areas on the south coast. In the coastal area between Walpole and Albany 176 species have been recorded (Blakers *et al.* 1984), 173 species have been recorded in the Fitzgerald River National Park (Jenkins 1980; B and K Newbey[11] personal communication; Smith and Moore unpublished data[12]), and 120 in the area from Esperance to the Cape Le Grand National Park (Kitchener *et al.* 1975).

Comparison of the number of passerine and non-passerine land birds from Two Peoples Bay, which have also been recorded in the other areas, indicates a high degree of apparent similarity in the avifauna (Table 15.1). However, the lack of data on the status of the birds in these other areas make a more detailed comparison difficult. Rare and uncommon visitors make up 45 per cent of the species recorded from Two Peoples Bay, which is undoubtedly a higher percentage than that recorded in the other areas. K and B Newbey (personal communication) found 29 per cent of the species recorded from the Fitzgerald River National Park could be regarded as uncommon or rare.

The number of resident passerine and non-passerine land birds from Two Peoples Bay that are also found in the other areas are shown in Table 15.2, together with a list of those species not present in these areas. All the residents from Two Peoples Bay, except the Noisy Scrub-bird, Western Whipbird and Western Bristlebird are found in the Walpole-Albany area, and these species also occurred there in the last century (Smith 1977). The three species missing from the Fitzgerald River National Park are the Noisy Scrub-bird, White-breasted Robin and Red-winged Wren, while further east of Esperance, at Cape Le Grand, 12 species are missing. Similarly, with the non-passerines, all the residents are found in the Walpole-Albany area and the number of species declines towards the east. Given the limited data, these results indicate that the avifauna of the Reserve is typical of the wetter south-coastal areas and that Two Peoples Bay is near the eastern edge of this region.

The 23 mammals on the Reserve consist of ten marsupials, 13 eutherians (including four bats, two seal, and five introduced mammals). Since the Museum survey, the presence of the Western Brush-wallaby, Common Dunnart, Australian

11 K. Newbey, botanist, Ongerup WA (deceased); B. Newbey, (widow of K. Newbey), naturalist, Ongerup WA.

12 G.T. Smith and L.A. Moore, checklist of birds in Fitzgerald River National Park, 1976.

Sea-lion and New Zealand Fur-seal have been confirmed. However, the Common Brushtail Possum has not been sighted since that survey. Sightings of the Echidna are needed to confirm Friend's observation. Thirteen mammals (excluding bats and introduced species) have been recorded in the coastal districts to the west of Two Peoples Bay (Kitchener and Vicker 1981; How *et al.* 1987). The three species not found in the Reserve are *Phascogale tapoatafa*, *Dasyurus geoffroii* and *Pseudomys albocinereus*. For two species (Quokka - on the mainland - and Western Ringtail Possum), the Reserve is on the eastern edge of their distribution, while for the Water Rat the Waychinicup River is the eastern boundary of its distribution. In the coastal districts to the east of the Reserve 14 species have been recorded, (Kitchener and Vicker 1981; How *et al.* 1987), eight of which are also found on the Reserve. The distributions of five of the species not found on the Reserve (*Parantechinus apicalis*, *Sminthopsis crassicaudata*, *Notomys mitchelli* and *Pseudomys albocinereus*) are mainly in the drier areas to the north and north-east, while *Pseudomys shortridgei* has recently been discovered in the Fitzgerald River National Park (Baynes *et al.* 1987). The past distribution of *P. shortridgei* extended as far west along the south coast as Augusta and it is possible that it may still survive in other areas of the south coast, such as Two Peoples Bay. The fauna is typical of the southern wet fauna with the Reserve being on the eastern edge of its distribution.

The herpetofauna consists of 24 reptiles and nine amphibians, an increase of seven reptiles and three amphibians over those recorded in 1970. How *et al.* (1987) recorded four species of reptiles (*Diplodoctylus granariensis*, *Delma australis*, *Egernia multiscutata bos*, *Tiliqua occipitalis*) in the region between Albany and Two Peoples Bay, which have not been recorded on the Reserve. Storr (in Bannister 1970) summed up the fauna as being wet south coastal, `characterised less by the presence of certain species than by the absence of species that occur on the drier coastal plains to the east and north-east'. He further concluded that the fauna was near the eastern limits of its range. The present list of species confirms Storr's conclusion that Two Peoples Bay is at the eastern edge of this fauna.

In conclusion, the vertebrate fauna of the Reserve is representative of the wet south coastal fauna. The Reserve is an important conservation area, not only for its rare birds, but also because its diverse vertebrate fauna forms an important link in the chain of south coastal Reserves. A list of species with special conservation interest is given in Table 15.3.

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CHAPTER 16

Ecology of the Rare Birds of Two Peoples Bay

G.T. Smith

INTRODUCTION

The genera *Atrichornis*, *Psophodes* and *Dasyornis* are generally considered to be members of the ancient endemic avifauna (Sibley 1976; Keast 1981; Schodde 1982; Bock and Clench 1985) and were probably present prior to Australia making contact with Asia in the Miocene (Powell *et al.* 1981). Both the Noisy Scrub-bird *(Atrichornis clamosus)* and Western Whipbird *(Psophodes nigrogularis)* in Western Australia have a closely related congenitor in eastern Australia, while *Dasyornis longirostris* (Western Bristlebird) has two in eastern Australia and one in Western Australia (probably extinct). This distribution pattern, together with the habitat requirements and presumed antiquity of the three genera, suggest that their ancestors had a wider, trans-Australian distribution in the past (Smith 1977). The changes in climate and the concomitant vegetation changes from the Miocene onwards, especially the relatively rapid climatic oscillations during the Pleistocene (Galloway and Kemp 1981; Kemp 1981; Specht 1981), led to a contraction of the distributions that resulted in small, relict populations with disjunct distributions. In Western Australia this was more pronounced for the Noisy Scrub-bird and Western Bristlebird, which are older and more conservative species than the Western Whipbird, which probably evolved in the south-west of Western Australia during the Pleistocene and was better adapted to the cyclical environment (Smith 1977; Schodde 1982).

When Europeans first settled in Western Australia in 1826, Noisy Scrub-birds, Western Whipbirds and Western Bristlebirds were more abundant and widespread than they are today. All three species are terrestrial and territorial with weak powers of flight, characteristics that suggest that their powers of dispersal are poor. These attributes, together with a low reproductive potential, made the species vulnerable to the environmental changes caused by Europeans (Smith 1977). Today all three species are confined to a small number of isolated localities in the less populous areas of the south-west of Western Australia. The Two Peoples Bay Nature Reserve is the most important of these because it is the only locality that is managed specifically for these species, and in addition, its topography provides protection against fire - the major potential threat to the species.

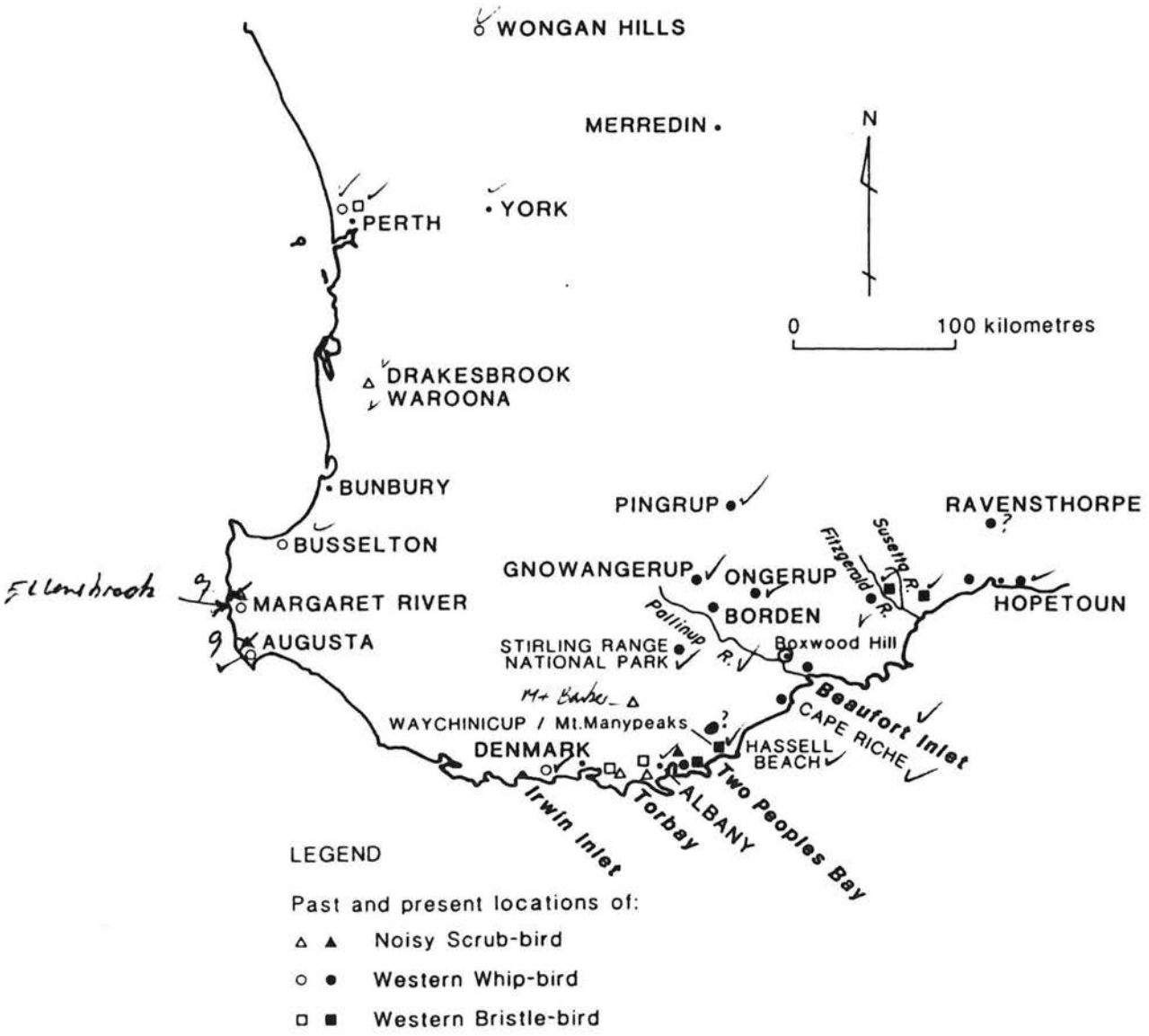
This article summarises the ecology of the species and is intended to form part of the background data required for the development of management policies for the Two Peoples Bay Nature Reserve.

NOISY SCRUB-BIRD

Various aspects of Scrub-bird biology have been given in Smith (1976), Smith and Robinson (1976), Robinson and Smith (1976), Smith (1977), Smith (1978), Smith and Forrester (1981), Smith and Calver (1984), Smith *et al.* (1983), Smith (1985a, b, c, d), and Smith (1987a). This account summarises these publications and adds previously unpublished data.

Distribution

The Noisy Scrub-bird was first discovered by John Gilbert in 1842 in Drakesbrook valley near Waroona (Whittell 1943) and later, on the same journey, at Augusta. There are no records from areas between these two localities. In 1843, while travelling from York to Albany, Gilbert found Noisy Scrub-birds from Mt Barker to Albany with numbers increasing towards the coast. Gilbert's general conclusion was that it was most numerous in the Albany district and was never found more than 40 miles (65 km) inland from the coast (Slater[1] 1973 and personal communication).



Logged to Boxwood Hill

No Ellenbrook ○

No MH Barker △

No Boojidup Creek △

M- Taylor ●

In 1866 and 1868/69 George Masters collected seven specimens (Whittell 1943) from the Albany area, the exact locations of which were not recorded. In the 1880s William Webb collected a number of specimens in the Albany area and recorded that they were common (Webb 1895). A.J. Campbell collected a single specimen at Torbay and later recorded having heard the species at Boojidup Creek in 1889 (Whittell 1943). Despite numerous searches, there were no further reports until Webster (1962) found the species in 1961 at Two Peoples Bay, which is the only known locality where the species had survived. It is clear that by the time of European settlement, the Noisy Scrub-bird had survived as relict populations in a small number of coastal areas between Drakesbrook and Two Peoples Bay. Locations are shown in Figure 16.1.

The possible reasons for the extinction of all but one of the populations since the explorations of John Gilbert have been outlined by Smith (1977, 1985c). The most potent cause was fire, at least the changes in fire frequency and intensity wrought by European settlers. The use of fire as a hunting tool by Aborigines in the Albany district has been documented by early observers such as Nind and Stokes (Hallam 1975; Green 1979), and its use generally in the south-west of the State has been summarised by Hallam (1975). Aborigines used fire for hunting during the summer. The largest fires were those lit in the forests by men hunting for kangaroos; they probably had little effect on the Scrub-bird's habitat. The women tended to light smaller fires while hunting small mammals and lizards. These fires would have been in or close to Scrub-bird habitat and may have destroyed areas of it; however, their small size and the likelihood of a patchy burn in such areas would have minimised any deleterious effect. In fact, such fires may have been beneficial in maintaining the habitat. Whatever the fire regime resulting from either accidental or deliberately lit fires, it is clear that in the Albany district Aboriginal use of fire had little, if any, deleterious effect on the Noisy Scrub-bird population.

European settlers made considerable changes to the fire regimes. In coastal areas large-scale fires were started every two to three years to provide new growth for stock. In the more forested areas the decline of Aboriginal burning, following displacement of the indigenous people, would have reduced the fire frequency but increased the intensity (Gill 1975). Such changes would have had severe effects on both plants and animals, especially those such as the Noisy Scrub-bird whose habitat is restricted. The fact that it survived at Two Peoples Bay, where the topography provides natural fire breaks, renders some support for the above contentions (Smith 1985d).

Agricultural clearing may have been a factor in areas such as Boojidup Creek and Albany. The more elevated forested areas that formed the feeding habitat have been destroyed, leaving only the wetter, more densely vegetated areas, which even today would provide suitable nesting habitat. Cattle can cause significant changes to the structure of the vegetation in such areas. In 1975 the swamp on Boojidup Creek had the potential of a good nesting area but it was far too open because of the numerous cattle tracks. However, in 1979, after cattle had been excluded for three to four years, the swamp had become an excellent breeding area.

Climate has been suggested as another factor in the decline of the Scrub-bird, because of the below average rainfall in the period 1880-1890 (Smith 1977). However, the rainfall in that period w[illegible]tle different to the last decade, when the popul[illegible] been increasing. While below average rai[illegible] adversely affect reproduction, its consequence may be in making [illegible] more vulnerable to fire.

Nothing is known of th[illegible] mammalian predators [illegible] Scrub-bird. For the ca[illegible] Scrub-bird habitat is t[illegible] chance of catching s[illegible] nests are so well con[illegible] unlikely to suffer [illegible] 1971-1976 none of t[illegible] were found showed [illegible] though there were f[illegible] effect of predation by [illegible] been negligible or non-existent.

Description

The Noisy Scrub-bird is a small bird [illegible] mm in length, with the females averagin[illegible] = 12) and the males 54 g (n = 18). T[illegible] plumage is brown with fine black bars, wh[illegible] the ventral plumage grades from white on the chin to rufous on the vent. The males differ from the females in having a black bar on the upper chest. Details of plumage changes are given in Smith (1985a).

Scrub-birds are solidly built birds with strong pointed bills, long powerful legs, short rounded wings and long graduated tails, as befits their

1 E. Slater, retired, former photographer, CSIRO Division of Wildlife and Ecology, Canberra ACT.

terrestrial mode of life. On the ground they are fast and agile runners in their dense habitat; their limited flying ability is used mainly to move from shrub to shrub without having to go down to the ground. While their colour and ground-hugging behaviour make them difficult subjects to observe, they are not as secretive as casual observations would suggest. They are inquisitive birds, in fact, quietly moving to observe the cause of some disturbance before moving off, often unheard or unseen.

Territory

The habits and habitat of the Scrub-bird make it virtually impossible to observe, without it being aware of the observer's presence. The only characteristic of the species that allows it to be located, often and reliably, is the territorial song of the male. This is loud and directional in character, and is given throughout the day in all seasons, most frequently during the winter (Smith and Robinson 1976). Females and immature males give only alarm calls.

The areas in which singing males are found are restricted and constant and given their wide separation it is convenient to consider these areas as territories. No adult males were banded and none of the males banded as chicks were seen after fledging. Therefore, the following remarks apply strictly to the areas defined as territories and do not imply anything about the identity of the bird in a particular area.

Territories are persistent, with little variation in usage from year to year (see below for exceptions), so that the data from 1970 to 1976 have been combined to provide the territorial boundaries shown in Figure 16.2. The mean size is 6 ha (between 4-9 ha) and within this area 80 per cent or more of the observations were made in a core area of 1 to 2 ha (mean = 1.25). While territories may overlap slightly, the males seldom approach the boundaries and conflict with neighbours is rare (Smith 1985d).

In the period 1970 to 1976 territories from which a male disappeared were not reoccupied for one (n = 3) or two (n = 3) years. Since that time non-singing adult males have been observed in an increasing number of territories. During the translocation program up to two subdominant adult males have been removed from one territory within one or two months (Burbidge *et al.* 1986). See Chapter 18, this publication for more details.

Smith and Forrester (1981) have divided territories into two classes. Long-term territories are those in which the male sings throughout the year and in the breeding season throughout the day. These territories have a good food resource (areas of thick litter) and suitable nesting habitat, and breeding is usually known to have occurred. The difficulty in finding nests means that lack of evidence of breeding does not necessarily mean that breeding does not occur. The second type are short-term territories in which males usually sing only during the breeding season. These are generally located on the edge of a long-term territory or in sub-optimal habitat where the food resource is poor and breeding areas are of poor quality or non-existent. No evidence of breeding has been found in such territories (Fig. 16.2).

The increasing population, especially since 1976, has tended to blur these distinctions which were so evident in the 1971-76 period. In 1988, there was an increasing number of territories in sub-optimal or, what would have been considered earlier, non Scrub-bird habitat (e.g. heath and thicket), where males sing all year (Location 21, Table 16.1 and Fig. 16.4). Further, nests have been found in sub-optimal breeding habitat away from recognised long-term territories. It is clear that with the growth in the vegetation because of the absence of fire from areas of Scrub-bird habitat during the last 20 years, and the increasing population, males and females are now being forced to occupy sites that were formerly unsuitable. It is likely that breeding in many of these areas will be uncertain but not impossible.

Observations of a male in captivity suggest that immature males (two-year-old) sing briefly during the breeding season. This suggests that it is probably this class of bird that holds short-term territories. The poor survival rate of these territories further suggests that new short-term territories are established by immature males.

Males move frequently but slowly around their territory during the day in the breeding season, with no apparent pattern in their movements, apart from their departure and return to their roost sites. Both males and females roost in the top of dense shrubs or mallee outside the core area. The movements of the female can be gauged only by fortuitous observation and by finding the nest. A limited number of observations suggest that females rarely move more than about 100 m from their nesting areas throughout the year.

Nests have been found in 27 of the 37 territories that have been searched at least once. Of the 21 territories with active nests, none had more than one nest in a season. This suggested that there may be monogamous pair bonds. However, there are four instances that suggest males may be polygamous if there is a surplus of females:

(1) In 1976 a territory with an active nest was found to have a one-year-old female nesting

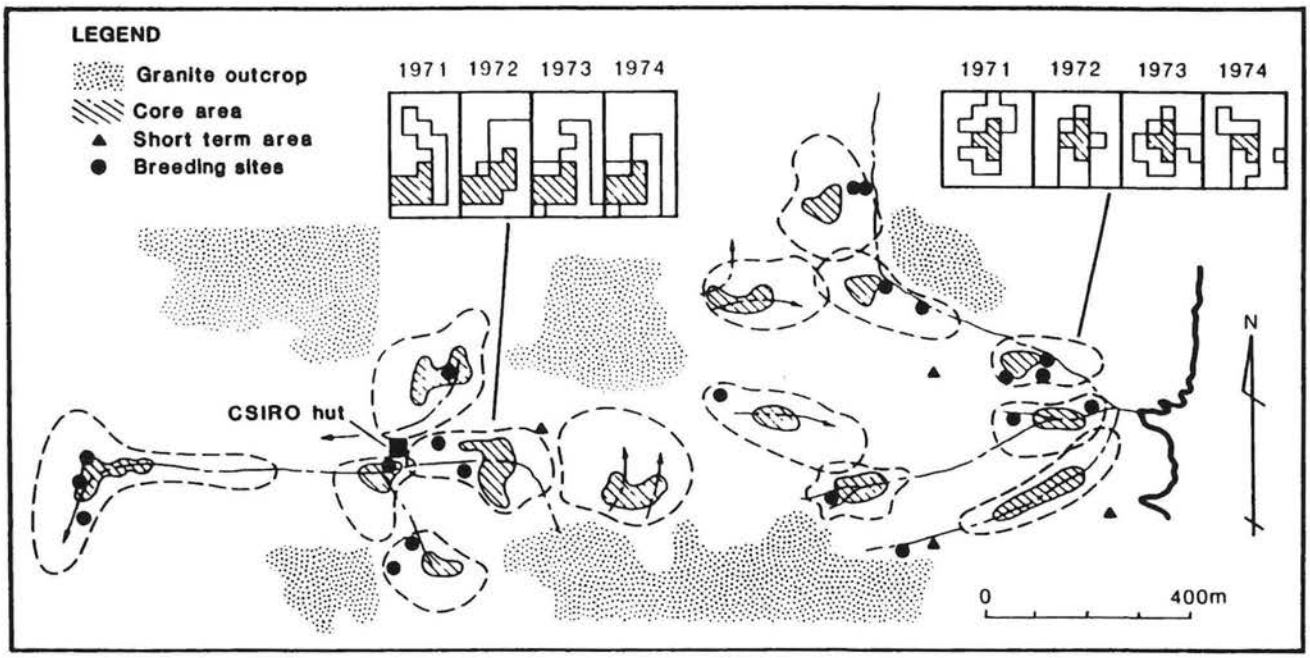


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Fig. 2

on the periphery of the territory; her offspring fledged.

(2) Another territory in 1976 with an active nest was found to have a nest in sub-optimal nesting habitat on the edge of the territory. This nest was found after the breeding season, but the male was known to have visited the area frequently during the breeding season, and breeding may have occurred concurrently.

(3) In the period 1970-1978 nesting took place every year in a territory that had been occupied for only two years by a male. During two breeding seasons a male was observed frequently moving to and fro between his territory and this area.

(4) The most convincing case occurred in two territories adjacent to the CSIRO field hut. In 1970 both had males and were known breeding territories. At the end of the 1970/71 summer 'A' male disappeared and in the following breeding season male 'B' started to visit this territory briefly on most days. No evidence of breeding was found that year. In 1972, at the start of the breeding season male B was followed frequently, as he moved from his territory to his neighbour's before dawn, returning shortly after sunrise. Similar journeys were made in the late afternoon. The females in both territories fledged young. In 1973, this territory was occupied by male 'C' who gradually increased the frequency and loudness of his territorial song. Meanwhile male B decreased the number and duration of his visits, which stopped by the end of the breeding season.

While the data are limited, they do suggest that males are basically monogamous, but may mate with females in adjacent unoccupied territories or with young females occupying areas on the edge of their territory. The assumption that males are capable of polygamy is supported by data from captive birds. In two successive breeding seasons a single male mated successfully with three females (Smith *et al.* 1983).

Breeding biology

The breeding season extends from May to November. The males, which defend their territory with song all year, rapidly increase the frequency of their territoral song in April and achieve a peak in May/June. The frequency remains high but variable until October when it begins to decrease. From April to June, birds assumed to be young males establish territories and there may be occasional boundary disputes with adjacent males.

Egg laying begins in late May, with a peak in late June, ending in early October. Little is known of the factors controlling the breeding season. Short photoperiod is probably the proximate factor, while the interaction of rainfall and temperature on the production of litter and its invertebrate fauna are probably other important factors in the control of timing of events during the breeding season.

The males play no role in nest building, incubation, or feeding the chick, and although they are probably aware of the location of the nest site, they rarely visit it.

The nest is globular in shape with a small side entrance usually covered by a short cowl. Some nests have a short platform under the entrance. Nests are constructed of up to 2000 pieces of *Lepidosperma* spp., occasionally *Anarthria scabra* and rarely the leaves of *Dryandra formosa*. The bottom half of the nest cavity is lined with decayed rush or wood. It appears that this is applied as a paste which dries to a hard, cardboard-like substance. The top of the nest may be camouflaged with the most common type of litter (leaves, twigs or rush). Nests built into clumps of *Lepidosperma* spp. usually have no camouflage cap but others may have a cap of fine twigs or leaves of *D. formosa* or eucalypts.

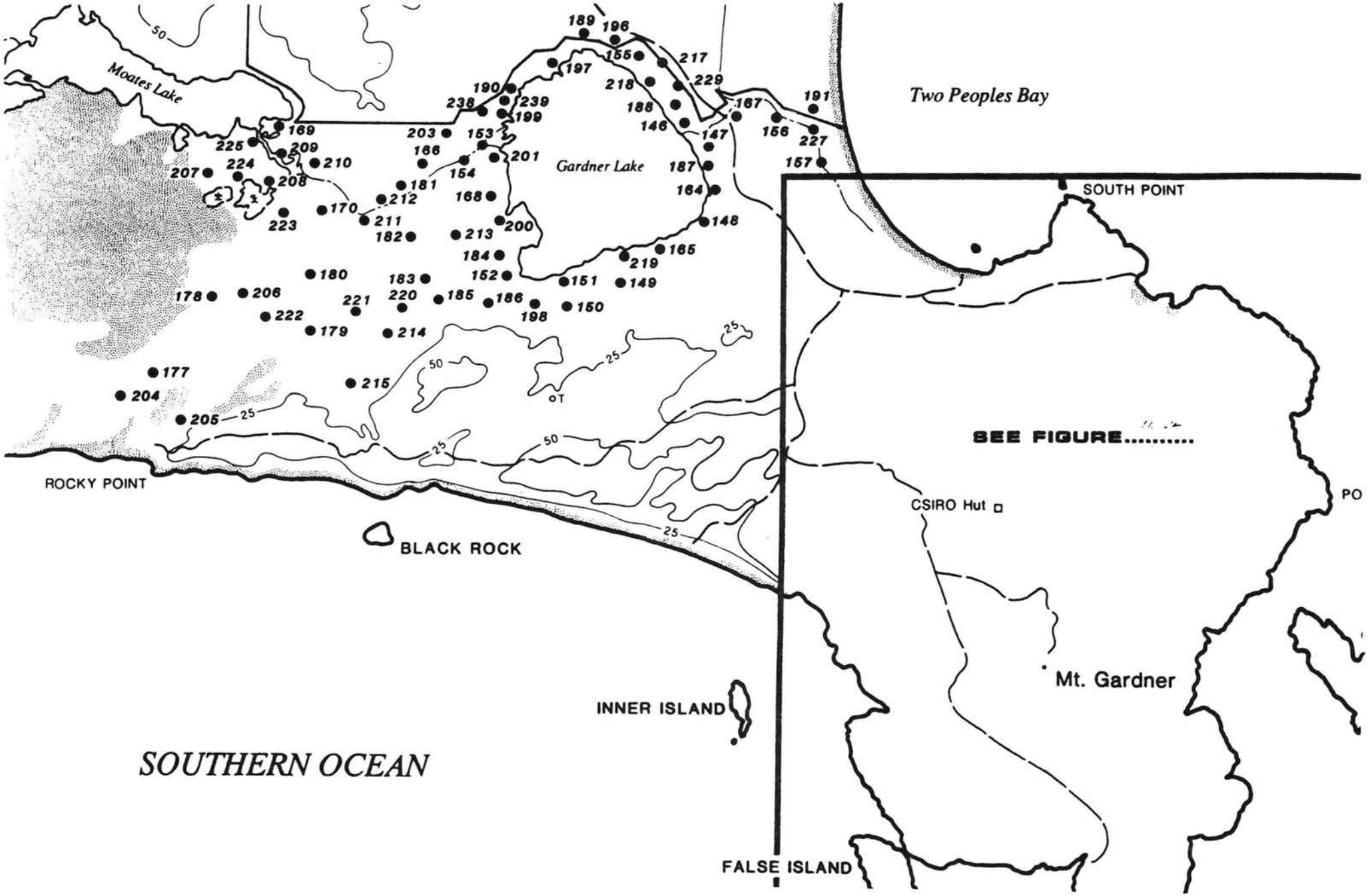
On average, nests are built 20 cm above the ground in clumps of *Lepidosperma angustatum* or *L. effusum*, occasionally in *Anarthria scabra* and less often in a variety of dense shrubs (Fig. 16.5). In wetter gullies the nests are usually within three metres of the stream bed. In drier gullies the location depends on the density of the vegetation rather than any other factor. Nest areas are outside the core area of the male's territory (Fig. 16.2).

The nest takes two to three weeks to build with a further seven to ten days for the lining to dry. Females building a second nest usually take about one week and only line the bottom of the nest.

The single egg is laid 10 to 16 days after the nest is finished and the female then begins the long incubation of 36 to 38 days. During this time she usually spends some hours feeding in the early morning, with short and infrequent feeding bouts in the afternoon. The long incubation period is a consequence of the low winter temperatures and the female doing all the incubation. Incubation periods for captive birds in Perth, with abundant and close food, ranged from 30 to 33 days (Smith *et al.* 1983).

