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Managing the Ground Parrot in its fiery habitat in south-eastern Australia

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Abstract

The Ground Parrot (*Pezoporus wallicus*) is a rare and iconic endemic of heathlands in southern Australia. It is threatened by frequent and widespread fire. The species has been an integral element in the development of our understanding of the impacts of fire regimes in heathlands and is an integral part of conservation management of these fire-prone ecosystems. This long-term study documents the densities of Ground Parrots in three areas of long-unburnt habitat in southern New South Wales. Using area searches and aural surveys, we estimated densities of Ground Parrots at Barren Grounds Nature Reserve–Budderoo National Park (1983–2009), Beecroft Weapons Range (1997–2008) and Nadgee Nature Reserve (1995–2009). At each location, the species occurred in long-unburnt habitat (20 years post-fire), sometimes at high densities (2 birds per 10 ha). We recommend that, in south-eastern Australia, fire should not be used to manipulate the ecological functioning of habitat for the persistence of Ground Parrot populations and conclude that there should be area-specific adaptive management plans that specify how the important elements of the biodiversity will be conserved and how this will be measured.

Keywords

australia, eastern, south, ground, habitat, managing, fiery, its, parrot

Disciplines

Life Sciences | Physical Sciences and Mathematics | Social and Behavioral Sciences

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Managing the Ground Parrot in its fiery habitat in south-eastern Australia

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Abstract

The Ground Parrot (*Pezoporus wallicus*) is a rare endemic species of heathlands in southern Australia. It is threatened by frequent and/or widespread fire. It has been iconic in the development of understanding the impacts of fire regimes in heathlands and is an integral part of conservation management of these fire-prone ecosystems. This long-term study documents Ground Parrot densities in three areas of long-unburnt habitat in southern New South Wales. Using area searches and aural surveys, we estimated Ground Parrot densities at Barren Grounds Nature Reserve – Budderoo National Park (1983-2009), Beecroft Weapons Range (1997-2008) and Nadgee Nature Reserve (1995-2009). At each location, the species occurred in long-unburnt habitat (≥ 20 years post-fire), sometimes at high densities (≥ 2 birds per 10 ha). We recommend that in south-eastern Australia, using fire to manipulate the ecological functioning of habitat is currently not needed for the persistence of Ground Parrot populations and conclude that there is a need for area-specific

adaptive management plans, which specify how they will strive for and measure the persistence of important elements of the biodiversity to be conserved.

Key words: conservation, fire, heathland, *Pezoporus wallicus*, population, threatened species

Running head: Ground Parrot persistence in long-unburnt habitat

Introduction

Managing for biodiversity conservation is about identifying and conserving populations and ecological communities, not about maximizing the numbers within individual species (May 1994); not even iconic species like the Ground Parrot (*Pezoporus wallicus*). Autecological studies build knowledge to guide the management of populations and single species but the pragmatism and compromise inherent in synecology is needed in order to manage the many populations that comprise an ecological community (Bradstock *et al.* 2005). The Ground Parrot, which has been iconic in the investigation of fire regimes in heathlands, has played an integral and sometimes leading part in the conservation management of these fire-prone communities.

Heathlands cover a small proportion of Australia yet their nutrient-poor soils support a diverse flora and fauna (Keith 2004). The structure and composition of the heathland vegetation produces fire fuels that are fine, suspended and well aerated. Consequently, heathlands in south-eastern Australia are highly fire-prone (Recher 1981; Keith *et al.* 2002). The management of fire in these ecosystems has been a matter of considerable debate and research. For the maintenance of plant diversity in heathlands of New South Wales (NSW), the established domain of fire intervals is considered to be 7 to 30 years (Kenny *et al.* 2004). The flammability of heathland should not be misinterpreted as a

reason to burn every 7 years; Kenny *et al.* (2004) stressed the need for the interval between fires to be greater than 20 years in some parts of a landscape.

