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Management of the Ground Parrot *Pezoporus wallicus* in Victoria.

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CONTENTS

Introduction

In an earlier study by the Ministry for Conservation on the status and ecology of the Ground Parrot in Victoria, the bird's dependence on a suitable fire regime in its heathland habitats was shown (Meredith and Isles 1980). That study produced a set of general guidelines for the management of those heathlands, particularly by the use of fire, but did not give specific management prescriptions for local areas. Due to the complex and dynamic nature of the heathland ecosystem and the unpredictability of unplanned fires, such specific recommendations were beyond the scope of that initial study. Rather, it was hoped that, over time, the general management guidelines would be incorporated into detailed fire management plans by the local land managers.

While this process had begun, the extensive fires in East Gippsland in January 1983, which burnt very large areas of heathland, made the completion and implementation of management plans for the Ground Parrot a matter of some urgency. The Fisheries and Wildlife Division made available, through the World Wildlife Fund Australia, funds for the assessment of the effects of these fires and for the preparation of a management plan for the bird in Croajingolong National Park. The brief also included an assessment of the status and management requirements of the parrot in western Victoria, where its populations are small and isolated.

This report presents the results of this work. It is divided into two sections. In the first, the current status of the Ground Parrot and its habitat in Victoria is discussed. The second section deals with the management of the bird and its habitat.

This report does not deal in detail with all Victorian populations of the Ground Parrot. Three areas are only briefly discussed as they are lacking suitable base data. These areas are: the heathlands between Croajingolong National Park and the Princes Highway, those between Bemm River and Marlo, and those at Wilsons Promontory. Collection of the needed data from these regions was beyond the scope of this study.

Unless otherwise referenced, the ecological data used to generate the management proposals in this report is from Meredith and Isles (1980), which should be read in conjunction with this document.

SUMMARY

1. The 1983 fire in Croajingolong National Park has reduced the Ground Parrot population to 75-85 birds (75% of the pre-fire population), but the heathlands are regenerating well, and there is no long-term threat to the survival of the Ground Parrot in the Park.

2. The Ground Parrot is now locally extinct in the Blanket Bay heathlands in Cape Otway National Park. The reasons for this extinction could not be determined.

3. At least three Ground Parrots were located in the Carlisle heathlands. The Ground Parrot population in this area is considerably reduced below the carrying capacity of these heathlands at present, and modelling suggests that this is due to several recent periods of widespread fuel-reduction burning.

4. The Ground Parrot population at Long Swamp, Discovery Bay Coastal Park, is restricted to 300ha of Baumea juncea sedgeland, and comprises 50-60 birds.

5. A model of Ground Parrot population changes after fire in heathlands is developed, and used to design management burning regimes.

6. Management proposals for Croajingolong National Park are:
(a) graminoid heathlands - 240ha to be burnt every two years, over a 20 year cycle;
(b) diverse shrub heathlands - 40ha to be burnt every two years, over a 16 year cycle;
(c) sedgelands - no active management required.

7. Management proposals for the Carlisle graminoid heathlands are: 210ha to be burnt every two years, on a 16 year cycle.

8. It is suggested that discussions on the possibility of undertaking management burning in the Crinoline Creek reference area, Carlisle heathlands, be initiated with the Reference Areas Committee by the Fisheries and Wildlife Division and the Division of Forests.

9. The possibility of re-introducing Ground Parrots to the Blanket Bay heathlands is considered feasible, but unlikely to justify the effort and cost.

10. Heathlands at Wilsons Promontory, the Bemm River - Marlo region and north of Croajingolong National Park require further study before management plans can be prepared for the Ground Parrot in these areas.

11. The heathlands at Gellions Run no longer support Ground Parrots due to past frequent burning, and thus require no management for the bird at present.

12. The sedgelands in the Gippsland Lakes require no active management for the Ground Parrot.

13. The Long Swamp population needs no management of its habitat at present, but water levels in the Swamp should be monitored. The very small size of the population and its isolation indicate that genetic management may be needed.

14. Genetic aspects of the management of the Ground Parrot are discussed.

IMPORTANT NOTE

The names of the heathland vegetation types used in Meredith and Isles have been changed in this report to conform with the terminology of Gullan *et al.* (1981) and Meredith *et al.* (in press). These changes are set out below:

Vegetation classification of Meredith and Isles (1980)	Revised names following Gullan *et al.* (1981) and Meredith *et al.* (in press)
CLOSED HEATH COMMUNITY	COASTAL HEATH COMMUNITY
Xanthorrhoea component	Graminoid sub-community
Casuarina component	Diverse shrub sub-community
SEDGELAND COMMUNITY	SEDGELAND COMMUNITY
Baumea component	*Baumea* sub-community
Leptocarpus component	*Leptocarpus* sub-community
Juncus component	Diverse *Juncus* sub-community

THE CURRENT STATUS OF THE GROUND PARROT IN VICTORIA

(A) Croajingolong National Park.

Field work was carried out in the Park from 19-29 September 1983. Colour aerial photographs, taken since the 1983, fire were used to map the burnt heathlands and ground checking was done where necessary. All accessible unburnt heathlands and sedgelands were visited and censused for Ground Parrots using the method of Meredith and Isles. Many burnt heathlands were also visited in order to assess the severity of the fire and the progress of regeneration.

Effects of the 1983 fire on Ground Parrot population size

The extent of the 1983 fire and the localities of those heathlands not burnt in that fire are shown in Figure 1. More detailed maps are referred to in the management section. Further field, checking made possible by the increased accessibility of some heaths following the fire, has led to a slight upward revision of the amount of heath suitable for the parrot in the Park. These changes are summarised in Table 1. Of the 2700 ha of coastal heathland in the Park, only 940 ha (35%) were not burnt. In addition, none of the sedgelands were burnt.

Table 1. Summary of alterations to Meredith and Isles' (1980) maps of the heathlands of Croajingolong National Park.

ADDITIONS:
Five graminoid heath areas just south of the Mueller Link Track, between the Mueller River and the West Wingan Road.

MODIFICATIONS:
An area of diverse shrub heath (#346) between Camp Creek and the mouth of the Mueller River is increased in size.
A graminoid heath north of the Golden Slipper (#421) is decreased in size.

DELETIONS:
Many small (<10 ha) heath patches have been deleted.

These unburnt heathlands are restricted to five localities (see Map 1). One group comprises the relatively inaccessible graminoid heathlands near Lake Wau Wauka. These heaths were not surveyed, but a bushwalker (J.Sams, pers.comm.) recorded Ground Parrots there in April 1983. The area of these heaths is 130 ha, their post-fire age is three years and the expected present population of Ground Parrots is 10-15 birds. Another 130 ha of unburnt graminoid heath occurs along the Lakeview Track, north of Howe Flat. This area is five years old and I recorded Ground Parrots there at densities of 0.8-1.1 birds/10ha., giving a total population of 10-14 birds. No birds were recorded at Howe Flat sedgelands, but Meredith and Isles found that the bird was very uncommon at this time of year at this locality during their study although they were common during autumn and winter. They suggested that the Flat is poor breeding habitat but an important wintering location for dispersing birds.