At hatching the chick weighs four to five grams and is naked except for a line of long natal down on

16.3


Moates Lake
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SOUTH POINT
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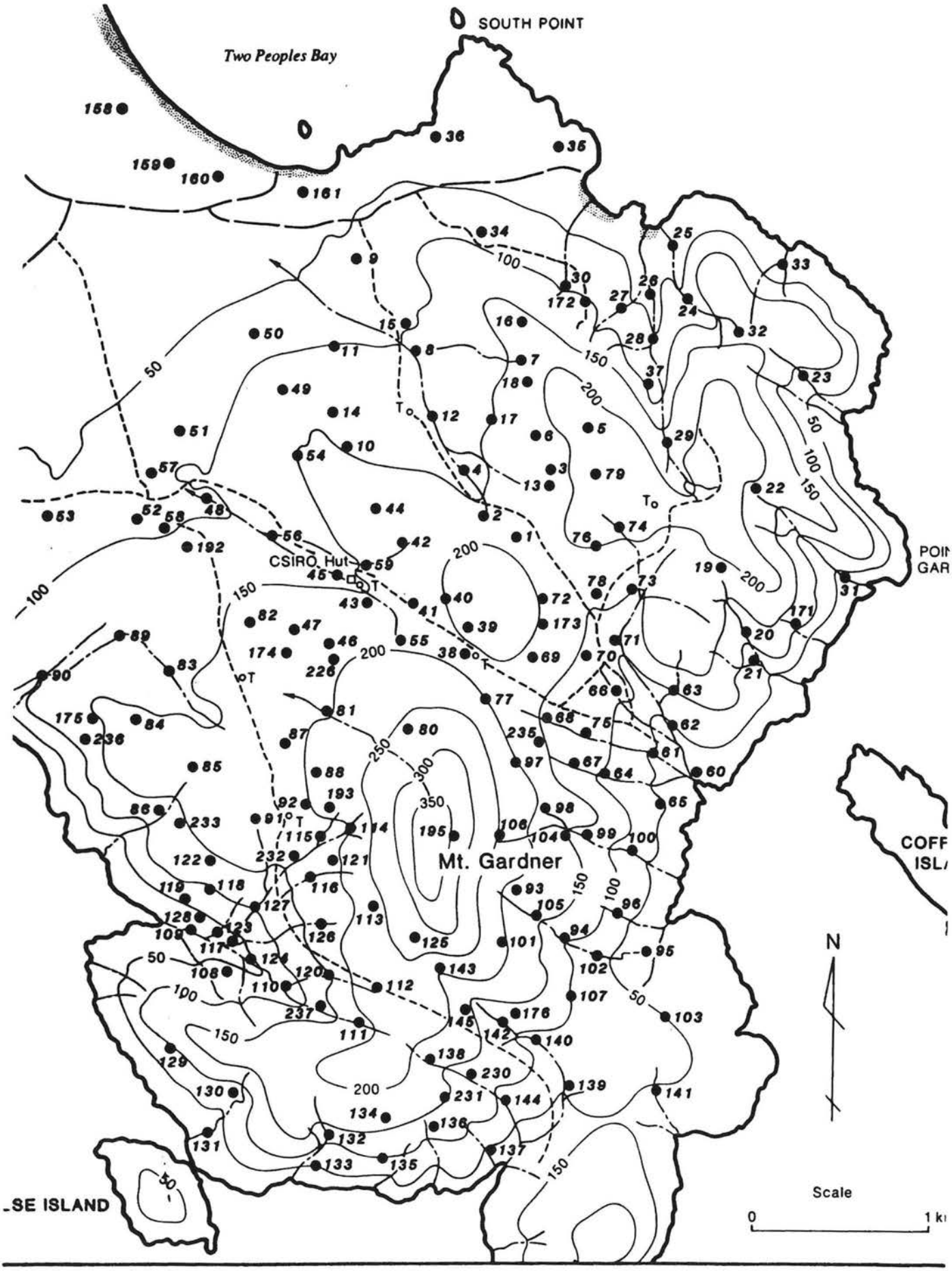
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16.4

the crown and mid back (Smith 1985a). For the first week of its life the chick is fed about six times an hour and is brooded after every feed. Thereafter, diurnal brooding decreases rapidly although the chick continues to be brooded at night until it fledges. Nest sanitation is maintained by the female removing the faecal sacs and placing them in a nearby creek pool or under a bush.

The chick fledges when it is from three to four weeks old. At this stage it is nearly fully feathered and weighs from 24 g to 32 g, with females in general being lighter than males. The legs are almost fully developed, however the wings and bill are about 80 per cent of adult size, and the tail is but a stub. After the chick leaves the nest it stays with its mother; for just how long is uncertain, but probably until the post-fledging moult is finished when the bird is about three months old (Smith 1985a). One chick raised in captivity was weaned at 5 months.

If the egg is lost, the female may build another nest and re-lay. The interval between the first and the replacement egg increases with the length of time the first egg was incubated.

Females breed in their first year but males are probably three-years-old or more before they first breed.

Food

Scrub-birds feed mainly in the litter where they poke under the leaves or turn them over with a quick flick of the head. They sometimes rapidly drum the litter with one foot, presumably trying to flush prey. They also search through and in the bases of rush clumps and dense shrubs, as well as probing in rotten logs. The range of prey taken by adults is unknown but the diet of nestlings has been documented from nest observations and examination of faecal sacs. A total of 19 taxa have been recorded as prey items, with the most frequent being Araneae (35 per cent), Orthoptera (29 per cent) larvae (13 per cent), Blattodea (7 per cent), Hymenoptera (4 per cent) and Chilopoda (3 per cent). Besides these invertebrates, two species of small frogs, one gecko and a skink were also eaten (Smith and Calver 1984).

Analyses of these data indicate that Scrub-birds are generalist predators and the differences in the proportions of different prey items between nests and years is a reflection of prey abundance rather than preference.

Population

The only practical population index is the number of singing males. Details of the methods are given in Smith and Forrester (1981) and Smith (1985b). Analysis of population data from 1970 to 1976 shows that, to obtain reliable data, at least three censuses during each breeding season are required.

The locations of all known Scrub-bird territories up to 1988 are shown in Figures 16.3 and 16.4 and the years in which they were occupied are given in Table 16.1.

In providing population estimates for the years 1962-1977, Smith and Forrester (1981) were able to partition territories into two broad classes - breeding and non-breeding. Since that time the increasing use of habitat of uncertain status and the limited number of observations has made this dichotomy less useful and it was not used by Smith (1985b). The changes in the population index up to 1988 (number of singing males) are given in Table 16.1, together with the numbers on the Mt Gardner headland and the area between the lakes .

In the three years after the Noisy Scrub-bird's discovery the population was about 40 to 45 males and by 1968 was probably about 50 males (Smith and Forrester 1981). The first census in 1970 gave a figure of 45, declining to 44 in 1971 and thereafter there was an increase which accelerated after 1977. In 1987, 193 singing males were recorded, falling to 179 in 1988. This decline was owing to the loss of birds in one area to the south-west of Gardner Lake - the cause of this loss is unknown (A.H. Burbidge[2] and A. Danks[3], personal communication). Photo-interpretation of available habitat on the 1946 aerial photographs indicates that the population at this time was about 20 to 30 males. These photos show evidence of numerous small fires on the Mt Gardner headland and one large fire on the isthmus area. By the time of the next aerial photographs (1965) the pattern had changed, there being larger, less frequent fires, mainly on the isthmus area. The last fire to burn Scrub-bird habitat was in 1970. The change in fire pattern and decline in frequency is the simplest explanation for the increasing population (Smith, 1985c).

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2 A.H. Burbidge, Senior Research Scientist (CALM), Western Australian Wildlife Research Centre.

3 A. Danks, Reserve Management Officer, Two Peoples Bay Nature Reserve.

The increasing population has occupied most of the suitable habitat on the Mt Gardner headland, either occupying previously unused habitat or areas that, because of vegetation changes, have become suitable in the last 10 years. There are no data to suggest that the population was restrained by lack of suitable habitat. Since 1975 the population has also been able to expand along Gardner Creek, around Gardner Lake, and into the area between Gardner Lake and Moates Lake. This increase is partly caused by the regeneration of the vegetation between the lakes since the 1970 fire and also as a result of breeding from the initial colonists. Since 1970 there has been an increasing number of males in sub-optimal habitat, all of which are on the Mt Gardner headland. This suggests there is little suitable habitat left in this area and that the population here may well be approaching its saturation level (Smith 1985b).

The use of the number of singing males as a population index has some limitations. At low population levels, where it is reasonably easy to define the status of a territory, the index provides a good measure of the breeding potential of the population. The number of areas without either a male or female is low (in two of 19 areas) and probably equal for both situations. With increasing population size the number of females breeding on the periphery of territories probably increases, and the index will give increasingly reduced estimates of the breeding potential of the population. Likewise there may be an increasing number of non-singing males who are unable to find a suitable territory. As long as these limitations are considered then the index provides an economic method of monitoring the population fluctuations, as well as the longevity of areas suitable for Scrub birds.

WESTERN WHIPBIRD

The following account is based on unpublished data from Two Peoples Bay during the period 1971 to 1982.

Distribution

The Western Whipbird was first discovered by John Gilbert in 1842, on his second trip to Western Australia, when he recorded it at Wongan Hills, Perth, Busselton, Augusta and Albany (Whittell 1951). George Masters collected eight specimens during a trip to Albany in 1868-69. There are no exact localities and they may have been collected as far from Albany as the Pallinup River, which Masters visited. In 1898, J. Harris collected the species at Bunbury (North 1904) and Milligan (1902) found it at Ellensbrook in 1901. Jackson recorded it near the Irwin Inlet in 1912 (Whittell 1952), Collins recorded it at Ongerup in 1929 (Howe and Ross 1933) and Watts found it at Gnowangerup in 1934 (Whittell 1939). Lindgren (1958) found the species 64 km west of Ravensthorpe, the Sedgwicks found it north of the Stirling Ranges (Sedgwick (1964) and Webster (1966)) recorded it at Two Peoples Bay in 1962, while Ford (1971) found it at Mt Taylor in 1963 and 11 km east of Ravensthorpe in 1966. Since these records it has also been recorded at Hopetoun, Fitzgerald River National Park, Beaufort Inlet, Cape Riche, Mt Manypeaks, Waychinicup Inlet, Boxwood Hill, Borden and Pingrup (Smith 1977; K. and B. Newbey[4], personal communication; N. Kolichis[5], personal commun- ication). McNee (1986) documents the records from published and unpublished sources and, during a survey in 1985, found Whipbirds in 38 of the 54 localities visited within the known distribution bounded roughly by Two Peoples Bay, Hopetoun, Ravensthorpe and Pingrup. These localities are shown in Figure 16.1. The species also occurs in a number of areas in South Australia (Condon 1968; Parker and Reid 1978).

In Western Australia, the Whipbird stronghold appears to have been the mallee heath, with extensions to the west and south along the coast where structurally similar vegetation occurs. Like the Noisy Scrub-bird, populations in the more developed areas have become extinct, because of the changed fire environment and agricultural clearing.

Description

Western Whipbirds are slightly larger than Noisy Scrub-birds, ranging in length from 240 mm to 255 mm and weighing about 50 g. Their general colouration is olive green, apart from the black throat with white sides. There is no sexual dimorphism.

Like the Scrub-bird, they are stoutly built with long powerful legs, a long graduated tail and short rounded wings. Although mainly terrestrial they spend a considerable amount of their time in the dense understorey vegetation where they may use their wings to elbow their way through the dense vegetation. They may also move to the top of the canopy to feed and occasionally sing. Their powers

4 B. Newbey, amateur naturalist, Ongerup, W.A.; Newbey, K., Botanist, (deceased) formerly of Ongerup W.A.

5 N. Kolichis, licensed amateur egg collector, Carine W.A.

of flight are limited and are usually restricted to short, low flights above the heath or thicket. The longest flight observed was about 50 m. Generally they are difficult to observe because they spend most of their time on the ground or in the dense understorey. However, on calm days during the breeding season, they spend more time in the upper storey where they are easier to observe.

The most obvious sign of Whipbirds are their territorial songs. There are two variable song types whose mnemonics are 'its for teachers pet' and 'quick more beer'. For convenience these have been called 'I' song and 'R' song respectively. I song is the most frequent type and usually has more songs per bout. In 93 per cent of all song bouts I song was the first, and in 50 per cent of these bouts there was a response with R song. In the 7 per cent of song bouts that started with R song, only 10 per cent were responded to with I song.

Observations of banded pairs ($n = 7$) suggest that each sex has its own song type, although under stressful conditions (e.g. after being handled) a bird may give both types of song. Although no birds have been sexed, behavioural observations suggest that the bird giving I song is probably the male and that giving R song is female. This conclusion is based on the facts that the bird giving I song is the dominant singer, spends less time incubating and feeding the young, feeds the other bird on the nest, and does not brood at night. While this conclusion is tentative, it will be used for convenience in the following sections.

Home Range

Observations on home ranges were made by plotting the position of singing birds and by observing individually marked birds, in an area of about 300 ha around the CSIRO field hut. Observations of five individually marked birds in this area, during the period 1971 to 1976, suggest that home ranges are probably maintained for life. Both males and females remained in their home range after losing their mate, either from separation or by death.

The home ranges in the study area in 1976 are shown in Figure 16.8 and are about 13 ha, although the pair spend most of their time in one or two core areas (Fig. 16.6), which presumably have a better food resource. The pair advertise their occupancy with song throughout the year. Most songs are given in the first hour after sunrise with a smaller burst before sunset and the frequency of singing is greatest during the breeding season.

The pair usually stay fairly close together during their daily activities, maintaining sporadic contact with their songs or, if they are within sight, with soft contact calls. It is noticeable that if a pair is more than 50 m apart when a duet starts, then both birds move towards each other and the duet ends shortly after they make contact. This rarely happens when the birds are less than 50 m apart.

There is considerable overlap in home range boundaries (Figure 16.6) and birds move freely through these overlap zones. Boundary disputes are rare and usually involve all four birds singing loudly at each other, but there appears to be little if any physical contact.

Breeding biology

The breeding season extends from July to October, with egg-laying from late July to early September, the peak being in early August.

The cup-shaped nest takes one or two weeks to build and the eggs are laid up to 10 days after the nest is finished (Fig. 16.7). If the nest site is disturbed while the nest is being built, the pair may desert and start another nest some distance away. Pairs tend to build their nests in the same area year after year. Nothing is known of which sex selects the nest site or does the building, although a few observations suggest that both birds help build the nest.

Incubation of the two eggs is shared, but the female sits twice as often as the male and for longer periods and always sits at night. The eggs may be left unattended for periods of five to ninety minutes. The longer periods usually occur when the female leaves the nest after sunrise to join the male for the first feed of the day. Occasionally, the male may feed the female, after calling her off the nest.

The eggs hatch after 21 days incubation and the chicks spend a further 10 to 14 days in the nest before fledging. Both parents feed the chicks, who are brooded after each feed for the first three days. After seven days they are rarely brooded during the day, but the female continues to brood them at night. Nest sanitation is maintained by the parents removing faecal sacs.

The parents appear to induce the chicks to fledge by decreasing the number of visits to the nests and by visiting the nest but not feeding the young. The chicks' tails and wings are not fully grown when they leave the nest and they are incapable of flight. They stay with their parents, usually one chick to a parent, until at least December and possibly until the start of the next breeding season. The parents continue to

LEGEND
Core area
Granite outcrop
CSIRO hut
N
0
400m

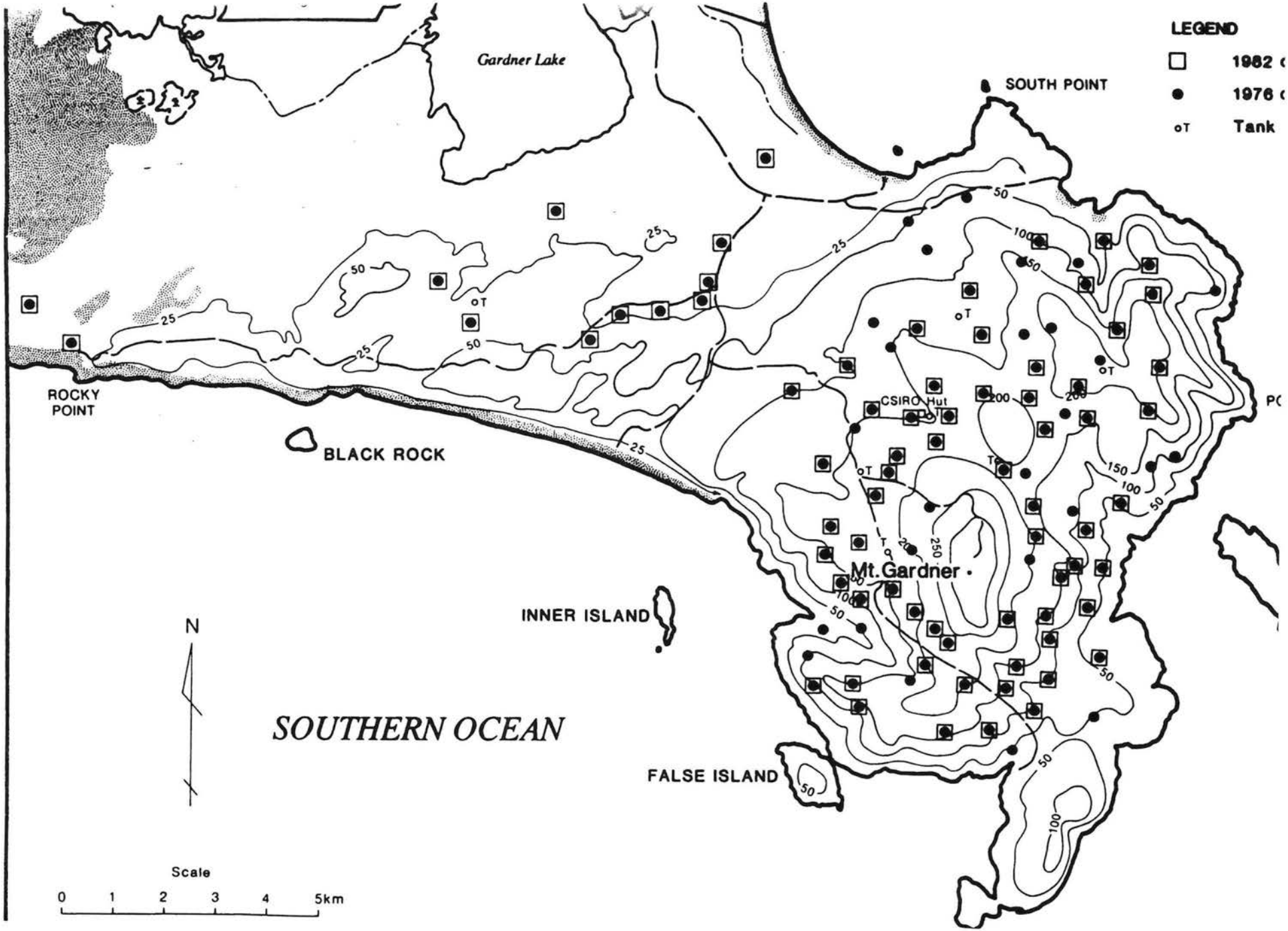


Fig. 16.8 needs changes

feed their young for at least one or two months after fledging.

Food

Whipbirds are active feeders, constantly on the move, digging into the litter with their bill, searching through the dense rush and shrubs of the understorey, and probing into and pulling off the bark of trees. They also search the flowers of the proteaceae family and may pull them to pieces in their search for insects and possibly seeds. In moving through the thick vegetation they scramble and literally claw their way through, occasionally using their wings to elbow their way through particularly tight situations. When feeding on the bark of a tree they may fan the tail and use it as a prop while they probe into and remove bark to search for insects.

Observations and examination of faeces suggest that Whipbirds are mainly insectivorous, taking a few seeds and small vertebrates. Of the prey items brought to nestlings, 45 per cent were insect larvae, 25 per cent were orthopterans, and the rest were made up of a wide variety of invertebrates, and one skink *Hemiergis peronii*.

Population

The index of population size is the number of singing pairs. The locations of all pairs recorded in 1976 are shown on Figure 16.8. The data were obtained during the five Noisy Scrub-bird censuses and numerous other visits to all parts of the Reserve (see Smith and Forrester 1981 for details). The 87 pairs were all confined to the Mt Gardner headland. In 1970 the population was estimated to be a maximum of 60 pairs. This figure was estimated by using the known distribution in 1970 and assuming that within this area the density of territories was the same as in 1976. In 1982 the locations of all Whipbird territories were again plotted during three censuses for Noisy Scrub-birds, plus a small number of visits to other areas. Although the number of territories was smaller, the data suggest that in the Mt Gardner area the numbers of Whipbirds were probably the same and may have increased slightly. Since 1976 the birds have expanded out of the Mt Gardner headland and are now common on the isthmus, having moved west as far as Moates Lake. In 1982 the population was probably of the order of 100 pairs.

WESTERN BRISTLEBIRD

The following account is based on observations at Two Peoples Bay from 1971 to 1982 (Smith 1987b).

Distribution

The Western Bristlebird was first discovered near Perth by John Gilbert in 1839 (Whittell 1936) and later in the Albany district. He considered it to be generally distributed and implied that it had a similar distribution to that of the Noisy Scrub-bird, but more restricted than that of the Western Whipbird (Slater 1973, personal communication). In 1866 and 1868-69 Masters collected 12 specimens in the Albany district; Webb also collected a number of specimens around Albany in the 1880s. Whitlock discovered the species to the east of Denmark in 1907 (Whittell 1936). By 1924, Carter (1924) noted that 'Bristlebirds were now rarely seen in areas where they were common twenty years ago'. Since then it has been found at Two Peoples Bay (Buller 1945), Mt Manypeaks, Waychinicup River (Ford 1963), Fitzgerald River National Park (Smith and Moore 1977) and the upper reaches of the Susetta River (K. Newbey, personal communication). A recent survey by McNee (1986) has shown that Western Bristlebirds occur between Two Peoples Bay and the southern end of Hassell Beach, and at three locations within or close to the Fitzgerald River National Park. The population found by Smith and Moore (1977) was apparently wiped out by a large fire in early 1985. McNee was unable to confirm the presence of the species at Beaufort Inlet. These locations are shown on Figure 16.1. It would appear that, in the last century, the Western Bristle-bird was most common on the south coast between Denmark and Hopetoun with perhaps smaller and more isolated populations in coastal districts as far north as Perth.

The extinction of the populations to the west of Two Peoples Bay can be explained by the frequent burning of the coastal heath in this area. This effect would have been exacerbated by the clearing of heath and the draining of swamps for agriculture, especially in the Albany district (Smith 1977; Smith 1985c).

Description

The Western Bristlebird is the smallest of the three birds considered here, being 180 mm - 200 mm in length and weighing about 30 g. Both sexes have the same brown plumage with grey speckling. Their build is similar to that of the Scrub-bird.

They are almost entirely terrestrial, moving quickly and agilely through the dense vegetation, often using tunnels made by bandicoots *(Isoodon obesulus)*. While they appear to spend some time foraging in the dense heath, they rarely show more than a head above the heath. Their flight is feeble and appears to be used more as a mode of surprise escape than for locomotion. Ten metres is the longest observed flight.

Bristlebirds are generally quiet, observing more than being observed. The main clue to their whereabouts is their song which is given throughout the year, most frequently in the early morning and late afternoon and during the breeding season when song may be given throughout the day.

The most frequent song type is 'A' song, a highly variable melodious whistle of five to eight notes. The second song type ('B' song) is a harsher whistle of three or four notes. In 59 per cent of all song bouts the A-song was followed by the B-song in a duet. B-song was given alone in 1.5 per cent of song bouts, in each case responding to the duet of a neighbouring pair. Only two birds have ever been recorded singing at the same time in a territory. Like Whipbirds they have been seen to give both song types in stressful situations. Without banded birds it is impossible to say whether one sex normally gives only one type of song.

Home Range

Song is the only practical method that can be used to obtain data on the size of home ranges. Because song bouts are short and infrequent, large numbers of observations are needed to build up an adequate picture of the home ranges. In 1976 the positions of singing birds were located on 609 occasions, including 63 occasions when two or more pairs were singing at the same time. These data together with a small number of observed movements indicated that in the 80 ha study area on Tick Flat there were eight home ranges, with a further four adjacent to them. Smaller numbers of observations in 1975 and 1974 (376 and 181) gave the same picture. The data from 1974 to 1976 were combined and are shown in Figure 16.9.

Limited data (50 observations) indicate that Bristlebirds also occupied these home ranges in 1972, 1973, 1977 and 1982. Data from another 12 home ranges suggest they too were occupied continuously from 1971 to 1982.

Home ranges varied in area from 6 to 8 ha (mean 6.5 ha), and within each home range the pair spent at least 60 per cent of their time in one or two core areas of 1-3 ha (Fig. 16.10). The daily pattern of movement varied from day to day, but the pair appear to be constantly on the move in the morning and afternoon at least. There are too few observations in the middle of the day to be sure of movements, if indeed they were active at that time. The pair spent most of their time together and of the 394 occasions when the distance between the birds was noted, 54 per cent were together, 25 per cent were less than 50 m apart, 16 per cent from 50-100 m apart and five per cent were from 100-200 m apart. A limited number of reliable sightings (20 out of 30) gave the same result.

Pairs do not appear to defend their home ranges. Only three instances of presumed boundary disputes were recorded. On each occasion all four birds were within 20 m of each other. The birds giving A song sang continuously with only a few B songs from the other birds; these interactions lasted from two to five minutes. Song appears to function as a method for the pair to maintain contact, as well as proclaiming occupancy of the territory. There is no reaction to birds singing in an overlap zone between home ranges, perhaps suggesting that pairs hold their home ranges for a number of years and are well known to their neighbours.

Breeding biology

While information on the breeding of the Bristlebird is fragmentary (Smith 1987b) it suggests that August to September is the main egg laying period. However, in mid-January 1988, L. Harrison found a nest with two chicks (A. Danks, personal communication.) which suggests that Bristlebirds may lay more than one clutch in a breeding season or at least attempt to replace losses.

The nest is globular (about 10 cm diameter) with a large side entrance. The base is made of the leaves of *Dasypogon bromeliifolius, Lepidosperma* sp., *Cyathochaeta clandestina* and *Anarthria scabra*, with finer twigs and leaves of *Loxocarya* spp., *Anarthria prolifera* and *Restio* spp. forming the bulk of the nest. The nest chamber is lined with fine *Restio* spp. and is about 5 cm in diameter. The nests are situated close to the ground usually in a dense shrub, *Dasypogon bromeliifolius* or *Anarthria prolifera.*

Nothing is known of the role of the sexes in nest building, incubation or feeding the chicks. Clutch size is probably two, as both Gilbert and Masters found nests with two eggs and Harrison found a nest with two chicks. Only one fledgling bird has ever been seen with the adults. It is not certain how long the young birds stay with their parents. Direct observations suggest at least a month after fledging,

however, the behaviour of adults in response to human disturbance suggests at least four months.

Food

Bristlebirds are active feeders, whether on open ground or in dense heath. On the ground they are constantly on the move, pecking at the ground or occasionally digging into the sand with their bills. Their movements are quick and jerky, as the bird constantly turns from side to side by pivoting on its feet or moving the feet. Between feeding movements they walk or hop slowly, interspersed with fast, short 50 cm dashes. Under jarrah clumps in the heath there is usually a layer of litter from 1-4 cm deep. The birds feed in these areas by probing under the leaves or by sweeping the leaves aside with a swinging action of the bill.

Buller (1945) reported that the stomach contents of one bird contained the remains of small Coleoptera, Hymenoptera, one small Tenebrionid larva, seven Acridiidae and seven small seeds. One sample of faeces from Two Peoples Bay had both arthropod and plant remains, while the stomach contents from a road kill had arthropod remains and seeds, including those of *Anarthria scabra*, *Daviesia* spp. and *Acacia* spp. The stomach of this bird was large with thick muscular walls, indicative of a seed-eating bird, and in contrast to the thin walled stomach of the Noisy Scrub-bird. Observations have shown the species to feed on Tenebrionid larvae, earthworms and small unidentified insects.

Population

The only index of population size that can be obtained easily is the number of singing pairs. There are problems in obtaining this type of data because the song bouts are short and infrequent. These two factors make it difficult to accurately locate birds and make it unlikely that neighbouring pairs will be singing at the same time. The latter point is important because of the overlap in territory boundaries. Without data from the simultaneous singing of neighbouring pairs, the number of pairs may be over-estimated and the low song frequency will lead to under-estimates of the numbers of pairs in areas that are visited infrequently.

No work has been done to develop an adequate census technique, however, intuitively, it would seem that each area of suitable habitat should be visited at least five times in winter, during the two hours after sunrise.

The location of all singing birds was recorded during the five Noisy Scrub-bird censuses in 1976 and during the course of other work on the Reserve (see Smith and Forrester 1981 for details). Where the data were ambiguous, data from 1975 and 1977 were used to help clarify the situation. If there was any doubt as to the number of pairs in a given area, the smaller number was chosen. The locations of 86 pairs in 1976 are shown in Figure 16.10.

On the Mt Gardner headland there was an average of 7 ha of heath per pair, which compares well with the 6-8 ha per territory found in the study area and suggests that the census was reasonably accurate. It further suggests that there is little vacant habitat available. The maximum population in 1970 was calculated to be 60 pairs, by using the known distribution and assuming that the density was the same as in 1976.