The Ground Parrot is a rare endemic of coastal and adjacent elevated heathlands in southern Australia and is threatened by frequent and/or widespread fire (Higgins 1999). Because of its camouflaged plumage and cryptic nature, studying the Ground Parrot presents some logistic difficulties. Until recently, two subspecies, the Western Ground Parrot (*P. w. flaviventris*) and Eastern Ground Parrot (*P. w. wallicus*), were recognized (Higgins 1999), although Murphy *et al.* (2009) foreshadowed a separation into two distinct species based on recent genetic evidence. The Ground Parrot is listed as Threatened in NSW, Victoria and Queensland and as Critically Endangered in Western Australia. Lore had it that frequent fire, about once per decade or less, was necessary to maintain suitable habitat for the Ground Parrot (e. g. Forshaw 1969) and earlier studies sought to define suitable fire frequencies in southern Queensland (McFarland 1989), Barren Grounds in central NSW (Jordan 1987), Victoria and southern NSW (Meredith and Isles 1980; Meredith and Jaremovic 1990), Tasmania (Bryant 1991) and Western Australia (Burbidge *et al.* 1989). However, Meredith *et al.* (1984) concluded that sedgeland without frequent fire can provide habitat for the Ground Parrot, Baker and Whelan (1994) suggested that the species might persist in long-unburnt habitat, Bryant (1994) recommended against prescribed burning for Ground Parrot habitat in Tasmania and Burbidge *et al.* (1989; 1997) recommended fire exclusion in Ground Parrot habitat in Western Australia. In Queensland, information on long-unburnt habitat was lacking as nearly all heathlands with known fire age were less than 15 years post-fire (McFarland 1991a). Importantly, the Ground Parrot should not be regarded as a fire-dependent species (Meredith *et al.* 1984), although it appears to be adapted to its fiery habitat.

In January 1983, an unplanned fire burned 280 ha at Barren Grounds Nature Reserve, much of it considered to be potential habitat for Ground Parrots. At that time, the conventional wisdom

guiding habitat management for Ground Parrots was to prescribe a fire frequency of 6-10 years for the whole reserve. Given the dearth of knowledge specific to this important reserve, it was pertinent to ask: What is the appropriate fire frequency to maintain habitat suitable for the local Ground Parrot population? An 80 ha study site was established, and recolonization started after about a year (Jordan 1984). A decade later, survey results showed a high density (2.8 birds per 10 ha) of Ground Parrots (Baker and Whelan 1994). Given this observation at a single site, our interest broadened to include other sites in NSW and the question shifted to: What happens to Ground Parrot numbers in long-unburnt habitat?

The aims of this paper are (i) to draw together results from three geographic areas for which we have estimated the density of Ground Parrots in long-unburnt habitat and (ii) to highlight the implications of this current knowledge for future management of the species and its habitat in south-eastern Australia.

Methods

The Ground Parrot was surveyed and time-series data were collected at Barren Grounds Nature Reserve and the neighbouring Budderoo National Park (34.7°S, 150.7°E) 1983-2009, Beecroft Weapons Range at Jervis Bay, (35.0°S, 150.8°E) 1997-2008 and Nadgee Nature Reserve (37.4°S, 149.9°E) 1995-2009. The centres of the survey sites at each location are given to the nearest second of latitude and longitude. Fire age at each site was determined by using internal documents from the land managers at each location, which were confirmed in the field by the authors.

At Barren Grounds – Budderoo, there was a mosaic of fire-ages spanning 0-30 years. Data were collected at five sites within the vegetation class Sydney Coastal Heaths (Keith 2004) at 570-600 m above sea level. The main survey area was 80 ha of Redbank Gully (37° 27' 12"S, 37° 27' 12"E),

which burned in an unplanned fire in January 1983. The other areas we named Fox (37° 27' 12"S, 37° 27' 12"E), Griffiths (37° 27' 12"S, 37° 27' 12"E), Noorinan (37° 27' 12"S, 37° 27' 12"E) and Budderoo (37° 27' 12"S, 37° 27' 12"E). At Beecroft, data were collected at four sites in a mosaic of fire-ages spanning 0-38 years in Sydney Coastal Heaths (Keith 2004) at 10-80 m above sea level. The sites were named Beekeepers (37° 27' 12"S, 37° 27' 12"E), Boat Harbour (37° 27' 12"S, 37° 27' 12"E), Gunnery (37° 27' 12"S, 37° 27' 12"E) and North (37° 27' 12"S, 37° 27' 12"E). At Nadgee, there was a uniform fire-age resulting from an extensive unplanned fire in 1980. Data were collected at three near-coastal sites in South Coast Heaths (Keith 2004), at 10-50 m above sea level. The sites were named Nadgee Moor (37° 27' 12"S, 149° 57' 41"E), Endeavour Moor (37° 28' 30"S, 149° 57' 52"E) and Impressa Moor (37° 25' 37"S, 149° 56' 59"E). Data were also collected at one site within South Coast Heaths (Keith 2004) at 410-480 m above sea level, near Mt Nadgee, which we called Upland Heath (37° 23' 49"S, 149° 52' 36"E).