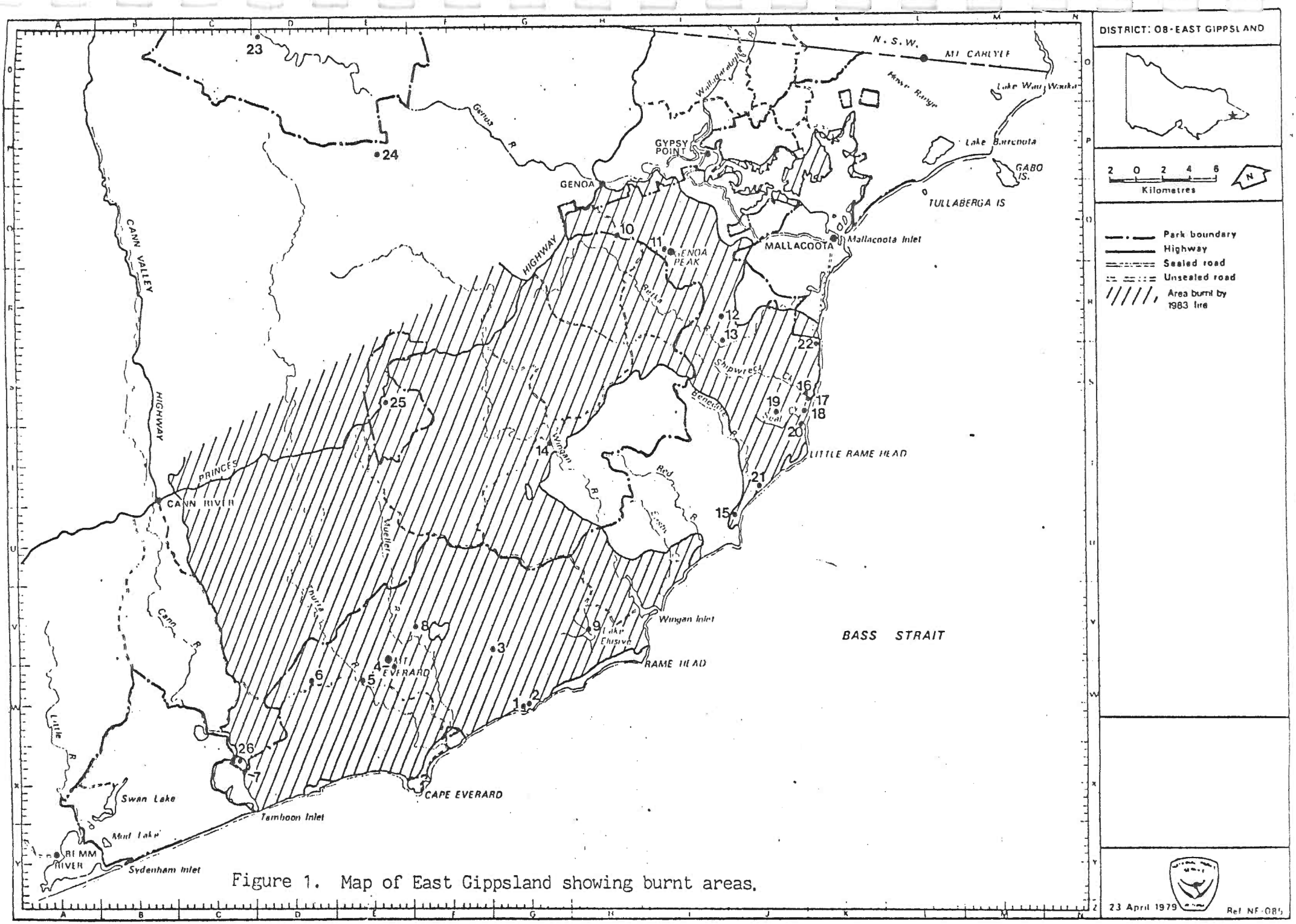


Figure 1. Map of East Gippsland showing burnt areas.

A series of graminoid and diverse shrub heaths between Sandpatch Point and Easby Creek (area 240 ha) did not burn. They were last burnt by the 1978 Wingan fire and were five years old at the time of the survey. Ground Parrots were present at a mean density of 1.1 birds/10 ha, giving a population size of 26. A smaller group of heaths (60ha, probable population six birds) to the north, near the Golden Slipper, also did not burn. These were not visited.

Fourty hectares of 20 year old heathland north of the Cicada Trail did not burn. Attempts to reach this area were unsuccessful. At twenty years post-fire, Ground Parrots are likely to be present only at low densities, if at all.

A very small patch of unburnt diverse shrub heathland remains at Bald Hills, between the mouths of the Mueller and the Thurra Rivers. The past burning history of this patch is unknown as it has clearly been burnt by fires not indicated on the fire history maps. On the basis of the condition of the vegetation, I estimate it to be 10-15 years old. Three or four Ground Parrots were heard at this site but the dissected topography makes accurate density estimates impossible. My subjective impression was that density was low, as would be expected of a diverse shrub heathland of that age.

A further 270ha of graminoid heathland between Tamboon Inlet and Sydenham Inlet did not burn. Its fire age is 32 years, too old to support Ground Parrots.

Other small (<5ha) areas of unburnt heath in the Park are too small to support Ground Parrots. This was confirmed by censusing several such areas.

Meredith and Isles estimated the total Ground Parrot population of the Park at the time of their study at 400 individuals. A model for predicting Ground Parrot population densities presented in the section on management in this report indicates that this estimate was too high and that 250-300 breeding residents in the heathlands and up to 20 breeding birds in the sedgelands is a better estimate. This number had probably increased by the time of the 1983 fire as the age structure of the heathlands changed. The 1983 fire has reduced this to 55-65 birds in the heathlands with up to 20 still in the sedgelands.

Effects of fire on the heathland vegetation

Australian heathlands are well known for their high degree of adaptation to fire and those that comprise the habitat of the Ground Parrot in East Gippsland are no exception. Regeneration of the heath vegetation was prolific at the time of the survey and there is nothing to suggest that this fire, despite its size and intensity, will have any adverse effects on the heathlands of the Park in the long term. Gullan *et al.* (1984) make similar observations. There were several small areas of heath (e.g. near the mouth of Easby Creek) where the intensity of the fire had been so great and the soil so dry that the highly organic top 2-4cm of the soil had actually burnt. There was little rootstock regeneration evident, seedling regeneration appeared to be delayed, compared to surrounding heath, and a dense layer of mosses and liverworts covered the soil. Such areas may be of scientific interest but their area is so minute (<1% of the total heath area) that no special management is justified.

Of more significance is the great reduction in the diversity of fire ages amongst the heaths in the Park. Table 2 compares the age structure of the heathlands in 1979 with that of the present. There is now a great

Table 2. Age structure of the heathlands in Croajingolong National Park in 1979 and 1984.

Age (years)	Area of heathland (hectares) 1979	1984
1	1065	1749
2	175	--
3	--	128
4	80	--
5	--	532
6	81	--
7	128	--
8	--	--
9	--	--
10	22	--
11	--	--
12	--	--
13	200	--
14	190	22
15	76	--
16	--	--
17	301	--
18	--	--
19	--	--
20	--	40
21+	371	218
TOTAL	2689	2689

preponderance of two young age classes as a result the 1983 fire and several fires in 1978.

Effects of fire suppression measures on the heathlands

Meredith and Isles stressed the very poor regeneration of heathlands once the soil has been disturbed by heavy machinery. Only in two localities was mechanical disturbance of heathland observed. The major fire break put in to protect Mallacoota was a bulldozed line that passed for about 200m through diverse shrub heathland at Shipwreck Creek. A small area of graminoid heathland next to the Point Hicks Road (#320 on the map in Meredith and Isles) was apparently used as a staging area and has been ploughed up by heavy equipment.

On the positive side, the decision to protect the Point Hicks area, including the Bald Hills heathland, resulted in the saving of what is now an important core population of Ground Parrots in that part of the Park. Attempts to protect critical heathlands (and other sites) should in future be a normal part of the planning of fire suppression.

Implications of the 1983 fire for the survival of the Ground Parrot in the Park

Although the Ground Parrot has suffered from a temporary 65% reduction in the area of its habitat in the Park and a 75% reduction in its population level, as a result of the 1983 fire, this single event does not constitute any threat to the survival of the bird. The burnt heathlands are regenerating well and will begin to be recolonised by Ground Parrots in the 1984/85 summer. Colonists will come from the remaining populations within the Park, from the adjacent Nadgee Nature Reserve in New South Wales, and possibly from the small population in the Bemm River-Marlo region.

The great extent of the 1983 fire, however, has meant that large areas of regenerating heathland are now dependent on just a few areas for colonists. **The importance of keeping fire out of these unburnt heathlands and sedgelands for the next two to three years is obvious.**

(B) BLANKET BAY - CAPE OTWAY NATIONAL PARK

Ground Parrots were known from the heathlands at Blanket Bay until 1976. They have not been recorded since then, despite two surveys by Meredith and Isles in 1980. A further visit in November 1983 as part of this study again failed to find the bird. It must now be presumed locally extinct.

The reasons for this extinction are unclear. Forests Commission fire records show that most of the heaths are presently of a suitable age to support Ground Parrots. About 70% of the total heath area was burnt in 1977/78. It may be that this relatively extensive burn left too little habitat available for the bird. Predation, disease or genetic problems due to inbreeding could also lead to the extinction of a small, isolated population such as this.

Table 3. Fire history of Carlisle heathlands.

Locality	Area(ha)	Fire Season 63-64	64-65	65-66	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	75-76	76-77	77-78	78-79	79-80	80-81	81-82	82-83
Rifle Range Tk	22	22	22	22		22										22					
Cricket Pitch Tk #1	22													22	22						
" " " #2	100					100								100	100						100
" " " #3	11			11										11	11						
Boggy Creek #1	39			39					39						39	39	39				
" " #2	28			28					28								28				
" " #3	58			58					58						58		58				58
" " #4	11			11					11						11		11				11
" " #5	14			14					14						14		14				14
" " #6	20			20					20						20		20				
" " #7	127				127				127								127				
" " #8	11				11				11								11				
Pumping Station #1	20	20																			
" " #2	11	?																			
" " #3	11	11																			
Egan Track #1	75									40						75					25
" " #2	50						50														
Sandy Creek	58		58																		
Mckenzie Old Tk #1	28			28								28				28					
" " " #2	53			53		53						53				53					53
" " " #3	20			20								20		20			20		20		
Mt McKenzie #1	28			28								28		28			28		28		
" " #2	36			36							36										
Crinoline Creek #1	140					70		70		40	70	70									
" " #2	45											45									
" " #3	20							20													
Mt McKenzie Tk #1	11						11					11									
" " " #2	30					30													30		
Lavers Hill Road #1	14													14				14			14
" " " #2	20													20							
" " " #3	25													25							
" " " #4	25													25							
Skinner Creek East	360																		180		
" " West	150																		150		
Colac Tree Rd East	100											100					100		100		
" " " West	140											140					140		140		
Atkinson Creek	150											150									
Telegraph Line	800			800		800			400				400		400		800		800		
TOTAL AREA	2083	62	80	1169	138	1075	61	90	708	80	106	645	400	265	675	217	1396	14	1448	-	275

(C) CARLISLE STATE PARK

Carlisle State Park was surveyed from 8-14 November 1983. For part of this time I was assisted by a group of volunteers from the Bird Observers Club and by Fisheries and Wildlife and Forests Commission field staff. Considerable effort was put towards ground-checking and improving the maps of the heathlands and in checking the fire ages of the heaths as indicated by Forests Commission records. The resulting map (Map 2) is considerably modified from that of Meredith and Isles.