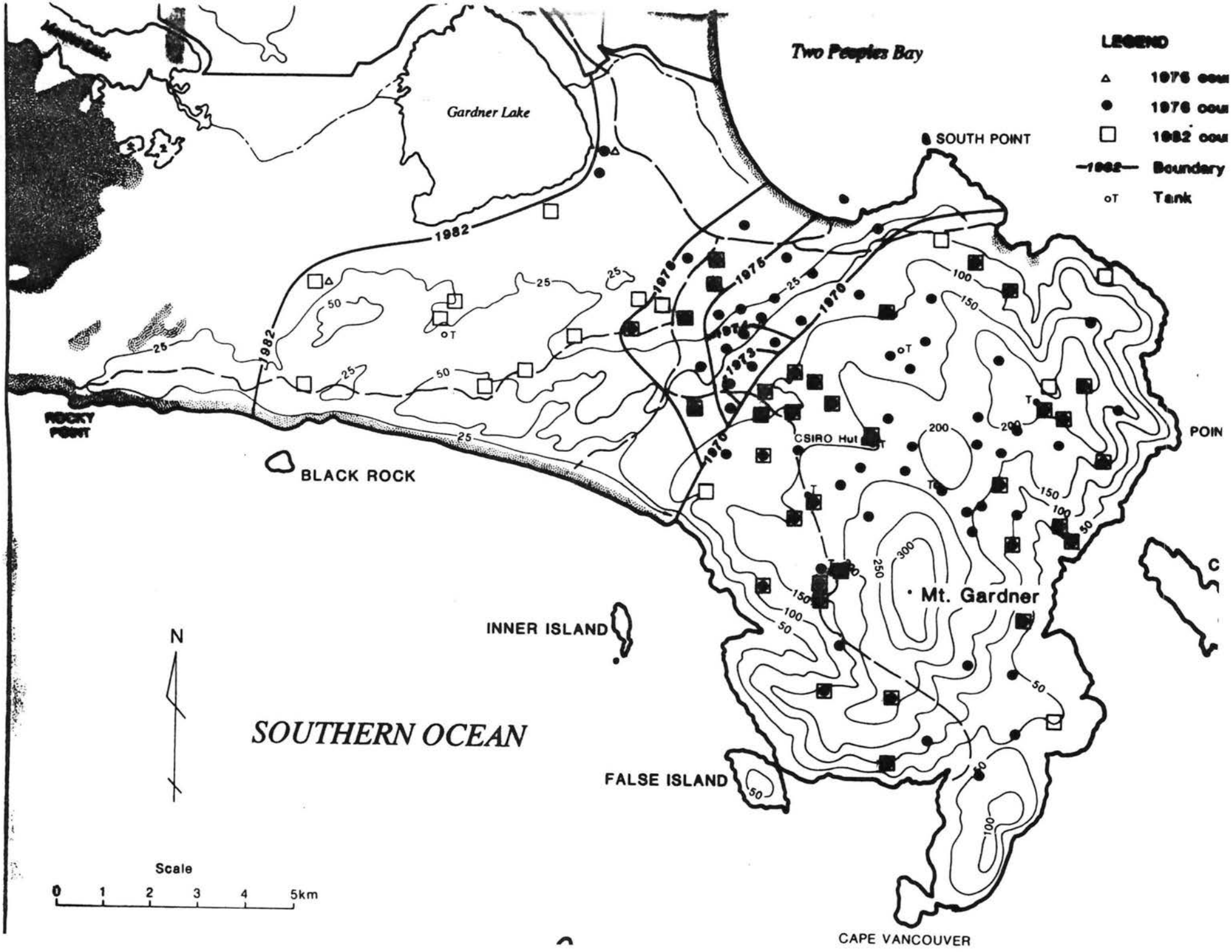
In 1982, 40 of the 86 pairs located in 1976 were relocated on the Mt Gardner headland, together with an additional five pairs in areas that had not previously had pairs. Given that the 20 home ranges that have been monitored over the last ten years were still occupied it is probable that the number of pairs on the Mt Gardner headland may have increased by at least five. This would give a minimum population on the reserve of about 100 (Fig. 16.10). Clearly, there has been a steady increase in population since 1970, which can be attributed to the absence of fire.

The distribution of Bristlebirds on the Reserve has changed considerably during the last 20 years (Fig. 16.10). Observations by H.O. Webster[7] (personal communication) indicate that in the early 1960s the birds were found throughout the heathlands of the Mt Gardner headland and the isthmus. By 1970 however, they were confined to the former area and although numbers did not start expanding again until 1973 they were approaching their 1960s distribution by 1982 (Fig. 16.10). These changes can be attributed to a number of fires in the Reserve during the period 1962 to 1970. There have been no wild fires in this part of the Reserve since 1970 and this has allowed the regeneration of the closed heath that is the species' preferred habitat. As shown by Hopkins and Smith (ch. 20 this publication) heath requires five to ten years to regenerate, depending on edaphic and moisture conditions. Such a time scale is consistent with the present expansion of the population.

CONCLUSIONS

Consideration of the possible evolutionary history of these three bird species suggests that their

7 H.O. Webster, amateur naturalist (deceased), Albany.


Two Peoples Bay
Gardner Lake
SOUTH POINT
LEGEND
1976 ccus
1976 ccus
1982 ccus
Boundary
Tank
1982
1976
1975
1970
1973
1974
1971
1972
25
50
100
150
200
300
250
oT
T
ROCKY POINT
BLACK ROCK
CSIRO Hut
Mt. Gardner
INNER ISLAND
SOUTHERN OCEAN
FALSE ISLAND
CAPE VANCOUVER
N
Scale
0 1 2 3 4 5km

distributions were more extensive in the past. At the time of their discovery by Europeans they were reduced to the status of relict populations by the severe climatic oscillations of the Pleistocene. Their status in terms of distribution mirrors the length of their assumed evolutionary history. The Noisy Scrub-bird (with possibly the longest history) was the most affected, being reduced to a small number of populations around the south coast. The Western Bristlebird's origins are assumed to be younger and it has a larger distribution, whereas the Western Whipbird is thought to have evolved during the Pleistocene (Schodde 1982) and had a comparatively large distribution in Western Australia and South Australia.

The advent of Europeans heralded a further decline in the distribution of all three species; the Noisy Scrub-bird to near extinction, the Western Bristlebird confined to two areas on the south coast, and the Western Whipbird to a number of isolated areas in the south-west. These changes are explicable in terms of the species' habitat requirements and ecology.

The Noisy Scrub-bird is essentially a conservative species with specific habitat requirements, low reproductive potential, and poor powers of dispersion. Its primary habitat, the ecotone between swamp and forest, is by its very nature limited in extent with a linear distribution, and is surrounded by sub-optimal to unsuitable habitat. This habitat is particularly vulnerable to severe climatic change and it is hardly surprising that after the Pleistocene its distribution was so restricted. Clearing and burning by European man nearly delivered the final blow. While the above scenario suggests that the Noisy Scrub-bird is not a successful species, the very fact that it has survived, perhaps indicates that it is a robust species that only needs a little help from humans to survive in today's environment. Ecologically, the Western Bristlebird is close to the Noisy Scrub-bird, however, its habitat is more extensive and the patches less isolated. In the last century its distribution was most likely confined mainly to wet closed heath, which is found only in coastal regions. Heath is, by its very nature, vulnerable to fire and has been so badly affected by fires caused by humans that the species has disappeared from the more developed areas. The Western Whipbird, perhaps because of its relatively recent origins, is within broad limits a habitat generalist. The widespread extent of suitable habitat and probably greater dispersive ability meant that the Whipbird was widespread and common at the time of European settlement. Subsequently the habitat has been greatly reduced; however, sufficient has remained undisturbed in isolated pockets for the species to survive.

In terms of management, all three species may be placed in the category of vulnerable - what Kitchener (1982) calls 'p' species - terrestrial, territorial with low powers of dispersal and low reproductive potential. It is clear from this study that alteration or destruction of habitat is the most potent hazard facing the species. Since the creation of the Two Peoples Bay Nature Reserve and the stationing of a permanent ranger there, the most serious hazard of fire has been controlled. The absence of fire has allowed considerable regeneration of the vegetation with a consequent expansion of the populations of all three species. If fire is kept out of the Reserve, all three will continue to expand and occupy all available habitat. One important consequence of the change will be the increased likelihood of the birds becoming established in areas to the north-east and west of the Reserve (Smith 1987a).

While the present protective management technique has been appropriate for the last 15 years, it may not work forever. For example, there is evidence that the areas of thicket are increasing at the expense of heath, favouring the Western Whipbird rather than the Western Bristlebird (Smith 1987a). In terms of their survival status this direction of change is undesirable and the situation needs to be monitored.

The other question that requires further study is how Scrub-bird habitat is affected by vegetation dynamics. It is clear from Chapter 17 (in this publication) that territories are still adequate 45 years after fire, but there are no data on just how much longer than this they will remain so. Further, some of the vegetation below the granite outcrops, which provides habitat for 29 per cent of the population, is of unknown age and status.

On the basis of conservation status, management objectives should be described in the order of priority: Noisy Scrub-bird, Western Bristlebird and Western Whipbird. This order does not result in incompatible stategies because of the complementary habitat requirements of the species. The main increases in all three populations have resulted from the effect of the absence of fire on the relative proportions of habitats and, indeed, the structural integrity of these types. These are aspects that need careful monitoring in the future and the overall management strategy may well require some carefully planned burning of senescent vegetation.

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Table 16.1

PRESENCE OF MALE NOISY SCRUB-BIRDS AT LOCATIONS ON FIGURES 16.3 AND 16.4, 1962-88. ALSO TOTALS FOR EACH YEAR AND NUMBER OF MALES IN THE MT GARDNER HEADLAND AND BETWEEN THE LAKES AREAS. ONLY PARTIAL CENSUSES WERE CARRIED OUT IN 1978 AND 1981.

	62/66	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
1									x	x						x		x	x		x	x	x	x
2											x	x	x	x	x	x		x	x	x	x	x	x	x
3	x					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
4	x					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
5	x					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
6									x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
7	x							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
8												x	x	x	x	x				x	x		x	x
9	x					x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
10								x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
11														x	x		x	x	x	x	x	x	x	x
12															x	x	x	x	x	x	x	x	x	x
13														x	x	x		x	x	x	x	x	x	x
14														x	x	x		x	x		x		x	x
15													x	x	x	x	x	x	x	x			x	x
16						x									x	x	x	x					x	x
17															x	x								
18																			x					
19	x					x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
20	x					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
21	x									x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
22						x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
23							x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
24	x					x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x
25	x		x	x																				
26	x		x	x			x	x									x	x	x	x	x			x
27	x			x											x	x	x	x	x	x	x	x	x	x

Table 16.1 (*continued*)

	62/66	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
28	x		x						x	x	x	x	x		x	x	x	x	x	x			x	x
29	x										x	x	x		x		x	x	x	x	x	x	x	x
30	x		x							x	x	x	x		x	x	x	x		x	x			
31															x			x		x	x	x	x	x
32													x		x	x	x	x	x	x	x	x	x	x
33													x				x	x	x			x		
34																x	x	x	x		x	x	x	x
35																		x						
36																x		x	x	x	x	x	x	x
37																		x	x	x	x	x	x	x
38	x	x	x					x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
39			x																			x	x	x
40										x	x	x	x	x	x	x		x	x	x	x			
41											x	x												
42	x	x	x	x	x	x			x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
43	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x			x	x	x
44	x																							
45				x						x	x	x	x	x	x	x		x	x	x	x	x	x	x
46	x	x	x	x	x	x			x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
47								x													x	x	x	x
48	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
49	x			x		x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x
50											x	x	x		x	x					x	x		x
51	x									x	x	x	x	x	x	x		x	x	x	x	x	x	x
52										x	x				x	x		x	x		x			
53															x	x			x		x	x	x	x
54															x	x		x	x	x	x	x	x	x
55																x		x	x	x	x	x	x	x
56																x		x	x	x		x	x	x
57																x		x	x	x	x	x	x	x
58																x		x						
59																			x	x		x	x	
60	x																		x					
61	x		x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x

Table 16.1 (*continued*)

	62/66	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
62	x		x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
63	x		x	x		x									x	x		x	x				x	x
64	x		x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
65				x					x						x									
66												x	x	x	x	x		x	x	x	x	x	x	x
67										x	x										x	x	x	x
68	x		x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
69				x		x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
70				x																		x	x	x
71	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
72							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
73	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
74												x			x	x	x	x	x	x	x	x	x	x
75														x	x	x			x	x	x	x	x	x
76																x		x	x	x	x	x	x	x
77																		x	x	x	x		x	
78																		x	x	x	x	x	x	x
79															x	x	x	x	x	x	x		x	x
80												x	x		x						x	x	x	x
81	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
82							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
83								x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
84										x								x	x	x	x	x		x
85							x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
86	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
87	x			x						x	x	x	x		x	x		x	x	x	x	x	x	x
88				x				x	x	x	x			x	x	x	x	x	x	x	x	x	x	x
89														x	x	x	x	x	x	x	x	x	x	x
90																x		x	x	x	x	x	x	x
91															x	x	x	x	x	x	x	x	x	x
92																x		x	x	x	x	x	x	x
93				x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
94						x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
95	x					x	x	x	x	x	x	x	x		x	x	x	x	x		x	x	x	x

Table 16.1 (*continued*)

	62/66	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
96										x	x									x				
97											x	x			x	x		x	x	x	x	x	x	x
98				x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
99											x	x	x		x	x		x	x	x	x	x	x	x
100	x		x					x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	
101													x					x			x	x	x	x
102															x	x	x	x	x	x	x	x	x	x
103															x	x	x							x
104																x	x			x	x	x	x	x
105																x		x	x	x	x	x	x	x
106																x	x	x	x	x	x	x	x	x
107																			x	x			x	
108				x		x						x	x		x	x	x	x	x	x	x	x		
109				x														x	x		x	x	x	x
110	x			x		x	x	x	x	x	x	x	x		x	x	x	x	x			x	x	x
111	x												x		x	x	x	x	x	x	x	x	x	x
112								x	x									x	x	x	x			
113				x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
114				x												x	x	x	x	x	x	x	x	x
115	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
116												x	x	x	x	x	x	x	x	x	x	x	x	x
117	x			x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
118	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
119									x	x														
120															x	x		x	x	x	x		x	x
121															x	x	x	x	x	x	x	x	x	x
122														x	x	x			x				x	x
123														x	x	x	x	x	x	x	x	x	x	x
124															x	x			x	x	x	x	x	x
125																x		x	x	x	x	x	x	x
126																		x	x	x	x	x	x	x
127																		x	x	x	x	x	x	x

Table 16.1 (*continued*)

	62/66	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
128																	x		x	x	x			
129						x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
130	x					x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
131	x					x											x		x		x	x	x	x
132	x					x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
133												x												
134						x	x											x	x	x		x	x	x
135									x															
136	x					x	x	x	x	x	x	x	x		x	x		x	x	x	x	x	x	x
137	x					x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
138	x					x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
139						x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
140	x					x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
141										x	x	x	x		x	x			x					
142	x					x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
143	x					x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x
144																	x	x	x	x	x	x	x	x
145																		x	x		x	x	x	x
146															x	x	x	x	x	x	x	x	x	x
147																	x	x	x	x	x	x	x	x
148															x	x	x	x	x	x	x		x	
149																x	x	x	x	x	x	x	x	
150																		x	x	x	x	x	x	
151																	x	x		x	x	x	x	
152																		x	x	x	x	x	x	x
153																		x	x	x	x	x	x	x
154																		x	x	x	x	x	x	x
155																		x	x	x	x	x	x	x
156															x	x	x	x	x	x	x	x	x	x
157															x				x	x	x		x	
158															x	x	x	x				x	x	x

Table 16.1 (*continued*)

	62/66	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
159															x	x	x	x	x	x	x	x	x	x
160	x				x				x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
161												x	x	x	x	x	x	x	x	x	x	x	x	x
162															x							x	x	
164																			x	x	x	x	x	
165																			x	x	x	x	x	
166																			x	x	x	x	x	x
167																			x	x			x	
168																				x	x	x	x	
169																				x		x	x	x
170																				x	x	x	x	x
171																					x	x	x	x
172																					x	x	x	x
173																					x	x	x	x
174																				x	x	x	x	x
175																					x	x	x	
176																					x	x		
177																					x	x	x	
178																					x		x	x
179																					x	x	x	
180																					x	x	x	x
181																					x	x	x	x
182																						x		x
183																					x	x	x	x
184																				x	x	x	x	
185																				x	x	x	x	
186																					x	x	x	
187																					x	x	x	x
188																				x	x	x	x	x
189																					x	x	x	x
190																				x	x	x	x	x
191																					x			x
192																						x	x	
193																						x	x	x

Table 16.1 (*continued*)

	62/66	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
195																						x	x	x
196																						x	x	x
197																						x	x	x
198																						x	x	
199																						x	x	x
200																						x	x	
201																						x	x	x
203																						x		x
204																						x	x	
205																						x		
206																						x	x	x
207																						x	x	
208																						x	x	x
209																						x	x	x
210																						x	x	
211																						x	x	x
212																						x	x	x
213																						x	x	
214																						x	x	x
215																						x	x	
216																						x		
217																							x	x
218																							x	x
219																							x	
220																							x	x
221																							x	x
222																							x	x
223																							x	x
224																							x	x
225																							x	x
226																						x	x	x
227																								x

Table 16.1 (*continued*)

	62/66	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
229																								x
230																								x
231																								x
232																								x
233																								x
235																								x
236																								x
237																							x	x
238																								x
239																								x
Totals	52			39		45	44	50	59	66	69	74	74	51	107	116	79	129	139	137	157	176	194	179
Mount Gardner	52			39		45	44	50	58	66	68	72	72	49	98	108	69	113	121	111	122	123	129	132
Lakes	-			-		-	-	-	1	-	1	2	2	2	9	8	10	16	18	26	35	53	65	47

4 July 91

CHAPTER 17

Habitats of the Rare Birds of Two Peoples Bay

G.T. Smith

INTRODUCTION

The presence of three rare birds, Noisy Scrub-bird *(Atrichornis clamosus)*, Western Bristlebird *(Dasyornis longirostris)* and Western Whipbird *(Psophodes nigrogularis)* makes the Two Peoples Bay reserve unique in Western Australia. The diverse topography and vegetation of the Reserve provide habitat for each species in a number of areas of the Reserve (Fig. 1.3 and Fig. 11.1 this publication).

The most important area is the Mt Gardner headland. In the period 1962-70 a number of fires burnt large areas of the Reserve, with the result that the three species were confined to the headland. This suggests that the area has been and will continue to be an important refuge for these and other species. The value of the area as a refuge results from the topography and soils that have allowed the development of a mosaic of the habitats that suit all three species. In addition, the dissected topography and extensive outcrops of bare granite provide a natural network of firebreaks which prevents the whole area being burnt at one time (Smith 1985a, 1987a).

The Reserve is the only area in which the Noisy Scrub-bird is known to have survived. However, the Western Bristlebird and Western Whipbird are found in a number of other localities (ch. 16 this publication). While the Reserve is clearly important for all species, top management priority should be given to the Noisy Scrub-bird.

This chapter describes the habitat of the three species on the Reserve, as well as the habitat in other localities in which the species are found, or are known to have occurred in the past.

HABITAT: MT GARDNER HEADLAND

Vegetation

The topographic and edaphic features of this area have resulted in the development of three broad structural vegetation types: Heath, Thicket and Forest. Heath is confined to the interfluves or on the shallow valley walls of drainage lines. Thicket is mainly a transitional formation on the break in slope between the valley walls and the interfluves, as well as below granite outcrops. It may also occur in the drier areas of the shallow gullies or on stoney ridges. Forest is found in all the drainage lines and in small patches downslope of the granite outcrops (Fig. 17.1). These formations, in relation to the bird habitats, are described below.

Forest

This is defined here as any three-layered plant formation. Hopkins *et al.* (ch. 11 this publication) have mapped this formation in this area as Mixed Jarrah/Marri/Bullich Low Forest A and Gully Mixed Dense Low Forest. The height mainly ranges from 3 m in areas downslope of granite outcrops, up to 12 m in the deeper, wetter gullies. The top storey is dominated by *Eucalyptus calophylla, E. marginata, E. conferruminata, E. megacarpa* and *E. cornuta*. In some gullies *Agonis flexuosa* and *Hakea elliptica* may be the dominants in small patches. The latter species is often the dominant in areas of shallow soil, downslope of granite outcrops and in drier areas within the gullies. The middle storey is dominated by *D. formosa, H. elliptica, Bossiaea* spp., *Thomasia* spp. and *Hibbertia* spp. The dense understorey is dominated by *Lepidosperma brunonianum, L. effusum, L. tetraquetrum, L. angustatum, Restio*

spp., *Anarthria scabra* and *A. prolifera* together with a number of smaller, lower shrubs and herbs.

Thicket

This is mainly a closed formation of two layers and up to 2-3 m tall. The most common dominants are *Agonis marginata, Hakea trifurcata, Dryandra formosa, Acacia myrtifolia, Eutaxea obovata, H. elliptica, Gastrolobium bilobum, Eucalyptus marginata*, and *E. calophylla*. In favourable areas patches of *Eucalyptus* spp. and/or *H. elliptica* may grow to 5 m. The understorey may be open or closed and is primarily composed of *Anarthria scabra, A. prolifera, Restio* spp. and a number of smaller shrubs.

Thickets have a continuous layer of litter that may be up to 5 cm thick. Most of it is composed of hard, small and round sclerophyllous leaves that compact to form a mat, which is difficult to probe into or turn over, when compared with eucalypt litter. The invertebrate fauna in this type of litter is also less abundant than in the litter from *Eucalyptus* spp. and *H. elliptica*. Hopkins *et al.* (ch. 11 this publication) have mapped this formation as Mt Gardner Thicket and Gully Thicket.

Heath

This is a single-layered formation 1-1.5 m tall. Although it is floristically diverse (over 120 species of shrubs) the prominent species are *Melaleuca thymoides, M. striata, Agonis parviceps, A. hypericifolia, Acacia leioderma, Anarthria scabra, Dasypogon bromeliifolius*, and *Cyathochaeta clandestina*. Within any given area, the heath may be dominated by one or two species, with the space between the dominant shrubs being filled in with varying proportions of *Anarthia scabra, A. prolifera* and *Restio* spp., together with a small number of smaller shrub species. Within the heath there may be small clumps (2-10 m diameter) of wind-pruned marri *(Eucalyptus calophylla)* and jarrah *(E. marginata)* 2-3 m tall which, although open, provide an area of thick litter. (Litter is generally sparse under heath in this area.) In some places there may be scattered patches of thicket. Hopkins *et al.* (ch. 11 this publication) have mapped this formation as Isthmus Mixed Dense Low Heath and Headland Mixed Dense Low Heath.

BIRD HABITATS

The above descriptions of the vegetation are based on the core area of the territories of the species, such areas being defined as areas where a bird is located on more than 60 per cent of occasions (ch. 16 this publication). It is reasonable to assume that these areas are the primary habitat of the species, even though other areas of the territories may provide useful or essential resources during the lifetime of an individual.

Noisy Scrub-bird

The prime habitat of this species is forest and may be divided broadly into nesting and feeding areas. Breeding occurs in the wetter areas with a dense ground storey, especially of *Lepidosperma* spp., which provide the main nest site and nest material. In these areas the ground storey is generally closed and the light intensity is relatively low. Feeding areas tend to be on the drier side of the breeding areas where the ground storey is more open and there is a thick layer of litter. In the wetter gullies the breeding habitat is generally confined to within 5 m of the creek, with the feeding zone on the uphill side. In the drier, shallow gullies there is a mosaic of small patches of both habitats. These patches may be as small as 2-3 m wide, at their widest point, and are rarely longer than 50 m.

The expanding population of Noisy Scrub-birds since 1972 has resulted in an increasing number of males occupying thicket and to a lesser extent heath (Smith 1985b). While many territories may have such formations within their boundaries they are rarely used by males with better habitat (forest) at their disposal (Fig. 17.2).

Western Whipbird

The prime habitat for this species is thicket (Fig. 17.2) which provides the right amount of cover, while at the same time not restricting the birds' movements. Thicket holds the food resources required by the carnivorous Whipbird. Less frequently they may forage in forest, but their larger size and lower agility (cf. Noisy Scrub-bird) would make them more vulnerable to predators in this habitat. All nests found to date have been in heath adjoined to thicket, as the heath provides the all important protection for the bird and support for the cup-shaped nest.

Western Bristlebird

The prime habitat is dense closed heath (Fig. 17.2) which provides cover from the aerial and ground predators of this almost flightless species. The heath is relatively open at ground level and even in very densely-vegetated areas mammal tunnels allow the birds to move around while foraging.

Bristlebirds eat seeds and a variety of invertebrates (Smith 1987b). Many of the heath plants such as *Anarthria scabra, Acacia* spp. and *Daviesia* spp. provide an abundance of seeds, which presumably are easier to find on the ground under heath, with its thin or non-existant litter layer. While the abundance of terrestrial invertebrates is low when compared with thicket and forest, there are small areas where they are more abundant, such as the small Eucalypt patches and clumps of *Anarthria scabra.*

All nests found so far have been in or associated with *D. bromeliifolius* (Smith 1987a). In areas without this species they may use *C. clandestina* or *A. scabra.* These plants, together with *Restio* spp., *Loxocarya* spp. and *Anarthria prolifera*, provide the nesting material.

Habitat Use

The prime habitat of each of the three species is one of the dominant vegetation formations on the Mt Gardner headland. Occasionally, however, each species will use areas of their non-preferred habitat. This use of habitat is illustrated in Figure 17.3, which shows the core areas and territory boundaries of the species in relation to the vegetation. While there are considerable overlaps in territories, core areas never overlap.

Western Whipbirds have the least specialized habitat requirements in relation to vegetation type. However, the expanding population of Noisy Scrub-birds in the area has demonstrated how labile are its habitat needs. As noted in Chapter 16 (this publication) there is an increasing number of birds occupying territories in thicket and to a lesser extent heath. While breeding in such areas may be irregular or may not occur, the fact that they can survive in these habitats has important implications for the survival of the species. There are no comparable data for the other species.

HABITAT: OTHER AREAS

For species such as those under consideration, habitat preferences of the surviving population(s) may not represent the species major habitat preference (Smith 1977). Therefore, it is important to attempt to gain a broad understanding of habitat preferences, by examining data from localities where the species has been found in the past and from areas into which the species has expanded during the last eight years. It should be noted that the following descriptions are for the general areas in which the species live and do not simply apply to the vegetation that the species actually uses within those areas.

Noisy Scrub-bird

The nineteenth century descriptions of Scrub-bird habitat have been collated by Robinson and Smith (1976). From these observations, together with observations of these areas in the 1970s, it is clear that Scrub-birds were confined to the wetter areas of the marri/jarrah forest. Within this broad region, it is the ecotone between swamp and forest that appears to have been their preferred habitat. The abundance of such habitat around Albany in the last century explains their greater numbers in this area in the period 1840-1890 (Smith 1977). On the Mt Gardner headland the functional equivalent of this ecotone is confined to a narrow zone along the creek beds in the wetter gullies (Fig. 17.4). In other areas suitable habitat forms part of a mosaic of vegetation types. The expansion of the population along Gardner Creek and into the area between the lakes (Figs. 1.4, 16.3 and 16.4 this publication) has been into areas where the dominant over-storey species are *Agonis juniperina, A. flexuosa, Banksia littoralis* and *Oxylobium lanceolatum.* The middle storey species are the same as on the Mt Gardner headland, while the ground storey is dominated by *Lepidosperma effusum* and *Restio* spp. Surface flooding in these areas in winter is common.

The habitat preferences of a species can be judged from how common it is in different habitats and from its breeding success in these places. The difficulty of finding Scrub-bird nests makes the second criterion difficult to use, while the first criterion is complicated by the fire history and the difficulty of quantifying the area of the various habitat types. However, a subjective ranking (in descending order) can be attempted: wet gullies (and lake margins), dry gullies, thickets, heath. This ranking can be related to a decreasing amount of cover, increasing light intensity at ground level, decreasing prey abundance, and decreasing availability of the preferred nesting material *Lepidosperma* spp, which is not found in heath. The last two habitats can be viewed as primarily survival habitats. While breeding in thicket is probably infrequent there are no records of Noisy Scrub-birds breeding in heath.

Western Whipbird

Gilbert (in Whittell 1942) found this species in:

> ...dissimilar places, on the southern west coast it was only found in the rankest vegetation growing around swamps, near Perth I found it on the dry sand hills, at Albany it was in groves growing almost on the beach and in the interior it was in dense thickets where for a

> portion of the year not a drop of surface water is to be met with for many miles...

Milligan (1902) found it in coastal thicket at Ellensbrook in 1901.

All recent observations have been in plant associations that can be described as mallee, mallee/heath, scrub/heath, and coastal dune thicket. These are all two-layer formations with open to closed upper and lower layers. The descriptions of the vegetation of 32 Western Whipbird locations throughout its range by McNee (1986) support these observations. This accords well with the descriptions from South Australia, where it has been reported from dense heath, mallee-heath and coastal dune scrub (Parker and Reid 1978).

The new areas occupied on the isthmus have been thicket-dominated by *Dryandra sessilis* and coastal dune thicket.

The basic essentials of Whipbird habitat appear to be a short, two-layered association with the bottom one being closed and the upper one open to closed (Fig. 17.5). There appears to be no floristic factor, either directly or indirectly, in the form of litter type. Within the broad criteria of the habitat being short and two layered, the species seems flexible in its requirements. Habitat of this type can be found from the semi-arid inland to the humid coast.

Western Bristlebird

There are two historic descriptions of the habitat of the Western Bristlebird. Gilbert, (most likely referring to the Perth area), stated that it 'inhabited reed beds and long grass and is occasionally seen in scrubby places' (Gould 1972). This is the only record of the species from the Perth area and it is unlikely that this type of swamp margin represented a preferred habitat. The only other early description of habitat is from an area east of Denmark, where Whitlock (in Whittell 1936) found them on *Xanthorrhoea* flats where gravel ridges were covered with dense heath about 1 m high.

Near Woolbernup Hill in the Fitzgerald River National Park (Fig. 1.1 this publication), Bristlebirds were found in areas of mainly open to closed heath in which there were elongate patches of eucalypts, 2-4 m tall, with a dense understorey of closed heath 1-1.5 m tall (Smith and Moore 1977). At the Waychinicup River in 1976 they were found to inhabit open to closed heath 50 to 100 cm tall with dense closed thickets along the narrow drainage lines, along river frontage and downslope of the granite outcrops. As the heath in this area has been subjected to a number of low intensity burns during the last ten years, the Bristlebirds have probably found refuge in the wetter areas with thicket, which appears to have been little affected by fire. The vegetation at 11 Bristlebird locations from Two Peoples Bay to Fitzgerald River National Park has been described by McNee (1986). The data clearly indicate a preference for low, dense heaths in all locations.

Expansion of the distribution from the Mt Gardner headland onto the isthmus has been into areas of open heath, that have very dense but small patches of *Cyathochaeta clandestina* and *Dasypogon bromellifolius*, and dense regrowth coppices of *Agonis flexuosa* and *Eucalyptus* spp. in the swales of the old dunes (Fig. 17.6). In this area the heath is open because of heavy grazing by Grey Kangaroo (*Macropus fuliginosus*).

These observations suggest that Bristlebirds are almost entirely confined to closed heath; open heath is used only if there are sufficient patches of denser vegetation in the area. The use of structually more complex plant associations, or swamp vegetation, occurs only on the edges of the distribution or after fire when they are used as a refuge.