It is not possible to count Ground Parrot populations precisely because of their dense habitat and cryptic nature. The density of birds was estimated by aural survey and by area search. Aural surveys were conducted at dusk and dawn during the period of maximum Ground Parrot calling, which is for approximately 20 min - starting 20 minutes after sunset and 40 minutes before sunrise (McFarland 1991b). Surveyors were trained by experienced personnel to count 'rising' calls and 'level' calls (*sensu* McFarland 1991b) using a recording of these calls and with practice in the field. One survey was conducted from a fixed point at each site during each survey period (annually except for Redbank Gully), in habitat of known fire-age. Following the protocol of Bryant (1991) and from our own experience, we assumed that in ideal conditions of no wind or rain, the maximum distance for a Ground Parrot call to be detected was 400 m, which gives a listening area of 50 ha. In less-than-ideal conditions, the detection distance and hence the survey area was reduced with increasing wind and/or rain and, in the case of Nadgee, noise from the surf. For each survey, the position of every call was mapped, the separate calls were counted and attributed to individual birds

and from the map of calls, the number of birds was estimated as the minimum justified by the call survey data. Surveys were generally conducted by one person but if several surveyors were present, the number of birds was estimated by consensus. This method of density estimation has some shortcomings. While estimating the number of birds is easy to do when individual birds are widely separated and call repeatedly from a single location, it becomes increasingly difficult with more birds, more calls, and when birds move about. Furthermore, data are biased by the calling rates of the birds on the day of the survey, and the surveyors' ability to hear calls and estimate the detection distance and the number of birds.

The area searches used 'beaters' spaced at approximately 10 m that proceeded slowly and noisily through the area and counted the Ground Parrots that were flushed. To minimise double counting, the place where each flushed bird landed was noted and if a bird was flushed from that vicinity it was not counted (called a 'recount'). The area search method obviously requires many people and considerable time and effort compared to the aural survey and relies on all birds being flushed and seen.

Area searches began at the Redbank Gully site at Barren Grounds in 1983. After 1995, aural survey was used at Beecroft and Nadgee and it was also used at Barren Grounds – Budderoo to supplement the area search counts, particularly at Redbank Gully for which there was an aural survey each year to coincide with the area search. In recent years, with the apparent drop in population numbers at Redbank Gully, aural surveys were conducted more frequently, though on an *ad hoc* basis throughout the year.

Results

For Barren Grounds – Budderoo, at Redbank Gully, at least one area search of 80 ha was conducted every year from 1983 to 2007 (Fig. 1a). The exceptions were 8.2, 8.7 and 15.6 years post-fire when 67%, 80% and 70% of the area was searched. No Ground Parrots were detected at one and seven months post-fire (Jordan 1984) or in 2003 (20.6 years post-fire), although one bird was flushed from the survey area the day before the area search in 2003. In 2001, 18.6 years post-fire, the area search gave a low estimate (1 bird per 10 ha); this result is compared with five coincident aural surveys (see below).

At Redbank Gully, 44 aural surveys were conducted 12.6-26.8 years post-fire (Fig. 1a). On 13 occasions, an aural survey coincided with the annual area search, usually the night before, and there was a high correlation between the estimated density for the two methods ($r = 0.90$, $P < 0.001$), with the aural survey method yielding lower density estimates (64%) than the area searches. In the period 20-27 years post-fire, although the area searches yielded low densities (<1 bird per 10 ha), 19 aural surveys outside August, the month of the area searches, yielded moderate densities (mean 1.5 birds per 10 ha, range = 0.75-2.3).

The average number of beaters helping with the Redbank Gully area searches from 1991 to 2007 was 49 people ($n = 17$ surveys; range = 27-101 people). The number of beaters was not correlated with the density estimates of Ground Parrots in the area ($r = 0.037$; $P > 0.5$).

At Barren Grounds – Budderoo there were three area searches in 40 ha at Fox (using 8, 9 and 31 beaters respectively), one in 8 ha at Noorinan (2 beaters) and one in 20 ha at Griffiths (22 beaters) and there were 20 aural surveys outside Redbank Gully (Fig. 1b). In 2001, to coincide with the annual Redbank Gully area search, simultaneous aural surveys in ideal conditions were conducted at five locations across a span of 5 km at Barren Grounds – Budderoo in habitat with fire-ages of 6.3, 10, 18.6, 20 and 22 years. Only one Ground Parrot was detected and this was at Redbank Gully.

