

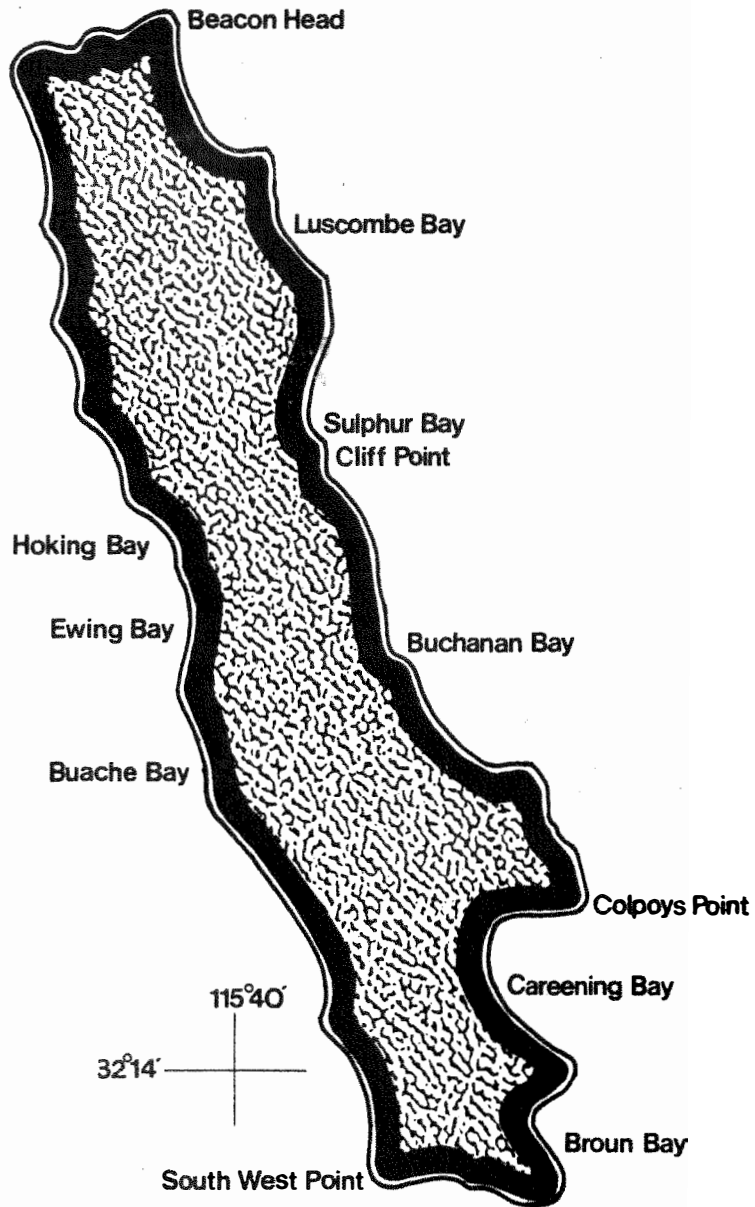
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# GARDEN ISLAND REPORT

## Western Australian State Working Group

*BULLETIN No. 1.*

*DEPARTMENT OF  
ENVIRONMENTAL PROTECTION.*



# MARCH 1974

TO THE HON SIR CHARLES COURT, MLA  
PREMIER OF WESTERN AUSTRALIA

GARDEN ISLAND

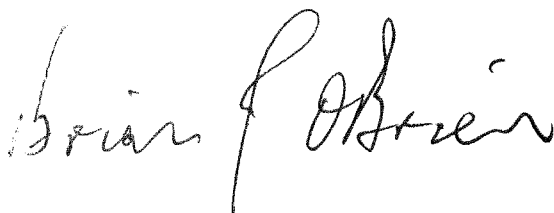
I have pleasure in forwarding to you a copy of a report on the West Australian interests in Garden Island. The report includes preliminary management plan details and costing estimates.

The importance of Garden Island to the people of WA was recognised by Cabinet's appointment on 19 June 1973 of a State Working Group. Members are Mr F. Knight (Premier's Department), Mr G.A. Greaves (Mines Department), Mr P. Greaves (Department of Tourism), Mr D. Davis (Treasury Department), Mr P. Wright (Fremantle Port Authority) with myself as Chairman.

Further recognition was given by the allocation to this Department of special funds for the appointment of Mrs Jenefer M. Blackwell-Miles to be Secretary to the Working Group. Over the past several months, Mrs Miles, in liaison with State and Federal Government officers, and with their full co-operation, has been largely responsible for the preparation of this document.

The report, Sir, represents the most definitive document yet prepared on this State's interests in Garden Island in matters other than defence. It could not have been prepared without the ready assistance of many persons, whom I wish to thank at this time.

I believe that this document can serve as a definitive plan to be presented when State-Federal Government conferences on legal, financial and management details resume.



Brian J. O'Brien  
CHAIRMAN  
Garden Island Working Group

6 May 1974

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## SUMMARY

1. This Report includes a brief account of the historical background of Garden Island, including developments leading up to current work towards the establishment of a Naval Support Facility on the Island.
2. As part of the Western Australian environment, Garden Island is important from both ecological and public recreational needs. This Report has therefore been prepared to summarise these.
3. Recommendations are made relating to:
  - i) development of the Cliff Head Historical site on Garden Island because of its importance to the heritage of the State;
  - ii) the environmental research required to ensure adequate management of the ecology on the Island;
  - iii) the extent of public recreational usage of the Island, and the allocation of funds necessary to develop appropriate public recreational facilities;
  - iv) the necessity to retain some co-ordinating working group to ensure an overall balanced approach to the management of the Island, including effective liaison with the Federal Government; and
  - v) the employment of personnel to control the areas of public recreational usage on Garden Island so as to meet the goals of the Report.

## 1. INTRODUCTION

### 1.1 Historical Background

Historically but not geologically, Garden Island is believed to have emerged from the misty past of the Indian Ocean and its shores in the year 1648, when the skipper of the "Walkende Boey" came seeking the wrecked Dutch vessel the "Golden Dragon". This skipper charted our shores in part, and reported on the island, now known as Rottnest. His chart (in The Hague Archives) proves that he saw Garden Island southward.

Again in 1697, Garden Island (then unnamed) appears clearly in the map of Vlaming's expedition to Rottnest and to the mouth of the Swan River.

The next voyager to chart the Island is uncertain, but Peron shows the Island clearly in the maps of the French Expedition of 1801-1803 in the vessels "Geographe" and "Naturaliste". This expedition visited the Island in 1801 and named it Buache after the cartographer of the Ministry of Marine in Paris under whose direction various French expeditions sailed.

The French were again in the vicinity in 1803 when the "Casuarina" was nearly wrecked between Point Peron and Garden Island. Captain King too was near it in 1822 but both appear to have omitted it from their itineraries.

The next official visitors to the Island were members of Stirling's party from the "Success" in 1827, when Charles Fraser the botanist of NSW reported on the soil, the vegetation, and the garden he planted on the north side of the Island. A cow, three goats and three sheep were left on Buache.

On 25 April 1829 Captain Fremantle arrived in the "Challenger" and on 28 April he took possession of the Island. On 1 June Captain Stirling arrived in "Parmelia" and determined to make his first settlement on Garden Island. On 7 June he went ashore and officially renamed the island Garden Island. Crews from the "Challenger" and the "Sulphur" were commissioned to aid the "Parmelia's" crew in building huts and gardens and the first official non-convict settlement of Australia was established. A contemporary sketch of the site was made by Mrs Currie, wife of Captain Currie the first Harbour Master.

Late in 1829 Stirling left the Island and took up residence on the mainland. The Government Store was maintained on Garden Island and a letter written by him is evidence that the Storekeeper, John Morgan, was still resident there in July 1830.

In May 1834 privates of detachments of the 45th, 55th and 63rd Regiments from the "Lonach" transport went ashore and set fire to Garden Island occasioning the destruction of the buildings erected by Governor Stirling. Traces of the settlement are still to be found on the Island but Western Australia's first official settlement was shortlived.

Cowan and Caldwell (1937) report that a Mr John Watson visited Garden Island in 1858, 1863, 1865 and 1868. He recalls that Mr James Read, one of the original immigrants to arrive on the "Rockingham" in 1830, and his wife resided on the Island for years and also Mr George Fry. These men cultivated land situated about half way from Sulphur Town and Careening Bay. In 1859 Mr Read was the victim of an attack from five convicts who had escaped Fremantle Prison. J.K. Hitchcock in "The History of Fremantle" reports that Read and his family left Garden Island after their ordeal but conflicting reports say that Mrs Read remained on the Island alone for years after her husband's death (see Cowan and Caldwell, 1937).

About the period of the Great War in 1914 an old German couple who had come from Queensland with a black boy named Russell were settled firstly in Careening Bay and latterly further up the Island near Sulphur Town. After their deaths the house and property were gradually stripped bare by visitors to the Island who tore the place up looking for supposedly hidden money.

During the Second World War (1939-45) Garden Island was prohibited to the public and taken over as an Army establishment. Remnants of gun postings and other Army buildings still remain on the Island and a memorial to members of the Z Force has been erected.

Since the War the Island has acted primarily as a holiday resort. The Island is freehold Commonwealth territory and cottage owners held leases recoverable at will by the Commonwealth.

## 1.2 Development of a Naval Facility

Many schemes to establish a naval base in Fremantle-Cockburn Sound waters have been proposed over the past 100 years.

In 1911 a report on the siting of a naval base in Western Australia was made at the request of the Federal Government. Surveys were made in Cockburn Sound, Bunbury, Albany, Broome, Cone Bay, King Sound and Wyndham. Cockburn Sound was chosen as the site and the base was to be financed by the British and

Commonwealth Governments. Preliminary work was brought to a standstill at the outbreak of World War I.

In 1957 the Commonwealth Government stated that a naval base would not be established in Cockburn Sound. Garden Island was offered to the State for the sum of £1,000,000 but the State was unable to meet the cost and the Commonwealth retained ownership.

On 8 October 1969, the Commonwealth Government announced that it would develop a naval base at Cockburn Sound as soon as possible. By resolution on 4.9.70 the House of Representatives referred to the Parliamentary Standing Committee on Public Works, for investigation and report to Parliament, the proposal to construct a causeway between Point Peron and Garden Island, Western Australia to enable a naval support facility to be established in Cockburn Sound. The report was made on 27.10.70. Work on the Causeway commenced on 4.1.71. By resolution on 2.3.72 the Senate referred to the Parliamentary Standing Committee on Public Works for investigation and report to the Parliament the proposal for the construction of a naval support facility (HMAS Stirling) on Garden Island in Cockburn Sound, Western Australia.

In November 1971 the then Prime Minister, the Rt Hon W. McMahon, advised the Premier of Western Australia that consideration had been given by the appropriate Commonwealth Authorities to the practicability of public access to parts of Garden Island for recreational purposes, and it had been concluded that, having regard to the problems of safety and security, and the need to preserve as far as possible the natural environment and to safeguard the limited and vulnerable vegetation with its unique single-cover properties, and having regard also to the high fire risk, it would not be practical to allow the general public access into any sections of the island.

The Report of the Parliamentary Standing Committee on Public Works on the proposal for the construction of a naval support facility on Garden Island was made on 11.5.72 and included recommendations relating to public access; environmental protection and conservation; and areas of historical interest. It recorded that 1800 acres (728½ ha) or about 60% of the area of Garden Island and involving ten miles of coastline will be accessible to the public, and that the day to day care and management of public recreation areas are obviously not a Navy function and properly should be a State responsibility, and there would clearly be a need for detailed discussions between the Commonwealth and the State.

At meetings held between Commonwealth and State officials on 1 and 2 November 1972, agreement was reached in producing an Outline of Understandings in respect of public access and the possible location of a State Explosive Depot on Garden Island. On 19.11.72 a joint press statement by the Prime Minister, the Rt Hon W. McMahon, and the Premier of Western Australia, the Hon J. Tonkin, was released, announcing that agreement in principle had been reached on:

- i) the State Government's proposal to transfer the Explosives Depot from Woodman Point to Garden Island thus releasing the Woodman Point land for public access; and
- ii) on the areas of Garden Island to be opened for public access following completion of the Naval Support Facility and the nature of such access.

The need for a document co-ordinating the requirements of the Naval Support Facility, the facilitation of public recreational usage of the Island, and the maintenance of an ecological balance on the Island was apparent. In May 1973, a State Ad Hoc Working Group met to discuss the formulation of such a document. The membership of this group and their interests in the Island appear in Appendix I.

The meeting agreed on the formation of a State Working Group on Garden Island represented by the Premier's Department, Mines Department, Department of Tourism, Treasury Department and the Department of Environmental Protection. State Cabinet approved the appointment of this State Working Group to be convened by the Director of Environmental Protection and with the additional membership of the Fremantle Port Authority in June 1973.

The Causeway was completed on 18.6.73 and work then began on construction of the Naval Support Facility, HMAS Stirling on Garden Island.

This report is the direct result of liaison between the State Working Group and representatives of the Australian Government Department of Housing and Construction. No new submissions from the public were sought. Public comments are taken to be those expressed at the Parliamentary Standing Committee on Public Works held in April 1972. The report seeks to draw attention to the environmental management of the Island, the research required and the expenditure involved in facilitating public recreational usage of the Island.



## 2. NAVAL SUPPORT FACILITY

### 2.1 Requirements

The areas of Garden Island required for both immediate and future development of the Naval Support Facility HMAS Stirling, are indicated in the Zone Plan shown in Fig. 1. Also indicated are the areas which, following the 19 November 1972 Prime Minister-Premier press release, will be available for limited and unrestricted public access. For security reasons the Navy requires:

- i) that such public access be limited to day trips and that no overnight accommodation be available on the Island;
- ii) that prohibited Naval Areas be fenced off;
- iii) that public access be by means other than the causeway except in the case of possible limited coach tours.

Originally the date for completion of all programmed works for the Support Facility (see map Fig. 1) was December 1975 but the Prime Minister in a letter to the Premier dated 17 August 1973 announced an extension of this date to December 1978 with indefinite deferment of the Large Ships' Wharf proposed for construction in Careening Bay and the Armaments Depot and Armaments Wharf proposed for the north end of the Island. Lease owners on the south end of Careening Bay will now be required to vacate their cottages by June 1976.

A long range view of the viable functioning of a Naval Support Facility necessitates that all the proposed elements in the Zone Plan be eventually completed. Environmental management must therefore take into account all these elements and the maximum degree of possible public recreational usage should, in the long term, be limited accordingly. Nevertheless it should be pointed out that the public will still be visiting the Island on a day trip basis after the termination of Careening Bay leases and before the completion of the Naval Support Facility. Since Careening Bay has to date provided the only day trip facilities available on the Island some thought should be given to providing the necessary recreational facilities in the areas where public access will be unrestricted at a time to coincide with the lease terminations.

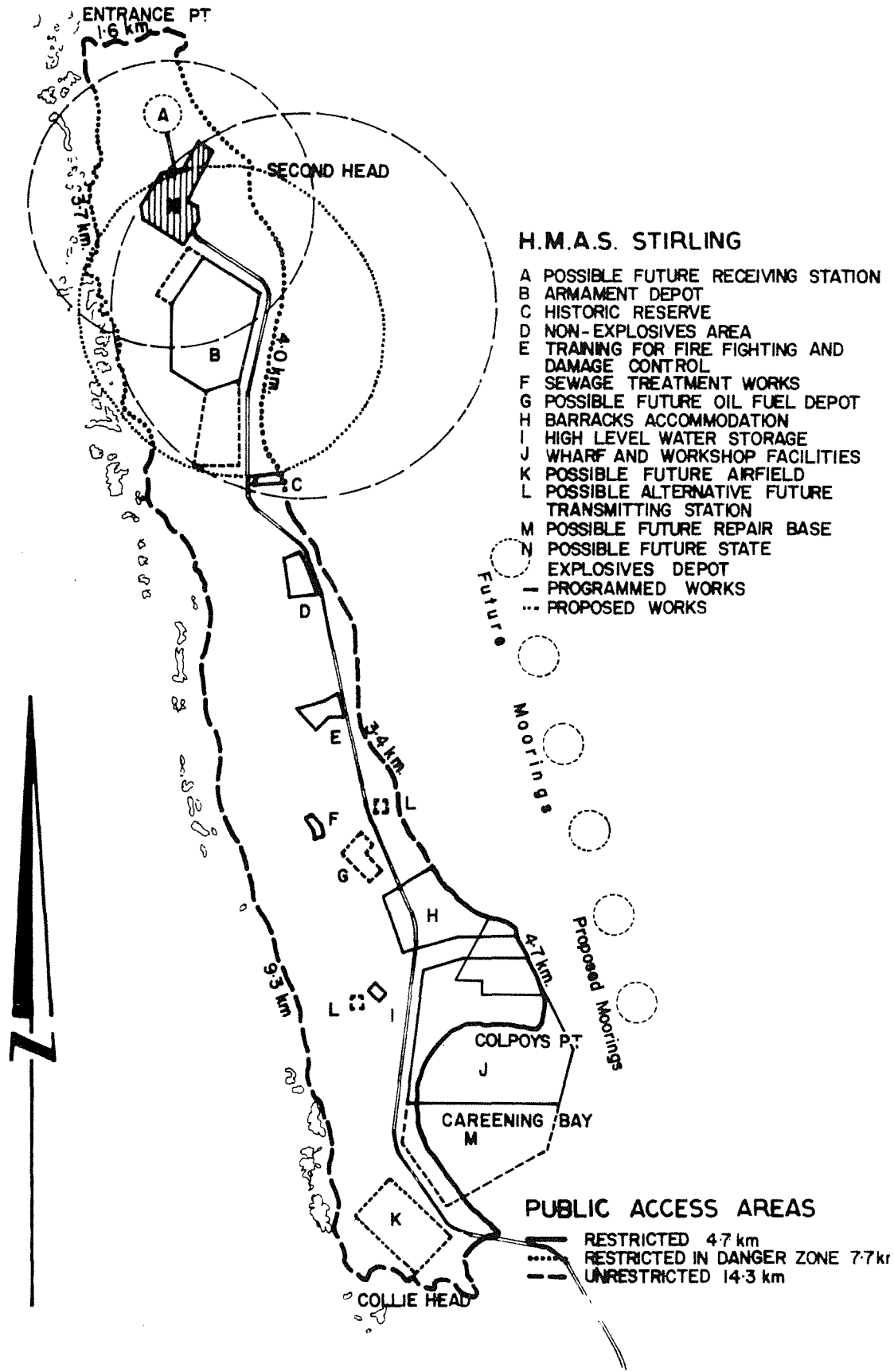


FIG. 1: Zone plan for Naval Support Facility on Garden Island showing public access areas

As part of the agreement between Commonwealth and State officials leading up to the Prime Minister-Premier press release the costs involved in providing public recreational facilities were to be the responsibility of the State. A certain reluctance to allocate State funds must exist until the matter of legal control of public access areas is resolved.