DISCUSSION

Qualitative examination of the data on habitat indicates that it is structure rather than the floristics of the vegetation that is the important determinant of whether an area is suitable for any of these three rare species. In turn, the edaphic and microclimatic conditions at any site determine both the floristics and structure, and hence the basic resources required by the species. The suitability of the vegetation of any site will also be modified by the fire history of the area. The effect that fire has had on the populations of the three species at Two Peoples Bay has been documented by Smith (1985b and c).

The widespread occurrence of *Phytophthora cinnamomi* in the Reserve may lead to changes in the vegetation that are deleterious to the rare birds. To date there are no data to suggest that *P. cinnamomi* has caused any adverse changes in the habitat for this species, but the situation needs to be closely monitored.

While broad generalisations can be made of the habitat requirements of each species, there are various degrees of flexibility in the use of the various formations by the species. The Noisy Scrub-bird's primary habitat is the ecotone between forest and swamp. While this ecotone is rare on the Reserve, its structural and resource equivalent is found in a number of situations in which the vegetation may appear to be quite dissimilar, e.g. *Agonis juniperina*

forest around the lake margins and *Hakea elliptica* low forest below granite outcrops. The species may also use areas of thicket and, to a lesser extent, areas of heath adjacent to its primary habitat. In addition, territories are now being established in old heath and thicket and although breeding is infrequent in such areas, their use suggests a degree of flexibility in the Scrub-bird's survival requirements.

The primary habitat of the Western Bristlebird is dense closed heath, although it will use open heath if there are sufficient patches of dense closed vegetation. Its use of open heath, thicket and forest is uncommon and generally confined to small patches of these formations within an area of closed heath (Fig. 17.3). While the primary habitat of the Western Whipbird is thicket, nests have been found in heath within 50 m of thicket. The species may also use areas of low forest adjacent to its thicket abode. In general, this species appears more flexible in its use of vegetation, a factor that probably explains its wider distribution, which in turn may be a consequence of its more recent evolution (Schodde 1982).

Although the descriptions of the habitats are qualitative, they do provide a reasonable basis for assessing the extent of suitable habitat for each species, providing that the fire history for the area is known. If Two Peoples Bay Nature Reserve is to be managed for these species then such assessments will be essential in planning for the future management of the area.

ACKNOWLEDGEMENTS

I would like to thank M.C. Ellis and L.A. Moore for assistance in the field and L.A. Moore for identifying the plants; Dr. J. Green for kindly allowing the use of the Western Australian Herbarium collection; and Allan Burbidge, Mike Brooker, Angas Hopkins and Ian Rowley for a number of valuable criticisms of various draft manuscripts.

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3 HABITAT PHOTOS
TO BE INCLUDED WITHIN
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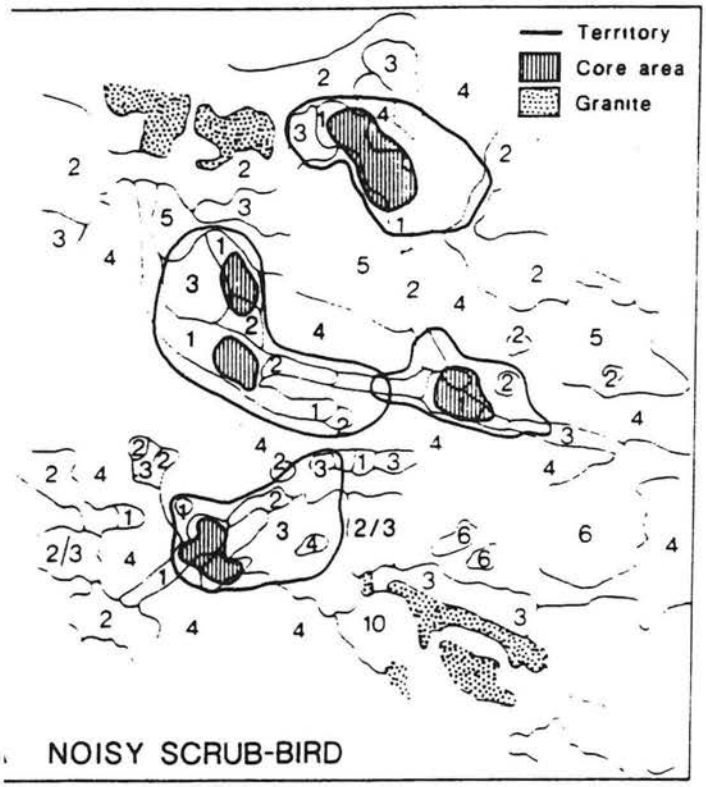

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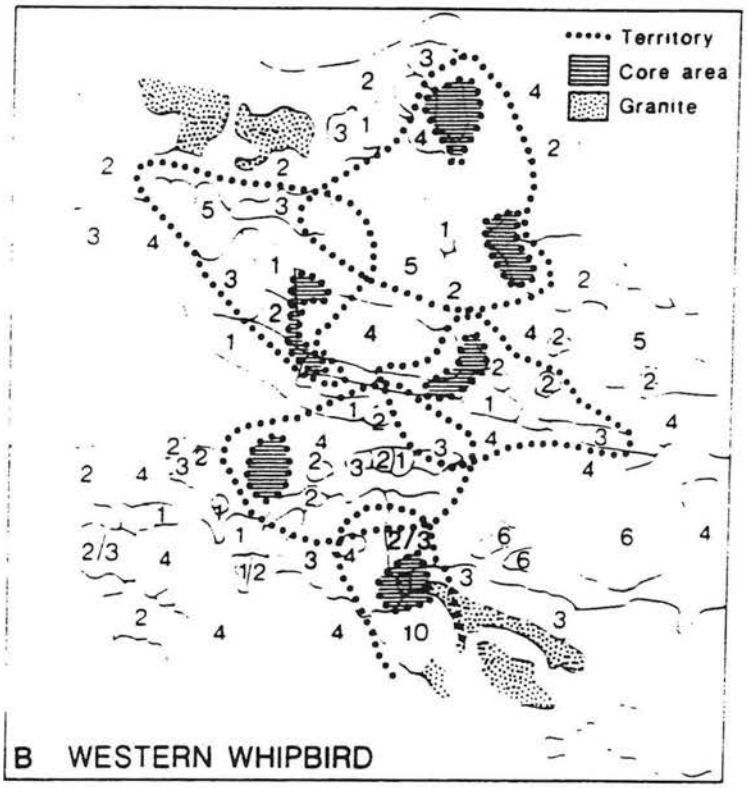

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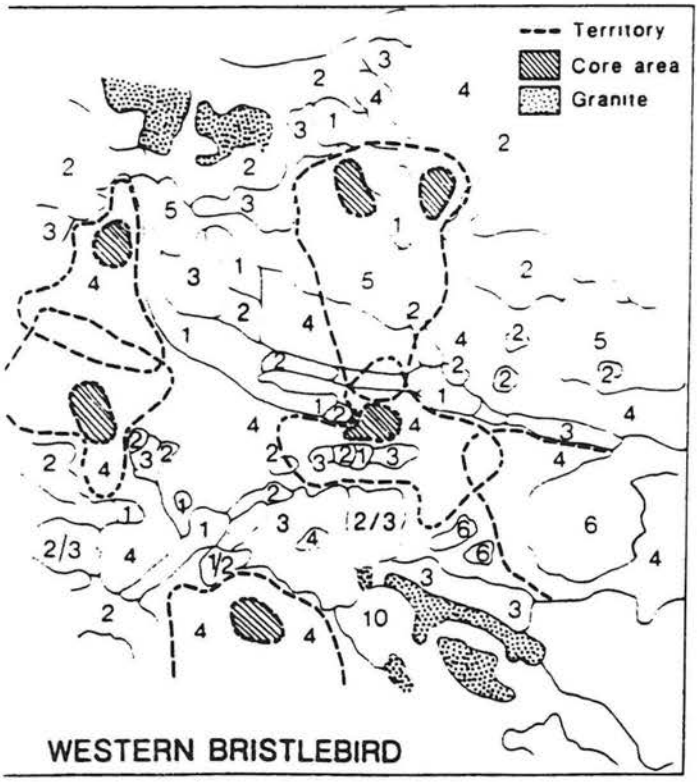

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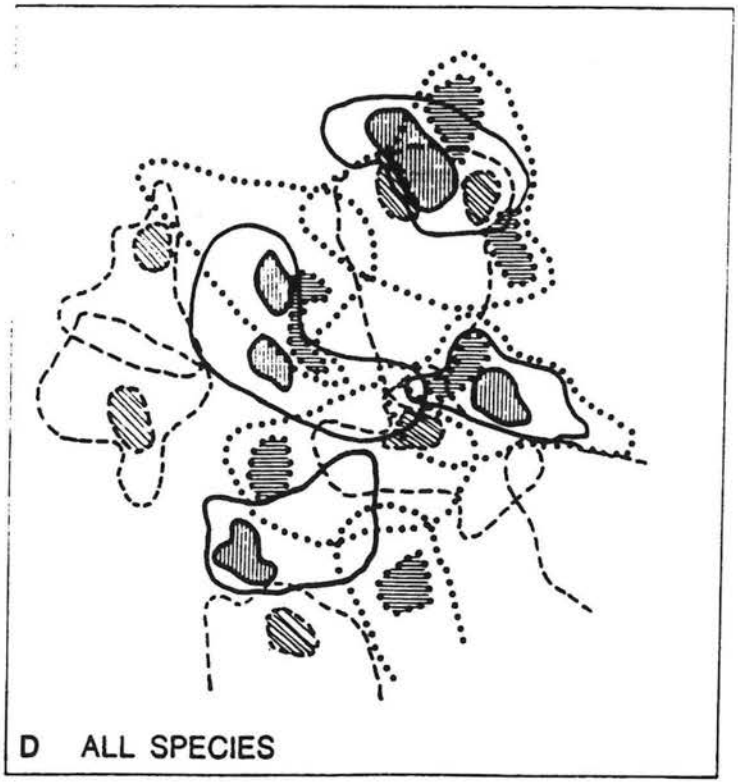

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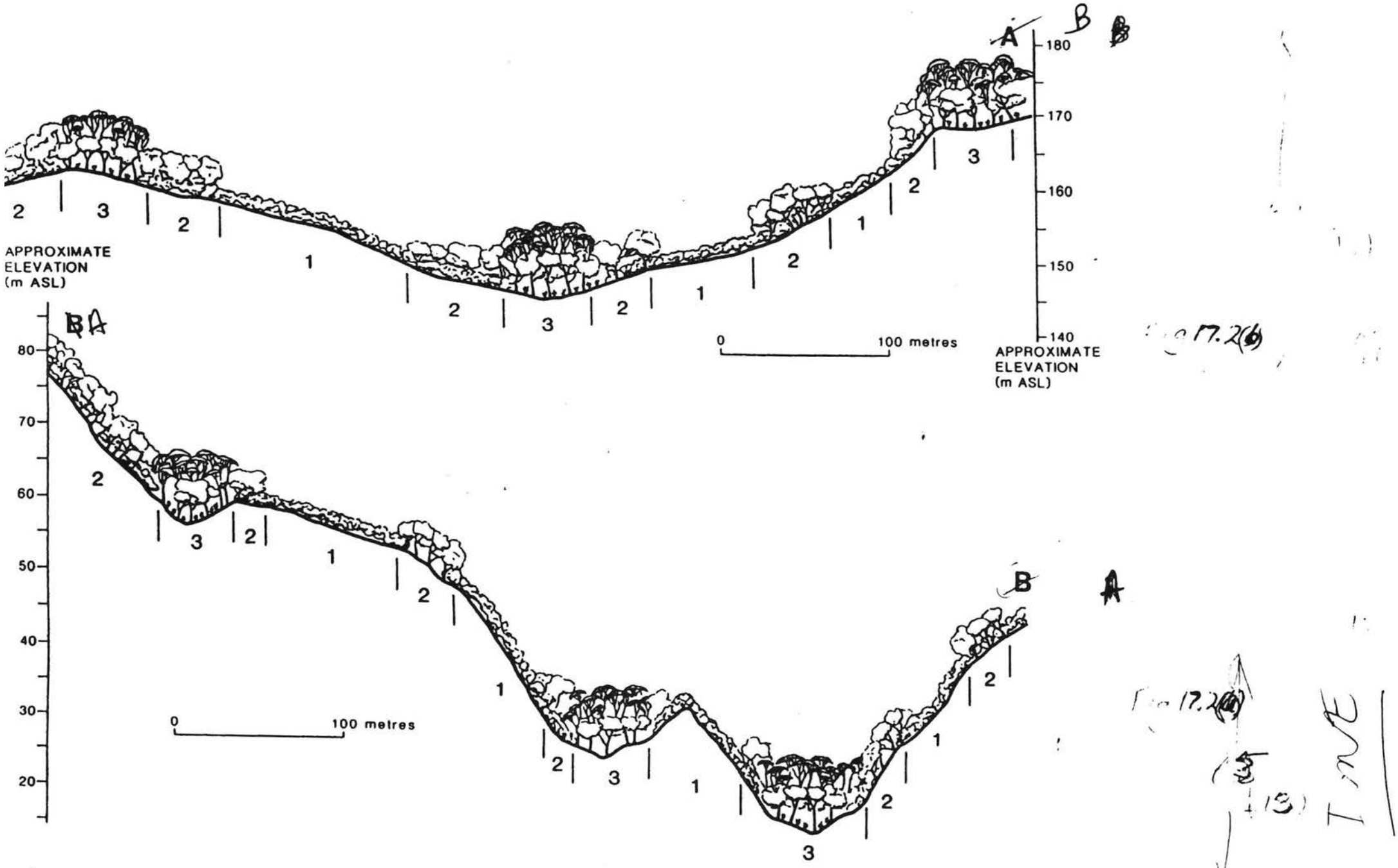
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CHAPTER 18

Effects of Removal of Birds from the Noisy Scrub-bird Population

A. Danks and G.T. Smith

INTRODUCTION

A species with a small population and a restricted range is at risk from a variety of stochastic events as well as the loss of genetic heterozygosity even if its habitat is well managed. One method of enhancing a species survival chances is the establishment of other populations by translocating individuals from the extant population to other areas.

The desirability of establishing new populations of Noisy Scrub-bird (*Atrichornis clamosus*) has long been considered an important component in the management of the species. The growth of the Mt Gardner population and the emergence of a new sub-population around Gardner Lake from 1980 (Smith 1985a), prompted the then Fisheries and Wildlife Department (subsequently Department of Conservation and Land Management) to initiate a translocation program in 1983.

Following the apparent success of the first translocation program for Noisy Scrub-birds a management plan for the species was drawn up which incorporated translocation as a major strategy. The main objective of the plan is the establishment of additional populations so that there will be at least four separate reproducing populations at any one time (Burbidge *et al.* 1986).

Because the Two Peoples Bay population is likely to be the major source of Noisy Scrub-birds for translocation for some time, it is important that removals are regulated so that this population remains viable. When the translocation program began, it was not known how many Scrub-birds could be removed without affecting the population; thus the number of birds removed has been largely determined by the ability and time available to capture them. For future translocations, it would be useful to know the effects of regular removal of breeding adults.

The effects of removal of Scrub-birds from the parent population at Two Peoples Bay have been monitored since 1983. The purpose of this paper is to report on the results of this monitoring and on some additional insights into the population dynamics of the species brought to light by the translocation program.

METHODS

1. Census

The Noisy Scrub-bird is a cryptic species that lives in dense vegetation and the only easily observable activity of the bird is the loud territorial song of the male. The number of singing males is a measure of the number of territories being defended during the breeding season and provides a population index. Complete censuses of singing males are carried out annually at Two Peoples Bay, using the techniques of Smith and Forrester (1981) and Smith (1985a). A census involves several visits to each territory during the breeding season after the capture and removal of birds for translocation has ceased. To monitor the replacement of captured territorial males, additional visits were made to territories where males had been removed. This monitoring was often opportunistic and the more accessible territories received greater attention than others. Some territories were not visited until the next census several months later.

There is no practical method for censusing female Scrub-birds. Replacement of females captured at nests was determined by nest searches in the same territory in the years following capture.

2. Capture Methods

A number of techniques have been used to capture Scrub-birds during this program. Most originated in the first translocation project in 1983 and have been developed and modified since then. The major methods are summarised here: territorial males were captured using a song playback system in conjunction with a modified mist net; breeding females were captured at the nest using a specially designed nest trap; both males and females (mostly non-breeding) were captured in Elliott mammal traps modified for use with ground dwelling birds, and mostly used in conjunction with a drift fence.

RESULTS

Population effects

During the years 1983, 1985, 1986 and 1987 a total of 63 Scrub-birds were removed from the Two Peoples Bay population for translocation. Of this number 35 were male and 28 were females. At the time of capture, the majority of the males (32) were territory holders, whose removal might be expected to directly effect the census of singing males in the year of capture or in subsequent years.

The singing male census results for the years 1982-1988 for the Two Peoples Bay population and for the Lakes Area and Mt Gardner sub- populations are given in Table 18.1. The numbers of males and females removed from the two sub-populations, are also given in the table.

The number of occupied territories in the lakes area increased from 16 in 1982 to 65 in 1987, before declining to 47 in 1988. During this period eight females and 16 males were removed from this sub-population. When eight males and four females were removed in 1983 (the largest removal from this area) the population index increased from 18 in 1983 to 26 in 1984. Fewer Scrub-birds were removed in subsequent years.

On Mt Gardner the number of singing males increased from 114 to 132 during the period 1982-1988 when a total of 20 females and 19 males were removed. The sub-population has continued to grow slowly over this period although there was a small drop in the population index in 1984.

Replacement time

Data on the time taken for 32 captured territorial males to be replaced within their territories were as follows (Table 18.2a): five were replaced within one day, four within a week, six in less than a month, 10 within six months and another six were replaced by the next breeding season. Only one territory has remained vacant since the territorial male was removed in 1985, i.e. 96.9 per cent of the captured territorial males have been replaced.

A total of 28 females were captured between 1983 and 1987. Only 22 of these were considered to be breeding at the time of capture, i.e. were captured at the nest or had a well developed brood patch or an egg in the oviduct when captured at a trapline. There is evidence (from nest searching and trapping in 1985, 86, 87 and 89) for replacement of 12 (54.5 per cent) of these breeding females (Table 18.2b). Four were found to have been replaced by the following breeding season, three after two years, three after three years and two after four years. For 10 of the captured breeding females there is no evidence for replacement to date.

Two adjacent territories, 159 and 160 (Fig. 16.4 this publication), were trapped more intensively than other territories and, because of their locations, could be monitored more closely. Between 1983 and 1987, 12 males (including nine territorial males) and seven females were removed from these two territories using either song playback or modified Elliott traps. In each territory removal of the territorial male was followed by a generally rapid replacement by another male (Table 18.3). This occurred five times in both territories.

The initial replacements occurred with 24 hours while later replacements required periods of from two days to three weeks. The replacement males were captured at the same locations as the territorial male they were replacing, suggesting close knowledge of the territory and of the previous territorial male's movements. Adjacent territories 158 and 161 were also monitored at the time of the captures in 159 and 160 and appeared to retain their territorial males.

In 1986, after capture and removal of the territorial male from 160 the replacement was a young male with a poorly developed song (possibly in his first year; see Smith *et al.* 1983). The song improved over the next six months and eventually became like regular Noisy Scrub-bird territorial song. After capture of two non-territorial males in a trapline between 159 and 160 in 1987, removal of the territorial male from 159 resulted in that territory being occupied by the territorial male from 158. This male defended both territories until six months later when each territory had its own territorial male.

DISCUSSION

In general the number of Noisy Scrub-bird territories at Two Peoples Bay has continued to

increase, despite the removal of 34 males and 28 females for translocation over the period 1983 to 1987. This suggests that the population is able to cope with the removal of adult breeding birds in this program and that the current rates of removal are not excessive.

On Mt Gardner, during the early years of the translocation program, the rate of growth of the population index appeared to slow. Whether this was because of the removal of Scrub-birds or an expression of habitat saturation (Smith 1985a) is not known, but there appears to be no correlation between the annual census results and the number of birds removed.

In the lakes area vacant habitat and local breeding, probably augmented by immigration from the Mt Gardner population, have allowed a rapid increase in the population index. Apart from in 1983, the number of birds taken from this area has been small and does not appear to have affected this growth. No explanation has so far been found for the sudden decline in the number of occupied territories recorded in 1988. The decline was localised and well away from areas where Scrub-birds had been trapped in years immediately preceding the decline.

After removal, territorial males were generally observed to be replaced fairly quickly by another male singing territorial song, at least in those territories where frequent checking was possible. Many territories could not be checked until the next census, however, and this would over-emphasise the `6 months' and `next year' categories. Only one territorial male has not been replaced from within the population. This territory remains vacant presumably because the habitat is sub-optimal.

Sequential trapping of males in territories 159 and 160 indicates the presence of a number of non-territorial males, within or associated with these territories, who are capable of taking over the territorial male's role after his removal. The residential status of these males could not be positively determined, but the pattern of replacement strongly suggests that they were resident in the territories. Certainly, the inheritance of territory 160 by a very young male after removal of a number of other males, and the occupation of 159 by the neighbouring territory holder, would have been unlikely if numbers of dispersing males were present in the area.

The presence of non-territorial males in Noisy Scrub-bird territories was first noted in 1975 (Smith 1985b) and observations during the translocation program have amply confirmed this. However, the number of non-territorial males which could be successively removed from territories 159 and 160 was surprising, and suggests the habitat is very favourable. One non-territorial male which died during the capture program had active gonads (R. Johnstone,[1] personal communication). This, and the rapidity of replacement of captured territorial males, suggests that these extra males are important in ensuring the continuity of breeding within a territory, despite the disappearance of the territorial (breeding) male.

The extent and rate of replacement of captured females was much more difficult to determine since it depended largely on finding active nests in the years following capture. In practice, nest searching was limited to areas of likely nesting habitat and confined to a particular time period within the breeding season. These factors create problems in observing the number of breeding females replacing those captured. Although a little more than half the areas appear to be reoccupied this is likely to be an underestimate. The continued growth in the population index despite removal of males and females over a number of years suggests that, as with territorial males, most breeding females are being replaced after removal.

ACKNOWLEDGEMENTS

The first translocations of Noisy Scrub-birds were carried out under the direction of Graeme Folley and Don Merton and we would like to acknowledge their major contribution to Scrub-bird management.

Many people involved in the translocation work since 1983 have contributed to the results presented here, and our thanks are due to them. Otto Mueller, Peter Cale, Ian Wheeler and Allan Rose deserve special mention for their efforts over many years. Angas Hopkins, Mike Brooker and Allan Burbidge made valuable criticisms on the manuscript.

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1 R. Johnstone, Western Australian Museum

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Table 18.1
The numbers of singing males in the Mt Gardner and Lakes sub-populations together with the number of males and females removed from those sub-populations during the period 1982 to 1988.

	1982	1983	1984	1985	1986	1987	1988
Mt Gardner	114	121	111	122	123	129	132
Males removed	-	2	-	5	6	6	-
Females removed	-	2	-	6	7	5	-
Lakes	16	18	26	35	53	65	47
Males removed	-	8	-	3	2	3	-
Females removed	-	4	-	1	1	2	-
Total	130	139	137	157	176	194	179
Males removed	-	10	-	8	8	9	-
Females removed	-	6	-	7	8	7	-

Table 18.2
Times taken for male (a) and female (b) Noisy Scrub-birds to be replaced after removal from their territories. Only data for territorial males (32) and females known to be breeding (22) are shown.

Time to be replaced

(a) Males

Year	1 day	1 week	1 month	6 months	Next year	Not replaced to date
83	3	2	2	-	3	-
85	1	-	1	5	-	1
86	-	1	-	4	2	-
87	1	1	3	1	1	-
Total	5	4	6	10	6	1

(b) Females

Year	Next Year	2 years	3 years	4 years	5 years	Not replaced to date
83	-	-	1	-	-	1
85	1	-	-	2	-	4
86	3	-	2	-	-	2
87	-	3	-	-	-	3
Total	4	3	3	2	-	10

Table 18.3
Dates for the capture and removal of males from territories 159 and 160 and dates for the first observation of territorial song after removal.

Year	Territory	Capture	Replacement
83	160	5/6	5/6
		8/6	14/6
		19/7	-/7
	159	1/7	1/7
		1/7	2/7
		2/7	4/7
85	160	23/6	24/6
	159	9/7	-/8
86	160	2/6	6/6[a]
87	159/160[c]	20/6[b]	
		28/6[b]	
	159	28/6	29/6[d]
			26/12[e]

a = replacement by young male with partly developed song
b = non-territorial male
c = trapline between territories 159 and 160
d = male from adjacent 158 defending both 158 and 159
e = 158 and 159 defended by separate territorial males

THESE TABLES TO BE REPOSITIONED WITHIN TEXT

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CHAPTER 19

Fire History

J.M. Harvey, A.J.M. Hopkins and G.T. Smith

INTRODUCTION

An appreciation of the fire history of the Two Peoples Bay Nature Reserve is vital for both the understanding and future management of the plant and animal communities there. Changes to the fire regime throughout the south-west of Western Australia are thought to be a critical factor in the decline of the populations of three rare birds; Noisy Scrub-bird (*Atrichornis clamosus*), Western Bristlebird (*Dasyornis longirostris*) and Western Whipbird (*Psophodes nigrogularis*). Increased wildfire frequency that resulted from post World War II land clearing activities has also been a significant factor. This view is supported by research data from the Two Peoples Bay Nature Reserve.[1]

This chapter describes the fire history of the Reserve by summarising all available data which have been pieced together from records on Department of Conservation and Land Management files, delineation of fire scars on aerial photographs, and personal records of local people and Departmental staff.

ABORIGINAL USE

The main accounts of the use of fire by Aborigines in the Albany district are those of Menzies and Vancouver (1791), Flinders (1801), King (1818), Nind (1827-9), Collie (1831-2), Dale (1832), Stokes (1840) and Eyre (1845).[2] These accounts have been summarised by Smith:

> Aborigines from the surrounding districts gathered at Albany for the summer; the men burning off large areas of forest to hunt kangaroos while the women lit smaller fires in the swampy areas to hunt bandicoots and lizards. Areas were burnt consecutively so that no one area was burnt too frequently.[3]

Several of these accounts also mention the use of fire to regenerate a sweeter crop of grasses, as noted by explorer John Eyre in 1840/41:

> ... burning off the grass enable [sic] the natives to take the older animals more easily, and to provide a new crop of sweeter grass for the rising generation of the forest...[4].

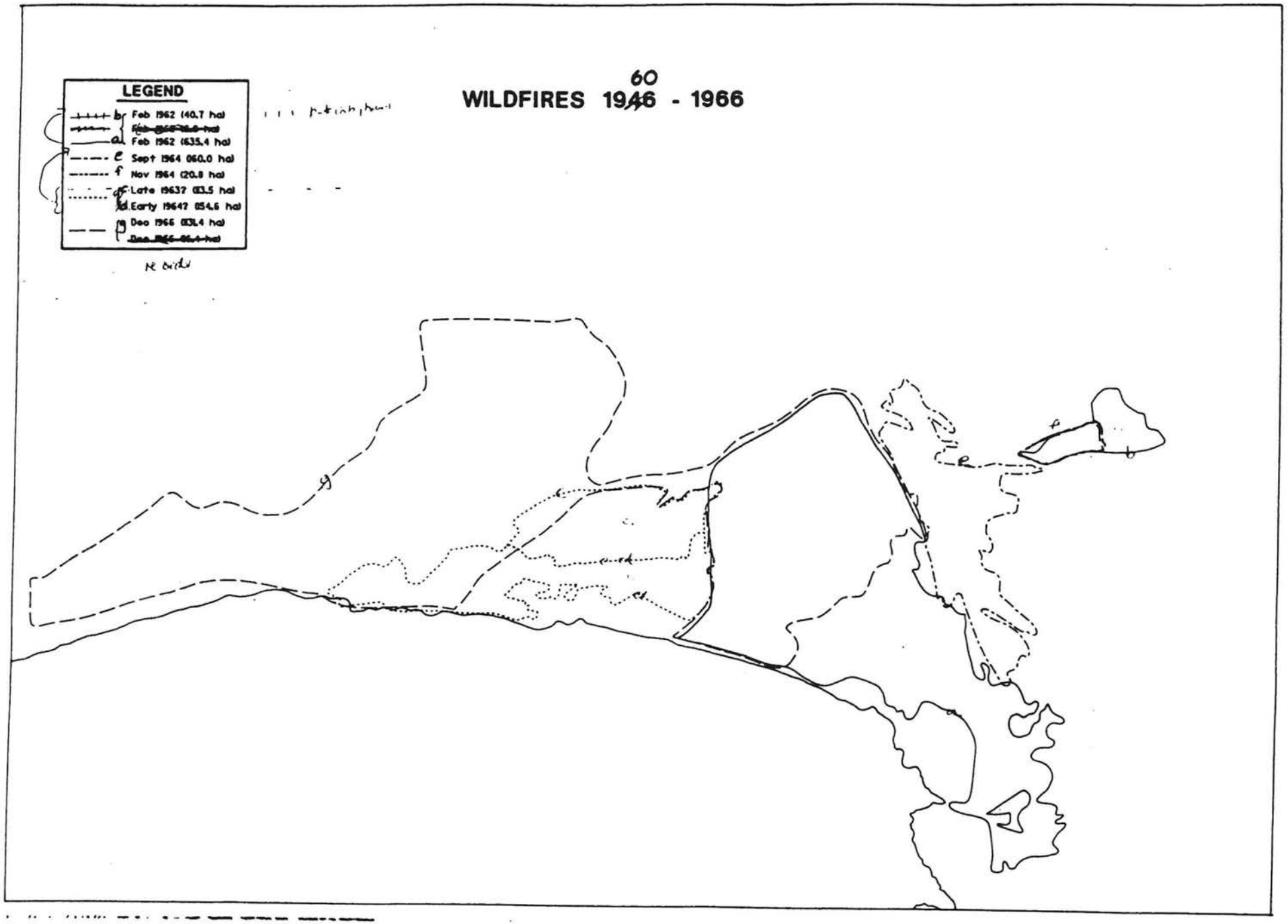
We do not know whether the Aborigines used Two Peoples Bay in this manner. We can only surmise that they did so, as they were certainly known to visit the area.