For Beecroft, aural surveys at Beekeepers, Boat Harbour and North detected Ground Parrots in the oldest fire-age habitat at each site (Fig. 2). At Gunnery, surveying began in 1997, with 25% of the site last burned in 1990 and 75% last burned in 1992. A fire in 2003 burned across some parts of both the 1990 and 1992 fire-ages, resulting in a site with three fire-ages: 40% burned in 1990, 20% burned in 1992 and 40% burned in 2003. This mosaic of fire-ages resulted in areas which were too small to use for bird densities calculations but did demonstrate that Ground Parrots can inhabit adjacent areas that are recently burned (1-5 years post-fire) and older habitat (13-16 years post-fire). For Nadgee, aural surveys were conducted 14.9-28.8 years post-fire (Fig. 3).

Discussion

The Ground Parrot in long-unburnt habitat

In our study of Ground Parrot densities in relation to time since last fire, the most important conclusion is that the species often occurs in long-unburnt habitat, sometimes at high densities. This has happened at Barren Grounds, Beecroft and Nadgee where densities of ≥ 2 birds per 10 ha were recorded in heathlands ≥ 20 years post-fire. These results are consistent with the pattern found in a number of earlier studies, which cited two sites with 2 birds per 10 ha in habitat 28 years post-fire at Croajingalong National Park in Victoria, an area which is contiguous with Nadgee in NSW (Meredith and Isles 1980); six sites 11-13 years post-fire with 2 birds per 10 ha (McFarland 1989), five sites 15-20 years post-fire with 0.8-2.9 birds per 10 ha (Spearritt and Krieger 2007) and 3 sites 20-37 years post-fire with 0.5-1.8 birds per 10 ha (McFarland, unpubl. data) in Queensland; five sites >30 years post-fire with an average of 1.2 birds per 10 ha in Tasmania (Bryant 1991); and a very high frequency of calling from the Western Ground Parrot in habitat not burned for >40 years at Fitzgerald River National Park (Burbidge *et al.* 2007). Also consistent with a pattern in some

earlier studies, was that at some of our sites the highest Ground Parrot densities occurred at intermediate post-fire ages.

The long-term, longitudinal study at Barren Grounds – Budderoo has provided insights into the fine-scale and short-term variations in Ground Parrot density at a particular site, which highlight the difficulties of interpreting survey data and caution against management decisions based on a single survey for the species. The low density estimate for August 2001 (18.6 years post-fire) was the first indication that bird numbers at Redbank Gully might have fallen, fitting with the idea that the density of Ground Parrots declines to zero in long-unburnt habitat. The area search gave a density of only 1 bird per 10 ha (8 birds and 2 recounts) and the aural survey gave 0.2 birds per 10 ha (just one call from one bird). At the time, we interpreted this as a population crash from the large numbers of the previous year, when the area search estimated 3.4 birds per 10 ha (27 birds and 28 recounts) and the aural survey estimated 2.8 birds per 10 ha (103 calls were heard from an estimated 11 birds in 40ha). However, later surveys revealed that the population was not simply declining to zero. In 2002, the estimated density was high again (2.6 birds per 10 ha; 21 birds and 14 recounts) and the population was persisting (2.3 birds per 10 ha) at our last aural survey in 2009 (26.8 years post-fire). Moreover, aural surveys in 2001, in habitat spanning 5 km in all five different fire-ages across the two reserves, revealed that birds were generally in low numbers or absent. Most importantly, no birds were detected in the habitat with fire-ages 6.3 years or 10 years. This suggests that Ground Parrots were scarce in the broader area, regardless of the post-fire age of the habitat. If larger numbers of birds had been detected in the habitats with younger fire-ages, this could have been taken as evidence of preference for more recently burned areas over those with older fire-ages. As an aside, aural surveys at Gunnery, Beecroft, in 2004 and 2005 detected no Ground Parrots in the older fire-age areas of the site and high densities in the recently burned area. However, once again this pattern broke down over time because in 2008, the areas that were 5 and 16 years post-fire both had Ground Parrots.