## 2.2 Legal Considerations

Following a meeting of the State Working Group held on 26 October 1973 the following resolution was forwarded to the State Government Minister for Environmental Protection proposing that the matter be taken up with Australian Government officials:

### Original Agreement - Clause 6(e)

"The Australian Government must be asked how it expects the State to exercise effective control of the area to which public access is to be permitted. Usually control of this sort is exercised through by-laws. In this case, by reason of the fact that the area in question is Commonwealth property, the State has no by-law making power and cannot be given that power by Commonwealth legislation (Commonwealth Constitution S.52(i)). A solution could be devised and implemented through joint legislation, but at the moment there seems to be no realisation that any such measure is necessary. The matter should be taken up by the Commonwealth with its legal advisors without delay."

The urgent need to resolve these legal considerations before any Garden Island Management Plan can be truly implemented must be stressed and it is RECOMMENDED that both Australian Government and State Government officials attend to the problem without delay.

### 3. STATE EXPLOSIVES DEPOT

As part of the 19 November 1972 Prime Minister-Premier press release agreement was reached in principle to transfer the State Explosives Depot from Woodman Point to a location adjacent to the Naval Armament Depot on Garden Island (see map Fig. 1). This would free the area currently occupied by the State Depot at Woodman Point for inclusion in the State's plan for development of tourist facilities in that area.

Since this announcement State Government Mines Department representatives have been re-examining the proposal and certain disadvantages in this relocation have become apparent. A committee is currently researching the problem.

This report seeks primarily to draw attention to the environmental management procedures necessary to coordinate and control development of the Island. It is therefore only necessary to point out the possible effects on the environment should a State Explosives Depot be located on the Island.

#### 4. THE GARDEN ISLAND ENVIRONMENT AND MANAGEMENT

##### 4.1 Location and Climate

Garden Island is situated 45 km southwest of Perth centred near latitude  $32^{\circ} 12'$  and longitude  $115^{\circ} 40'$  (see map Fig.2). It is  $9\frac{1}{2}$  km long and  $1\frac{1}{2}$ -2 km wide at its widest point. The southern tip of the Island is only 2 km off Point Peron on the mainland but for most of its length it lies between  $5\frac{1}{2}$  km and 9 km due west of the mainland coast. The area of the Island is approximately 3000 acres (1214 ha) at low water level.

The Island has a typically Mediterranean climate with a cool wet winter (June-September) and a hot dry summer (November-March) with short periods of unstable weather during the transition between these two seasons. Summer weather may be modified under the influence of cyclones from northern latitudes. It is only during the period May-August that the Island is subject to constant rain-bearing winds. 72% of annual rainfall is received during these months and 93% during the months of April to October. Ecologically the distribution of rainfall is therefore more important than the yearly total. During the winter there is a surplus while during summer there is a marked deficiency, ie for about half the year conditions become semi-arid or drier. There is no permanent fresh water on the Island and no evidence that there has been in the past.

##### 4.2 Geomorphology and Soil Conservation

A study of the bathymetry (see map Fig.3) of the Perth region by McArthur (1957) showed that Garden Island lies on one of two physiographically distinct ridges which lie roughly parallel to the mainland coast between  $32^{\circ}$  and  $32^{\circ} 30'$  south latitude. The easternmost ridge passes through Penguin Island, Point Peron, Garden Island, and Carnac Island. The other, about 3 km further west, passes through Coventry Reef, Hawley and Casuarina Shoals, and Rottnest Island. These ridges are composed of Pleistocene to Recent aeolianite. They have been described (Teichert 1947; Fairbridge 1950) as being the remnants of a peninsula which extended about 32 km from the present coastline when the level of the sea was considerably lower. With the rising of the sea the ridges have become more and more dissected until now there remain only four major land surfaces and several small rocky islands. Erosion is still going on, but only slowly. Point Peron has since been reunited to the mainland by blown sand (Fairbridge, 1948). From the evidence of the eustatic changes in sea level (Godwin et al, 1958) Main (1961) estimated that Garden Island has been separated from the mainland for at least 6000 to 7000 years.

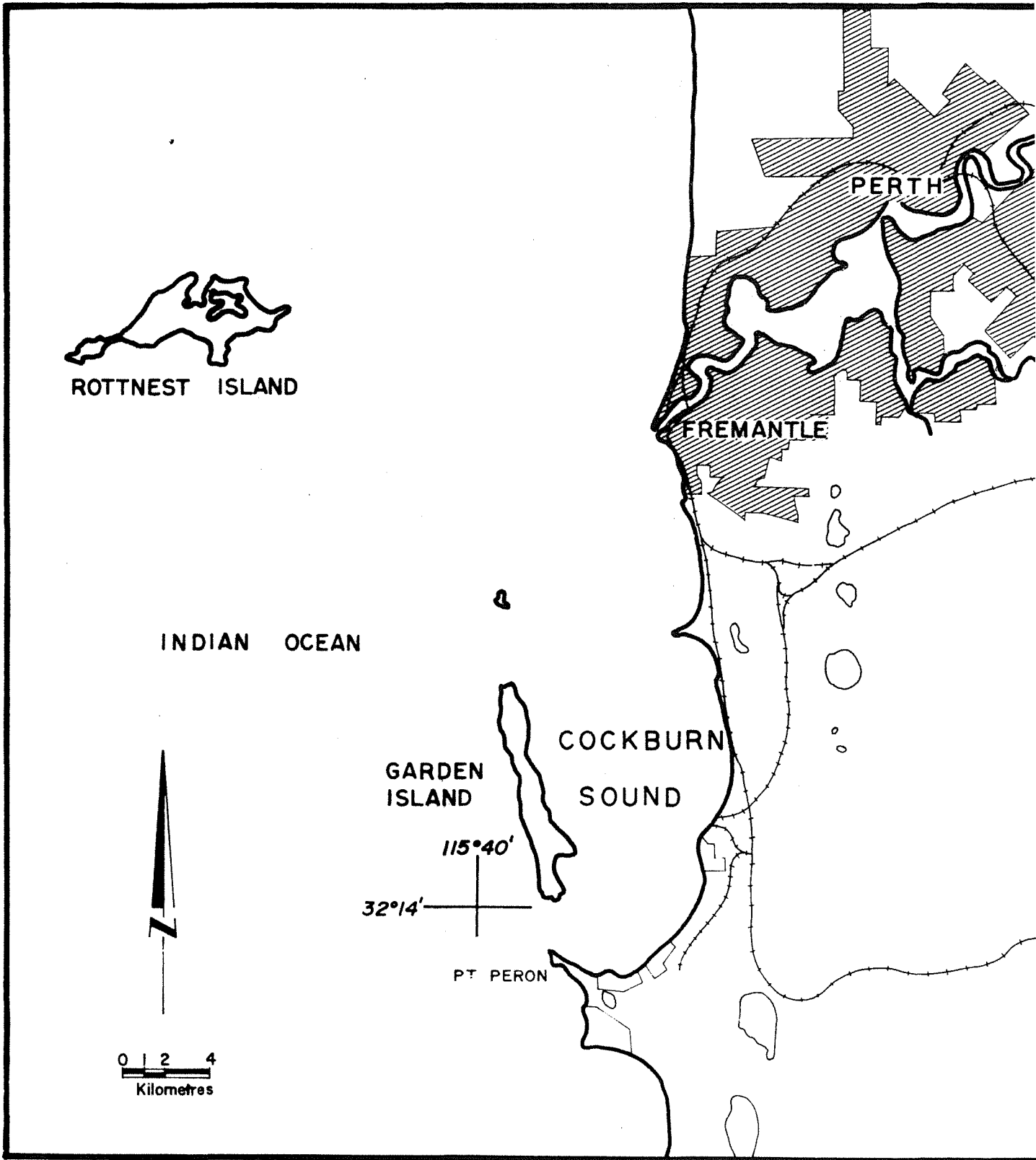
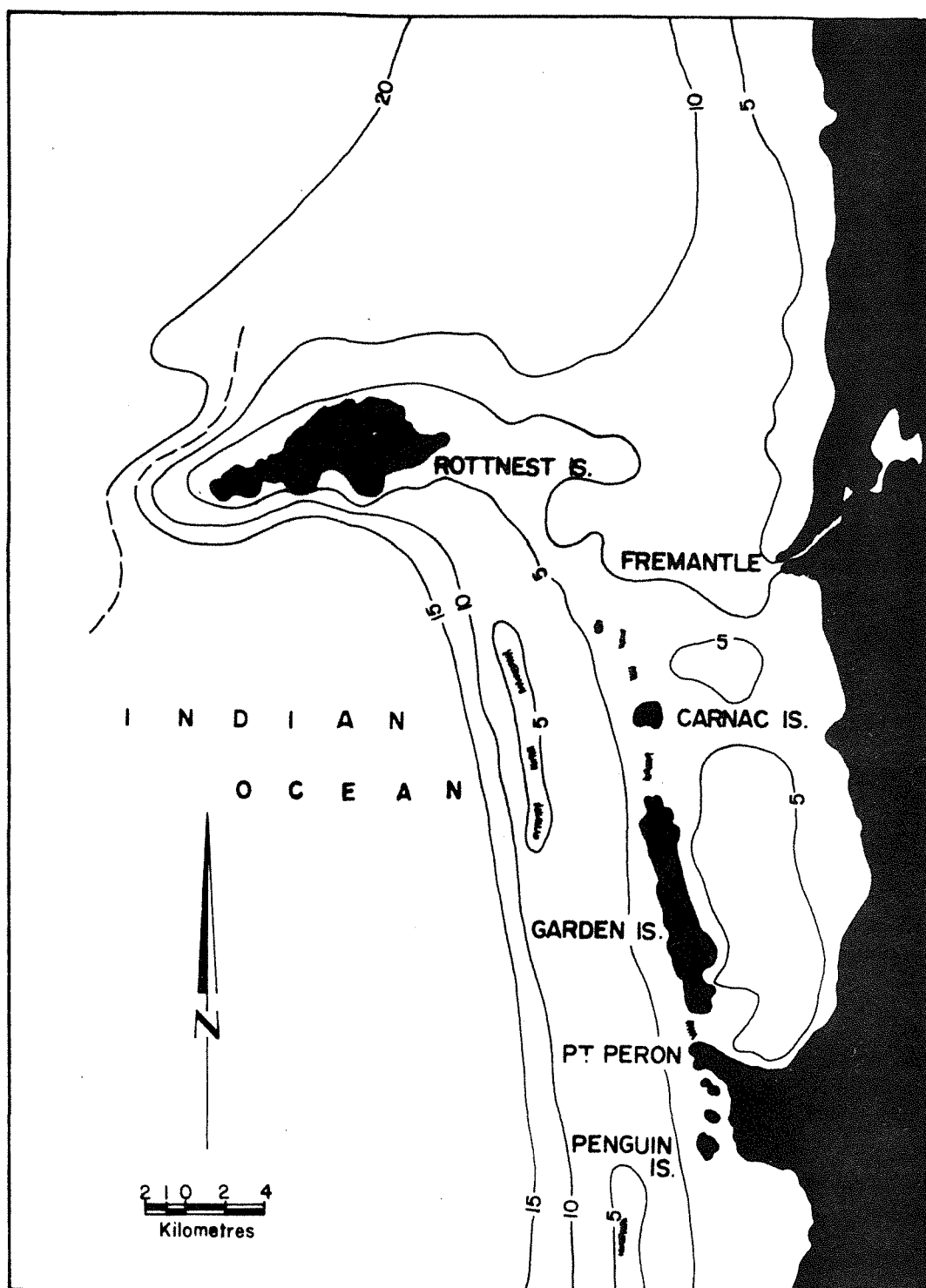


FIG. 2: Plan showing location of Garden Island in relation to Perth Metropolitan Area



**FIG. 3:** Plan showing location of Garden Island and bathymetry of the surrounding ocean (in fathoms) (From: McArthur, 1957)

The islands have a hard core of travertinized calcareous dune rock which is generally taken to be late Pleistocene in age (Fairbridge, 1948). This rock is exposed extensively on Rottneest and Carnac Islands while on Garden Island it is largely blanketed by more recent sand dunes. Exposures in the dunes on Garden Island show the typical cross-bedding of aeolianite. The upper 6-8 feet is still quite loose, but below this there is incipient cementation and a few travertinized root channels.

The geomorphology of Garden Island poses two problems with regard to development and to increased public access:

- i) the limestone rock faces on the west coast of the Island are deeply undercut due to wave action and, because of their soft structure, are a potential hazard to pedestrian visitors;
- ii) the sandy composition of the Island poses both natural erosion problems and potential erosion problems in areas cleared for development.

During the construction phase of development of the Naval Support Facility areas cleared have been stabilised by the planting of cereal rye. While an obvious necessity such interference with the ecological balance of the Island is having its effect upon the natural fauna (see Section 4.4.1). Studies of aerial photographs taken before and after construction began show an increase in the number of vehicle tracks around the Island. Where these tracks cross elevated sandy hills the vegetation regenerates poorly and potential erosion areas are formed. These serve to emphasise the necessity to keep vehicular traffic on the Island to a minimum both now and in the future.

The areas of natural erosion on the Island have been mapped (see Fig. 4) by the Department of Agriculture Soil Conservation Officers. The specific areas where soil erosion will take place, or will become more severe if there is a significant increase in public recreational usage of the Island are as follows:

- (1) On the north coast one third of the way across from west to east - an area of steep bare sand and limestone rubble cliff.
- (2) At Entrance Point on the northwest corner of the Island - a steep blow-out area below the old army gun position (see photo Fig.5).
- (3) At Mt Lotus - old erosion damage.



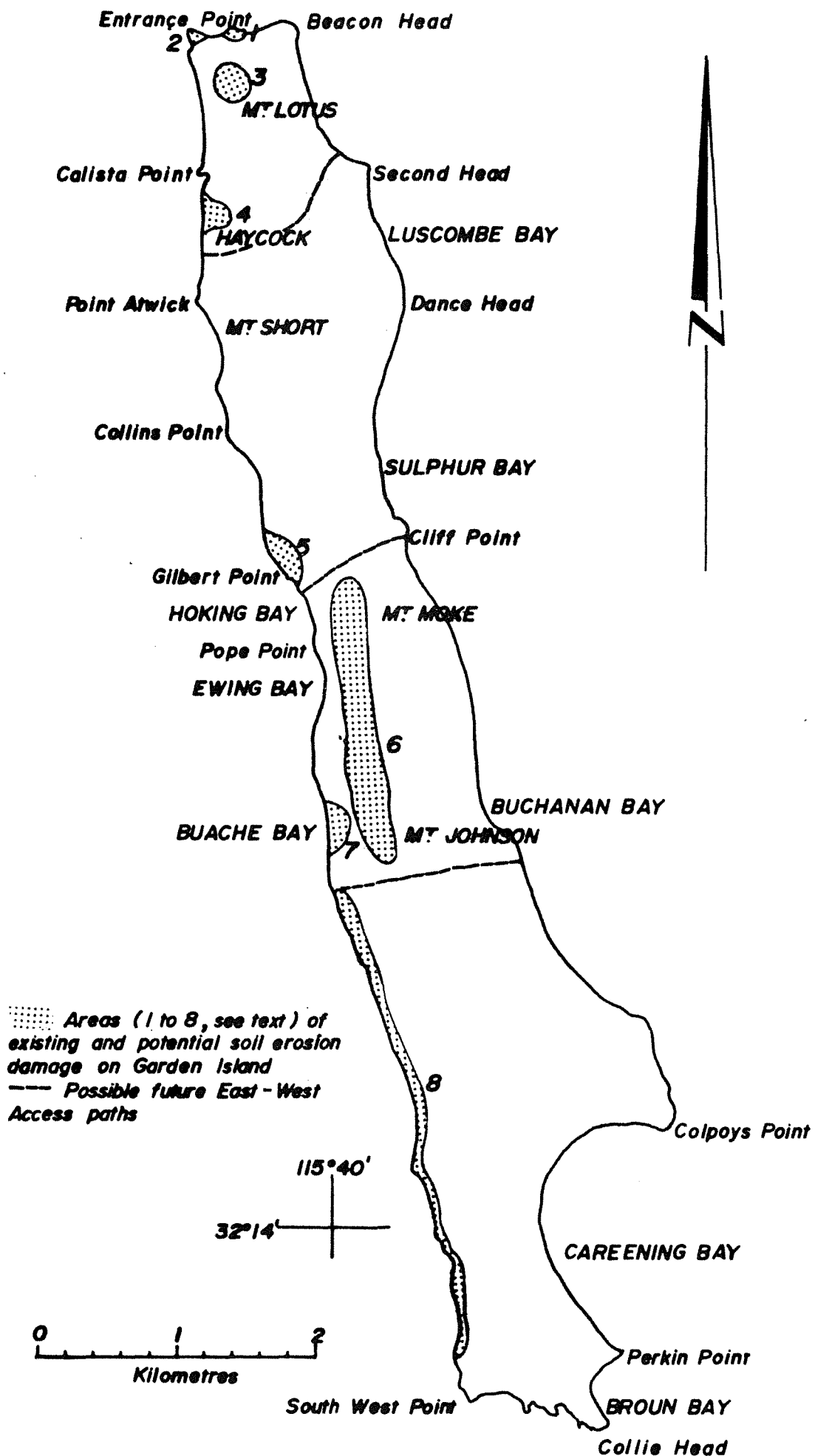


FIG. 4: Existing and potential soil erosion areas on Garden Island

Fig.5 Steep blowout area below old Army gun position  
at Entrance Point on Garden Island.

Fig.6 Two large blowout areas on centre west coast of  
Garden Island at Buache Bay (see Area 7 of Fig.4)  
A - north blowout; B - south blowout

Fig.7 Examples of small blowout areas along the west coast of Garden Island generally from Buache Bay to South West Point (see Area 8 of Fig.4).

Fig.8 Marram regeneration trials at area 7 (see Figs.4 & 6) of natural erosion on Garden Island.

- (4) At Haycock Trig point - a bulldozed track up to the top plus 800-1000 metres southwest of this a small coastal blow-out.
- (5) At Gilbert Point - two moderate size blow-outs two or three small and several tiny blow-outs.
- (6) The central area of the Island - many steep, presently well-vegetated sandhills plus some old army tracks still relatively bare.
- (7) On the centre west coast at Buache Bay - two large blow-out areas (see photo Fig.6).
- (8) The west coast generally from Buache Bay to South West Point (eg see photo Fig.7).

The areas of bare and almost bare sand in these natural soil erosion regions have been estimated using aerial photographs. They are:

i)	northern blowout at area 7	approx 17,000 m <sup>2</sup>
ii)	southern blowout at area 7	approx 15,000 m <sup>2</sup>
iii)	the sum of smaller blowout areas along the west coast	approx 50,000 m <sup>2</sup>
	<u>TOTAL</u>	approx 82,000 m <sup>2</sup>

The stability of these sandy formations is dependent on the sand binding properties of the vegetation. Trials have already commenced at area 7 to attempt to regenerate the denuded dunes with Marram grass (see photo Fig.8). Some successful attempts at Marram regeneration have been made by the Forests Department on the southwest mainland coast (P. Hewett, personal communication). However, in general the success rate is poor and many attempts at replanting are usually necessary before regeneration occurs. If the marram grass becomes established the naturally occurring species should follow in succession until eventually a stable system is formed. A continuous monitoring and regenerating program will be necessary to manage the erosion problem. In some cases it may be necessary to fence off areas from the public whilst regeneration trials are in progress.