The early explorers, sealers and whalers set up camp in the Bay where there was a supply of fresh water and game. It is possible that wildfires would have started from their camp fires and from the fires used to process whale oil. The whale carcasses were a great attraction to the local Aborigines and undoubtedly led to more frequent visits to the area (ch. 2 this publication) and hence increased the likelihood of burning by Aborigines.

EARLY ATTITUDES TO FIRE

After the turn of the century, the Two Peoples Bay area progressively increased in popularity as a place for fishing, camping and picnicking. By the 1920s people began building rough shacks to enhance their weekend and holiday enjoyment at the Bay (ch. 2 this publication). These activities would have increased the incidence of fire in the area.

There are no records on the frequency or extent of fires before the 1960s, however communications with several local identities have contributed to an understanding of attitudes to fire during the first 60 years of this century. Local fishermen were reputed to have lit occasional fires to allow easy access to their favourite fishing spots and kangaroo shooters also burnt the bush to attract their quarry to the fresh regrowth in a similar vein to the Aborigines before them. Although land clearing for farming purposes began on a small scale in the 1930s this factor had a significant impact on the area, after World War II


LEGEND
b Feb 1962 (40.7 ha)
a Feb 1962 (635.4 ha)
e Sept 1964 060.0 ha)
f Nov 1964 (20.8 ha)
c Late 19637 (83.5 ha)
d Early 19647 (54.6 ha)
g Dec 1966 (83.4 ha)
WILDFIRES 1946 - 1966

when bulldozed timber was burnt in windrows, as wholesale land clearing progressed. Another important local influence was the pumping station on the Angove River which required a continuous supply of dry wood to feed the boilers during a 40 year span between 1913 and 1953 (ch. 2 this publication). In forested sections the woodcutters reputedly fired the bush to kill trees prior to felling and cutting the dried wood the following year. Local legend tells of a pyromaniac who worked at the pumping station before World War II.[5] In 1939 the voluntary Lower Kalgan Bushfire Brigade (LKBB) was formed and, after maintaining control over local fires throughout the war, has remained active to the present day. The LKBB has generally relied on local farmers for its membership. In the early days it was customary to set alight small patches of thick scrub before summer, along roads and in uncleared areas, to provide fire breaks and prevent the occurrence of large wildfires.[6]

Examples of these patterns can be seen on the earliest available aerial photography of the area, taken in March 1946 by the Department of Defence for mapping purposes. This shows the scars of numerous small fires that originated along the coast and between the granite outcrops throughout the Mt Gardner headland. Larger fire scars are evident in the isthmus and western boundary areas[7] (Fig. 19.1).

A local resident recalls that there were fewer fires in the 1950s, however, at least one wildfire in that decade occurred near the mouth of Gardner Creek and burnt down one of the shacks. In 1958/59 the LKBB was issued with a new fire truck and they carried out a `controlled' burn near the Gardner Creek crossing.[8]

WILDFIRES 1960-66

Following a request from the Western Australian Wildlife Authority in September 1968 to provide information for a future management program, Mr H.O. (Harley) Webster, the Albany Primary School headmaster and a keen ornothologist, submitted details of fires in the Reserve area.[9] Some of these were evident on the large scale c. February 1965 photograph and the aerial photographs taken of the coastline in December 1965.[10] Webster outlined the fires he knew about on the June 1970 photography.[11] He stated that there were `practically annual fires in parts of the reserve adjacent to the farm' (`Tandara'), such as the fire along the lake (Gardner) shore in 1961[12] (Location unknown).

Webster's letter also described a fire in February 1962 which escaped from an angler's driftwood fire at the bottom of a large gully (West Gully) west of Mt Gardner. (D. Wilson, personal communication, remembers this fire occurring in 1957/58). Four known Noisy Scrub-bird territories were burnt but three of the birds survived this fierce fire. One territory is known to have been reoccupied in 1966[13] (Fig. 19.2(a)).

On 18 February 1962 Fisheries Inspector Mr Neil McLaughlin saw a fire that originated in the squatters' shacks area, burn towards the south east point (of the Bay) but it was stopped by a track[14] (Fig. 19.2(b)).

The December 1965 coastal photographs show two fire areas on the coast south of Lake Gardner. The fires appear to have occurred in the previous summer (1963/64) and the location of the southern fire suggests that it was started along the Rocky Point track and stopped by the recently burnt edge of the northern fire area (Fig. 19.2(c,d)).

A fire on 20 September 1964 started in low, thick scrub near the squatters' huts and burnt fiercely in a south-south-easterly direction up over the hill and through the next gully, burning at least 120 ha[15] (Fig. 19.2(e)). Rain the following morning put the fire out. Albany recorded 9.7 mm in the 24 hours to 0900 h on 21 September 1964.[16] This 1964 fire had no effect on any long term Noisy Scrub-bird territories.[17]

In November 1964 a fire escaped from a picnic fire in the seaweed on the Two Peoples Bay beach. No shacks were damaged but a Noisy Scrub-bird territory was burnt. The male bird disappeared in September 1965.[18] The boundary of this fire is difficult to discern on the December 1965 photography because the vegetation was very thick and the tree canopy was not badly burnt (Fig. 19.2(f)).

The Albany Fauna Warden, Mr Malcolm McDonald, reported a large fire on 20 December 1966. The fire appeared to have been lit in the middle of the day, on a wide front on the southern side of the main road through the Reserve, north-east of Gardner Lake. The manager of Tandara, Mr Jim Marden, and farmhands were present. Members of the LKBB, of which Mr Marden was Captain, assessed the situation and as there was a shortage of water and a strong wind, they decided not to attempt to extinguish the fire. Mr McDonald worked alone until midnight to exinguish small fires that had `hopped over' the Mt Gardner track. The fire was fanned by a strong easterly wind and burnt from west of the Sinker Reef track across the dunes and swales towards Nanarup. The following day the eastern edge of the burnt area reignited and the fire burnt toward Mt Gardner. Mr McDonald again approached the Brigade, then present on Tandara, to help prevent the fire from

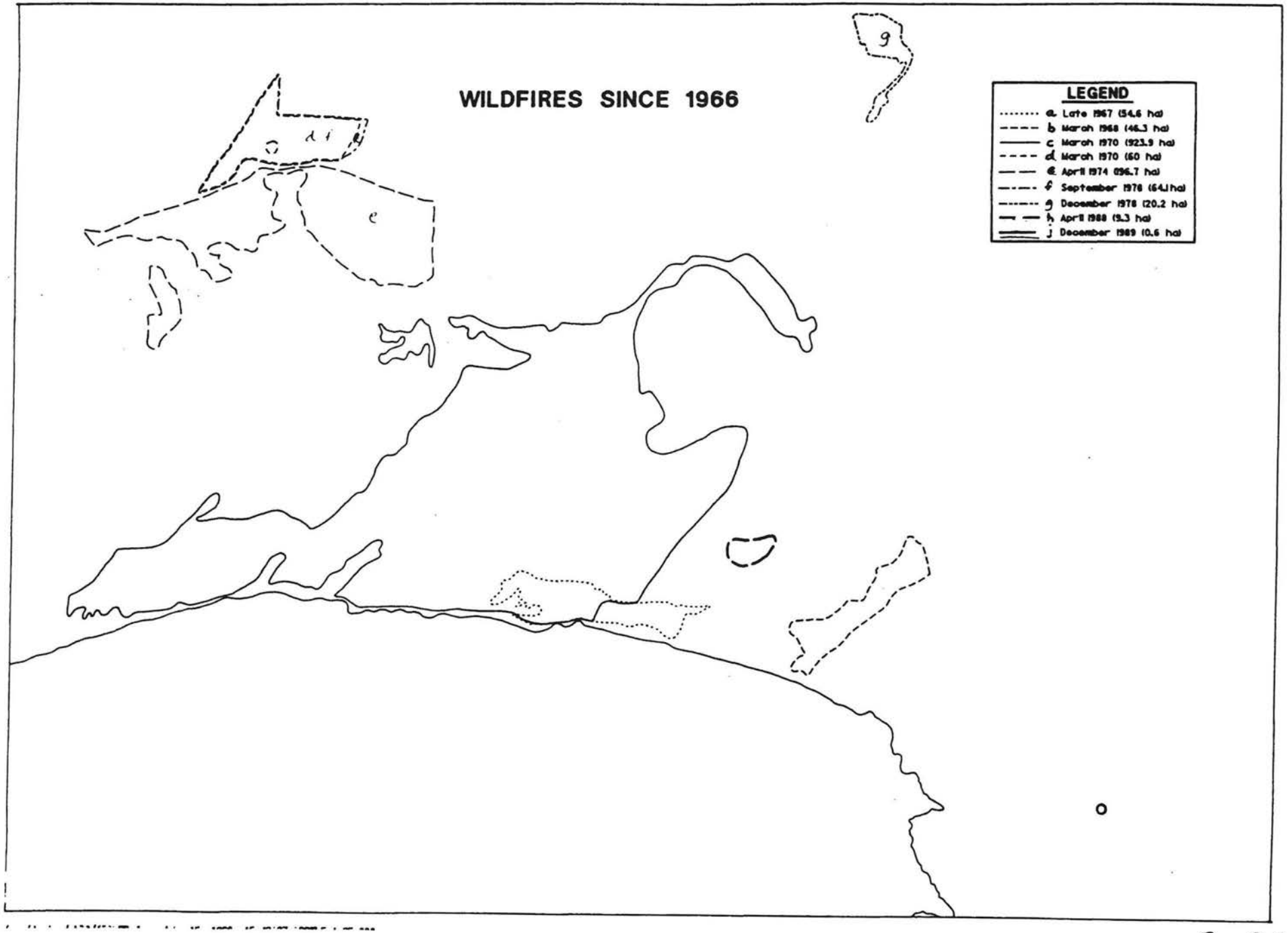

WILDFIRES SINCE 1966
LEGEND
a Late 1967 (54.6 ha)
b March 1968 (46.3 ha)
c March 1970 (923.9 ha)
d March 1970 (60 ha)
e April 1974 (196.7 ha)
f September 1978 (64.1 ha)
g December 1978 (20.2 ha)
h April 1988 (9.3 ha)
j December 1989 (10.6 ha)
9
d
e
o

Fig 9:3

threatening the main concentration of Noisy Scrub-birds. His request was refused on the grounds that their equipment was unsuitable for the sandy soils and that they thought the fire was a `good thing'. They had, however, been to the site earlier and lit a backburn along the Mt Gardner track. Fortunately light rain started to fall and, with the assistance of his two sons, Mr McDonald was able to extinguish the fire[19] (Fig 19.2(g)).

Early in 1967 Departmental officers discussed fire control with the Captain of the LKBB and agreed on an initial system of bulldozed firebreaks. These discussions paved the way for future co-operation between the Department and the Brigade, with the former becoming a member of the LKBB in 1968. An indication of the Brigade's change of attitude was reflected in a letter dated 15 February 1967:

> ... the Brigade will always be available to carry out protective burning in co-operation with your Department. The active officers of this Brigade are all farmers who had a lot of experience with fires under local conditions and there is no doubt that working together we would give the Noisy Scrub Bird maximum protection from bushfires ...[20]

FIRES 1967-1990
(Since establishment of the Reserve)

The following two sections are a summary of available records pertaining to wildfires (Fig. 19.3) and management fires (Fig. 19.4) at Two Peoples Bay N.R. since the gazetting of the full Reserve in June 1967.

Wildfires

The February 1969 aerial photographs show there was a fire on the south coast which probably originated on the beach and was contained in some parts by the Rocky Point track. The fire scars appear to predate the photography by about two years[21] (Fig. 19.3(a)).

On 24 March 1968, six days after firebreaks were burnt along the Mt Gardner track, a wildfire pushed by strong and gusty easterly winds burnt an area of approximately 50 ha south-west of the track. This fire, thought to have escaped from a log left burning in the firebreak, was first noticed at 1800 h on 24 March. The Albany Fauna Warden, Arthur Pearce, and three Departmental personnel who were on leave in the Albany area extinguished the fire by 1330 h the following day. They were assisted by light rain[22] (Fig. 19.3(b)).

A large fire that burnt over six days from 11 March 1970 was recorded by Dr A.A. Burbidge. This originated from a burning log pile on Location 3777 (Tandara) on the north side of the main road just west of the bridge. It entered the Reserve at about 1000 h and was fanned by a fresh easterly wind. The fire edge nearest to Mt Gardner (along the creek) was extinguished but the west side remained out of control. By next morning it had burnt through to the coast and adjacent dunes and, under the influence of a strong north-easterly wind, it continued to burn in a westerly direction towards Nanarup. A large backburn, lit that same day from the north-south firebreak running east of Gardner Lake, stopped the fire when it returned on the predicted north-west wind. The next day the fire reignited and jumped Gardner Creek near the northern edge of Gardner Lake and, pushed by the north-west wind, started to burn towards Mt Gardner. It was finally extinguished by rain. The fire burnt more than 800 ha[23] (Fig. 19.3(c)).

On 31 March 1970 most of the 60 ha section of the Reserve north of the main road was burnt in a fire which was lit on the farm on Location 6452 (Fig. 2.4 this publication) on 28 March. It escaped into the Angove River water reserve and then into the Nature Reserve. It was still smouldering on 4 April when inspected by Mr Pearce who finished putting out burning stumps the following day[24] (Fig. 19.3(d)). Most of the boundaries of both the 1970 fires are visible on the February 1973 photography.[25]

In April 1974 a fire escaped from Black Cat Creek Farm, to the west of the Reserve, crossed the Goodga River and burnt an area north of Moates Lake. It was considered a very hot fire and back-burns were lit along the eastern edge of the woodland north of Moates Lake.[26] (Fig. 19.3(e)).

The northern forest block was burnt in the afternoon of 8 September 1978 by one of the local farmers under the direction of the local LKBB.[27] The fire was intended as part of the brigades' fuel reduction program for the adjacent water reserve and the fire resulted from the incorrect interpretation of boundaries (Fig. 19.3(f)).

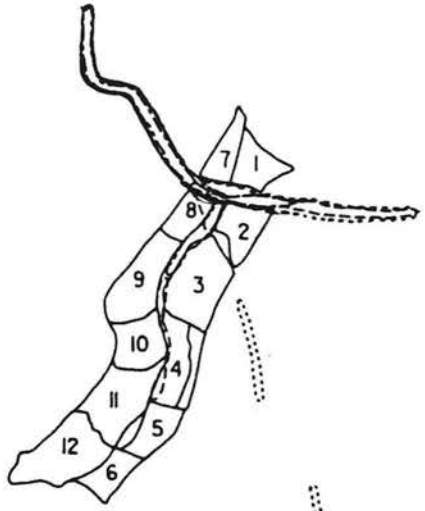
In December 1978 a small part of the Reserve north of Angove Lake was burnt in a large wildfire which started east of the Mt Manypeaks Nature Reserve and burnt to near Betty's Beach[28] (Fig. 19.3(g) and Fig. 2.1 this publication).

A lightning strike in the area known locally as the 'Tumbledowns' (Fig. 1.4 this publication), 400 m west of Block 9, burnt an area of approximately 15 ha on 19 April 1988. This fire was extinguished by the LKBB (Fig. 19.3(h)). On 15 December 1989 lightning also started a fire on Mt Gardner but it soon went out after burning less than 1 ha[29] (Fig 19.3(j)).

FIREBREAKS

LEGEND

- a March 1968 (6.6 ha)
- b 1969/70 (13.5 ha)
- c September 1972 (14.3 ha)
- f. June 1985 (6.3 ha)
- d September 1975
- e September 1976



BLOCKS BURNT

1	Sept. 76, June 88 (7.9 ha)
2	April 1983 (8.3 ha)
3	September 1977 (17.2 ha)
4	Partial, 1979 (9.7 ha)
5	Sept. 78, October 87 (9.1ha)
6	September 1980 (6.7 ha)
7	September 1979 (6.5 ha)
8	September 1980 (6.3 ha)
9	September 1978 (15.0 ha)
10	Sept. 76, Sept 86 (10.0 ha)
11	September 1981 (15.7 ha)
12	September 1977 (18.3 ha)

Fig 19:4

Management Fires

Following the gazetting of the full Reserve area in 1967 (ch. 3 this publication) one of the first issues to be tackled was fire management. It became apparent early in the history of the Reserve that fire was a major management problem and that the construction of strategic firebreaks and buffer strips was necessary. Fire buffers were burnt along parts of the tracks to Little Beach and Mt Gardner on 18 March 1968[30] (Fig. 19.4(a)).

In late 1969 and early 1970 tracks were constructed to Sinker Reef and through Firebreak Gully. Buffers were burnt along the main road from the old Mt Gardner turn-off, to the Firebreak Gully turn-off, including a triangular block near the Sinker Reef corner[31] (Fig. 19.4(b)). Buffer strips were also burnt in September 1972, between a firebreak and the southern side of the main road east of Gardner Creek, to near where the Reserve Management Officer's house now is, and along parts of the Sinker Reef track[31] (Fig. 19.4(c)).

In September 1973 both sides of the road north of Moates Lake were burnt as firebreaks[32] (Fig. 19.4(d)).

Strategic Fuel Reduced Zone

In 1976 a decision was made to establish a Strategic Fuel Reduced Zone (SFRZ) across the narrowest part of the isthmus, in order to isolate the Noisy Scrub-bird population on Mt Gardner from sources of fire.[33] The fire history records detailed above indicated that major fires in the previous 15 years had come from the west and north-west. Wood-fired barbecues in the picnic area could also be a source of wild fire. These were later replaced with gas-fired barbecues and fires were banned from the rest of the Reserve. Later, when Noisy Scrub-birds spread to Gardner Lake, the SFRZ isolated this new sub-population from any outbreak of fire on Mt Gardner.

The SFRZ consisted of 12 manageable blocks (Fig. 19.4) and the plan was to burn two blocks each year for the next six years and then review the situation.

In September 1976 Blocks 1 and 10 were burnt. Prior to the first burn more than 8 mm of rainfall was recorded on each of the preceding eight days. The forecast maximum temperature was 17°C, with winds from the south-west. The fire hazard was calculated as being 1.4 with an estimated 15 km/h rate of spread. Block 1 was lit at 0900 h on 7 September and the open heath burnt well but the fire stopped short of the swamp, and 2.5 mm of rain fell during the burning period. Later that day (1100-1430 h) a firebreak was burnt along the edge of the Little Beach Road, in a patch of *Allocasuarina fraseriana*, and a 60-70 per cent burn was achieved. The next day 80 per cent of Block 10 was burnt from 0900 h to 1330 h. Maximum temp- erature was 13°C.[34] A study plot consisting of sixty-four 4 m^2 quadrats was established to monitor the effects of that fire on the vegetation and subsequent regeneration[35]

As north-east to south-east winds were forecast for 9 September it was decided to burn the swamp area. Wind speed at the time of ignition (0900 h) was nil but 30 minutes later it had increased to 5 km/h from the north. It then swung around to the west thus altering the source of inflamable material on an upwind face. This resulted in a hot fire through 90 per cent of the swamp. Firebreaks were also burnt on the same day along the main road east of Gardner Lake[36] (Fig. 19.4e).

On 6 September 1977 Blocks 3 and 12 were burnt. No details are available but the general weather conditions for Albany for that day were winds averaging 15 km/h from the north-west and a recorded maximum temperature of 19°C.[37]

Blocks 5 and 9 were burnt on 7 September 1978. In Albany the wind in the morning was 10 km/h from the north-west. This swung around towards the north and dropped in the afternoon. Maximum recorded temperature was 18°C at 1300 h. The eastern edges of Block 4 were also burnt in preparation for a summer burn the following year.[38]

On 23 February 1979 the main part of Block 4 was burnt. Fuel moisture at 0930 h was less than 5 per cent, winds were easterly at 15 km/h, temperature was 18.5ÉC and relative humidity 65 per cent. The fire was lit at 1030 h when the winds were easterly at 17 km/h, temperature had risen to 20.5°C and the humidity was 53 per cent. By 1045 h the plot was burnt with the five soil temperature sensors showing that the lowest temperature on the sensor (950°F) had not been reached.[39] An additional study plot was established within this block.[40] Later that year (11 September) block 7 was burnt.[41] Conditions in Albany were westerly winds 10-15 km/h and a maximum recorded temperature of 16°C.[42]

On 10 September 1980 Blocks 6 and 8 were burnt. The Block 6 fire commenced at 0715 h when the fuel moisture was 75 per cent, following a heavy overnight dew. Winds were 5 km/h from the north-north-west and temperature was 12°C. Edge burns along the south and east sides were underway at 0900 h when the wind was tending westerly at 7.4 km/h, with temperature 18°C and relative humidity 62 per cent. By 0930 h the wind had freshened to 13

km/h from the west-south-west and the northern edge was lit. An hour later the wind had dropped to 7.5 km/h and the temperature had risen to 20.5°C and relative humidity had fallen to 54 per cent. The southern half was burnt with the front moving quickly towards the northern edge burn. The fire was completed by 1100 h with only small isolated patches of vegetation smouldering in a 6-7 km/h west-south-west breeze. By 1300 h conditions (15 km/h south-south-west winds, temperature 19.5°C and humidity at 40 per cent) were favourable to burn Block 8. A backburn was lit along the northern edge and then the eastern and western edges were lit from the north to the south. At 1330 h the wind was 15.5 km/h from the south-south-west, temperature 18.5°C and humidity 50 per cent, and by 1430 h the burn was completed. Final conditions were winds 17 km/h from the south-south-west, temperature 18°C and humidity 54 per cent.[43]

Another spring burn was carried out in Block 11 on 8 September 1981. The fire along the eastern edge was lit in the south-west corner of the block at 1330 h with the wind 11.5 km/h from the west and relative humidity 45 per cent. By 1415 h this edge was burnt and the west-north-west wind had increased to 15 km/h; temperature dropped to 20°C and humidity increased to 51 per cent - probably because of the 60 per cent cloud cover. The northern edge was then lit, followed by the southern edge 15 minutes later at 1515 h. The wind was 12 km/h from the north-north-west, temperature 17°C, humidity 69 per cent and 75 per cent cloud cover. By 1545 h the wind had swung around to the south-south-west at 6.5 km/h but most of the block had burnt and the remaining patches were lit by hand. Temperature was 16°C with 79 per cent relative humidity.[44]

An autumn burn took place in Block 2 on 19 April 1983 following two weeks without rain. At 0845 h with 12.6 km/h east-north-east winds, temperature of 21°C and relative humidity of 85 per cent, a firebreak was burnt along the south-western edge in a westerly direction. This was completed by 0950 h when the wind was north-east at 12 km/h, humidity 76 per cent and temperature 23°C. Then, as a south-easterly wind change was predicted, the northern edge was lit from west to east. At 1100 h the main burn was lit, and with the wind shifting to the south-east at 18.5 km/h, humidity dropped to 60 per cent and temperature remained the same as at 1000 h. The wind dropped to 11 km/h and by 1200 h only 30 per cent of the block was burnt. The burn was completed by 1230 h and final conditions were reported as south-east wind at 13 km/h, relative humidity 58 per cent and temperature 24.5°C.[45]

In June 1985 a buffer strip was burnt on the southern side of the main road, north of Moates Lake, by Reserve Officer Graeme Folley.[46] Some of the other planned burns were not carried out as mown fire breaks are now preferred along access tracks, thus reducing the incidence of soil erosion and weed invasion.

On 2 September 1986 Block 10 was reburnt after ten years.[47] Morning conditions in Albany were north-west winds 5-10 km/h, temperature 13°C at 0900 h and 15°C at 1200 h.[48]

Block 5 was reburnt after nine years on 6 October 1987.[49] Conditions prevailing at the time were south-west winds at 5-10 km/h and the temperature ranged between 14-16°C.[50]

A winter burn was carried out on Block 1 on 11 June 1988.[51] In Albany winds were from the north-west at 15-20 km/h. The temperature was 20°C (high for that time of year).[52]

CONCLUSION

A pattern of fire in the Two Peoples Bay area emerges from this historical compilation. Early fires tended to be small and numerous on the Mt Gardner headland and more extensive in other parts of the Reserve. After few fires in the 1950s there was a high incidence of large, hot fires, just prior to the establishment of the Reserve and for a few years afterwards. Departmental fire management practises and the presence of resident staff have greatly reduced the incidence of wildfires on the Reserve and, since 1970, no prime Noisy Scrub-bird habitat has been destroyed by wildfire. The vegetation has aged and the consequent accumulation of litter and litter invertebrates has provided extensions of suitable Noisy Scrub-bird habitat. The expanding potential habitat and corridor areas should ensure the survival of this species.

ACKNOWLEDGEMENTS

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ABBREVIATIONS

B of M : Bureau of Meteorology

CALM : Department of Conservation and Land Management

Department of Conservation and Land Management Files appertaining to the Two Peoples Bay Nature Reserve:

Tenure 1: CALM 015749F3102 (Tenure vol. 1)
Tenure 2: CALM 015750F3102 (Tenure vol. 2)
Tenure 3: CALM 015751F3102 (Tenure vol. 3)
Management 1:CALM 016178F3102
(Management vol. 1)

DFW : Department Fisheries and Wildlife

DOLA : Department of Land Administration

LKBB : Lower Kalgan Bushfire Brigade

PWD : Public Works Department

NOTES

1 G.T. Smith, The effect of environmental change on six rare birds. *Emu* (1977), 77, pp. 173-9; G.T. Smith, Fire effects on populations of the Noisy Scrub-bird (*Atrichornis clamosus*), Western Bristlebird (*Dasyornis longirostris*) and Western Whipbird (*Psophodes nigrogularis*). In *Fire Ecology and Management of Western Australian Ecosystems*, (ed. J.R. Ford). WAIT Environmental Studies Group Report No. 14, (Western Australian Institute of Technology, Bentley 1985), pp. 95-102.

2 S.J. Hallam, *Fire and Hearth.* (Australian Institute of Aboriginal Studies, Canberra, 1975). Summary of Aboriginal fires in Appendix, pp 114-26; N. Green, *Nyungar, The People. Aboriginal customs in the south-west of Australia.* (Creative Research, Perth, 1979), p. 85.

3 Smith (1985), p. 95.

4 Hallam, References to sweet, crop grasses, pp. 14, 15, 19, 42, 75, 111.

5 D.A.P. West, personal communication.

6 E. Poole, personal communication; Bush Fires Board registration records show the brigade was officially registered on 22 November 1940.

7 Aerial Photography: SVY94 Defence, Mt Manypeak Run, Restricted, 25 March 1946. Australian Army, Department of Defence.

8 E. Webb, personal communication.

9 H.O. Webster, 1968 letter to W.A. Wildlife Authority. Tenure 2, 1-3. Department of Conservation and Land Management, Two Peoples Bay Nature Reserve, File No. 015750F3102 (Tenure 2). Tenure 2, pp. 1-3.

10 Aerial Photography: WA 938 Coastline Kalbarri-Israelite Bay, 7920 ft, Proj. E51, 11 December 1965 (PWD) DOLA.

11 Aerial Photography: WA1237 Noisy Scrub-bird Run 7920 ft, Proj. K63, 28 May 1970 (DFW) CALM.

12 H.O. Webster 1967, letter to Chief Warden of Fauna. CALM File No. 015749F3102, Tenure 1, pp. 65-6.

13 Webster, 1968.

14 Webster, 1968.

15 Webster, 1968; personal communication, D. Wilson, personal communication, signifies this fire may have been in 1961/62.

16 Records from Bureau of Meteorology, Perth, 21 September 1964.

17 G.T. Smith and A.J.M. Hopkins, ch. 20 this publication.

18 Hopkins and Smith ch. 20; Webster 1968.

19 M. McDonald to Warden S.W. Bowler, 23 December 1966. Fire Report. Tenure 1, pp. 55-60.

20 Letter to Warden A. Pearce from W.P. Norman, Honorary Secretary, Lower Kalgan Bushfire Brigade, 15 February 1967. Offering cooperation to control burn the Reserve. Tenure 1, p. 73.

21 Aerial Photography: WA1137 Noisy Scrub-bird, 20 000 Proj. H46, 10 February 1969, (DFW) CALM.

22 A. Pearce to Fauna Officer, 4 April 1968, Fire Report. Tenure 1, pp. 171-4.

23 A.A. Burbidge, 11-17 March 1970. Report on fire. Tenure 2, pp. 64-6.

24 A. Pearce to A.A. Burbidge, 10 April 1970. Fire Report. Tenure 2, pp. 64-6.

25 Aerial Photography: Two Peoples Bay Wildlife Sanctuary 1:40 000 Proj. N74, 15 February 1973 (DFW) CALM.

26 R.E.S. Sokolowski and G.T. Smith, personal communcation.

27 A.J.M. Hopkins, personal communication.

28 J. Edwards, personal communication.

29 A. Danks, personal communcation.

30 A. Pearce to Fauna Officer, 4 April 1968. Fire Report. Tenure 1, pp. 171-4.

31 Aerial Photography: WA 1137, 1969, N74, 1973.

32 R.E.S. Sokolowski, personal communication.

33 R.E.S. Sokolowski, A.J.M. Hopkins, A.A. Burbidge, 28 April 1976. CALM File No. 016178F3102, Management 1, pp. 150-1.

34 T. Evans to A.A. Burbidge, 13 September 1976. Control Burning at Two Peoples Bay Wildlife Sanctuary. CALM File No. 015751F3102, Tenure 3, p. 126.

35 Hopkins and Smith, ch. 20.

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37 R.E.S. Sokolowski, Reserve Officer, Reserve works diary 6 September 1977; B of M, 3 hourly synoptic charts, 6 September 1977.

38 R. Esket, Relieving Ranger, Reserve works diary 1978, at Two Peoples Bay Nature Reserve; B of M, 7 September 1978.

39 C.J. Robinson, 1979 Field Note Book, held at Western Australian Wildlife Research Centre, Woodvale.

40 Hopkins and Smith, ch. 20.

41 G. Folley, Reserve Officer, Reserve works diary 1979.

42 B of M, 11 September 1979.

43 J.M. Harvey and A.J.M. Hopkins, 1980 Field Note Book, Woodvale.

44 J.M. Harvey, 1981 Field Note Book, Woodvale.

45 J.M. Harvey, 1983 Field Note Book, Woodvale.

46 G. Folley, Reserve Officer, Reserve works diary 1985.

47 G. Yates, Reserve Management Officer, Perth. Reserve works diary 1986.

48 B of M, 2 September 1986.

49 A. Danks, Reserve Management Officer, Reserve works diary 1987.

50 B of M, 6 October 1987.

51 A. Danks, Reserve Management Officer, Reserve works diary 1988.

52 B of M, 11 May 1988.

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PERSONAL PAPERS

Field note books held at Western Australian Wildlife Research Centre, Woodvale.