The results for Redbank Gully at Barren Grounds 20-27 years post-fire show strong intra-year variations (Fig. 1a). Given that density estimates for the aural surveys and area searches in winter each year are generally in alignment and that aural surveys have typically yielded higher estimates in other seasons over multiple years, we consider this to be a true pattern, not an error of sampling. This is an intriguing pattern but we are unable to suggest an underlying causal process.

Management and conservation

Current knowledge of the Ground Parrot allows us to make the following eight recommendations for management and conservation of the species and its habitat in south-eastern Australia.

Although planned fire is a tool with widespread value in modifying habitat to meet particular management objectives, maintaining the ecological processes needed for long-term persistence of Ground Parrot populations does not require the application of fire. This recommendation is based on the evidence which shows that Ground Parrots in south-eastern Australia are found in long-unburnt heathlands but comes with the strong caveat that our current understanding is based on the relatively short period of only the last few decades. It removes the emphasis on frequent fires and allows for an adaptive management approach, which in turn necessitates monitoring.

We recommend against applying a single fire prescription across areas with Ground Parrot habitat. Williams *et al.* (1994) demonstrated that a fire prescription in an ecosystem may not deliver the same conservation outcomes through time or across different places; that is, the prescription may not be ‘portable’. For the three locations we studied, each takes an adaptive approach to management planning. For instance, notwithstanding the recommendations of Kenny *et al.* (2004) for fire intervals in NSW vegetation communities, in recognition that the Endangered Eastern

Bristlebird (*Dasyornis brachypterus*) is fire-sensitive (Baker 2000), the Plan of Management for Nadgee (NPWS 2003) specifies that upper biodiversity vegetation thresholds may be exceeded if the Eastern Bristlebird population continues to recover. The response of populations, including the Eastern Bristlebird and Ground Parrot, to the management of processes such as fire and predation is being monitored and will be used to inform future planning for Nadgee. For Barren Grounds – Budderoo, the Plan of Management acknowledges that maintenance of the different vegetation communities requires differing fire regimes (NPWS 1998) and on-ground management for the last decade has been guided by studies of several iconic threatened species, particularly the Long-nosed Potoroo (*Potorous tridactylus*) (Norton 2009), Ground Parrot and Eastern Bristlebird.

Specifically for Ground Parrot habitat, we recommend fire exclusion for at least 7 years post-fire. This is based on the minimum fire frequency proposed for heathlands by Kenny *et al.* (2004) and recognition that Ground Parrot populations are threatened by frequent fires. Fire kills individuals (Fox 1978) and causes habitat to be unsuitable for feeding or breeding for up to 3 years (McFarland 1989). Current planning for Nadgee (NPWS 2005), Beecroft (Bushfire and Environmental Services 2001) and Barren Grounds – Budderoo (NPWS 1998) is explicit in this regard. We also recommend that management plans should identify long-unburnt refuges for Ground Parrots, wherever this is feasible, and detail how these refuges might be protected from fire. This is based on the threat posed by widespread fires, which temporarily convert large tracts of habitat to an unsuitable state and isolate these areas from potential sources of colonists once the habitat again becomes suitable post-fire, and the inevitability of extensive unplanned fires in Ground Parrot habitat. Extensive fire is a major threat to the Western Ground Parrot (Burbidge 2003) and the same is almost certainly true for Eastern Ground Parrot populations. Protection of habitat in fire refuges was proposed by Baker (1998) for the Eastern Bristlebird and is currently stipulated for Nadgee (NPWS 2005) where aerial suppression of unplanned fire is the only practicable means of attempting control. Incidentally, the success of pro-active management for the protection of a bird population was graphically illustrated

during the ‘Black Saturday’ forest fires in Victoria in February 2009. A wild population of the critically endangered Helmeted Honeyeater (*Lichenostomus melanops cassidix*), which was established in 2001 in Bunyip State Forest, was protected and saved by the prompt on-ground actions initiated by the Incident Control Officer (Menkhorst *et al.* 2009).