Ground Parrots had been recorded breeding in the Mt McKenzie region of the Park in 1960 (Hodges,1961), but there were no published records since then, and Meredith and Isles were unable to find the bird during two surveys in 1980. Mr J.Alderson (pers. comm.) reported seeing a Ground Parrot in the Mt McKenzie region "several years ago", so survey work for this study was concentrated in that area.

This time the survey was successful in locating Ground Parrots. Calls were heard and one Ground Parrot was seen near the summit of Mt McKenzie, close to the nest site reported by Hodges. Further searching in the Mt McKenzie area was unsuccessful. Two of the volunteers made a tentative call identification at Egan Track, but this requires confirmation. Two more Ground Parrots were heard in the extensive heathlands along Colac Tree Road, a locality not previously surveyed.

The low numbers of Ground Parrots and their patchy distribution in this area are related to the recent fire history of the region and its isolation fron other Ground Parrot populations. This fire history is summarised in Table 3. It can be seen that the age stucture of the heathlands is highly biased towards young heaths, less than six years post-fire. Over 1800 ha of heathland falls into this category, 87% of the total area. This is the product of two periods of extensive fuel-reduction burning in 1978/79 and 1980/81. Since 1963 there have been six other years of large scale burning, although none as extensive as these recent burns. As there are no other Ground Parrot populations within dispersal distance of the Carlisle heaths, population increase after these fires would not be aided by immigration.

The data in Table 3 were used to generate the past population changes in the region, using the model of Ground Parrot population cycles set out in the section on Management, and assuming a reasonably high population level prior to 1963. The results are indicated graphically in Figure 2. This figure shows the carrying capacity of the heathlands (that is the maximum number of Ground Parrots that they could support at any one time if all the available habitat was utilised, which varies according to the age structure of the heathlands) and the predicted actual population levels, assuming different rates of recruitment into the population. It can be seen that the effect of a single large fire is to reduce the population to low levels by reducing carrying capacity. Although carrying capacity increases rapidly after fire, the small population size and the low recruitment rate means that population increase lags behind. If the recruitment rate is around 0.5 young per pair per year then population increase is very slow and if there are further regular large fires, as was in fact the case, **the population remains static or even drops further.** In an isolated population such as this, immigration will not aid recovery.

The extensive fires of 1978/79 and 1980/81 caused a massive drop in carrying capacity and Ground Parrot population levels, which were already low. Though carrying capacity is now high (200 birds), there are probably not more than 25-30 birds actually present, and Ground Parrot numbers are likely to take years to build up again, even with management. This explains

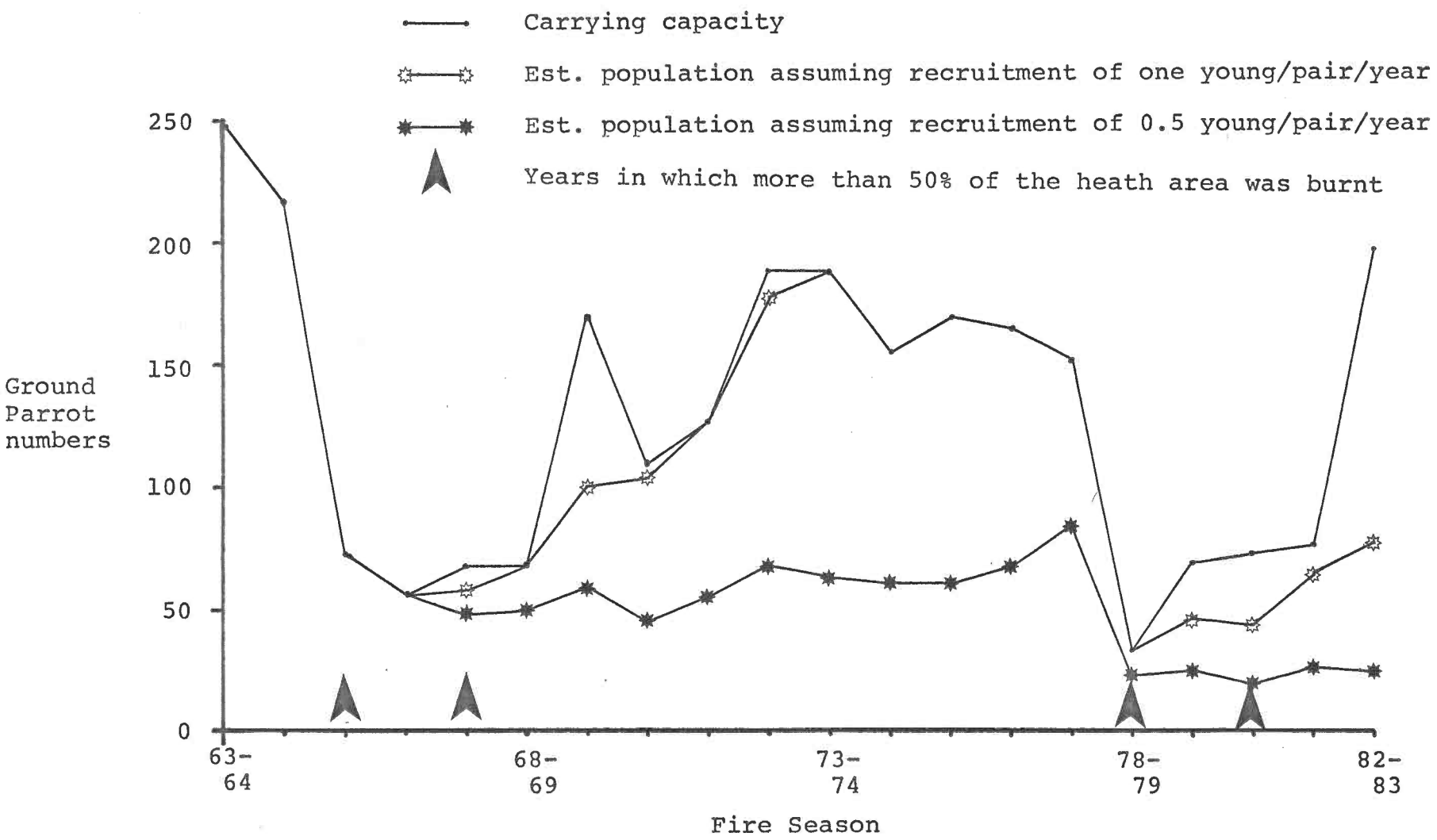


Figure 2. Estimated effects of past fires on the Ground Parrot population in the Carlisle area. Only deviations from carrying capacity are indicated.

why our survey found large areas of apparently suitable habitat occupied by only a few birds.

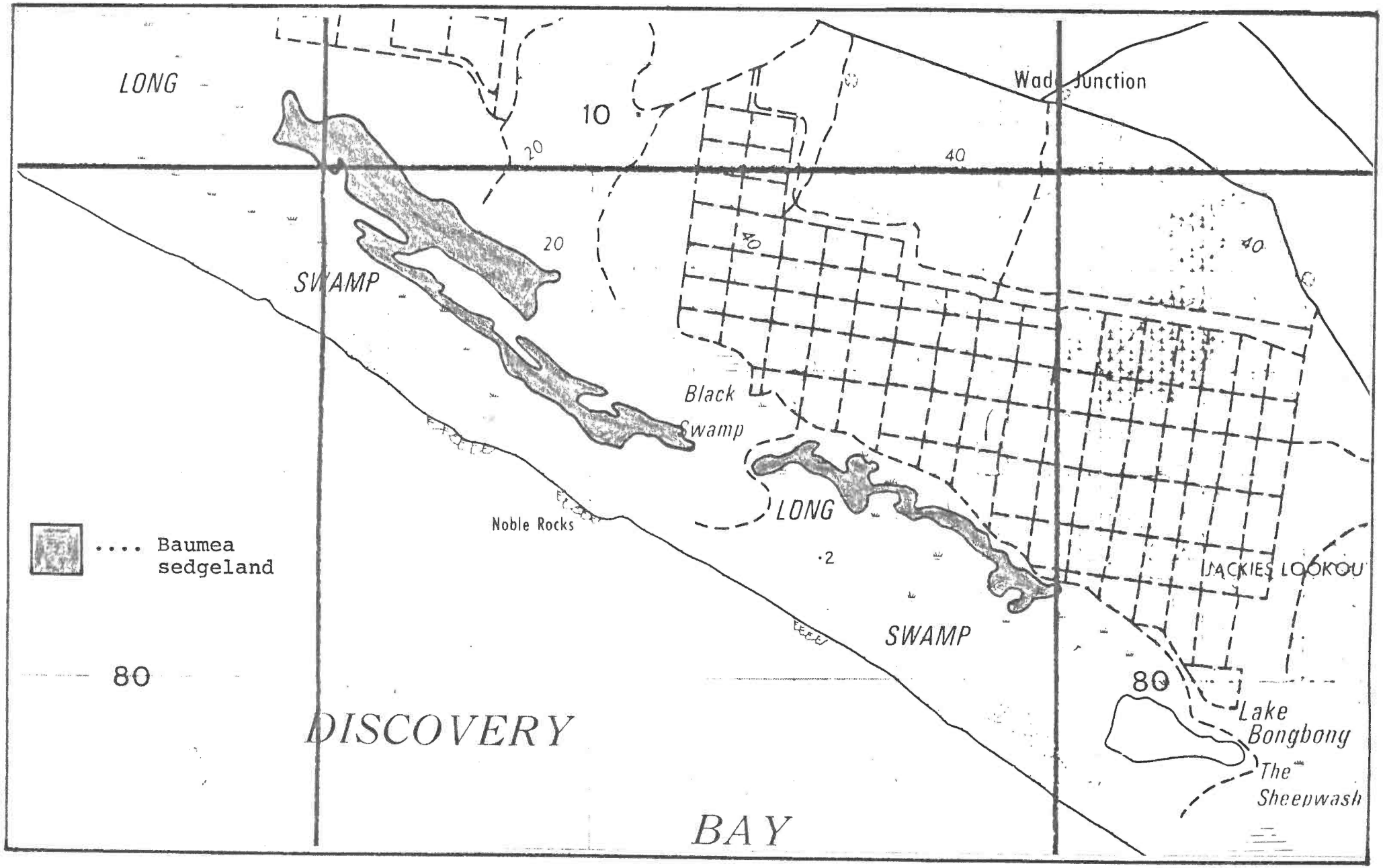
Due to the very high burning frequency in some areas of heathland close to roads or private property, many of these heaths are probably no longer suitable for the Ground Parrot. These heaths amount to about 25% of the total heath area and, unfortunately, include the largest single patch. It is unlikely that these heaths will become suitable for Ground Parrots in the foreseeable future, (but see p. 16) and so any future high frequency burning should be restricted to these areas. They are indicated by stars on Map 2.