Reserve works diary at Two Peoples Bay Nature Reserve.

PERSONAL COMMUNICATIONS

Danks, A., present Reserve Management Officer at Two Peoples Bay Nature Reserve.

Edwards, J., present Manager of Tandara.

Poole E., resident of Tandara 1924-49, now of Kalgan.

Sokolowski R.E.S., former Reserve Officer (1972-79) at Two Peoples Bay Nature Reserve.

Webb, E., resident of Tandara 1924-72, now of Kalgan.

West, D.A.P., local historian and author, Mt Barker.

Wilson, D., former fisherman of Two Peoples Bay, now Assistant Reserves Officer at the Reserve.

/

Only map preparations so far exclude the MT Gardner Headland
each total map will be reduced to A4?

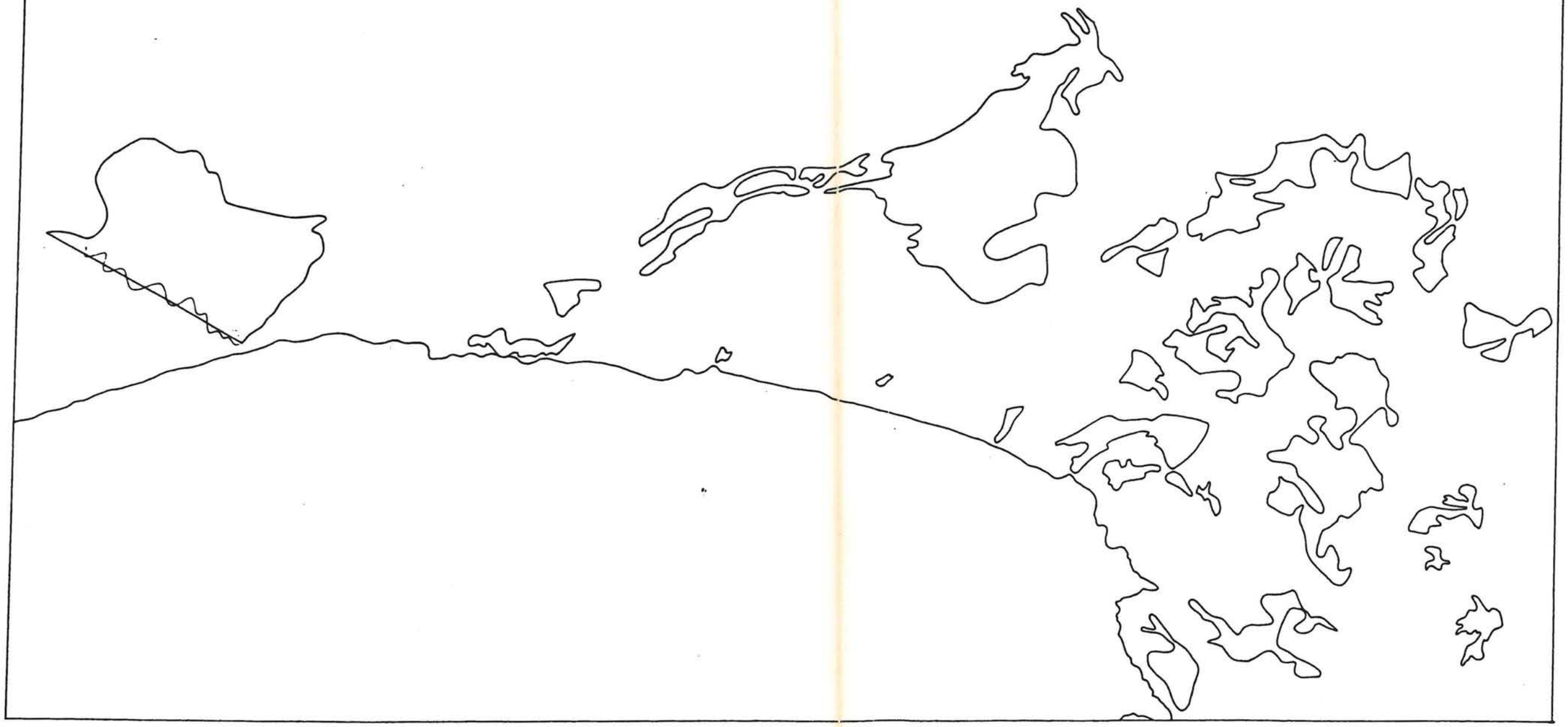
Connections are to GB

FIRE MAP - PRE 1946

LEGEND

Pre 1946
~~Total 720.2 ha~~

Figure to be as full part as it is actually much more detailed than this, extending ⟷ Coastline / other features on separate layer of GIS



projected extension of the BAT transect in the unburnt heath (Fig. 1.4 this publication).

In April 1970 the only vegetation along BAT was remnants of a number of *Agonis flexuosa* clumps. No birds were recorded along this transect during a three hour observation period. By 1976 the open heath had grown to a height of 0.5 m with some emergent clumps of *A. flexuosa*. Nine plant quadrats (2 x 2 m) sampled in each of the BAT and OBAT transects in 1976 showed that there were no significant differences in the floristics between the transects, although the plants in BAT were more numerous and smaller.

Twenty-two species of birds were recorded from 1970 to 1976 in both transects and these are listed in Table 20.1, together with the mean number of individuals of each species recorded in each year.

Only seven of the 16 species recorded on OBAT were either resident or used the Reserve regularly. These were Rock Parrot (*Neophema petrophila*), Richard's Pipit (*Anthus novaeseelandiae*), Southern Emu Wren (*Stipiturus malachurus*), Calamanthus (*Sericornis fuliginosus*), New Holland Honeyeater (*Phylidonyris novaehollandiae*), White-cheeked Honeyeater (*P. nigra*) and Tawny-crowned Honeyeater (*P. melanops*). It is reasonable to assume that before the fire these were also the most common species on BAT.

In the six months after the fire only three species [Richard's Pipit, Calamanthus and Australian Magpie (*Gymnorhina tibicen*)] were recorded on BAT. As regeneration proceeded the numbers of Richard's Pipits declined and in 1976 they were not recorded on BAT, although they were recorded in another area that had been burnt in 1970. On OBAT only a single Richard's Pipit was seen in both 1975 and 1976, but with the increasing density of vegetation Calamanthus replaced the Richard's Pipits.

After the 1970 fire the numbers of Calamanthus remained fairly stable in BAT while the numbers in OBAT were lower. With increasing density of the vegetation Calamanthus may be replaced by Bristlebirds, as it has been in other parts of the Reserve. The Southern Emu Wren was first recorded in BAT in 1972 and increased in numbers to 1975-76, and again, numbers were greater in BAT than OBAT.

Three honeyeaters - New Holland, White-cheeked and Tawny-crowned were the common birds on OBAT and all bred in that area; however, they showed considerable differences in their recolonization of BAT. Tawny-crowned Honeyeaters were recorded in 1971 and numbers peaked in 1973 and then declined to OBAT levels. White-cheeked Honeyeaters were first recorded in 1973 and remained at relatively low levels whereas New Holland Honeyeaters were only recorded in 1976.

Management Fire

In September 1976 a c.12ha area of heath was burnt (Fig. 19.4 this publication). Prior to this controlled burn the numbers of each species of bird were recorded during four early morning censuses. Each census consisted of walking five transects across the area to be burnt. Post-fire censuses were carried out six, 22 and 56 days after the burn. The data recorded on these censuses are shown in Table 20.2.

The burn was cool (see Chapter 19 for details) and many of the larger shrubs, especially *D. sessilis*, were not killed. The most notable change after the fire was the influx of Australian Raven (*Corvus coronoides*), Richard's Pipit and Black-faced Cuckoo-shrike (*Coracina novaehollandiae*), and the increase in the numbers of Grey Currawong (*Strepera versicolor*). At 56 days post-fire, Australian Raven and Grey Currawong were not recorded and only one Black-faced Cuckoo-shrike was seen; however, the number of Richard's Pipits had increased.

All the residents or regular visitors were still present after the fire, but in reduced numbers, except for White-cheeked Honeyeaters, which showed a large increase. The abundance ranking of the residents before the fire and at 56 days post-fire was not significantly different (Spearman rank correlation: rs = 0.18)

Effects on Mammals

All Caps as for Introduction.

The effects of fire on the particular mammal species in the Reserve are unknown; however, it is worthwhile making some general comments based on research undertaken in other areas.

Reviews of the work of Christensen and Kimber (1975), Newsome *et al.* (1975), Catling and Newsome (1981), Recher and Christensen (1981) and Christensen and Abbott (1989), indicate that none of the resident species on the Reserve is likely to be endangered by fire. Even a catastrophic fire of the proportions of the 1972 Nadgee fire in New South Wales (Newsome *et al.* 1975; Posamentier *et al.* 1981) is likely to leave sufficient unburnt patches in which animals can survive. In general, fires on the Reserve have been small and of moderate intensity

and therefore appear to pose little threat to any species. However, the apparent absence of Dibbler (*Parantechinus apicalis*) may, in part, be a result of past fires, while the lack of any sightings of the Common Brushtail Possum (*Trichosurus vulpecula*) since 1970 in [illegible] a result of fires in the preceeding 10 - 20 years.

The fire regime during the last 20 years may have been beneficial to the Western Grey Kangaroo (*Macropus fuliginosus*) by providing increased access to food. The small controlled burnt patches in the Strategic Fuel Reduced Zone certainly attract large numbers of kangaroos which, as noted above, have a considerable effect on the regeneration of the heath.

While fire may not pose a threat to any of the mammals, absence of fire may be detrimental to the Quokka (*Setonix brachyurus*). Christensen and Kimber (1975) have shown that its preferred swamp habitat deteriorated 15 years after fire. On the Reserve, Quokkas have been observed in gullies that have not been burnt for at least 50 years. It is possible that the heterogeneity of the vegetation in the gullies ensures that there is always some suitable habitat (see ch. 17 this publication). However, there are insufficient data on the population of this species in the Reserve to be able to forecast the long-term effect of absence of fire on the species' habitat.

DISCUSSION

The studies undertaken to date on the effects of fire at the Two Peoples Bay Nature Reserve have been opportunistic rather than comprehensive and integrated. Nevertheless, the results can be drawn together to provide an insight that is of value for future management.

Vegetation

Heath is the most widespread vegetation formation on the Reserve and the heath species make up much of the understorey of drier woodland associations. Therefore the results of the individual studies of heathy sites may be broadly extrapolated; however they may not be applicable to the wetter forest and woodland associations.

Viewed simply in terms of biomass, the vegetation in the Reserve recovers quickly after fire, returning to pre-fired levels within ten years. Thereafter, the rate of accumulation declines as growth slows and there is an equilibration between litter accumulation and decay. At this stage the vegetation can be described as mature.

The pattern of biomass accumulation is consistent with those observed elsewhere for heath (kwongan) in Western Australia (Bell *et al.* 1984; Delfs *et al.* 1987) and in South Australia and Victoria at sites where there is no *Banksia* overstorey (Jones *et al.* 1969).

The study of the isthmus heath gave maximum species richness at year five after fire. However, the species which were present in the early post-fire years and subsequently disappeared were all species with small, mobile seed or species which would be likely to have long-lived seed stored in the soil. From a management point of view, the apparent absence of these species is not a matter of concern and is consistent with the model of regeneration applied to these sclerophythous vegetation types (e.g. Purdie and Slatyer 1976).

From a biological perspective, data on biomass and species richness suggest there is no cause to burn the vegetation more frequently than once every ten years. The point is made, however, that a regime of burning for fuel reduction/management purposes, based on a minimum between-fire interval of greater than six years, may well be ineffective. After six years the levels of available fire fuels may well exceed levels acceptable for the safety of fire-fighting personnel.

The reproductive biology of component species of the heaths can also be used to provide a guide for fire management. Available data suggest that the vegetation should not be burnt more frequently than once every 12-15 years if extinctions of the more vulnerable species are to be avoided.

Rare Birds

Data on studies of the rare birds are drawn from a wider range of habitats, including the forests and woodlands of the wet gullies on the Mt Gardner headland. However, similar conclusions emerge.

Occupation of burnt areas by the rare birds took place four to 20 years after fire. The period between fire and occupation depended on the proximity of available colonists, the vegetation association and the edaphic conditions. In wetter areas, such as the gullies or adjacent heath, the period varied from four to 10 years; while the period in drier areas, where the vegetation usually developed into sub-optimal habitat and/or those areas further away from potential colonists, ranged up to 20 years. The recolonization times for Bristlebirds were similar to the time taken by heath in the same area to reach pre-fire biomass. The effect of trampling and grazing on the increase of heath biomass may well influence the timing of the succession from Richard's Pipit to Calamanthus to

Western Bristlebird and whether or not the full sequence is completed. There are no data on biomass or structural growth of the vegetation in other associations but we would expect recolonization by Whipbirds and Scrub-birds to coincide with the approach of pre-fire biomass in the vegetation. The criterion for Scrub-birds in gullies would be the stage of regrowth of the understorey vegetation.

An explanation for the historical decline in the distribution and abundance of the rare bird species may be in the disparity between fire regimes since European settlement and the time required after fire for regeneration of habitat. The effect of the disparity would be to cause loss of habitat and fragmentation of populations into potentially non-viable sub-populations. The disparity is most evident for Bristlebirds whose coastal heath habitat was burnt every two to three years by the early pastoralists (Smith 1977); evidence cited above indicates that it may take six to ten years for breeding to recommence in areas burnt by a single fire while areas burnt frequently may suffer a permanent loss of important habitat species. In the case of Noisy Scrub-birds, habitat fragmentation may have been a more significant consequence of post-settlement fire regimes.

The effect of fire on heath birds is variable and depends to some extent on the intensity of the fire. In the low intensity management fire in 1976, short-term changes in the bird community were minimised; however, in the high intensity 1970 fire, the community had not returned to its pre-fire condition by 1976. Casual observations in 1982 suggest a return to pre-fire status.

The bird data suggest that management of the Reserve should be based on ensuring that the ~~fire frequency~~ is no less than 10 years and preferably not less than 20 years. In fact, there are no data to suggest the habitat needs to be managed by the use of fire. On the contrary, the absence of fire during the last 20 years has allowed the populations of the three species to increase to levels that would minimize the genetic consequences of small populations or various stochastic disturbances that could lead to their demise. Management should aim at ensuring that wildfires (or management fires) do not affect the habitat of the rare species. At the same time the populations of the species should be monitored to detect any onset of habitat deterioration.

To date, there is no evidence to suggest that ageing of the vegetation in the habitat of the species will lead to areas becoming unsuitable for at least 50 years. While data for the Bristlebirds suggest that old heaths may be less productive, we have no data on changes in population density with age of habitat. However, the collection of additional data could be initiated. Because the collection of such data is time consuming, the work will have to fit in with the Reserve management officers' other duties.

The information presented in this chapter reveals the limits of our understanding of the role of fire in the ecological dynamics of the reserve. There is a need to apply experimental fires in a wide range of habitats and to document the responses of the biota. It is also necessary to collect data on habitat utilization in long-unburnt vegetation.

While fire is a useful tool for the management of natural areas such as Two Peoples Bay Nature Reserve it may not be the best one. For Noisy Scrub-birds, simple measures such as opening up the canopy to allow the regeneration of the understorey may be cheaper and quicker. Detailed studies of the habitat will be required to develop alternative management techniques that are less destructive than fire.

While we have concentrated in this paper on the relationship of both wildfire and management fire to the primary conservation aim of the Reserve, we realise that other considerations must be taken into account. However, we believe that practices such as fuel reduction burning, to prevent a perceived future threat, need to be examined in detail before being implemented.

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Table 20.1

Mean numbers of each species recorded for transect walk for BAT and OBAT from 1970 to 1976: See Figure ...?

	BAT						OBAT					
	1970	1971	1972	1973	1975	1976	1970	1971	1972	1973	1975	1976
Falco berigora	0	0	0	0	0.4	0.2	0	0	0	0	0.1	0.6
Falco cenchroides	0	0	0	0	0.2	0	0	0.3	0	0	0	0
Coturnix australis	0	0.1	0	0	0	0	0	0.3	0	0	0	0
Coturnix novaezelandiae	0	0.1	0	0	0	0	0	0.1	0	0	0	0
Neophema petrophila	0	0	0	0.6	0	0	0	1.0	1.3	0	0	0
Cuculus pyrrhophanus	0	0	0.2	0	0	0	0	0	0	0	0	0
Hirundo neoxena	0	0.1	0	0.2	0.4	0.3	0	0.3	0.1	0.1	0.2	0.3
Anthus novaeseelandiae	0.5	1.7	1.5	0	0.3	0	0	0	0	0	0.2	0.3
Coracina novaehollandiae	0	0	0	0	0	0	0	0	0.1	0	0	0.3
Rhipidura leucophrys	0	0.1	0	0	0	0	0	0	0	0	0	0
Malurus elegans	0	0	0	0	0.2	0	0	0	0	0	0.2	0
Stipiturus malachurus	0	0	0.8	0.6	2.7	2.5	6	0.5	0.7	0.8	1.0	0
Sericornis fuliginosus	0.5	2.0	1.3	0.4	1.0	2.3	0	1.3	0.3	0.3	0	0.8
Phylidonyris novaehollandiae	0	0	0	0	0.3	0	0.5	0.7	2.0	0	0.8	0
Phylidonyris nigra	0	0	0	1.0	1.7	0.8	0	1.0	0.3	2.0	3.0	4.8
Phylidonyris melanops	0	2.2	2.3	7.6	4.0	2.3	0.5	2.5	4.7	4.0	0	2.8
Acanthorhynchus superciliosis	0	0	0	0.1	0	0	0	0	0	0.1	0	0.3
Zosterops lateralis	0	0	0	0.1	0.2	0	0	0	0	0.1	0	0.3
Artamus cyanopterus	0	0	0	0	0.1	0.1	0	0.5	0	0	0.1	0.5
Gymnorhina tibicen	0.5	0	0	0	0	0	0	0	0	0	0	0
Strepera versicolor	0	0.1	0.2	0	0	0	0	0	0	0	0	0
Corvus coronoides	0	0	0	0	0.1	0	0	0	0	0	0	0
No of Traverses Walked	3	7	6	9	5	6	3	4	8	10	5	4

Figure 20.1.
Effects of fire and subsequent regeneration on above ground biomass in Isthmus Mixed Dense Low Heath at Two Peoples Bay Nature Reserve. Vegetation was sampled by harvesting five 4 m^2 quadrats on each occasion. Main data are from within a 625 m^2 plot, fenced to exclude Western Grey Kangaroos. Data on effects of grazing are from quadrats outside the fenced exclosure.

Figure 20.2.
Numbers of vascular plant species recorded from within the 625 m^2 study plot in Isthmus Mixed Dense Low Heath at Two Peoples Bay Nature Reserve. Data on effects of grazing are from five 4 m^2 quadrats sampled outside the fenced grazing exclosure.

Table 20.2

The mean numbers of each species recorded in four pre-fire censuses and the number of each species recorded in three censuses at 6, 22 and 56 days after burning.
Regular visitors or residents are marked with an asterix.

	Pre-fire	Post-fire			
	mean	6d	22d	56d	mean
*Phylidonyris novaehollandiae**	13.8	6	6	4	5.3
*Zosterops lateralis**	13.8	2	34	0	12.0
*Phylidonyris nigra**	7.3	5	33	23	20.3
*Phylidonyris melanops**	6.3	1	2	3	2.0
*Stipiturus malachurus**	2.0	0	3	2	1.7
*Acanthorhynchus superciliosus**	1.3	0	0	2	0.7
Purpureicephalus spurius	1.0	0	0	0	0
Strepera versicolor	0.8	5	5	0	3.3
*Sericornis fuliginosus**	0.8	3	1	2	2.0
Calyptorhynchus funereus latirostris	0.5	0	0	0	0
Chrysococcyx basalis	0.3	0	0	0	0
Corvus coronoides		9	3	0	4.0
Anthus novaeseelandiae		2	6	6	4.7
Hirundo neoxena	0	0	0	3	1.0
Coracina novaehollandiae		3	0	1	0.7
Cracticus torquatus			1	0	0.3

Table 15.1

Number of passerine and non-passerine land birds recorded at both Two Peoples Bay Nature Reserve and at Walpole-Albany, Fitzgerald River National Park and Esperance-Cape Le Grand respectively. The number of species in common between Two Peoples Bay and the other areas is expressed as a percentage of the birds in a particular area.

	Walpole-Albany	Fitzgerald R. Nat. Park	Esperance C. Le Grand	Two Peoples Bay
Passerine	43 (83%)	47 (71%)	33 (89%)	52
Non-passerine	39 (74%)	41 (79%)	25 (86%)	44

Table 15.2

The number of passerine and non-passerine resident land birds recorded at Two Peoples Bay Nature Reserve that have also been recorded in Walpole-Albany, Fitzgerald River National Park and Esperance-Cape Le Grande. The number of species in common is also expressed as a percentage of the number of resident species at Two Peoples Bay.

	Walpole-Albany	Fitzgerald R. Nat. Park	Esperance C. Le Grand	Two Peoples Bay
Passerine	27 (90%)	27 (90%)	18 (60%)	30
Non-passerine	15 (100.0%)	14 (93%)	11 (73%)	44

Note: The Passerine species not found at Walpole-Albany are the Noisy Scrub-bird, Western Bristlebird, Western Whipbird; at Fitzgerald River National Park - Noisy Scrub-bird, White-breasted Robin, Red-winged Fairy-Wren; at Esperance-Cape Le Grande - Noisy Scrub-bird, Grey Fantail, Scarlet Robin, White-breasted Fairy-Robin, Western Bristlebird, Splendid Fairy-Wren, Red-winged Fairy-Wren, White-cheeked Honeyeater, Grey Currawong. The non-passerine species missing from Esperance-Cape Le Grande were Brown Goshawk, Little Eagle, Western Rosella and Kookaburra while only the Western Rosella was missing from the Fitzgerald River National Park.

Table 15.3

Vertebrate Fauna of Special Conservation Interest. The classes are: A. Declared to be 'fauna which is likely to become extinct, or is rare'. B. Declared to be 'fauna in need of special protection'. C. Listed on CALM's 'Reserve List' for consideration as 'fauna which is likely to become extinct, or is rare'. D. Seabirds with nesting sites restricted to islands. E. Geographically restricted. F. At or near eastern limit of geographic range.

Birds

Noisy Scrub-bird	*Atrichornis clamosus*	A
Western Bristlebird	*Dasyornis longirostis*	A
Western Whipbird	*Psophodes nigrogularis*	A
Peregrine Falcon	*Falco peregrinus*	B
Red-eared Firetail	*Emblema oculata*	C
Great-winged Petrel	*Pterodroma macroptera*	E
Little Penguin	*Eudytula minor*	D
Flesh-footed Shearwater	*Puffinus carnipes*	D
Little Bittern	*Ixobrychus minutus*	C
Square-tailed Kite	*Lophoictinia isura*	C
Hooded Plover	*Charadrius rubricollis*	C
Carnaby's Cockatoo	*Calyptorhynchus latirostris*	C

Mammals

Western Ringtail	*Pseudocheirus perigrinus occidentalis*	A
New Zealand Fur-seal	*Arctocephalus forsteri*	B
Australian Sea-lion	*Neophoca cinerea*	B
Quokka	*Setonix brachyurus*	F

Reptiles

Carpet Python	*Morelia spilota*	B
Short-nosed Snake	*Notechis minor*	E
Beautiful Skink	*Egernia pulchra*	F
Mournful Skink	*Egernia luctuosa*	F

Amphibians

	Ranidella subinsignifera	E

CHAPTER 20

Fire: Effects and Management Implications

A.J.M. Hopkins and G.T. Smith

INTRODUCTION

The use of fire as a tool for the management of natural lands in south-western Australia is the subject of continuing debate (e.g. Ford 1985). On the one hand there is the view that prescribed burning for fuel reduction is essential for the protection of property values, and in some cases, the natural values. In these latter instances, the rationale for fuel reduction burning includes reference to burning as a natural process. On the other hand, whilst there is recognition that fire has been a part of the evolutionary environment of the region's biota, there is concern that the type of fire regime that might be imposed for the purposes of management might cause loss of nature conservation values.

This debate is particularly relevant to the Two Peoples Bay Nature Reserve. There has been speculation that the major reason for the survival there of the three rare bird species, the Noisy Scrub-bird (*Atrichornis clamosus*), the Western Whipbird (*Psophodes nigrogularus*) and the Western Bristlebird (*Dasyornis longirostris*), is the relative lack of burning in historic times (Smith 1985). It was as a response to this view that the fire management plan drawn up for the Reserve in 1976 emphasised fire exclusion through strategic protection (Hopkins 1985).

Since 1976 there has been some attempt to gain a better understanding of the role of fire in the management of the Reserve through direct study and through collation and analysis of relevant information. However, there are still major gaps in knowledge; for example, not enough is known about effects of fire on the herptofauna or on invertebrates. This chapter provides a summary of available information with a focus on options for future management.

PREHISTORIC FIRE

Fire has been a feature of the evolutionary environment of southern Australia at least since the late Pleistocene (Singh *et al.* 1981; Clark 1983) and possibly for much longer (Kemp 1981). The generally moist conditions to the end of the Miocene would have resulted in a low fire frequency; however, the increasing aridity and seasonality of rainfall after this time (Bowler 1982), together with the increasing preponderance of sclerophyllous vegetation (e.g. Lamont *et al.* 1984), would have led to a commensurate increase in fire frequency.

The significance of fire increased with the colonization of the Australian continent by Aboriginal people about 40,000 years ago (Pearce and Barbetti 1981). That the Aboriginal people intentionally used fire for a variety of purposes (e.g. Hallam 1975; Nicholson 1981) is accepted. However, the actual style of usage in any particular region is a matter of continuing debate and research (Hallam 1985; Lewis 1985; Horton 1982; Clark 1983).

Within the south-west of Western Australia, there is palynological evidence of fire being a common and widespread phenomenon during the last 5000 years (Churchill 1968). This period is considered to be one of increasing aridity following the mesic interglacial around 10,000 years Before Present (BP) (Martin 1973; Lamont *et al.* 1984).

The first hand accounts of Nind and Collie (in Green 1979) report the widespread and systematic use of fire by Aborigines in the Albany district in the early 1800s. The accounts make no specific reference to Two Peoples Bay. However, it is known that Aborigines were there. Ransonnet reported meeting a party of Aborigines in February 1803 (Peron and Freycinet 1818) and later, when a sealing and

whaling station was established, Aborigines would come by and feast on whale-meat and sometimes run errands for the sealers (see Chapter 2 this publication). It seems reasonable to assume that the Aboriginal burning practices observed around Albany would have extended to Two Peoples Bay, it being nearby and consisting of similar habitats.

FIRE IN HISTORICAL TIMES

A comprehensive review of historical records of fire and burning at Two Peoples Bay Nature Reserve is provided in chapter 19 of this publication. A brief summary of these findings is included here for completeness.

Aerial photography of the Two Peoples Bay area is available for the period since 1946 and has been used to supplement written records of fire. The 1946 photography showed numerous small fires around the Mt Gardner headland which may well have been started by anglers. A number of more extensive fires are known to have entered the Reserve from adjacent farmland or to have started in the vicinity of the Casuarina squatter settlement. By the 1960s, when the next aerial photography was taken, the pattern of wildfires had changed to one of fewer but larger fires throughout the Reserve.

The establishment of a management presence on the Reserve caused a change in the incidence of wildfire. Since 1971 only three wildfires have occurred on the Reserve. Two small fires were caused by lightning and one larger fire on the western boundary entered the Reserve from a windrow fire on the adjacent property. The only other area of the Reserve that has been burnt since then is the Strategic Fuel Reduced Zone where a number of small blocks have been burnt since 1976 (ch. 19 this publication).

EFFECTS ON THE VEGETATION

In describing the vegetation of the Reserve, Hopkins *et al.* (ch. 10 this publication) commented on changes that could be observed in aerial photographs and in photographs of particular sites around the Reserve. Many of these changes, particularly the increasing height and cover of the vegetation in recent years, can be related to the lack of fire.

Fire affects the vegetation by consuming litter and above-ground plant material. Some species of plants are fire sensitive and individual plants are killed. These species regenerate from seed. Other species of plants survive and individual plants resprout from protected buds (Bell *et al.* 1985). This means that vegetation cover and above-ground biomass are abruptly reduced by fire; thereafter there is a gradual recovery. The rate of this recovery process varies amongst vegetation associations and from place to place.

Only one vegetation association at Two Peoples Bay Nature Reserve has been studied in detail with respect to fire - the Isthmus Mixed Dense Low Heath. This association is the most extensive of those mapped by Hopkins *et al.* (ch. 10 this publication). It is closely related floristically to the Peninsula Dense Low Heath and has considerable floristic continuity with the *Banksia littoralis* and *Agonis flexuosa* Low Woodland/Low Forest associations.

The effects of fire and subsequent regeneration over a ten year period are summarised in Figure 20.1. The fire in September 1976 reduced the above-ground biomass from 15.5 tonnes per hectare to 3.2 tph (oven dry weight). This remaining biomass consisted entirely of woody material which was too thick to burn under the prevailing conditions - the woody material was generally greater than 0.5 cm in diameter.

In the absence of grazing by kangaroos the above-ground biomass of the vegetation returned to pre-fire levels within about seven years. After ten years, ungrazed vegetation weighed 17.4 tph and the rate of accumulation appeared to be tailing off. Grazing, however, had a pronounced effect on the accumulation of biomass. At year five the grazed vegetation was only half the weight of the ungrazed vegetation. At year ten this proportion was 74 per cent.

Two comments can be made about these results. Firstly, the above-ground biomass at year ten (and the projected maximum value) are higher than that recorded for pre-fire vegetation, despite the fact that the site had not been burnt for ten years at the time of pre-fire sampling. It is probable that the differences between the pre-fire and year ten biomass values reflect a grazing and trampling effect.