The remaining recommendations relate to monitoring and survey. The mainland populations of the Ground Parrot should be monitored for decades to come. This is based on the rarity and vulnerability to extinction of the species (Garnett and Crowley 2000) and the understanding that the potential for Ground Parrot habitat in a given heathland depends on the dynamics of the plant community. The distribution and abundance of the Ground Parrot in NSW need to be thoroughly documented before monitoring can be used as an effective indicator of population trends within the state. This is because the species’ occurrence is poorly understood in NSW (Higgins 1999), with the exception of the populations in the present study. Aural surveys are adequate for future population monitoring. Our study suggests that they are probably no less precise and certainly much less effort and environmental impact than the area search method. Although we found a high correlation between the estimated densities of the Ground Parrot for aural surveys and area searches, we have not calibrated the methods because of discrepancies with results from Queensland (McFarland 1991a). In the future, automated recording and data analysis may provide a more cost-effective means of ‘aural’ survey (Shukla *et al.* 2004; Acevedo and Villanueva-Rivera 2006). Finally, the adequacy of seed supply to maintain viable Ground Parrot populations in heaths of older fire-age in south-eastern Australia is uncertain and warrants investigation.

We conclude that managing for conservation in the heathland communities where the Ground Parrot occurs should not be determined by simple fauna-fire-dependency models but by area-specific adaptive management plans which specify how they will strive for and measure the persistence of important elements of the community being conserved.

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References

- Acevedo, M. A., and Villanueva-Rivera, L. J. (2006). Using automated digital recording systems as effective tools for the monitoring of birds and amphibians. *Wildlife Society Bulletin* **34**, 211-214.
- Baker, J. (1998). Ecotones and fire and the conservation of the endangered eastern bristlebird. Ph. D. Thesis, University of Wollongong, Wollongong.
- Baker, J. (2000). The eastern bristlebird: cover-dependent and fire-sensitive. *Emu* **100**, 286-98.
- Baker, J., and Whelan R. J. (1994). Ground Parrots and fire at Barren Grounds, New South Wales: a long-term study and an assessment of management implications. *Emu* **94**, 300-304.
- Bradstock, R. A., Bedward, M., Gill, A. M., and Cohn, J. S. (2005). Which mosaic? A landscape ecological approach for evaluating interactions between fire regimes, habitats and animals. *Wildlife Research* **32**, 409–423.

- Bryant, S. (1991). 'The Ground Parrot, *Pezoporus wallicus*, in Tasmania: Distribution, Density and Conservation Status.' (Parks, Wildlife and Heritage, Tasmania: Hobart.)
- Bryant, S. (1994). Habitat and potential diet of the Ground Parrot in Tasmania. *Emu* **94**, 166-171.
- Burbidge, A. H. (2003). Birds and fire in the Mediterranean climate of south-west Western Australia. In 'Fire in Ecosystems of South-west Western Australia: Impacts and Management'. (Eds I. Abbott and N. Burrows) pp. 321–347. (Backhuys: Leiden.)
- Burbidge, A. H., Watkins, D., and McNee, S. (1989). 'Conservation of the Ground Parrot in Western Australia.' (WWF Australia: Perth.)
- Burbidge, A. H., Blyth, J., Danks, A., Gillen, K., and Newbey, B. (1997). Western Ground Parrot Interim Recovery Plan 1996–1999. In 'Interim Recovery Plans 4–16 for Western Australian Critically Endangered Plants and Animals. Western Australian Wildlife Management Program No. 29'. (Eds J. Pryde, A. Brown and A. Burbidge.) Interim Recovery Plan No. 6. pp. i–v, 1–22. (WA Department of Conservation and Land Management: Perth.)
- Burbidge, A. H., Rolfe, J., McNee, S., Newbey, B. and Williams, M. (2007). Monitoring population change in the cryptic and threatened Western Ground Parrot in relation to fire. *Emu* **107**, 79–88.
- Bushfire and Environmental Services, (2001). 'Fire Management Plan, Beecroft Weapons Range.' (Environment Australia: Canberra.)
- Forshaw, J. M. (1969). 'Australian Parrots.' (Lansdowne: Melbourne.)
- Fox, A. M. (1978). The '72 fire of Nadgee Nature Reserve. *Parks and Wildlife* **2**, 5-24.
- Garnett, S. T., and Crowley, G. M. (2000). 'The Action Plan for Australian birds 2000.' (Environment Australia: Canberra.)
- Higgins, P. J. (Ed.) (1999). 'Handbook of Australian, New Zealand and Antarctic Birds. Vol. 4. Parrots to Dollarbird.' (Oxford University Press: Melbourne.)
- Jordan, R. (1984). The Ground Parrot: Effect of fire on a population. In 'Barren Grounds Bird Observatory and Field Study Centre Report 1982-84.' (Eds P. Jordan and R. Jordan.) pp. 28-29. (RAOU: Melbourne.)