The Colac Tree Road heathlands deserve special mention. Due to their extent and lack of frequent past burning they potentially represent the most important Ground Parrot habitat in the region. They did not show up clearly on the aerial photos that I used, having been burnt just prior to the taking of the photos. They were misinterpreted as recently cleared land and were thus only visited by chance during the latter part of the field work, and so they have yet to be properly mapped and surveyed.

(D) LONG SWAMP - DISCOVERY BAY COASTAL PARK

The Long Swamp population is now the most westerly occurrence of the eastern Australian sub-species of the Ground Parrot, P.w.wallicus. It is the last remnant of a much larger population that occurred in Baumea sedgelands along the coast from near Cape Otway well into South Australia. These sedgelands form in peaty dune swales along the coast and around estuary flood plains and have been mostly cleared for agriculture.

Survey work in February 1984 confirmed that the Long Swamp population is restricted to those sedgelands that are dominated by Baumea juncea, a cyperaceous sedge that is a known food plant of the Ground Parrot. The distribution of these sedgelands was checked using aerial photos and ground-checking and is shown in Map 3. This map corresponds closely to that of Meredith and Isles, with the exception that the sedgelands numbered 1,2,5 and 6 in their map have been excluded. The total area of Baumea sedgeland is 300 ha. The census results were similar to those of Meredith and Isles, indicating a total population of 50-60 Ground Parrots.



Map 3. Areas occupied by Baumea sedgelands at Long Swamp. Scale: 1 to 50 000.

MANAGEMENT OF THE GROUND PARROT IN VICTORIA

Important Note

It must be stressed that the forms of management discussed here are almost certainly only suitable for Ground Parrot populations in Victoria and southern New South Wales (south of about Wollongong). They should not be assumed to be applicable to Queensland, northern New South Wales, Tasmanian and Western Australian populations. Mounting evidence suggests that the northern New South Wales and Queensland heathlands require quite different burning regimes compared to the southern heathlands, due to the different relative growth rates of the sedges and the shrubs in the warmer climate (A.M.Gilmore, unpublished data). Little is known of the ecology of the parrot in Tasmania, but what evidence there is suggests that the birds requirements differ there also. Virtually nothing is known about the bird in Western Australia.

It should also be noted that the management proposals made here concern only the Ground Parrot, and it may be that other components of the heathland biota have different management requirements. As far as I am aware, there is no evidence to suggest that the proposals made here will lead to the decline of other heathland animals or plants, but there is a real lack of data with which to assess this.

Coastal Heathlands

(i) A Model of Ground Parrot Population Changes After Fire.

The survival of Ground Parrots in the coastal heathland community is dependent on the maintenance of a suitable fire regime. Meredith and Isles showed that, after a fire, Ground Parrot populations go through a cycle that can be conveniently divided into five phases. In the initial phase, immediately post-fire, Ground Parrots are absent from burnt heaths. This phase lasts around two years and ends when the birds begin to recolonise the regenerating heaths (providing other populations still remain within dispersal range). During this next phase of recolonisation, Ground Parrots return and breed in the heathlands and their population levels consistently increase. The length of this phase varies between sub-communities and between climatically different regions, ranging from three to eight years. The third phase is the plateau phase, when population densities are at their peak and remain fairly constant for about five years. A decline phase then follows, during which time densities decrease, reaching zero by 16-20 years post-fire, depending on the vegetation type and the region. The fifth phase is when the heaths are too old to support Ground Parrots. A fire occurring at any time in this cycle, even in very old heathlands, will re-initiate the cycle. This cycle is diagrammed in Figure 3 and the relative timing of the phases in the different heath types and regions is shown in Table 4.

Table 4. Summary of the Ground Parrot's population cycle for different heath types and regions.

	Eastern Victoria		Western Victoria	
	Graminoid	Diverse Shrub	Graminoid	Diverse Shrub
Phase 1	2 years	2 years	2 years	2 years
Phase 2	8 years	3 years	4 years	3 years
Phase 3	5 years	5 years	6 years	5 years
Phase 4	5 years	5 years	3 years	5 years
Phase 5	Age >21 years	Age >16 years	Age >16 years	Age >16 years

This five phase cycle is used to construct a model that predicts the effects of different burning regimes on the Ground Parrot population of a region. A table showing the age structure of the heathlands is constructed from the fire history maps. The rows correspond to the range of fire ages applicable to the area (usually stopping at the beginning of phase five) and the columns represent consecutive fire seasons. The rows are further sub-divided into the five population phases. For each year the area in hectares of the heath in each fire age is recorded on the table, and so a picture of the age structure of the heathlands is built up. Table 5 is an example. It shows the changing age structure of the Carlisle heathlands since 1963 (see below for a full explanation of its construction and use).

These tables can then be used to calculate the carrying capacity of the heathlands. The carrying capacity is the number of Ground Parrots that the heathlands could support in any one year if the habitat was fully utilised. It is obtained by multiplying the area of heath in each population phase by the mean density of Ground Parrots (in birds/10ha) for that phase, adding these values and dividing by ten. The mean densities in birds per ten hectares, calculated from the data of Meredith and Isles (and

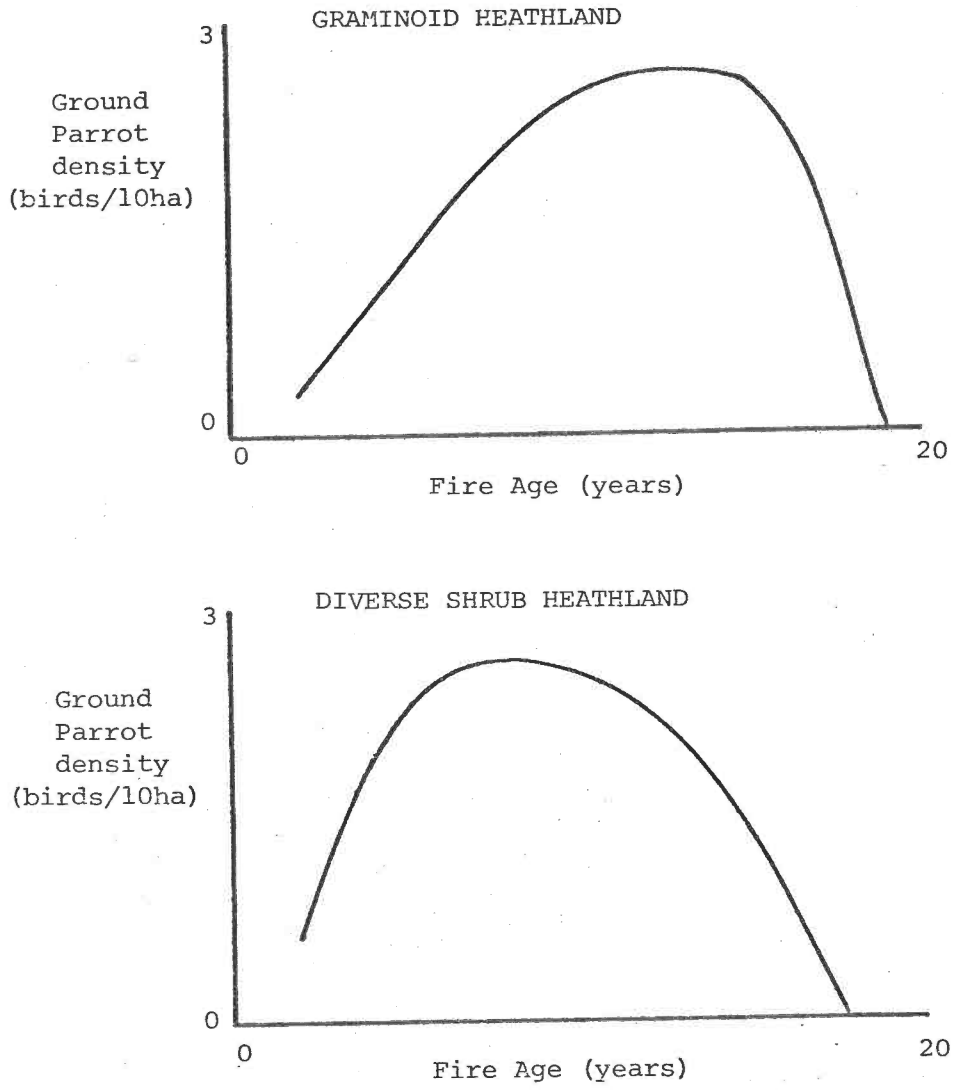


Figure 3. Diagram of the Ground Parrot's population cycle after fire.

slightly, although not significantly, rounded for convenience) for phases one to five, are zero, one, two, one and zero respectively. Such a table can be used to analyse the effects of past fires, predict future population changes and to design mangement burning programmes.