Secondly, it is likely that the intensity of kangaroo grazing at the site was above average for post-fire situations because of the small size of the area burnt (12ha). Extremely heavy grazing pressures were observed in all the blocks burnt in the Strategic Fuel Reduced Zone (Hopkins 1985) with 50-60 kangaroos concentrated in areas of 10-15 ha at sunset (Hopkins, personal observation; Smith and Moore, ch.15 this publication).

A biomass accumulation curve can be drawn between those for grazed and ungrazed vegetation to approximate a normal regeneration situation with

some grazing. This curve would plateau at between 16 to 18 tph (Figure 20.1).

It is possible to get some estimate of the value of fuel reduction burning as a fire management tool for use at Two Peoples Bay. Assuming that the biomass remaining unburnt after the 1976 fire was unavailable fuel and taking a value of 8 tph available fuel as a limit above which fires might become uncontrollable (this is the value used in the jarrah forest; Underwood *et al.* 1985), then broadscale fuel reduction burning in this kind of vegetation will be effective for no more than six years. Clearly, grazing by kangaroos will extend the period of effectiveness of small scale, fuel reduction burning; however, before applying such a technique, long-term effects of combined fire and grazing will need to be evaluated.

The hypothesised pattern of regeneration under the influence of moderate grazing is comparable with that for similar vegetation in the northern kwongan region (c.500 mm annual rainfall) (Rullo 1982[1], Bell 1985, Delfs *et al.* 1987). Those authors reported a biomass plateau of 16-18 tph with this plateau being achieved by about ten years after fire. Both sites have similar, high proportions of resprouting species (c. 60 per cent on the Reserve). However, the biomass accumulation curves produced as a result of the northern kwongan study do not appear to take into account the residual, post-fire biomass which, at Two Peoples Bay Nature Reserve, was 3.2 tph.

The results from this study of only one vegetation type at Two Peoples Bay can be regarded as only broadly indicative of patterns of regeneration for the Reserve as a whole. Any extrapolation should be conservative with particular attention being paid to proportions, and regeneration rates, of non-resprouting species in the particular community of interest.

EFFECTS ON FLORISTICS

Studies of the effects of fire on sclerophyllous vegetation types in southern Australia reveal a pattern of regeneration that accords closely with the Initial Floristic Composition Model of Egler (1954; see Purdie and Slayter 1976). In this, all the species ever to be present at a site appear within the first year or so after disturbance. There is little or no subsequent invasion or colonization as would be expected in the more classical succession situation (the Relay Floristics Model; Purdie and Slayter 1976).

A corollary of the Initial Floristic Composition model can be seen in the pattern of species richness following fire. Richness is highest in the early years after fire and gradually declines as some of the early successional species die off or, in the case of annuals and pauciennials, fail to regenerate. Most of these short-lived species have substantial stores of long-lived seed in the soil. Thus, although the species are not present as identifiable plants, they remain at the site as seed.

The comprehensive study of fire effects on Isthmus Mixed Dense Low Heath at Two Peoples Bay Nature Reserve, referred to earlier, included species-level investigation. Data for the whole 625 m^2 study plot showed that maximum species-richness occurred at year five and thereafter declined. Results are summarised in Figure 20.2.

Six species were not recorded in the early parts of the study but appeared in years seven and ten. These were *Agonis flexuosa*, *Aira caryophyllea*, *Heliophila pusilla*, *Lagenifera huegelii*, *Mitrasacme paradoxa* and *Quinetia urvillii*. With the exception of *A. flexuosa*, all these are small herbs often associated with disturbed sites. Two species, *A. caryophyllea* and *H. pusilla*, are weeds. The *A. flexuosa* was clearly invading the plot via seed from nearby trees since this species has its seed store in woody capsules held in the canopy. One further species which became prominent towards the end of the study was *D. sessilis*, which is known to have the capacity to invade relatively undisturbed vegetation (Main 1981).

Species that were present in the study plot immediately after the fire but declined and were not present by year 10 were mainly annuals and short lived perennials. Included were *Crassula colorata*, *Isotoma hypocrateriformis*, *Isotropis cuneifolia*, *Mitrasacme prolifera*, *Podolepis* sp., *Podotheca gnaphalioides* and *Trachymene* sp. *Pimelea longiflora* also disappeared from within the plot but plants were observed in the vicinity in year ten. It may be that the few plants that established after the fire were harvested by year seven.

The results of the floristic analyses are consistent with the Initial Floristic Composition Model of regeneration with a minor amount of invasion towards the end of the study. However, it should be noted that seedlings of many of the species recorded for the study were encountered throughout and into later stages of the study.

1 Rullo, J.C. (1982). Post fire response in northern sandplain heath species important to bee pastures and fire control management. Unpublished Honours Thesis, Department of Botany, University of Western Australia.

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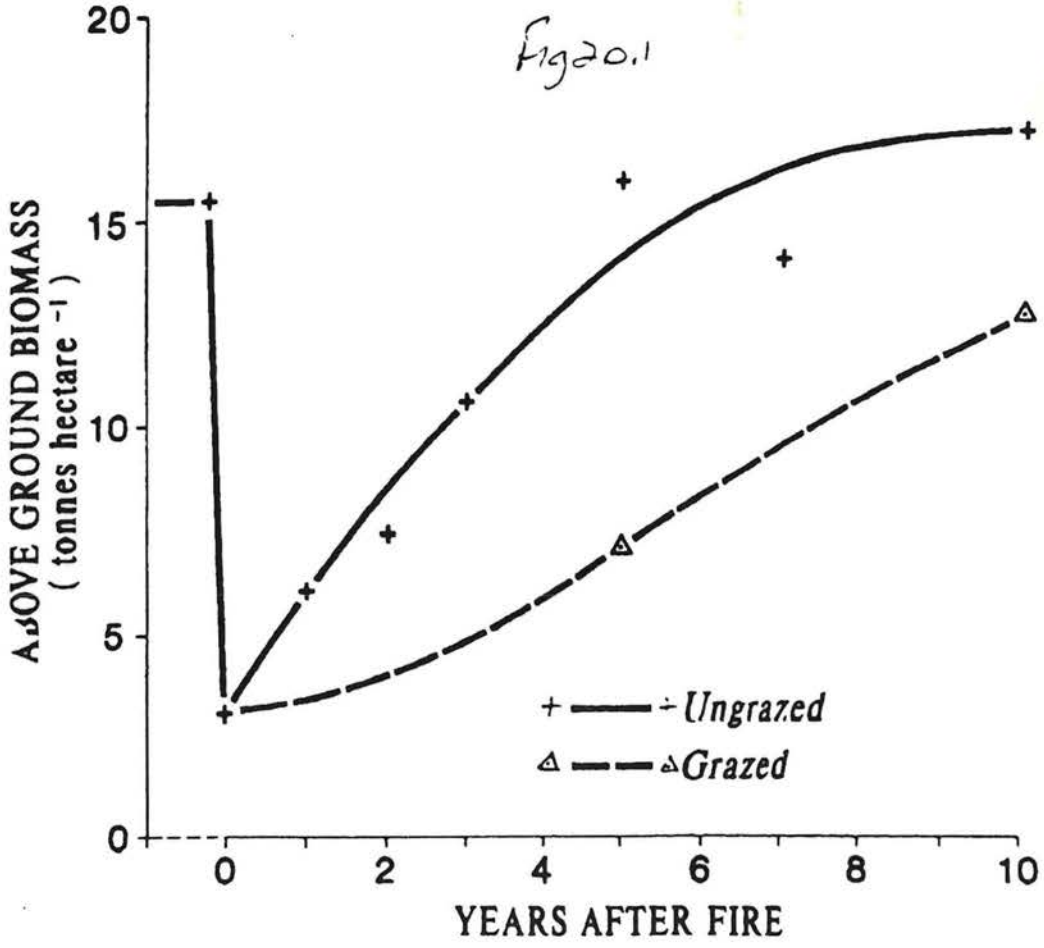
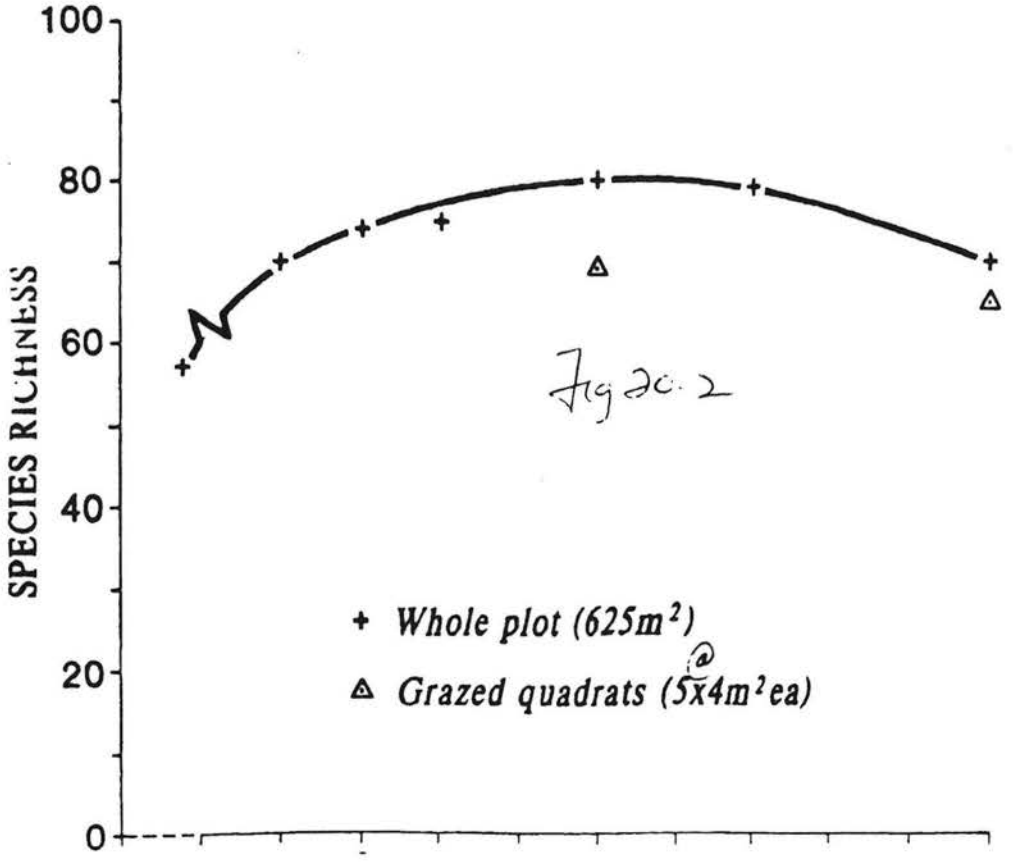


Figure 20.1



Two obligate seed regenerating species, *Lysinema ciliatum* and *Andersonia simplex* (both Epacridaceae), which were important components of the heath vegetation at the site produced occasional flowers in year three but were flowering profusely by year five. By year five all the resprouting species had also flowered and species with conspicuous fruit had produced substantial quantities of apparently viable seed.

These observations can be used to develop fire management guidelines because a minimum between-fire interval can be calculated (Hopkins and Griffin 1989; Gill and McMahon 1986).

On this basis, the heath vegetation should not be burnt more frequently than once every 12-15 years, if local extinctions are to be avoided.

Grazing and trampling by kangaroos reduced the richness of native plant species but, at the same time allowed for invasion of a number of small annual and perennial species that were rare or absent from the ungrazed plots.

EFFECTS ON BIRDS

With few exceptions, studies on the effects of fire on birds have concentrated on changes in abundance and species diversity (see reviews by Recher and Christensen 1981; Catling and Newsome 1981 and Christensen and Abbott 1989). Birds are able generally to escape the direct effects of wildfires; however, the impact increases with increasing extent and intensity of the fire. Immediately after fire, abundance declines, but few species are lost. The decline in abundance is considered to be due mainly to birds moving away from the burnt area. Bird species with strongly territorial behaviour tend to return to their former sites. The contribution of increased mortality due to fire on the decline in abundance is unknown. In the years immediately after the fire, the abundance and species diversity increase; the particular detail of these changes depends on the community composition, habitat and intensity of fire. In forest, the greatest changes are in the species inhabiting the lowest stratum.

In the decades after a fire, abundance and species diversity may decline again because of structural changes in the vegetation.

Detailed studies have been undertaken on the effect of fire on the demography of the Splended Fairy-wren *Malurus splendens* (Rowley and Brooker 1985) and on the nesting behaviour of this species together with the Yellow-rumped thornbill *Acanthiza chrysorrhoea* and Western thornbill *Acanthiza inornata*. Less detailed data are available on a further 27 species (Brooker and Rowley 1991). The results of these studies indicate the various responses to the post-fire environment and show how they can effect mortality, productivity and age structure of the populations of the speices. Fire may not have a significant immediate effect on the population but may have deleterious long-term effects on the viability of populations, especially those in small reserves, if fire occurs too frequently. The study suggests that management should aim to ensure that fires do not occur more than once every decade.

Studies on the Ground parrot *Pezoporus wallicus* (Meredith *et al.* 1984) provide data on minimum and maximum fire intervals for the sedgeland and heathland habitats used by this species in eastern Australia. The minimum times are comparable with those for the Noisy Scrub-bird *Atrichornis clamosus*, Western Whipbird *Psophodes nigrogularis* and Western Bristlebird *Dasyornis longirostris* (Smith 1985), bird species which also use dense low vegetation. The upper limits for these species are unknown but greatly exceed the 20-25 years for the Ground Parrot. The main reason for this difference is that the Ground Parrot is granivorous, while the other species are either insectivorous or, in the case of the Western Bristlebird, eat both insects and seeds.

Effect on Birds

At Two Peoples Bay there are three sets of data: recolonization after fire by the rare species; recolonization of heath after fire; and short term changes in the avian community in heath after a small management fire.

Rare Birds

(a) **Noisy Scrub-bird:** In February 1962, a fire destroyed the territories of four male birds in West Gully (Fig. 19.2(a) this publication). Three of these birds appeared to have survived the fire in thicket vegetation around the granite outcrops on the periphery of their territories. However, all three territories were unoccupied during the following breeding season (H.O. Webster[2], personal communication). One of these territories was reoccupied in 1966 and, in 1968, there were five territories in the burnt area (F.N.

2 H.O. Webster, naturalist Albany (deceased) accredited with rediscovering the Noisy Scrub-bird in 1961.

Robinson[3], personal communication). In the drier drainage lines adjacent to West Gully and in its tributary streams, single territories were established during the breeding season in 1971 and 1972. In the wetter gullies of the West Gully system, territories were established in sub-optional habitat from six to 16 years after the fire (mean 11 years, n = 6). In drier areas with sub-optimal habitat, territories were established from 17 to 19 years after the fire (mean 18 years, N = 4). It is impossible to determine if these periods reflected the time required for the vegetation to develop into suitable habitat or a lack of birds to colonize the area or a combination of the two. It is worth noting that the areas on the Mt Gardner headland with the greatest increases in population since 1970 were all burnt in the 1962 fire.

Data on the period between a fire and successful breeding are scant but suggest that, in two territories in West Gully that were occupied four and six years after the 1962 fire, breeding probably started one or two years after the sites were occupied.

The 1964 fire (Fig. 19.2(e) this publication) burnt half of one territory; the male disappeared and the site was not reoccupied until 1967. In two areas of sub-optimal habitat, territories were established nine and 12 years post-fire.

In 1970 the area around Gardner Lake was burnt and only the larger trees survived (Fig. 19.3(c) this publication). By 1975, a number of areas on the south side of the lake (and perhaps elsewhere in the area) had excellent Scrub-bird habitat; however, the first territories were not established until 1979 (n = 2). Thereafter, there was a rapid increase in the number of birds establishing territories.

At the other end of the scale, there are few data on how long Scrub-bird habitat will remain suitable after fire. One territory in Robinson's Gully has been occupied continuously from 1966 to 1991. Aerial photographs from 1946 onwards suggest that this area probably has not been burnt for at least 50 years. A further ten territories that showed signs of having been burnt in the 1946 aerial photographs (Fig. 19.1 this publication) also have been occupied continuously since 1966. All these territories are in optimal habitat and all are known breeding territories. The longevity of territories in sub-optimal habitat is poorly known, but there are five territories that have been occupied for most of the last 20 years.

(b) **Western Whipbird:** By the time the first observations were made in 1971, Whipbirds were well established in the area of West Gully that was burnt in 1962, and more territories were established in the following years. In the area burnt by the 1964 fire, five territories were established 7 years (n = 1), 8 years (n = 3) and 10 years (n = 1) after the fire.

(c) **Western Bristlebird:** Data are available on the time after fire that territories become established for both the 1962 and the 1964 fires. In the areas that were burnt by these fires (Fig. 19.2 this publication), within the distribution of the species on the Reserve, territories were established from eight to 11 years after the fires (8 years, n = 1; 9 years, n = 4; 10 years, n = 11; 11 years, n = 6). Other areas that had been burnt by these fires, but which were outside the range of the Bristlebird's distribution at that time, were not occupied for 12 to 14 years. In the heath on the southern side of Gardner Lake two Bristlebirds had established territories five years after the area had been burnt.

In the 6-18 ha patches of heath in the Strategic Fuel Reduced Zone (Fig. 19.4 this publication), Bristlebirds had established territories four to six years after the patches were burnt. Heath remains suitable habitat for Bristlebirds for at least 45 years after fire, although at that age bird density is lower than in 20 year old heath. While the structure of the heath may remain suitable, its productivity in terms of seed production and insect abundance may decline with age.

Heath Birds

In March 1970 a large fire burnt more than 800 ha of the Reserve, including an extensive area of heath south of the area between the lakes (Fig. 19.3(c) this publication). In June 1970 a 500m transect (BAT = Burnt Area Transect) was established transversely to the eastern boundary of the burnt area. On the opposite side of an access track, another 500m transect (OBAT = Opposite Burnt Area Transect) was established along a

3 F.N. Robinson, retired scientist ex CSIRO, Perth.

CHAPTER 21

Dieback caused by *Phytophthora cinnamomi*

R. Hart

INTRODUCTION

Examination of plant damage at the Two Peoples Bay Nature Reserve led to the discovery there in 1981 of the soil-borne fungus *Phytophthora cinnamomi* (see ch. 3, this publication). Subsequent studies have shown *P. cinnamomi* to be widespread in the Reserve. It would appear to have been present at some sites for so long that the 'dieback' symptoms have become obscured, as dead plants or susceptible species have either decayed or been burnt.

At the time of the discovery, *P. cinnamomi* was regarded as primarily a disease of the jarrah forest, although Newhook and Podger (1972) had warned of the threats to a broad range of plant communities. It is now known that the pattern of infection found at Two Peoples Bay is typical of most areas along the south coast from Augusta to east of Albany (Brandis and Batini 1985).

The presence of *P. cinnamomi* in Two Peoples Bay Nature Reserve has important consequences for management because of its impact on conservation values. This chapter documents the present known extent of dieback in the Reserve and reports on studies that have taken place there since 1981.

P. CINNAMOMI AS THE CAUSE OF DAMAGE TO THE VEGETATION

At the time of the initial survey in 1983, severe damage to the native vegetation was apparent in many parts of the Reserve. The damage was similar to that reported for the jarrah forest, including the understorey components of that forest, and which had been shown to be caused by the dieback fungus *P. cinnamomi*, (reviewed in Dell and Malaczuk 1989). On the Reserve, it was possible to demonstrate a similar, close relationship between the presence of the fungus and damage to the vegetation. The extent of the damage was carefully mapped in one area (Fig. 21.1). *Phytophthora cinnamomi* was not isolated from any of 30 samples collected where there was no damage but it was isolated from 34 (85 per cent) of 40 root stock samples taken from an area of extensive plant deaths. Subsequent sampling and mapping has confirmed the association between the dieback fungus and changes to the vegetation.

IMPACT ON THE FLORA

The most severe damage to the native vegetation appeared to be in the banksia/heath communities (vegetation types T14 and T15 in ch. 11 this publication). An apparently homogeneous area to the north of Moates Lake was selected for a detailed study of the impact of infection. Individual plants were counted in two blocks of fifty, adjacent, 1 m^2 quadrats on either side of an infection front. These blocks were only 12 m apart and, before infection with *P. cinnamomi*, would have had similar vegetation (*cf.* 1946 aerial photography referred to in ch. 19 of this publication). Some species which propagate vegetatively, such as in the Cyperaceae and Restionaceae, could not be counted as individual plants and so were measured by total biomass. Results of both comparisons are given in Table 21.1 and Figure 21.2.

The results in Table 21.1 are not suitable for rigorous statistical analysis, but the significance of the differences was estimated by a Chi-squared test. It can be seen that many species and groups of species were severely reduced in the affected area. The groups most affected were the families Proteaceae, Papilionaceae and Epacridaceae, and the genus

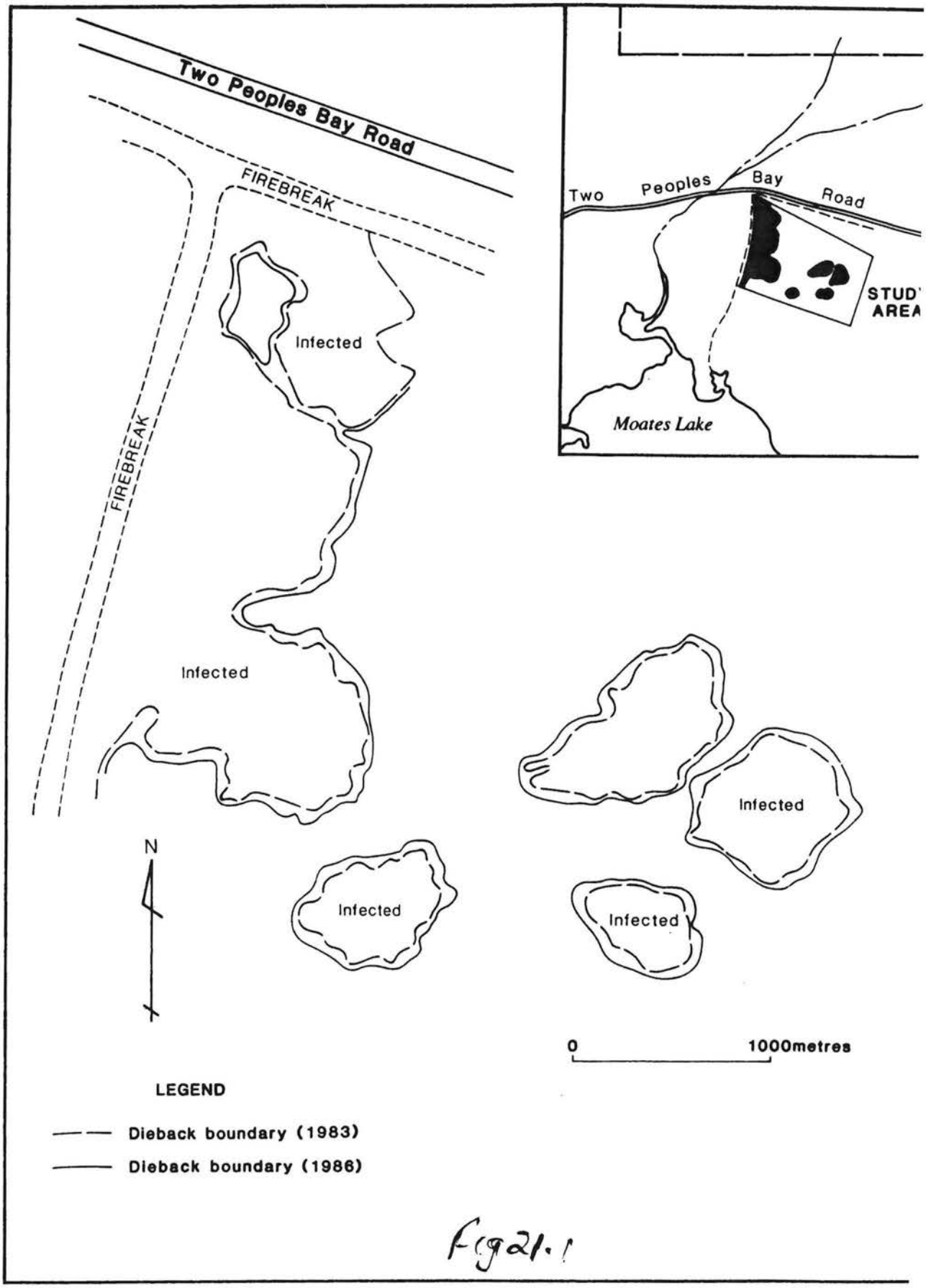


Fig 21.1

Figure 21.1

Sketch map of the *Phytophthora cinnamomi* study area north of Moates Lake (inset), showing the changes in boundaries of infected areas from 1983 to 1986. The positions of the 1983 boundaries were mapped on the basis of plant damage supported by sampling results (Hart, unpublished report). The 1986 boundaries were drawn from observations of plant damage based on experience gained in the 1983 study.

Hibbertia. Species of *Banksia* appeared, from observations over bare areas of the Reserve, to be the worst affected. This is not apparent in Table 21.1 because of the small number of plants. In these plots the impact was greater than the results suggest because all the *Banksia* individuals recorded in the infected area in Table 21.1 were seedlings which had germinated after infection. Results discussed below suggest that none of these would survive for long. The Myrtaceae are mixed, with some species apparently affected but others not affected, and they cannot be regarded as a single group. These results on the species affected agree with what is known of the host range of the fungus in other situations (e.g. Hill 1990; Zentmyer 1980). However there are some notable differences: hosts *Allocasuarina fraseriana* and *Dampiera linearis* are more prolific in infected quadrats.

Table 21.1 shows that the normal vegetation had 6451 plants in 50 m^2 and the infected area had 692 plants in 50 m^2, for the species counted. This represents a loss of almost 90 per cent of individual plants of the species counted. Conversely, some species were unaffected or even increased in abundance. Presumably, most of these species are tolerant of *P. cinnamomi* and may benefit from the reduced competition at infected sites. This conclusion was also supported by observation of the few surviving individuals of susceptible species, such as *Leucopogon flavescens*. These were often larger than normal. Resistant species such as *Stylidium scandens* were also observed to flower more profusely in the infected areas.

There is no evidence that new species invade the infected areas, or of an increase in exotic species. Both of these trends may occur in time. Weed invasion after loss of native species due to infection by *P. cinnamomi* has been reported by Weste (1974) in Victoria.

The results for standing biomass show that, apart from the sedges, there is a dramatic decline in the number of individual plants (Fig. 21.1). The biomass figures are from five 1 m^2 quadrats taken from the plots used for the plant counts described above. All live plants were harvested at ground level and divided into sedges (Restionaceae and Cyperaceae) and all other species. The species other than sedges were reduced from 556 g/m^2 dry weight to 119 g/m^2 by infection, while the sedges were unchanged at approximately 200 g/m^2 in both cases. All sedge species appear to be resistant to *P. cinnamomi*. The species present included *Anarthria gracilis, A. prolifera, A. scabra, Hypolaena exsulca, Lyginia barbata* and unidentified species of *Restio* and *Schoenus*.

The final impact of infection on these banksia communities (T14 in ch. 11) is to turn them into a low open shrubland and sedgeland (T15 in ch. 11). The only remnant trees are *Eucalyptus staeri* and *Allocasuarina fraseriana* which, although considered by Zentmyer (1980) to be host species, appear to be resistant at this location. The ground stratum is impoverished in both species and density of plants, and there is considerable bare ground. Tree stumps may be visible where there are no longer any live trees, but these are progressively burnt out and will eventually disappear. A dramatic illustration of the changes in the structure of the vegetation was found in one area, where all old banksia trees were mapped in classes according to their degree of damage by dieback and subsequent destruction by fire and decay. The map (Fig. 21.1) shows a contour effect parallel to the edge of the infection and correlating with the time since infection (see Hart[1], unpublished report, for sampling details).

There is a great decrease in total standing biomass and no evidence of any large increase in resistant species to fill the gaps created by loss of individuals. The sedges appear to show no increase at all. This finding is in contrast to that of Weste (1981) who found an increase in the number of sedges after infection of dry sclerophyll woodland by *P. cinnamomi* in Victoria.

The impact of infection on other plant communities at Two Peoples Bay has not been measured, but it appears to be not as great. Many of the lowland communities may have suffered damage in the past, but all are not uniformly infected and it is not possible to describe what damage may have occurred. The upland jarrah communities are mildly affected. The coastal dune communities are probably not prone to infection, as these show very little impact from infection. This is probably because of the deep free-draining sands and the lack of susceptible species. The scrubs and heaths of the Mt Gardner Headland contain relatively few susceptible species, but it is not known whether susceptible species have been largely eliminated from these areas or never occurred there. Without further information it is not possible to describe the impact of infection in these areas.

The impact of the infection is so great on the banksia communities that the edge of the infection can be clearly and exactly identified as a line of dead and dying plants. Other vegetation types do not show such

1 Hart, R.P. (1983). Report on dieback due to *Phytophthora cinnamomi* in Two Peoples Bay Nature Reserve. Unpublished report to Department of Fisheries and Wildlife, Perth.