- Jordan, R. (1987). The Ground Parrot in Barren Grounds Nature Reserve. In 'Barren Grounds Bird Observatory and Field Study Centre Report 1984-86.' (Eds P. Jordan and R. Jordan.) pp. 19-23. (RAOU: Melbourne.)
- Keith, D. A. (2004). 'Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT.' (Department of Environment and Conservation (NSW): Hurstville.)
- Keith, D. A., McCaw, W. L., and Whelan, R. J. (2002). Fire regimes in heathlands and their effects on plants and animals. In 'Flammable Australia: The Fire Regimes and Biodiversity of a Continent.' (Eds R. A. Bradstock, J. Williams and A. M. Gill.) pp. 199-237. (Cambridge University Press: Cambridge)
- Kenny, B., Sutherland, E., Tasker, E., and Bradstock, R. (2004). 'Guidelines for ecologically sustainable fire management.' (NSW National Parks and Wildlife Service: Hurstville.)
- May, R. M. (1994). Ecological science and the management of protected areas. *Biodiversity and Conservation* **3**, 437-448.
- McFarland, D. C. (1989). 'The Ground Parrot *Pezoporus wallicus wallicus* (Kerr) in Queensland: Habitat, Biology and Conservation.' (Department of Conservation (Qld): Brisbane.)
- McFarland, D. (1991a). The Biology of the Ground Parrot, *Pezoporus wallicus*, in Queensland. III. Distribution and Abundance. *Wildlife Research* **18**, 199-213.
- McFarland, D. (1991b). The Biology of the Ground Parrot, *Pezoporus wallicus*, in Queensland. II. Spacing, calling and breeding behaviour. *Wildlife Research* **18**, 185-197.
- Menkhorst, P., Ingwersen, D., Quin, B., and Cartwright, K. (2009). Surviving 'Black Saturday': The Helmeted Honeyeater and Victoria's bushfire disaster. *Wingspan* **19**, (2), 14-15.
- Meredith, C. W., and Isles, A. C. (1980). 'A study of the Ground Parrot *Pezoporus wallicus*, in Victoria.' (Ministry for Conservation: Melbourne.)
- Meredith, C. W., Gilmore, A. M., and Isles, A. C. (1984). The Ground Parrot (*Pezoporus wallicus* Kerr) in southeastern Australia: a fire-adapted species? *Australian Journal of Ecology* **9**, 367-380.

- Meredith, C. W., and Jaremovic, R. (1990). 'Current status and management of the Ground Parrot in Victoria. Arthur Rylah Institute for Environmental Research Technical Report Series No. 58.' (Department of Conservation and Environment, Victoria: Melbourne.)
- Murphy, S., Berryman, A., Burbidge, A., Joseph, L., and Austin, J. (2009). Raising the stakes. *Wingspan* **19**, (2), 19.
- Norton, M. (2009). Habitat associations of the Long-nosed Potoroo. Master of Science thesis, University of Wollongong, Wollongong.
- NPWS (1998). 'Budderoo National Park, Macquarie Pass National Park, Barren Grounds Nature Reserve and Robertson Nature Reserve Plan of Management.' (NSW National Parks and Wildlife Service: Hurstville.)
- NPWS (2003). 'Draft Fire Management Strategy Nadgee Nature Reserve.' (NSW National Parks and Wildlife Service: Merimbula.)
- NPWS (2005). 'Nadgee Nature Reserve Plan of Management.' (NSW National Parks and Wildlife Service: Merimbula.)
- Recher, H. (1981). Bird communities of heath and their management and conservation requirements. In 'Heaths in New South Wales'. (Ed. C. Haigh.) pp. 27-40. (NSW National Parks and Wildlife Service: Hurstville.)
- Shukla, S., Bulusu, N., and Jha, S. (2004). 'Cane-toad monitoring in Kakadu National Park using wireless sensor networks.' Network Research Workshop 2004, Cairns, Australia in 2-7 July 2004 as part of 18th APAN Meetings.
- Spearritt, A., and Krieger, G. (2007). 'A review of a long term monitoring program of the Ground Parrot (*Pezoporus wallicus wallicus*) population within the national parks of the Sunshine Coast, south-east Queensland.' (Queensland Parks and Wildlife Service: Moggill.)
- Williams, J. E., Whelan, R. J., and Gill, A. M. (1994). Fire and environmental heterogeneity in southern temperate ecosystems: implications for management. *Australian Journal of Botany* **42**, 125-137.