The model provides a conservative estimate of carrying capacity as it slightly underestimates the peak population densities reached and it ignores dispersing and non-territorial birds. It is not applicable to sedgelands which probably have fairly uniform populations of breeding birds but highly fluctuating populations of dispersing birds. However, as an estimate of the heathland carrying capacity, I believe it is unlikely to be in error by more than 15-20%.

As an estimate of actual population levels, it is an oversimplification as it ignores the constraints on population growth caused by the levels of fecundity, juvenile survival and colonisation from other populations, as well as the effects of adult mortality, other than that caused by fires. I believe the adult mortality can be reasonably ignored in a simple model such as this as it is generally low in other related parrots, and there is no evidence of significant predation of adults (Meredith, 1983).

The other factors mentioned above do need consideration. The rate of colonisation by dispersing birds from surrounding populations will depend on the size and population phase of those populations. If the surrounding populations are in either phase one or five, when Ground Parrots are absent, they will not contribute colonisers. If they are in the recolonisation phase, many of the young they produce will remain, increasing the local population, and dispersal to other populations will be slowed. If, on the other hand, they are in the plateau or decline phases most of their young will disperse.

Little is known about fecundity and juvenile survival in the Ground Parrot (Meredith and Gilmore, in prep.). In Victoria, limited data indicate that clutch size is three to four and that about 50% of eggs layed reach the fledgeling stage. There is no evidence of more than one brood per year. Thus, each pair of Ground Parrots potentially reproduces itself each year. Post-fledgeing mortality is, however, likely to be high as it is during this period that the young become independent and leave their natal range. In the absence of real data, two intuitively reasonable figures for the number of young that survive for at least one year per breeding pair were used to model actual rates of population increase. These values are 0.5 young per year and one young per year.

Assuming that exponential growth occurs at these rates, simulations using the model show that these restraints on population growth are only significant if more than 50-60% of the total heathland area is burnt in one year or over several consecutive years, in the absence of immigration. Below these levels, population increase will be rapid enough to be able to reach carrying capacity within one to two years post-fire. At high levels of burning the effect becomes quite marked: if over 70% of the heath has been burnt it will be at least five years and up to seven before population numbers reach carrying capacity if the one young per year value is used. If the 0.5 young per year value is used, then this lag period increases to 10-12 years.

These calculations assume no, or very little, immigration, as would be the case for the Carlisle or Wilsons Promontory populations. If immigration does occur at reasonable levels, as would be expected in Croajingolong, the model shows that population levels should reach carrying capacity rapidly.

How much and how often to burn

Any management strategy for the heathland populations of the Ground Parrot should aim to both maintain relatively stable numbers over time in an ever-changing environment and to be resilient to the effects of unplanned fires, particularly large ones. Using the model set out above, the most stable situation is one in which an equal proportion of the total heath area is burnt every two years, that proportion being:

$$\frac{2}{\text{number of years for population to reach phase 5}} .$$

That is, in graminoid heathland in East Gippsland, phase five (heath too old to support Ground Parrots) is represented by heaths older than 20 years post-fire. Therefore, the amount of heath to be burnt every second year is 2/20 = 10%. This proportion need not be strictly adhered to, but the variation should not be too great. The two year period between burning is chosen so as to minimise the proportion of the population in phase one (pre-colonisation), which lasts for two years.

Quite clearly, nowhere in Victoria does such an equal distribution of heath age classes exist at present. Again, to use Croajingolong as an example, in the 1984/5 summer 62% of the graminoid heath will be in the one year old age class, 5% three years old, 22% five years old, 2% twenty years old, and 9% will be 32 years old. The tactic in this situation is still to burn 10% every two years, starting with any heaths that are in phases four or five (decline or too old) and then burning segments of heaths in phase three, and two if need be, where the proportion in any particular age class is too large. Heaths in phase one should not be burnt.

To illustrate how this system would work, a hypothetical example will be used. Table 5 is a heath age structure table for a heath type that has a twelve year cycle to the beginning of phase five, in a region containing 1200 ha of this heath. The entries are the areas (ha) of heath in each age class at the beginning of each fire season. Next to the area figures, the area proposed for management burning each season is shown as a number prefaced by M, and any areas burnt by wildfires that season are shown prefaced by W. The carrying capacity at the beginning of the fire season is shown at the bottom of each column.

In this hypothetical data set, the proportion of heath in the various age classes is initially very uneven. The ensueing burning programme was designed to burn 200 ha every second year (2/length of cycle = 2/12 = 1/6; 1/6 of 1200 = 200 ha). After nine years, a stable population size of of 140 birds had been reached. A wildfire two years later again altered the proportions of the heaths in each age class, and so a similar programme of selective burning was again undertaken. It is clear that in regions such as East Gippsland where wildfires are relatively frequent, management will often be a case of "chasing the tail" of the last major fire.

These tables of age structure are not only useful for deciding what should be burnt but, equally importantly, in deciding what should be protected. If critical areas of heath can be protected, even partially, from unscheduled burning then it will be considerably easier to maintain stable population levels. In the example above, if it had been possible to prevent the wildfire in year 11 from burning the 200 ha of five year old heath the long-term effect of that fire on the Ground Parrot population would have been far less. Additionally, the table suggests that no special effort need be spent in protecting the 11 year old heath.

Table 5. Hypothetical heathland age structure table and burning programme.

POPn PHASE	FIRE AGE	FIRE SEASON									
		YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
1	1	500		200		200		200		200	
	2		500		200		200		200		200
2	3			500		200		200		200	
	4	200			500		200		200		200
	5	50	200			500		200		200	
3	6		50	200			500M100		200		200
	7	350		50	200	200		400		200	
	8		350M100		50	50	200		400M200		200
	9			250			50M50	200		200	
4	10				250M200				200		200
	11					50				200	
	12						50M50				200M200
5	13+	100	100M100								
Carrying capacity:		95	100	150	125	125	175	160	160	140	140
		YEAR 11	YEAR 12	YEAR 13	YEAR 14	YEAR 15	YEAR 16	YEAR 17	YEAR 18	YEAR 19	YEAR 20
1	1	200	320		180		200		200		200
	2		200	320		180		200		200	
2	3	200		200	320		180		200		200
	4		200		200	320		180		200	
	5	200W200		200		200	320		180		200
3	6				200		200	320M100		180	
	7	200W80				200		200	220		180
	8		120				200		200	200	
	9	200		120M20				200		200M200	200
4	10		200		100				200		
	11	200W40		200		100				200	
	12		160		200		100				200
5	13+			160M160		200M200		100M100			
Carrying capacity:		140	80	84	122	102	140	162	142	156	136

If the management programme proposed here is to work as effectively as possible, decisions on protection from fire are just as important as decisions on when to burn. Although it is obvious that managers will have less control in this regard than they do when they are initiating burns, even moderate success in this area will greatly simplify management in the long term. As well as helping determine which heaths it should be attempted to save in the event of a wildfire, these tables should be used to help plan fire protection works around critical heathlands.

Where to burn

Knowledge of the heathland age structure tells us how much to burn and when, but it does not tell us where. The maps of the heathlands provided by this report and by Meredith and Isles are used for this. These maps show the distribution of the heaths, the area of each patch in hectares and the fire history of each patch. **These maps should be revised each year by local managers and used to determine where within each age class burning or protection should take place.** No hard and fast criteria can be laid down for this as the many factors that determine the exact priorities out in the field - access, equipment and staff availability, weather,etc - can only be assessed by the local manager. There are, however, a number of basic principals.

Firstly, in a large area like Croajingolong or Carlisle areas of heath in each population phase (not necessarily each age class) should be spread throughout the region so as to minimise the chance of a single fire removing all of one population phase and to maximise the number of potential sources of colonisers after a large fire. In smaller areas or sub-sections of large areas, spatial diversity of age classes is much less important.

Secondly, care should be taken to prevent particular heaths from being burnt too frequently while others, perhaps less accessible, are not burnt at all.

Finally, certain heaths may need to be excluded from the burning programme for various reasons - they may have become unsuitable for Ground Parrots due to frequent burning, their zoning may preclude management, or they may be too inaccessible to manage. These heaths should be excluded from the data from which management decisions are made, though records of their fire history should still be kept.

Size of burns

The minimum size of heath that can support Ground Parrots is 10-20 hectares. Patches smaller than this do not warrant management effort unless they are in a compact group whose total area exceeds 20 hectares. Heaths less than 60-80 ha should be burnt as a single unit. Heaths larger than this need not necessarily be burnt on an internal mosaic pattern, but can be if so desired. In such cases, the minimum area burnt should be 40-50 hectares. Where there are a number of small (10-20 ha) heath patches in close proximity to each other (within half a kilometer), they should be managed as a unit.

These guidelines are designed to ensure that management burns are on a scale that is of the order of one-to-several Ground Parrot territories in size at the minimum.

Shape of burns

Most often the shape of a heath burn will be dictated by the shape of the heath patch. When a large heath patch is being burnt on an internal mosaic pattern, the burnt areas should have a low edge-to-area ratio. In other words, they should be roughly circular or square rather than long and thin. Fingerburns or narrow burns along tracks will have little effect on habitat quality compared to square or round areas.