#### 4.3 Vegetation Management

Three major vegetation associations occur on Garden Island with the dominant species in each case being *Callitris preissii* (formerly *robusta* and known commonly as the Rottnest Island Pine), *Melaleuca lanceolata* (formerly *pubescens* and known commonly as the Rottnest Island Ti-tree) and *Acacia rostellifera*. In 1969 before construction of the Naval Support Facility commenced the areas occupied by these associations were mapped (see Fig.9) by students of the University of WA Botany

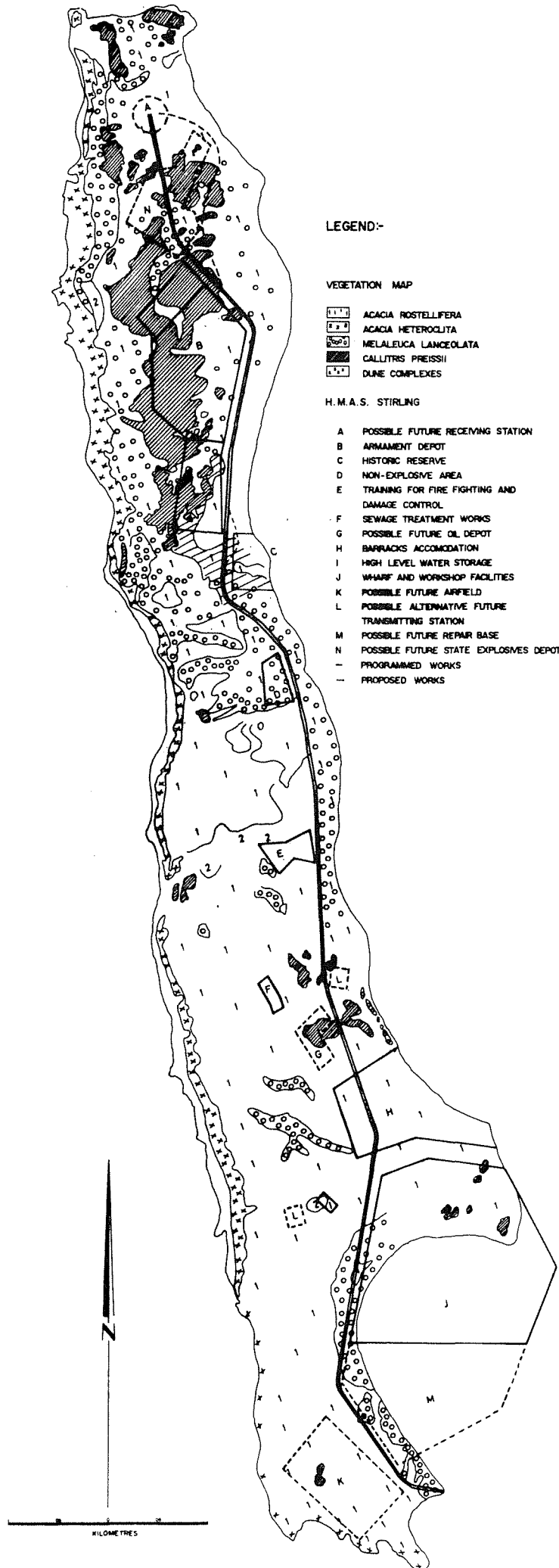


FIG 9: Zone Plan for H.M.A.S. STIRLING superimposed on Garden Island Vegetation Map

Department using aerial photographs and ground verifications. From this Vegetation Map the percentage areas occupied by these associations and their combinations were calculated and acreages estimated (see Table 1). The potentially vegetated area of the Island from which these figures were calculated was taken as 2800 acres (1133 ha). This was based on the assumption that an average unvegetated beach frontage of 100 feet (30½ metres) around the 16½ miles (26½ km) of Island coastline will account for approximately 200 acres (90ha) of the Island's 3000 acres (1214 ha) low water level area.

The *C. preissii* association occupied approximately 8.8% (246 acres; 100 ha) of the total area of the Island restricted mainly to a large clump in the northern sector. The average height of the trees in these clumps is around 20 feet (approx 6 metres) although many individual trees in the open grow to 35 feet (approx 10½ metres) as depicted in the photo Fig.10. In the clumps the trunks are straight and unbranched and the canopy completely closed giving the community the structural characteristics of a forest (see photo Fig.11). The undergrowth is very limited (see photo Fig.12) and a thick layer of leaf litter is present commonly consisting of 2-3 inches of undecomposed leaves on the surface below which is about 1-2 inches of decomposing leaves. There are no obvious factors limiting the distribution of *C. preissii*. It grows as individual trees and small clumps throughout the *A. rostellifera* scrub and competes on equal terms with *M. lanceolata*. Dispersal of seeds is by wind and McArthur (1957) showed that ring counts of trees indicated a gradual spread of the clumps into the *A. rostellifera* scrub in a northeasterly direction (represented diagrammatically by the lineation in the map Fig.9) due to predominant south-west winds in the summer months when the seeds are being shed.

The *M. lanceolata* association occupied approximately 7.3% (205 acres; 83 ha) of the total area of the Island and is similar in character to the *C. preissii* community occurring as clumps of trees about 20 feet high with little or no understorey (see photo Fig.13).

The *A. rostellifera* association occupied 60.4% (1691 acres; 684 ha) of the total area of the Island and is thus the most widespread community on the Island. It forms an extremely dense and tangled scrub (see Fig.14) of uniform height 8-10 feet (approx 2½-3 metres). Other *Acacia* species (eg *A. cyanophylla* and *A. heteroclita*) and *M. huegii* are interspersed in the *A. rostellifera* community but rarely occur as pure stands. Dense undergrowth is present, formed predominantly of *Acanthocarpus preissii* (see Appendix III). When *A. rostellifera* occurs in mixed stands with *C. preissii* and/or *M. lanceolata* it takes on the tree form, viz tall and slender with only a tuft on top (see photo Fig.15) and no understorey occurs. The *A. rostellifera* scrub shows a remarkable ability to regenerate vegetatively, exposed or damaged roots giving

TABLE 1. Areas of Garden Island covered by the major vegetation types and their combinations calculated in 1969 before construction of HMAS Stirling had commenced; the number of acres of each vegetation type actually cleared for construction of all programmed works (see Table 2); and the consequent % reduction of each vegetation type

VEGETATION TYPE	% AREA OF ISLAND COVERED	NUMBER OF ACRES	NUMBER OF ACRES CLEARED	% REDUCTION	ACRES REMAINING
<i>A. rostelifera</i>	60.4%	1691 (684 ha)	154 (62 ha)	9.1 %	1537 ( 622 ha)
<i>A. heteroclita</i>	0.5%	14 ( 5½ ha)	1 ( ½ ha)	7.1 %	13 ( 5 ha)
<i>M. lanceolata</i>	7.3%	205 ( 83 ha)	24½ (10 ha)	12.0 %	180½ ( 73 ha)
<i>C. preissii</i>	8.8%	246 (100 ha)	22½ ( 9 ha)	9.1 %	223½ ( 90½ ha)
<i>A. rostelifera</i> + <i>M. lanceolata</i>	13.9%	390 (158 ha)	24 ( 9½ ha)	6.2 %	366 ( 148 ha)
<i>A. rostelifera</i> + <i>C. preissii</i>	0.8%	22 ( 9 ha)	1½ ( ½ ha)	6.8 %	20½ ( 8½ ha)
<i>A. rostelifera</i> + <i>M. lanceolata</i> + <i>C. preissii</i>	0.4%	11 ( 4½ ha)	0 ( 0 ha)	0	11 ( 4½ ha)
Dune Flora Complexes	7.9%	211 ( 89 ha)	0 ( 0 ha)	0	211 ( 89 ha)
TOTALS	100 %	2800 (1133 ha)	227½ (92 ha)	8.1 %	2572½ (1041 ha)

Acres to nearest ½ ha.

Fig.10 Examples of *Callitris preissii* trees grown in the open on Garden Island

Fig.11 *Callitris preissi* pure stand on Garden Island showing the structural characteristics of a forest.



Fig.12 Dense stand of *Callitris preissii* on Garden Island demonstrating complete lack of understorey.

Fig.13 *Melaleuca lanceolata* pure stand on Garden Island illustrating the same structural characteristics of a forest as the *Callitris preissii* pure stands. Note: cereal rye in foreground planted to stabilise soil after clearing for main north/south road.

Fig.14 Demonstrates extremely dense and tangled scrub of the *Acacia rostellifera* association on Garden Island.

Fig.15 Mixed stand of *Acacia* (A), *Melaleuca* (B), and *Callitris* (C) on Garden Island.

rise to new bushes. McArthur (1957, work actually carried out in 1952 (see Baird, 1958)) noted that the roads made by the Army during the period 1939-1945 had completely grown over.

Other minor communities and seasonal communities occur on the Island but the above three predominate. From a purely botanical interest it is desirable that sufficient areas of these three major vegetation types remain in an undisturbed state even after the development of the Island. The interests are threefold:

- a) the vegetation types are unique in that certain important families of the mainland are either absent (*Proteaceae*), or present in restricted numbers (*Myrtaceae* and *Papilionaceae*);
- b) the pure *C. preissii* stands are of rare occurrence in Western Australia in general;
- c) the single storey structure of the *C. preissii* and *M. lanceolata* stands is unique and contrasts markedly with the three distinct storeys found in the *Eucalyptus marginata* and *E. gomphocephala* communities of the mainland.

From a zoological viewpoint it is important that representative areas of the three vegetation types remain undisturbed so that the full range of invertebrate and vertebrate fauna (including reptiles and birds as well as the macropod marsupial tammar) may be maintained.

The actual acreages of vegetation cleared within each of the areas of programmed works for the Naval Support Facility were supplied by representatives of the Australian Government Department of Housing and Construction. By studying the Zone Plan for the Support Facility superimposed on the Vegetation Map (see map Fig.9) of Garden Island it was possible to calculate the percentage reduction of each of the major vegetation types (see Tables 1 and 2). The percentage reductions thus calculated are low and it is desirable that they remain so. Further reductions are possible:

- i) from the formation of tracks and firebreaks around the Island;
- ii) from the possible location of the State Explosives Depot on the Island (see N, map Fig.9);

TABLE 2. Number of acres of each vegetation type actually cleared for programmed works of HMAS Stirling (see map Fig.1) on Garden Island

PROGRAMMED WORKS	VEGETATION TYPE	ACRES CLEARED
B	<i>A. rostellifera</i> + <i>M. lanceolata</i>	* 15 ( 6 ha)
	<i>C. preissii</i>	15 ( 6 ha)
D	<i>M. lanceolata</i>	* 8 ( 3½ ha)
E	<i>A. rostellifera</i>	# 14 ( 5½ ha)
F + access road	<i>A. rostellifera</i>	* 6 ( 2½ ha)
	<i>C. preissii</i>	½ ( )
H	<i>A. rostellifera</i>	* 34 (14 ha)
I	<i>A. rostellifera</i>	# 1 ( ½ ha)
	<i>A. heteroclita</i>	1 ( ½ ha)
J	<i>A. rostellifera</i>	* 66 (26½ ha)
	<i>M. lanceolata</i>	10½ ( 4 ha)
	<i>C. preissii</i>	3½ ( 1½ ha)
Main Access Road	<i>A. rostellifera</i>	* 33 (13½ ha)
	<i>M. lanceolata</i>	6 ( 2½ ha)
	<i>C. preissi</i>	3½ ( 1½ ha)
	<i>A. rostellifera</i> + <i>M. lanceolata</i>	9 ( 3½ ha)
	<i>A. rostellifera</i> + <i>C. preissii</i>	1½ ( ½ ha)

\* Figures supplied by Australian Government Department of Housing and Construction.

# Calculated from Zone Plan

Acres to nearest ½ ha

- iii) from the possible future receiving station (A), future extension of the armaments depot (B), future oil depot (G), future airfield (K), future transmitting station (L), and future repair base (M) (see map Fig.9);
- iv) from control burning programs necessary to reduce fire risk on the Island which do not permanently reduce the area occupied by a particular vegetation type but reduce the area of habitat available to the fauna at any one time; and
- v) from development of public recreational facilities on the Island.

The effect of item (i) on percentage reduction of each vegetation type is difficult to gauge but the increased number of vehicles on the Island over the last year has already seen a great increase in the number of tracks on the Island (see Section 4.2). This plus items (ii) and (iii) will probably stretch development near to an environmental limit from the viewpoint of survival of both flora and fauna on the Island (see Section 4.4.1). Precision planning is therefore required for items (iv) and (v).

Before bush fire control measures are instigated it is essential to have some knowledge of (a) the regenerative potentials of the various plant species on the Island; and (b) the habitat requirements of the fauna on the Island.

Studies by Baird (1958) following the 1956 fire on Garden Island showed that, of the major species mentioned above *A. rostellifera* and *Acanthocarpus preissii* can regenerate by sprouting from underground shoots while *M. lanceolata*, *M. hueglinii* and *C. preissii* can regenerate from seed only. The different species regenerating by seed will also show different resistances to heat caused by fire. Baird (1958) showed that after the 1956 fire *A. rostellifera* seedlings were found only on the fringe areas where the heat had not been so intense. Laboratory trials currently being carried out by the Forests Department (P. Hewett, personal communication) show that the seeds of different indigenous scrub and wildflower species have different resistances to dry heat. In some areas it may be ill-advised to burn at all but in areas where control burning may be necessary the best way to gauge the effects of various regenerative potentials is to survey small areas before and after the burn and actually monitor the species regenerating and the time taken to return to climax condition.

In the case of the *C. preissii* pure stands burning at the present stage of the forest's development is undesirable. Fire control would be best brought about by clearing excessive fuel (dead branches, etc),

providing adequate firebreaks, and thinning the forests. Thinning trials should first be carried out in small areas before a major program is put into action. Forests Department representative Mr P. Hewett believes the effect will not only be to reduce fire hazard but also to enhance the appearance of pure stands (see Fig.11) so that the trees take on the appearance of those grown in the open (see Fig. 10). There is some doubt as to whether the lower parts of the main trunks already denuded of foliage would regenerate new branches and foliage. However, as the tree grows the extra 15-20 feet to full size, this top section of the tree should retain branches and foliage all the way up rather than showing the usual loss of the lower branches as height is increased.

In the pure *M. lanceolata* stands and in mixed stands little fire hazard should be found provided once again that excessive fuel is kept cleared and adequate fire breaks surround these areas.

The dunal vegetation complexes distributed mainly down the western coast of the Island (see map Fig.9) are low and heavily pruned by wind. They offer little fire hazard and burning of these areas would be highly undesirable because of the danger of blow-outs (see Section 4.2) on the steep dunes which would then be left unprotected against the west and south-west winds.

The *A. rostelifera* scrub is potentially the greatest fire risk on the Island. In areas on the south end of the Island which missed the 1956 fire (see map Fig.16) the *A. rostelifera* bushes are over-mature, chloritic, and dying with horizontal root systems infected by larvae of wood-boring moths and upright stems heavily infected by longicorn beetles (family *Cerambycidae*) and their larvae (Main, 1971). A small section of this was control burned in November 1973 prior to which a quantitative survey was made to determine species composition and their dominance-diversity relationships (see Appendix III). This will form the basis of a monitoring program which should be continued over the next five to ten years. After rains in late January *A. rostelifera* and *Acanthocarpus preissii* began to shoot from old root systems. On the basis of McArthur's (1957) observation of regeneration on Army tracks and Baird's (1958) post-burn observations it is estimated that, although food will be available earlier, up to ten years regeneration will be required before the scrub provides suitable cover for tamarin habitation (see Section 4.4.1). Exclosures have been constructed on the control burn site to monitor the effect of tamarin regulation of the regeneration.

Taking into account the knowledge that maximum density of tamarins occurs in the *A. rostelifera*

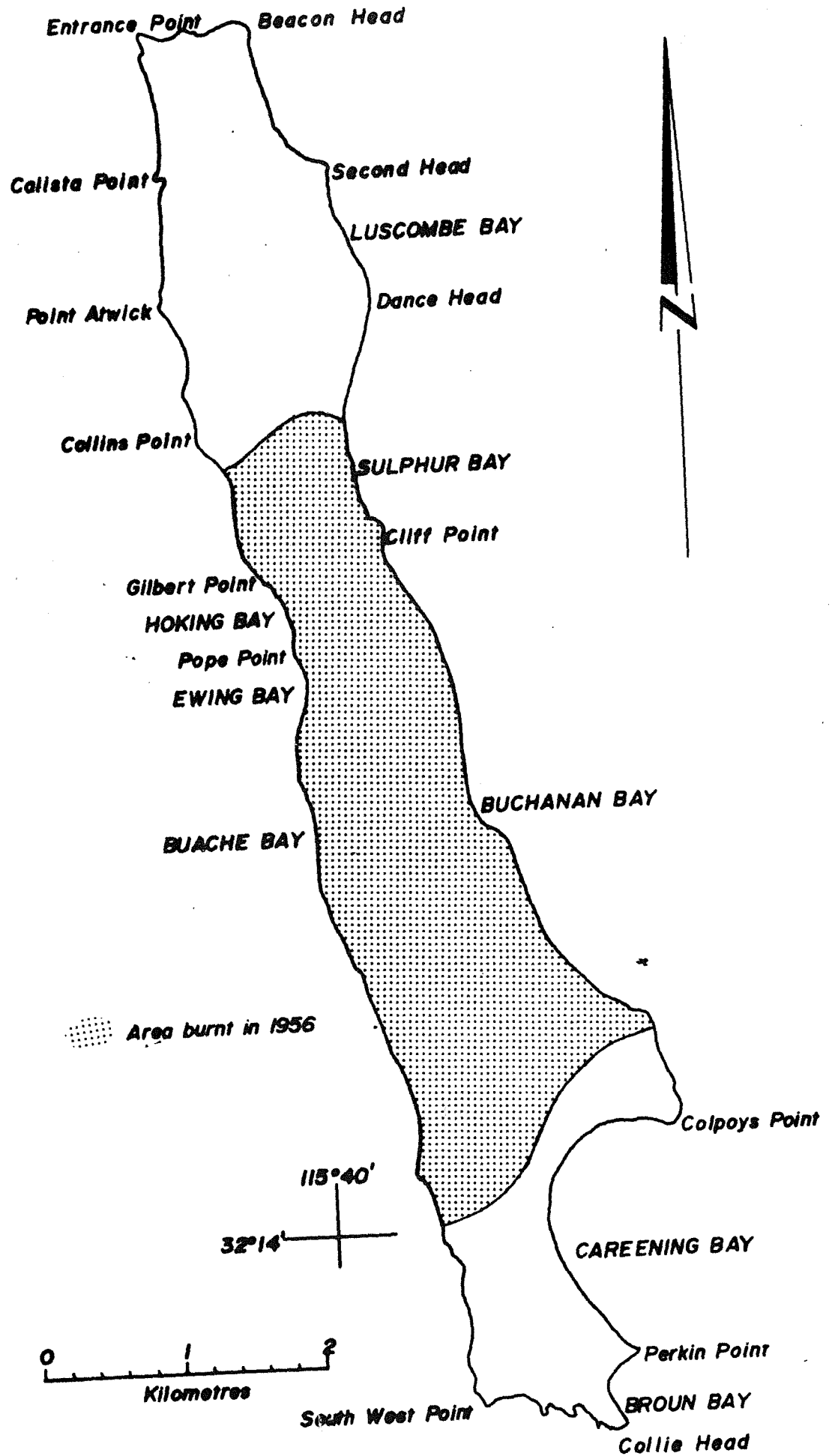


FIG. 16 : 1956 Burn Site on Garden Island

scrub (1 per 2 acres, see Section 4.4.1) and the ten-year regeneration time necessary for return of an area to habitable condition for tammars, it is RECOMMENDED that not more than 200 acres (reducing the carrying of the Island by 100 animals) be under various stages of post-burn regeneration at any one time. The total area requiring control burning after construction of the programmed works of the Support Facility will be about 1440 acres (ie outside fenced areas). If 20 acres per year is burned then in any given ten year period a total of 200 acres will be unavailable for tamarin habitation. By the time the whole 1440 acres have been burned once approximately 60 to 70 years will have elapsed and the first areas will be reaching climax condition and require burning again.