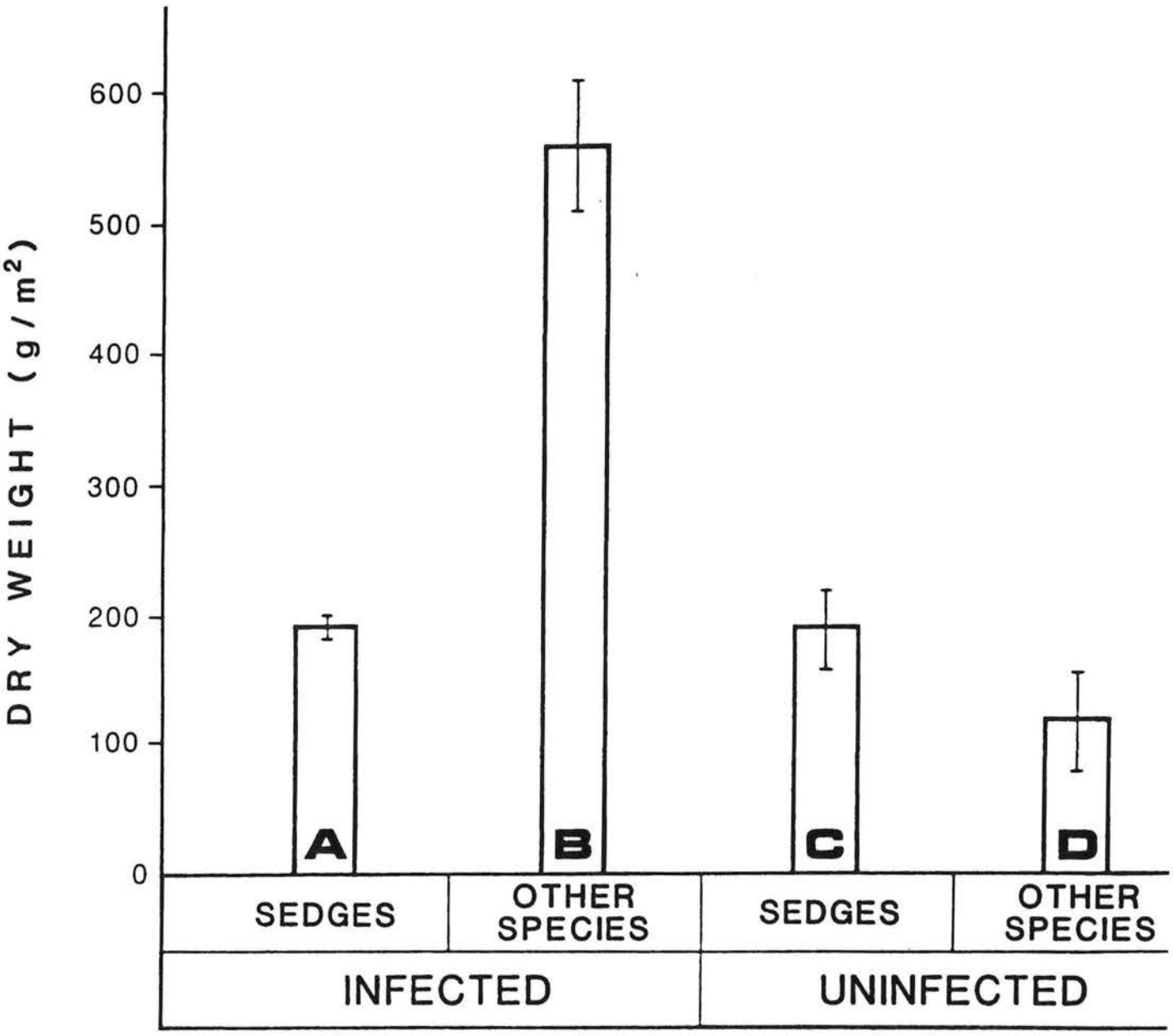


Figure 21.2

Comparison of total above-ground biomass in the 50 m^2 quadrats on either side of the *Phytophthora cinnamomi* infection front at the Moates Lake study area (Fig. 21.1).

Fig 21.2

a clear pattern and the edges of infected areas may be obscure.

The banksia woodland communities contain a large number of susceptible plants and therefore show results of infection very dramatically. The soils are deep and sandy and not prone to flooding (see ch. 5 this publication). There is no evidence that impeded drainage is important in the suscrptibility of this vegetation type, as has been shown in the jarrah forest (e.g. Dell and Malaczuk 1989).

THE RATE OF SPREAD OF THE INFECTIONS

Phytophthora cinnamomi is known to be disseminated primarily by human actions which transport infected soil and roots (Podger 1972). Within an infected area it may be spread further by water and by active movement of spores towards the roots of new hosts. Dissemination of spores in moving water is very rapid and can extend for hundreds of metres in a single episode. The unassisted rate of spread is much lower (Shea and Dillon 1980).

The unassisted spread of the disease through the soil at Two Peoples Bay Nature Reserve was measured in four ways:

1. By examining aerial photos and measuring the expansion of infected areas over time.
2. By measuring the width of the band of dead vegetation behind an advancing front of the disease, and comparing this with the time since the last fire.
3. By estimating the time required to produce the successive levels of degradation seen in the banksia trees after infection (described above).
4. By measuring the actual rate of spread of the edges of infected areas over three years between January 1983 and January 1986 (Fig. 21.1).

These methods produced the following estimates: 1 m/year; 0.6 m/year; 1.5 m/year and 1.3 m/year. These estimates assume that the rate of spread is constant between years and is the same all along an infection edge. It is more likely that the rate varies considerably both between years and spatially, but an average of 1-1.5 m/year is probably a reasonable estimate. This figure agrees well with an estimate of approximately 1 m/year in the jarrah forest (Shea and Dillon 1980) The mechanism of spread is presumably the same in these two cases and the only difference may be in the length of time each year when conditions are suitable for spore release and spread.

THE DATE OF THE ORIGINAL INFECTION

The rate of spread of the infections can be used to estimate when an infection was initiated, if the original site of infection is known. This was done for five adjacent areas where the infected areas are isolated patches and the origin of the infection is assumed to be the centre. These estimates produced dates of between 1939 and 1959. Although subject to errors, these estimates clearly show that infections have been present on the Reserve for at least some decades. These five infections are unlikely to be the oldest infections because they are on elevated sites, they are isolated, and they are away from the main infections along the drainage lines. These five infections are almost certainly secondary. The original infections were probably initiated well before these dates. The earliest aerial photographs available (1946) showed no clear dieback infections, but they are of poor quality and dieback may have been present.

PERSISTENCE OF THE INFECTIONS

It was obvious in the field and from inspection of aerial photographs that old infected areas had not returned to the original vegetation even though the original edge of the infection must have passed by some decades ago. The persistence of spores was examined by sampling for spores in the soil of infected areas and by testing the occasional susceptible individual plant which was killed well behind the edge of the infection.

Soil samples were tested up to 6 m behind the edge of the infection, and chlamydospores were recovered 4 m behind the edge. The overall rate of recovery of positive samples from soil testing was much lower than from roots (12 per cent to 73 per cent). It is likely that, with sufficient testing, spores would be found further back from the leading edge. Recently-dead banksia plants were found up to 30 m behind the edge of the infected area and no doubt larger distances would be recorded if plants could be found.

These results clearly show that there is survival of spores behind the edges of the infections, and that the infection persists for many years. It is likely that the fungus survives in dead root material and infects any susceptible plant which germinates in the infected area. The spores may also be released from hosts

which the fungus is able to live on without killing them.

The result of this pattern of infection, survival and re-infection is that the impact of the infection is permanent.

THE IMPACT OF INFECTION ON THE FAUNA

Infection by *P. cinnamomi* causes severe damage to the banksia communities. This damage is likely to have a similar impact on the fauna because it changes the structure, species composition, and density of the vegetation.

This was tested by observing the use of adjacent (infected and normal) areas by small bird species which actually feed in this vegetation. Four, 1-hour, observations were made in each category, starting just after sunrise in each case. The normal vegetation was visited by 42 individual birds from seven species, while the infected vegetation was visited by five individuals from three species. This difference of 88 per cent in the number of individuals is similar to the loss of individual plants and biomass, and probably relates directly to the loss of habitat and feeding opportunities.

The impact on the terrestrial fauna has not been measured but can be expected to be significant because of the loss of shelter, food resources and habitat for prey species.

The impact of infection by *P. cinnamomi* is particularly severe on the Proteaceae. Many of these species may be critical for the survival of nectar feeding animal species; including insects, birds and mammals. These animal species may be largely dependent on one or a few plant species at particular times of the year, and the loss of even one species may cause a sharp decline in the population. For example Honey-possums are largely sedentary and Wooller *et al.* (1984) have described how they make use of different plant species in different seasons. Alternative resources may not be available or only present in smaller quantities, and the population must decline accordingly if an important species is lost.

DISTRIBUTION OF DIEBACK ON THE RESERVE

The Reserve was surveyed for the presence of dieback in 1983 (Hart[1], unpublished report) and from November 1987 to September 1989, by Department of Conservation and Land Management interpreters (Brittain[2], unpublished report).

The extent of dieback infections can be mapped by the characteristic damage to the vegetation and by the isolation of the fungus from root samples. Figure 21.3 shows that all major drainage lines are infected, and the infections have spread out of the drainage lines into the adjacent vegetation. Infections also occur where there has been road building or other activities involving the movement of soil. The map gives no clues to the original source of the infection, but obviously water has been important in its dispersal and the fungus may have been introduced on more than one occasion.

The map clearly shows that infections occur all over the Reserve, except for the coastal dune areas. This agrees with the conclusion that the infections have been present for many years.

Some areas are either impossible to map for the presence of the fungus, or they show so little impact that the fungus is probably not able to survive there.

The areas around Mt Gardner are infected, but it is not possible to map the infected area accurately because of the diffuse impact of infection. The Mt Gardner headland has traditionally been regarded as relatively remote and apparently has not seen extensive use of machinery or other obvious vectors. Vehicle traffic has probably been more extensive than generally believed and foot traffic may have contributed to the spread. The elevated parts of Mt Gardner are an obvious destination for visitors because of the views given from the summit. Transport by animals (especially kangaroos) is possible, but there is no clear evidence that this is an important vector in any situation. There is evidence that animals are not important vectors in that most infections are associated with drainage lines and roads, and are not dotted about all over susceptible areas as would be expected if animal vectors were important. Whatever the cause, there is no doubt that *P. cinnamomi* is now well- established all over the Mt Gardner headland.

The 1987-89 survey investigated dieback in 13 different landforms within the Reserve. The results of the survey indicate that *P. cinnamomi* generally reached its peak of activity many years ago in the Meerup and Gardner landform units (ch. 5 this publication). In these areas of old and

2 Brittain, T. (1989). A survey of dieback disease due to *Phytophthora cinnamomi* in Two Peoples Bay Nature Reserve. Unpublished report. Department of Conservation and Land Management, Manjimup.

Place table in list of tables.

Table 21.1

Comparison of 1983 plant densities in 50 m^2 quadrats located on either side of the *Phytophthora cinnamomi* infection front at the Moates Lake study area (Fig. 21.1). Data labelled 'Normal' are from a quadrat centered 15 m from the front and showing no obvious signs of recent plant deaths. The infected quadrat was located downslope in similar habitat, 11 m from the front and within the area mapped as being infected. All values of χ^2 have one degree of freedom; ns - not significant.

Species marked with * are listed by Zentmyer (1980) as hosts.

Species	Normal	Infected	$\chi 2$	Significance
DASYPOGONACEAE				
Dasypogon bromeliifolius	20	12	2.0	n.s.
ANTHERICACEAE				
Johnsonia lupulina	9	17	2.46	n.s.
Thysanotus glaucifolius	0	2	-	
CASUARINACEAE				
*Allocasuarina fraseriana**	4	5	-	
PROTEACEAE				
Adenanthos cuneatus	24	7	9.32	**
*Adenanthos obovatus**	10	3	3.77	n.s.
*Banksia attenuata**	6	1	-	
*Banksia coccinea**	8	1	-	
*Banksia grandis**	1	0	-	
Banksia nutans	31	1	28.1	***
Petrophile longifolia	13	0	13.0	***
Petrophile rigida	12	7	1.32	n.s.
All Proteaceae	105	20	57.8	***
PAPILIONACEAE				
Daviesia benthamii	6	0	-	
Daviesia decurrens	2	0	-	
Jacksonia spinosa	3	0	-	
Latrobea genistoides	109	0	109	***
Latrobea hirtella	117	1	114	***
All Papilionaceae	237	1	234	***
DILLENIACEAE				
Hibbertia desmophylla	226	1	223	***
MYRTACEAE				
*Agonis hypericifolia**	0	7	-	
Agonis linearifolia	12	3	5.4	*
Beaufortia anisandra	111	31	45.1	***
Calytrix asperula	9	29	10.5	**
Darwinia vestita	5	7	0.33	n.s.
Melaleuca thymoides	50	35	2.65	n.s.
APIACEAE				
Actinotus glomeratus	31	78	20.3	***
*Platysace compressa**	6	18	6.0	*
Xanthosia rotundifolia	13	22	2.3	n.s.

Table 21.1 (*continued*)

Species	Normal	Infected	$\chi 2$	Significance
All Apiaceae	50	118	27.5	***
EPACRIDACEAE				
Andersonia caerulea	302	25	235	***
Andersonia simplex	254	6	237	***
Leucopogon elegans	3239	16	3191	***
Leucopogon flavescens	560	19	505	***
*Leucopogon glabellus**	456	30	373	***
Lysinema ciliatum	601	30	517	***
All Epacridaceae	5412	126	5045	***
GOODENIACEAE				
*Dampiera linearis**	1	15	12.2	***
STYLIDIACEAE				
Stylidium scandens	68	219	79.4	***
Stylidium spathulatum	78	44	9.5	**
Sp. 44	17	0	17.0	***
Sp. 67	37	0	37.0	***
Total of all species	6451 (100%)	692 (10.7%)		

well-established infection, where susceptible species have been eradicated by the disease, the changed vegetation appears healthy. At present the most active infections are in the Dempster Sand units, north of Moates Lake, where the vegetation is undergoing substantial change (Brittain[2]).

THE ULTIMATE IMPACT OF INFECTION

The results of the 1983 and 1987-89 surveys indicate that the impact of infection by *P. cinnamomi* is low on coastal dunes; variable on wetland and drainage line vegetation; severe on banksia communities; moderate on jarrah forests; and high on the scrubs and heaths of the Mt Gardner headland. The impact of infection appears to be permanent as the vegetation does not recover even after decades.

The existing infections occur all over the Reserve and are spreading without assistance at a rate of at least one metre per year. There are no large areas that do not contain infections.

Ultimately, all of the banksia communities will be infected and effectively lost as a vegetation type on the Reserve. They will be replaced by vegetation of a different structure, with fewer species and a greatly reduced plant density, and a corresponding increase in bare ground.

In the long term many plant species may be lost from the Reserve. Species such as *Banksia attenuata, B. coccinea, B. ilicifolia, B. nutans* and *B. quercifolia* may become extinct, unless a practical method of controlling the impact of *P. cinnamomi* can be found. A study of large numbers of individuals of these species failed to show any apparently resistant individuals, and they are rare in the infected areas. Of greater concern is their failure to reach flowering age in the infected areas, as the result of inevitable infection and death as they grow larger. If this process continues indefinitely the seed stock will be depleted and these species will no longer occur in the infected areas. Many other plant species are similarly affected and are also in danger of being severely reduced or rendered locally extinct. Comparison of the area of existing infections in Figure 21.3 and the vegetation map (Fig. 11.1 inside back cover) suggests that the loss of these areas is already severe and may be largely complete within decades.

Phytophthora infection, coupled with recurrent burning has altered the structure of some vegetation types to such an extent that they now appear unaffected. All the susceptible species have been removed and species such as *Anarthria prolifera, Evandra aristata, Agonis juniperina* and *Agonis parviceps* now dominate.

This loss of important vegetation types must inevitably lead to a decline in the fauna. Species dependent on the nectar of the Proteaceae may be the worst affected, but many species could be affected in less obvious ways. Many invertebrates may be affected by the loss of plant species which are critical to a stage of their life cycle.

While the assisted spread of the disease can be controlled by hygiene procedures, the unassisted spread through the soil cannot be prevented. If the gloomy ultimate impact of infection described here is to be prevented, then it will be necessary to find a means of arresting the spread of the disease or of preventing its impact in the native vegetation.

Newhook and Podger (1972) in a review of *P. cinnamomi* in Australia and New Zealand stated:

> The epidemic [of *Phytophthora cinnamomi*] poses a serious problem for conservation in dry sclerophyll heath, woodland, and forest communities, not only for the flora including the wildflowers for which these communities are famous, but also for the many dependent species in the fauna. Many of Australia's national parks and reserves are in jeopardy; it is a matter of the utmost urgency that they be protected from *P. cinnamomi* infestation for as long as possible. Without protection all of the highly susceptible elements of vulnerable communities will be eliminated.

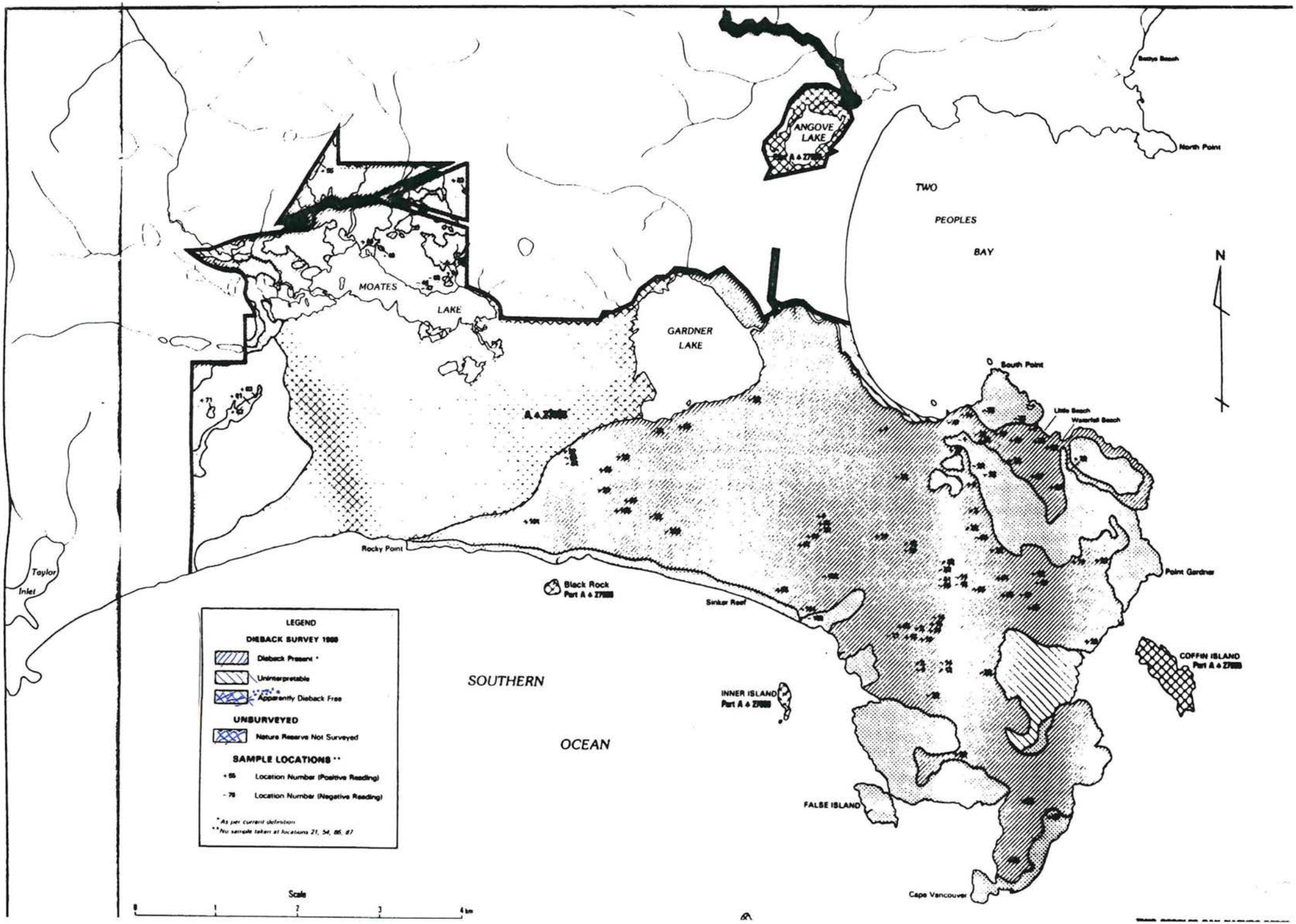
Unfortunately this process had already begun in the Two Peoples Bay area long before 1972, and even before the Reserve was established in 1966. Within decades we may see the end point described by Newhook and Podger (1972).

MANAGEMENT

Further dissemination of the disease by human activities can be limited by standard hygiene procedures which are now being widely used throughout the south-west of Western Australia. These have evolved in response to the problem of dieback due to *P. cinnamomi* and other species of this genus.

It is imperative that these hygiene procedures are applied rigorously throughout Two Peoples Bay Nature Reserve. Furthermore, all secure, dieback-free areas should be closed for access to public and non-essential staff, to protect remaining nature conservation values.

The unassisted spread of the disease cannot be prevented and research into control and treatment methods is the only hope of providing an answer to the problem.


ANGOVE LAKE
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Bootya Beach
North Point
TWO
PEOPLES
BAY
N
MOATES
LAKE
GARDNER
LAKE
South Point
Little Beach
Waterfall Beach
Rocky Point
Taylor
Inlet
Black Rock
Part A & Z7888
Sinker Reef
Point Gardner
COFFIN ISLAND
Part A & Z7888
SOUTHERN
OCEAN
INNER ISLAND
Part A & Z7888
FALSE ISLAND
Cape Vancouver
LEGEND
DIEBACK SURVEY 1988
Dieback Present *
Uninterpretable
Apparently Dieback Free
UNSURVEYED
Nature Reserve Not Surveyed
SAMPLE LOCATIONS **
+55 Location Number (Positive Reading)
-78 Location Number (Negative Reading)
* As per current definition
** No sample taken at locations 21, 54, 86, 87
Scale
0
1
2
3
4 km

While management may be too late to save much of the Two Peoples Bay Nature Reserve from damage, the information gathered here is of use in protecting other areas. The protection of conservation areas in the region which are not already infected must be an important part of any regional management plan. Research to find practical control methods must also be a priority.

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CHAPTER 22

Future Directions

A.J.M. Hopkins

INTRODUCTION

Since its gazettal, the Two Peoples Bay Nature Reserve has occupied a most significant place in the nature conservation estate. After 30 years of research into the Reserve's biota and ecology, this has become the most comprehensively documented area in Western Australia. In addition, it has become the site of many innovative management practices. Such is its importance and status within the scientific and conservation community that it can be viewed as the 'jewel in the crown' of the nature reserve system.

The various contributors to this research bulletin have acknowledged that there is much still to be learned about the Reserve and its biota. Thus, this bulletin should not be viewed as a final, definitive statement; rather it should be considered as the basis for further work. The function of this concluding chapter is to identify priority research needs and to raise a number of as yet unresolved management issues.

PRIORITY RESEARCH NEEDS

The information brought together in this bulletin provides a sound basis for a great range of research projects. More importantly, however, the process of review culminating in this publication has facilitated identification of major gaps in knowledge. Four of these are are considered sufficiently critical to warrant priority research:

(1) the composition and ecology of the native terrestrial and aquatic invertebrate fauna;

(2) the impacts of *Phytophthora cinnamomi* and long-term fire exclusion on habitat and food resources of the rare bird species;

(3) the composition of the fauna in coastal and near-shore marine habitats surrounding the Reserve; and

(4) the distribution and significance of cultural heritage resources.

The native terrestrial and aquatic invertebrate faunas of the Reserve have not been comprehensively surveyed or studied from an ecological perspective. The problem of inadequate knowledge of the invertebrate fauna is a national one and is considered critical because invertebrates are functionally important in most, if not all, Australian ecosystems (Hopkins *et al.* 1990). At the Two Peoples Bay Nature Reserve, the fact that the three rare species of birds are invertebrate feeders serves to emphasise this point. The lack of information about this significant component of the biota may well impede long-term development of an understanding of the dynamics of the biota as a whole.

Two questions arise about the long-term viability of habitats of the rare bird species. The first of these involves the impact of *P. cinnamomi*: to what extent do changes to vegetation structure and composition affect food resources, shelter and availability of nest sites? This question is relevant to other components of the fauna, particularly insectivorous birds, mammals and insects, but priority should be given to studies of impacts on rare birds.

The second concern is over the capacity of vegetation types on the Mt Gardner headland to provide habitat and food resources for the rare species of birds in the absence of fire. Present data suggest that, for example, Noisy Scrub-birds adjust by migrating to gully margins as vegetation in the gullies matures. Will the vegetation senesce and become completely unsuitable as habitat and, if so, can it be rejuvinated? There is a case for including some habitat observations into the rare bird monitoring program and for undertaking some experimental management of one of the gullies on the Mt Gardner headland.

There has been some biological collecting of coastal and near-shore marine habitats adjacent to the

Two Peoples Bay Nature Reserve but results have not been collated. This will need to be done and further, systematic survey may subsequently be required to support the argument for the creation of a marine conservation reserve in the area.

Finally, it is known that the Reserve was formerly the site of sealing and whaling activities. Furthermore, documentary evidence indicates the presence of Aboriginal people in the area and reports interactions with the sealers and whalers. A thorough archeological survey of the Reserve should be undertaken to provide information for management and for incorporation into interpretive and educational programs.

PRIORITY MANAGEMENT ISSUES

The environmental challenges of the future are numerous. The Two Peoples Bay Nature Reserve must be managed to ensure the persistance of the present suite of species of plants and animals or, in the event of global climate change, to conserve a new suite (e.g. Hobbs and Hopkins 1991). There are, however, some more immediate issues that require attention. In addition, there is the opportunity for the Reserve to continue in its role as a management model for conservation areas within the region.

Key management issues warranting priority attention are:

(1) the conflict between conservation and recreation;

(2) the presence of *P. cinnamomi*;

(3) the consequences of kangaroo grazing on fire management;

(4) the integration of management of adjacent lands; and

(5) the development of a computerised land management information system.

The Two Peoples Bay area is set aside as a Nature Rreserve which means that, under Section 56 of the Conservation and Land Management Act, it should be managed '...to maintain and restore the natural environment, and to protect, care for, and promote the study of, indigenous flora and fauna...' This purpose is completely appropriate for an area that is the last natural repository of Noisy Scrub-birds and also an important conservation reserve for other reasons.

At present there is a high level of recreational use of the Reserve. This use is a carry over from activity patterns prior to gazettal of the Reserve; however, most visitors are oblivious to the conservation significance of the area. The present levels of recreational use create conflict with conservaton objectives for the Rreserve. This conflict will become more acute if recreational pressures are permitted to grow.

There is an urgent need to begin redirecting the public usage of the Two Peoples Bay Nature Reserve towards educational activities. The information contained in this bulletin is a valuable resource which can be used to enhance public appreciation of the Reserve and of nature conservation generally. However, some specific interpretation facilities will need to be constructed. It may be necessary to seek corporate sponsorship for this purpose. Consideration should be given to closing the Reserve to the public at times when recreational use creates excessive management problems, such as during high fire risk periods. The future of the commercial fishery operating from the Reserve should also be reviewed.

The presence on the Reserve of *P. cinnamomi* and the widespread nature of infections pose a very serious threat to the nature conservation values of the area. Every effort must be made to limit activities which can spread the disease and/or promote the development of its symptoms.

Studies of the effects of fuel-reduction-burning on vegetation in the isthmus area have shown the major adverse impact of grazing by kangaroos on the regenerating vegetation. Heavy grazing leads to a loss of species, some of which are important for rare bird habitat. The disturbance associated with this heavy grazing appears to promote weed invasion. Future proposals for fire management will need to recognize this fire-grazing interaction if widespread degradation of vegetation is to be avoided.

Some of the work reported here, together with more recent studies (e.g. Danks 1991), highlight the value of considering individual reserves as merely a component of the interacting network of conservation land resources. The efficacy of this network hinges on land outside the system: in the case of Two Peoples Bay the adjacent water reserve and remnants of native vegetation on private property serve as corridors for the natural dispersal of Noisy Scrub-birds into nearby conservation reserves. These other lands also form the catchment for the major wetlands of the Reserve.

The continued existence of conservation values on the non-Reserve lands is dependant on goodwill. They are vulnerable to clearing, grazing and burning. Consideration should be given to entering into formal

management agreements (contracts) with holders of adjacent lands with the aim of securing specific natural values of those lands in perpetuity.

The importance of effective management of the Two Peoples Bay Nature Reserve has been recognized since the discovery there of the Noisy Scrub-bird. The first resident management officer with the Department of Fisheries and Fauna was stationed at the Reserve and the 1971 management plan was the first ever produced by the Department.

A number of innovative approaches to conservation management have been developed at the Reserve. These include the use of slashed firebreaks in erosion-prone situations, the installation of free gas-barbeques to reduce the fire risk associated with picnickers, and the application of experimental management principles (Hopkins 1985; Hopkins and Saunders 1987). The Reserve has served as a model for management of conservation lands in the region and elsewhere in the State.

The information that has been drawn together in the preparation of this bulletin provides a sound basis for development of management principles and further innovative management practices. One particular opportunity has been identified: all the mapped information is now available in digital form and could be used to develop a computerised, land management information system. Such a system could be used for planning purposes as well as for day-to-day management. Computerised land management information systems constitute a powerful research tool for developing management practices and principles (e.g. Kessell *et al* 1984).

Marine Conservation

The Western Australian Government has initiated moves to create a system of marine parks and marine nature reserves which would complement the system of terrestrial conservation reserves. The waters off the Two Peoples Bay Nature Reserve are well suited to becoming a marine conservation area, since they incorporate a good range of habitats. Major habitats include the limestone platform reef along the south coast (Sinker Reef); the Mt Gardner headland; the islands (especially Coffin Island with its seal and sea-lion populations); the rock stack off South Point; and the seagrass meadows and sandy beaches within Two Peoples Bay.

CONCLUSIONS

This compilation of information about the Two Peoples Bay Nature Reserve confirms that the Reserve is a very important component of Australia's conservation estate. Its rich and diverse biota includes a number of species and communities which are rare or poorly represented in conservation reserves elsewhere. It also contains good representative examples of the landforms and plant and animal communities of the south coast.

The Reserve has been an important site for the development of ideas on the dynamics of these native plant and animal communities as well as for the development of management principles and practices. These ideas, principles and practices will remain the cornerstone of effective nature conservation. Work on the Reserve must continue if all the knowledge and understanding built up over the years is to be put to best effect.

Public awareness is also a cornerstone of effective nature conservation. It generates the necessary political and community support that allows conservation agencies to operate. More importantly, however, such awareness creates an environment where the public willingly contribute as volunteers to particular works programs, or by better management of their own land. The Two Peoples Bay Nature Reserve has a major role to play in public education about conservation issues and this should be developed as a matter of priority.

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