Season of burning

There are no data on the effects of burning at different times of the year on heathland vegetation. On the basis of maximising recruitment of young Ground Parrots into the population each year, burning would be best done in February to May. This would allow the young of the year to have become independent and to have begun dispersing from the parental territory.

Some comments on the management of fire in heathlands

The management proposals in this report refer only to the burning regime of heathlands, not of the surrounding forests or woodlands. This raises the question: is it possible to burn heathlands separately from their surrounds? Discussions with a wide cross-section of field staff suggest that in many localities, it is. The fact that forest understoreys take longer to dry out after rain than do the adjacent treeless heathlands was frequently proposed as a situation that could be exploited to this end. The much slower rate of increase in forest fuel levels after a fire compared to in a heathland might also be used to advantage in some situations.

I believe that slashed firebreaks can also be very useful in controlling fire in heathlands. **Bull-dozed or graded lines should be avoided as regeneration is extremely poor if the soil is disturbed.** However, research on the extensive network of slashed breaks in the heathlands of Wilsons Promontory (Durkin, 1981)has shown that slashed lines do not deleteriously affect heathland vegetation. Thus, slashed breaks could be used to contain management burns or as fire protection measures. If possible, rubber-tired tractors should be used for slashing, and preferably with a "non-aggressive" tread.

Phoschek and other phosphorus-based fire-retardants should not be used on heathlands, especially diverse shrub heathlands, as phosphorus is poisonous to most heath shrubs, even in small amounts (Specht, 1975).

The burning regimes required for maintenance of Ground Parrot populations will sometimes be at variance with broad-scale fuel-reduction burning programmes, although it is to be hoped that they would be integrated where possible. When there is a conflict, the two systems should preferably be managed separately.

The effects of burning too frequently

Graminoid heathlands that are burnt too frequently become floristically depauperate and lose their ability to support Ground Parrots. Exactly what "too frequently" is has yet to be accurately determined but it appears that a safe yardstick would be five fires or more, each less than four or five years apart. Diverse shrub heaths do not seem to be affected to the same extent by frequent burning, although they too will eventually be degraded.

The mechanism of this loss of floristic diversity is uncertain but Meredith and Isles found that the result is a marked reduction in both the

species richness and the abundance of the sedges whose seeds make up the bulk of the Ground Parrot's diet. Heaths affected this way do not return to their former condition once frequent burning ceases and the effect seems to be a long-term one.

Given their degraded state, any intensive fire protection burning in heathland should be done in such heaths. In regions where these degraded heaths are large in area (e.g. the Bemm River - Marlo region or parts of the Carlisle heathlands), their rehabilitation would be a worthwhile goal. In the very long-term, a continued low burning frequency might achieve this. An alternative technique that could be investigated is the application of superphosphate. Phosphate encourages sedge growth but inhibits shrubs. This would need to be carefully tested on a small scale before it could be considered for widespread use.

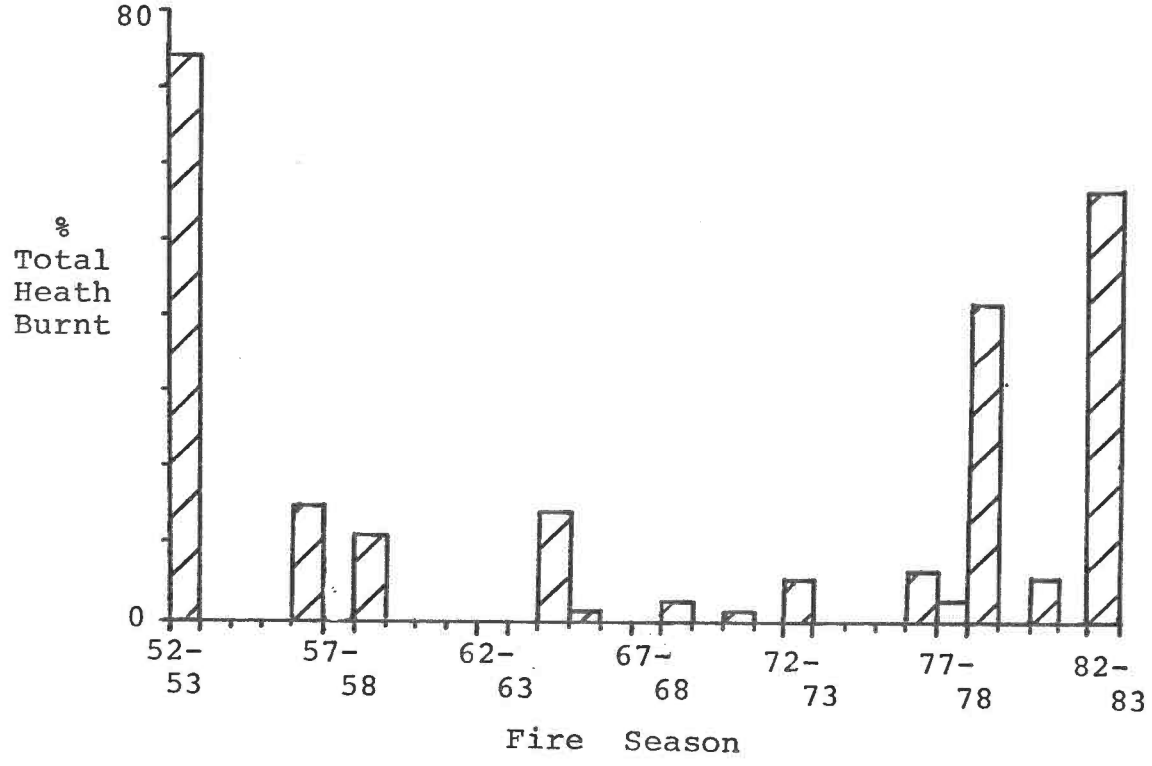


Figure 4. Proportions of total heathland burnt in past fire seasons in Croajingolong National Park.

REGIONAL RECOMMENDATIONS

Croajingolong National Park

(i) Fire history

Detailed fire history data from 1952 to 1979 for the Park were presented in map form by Meredith and Isles. Map 1 accompanying this report updates this map and modifies the boundaries of some heaths following further fieldchecking. The area in hectares of each heath is also indicated on the map. Very small heath patches have been omitted. Analysis of these fire history data shows that fires (including fuel reduction burns) affect heathlands in 43% of years. There appears to have been an increase in fire frequency in heaths since 1965, with fires affecting heaths in 53% of years after that date compared to 25% prior to that. This may represent a real increase or it may be a function of better record keeping in more recent years. In sixty percent of the years in which heathland burnt, less than 10% of the total area of heathland in the Park was burnt. In 15% of those years 11-20% of the total area was burnt and in 25% of years more than 40% was burnt. These data are illustrated graphically in Figure 4.

Although the mean proportion of the total heath area burnt each year is 8%, 1.6 times the amount recommended to maintain stable population levels (see below), this is biased by the occurrence of three very large fires, one in the 1952/53 summer, one in 1978/79 and one in 1982/83. The mean proportion burnt each year in the period between 1953/54 and 1977/78, inclusive, is 2.4%. Thus, while very large fires will occur, they are unusual and would not be expected more frequently than perhaps every 30-50 years. During the intervening years, even in a region as fireprone as East Gippsland, the actual areas of heathland burnt by wildfires are unlikely to be large enough to make management difficult. It should be feasible to establish the the sort of stable management regime discussed here between major fires. This would ensure that, as far as possible, the Ground Parrot population in the Park would be able to cope with the occasional large fire.

(ii) Burning programme

Table 6 lists the heathlands of the Park, grouping them into manageable units, and giving the area, vegetation type and fire age. The sedgelands are also listed. The heath groupings are indicated on Map 1. Of the 2700 ha of heathland in the Park, graminoid heath is by far the most common (2400 ha, 89%). Sedgelands occupy another 800 hectares.

Table 7 gives the age structure of the graminoid heathlands and indicates the recommended future management regime, assuming no unplanned fires. The programme will need to be suitably modified when unplanned fires do occur. The aim is to burn on a 20 year cycle, burning 10% every two years. Ten percent is 240 ha (maximum range of variation is 180-300 ha)

The present distribution of heath age classes is: a very widespread and large group of one year old heaths burnt by the 1983 fire; 130 ha of three year old heath at Lake Wau Wauka; around 500 ha of five year old heath divided between Lakeview Track (130 ha), Sandpatch Point (190 ha), Easby Creek (100 ha), Golden Slipper (60 ha) and Swan Lake (50 ha); 40 ha of 20 year old heath north of the Cicada Trail; and 220 ha of 32 year old heath near Tamboon Inlet (60 ha) and near Sydenham Inlet (160 ha).

The burning programme begins in 1984/85, with the burning of the 220ha of 32 year old heathland between Sydenham Inlet and Tamboon Inlet. In

Table 6. The heathlands of Croajingolong National Park.

Locality	Area (ha)	Age Since Fire (years)	Graminoid or Diverse Shrub
Wau Wauka	128	3	G
Lakeview Tk	128	5	G
Shipwreck Tk	250	1	G
Shipwreck/Seal Ck Coast	161	1	DS
Seal Ck - Benedore River	299	1	G
Benedore River Mouth	29	1	DS
Sandpatch Point	220	1/5	G
Easby Ck Mouth	150	1/5	DS/G
Golden Slipper	60	5	G
Mueller Link Tk	200	1	G
Humphrey Tk	40	20	G
Cicada Trail	170	1	G
Camp Ck Tk	36	1	G
Gale Hill	90	1	G
Mueller River Mouth	35	1	DS
Bald Hills	22	14?	DS
Thurra/Clinton	371	1	G
Everard Rd	28	1	G
Tamboon Inlet	61	32	G
Sydenham Inlet	157	32	G
Swan Lake	54	5	G

Table 7. Age stucture table for the graminoid heathlands in Croajingolong National Park, showing suggested management.