Further consideration should also be given to choosing the best time of year to burn. Table 3 shows that the highest average wind velocities occur in the months October to March when the sand is dry and most unstable while the lowest average wind velocities occur in April to September when the sand is constantly moist and more stable. From the point of view of potential erosion the ideal time to burn would therefore be in April following which rains would cause immediate regeneration. Open areas of sand denuded of vegetation would not therefore be left for months as potential erosion areas. Under natural conditions fire would be hardest to control at this time (right at the end of the long dry summer) but the technique of rolling the vegetation employed as pre-treatment in the December 1973 control burn plus adequate fire-breaking around the proposed burn area should make fire control possible. The rolling pre-treatment has the added advantage of leaving rich ash beds which provide nutrient for the newly regenerating plants. After months of high velocity winds these ash beds are scattered. The degree of regeneration which occurs following unpredictable summer rains (see Appendix III, photo Fig. 32) is not sufficient to prevent this erosion nor to prevent the growth of herbs (which is a possible danger with autumn burning) with the onset of winter rains.



TABLE 3. Average monthly wind speeds (mph) for Perth Metropolitan area over 67 years (1898-1964). Data from Commonwealth Bureau of Meteorology Report, 1966.

MONTH	WIND SPEED (mph)
January	11.7
February	11.3
March	10.4
April	9.0
May	8.6
June	8.9
July	9.2
August	9.3
September	9.6
October	10.1
November	10.9
December	11.4

#### 4.4 Fauna Management

##### 4.4.1 The Tammar - *Macropus eugenii* (Desmarest)

Under natural conditions Garden Island has supported only one mammalian species - the macropod marsupial tammar, *Macropus eugenii* (Desmarest) (see photo Fig.17). This is a small wallaby (3-7 kg) with a ruminant-like digestion (Moir, Somers, and Waring, 1956) which was once widespread over most of the southwestern part of Western Australia, large populations also occurring on the Abrolhos Islands as first described by Pelsart in 1629, who furnished "... the first proper account of a species of kangaroo written" (Alexander, 1922).

At present the tammar is distributed sparsely over widespread areas of the drier Western Australian mainland Jarrah forests with two well known small populations occurring at Pingelly and Port Gregory (see map Fig.18). Several larger populations also occur on a number of offshore islands including the Recherche Archipelago as well as the Abrolhos Islands and Garden Island (Ride, 1970). Although it was recommended by the Australian Academy of Science National Parks Committee in 1962 that selected areas of Garden Island be chosen and gazetted Class A Reserves for the preservation of fauna and flora and vested in an authority competent to provide adequate biological management, Garden Island being Freehold territory still remains the only one of these islands which is not a reserve for the preservation of fauna and flora.

Kelsall (1965) showed that the essential features of the tammar habitat include both food and suitable cover as protection against strong sunlight, storms, and avian predation. Low to medium closed canopies provide this protection and, whilst animals may be seen feeding on open fringe areas on still nights (see Appendix IV), during the daylight and at night when not feeding they restrict their movements almost completely to these areas of suitable cover.

In an undeveloped state Garden Island supported a large population of tammars. Approximately 2590 acres (1048 ha) of the Island's 2800 acres (1133 ha) was covered by dense scrub formed by *Acacia rostellifera*, *Callitris robusta* and *Melaleuca lanceolata* which, to varying degrees, formed suitable tammar habitat. According to Main (1968) the density of tammars on the Abrolhos Islands is one tammar per four acres. The animals on the Abrolhos are significantly smaller however compared with the Garden Island individuals and by the same argument of Main and Yadav (1971) in which they stated that decreased size of macropods on islands may be an adaptation to allow more reproductive units per given acreage,

Fig.17 The macropod marsupial tammar, *Macropus eugenii*.  
Garden Island animal reared in the animal yards  
of the University of Western Australia Zoology  
Department.

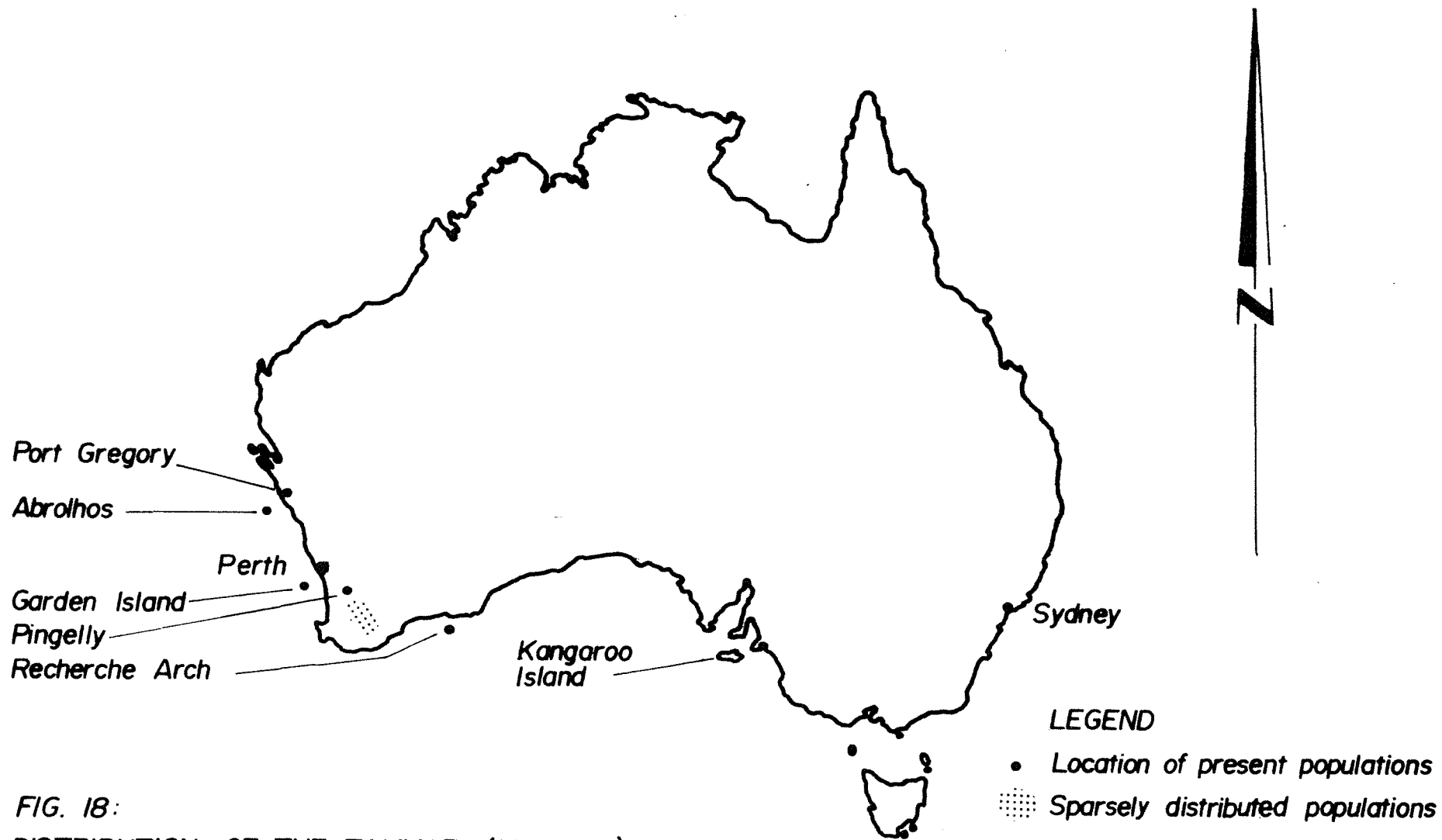


FIG. 18:  
DISTRIBUTION OF THE TAMMAR (*M. eugenii*)  
IN AUSTRALIA

it can be surmised that the Garden Island tammar, being large, has a lower density. The 2590 acres of Garden Island could thus, by this reasoning, have sustained a maximum population of approximately 600 to 650 animals. However, Garden Island has more than twice the rainfall of the Abrolhos and consequently a greater abundance of food and shelter. Working with an area of less than 400 acres (162 ha) Bakker (1973) was able to mark 200 individuals, and by visual observation suggested that, at most, 75% of the population was tagged. This figure gave more than one tammar per two acres. Although Bakker (1973) realised that this density may not be uniform over the Island (since his study areas were in rather favourable locations), he believed it would not be unreasonable to estimate the tammar population on Garden Island at being between 1000 and 1500 animals.

In 1973 cereal rye crops were planted on the Island for the first time to stabilise areas cleared for construction (see Section 4.2). During spring large numbers of tammars began feeding on the rye while it was still green. Under natural conditions the tammars are rather cryptic but this allowed comparative census data to be compiled (see Appendix IV). Assuming that an equal proportion of the population will be feeding on the rye in all areas comparative densities of animals in the different vegetation types were calculated by counting animals along a north/south transect (the rye planted in the area cleared for development of the major north/south road) which passed through the major vegetation types. This count was taken before the rye could affect the natural recruitment of young in any region (see later). The results indicated that under natural conditions the density of animals in areas where *A. rostellifera* is the dominant species with abundant lower storey ground cover was 8½ times the density of animals in the *M. lanceolata* pure stands, the *C. preissii* pure stands, or mixed stands of any combination of these three major species. This is due to the absence of ground cover associated with *M. lanceolata* and *C. preissii* (see photo Fig.12). The animals find no food or cover in these regions.

Bakker's (1973) trapping sites were in the favourable *A. rostellifera* vegetation type. If his figure of one animal per two acres is taken then density for the other vegetation types would be one animal per seventeen acres. On this basis the carrying capacity of the Island before construction began would have been approximately 900 adult tammars (see Table 4).

Although the actual percentage reductions of each vegetation type due to clearing for construction of the Naval Support Facility are small (see Section 4.3) the areas available for tammar habitation will be reduced by a much greater amount. Area B at the

TABLE 4. Original area of each vegetation type on Garden Island; total numbers of adult tammars supported by these areas; areas of each vegetation type unavailable for tamarin habitation after completion of all programmed works of HMAS Stirling (see Table 5); consequent reduction in adult tamarin numbers.

VEGETATION TYPE	NUMBER OF ACRES	NUMBER OF TAMMARS SUPPORTED	ACRES UNAVAILABLE	REDUCTION IN TAMMAR NUMBERS	TAMMARS SUPPORTED BY REMAINING VEGETATION
<i>A. rostellifera</i>	1691 ( 684 ha)	845	251½ (102 ha)	126	719
<i>A. heteroclita</i>	14 ( 5½ ha)	7	1 ( - )	½	6½
<i>M. lanceolata</i>	205 ( 83 ha)	12	31 ( 12½ ha)	2	10
<i>C. preissii</i>	246 ( 100 ha)	15	63½ ( 25½ ha)	4	11
<i>A. rostellifera</i> + <i>M. lanceolata</i>	390 ( 158 ha)	23	57 ( 23 ha)	) 3½ )	20½
<i>A. rostellifera</i> + <i>C. preissii</i>	22 ( 9 ha)	1	1½ ( ½ ha)	) )	
<i>A. rostellifera</i> + <i>M. lanceolata</i> + <i>C. preissii</i>	11 ( 4½ ha)	1	0 ( 0 ha)	0	1
Dune Flora Complexes	211 ( 89 ha)	0	0 ( 0 ha)	0	0
<b>TOTALS</b>	<b>2800 (1133 ha)</b>	<b>904</b>	<b>405½ (164 ha)</b>	<b>136</b>	<b>768</b>

Acres to nearest ½ ha.

north end and areas H, J, and M on the south end around Careening Bay will be fenced off from the remainder of the Island. It is difficult to imagine that a viable population of tammars could be maintained within these fenced areas in the remaining vegetation. Table 5 gives the number of acres of each vegetation type unavailable for tamarin habitation due to both the clearing of vegetation in all programmed works for the Support Facility and to the fencing off of the above areas. The totals of each vegetation type unavailable after completion of these programmed works and the consequent reductions in the tamarin population are given in Table 4. The carrying capacity of Garden Island for tammars will be reduced from 900 to about 770 adult animals.

The reduction of available tamarin habitat obtained in this way is a rather conservative estimate of the total reduction likely to occur. Should plans proceed with proposed works for HMAS Stirling and the State Explosives Depot (see map Fig.1) Table 6 gives the consequent reductions in available vegetation and hence in the tamarin carrying capacity. In this case a further reduction of about 70 adult tammars will bring the overall carrying capacity of the Island down to about 700 adult animals. The State Explosives Depot would account for only about 10 of this 70 animal reduction. Further to this no account is taken of clearing for fire breaks, tracks, or roads other than the major north/south road and the access road to the sewage treatment works (F). Further reductions especially in the favourable *A. rostellifera* scrub are likely to occur (a) due to the cyclical burning program (see Section 4.3); and (b) if development of recreational facilities for day tourists takes place. If this further development ever extended in total to 800 acres the carrying capacity of the Island would be brought within the range of the smallest viable population size for macropod marsupials calculated by Main and Yadav (1971) to be about 200 to 300 animals. Careful planning in the case of future development and a sound management policy for the tammars are therefore required.

In the case such as this of a species being conserved such management attempts to optimise the size and structure of the population so that (a) the resource upon which the population is dependent remains intact; and (b) the probability that the population will persist is maximised (Main, 1968). The aims of management can only be achieved by manipulating (a) the environment varying the resources available to the population; or (b) the population and its attributes, eg size, sex composition, and age structure which will change with time according to the way births contribute to changes in recruit classes and deaths remove variously

TABLE 5. Areas of vegetation types unavailable for tammar habitation and consequent reduction in tammar numbers after completion of programmed works (see map Fig.1) of HMAS Stirling due to clearing and fencing off.

PROGRAMMED WORKS	VEGETATION TYPE	ACRES UNAVAILABLE	REDUCTION IN TAMMAR NUMBERS
B	<i>A. rostellifera</i>	1½ ( ½ ha)	1
	<i>C. preissii</i>	53½ (21½ ha)	3
	<i>A. rostellifera</i> + <i>M. lanceolata</i>	48 (19½ ha)	3
D	<i>M. lanceolata</i>	8 ( 3½ ha)	½
E	<i>A. rostellifera</i>	14 ( 5½ ha)	7
F + access road	<i>A. rostellifera</i>	6 ( 2½ ha)	3
	<i>C. preissii</i>	½ ( - ha)	0
H	<i>A. rostellifera</i>	89½ (36 ha)	45
I	<i>A. rostellifera</i>	1 ( ½ ha)	½
	<i>A. heteroclita</i>	1 ( ½ ha)	½
J	<i>A. rostellifera</i>	106½ (43 ha)	53
	<i>M. lanceolata</i>	17 ( 7 ha)	1
	<i>C. preissii</i>	6 ( 2½ ha)	½
Main Access Road	<i>A. rostellifera</i>	33 (13½ ha)	16½
	<i>M. lanceolata</i>	6 ( 2½ ha)	
	<i>C. preissii</i>	3½ ( 1½ ha)	
	<i>A. rostellifera</i> + <i>M. lanceolata</i>	9 ( 3½ ha)	
	<i>A. rostellifera</i> + <i>C. preissii</i>	1½ ( ½ ha)	

Acres to nearest ½ ha



TABLE 6. Areas of vegetation types unavailable for tammar habitation and consequent reduction in tammar numbers if proposed works of HMAS Stirling and State Explosives Depot (see map Fig.1) are constructed on Garden Island

PROPOSED WORKS	VEGETATION TYPE	ACRES UNAVAILABLE	REDUCTION IN TAMMAR NUMBERS
A	<i>A. rostellifera</i>	8 ( ½ ha)	4
B	<i>A. rostellifera</i>	13½ ( 5½ ha)	7
	<i>C. preissii</i>	34 (14 ha)	2
	<i>A. rostellifera</i> + <i>M. lanceolata</i>	9 ( 3½ ha )	1
	<i>A. rostellifera</i> + <i>C. preissii</i>	6½ ( 2½ ha )	
G	<i>A. rostellifera</i>	8½ ( 3½ ha)	4
	<i>C. preissii</i>	4½* ( 2 ha)	
K	<i>A. rostellifera</i>	70 (28 ha)	35
	<i>C. preissii</i>	2 * ( 1 ha)	
L	<i>A. rostellifera</i>	3½ ( 1½ ha)	2
M	<i>A. rostellifera</i>	11 ( 4½ ha)	5½
	<i>M. lanceolata</i>	21 * ( 8½ ha)	1½ * added
N (State Explosives Depot)	<i>A. rostellifera</i>	18½ ( 7½ ha)	9
	<i>C. preissii</i>	15 ( 6 ha)	1
	<i>A. rostellifera</i> = + <i>M. lanceolata</i>	18 ( 7 ha)	1
<u>TOTALS</u>	<i>A. rostellifera</i>	133 (54 ha)	66½
	<i>M. lanceolata</i>	21 ( 8½ ha )	
	<i>C. preissii</i>	55½ (22½ ha)	
	<i>A. rostellifera</i> + <i>M. lanceolata</i>	27 (11 ha)	2
	<i>A. rostellifera</i> + <i>C. preissii</i>	6½ ( 2½ ha )	
	TOTAL	249½ (98½ ha)	73

Acres to nearest ½ ha

aged individuals from the population. A knowledge of the physiological functions of the species, eg nutritional requirements, kidney functions, temperature regulations, etc especially under extreme or unnatural conditions and the effect of possible predator or competitor interactions is desirable in determining the best management strategy.

It is fortunate that because of the biologist's fascination for "islands as natural laboratories" (Main, 1967) the tamarin on Garden Island has already been the subject of a considerable amount of ecological and physiological research in recent years.

The first detailed study was carried out by Kelsall (1965) who studied the variability between three isolated populations in Western Australia (one mainland and two island populations including Garden Island). He speculated that the interjection of primitive man and the dingo "... could well account for the withdrawal of the mainland animals to small pockets of optimum habitat". Before the coming of European man the islands off the coast do not seem to have suffered from this predation and many macropod marsupials have persisted and flourished on them. However, the records show that between 1840 and 1912 on Hermite Island and between 1912 and 1950 on Trimouille Island at least one species of macropod marsupial on each island (see Burbidge, 1971) became extinct. Serventy and Marshall (1964) endorse the suggestion of Montague (1914) that the introduction of competitors and predators in the forms of rats and cats probably caused the extinction. One of the major problems in tamarin management will therefore be to ensure that no competitors and certainly no predator cats and dogs become established on Garden Island.

As a result of the establishment of holiday resorts, Garden Island already supports a small population of feral cats members of which were sighted (including multiple sightings on some nights and sightings of kittens as evidence of breeding) on six out of twelve nights on which the Island was visited over the period 7 November 1973 to 14 February 1974 (see Appendix IV). The problem is intensified by the fact that Garden Island can no longer be considered an island. The construction of the Causeway linking the Island to the mainland means that cats can now cross to the Island of their own accord. That they are already doing so is evidenced by the fact that cats were sighted on the Causeway on three of the eleven occasions on which night crossings were made during the above period. The cat can never resist a "fish dinner" and it is possible that they are being attracted onto the Causeway by the current spate of amateur line fishing taking place from the two bridges (despite the fact that this is prohibited Commonwealth Territory).

Although it is possible that migration of cats is in both directions (from Garden Island to the mainland and vice versa) the far greater density of cats on the mainland than on Garden Island would almost certainly result in the pressure of migration being towards the Island. If, at worst, 100% of migration was from the mainland to Garden Island a projected estimate from the present limited number of sightings of cats on the Causeway is that about 100 cats would migrate to the Island each year. Even if, as is most unlikely, migration was 1 : 1 in both directions resulting in no net increase in the Island population, the introduction of new genetic material will support a viable outbreeding population rather than a small highly inbred insular population. If the situation remains unchecked the high reproductive rate of the feral cat will very soon result in a large population on the Island endangering the survival of the tamar.

The first RECOMMENDATION for the management of the tamar on Garden Island then is that:

- a) the present population of feral cats be eradicated;
- b) some measure be invoked to prevent the further introduction of cats from the mainland by way of the Causeway.

Although domestic dogs have been sighted there is no indication of the establishment of a wild population on the Island to date. While overnight accommodation is still available on the Island it is difficult to convince visitors that they should leave their dogs on the mainland (especially for extended periods) even though dogs are prohibited on the Island. When all overnight accommodation has been abolished on the Island the situation will be easier to control. Day visitors should not only be prohibited from taking dogs onto the Island but this should be strictly policed with a penalty involved.

Recent examination of the area (J. Buchanan, personal communication) also indicates that rats are colonising the Causeway between the mainland and Garden Island. It is RECOMMENDED that this development be monitored especially when the Support Facility goes into action with a view to controlling or eradicating this pest species.

Physiological parameters, when measured under natural conditions give not only an indication of the stresses acting on the animal during the period of measurement, eg water restriction, salt deficiency, inadequate nutrition, etc, but may also reflect the well-being of the animal. Their disadvantage is that their measurement often requires time-consuming processes and the use of sophisticated laboratory equipment. Bakker (1973) proposed a simple measurement, the "welfare state", which he showed correlated with the

physiological findings during the various seasons for tammars on Garden Island. This welfare state is a function of the weight and age (determined by measurement of pes length) of the animal and follows a scale of 1 to 10 for increasing well-being of the animal (see Appendix IV for details). Bakker (1973) showed that under natural conditions when changes in welfare state were compared with changes in mean bodyweight the tammar on Garden Island experiences its poorest condition in mid-winter in contrast with the tammar on the Abrolhos Islands (Main, 1968) and the quokka on Rottnest Island (Shield, 1959) both of which show a marked decline in summer. Only during extreme drought conditions and only in animals with no access to free water did the Garden Island tammars show a marginal decline in body condition during summer.

The reason why the tammar appears to be in such a poor condition in winter seems related to high water turnover. During the winter the newly-sprouted vegetation has a high water content and is frequently covered with free water. This is the only food source for the tammar since the dry food on which it feeds during summer has by then degenerated. If the animal eats to the capacity of its stomach it ingests largely water accompanied by little energy and protein. The animal thus finds itself in a paradoxical situation of being forced to consume large amounts of water and poor quality vegetation which inevitably lead to a lessening of condition.

Continual monitoring of comparative population densities and welfare states of the tammars will be essential in determining the effects of environmental interference such as the planting of cereal rye on the Island. Evidence from standardised counts (see Appendix IV) indicates that 1973/74 recruitment has been high. Large numbers of recruits plus adults are currently being observed feeding on the rye and look to be in good condition.

No trapping has been carried out near the rye to obtain welfare state measurements but animals trapped near Middle Bore (see map Fig.33, Appendix IV) are in good condition (welfare states  $8.54 \pm .32$ ) indicating a good year under natural conditions. The high quality herbage provided by the rye will therefore result in large numbers of "healthy" animals by the end of summer. Come winter when the rye crop has diminished two effects may be seen:

- i) large numbers of animals will lose condition rapidly and may even die;
- ii) territorial fighting particularly amongst males will accentuate the loss of condition.

In cases such as this where environmental interference increases recruitment beyond the natural carrying capacity of the Island it may be necessary to remove animals from the population and reduce population density. Although the population would naturally regulate itself, outcries may occur when the general public observe (a) the poorer condition of the animals; and (b) possibly the death of a number of animals.

On a long term basis the second major RECOMMENDATION for tammar management on Garden Island is that a regular program of census, trapping and calculation of welfare states be initiated and continued over a long period. Even when stability on the Island is reached after construction of the Naval Support Facility it will still be necessary to monitor the effects of increased public recreational usage of the Island.

#### 4.4.2 Other Terrestrial Fauna

Little is known of the terrestrial fauna of Garden Island other than the tammar. Reports from Army personnel stationed on the Island during the Second World War suggest that Carpet Pythons (*Morelia variegata*) once occurred in large numbers on the Island. None has been sighted during the present study. Avian fauna are plentiful on the Island but the extent of their diversity and the habitat requirements of the different species are unknown.

If representative areas of the major vegetation types are retained on the Island sufficient diversity of habitat should be available to maintain the present terrestrial fauna. However, it is RECOMMENDED that a survey be made of the area:

- i) to determine the current status of the Carpet Python population; and
- ii) to provide a baseline for future monitoring of environmental change on the Island.

#### 4.4.3 Marine Fauna

Reports are made from both the "Naturaliste" in 1801 (Alexander, 1914) and the "Challenger" in 1829 (Captain's log) of massive slaughters of seals on Garden Island. Today they are virtually non-existent and serve as a lesson to the effect of human intervention.

Incredible "fish stories" related to Garden Island were also told by Captain Irwin in his 1935 book on Western Australia -

"In the early days of the settlement the crews of the "Sulphur" and "Challenger" caught a vast quantity of king fish, filling three large boats with them, ... upwards of 300 people were amply supplied on this occasion, including the civil and military establishments then on Garden Island and also the crews of the above ships and the "Parmelia" transport."

"Close to Garden Island is a bank on which the finest whiting are caught in great quantities; they are larger than those taken on the English coast and equal to them in flavour."

"Mr B.H. MacLeod (and others) caught on the Five Fathom Bank outside of that island in less than two hours, and with half a dozen hooks and lines, snapper to an extent of 5 cwt. Some were 20 to 40 lbs each".

It is evident from such tales that marine fauna in the waters surrounding Garden Island have, in the past, been plentiful. Research in the area is being carried out on a continuing basis by the State Government Department of Fisheries and Fauna and the CSIRO Division of Fisheries and Oceanography. To date the only area specifically set aside for the protection of marine fauna is a research area on the northwest coast of Garden Island (see map Fig.19) which is restricted to the taking of rock lobsters by both amateurs and professionals. Both departments are anxious that this area be retained. It is RECOMMENDED that general policies relating to fisheries control in State waters should also be maintained in the Naval waters surrounding Garden Island.

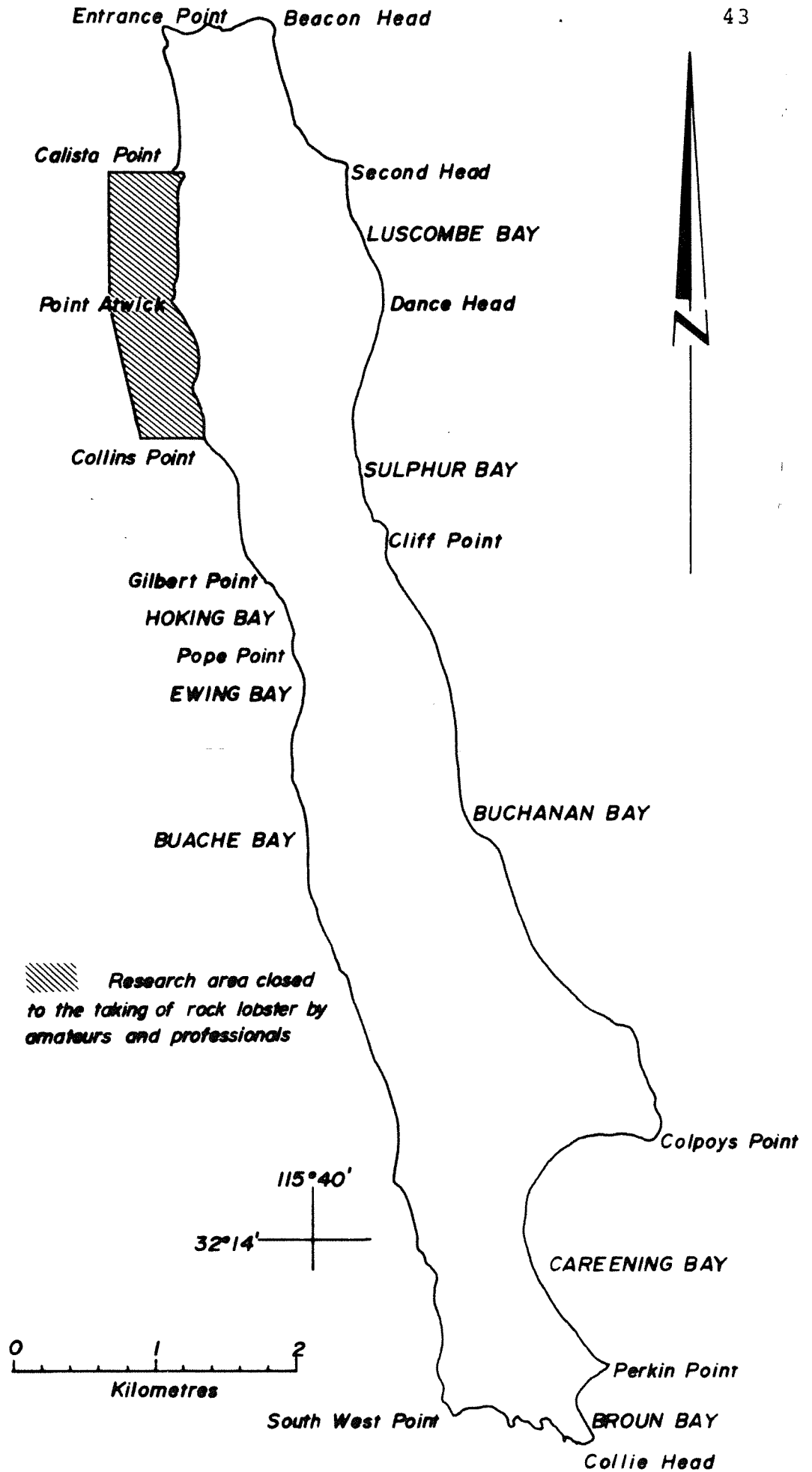


FIG. 19: Rock lobster research area on Garden Island

## 5. CLIFF HEAD HISTORIC SITE

### 5.1 Historical Significance

The historical significance of the site of first settlement at Garden Island was realised as far back as 1938 by the Memorials Committee of the newly formed Royal Western Australian Historical Society (RWAHS). In 1937 the Commissioner of Sea Scouts, Mr Hal McKail, with the assistance of scouts had carefully examined the site after a bushfire had cleared the area. The foundations of many huts were then visible and an amount of pottery, musket balls, etc were collected. The area was mapped by McKail. A paper on the historical significance of Garden Island had also been compiled by Misses D.C. Cowan and K. Caldwell and was read before the RWAHS on 27 August 1937. The Memorials Committee which included the present Governor General of Australia, Sir Paul Hasluck, proposed that a Memorial be placed on the site but the funds required were not available.

In 1968 a member of the Memorials Committee re-examined the site and found that several stone foundations were still intact on the raised areas of Cliff Head.

Communications between the RWAHS and the Department of Interior eventually resulted in the setting aside of an area around Cliff Head as an historic reserve which was included in the Zone Plan for the Naval Support Facility. The area (see photo Fig.20) was pegged and plotted by the Survey and Drafting Section of the Department of Interior following an investigation and site visit (19.9.72) by Mr David Hutchison, Curator of History at the WA Museum.

A committee was formed with representatives from the RWAHS, the Museum, the National Trust, the Australian Government Department of Housing and Construction, the Navy, and the State Government Public Works Department to discuss:

- a) preservation of the site,
- b) the erection of a suitable memorial,
- c) public access to the area.

### 5.2 Development of the Site

Following meetings of this committee and a subsequent meeting of the committee with representatives of the Department of Environmental Protection points of general agreement have been reached on the



Fig.20 Aerial photograph of the Cliff Head Historic Site on Garden Island.

extent of development of the Cliff Head Historic Site as follows:

- i) The pressure of over-visitation to the Site by members of the public would always be a threat to its preservation favouring a policy of limited access. The possibility of ultimately having to fence off the area and control access by having a warden in charge should therefore be considered.
- ii) The actual development of the Site should be limited to the construction of simple pathways linking the points of historical interest. The Memorials themselves could be of a simple nature such as was outlined by the Principal Architect, Public Works Department, in a memo to the Historical Society dated 7 April 1972:

"(a) A simple plaque set in the face of the limestone cliff, facing the sea, with a simple statement concerning Captain Stirling's landing, and of sufficient size to be easily seen from, say, a distance 50 yards out to sea.

(b) A second memorial on Cliff Head itself, located in one of the flattened areas which was, obviously, the site of one of the original buildings. This could take the form of a simple structure, probably built of limestone piers with a heavy timber superstructure and a central obelisk of granite on the top of which, in bronze could be a map of the Island with the various features mentioned in Stirling's diary indicated.

On the sides could be four plaques - also in bronze - giving the history of the two landings in 1827 and 1829, the reasons for them, the names of the ship's personnel - both Navy and civilian - and any other relevant information.

Other bronze plaques could reproduce sketches showing the first settlement. These could be reproduced from records held by both the Art Gallery and the Museum.

Visitors to the Site, having studied the map and looked at the plaques, could readily visualise the place as it was one hundred and forty years ago."

- iii) To fit in with overall management of the Island and to protect the Site itself it would be preferential if public facilities, picnic areas, possible bus turning facilities, and so on are concentrated in an area south of Cliff Head possibly near the Old Nanson's Landing in Buchanan Bay. Footpaths could then be constructed giving access to the Site and the various areas of interest inside the Historic Site. This would have the added advantage of keeping public facilities well outside the safety radii around the Munitions Depot planned for the north end of the Island (see map Fig.1).
- iv) In the case of people visiting the Island by boat the presence of facilities south of the Historic Site would encourage them to land there rather than near the Cliff Head area. This area would deteriorate rapidly if too many people made landings there and further damage to the Historic Site would result as they made their way inland.

Estimated costs for development of the Historic Site itself are as follows:

- |     |  |          |
|-----|--|----------|
| i)  | Memorials at Cliff Head  | \$17,000 |
| ii) | Access path to Cliff Head including steps - approx 1000 metres of path, 2 metres wide, of compacted limestone. | \$10,000 |

These estimates are included in the overall plan for development of public recreational facilities on Garden Island (see Section 6.2) and, in view of the longstanding interest shown in the Site, it is RECOMMENDED that this development take top priority.

## 6. PUBLIC RECREATIONAL USAGE OF GARDEN ISLAND

### 6.1 Potential Usage

Because of the requirements of the Naval Support Facility certain limitations are immediately imposed on the nature of future public recreational usage of Garden Island (see Section 2.1). It has also become apparent from the present discussion of the Garden Island environment that the various aspects of environmental management will also impose limitations upon the extent of public recreational usage of the Island. Environmental management -

- i) endorses the Naval Support Facility limitation to day trip visitation only on the grounds that further reductions of the areas of natural vegetation (and hence tamar habitat) will then, as desired, be limited to development of beach picnic facilities; and
- ii) recommends that public recreational usage of the inland areas be limited to pedestrian pathways linking the site of public facilities with west coast beaches and the Historic Site and, where possible, these pathways should follow existing tracks on the Island (to prevent further damage to the vegetation) and should avoid areas of present and potential soil erosion.

A survey carried out by Environmental Resources of Australia (1972) showed that, apart from the obvious attraction of any outdoor recreation, people using Garden Island cited the following three factors as their reasons for visiting Garden Island:

- 76% for the safety for children
- 84% for the quietness and lack of sophistication (no traffic, pubs, etc)
- 53% for the fishing.

The above limitations ensure a continuation of this lack of sophistication and are in keeping with this apparent public demand for quiet family recreational facilities. Rottnest Island will continue to serve the more sophisticated and commercialised needs for recreational facilities including overnight accommodation, shops, etc.

Even with this limited development of Garden Island public pressure of usage will increase and could become out of hand under the influence of several factors:

i) Industrial expansion in the Cockburn Sound area has progressed rapidly in the last 20 years. In 1954 Kwinana began industrially when the \$80M BP Refinery was developed. Its initial investment was greater than the total estimated value of all industrial plants and buildings in the whole of Western Australia. In 1968 BHP's \$60M blast furnace was commissioned which initiated the State's first integrated iron and steel industry and influenced Federal Government backing for the western sector of the standard gauge railway. The completion of the steel works was programmed for 1978. In 1964 the first shipment of alumina was made from the Alcoa refinery established at the initial cost of \$22M. In 1965 the annual capacity was doubled and in 1968 a second refinery was established near Pinjarra to meet international demand. In 1970 a \$30M nickel refinery was brought into operation in Cockburn Sound by Western Mining Corporation to produce nickel and ammonium sulphate. This industrial expansion in Cockburn Sound has resulted in:

- a) reduction of beach frontage available for public recreational usage in the Cockburn Sound area;
- b) a large population expansion in the Rockingham-Medina and other surrounding areas to meet the employment demands of the industrial works.

The nett result of both factors is an increased demand for public recreational facilities, especially beaches, in the area.

ii) The number of power boats currently registered in the Perth Metropolitan Area is in excess of 27,800\* and registrations are growing at the rate of approximately 10% per annum. Formerly the sign of the "privileged" it is now becoming the "norm" to own a boat. There is already a necessity to relieve the pressure of both power boats and yachts on the Swan River and the now sheltered area of Cockburn Sound with the Causeway provides an obvious outlet especially for the generally owned smaller craft. The ERA 1972 study showed that, although larger cruisers and yachts were concentrated in the Rottnest area many dinghies and small craft (characteristic of the "day tripper") were concentrated in the protected waters of Cockburn Sound, eg samples on two days over the Easter weekend of 1972 showed that totals of 581 and 472 boats were utilising Cockburn Sound and Garden Island waters.

iii) Part of the November 1972 agreement between Commonwealth and State officials was that -

\* Personal communication with Harbour and Lights Department - 1.4.74.

"public access to the island will continue to be dominantly by small craft, although an investigation will be made by the State for later presentation to the Commonwealth as to the possibility of erecting a jetty in the vicinity of the historical area of Cliff Head."