POPⁿ PHASE	FIRE AGE	FIRE SEASON										
		84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95
1	1		270		200		250		200		200	
	2	1500		270		200		250		200		200
2	3		1500		270		200		250		200	
	4	130		1500		270		200		250		200
	5		130		1500		270		200		250	
	6	500		130		1500M250		270		200		250
	7		500		130		1250		270		200	
	8			500M200		130		1250M200		270		200
	9				300		130		1050		270	
	10					300		130		1050M200		270
3	11						300		130		850	
	12							300		130		850M200
	13								300		130	
	14									300		130
	15										300	
4	16											300
	17											
	18											
	19											
	20											
5	21+	270										
Carrying capacity:		68	63	213	220	220	245	245	263	263	348	318

Table 8. Age structure table for the diverse shrub heathlands in Croajingolong National Park, showing suggested management.

POPn PHASE	FIRE AGE	FIRE SEASON										
		84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95
1	1	275		22			40		35		40	
	2		275		22			40		35		40
2	3			275		22			40		35	
	4				275		22			40		35
	5					275 M40		22			40	
3	6						235		22			40
	7							235 M35		22		
	8								200		22	
	9									200 M40		22
	10										160	
4	11											160 M40
	12											
	13											
	14	22										
	15		22 M22									
5	16+											
Carrying capacity:		2	2	30	30	32	50	50	48	48	44	32

		95/96	96/97	97/98	98/99	99/2000
1	1	40		40		40
	2		40		40	
2	3	40		40		40
	4		40		40	
	5	35		40		40
3	6		35		40	
	7	40		35		40
	8		40		35	
	9			40		35
	10	22			40	
4	11		22			40
	12	120		22		
	13		120 M40		22	
	14			80		22
	15				80 M40	
5	16+					40
Carrying capacity:		32	32	34	38	30

1986/87, 200ha of heath that will then be eight years post-fire should be burnt. This would be comprised of some (perhaps all) of the Lakeview Track heaths and some of the heaths between Sandpatch Point and the Golden Slipper. The Swan Lake heaths, although of suitable fire age, should not be burnt at this time as they are an important source of recolonising birds in the west of the Park. In 1988/89, 250ha of the 1500ha burnt in the 1983 fire is to be burnt. Burning will then be concentrated in this age class for the next decade.

The diverse shrub heathlands are of considerably less importance in maintaining the Ground Parrot population levels due to their small size. They are, however, the vegetation type most associated with the bird by both locals and visitors. This is because they are easily accessible and are easier to walk through than graminoid heaths, so that they are the areas where people most often see the Ground Parrot.

Of much greater significance are aspects of their vegetation. The diverse shrub heathlands in the Seal Creek - Shipwreck Creek area are exceptionally rich in plant species. **In terms of local diversity they are probably the richest vegetation type in Victoria and one of the richest in Australia.** They contain a number of rare plants. Russell & Parsons (1978) have shown that fire has a role in maintaining floristic diversity in heathlands and I believe that the burning regime recommended for the Ground Parrot is compatible with the maintenance of the botanical values of the area. The importance of avoiding bull-dozing breaks through this vegetation is again emphasised.

In some coastal sites (e.g. the mouth of the Benedore River) small areas of diverse shrub heathland grade into graminoid heathland. As it would be difficult to manage the two heath types separately, the burning programme suitable for the most abundant heath type at the site should be used.

Table 8 shows the heath age structure table for the diverse shrub heathlands in the Park, and shows the future management programme that would apply in the absence of unplanned fires. It would be altered when such fires occur.

The programme calls for the burning of the 20 ha of heath at Bald Hills in autumn 1985, then waiting three years before beginning the burning of 40 ha of heath every two years. This initial three year wait is to allow the very large area of heath burnt in 1983 to regenerate as much as possible before burning began in it.

(iii) Sedgelands

The sedgelands in Croajingolong National Park require no special management, although in general they should be protected from fire. They certainly need not be intentionally burnt. The occasional fire will probably not harm them. If it is proposed to burn them for any reason, they should be burnt in spring-early summer, as they harbour large numbers of dispersing birds outside this period.

Heathlands to the north of Croajingolong National Park

There are large areas of heathland between Croajingolong National Park and the Princes Highway that have yet to be mapped and surveyed for Ground Parrots. Their approximate distribution is indicated on Map 1. They are all graminoid heathlands and are likely to be suitable for Ground Parrots. Once the relevant base data has been collected, the design of a heathland

management programme would be as for the Croajingolong graminoid heathlands, with which their management should be integrated. I estimate that the data could be collected and incorporated into a management plan in six-eight man-weeks of field research and analysis.

Bemm River - Marlo region

Meredith and Isles have mapped the heathlands of this region, but did not assemble fire history data. Their brief survey in the region found Ground Parrots in the diverse shrub and graminoid heathlands near Cape Conran, but they did not locate any in the extensive inland graminoid heaths. They ascribed this absence to the effects of past frequent burning for cattle grazing purposes. However, the bulk of these inland heathlands were not surveyed, and it is very likely that some still support Ground Parrots. Further field work is required to determine the current extent of suitable heaths. If this is done, and fire histories prepared, management would be as for Croajingolong. This work would take six-eight man-weeks.

In the Cape Conran area, fire histories and some more field data are needed before a heath management plan can be drawn up (about two man-weeks).

Gippsland Lakes

The sedgelands of the Gippsland Lakes do not support any breeding populations of the Ground Parrot, but are used by dispersing birds. No special management is required.

Gellions Run

The existence of heathlands in this area was not known to Meredith and Isles. I have surveyed the area and did not find any Ground Parrots. The heaths appear to have once been suitable for the bird (although I could find no reliable past records) but have suffered from too frequent fires. No management is currently required for Ground Parrots.

Wilsons Promontory National Park

Meredith and Isles partially surveyed the heathlands of this Park and suggested that populations were rather low (<100 birds) due to the generally old age of the heaths. Further work by myself, for the National Parks Service in 1981, showed that there was a greater diversity of fire ages than first realised and that Ground Parrots were more abundant than thought, with an estimated population of 200-250 birds. Nonetheless, there remains a marked bias towards older ages in the age structure of the heathlands and more burning is required.

Detailed recommendations are not made here as a suitable map of the heathlands is lacking. My studies in 1981 showed that the heathlands of the Park are a very complex mosaic of different vegetation types and without an adequately ground-checked map it is impossible to know which heaths are suitable for Ground Parrots and which not. The basic floristic data for a map have been collected, but considerably more ground-checking is required. The production of a map would require eight man-weeks. The maps in Meredith

and Isles are totally inadequate except as a general indication of the extent of the heathlands.

Data on Ground Parrot densities at different fire ages show that the population cycle of the bird here is very similar to that in Croajingolong, so that management would be similar.

The several sedgelands in the Park do not require management, except that they should in general be protected from burning.

Blanket Bay - Cape Otway National Park

These small heathlands (mapped in Meredith and Isles' report) no longer support a population of the Ground Parrot. If it is desired to manage them so that they will be suitable for Ground Parrots that might recolonise from the Carlisle heaths or be reintroduced, then a burning cycle of 16 years should be used. The feasibility of reintroduction is discussed in the section on Genetics.

Carlisle heathlands

Map 2 shows the distribution, area and fire ages of the Carlisle heathlands. It replaces the inadequate map of Meredith and Isles. The recent survey results show very low population levels despite large areas of suitably aged habitat being available. As discussed on p. 8 this is the result of two periods of broad-scale fuel-reduction burning in the recent past. Management must aim to increase population levels and to prevent further population crashes occurring.

The proposed burning scheme is given in Table 9. Some heaths have been excluded due to their high past burning frequency. They are mostly small but one 800 ha patch between the Carlisle River - Gellibrand Road and Coles Creek is the largest single patch in the region. It is possible that parts of this large heath may still be suitable for the bird - this could be easily ascertained by occasional future censuses by field staff.

The burning cycle is a 16 year one, with 12.5% being burnt every two years (about 210 ha, with allowable variation 180-240 ha). This cycle is a provisional one, as there are no data from the area on population densities. It was arrived at by assuming that the higher growth rates of the heath vegetation in this climate, compared to Gippsland, would shorten both the recolonisation phase and the decline phase, and, to a lesser extent, the plateau phase. Once population levels return to normal, the actual population cycle should be determined. This burning cycle would result in a stable population of about 200 birds.

Table 3 gives the areas and fire ages of the heaths. Heaths older than 16 years occur at Sandy Creek, west of the pumping station and at Egans Track. Some of the Crinoline Creek heaths are now in the decline phase. All these areas, along with 36 ha of 12 year old heath at Mt McKenzie, should be burnt in 1984/85. Two hundred hectares of heath that is presently 11 years old at Crinoline Creek and Atkinsons Creek should be burnt in 1986/87. In 1988/89, the remaining heath at Crinoline Creek should be burnt, plus the Lavers Hill Road heaths and 60 ha of the large area of heath that is currently four years old. In 1990/91, a further 120 ha of this heath should be burnt along with 22 ha at Rifle Range Track, 20 ha near the old Mt McKenzie track and 30 ha at Cricket Pitch Track. The Boggy Creek heathlands would be burnt in 1992/93. The pattern of burning after this is clear from the table.