Past patronage of the ferry service to Garden Island has been high. Over the past 3-5 years the ferry master has averaged around 6000 passengers per annum to the Island. These have been concentrated in summer holiday periods as indicated by the ERA 1972 Easter weekend study when 815 passengers were transported to the Island (does not include return passengers). Representatives of the Department of Tourism have recently canvassed the interest of the Rottneest ferry owners and others in future ferry service to Garden Island. The potential was high and likely services were estimated at three separate operators varying in frequency between once and up to possibly four trips weekly for at least one operator, depending on demand. Likely passenger numbers were estimated at between 8000 and 10,000 per annum which would again be concentrated in summer holiday periods.

iv) A further part of the November 1972 agreement was -

"in addition to access by sea programmed bus trips could be made specifically to the historical area and for this the State would provide for bus parking and turn around facilities. The Commonwealth would investigate whether there could be defined stopping places for tourist buses at points of scenic interest on a non-interference basis (eg Z Force Memorial)."

Department of Tourism canvassing amongst the coach companies again indicates high interest. Estimated patronage ranges were from 4000 to 6000 passengers per annum.

These are the current trends but the situation may change in the future under the influence of the potential energy crisis. While power boat ownership is high it is RECOMMENDED that access to the Island be limited to private boats. Should the situation change in the future and tend towards a decrease of private ownership and an increased demand for public transport the possibility of including a ferry service could be explored. It should be noted that the Department of Tourism is in favour of the granting of a limited licence to one ferry owner to cater for tourists wishing to visit Garden Island by boat. This would be subject to negotiation with the Navy for landing facilities. Tourist bus access will also be subject to negotiation between Federal and State Governments.

## 6.2 Facilities Required

With the need to develop some facilities (see Section 2.1) for public recreational usage on Garden Island before completion of the Naval Support Facility to coincide with termination of leases on the south end of the Island it is RECOMMENDED that moves be made by the State to finance the following developments. Provisional cost estimates are given.

- |      |  |                    |
|------|--|--------------------|
| i)   | Memorials at Cliff Head Historic Site.   | \$17,000           |
| ii)  | Access path to Cliff Head including steps - approx. 1000 metres of path, 2 metres wide, of compacted limestone   | \$10,000           |
| iii) | Toilet facilities for male and female with small change rooms including water supply and septic tank installation.   | \$18,000           |
| iv)  | Development of lawned areas  | \$ 725<br>(per ha) |
| v)   | Barbecue/picnic facilities. 3 modern gas-fired double burners at \$700 each plus \$400 for seating, tables, rubbish bins, etc.   | \$ 2,500           |
| vi)  | Access paths to western beaches requires approx. 4,500 metres of 2 metre wide compacted limestone path @ \$10 per metre. Suggested locations of these paths so that they avoid natural and potential soil erosion areas but lead to good west coast beaches are illustrated in the map Fig.4 and are as follows: | \$45,000           |
|      | a) From a point north of Second Head on the northeast corner of the Island to Pt Atwick on the west coast - approximately 2000 metres required.  |                    |
|      | b) From Cliff Point on the east coast to Hoking Bay on the west coast - approximately 1000 metres required.  |                    |
|      | c) From just north of the barracks area near Buchanan Bay on the east coast to west coast just south of Buache Bay - approximately 1500 metres required.   |                    |
| vii) | Bus bay (approximately 750 sq metres) for tourist bus access including connecting road to main north/south road.   | \$14,000           |

Items (iii), (iv), (v) and (vii) to be developed at a site to be chosen south of Cliff Head somewhere in Buchanan Bay.

## 7. MANAGEMENT OF GARDEN ISLAND

### 7.1 Environmental Research Required

The present study indicates that IMMEDIATE steps should be taken by State Government Departments to budget for the following monitoring research on Garden Island:

- i) To ascertain the effect of public recreational usage of the Island on present and potential soil erosion areas. Regular aerial photography and ground surveys will be required. Marram regeneration trials which have already commenced through liaison between the State Government Department of Agriculture and the Australian Government Department of Housing and Construction should be continued. A brief report of the success to date, costs involved in this work and an estimated annual maintenance budget have been provided by Department of Agriculture Soil Conservation representatives and are included in Appendix II. It is RECOMMENDED that this work continue to be carried out under the direction of the Department of Agriculture.
  
- ii) To monitor post-burn regeneration of vegetation and to ensure overall control of areas to be burned annually so that sufficient tamar habitat is retained. A brief report of the pre and post burn vegetation studies already carried out on the Island are given in Appendix III along with an estimate of the time and personnel required for annual maintenance. Although they have not formerly been involved it is RECOMMENDED that such future research be carried out under the direction of the State Government Department of Agriculture State Herbarium.
  
- iii) Fauna survey work including an initial general survey to obtain a complete fauna list for the Island; tamar comparative census and trapping studies on a long term basis; and predator and competitor animal control measures. A brief report of tamar surveys carried out in conjunction with work for this document is given in Appendix IV along with an estimate of the time and personnel required for annual survey work. It is RECOMMENDED that this work be carried out under the direction of the State Government Department of Fisheries and Fauna.
  
- iv) To monitor public recreational usage of Garden Island to establish a record of the number of people visiting the Island, their methods of transport to and from the Island, and control measures necessary



to prevent over utilisation of the Island. It is RECOMMENDED that such research be carried out under the direction of the State Government Department of Tourism.

v) With the above Environmental and People Research proposals under the direction of different departments it will be essential to have some co-ordinating authority so that an overall approach to management can be maintained. It is therefore RECOMMENDED that co-ordination of research be under the direction of the State Government Department of Environmental Protection.

## 7.2 Upkeep and Control

Once the legal situation has been resolved it will be necessary to instigate laws controlling public behaviour on the Island. The predominant problem with public recreational usage of any area is the control and disposal of rubbish. Garden Island already has a 'rubbish problem' (eg see photo Fig.21) and it is RECOMMENDED that steps be taken to clean up the Island before new facilities are installed. The Island should be vested in a responsible State authority and, once facilities are established, it is RECOMMENDED that a warden be employed to control the areas of public recreational usage on the Island. This warden should have sufficient environmental training and background to be able to assist in the various areas of environmental research required.

Fig.21 Stack of empty drink bottles on Garden Island (13.2.74) - an example of the waste disposal problems associated with human recreational usage of the Island.

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## MEMBERSHIP AND INTERESTS OF STATE AD HOC WORKING GROUP ON GARDEN ISLAND

1. Premier's Department - involvement in formal State/Commonwealth agreement and Prime Minister/Premier liaison
2. Tourist Development Authority
  - (a) - involvement in
  - (b) - proposed coach tours across the causeway
  - (c) - development of tourist facilities, toilets and the like at Cliff Head
  - (c) - public access by boats
3. Fisheries and Fauna Department
  - (a) - involvement in
  - (a) - Tammar management including predator dog and cat control
  - (b) - Fisheries management
  - (c) - Rock Lobster research area
  - (d) - establishment of a Warden and Warden's quarters on the Island
4. Forests Department
  - involvement in
  - (a) - Rottnest Island Pine preservation in Munitions Depot region
  - (b) - general flora management including bush fire control
5. Department of Agriculture
  - involvement in
  - (a) - management of sand dunes
  - (b) - planning of access roads and tracks across the Island
  - (c) - development and grassing of recreation areas
6. Lands Department
  - involvement in
  - (a) - land tenure rights
  - (b) - potential role of National Parks Board or other controlling Boards
7. Museum - involvement in planning of Cliff Head and historic areas

- 8. Department of Mines
  - involvement in
  - (a) - establishment of Munitions Depot
  - (b) - access to same, including transport across the causeway and the cost to the State Government
  - (c) - explosives agents access to magazines
  - (d) - access for explosives vehicles other than State-owned vehicles
  - (e) - explosives agents not allowed to operate mixing units
- 9. Town Planning Department
  - involvement in
  - (a) - preparing policy for future use and public management of Garden Island
  - (b) - planning of Woodman Point area if State Munitions Depot is established on Garden Island
- 10. Crown Law Department
  - involvement in formal legal agreement between the State and the Commonwealth, involving in part responsibility and control of private individuals on the Island
- 11. Treasury Department
  - involvement in expenditure of State monies on control fencing and other financial interaction between the State and the Commonwealth
- 12. Department of Development and Decentralisation
  - involvement in potential utilisation of the outer harbour and causeway environs
- 13. Fremantle Port Authority
  - involvement in
  - (a) - potential utilisation of the outer harbour and causeway environs
  - (b) - feasibility of any proposed jetty
- 14. Department of Environmental Protection
  - co-ordination of environmental research/management.

## SAND DUNE EROSION

The areas of bare and almost bare sand in the dunes on Garden Island have been estimated using air photos. They are:

The northern large blowout in the centre of the island  
approx. 17,000 m<sup>2</sup>

The southern large blowout in the centre of the island  
approx. 15,000 m<sup>2</sup>

The sum of the smaller areas along the west coast  
approx. 50,000 m<sup>2</sup>

TOTAL - approx. 82,000 m<sup>2</sup>.

The cost of the preliminary exercise in revegetating with Marram grass on the southern large blowout, mentioned in Section 4.2 was \$1000 for 2500 m<sup>2</sup>. This included trials using Spinifex spp. seed heads, various types of surface protection and the costs of collecting the planting material. However, this trial has not been entirely successful, only half the Marram grass becoming established.

Costs from other situations, plus experience from the Victorian Soil Conservation Authority and from the hand planting and brush matting work done by the Australian Government Department of Housing and Construction, suggest that revegetation planting and protection should cost between 25 and 50 cents per m<sup>2</sup>.

These figures, together with the areas of bare sand estimated above, give costs of initial revegetation and protection of between \$20,500 and \$41,000.

In all sand dune control work, particularly if subjected to people pressure, failure in whole or part due to various climatic and soil factors, must be anticipated and budgeted for. The annual maintenance that should take place includes:

i) Aerial photography in colour at low altitude, 500ft, probably at five year intervals, total \$1500

Annual \$ 300

ii) Ground inspection annually in March-April - 1 officer 1 week

Annual \$ 200

iii) Replanting and general maintenance each year. Team of 6 for 4 weeks.

Annual \$2500

TOTAL ANNUAL \$3000  
(plus inflation allowance).

## VEGETATION STUDIES CARRIED OUT ON GARDEN ISLAND

Introduction

In developing a burning-management program it is necessary to have post-burn information on:

- a) species able to regenerate from seed or vegetative parts;
- b) in what order they reappear;
- c) whether distance from intact vegetation has any influence;
- d) time required for reasonable stability to be achieved and for return to suitable tamar habitat;
- e) changes in species diversity;
- f) effect of fauna on regeneration.

To acquire such information it is necessary to have some measure of the dominance relationships and the diversity of species before burning begins. The opportunity to obtain such data and to carry out follow-up post-burn studies came with the decision of the Australian Government Department of Housing and Construction to carry out a trial-burn in the *Acacia rostellifera* scrub on the south end of Garden Island in the spring of 1973. Preliminary results are presented here but further post-burn follow-up studies will be required over the next few years.

Materials and Methods

Three 10 metre x 10 metre quadrats were selected in the area of the proposed trial-burn site as follows:

Quadrat A - situated in mixed dune complex vegetation plus *A. rostellifera* scrub (see photo Fig.22)

Quadrat B - situated in the middle of the burn area in typical *A. rostellifera* scrub (see photo Fig.23)

Quadrat C - situated near the edge of the proposed burn site in typical *A. rostellifera* scrub.

Quadrats A and B were situated in the 6 acre (2 ha) section of the trial-burn site which was to receive rolling pre-treatment before burning (see photo Fig.24) and Quadrat C was situated in part of the 6 acre (2ha) area completely cleared for fire breaks (see photo Fig.25) A further 6 acre (2 ha) area of typical *A. rostellifera* scrub was set aside for burning without any pre-treatment.



Fig.22 Quadrat A situated in an area of the "dune complex" vegetation type on the December 1973 trial-burn site at the south end of Garden Island.

Fig.23 Quadrat B situated in dense tangled *A. rostellifera* scrub on the December 1973 trial-burn site at the south end of Garden Island.

Fig.24 Illustrates *A. rostellifera* scrub on the trial-burn site at the south end of Garden Island after rolling pre-treatment.

Fig.25 Illustrates areas of *A. rostellifera* scrub on the trial-burn site at the south end of Garden Island completely cleared for fire breaks.

Rooted frequencies for each species was determined by recording their presence or absence in each of 10 1 metre x 1 metre sub-quadrats taken down the eastern boundary of each of the large quadrats A, B, and C. The highest frequency of 1.0 is obtained when a species is present in all sub-quadrats and lower frequencies are expressed as a decimal fraction of 1.0. Dominance-diversity curves were constructed from the frequency data by assigning a rank to each species in the order of decreasing frequency and graphing rank against frequency.

Biomass estimates were obtained by randomly choosing (using a table of random numbers) 4 1 metre x 1 metre sub-quadrats within each of the large quadrats A, B, and C; cutting all plants within these sub-quadrats at ground level (see photos Figs.26 and 27) and sorting them into species; placing the separate species into brown paper bags and drying them in an oven at 60°C to a constant weight. Dominance-diversity curves were constructed from the biomass data by assigning a rank to each species in the order of decreasing dry weight and graphing rank against  $\log_{10}$  (dry weight). Species diversity was also measured quantitatively from the biomass data using the Shannon Weiner Function:

$$H = - \sum_{i=1}^s p_i \log_{10} p_i$$

where  $p_i = \frac{n_i}{N}$

and  $n_i$  = dry weight of the  $i$ th species

$N$  = total dry weight of all species together

$s$  = number of species.

The higher the value of  $H$ , the more diverse the sample is. There are two components of the Shannon Weiner Function: (a) number of species, and (b) evenness of allotment of individuals among the species. Both increase diversity measured by the function. If all species were equal in abundance ie maximum equitability conditions species diversity ( $H_{max}$ ) would be

$$H_{max} = \log_{10} s$$

The function  $E = \frac{H}{H_{max}}$  was used

to measure how close each sample was to maximum equitability conditions.

After burning of the site 2 10 metre x 10 metre exclosures were constructed, 1 in the rolling pre-treatment area and 1 in the firebreak area. Comparison of the areas inside and outside of these exclosures should allow a measure of the effect of tamar grazing on the regeneration.

Fig.26 Close-up of an area of Quadrat A (above) demonstrating sub-quadrats cleared for biomass estimates.

Fig.27 Close-up of an area of Quadrat B (above) demonstrating sub-quadrat cleared for biomass estimates.

Results

The species present in quadrats A, B, and C of the trial-burn area were:

1. *Acanthocarpus preissii*
2. *Carpobrotus aequilaterus*
3. *Asphoclelus fistulosus*
4. *Senescis lautus*
5. *Scirpus nodosus*
6. *Eromophila glabra*
7. (a) and (b) - two unidentified small grass species
8. *Anagallis arvensis* - blue
9. *Phyllanthus calycinus*
10. *Acacia rostellifera*
11. *Crassula glomerata*
12. *Anagallis* sp. - orange
13. *Solanum* sp.
14. *Trachymene pilos*
15. *Clematis microphylla*

Rooted frequency data:

<u>QUADRAT A</u>	Species Number	Frequency	Rank
	1	1.0	1
	2	0.7	3
	3	0.9	2
	4	0.7	3
	5	0.2	5
	6	0.7	3
	7	1.0	1
	8	1.0	1
	9	0.1	6
	10	0.2	5
	11	0.5	4
<u>QUADRAT B</u>	1	1.0	1
	3	0.3	5
	4	0.3	5
	6	0.3	5
	8	0.9	2
	10	0.5	4
	11	0.6	3
	12	0.3	5
	13	0.3	5
	14	0.1	6
<u>QUADRAT C</u>	1	1.0	1
	3	0.1	7
	4	0.6	4
	6	0.4	5
	8	0.8	3
	10	0.4	5
	11	0.3	6
	12	0.1	7
	13	0.1	7
	14	0.9	2

Dominance-diversity curves based on frequency data appear in Fig. 28.

Biomass data :

QUADRAT A

Species Number	Dry Weight (g)	Log <sub>10</sub>	Rank	$\frac{n_i}{N}$
1	683.2	2.8346	1	.4407
2	481.3	2.6824	2	.3105
3	106.0	2.0253	4	.0684
4	8.7	0.9395	8	.0056
5	62.7	1.7973	5	.0404
6	16.9	1.2279	7	.0109
7(a)	49.1	1.6911	6	.0317
8 + 12	133.6	2.1258	3	.0862
11	8.6	0.9345	9	.0055
N = <u>1550.1</u>				

$$H = .6362 \quad H_{\max} = .9542 \quad E = .6667$$

QUADRAT B

Species Number	Dry Weight (g)	Log <sub>10</sub>	Rank	$\frac{n_i}{N}$
1	3049.6	3.4842	1	.9876
4	8.2	0.9138	4	.0026
6	1.3	0.1140	7	.0004
7(b)	3.6	0.5502	5	.0012
8 + 12	20.1	1.3032	2	.0065
11	2.1	0.3222	6	.0007
14	11.9	1.0737	3	.0038
N = <u>3096.8</u>				

$$H = .0426 \quad H_{\max} = .7782 \quad E = .0547$$

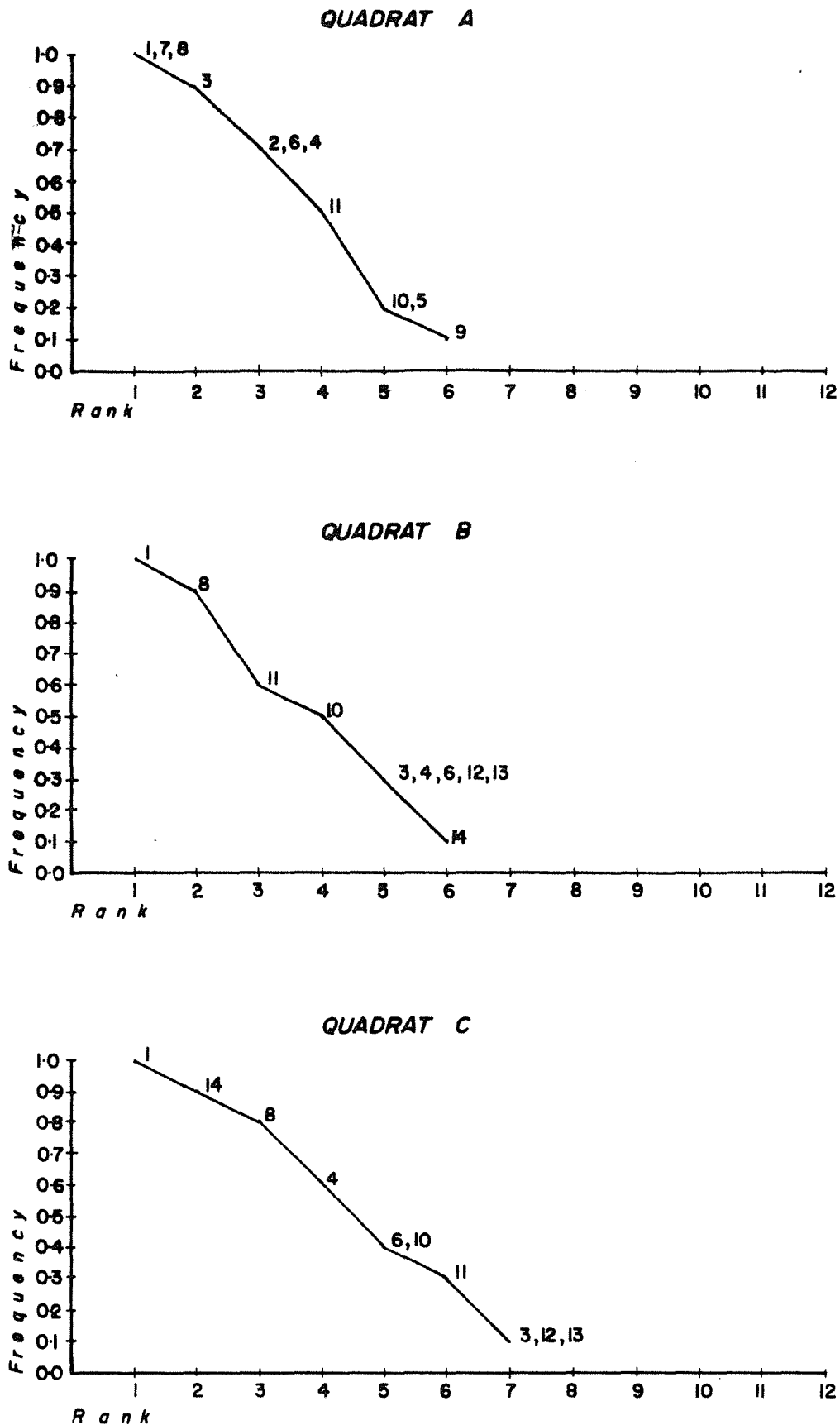


FIG. 28: Dominance diversity curves based on pre-burn frequencies of plant species 1 to 15 (see text) from Quadrats A, B, and C located on the December 1973 Control Burn Site on the southern end of Garden Island

QUADRAT C

Species Number	Dry Weight (g)	Log <sub>10</sub>	Rank	$\frac{n_i}{N}$
1	1152.6	3.0616	1	.9189
4	2.5	0.3979	7	.0020
5	30.9	1.4907	3	.0246
6	4.2	0.6232	5	.0033
7(b)	0.5	-0.3010	8	.0004
8 + 12	19.5	1.2900	4	.0155
11	0.35	-0.4559	9	.0003
13	0.15	-0.8239	10	.0001
14	39.5	1.5961	2	.0315
15	4.1	0.6128	6	.0033

$$N = 1254.3$$

$$H = .1734$$

$$H_{\max} = 1.0$$

$$E = .1734$$

Dominance-diversity curves based on biomass data appear in Fig.29.

Species 10, *A. rostellifera*, formed an obvious dominant species in quadrats B and C and was not included in biomass estimates due to bulk. In quadrat A seedlings of *A. rostellifera* were found in the frequency sub-quadrats but not in the biomass sub-quadrats. No mature *A. rostellifera* plants occurred in quadrat A.

Insufficient regeneration has occurred to date after burning to allow post-burn follow-up studies to commence. Fig.30 illustrates the degree of regeneration as to 14 February 1974 following January summer rains. Only the *A. rostellifera* plants and the *Acanthocarpus preissii* plants are regenerating from old roots. No seedlings of any species were observed. The rich ash beds present on the rolled and burned area immediately after the fire (see photo Fig.31) had disappeared due to wind erosion by 23 February 1974. The areas of *A. rostellifera* scrub left untreated before the burn failed to burn properly (see photos Figs. 31 and 32). The dune complex vegetation (see photo Fig. 32 around quadrat A) also resisted excessive burning.

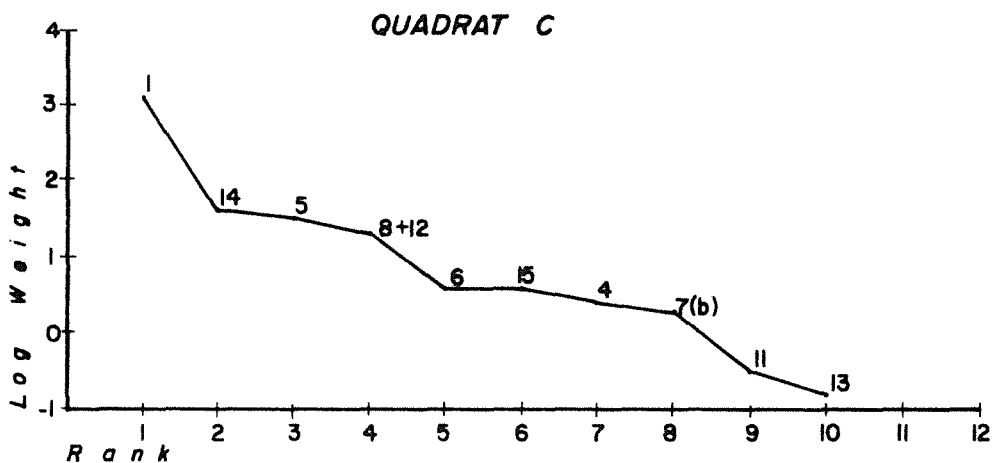
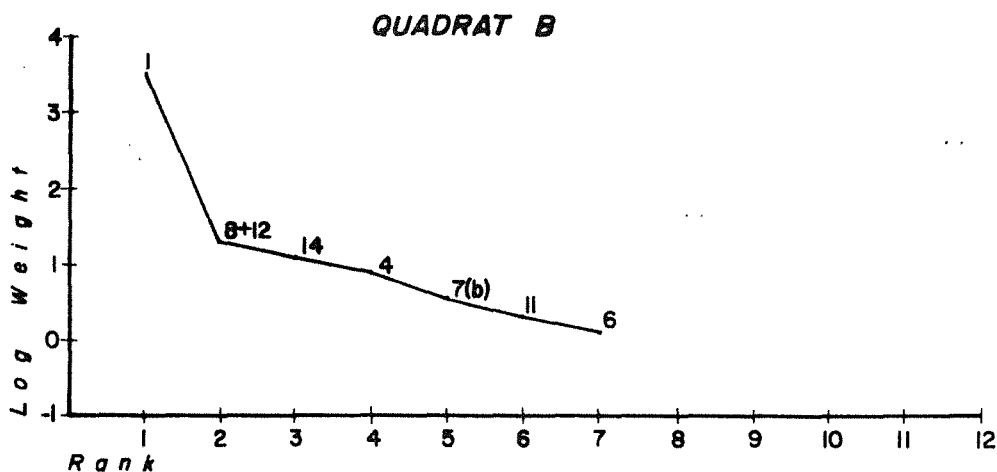
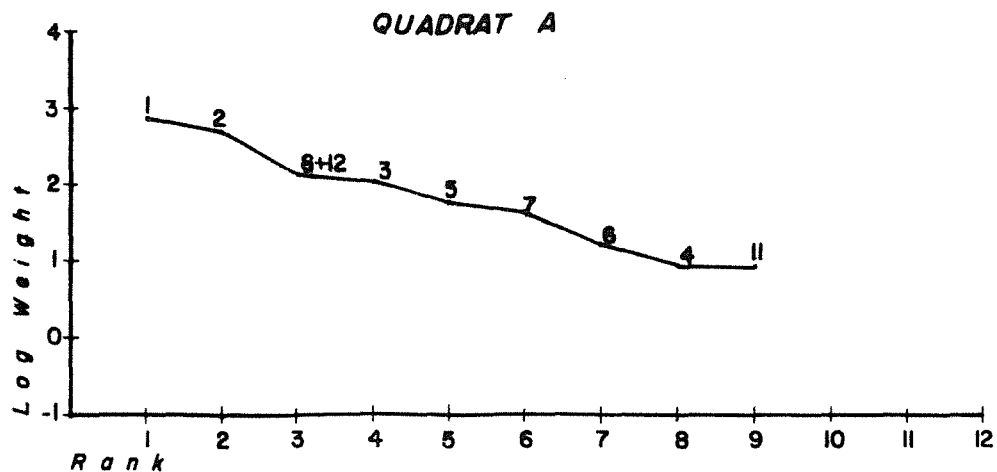
Discussion

Natural communities are a mixture of species which are unequally successful. One or a few species will be dominant and overshadow other species but the latter are what gives the community its diversity and all are important in



(x)

APPENDIX III (cont'd)



*FIG. 29: Dominance diversity curves based on pre-burn biomass (dry weight) estimates of plant species 1 to 15 (see text) from quadrats A, B, and C located on the December 1973 Control Burn Site on the southern end of Garden Island*

Fig.30 Close inspection reveals the small green shoots of the newly regenerated *A. rostellifera* plants on the rolled area of the trial-burn site at the south end of Garden Island. Follows summer rains at the end of January 1974 - picture taken 14.2.74.

Fig.31 Aerial photograph of trial-burn site at the south end of Garden Island taken on 11.12.73 immediately after the burn. NOTE: The rich ash beds of the area pre-treated by rolling and the failure to burn of the area to the left of the centre fire break which was not given the rolling pre-treatment.

Fig.32 Aerial photograph of the trial-burn site at the south end of Garden Island taken on 23.2.74 two months after burning. The rich ash beds seen in Fig.30 above have been blown away. A, B and C are approximate locations of vegetation quadrats.

considering the overall community as a biological habitat.

Species diversity and dominance-diversity relationships have here been measured using the Shannon Weiner Function. The dominance-diversity curves can be interpreted as follows:

- i) A single strongly oblique slope indicates low species number with one dominant species.
- ii) A curve with an initial strong oblique slope followed by a lesser oblique slope and then a strong slope again indicates the dominant species followed by the middle order species and finally species occupying the last remnants of niche space.
- iii) A curve with initial weak oblique slope followed by strong, weak, and then strong indicates two dominant species and poor diversity.

H values obtained from biomass data indicate greater diversity of species in the dune complex vegetation of quadrat A than in either of the *A. rostellifera* scrub quadrats B and C. The different species of quadrat A also show greater equitability. The seedlings of *A. rostellifera* found in this quadrat occupy the remnants of niche space as indicated by the dominance-diversity curve obtained from frequency data. The dominance-diversity curve obtained from biomass data shows *Acanthocarpus preissii* and *Carpobrotus aequilaterus* to be the dominant species. In the curve obtained from frequency data *C. aequilaterus* was a middle order species. This species creeps laterally by stems so that, although the rooted frequency of plants within any quadrat is low, the species is a dominant member of the community. In this instance biomass data is superior because it negates life form differences and dodges the controversy of what constitutes an individual plant.

In quadrats B and C *A. rostellifera* was obviously the dominant member of the community being the tallest shrub present with all other species forming a dense understorey. Again the dominance-diversity curves obtained from frequency data place *A. rostellifera* down with the middle order species. The plants were too big to include in biomass estimates. The curves obtained from the biomass data indicated that *Acanthocarpus preissii* was the strong dominant understorey species and the low equitability (E) values obtained in these quadrats support this fact. Most other species were occupying the remnants of niche space. These results are most likely due to the late climax stage of the *A. rostellifera* scrub on the south end of the Island which missed the 1956 burn (see map Fig.16). The only record of the Island being burned this century prior to this was in the late 1930s but the area mentioned was round Cliff Head and no mention was made of the south end of the Island (information from Royal WA Historical Society file on Garden Island).

The data obtained to date means little in relation to the control burn formation required (as outlined in the introduction to this Appendix). However, they form the baseline for follow-up studies which should be carried out in this and other trial-burn areas on the Island. It is proposed that two officers would be required for two three to four week periods (one in autumn and one in spring) each year to carry out the monitoring research required on the vegetation of Garden Island.

## TAMMAR SURVEYS CARRIED OUT ON GARDEN ISLAND

Introduction

In developing a management plan for the conservation of the tamar, *Macropus eugenii*, on Garden Island it is necessary to have information on:

- a) the natural density of animals on the Island in the different vegetation types (see Section 4.3);
- b) the effect of planting exotic plant species, eg cereal rye, on this density and hence on recruitment and deaths;
- c) the welfare state of animals on the Island both before and after environmental interference;
- d) the effect of introduced predators and competitors on the tamar population.

Ideally, mark and recapture studies giving absolute estimates of abundance and allowing collation of information on the individual animals' conditions, should be employed. Such absolute estimates are often prohibitive in time and money and there are many situations where a relative check on population numbers using a standardised transect routine will temporarily suffice. Such a situation occurs, for example, where comparative densities for different regions are required or where the effect of environmental interference is to be gauged.

The cryptic habit of the tamar has meant that, until recently, insufficient numbers could be counted to allow the effective use of a standardised transect routine. However, the planting of cereal rye on the Island has brought sufficient numbers of animals away from cover to allow this method to be used.

The present study employs both relative and absolute census techniques. Having been carried out over a limited period of time the data presented are necessarily limited. Their current value is that they allow an estimation from first hand experience of the time and personnel required to carry out a monitoring research program on the Island. It is hoped that they will also provide a baseline of information from which continuing research might progress.

Materials and Methods

## (a) Standardised Transects

Three transects (see map Fig.33) were chosen for routine

(ii)

BUACHE BAY

115°40'  
32°14'

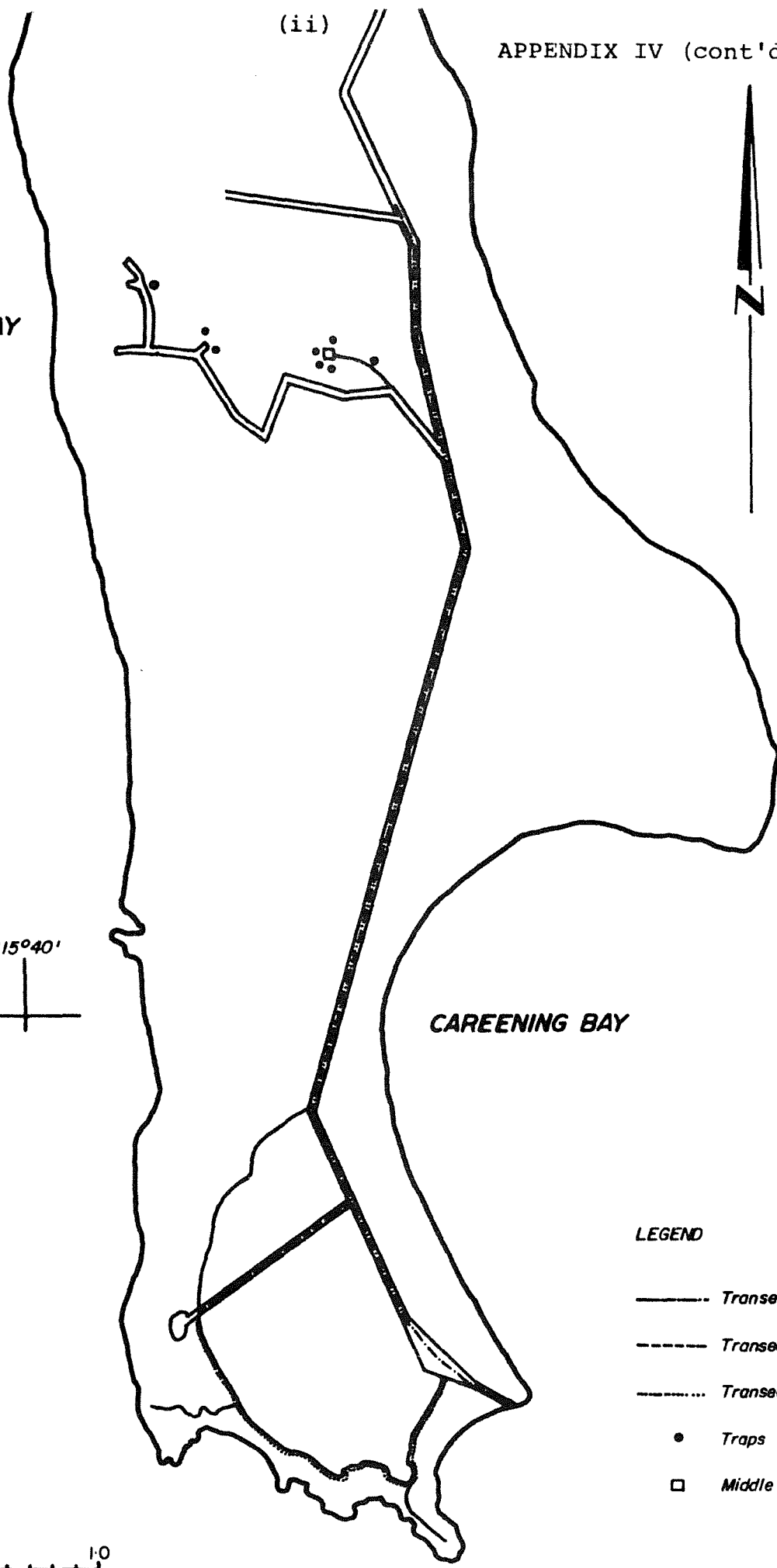
CAREENING BAY

LEGEND

- Transect 1
- Transect 2
- ..... Transect 3
- Traps
- Middle Bore

0.0 0.5 1.0  
Kilometres

FIG.33: Transect and trap positions used in Garden Island Tammar Survey



comparative census work. Transect One commenced at the "Caution : Tammars" sign at the end of the Causeway and ended at the road block at the junction of the major north/south road and the road to the sewage treatment works (see F, map Fig.1). Transect Two commenced approximately 10 metres from the junction of the major north/south road and the road leading to the limestone quarry on the south-west corner of the Island. Transects One and Two both occurred in *Acacia rostellifera* areas and both contained regions with cereal rye planted on either side of the road (eg. see photo Fig.13). For comparative purposes Transect Three followed a narrow bush track around the southern end of the Island through typical *A. rostellifera* scrub (see photo Fig.34).

Standardised counts were made along these transects beginning at first dark on eight nights during the period 22.11.73 to 14.2.74. Two persons carrying standard 6V sealed beam lamps stood on the back of a utility vehicle travelling at 6-10 mph and recorded the number of tammars sighted:-

- i) per 0.1 mile sector for left and right sides of Transects One and Two; and
- ii) for the whole of Transect Three.

On two nights a fourth transect was scored along the north/south road continuing from the termination of Transect One and proceeding approximately 3 miles north to the end of the cereal rye. This fourth transect passed through *Melaleuca lanceolata*, *Callitris preissii*, and mixed vegetation stands and allowed comparison of the density of animals in this region with the *A. rostellifera* region.

Weather conditions (wind direction and velocity in knots; Perth maximum temperature in °C; moon phase) were recorded for each night sampled.

#### (b) Trapping Studies

Traps (see photo Fig.35) constructed of soft mesh (to prevent injury) with a wire tunnel and trapdoor were used to capture tammars. Four traps were set close to Middle Bore (see map Fig.33) in *A. rostellifera* scrub and one slightly east of the bore in a pure *C. preissii* stand. Another three traps were periodically set in *A. rostellifera* scrub west of Middle Bore inland at Buache Bay (see map Fig.33). The traps were baited with peanut paste and bread plus aniseed essence on cotton wool at dusk and were generally checked for captures at about 9.30 p.m. and again at midnight. On one night a further check was made at 5 a.m.