Table 9. Age structure table for the Carlisle heathlands, showing suggested management.

POP^{n}. PHASE	FIRE AGE	FIRE SEASON										
		84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95
1	1		200		200		200		200		220	
	2	200		200		200		200		200		220
2	3		200		200		200		200		200	
	4	650		200		200		200		200		200
	5		650		200		200		200		200	
	6	220		650		200		200		200		200
3	7	50	220		650		200		200		200	
	8	30	50	220		650 M60		200		200		200
	9	70	30	50	220		590		200		200	
	10		70	30	50	220		590 M120		200		200
	11	270		70	30	50	220		470		200	
	12	40 M40	270		70	30	50	220		470		200
4	13			270 M200		70 M70	30	50 M50	220		470	M240
	14				70			30 M30		220 M220		470
	15	20 M20				70 M70						
5	16+	140 M140										
Carrying capacity:		181	213	186	251	244	255	250	236	236	207	207

Note: Those heathlands that have been degraded by frequent burning are not included in this table.

No allowance has been made in this burning programme for the present apparent prohibition on management burning in the Crinoline Creek reference area (shown on Map 2). The Land Conservation Council's final recommendations for this reference area state: "...these areas must not be tampered with, and natural processes should be allowed to continue undisturbed...experimental manipulation should not be permitted...". I believe that the Reference Areas Committee should be consulted by the Fisheries and Wildlife Division and the Division of Forests, and asked to consider allowing management burning in this area, due to its importance for the conservation of the Ground Parrot in the region.

The biota of the refernce area will not be able to tell the difference between a management burn and a "natural" fire. The only unnatural attribute of a management burn will be that its timing is determined by human agency. Already, however, the burning frequency of the reference area has been altered, by the active fire management that goes on all around it, which must alter the frequency of wildfires in the region. It is no longer possible to consider that such a small area has a "natural" fire regime.

If management burning is not to be allowed, then the area will be excluded from the programme and the heath age structure tables will need to be altered accordingly.

The low frequency of wildfires in the area should make it possible to follow this management programme reasonably closely, particularly given the high degree of flexibility inherent in it. Due to the present very low population levels and this isolation of this population, population growth will take between five and ten years to reach carrying capacity. For this reason, and for genetic reasons, the possibility of a transfer of birds from another population should be considered. **The addition of 20-40 birds could up to halve the time required before carrying capacity is reached.**

Monitoring of population levels should be carried out to assess the effectiveness of management. This could be done by local field staff and would require only a few evenings spent censusing the birds each spring.

Long Swamp - Discovery Bay Coastal Park

The management needs of the Baumea sedgelands are not known in any detail. Fire in this habitat does not have the important ecological role that it has in heathlands and so burning is not required. In fact, in such an isolated and small habitat patch as Long Swamp, **it is vital that it does not all burn at once should a wildfire occur, as this would lead to the extinction of the Ground Parrot population.** The very wet nature of these swampy areas is somewhat of a natural safeguard in this respect, but it can not be relied upon, especially in dry years.

The hydrological requirements of these sedgelands are also not known, but, judging from the sharp zonation of vegetation in such areas, they appear to be rather narrow. Changes in groundwater levels, therefore, may have major implications for the sedgelands. Although it is clear that parts of the Long Swamp system have seen a reduction in the area of open water in historical times (Cerini, 1971; M.Godfrey, pers.comm.), just where and how these changes occurred, or if they affected the Baumea sedgelands is not known. Palynological work in progress (L.Head, pers.comm.) suggests that there was a major change from lake to swamp (including the appearance of Baumea) about 4000 years ago, but more recent changes are difficult to interpret.

The hydrology of the Long Swamp system has not been studied, and, until this is remedied, only general comments can be made. Discussions with Mr

F.Aslin (S.A. Mines Dept.) indicated that local groundwater levels are probably very stable. This is because there is a large, elongate lens of fresh water in the limestone between the Glenelg River and the sea, rising up to 20m above sea level. This enormous reservoir of water is apparently unaffected by variations in rainfall and thus, it is presumed, it would act as a buffer against any change in groundwater level. It is notable in this regard that no obvious changes in the level of Long Swamp were reported during the recent prolonged drought.

Thus, it is likely that the local hydrology is very stable. Nonetheless, any major change in groundwater level would potentially endanger this population of Ground Parrots, so the situation should be monitored by the rangers.

If management were to become necessary, in order to ensure the survival of this population, two factors will need to be considered beforehand. One is the cost and effectiveness of any hydrological management. Probably the cheapest technique that might be applicable to the area would be the use of earth-moving equipment to open or close the various outlets of Long Swamp. This has been tried in the past and was basically ineffective (Cerini, 1971). There would also be problems with aesthetics, especially at Eel Creek. Other options (e.g. dredging, drains, pumping) are likely to be costly, aesthetically obtrusive and quite possibly ineffective. Any research planned should be directed towards finding practical management solutions.

The second factor to be considered is whether the Long Swamp Ground Parrot population merits saving. The Ground Parrot is not an endangered species, although extinction of many local populations has been a feature of its recent history. The Long Swamp population is of biogeographical interest as it represents the westernmost edge of the bird's eastern Australian range, but this is a somewhat artificial status as it is due to a recent man-caused range reduction (Meredith, 1983). If both Long Swamp and the vulnerable Carlisle population were lost, however, this would represent a major reduction in the Ground Parrot's Victorian range.

Aesthetic and cultural significance are difficult to determine for any species. A broad view of these categories might regard aesthetic value as any aspect of a species that contributes to human enjoyment and perception of the environment, excepting scientific and economic factors, and cultural value as any aspect of a species that is part of history, folklore, tradition or modern culture. On this basis, the Long Swamp population has no cultural significance and only limited local aesthetic significance.

Scientifically, the population is of interest as it is one of the few remaining populations in Baumea sedgelands, a habitat in which the bird's ecology has not been studied. A comparative study of the Ground Parrot in this very stable and non-diverse environment as compared to in the dynamic and very diverse heathland ecosystem would be potentially most interesting.

In terms of population genetics, this population must be considered already in danger of decline through inbreeding. This is discussed further in the section on Genetics.

GENETIC ASPECTS OF THE CONSERVATION OF THE GROUND PARROT

In his report "Conservation Genetics in Victoria", Brown (1983) discusses the genetic consequences of size and isolation of Ground Parrot populations in relation to their long-term viability. Using the data from Meredith and Isles he concludes that the East Gippsland populations are genetically continuous with those in southern New South Wales and are thus large enough to be free from genetic constraints, but that the Wilsons Promontory, Long Swamp and Carlisle populations do suffer from genetic constraints.

At Wilsons Promontory, Brown suggests that the size of the population is probably large enough to prevent inbreeding depression (the subsequent upward revision of population size confirms this) but that the population is genetically isolated and would require occasional artificial introductions from East Gippsland. This, in fact, may be the case, but it should be noted that there is a chain of coastal sedgelands from Corner Inlet to the Gippsland Lakes that may well allow dispersing Ground Parrots to travel between East Gippsland and Wilsons Promontory. If this is so, the rate of immigration would be very low - enough to maintain the same alleles in each population but not enough to swamp selection or drift in the Promontory population (A.Brown, pers.comm.).

Brown considers the Long Swamp population critically small and isolated and needing intensive artificial gene flow in order to survive, and that the Carlisle population would also need genetic management, and that without this neither population could contribute to the long-term survival of the species. This would be true also of any population at Blanket Bay.

I am in basic agreement with all his conclusions, though I remain cautious (as does Brown) of the exact quantitative predictions of population genetics until more supporting data have been collected from a wide variety of species and environments. Nonetheless, the qualitative conclusions are of great importance in planning management strategies and setting priorities.

The problem of inbreeding depression is, I believe, the most significant in the short term. The Long Swamp population (60 birds) is likely to suffer from it, as is the Carlisle population at its present very low levels. To alleviate this situation, an immediate input of birds from other populations would be required, followed by constant smaller inputs at Long Swamp. The Carlisle population should become large enough in five to ten years to be free of dangerous levels of inbreeding. Discussions with Brown indicate that the initial input should be at least four to five birds, preferably females. This means four to five birds that survive and breed, so, in practice, a higher number would be required. Thereafter, artificial immigration of one bird per generation would maintain variation.

While it would be possible to reintroduce the Ground Parrot to the Blanket Bay heathlands, it is clear from the above discussion that the population would need intensive genetic management if it were to be able to contribute to the long-term survival of the parrot in Victoria. It is quite possible that the Blanket Bay heaths might be recolonised by birds dispersing from the Carlisle heaths once numbers have built up there.

Brown emphasises in his paper the need to carefully choose the source of any stock for translocation. This is probably not of particular importance in this case as all Victorian Ground Parrot populations were presumably connected before European colonisation. However, there are no data on variation within the Victorian populations.

Finally, the Ground Parrot in Victoria provides an excellent opportunity to study the effects of small population size and isolation on

the genetics of a bird species. The Ground Parrot is present in a series of populations ranging in size from very large to very small. These populations vary in their degree of isolation and in their time since isolation, both of which are either known or easily ascertained. I believe that such a study should be considered, not only as a useful data base for making decisions on genetic management, but also for its potential value to the science of conservation genetics.

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