Upon capture the animals were sexed, ear tagged (on both ears for males and one ear for females), and weighed. The pes length was measured and a rectal swab was taken. Animals were released again at their site of capture.



Fig.34 Tammar Transect 3 on south end of Garden Island where sightings of animals were rare compared to the cereal rye areas of Transect 1 (see Fig.13).

Fig.35 Trap used to capture tammars on Garden Island. Illustrates the entrance tunnel with trapdoor held up by a twig and the soft mesh used for the trap so that captured animals incur no injuries.

From the weight and pes length of each animal a welfare state was calculated according to the method of Bakker (1973):-

$$\text{Welfare State} = 20(0.0168p - w^{1/3}) - 20$$

where p = pes length  
w = bodyweight

and resulting welfare states range from one to ten in order of increasing well-being.

The rectal swabs were cultured for bacterial infection by the Public Health Department and provided additional information on the well-being of animals.

Insufficient numbers of animals were marked and recaptured during the study period to allow any population estimates to be made.

#### (c) Observation of Feral Cats

Record was kept on each night of:-

- i) the number of feral cats seen along the transects and around trapping areas; and
- ii) the number of feral cats seen on the Causeway on the return trip to the mainland ie. around midnight.

### Results

#### (a) Standardised Transects

On 7.11.73 totals only were recorded for Transect One and Transect Four. Assuming that an equal proportion of the population would be feeding on the rye in all areas and scoring only for the regions of the transects bordered by rye, the following comparison was made:-

see over

	Transect One	Transect Two
Vegetation Type	<i>A. rostellifera</i>	<i>M. lanceolata</i> , <i>C. preissii</i> , and mixed stands
Length of transect bordered by rye on both sides	1.8 miles	1.3 miles
Length of transect bordered by rye on one side	0.4 miles	0.9 miles
Total equivalent distance of two-sided rye	2.0 miles	1.75 miles
Observed number of tammars	115	12
Expected number of tammars if density uniform	115	101

The comparison of observed and expected numbers of tammars in Transect Four suggested that the density of tammars in the *A. rostellifera* scrub of Transect One was some 8½ times the density associated with *M. lanceolata*, *C. preissii*, and mixed vegetation types. Using the known density of 1 tamarin per 2 acres for *A. rostellifera* scrub (Bakker, 1973) a density of 1 tamarin per 17 acres was calculated for these vegetation types.

This count was made soon after the adult tammars first started feeding on the rye and before 1973 recruits were being observed in the population. A similar comparison was made in late summer (13.2.74) when large numbers of recruits were present in the population. On this occasion a figure of  $4.7 \pm 0.9$  animals per 0.1 mile sector of two-sided rye transect was obtained for Transect One while  $1.5 \pm 0.5$  animals per 0.1 mile sector of two-sided rye transect was obtained for Transect Four. This indicates that the density of animals in the *A. rostellifera* area was only 3 times the density in the other vegetation types which would then be 1 tamarin per 6 acres.

The results of the routine transect counts made along Transects One, Two, and Three are presented diagrammatically in Figs. 36 and 37. A summary of weather data is also given.

The temperature data given is Perth maximum temperature for each day sampled. The absolute values of temperatures mean little and should be viewed only as a means of comparing relative temperatures on the different nights sampled.

The highest activity of tammars was associated with warm nights, light east to northeast winds, and last quarter moon phase. Least activity was associated with west to southwest winds, low temperatures, and new to first quarter moon phase. A definite positive association of animals with rye was

FIG. 36: Tammar transect histograms and weather conditions (wind speed and velocity; maximum temperature; moon phase) for eight nights over the period 22.11.73 to 14.2.74. The histograms are based on the number of tammars scored per 0.1 mile sector on the east side of Transect One and the north side of Transect Two (see map Fig.33), and the total number of tammars scored for Transect Three. — indicates the presence and **==** the absence of cereal rye.

see over

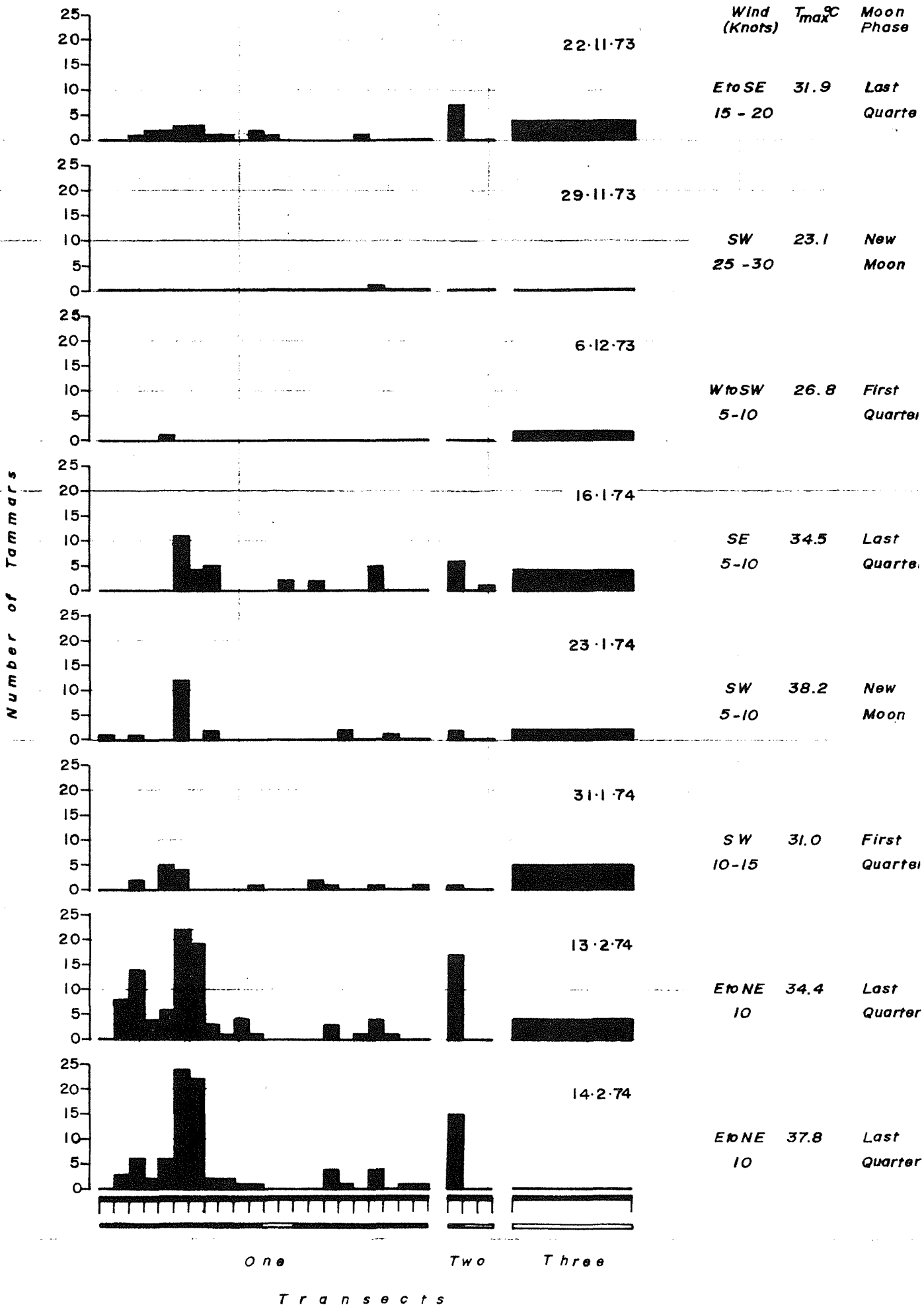


FIGURE 36

FIG. 37: Tammars transect histograms and weather conditions (wind speed and velocity; maximum temperature; moon phase) for eight nights over the period 22.11.73 to 14.2.74. The histograms are based on the number of tammars scored per 0.1 mile sector on the west side of Transect One and the south side of Transect Two (see map Fig.33), and the total number of tammars scored for Transect Three. — indicates the presence and == the absence of cereal rye.

see over

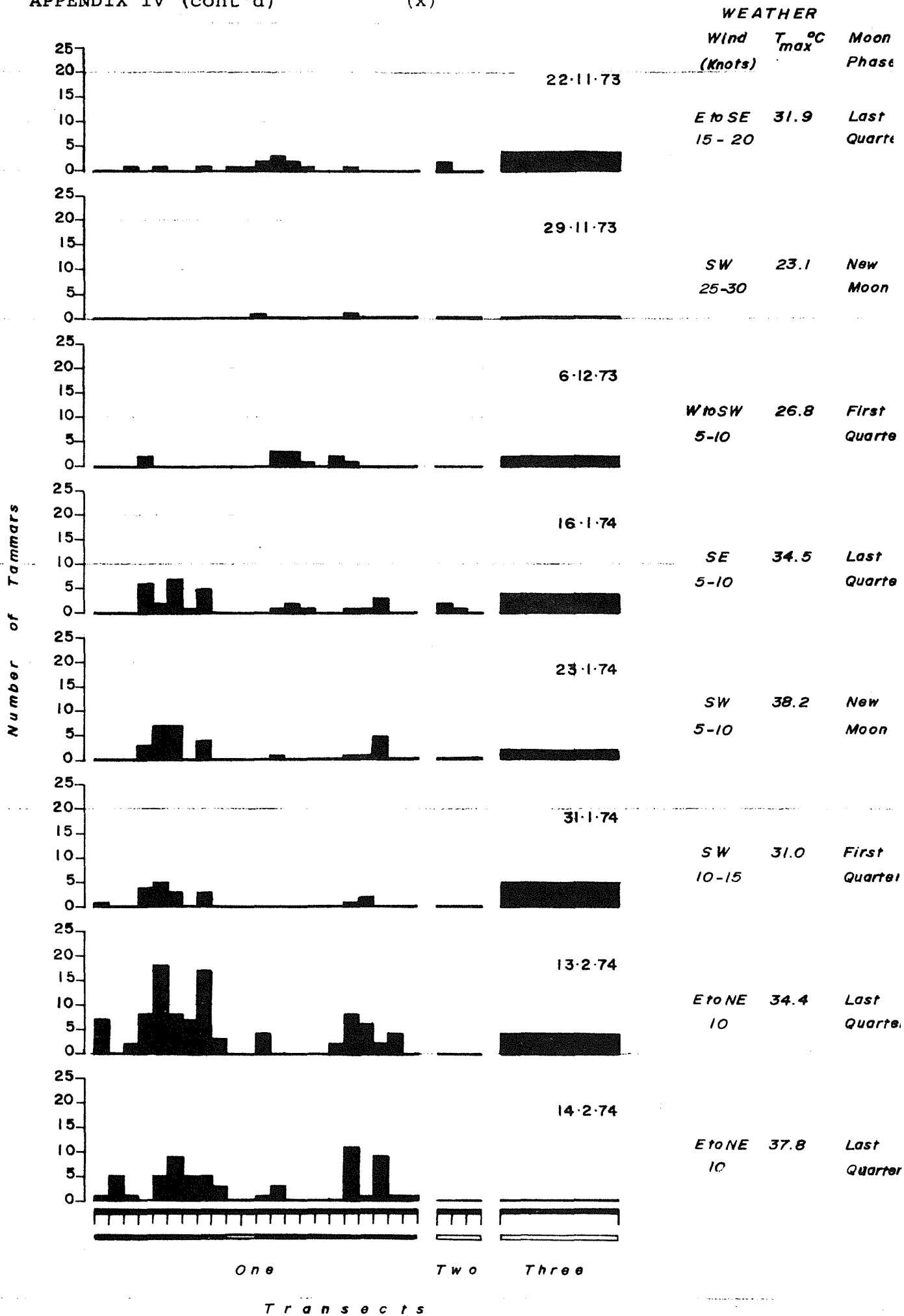


FIGURE 37

observed with the number of tammars counted for the whole of Transect Three, the natural bush track, being so small as to make division into 0.1 mile sectors unfeasible. This serves to emphasise the futility of using the standardised transect technique under natural conditions on Garden Island.

(b) Trapping Studies

Data on animals trapped in the four traps close to Middle Bore is as follows:

Date	Ear Tag Number	Sex	Weight (kg)	Pes Length (mm)	Welfare State	Swab Result
30.1.74	7001 7002	Male	5.60	138.8	8.9	-ve
31.1.74	7003 7004	Male	6.60	153.0	6.1	-ve
31.1.74	4053 4054	Male	6.67	145.8	8.6	-ve
31.1.74	7005 7006	Male	6.48	140.0	10.2	-ve
13.2.74	7007 7008	Male	7.26	149.5	8.5	-ve
13.2.74	7009 7010	Male	6.71	141.5	10.2	-ve
13.2.74	4090 4091	Male	6.26	142.4	9.0	-ve
13.2.74	7011 7012	Male	5.80	146.5	6.7	-ve
13.2.74	7013 7014	Male	6.12	143.4	8.4	-ve
14.2.74 am	7015	Female	4.33	138.0	6.2	-ve
14.2.74 am	4053 4054	Male	6.82	145.8	8.9	-ve
14.2.74 pm	7016 7017	Male	7.56	147.7	9.6	-ve
13.3.74	3600 3599	Male	6.82	144.0	9.5	-ve
13.3.74	7018* 7019	Male	6.27	142.7	8.9	-ve
28.3.74	7020 7021	Male	7.03	148.5	8.4	-ve

\* Tagged previously



## APPENDIX IV (cont'd)

The mean  $\pm$  standard error of welfare states for the 15 captures is  $8.54 \pm 0.32$  indicating that the animals in this population surrounding Middle Bore are in good condition. The fact that no bacterial infections were cultured from the rectal swabs taken supports this view. Attempts to capture animals from the other four traps, which were set in three of the four positions indicated in the map Fig.33 on all but the last night sampled, were all unsuccessful. The one 5 am check of traps made on 14.2.74 was successful in providing two animals from the four traps around the bore.

## (c) Observation of Feral Cats

During trapping and transect studies cats were observed as follows:

Date	Location and Comments
7.11.73	Two cats observed along Transect One.
22.11.73	Two cats observed along Transect One plus one along Transect Three. One cat observed on Causeway between the two bridges.
29.11.73	No cats observed.
6.12.73	No cats observed.
16.1.74	One cat observed along Transect One.
23.1.74	No cats observed.
29.1.74	No cats observed.
30.1.74	Three cats observed on the northern section of Transect One near the junction of the road to the bore. One cat observed on the Causeway between the two bridges.
31.1.74	No cats observed.
13.2.74	No cats observed. No night crossing of Causeway made.
14.2.74	Two kittens observed along Transect One. One cat observed on Causeway.
13.3.74	One cat observed on road to Middle Bore.
28.3.74	One cat observed on road to Middle Bore.

Discussion

The figure of 1 tammam per 17 acres for the density of tammams in *M. lanceolata*, *C. preissii* and mixed vegetation stands was considered to be the more accurate figure to use in calculating the carrying capacity of Garden Island for adult tammams (see Table 4, Section 4.4.1). Ideally several consecutive counts of two transects (Transects One and Four) divided into 0.1 mile sectors should have been made so that some measure of variation could be obtained. However, the low number of adult tammams observed for the whole of Transect Four at this time made this unfeasible. The later figure obtained (1 tammam per 6 acres) could have been affected by differential behaviour of juvenile tammams in the two different regions.

Visual observations suggested that a larger proportion of the tammams feeding on the rye along Transect Four were juveniles than amongst the tammams observed along Transect One. By the time this sample was taken natural food supplies would be reduced and higher competition for food in the *M. lanceolata*, *C. preissii*, and mixed stands could result in a higher proportion of juveniles being forced onto the rye to eat. If this density figure (1 tammam per 6 acres) was the more accurate figure then the calculation of the original carrying capacity of Garden Island for adult tammams would be increased by 94 animals to almost 1000 animals (see Table 4). The reduction in tammam numbers after completion of programmed works of HMAS Stirling would increase by only 16 animals to 152. The net result would therefore favour the tammam more than the original figure suggested (see Table 4). A further result of the increased number of juvenile tammams seen feeding on the rye and indeed of the general increase in numbers observed feeding on the rye as summer progressed will be that larger numbers of animals (including recruits) will survive the summer than may normally occur under natural conditions. Coupled with the fact that the tammams on Garden Island experience their worst condition in winter (Bakker 1973) this could result in:

- i) a large number of deaths in the population during winter; and
- ii) a general decrease in the condition of animals (especially males) due to increased territorial fighting.

Experience with the catching of tammams previously and of quokkas on Rottneest Island has shown that increased numbers are generally caught on nights with little or no moon (A.R. Main, personal communication). The result here obtained of higher numbers observed with the last quarter moon phase could be affected by :

- i) a general increase in number of tammams feeding on the rye as natural food supplies become depleted; and/or
- ii) the bright street lighting provided along the sides of Transect One negating the effect of moon phase on tammam behaviour.

Trapping success was also high on these occasions (13.2.74 and 14.2.74) which would seem to negate the latter reasoning. It is most likely that shortage of food plus warm and relatively windless nights were the major factors contributing to transect and trapping success on these nights. Trapping and transect programs carried out at this time of year would therefore be unaffected by moon phase.

The results of the trapping studies indicate that the tammars on Garden Island are currently in good condition (mean welfare state  $8.54 \pm 0.32$ ). This is higher than the figures obtained by Bakker (1973) for the bore population in April 1971 when welfare states ranged from as low as 3 up to a maximum of 8 and in March 1972 when they ranged from 5 to 8. The healthy condition of the animals is further born out by the lack of bacterial infection. This contrasts markedly with results obtained by the Public Health Department for the quokka on Rottnest.

The sitings of feral cats on Garden Island poses an interesting problem from the predator control aspect. The fact that young kittens have been sited on the Island is evidence that the cats are capable of breeding there. Sitings of cats on the Causeway poses the added problem of introduction of more animals from the mainland. In Section 4.4.1 of this report some postulation was made as to the number of cats which might migrate to the Island in any one year based on the sitings made in conjunction with this work. The data are minimal but, in the case of possible predation on an animal to be conserved, it would seem pointless to spend time and money actually surveying the number of cats entering the Island. The action which must be taken must surely be preventative and it is sufficient only to know that cats ARE crossing the Causeway. Measures must be taken to prevent more cats entering the Island (eg an electrified fence across the Causeway) and to eradicate the present population on the Island (eg with cat-specific poisoning and shooting).

If the status of the tamarin population on Garden Island is to be monitored sufficiently over the period of construction of the Naval Support Facility and of public recreational facilities it is suggested that the following may act as a guideline:

- i) Trapping trials should be carried out under optimum weather conditions over one to two weeks every three months. This should provide sufficient mark and recapture data to monitor population densities and will at least provide information on the size structure of the population and on the animals' welfare. Two or three persons experienced in the handling of animals could operate a maximum of ten traps in a night with two to three hourly checks at night and a further check next morning. Suggested that four or five traps be maintained around the Middle Bore region and the remainder away from free water closer to the west coast, possibly around the southern end of the Island.

- ii) While conditions are optimal standardised transect work should be maintained. This would require three persons in the field and could be carried out in conjunction with the trapping program.
- iii) An annual report should be written by a person qualified in management procedure so that the data could be incorporated into the overall environmental management plan for the Island.