Figure 1 Density estimates of Ground Parrots at Barren Grounds – Budderoo: (a) Redbank Gully; (b) ○ Noorinan, Δ Fox, ◇ Griffiths and □ Budderoo. Solid symbols are area searches and open symbols are aural surveys.

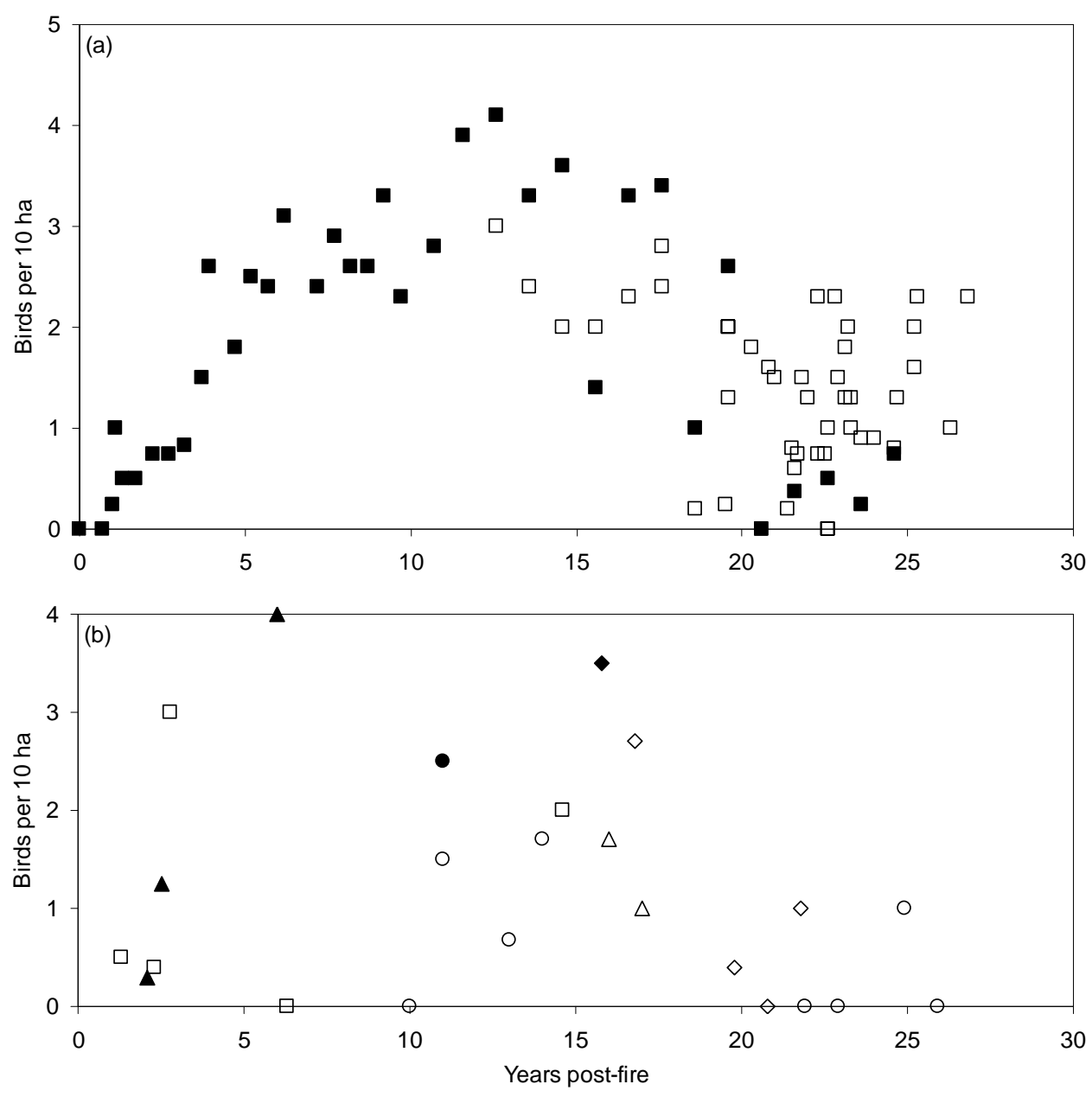


Figure 2 Density estimates of Ground Parrots at Beecroft Weapons Range: □ Boat Harbour, Δ Beekeepers and ○ North.

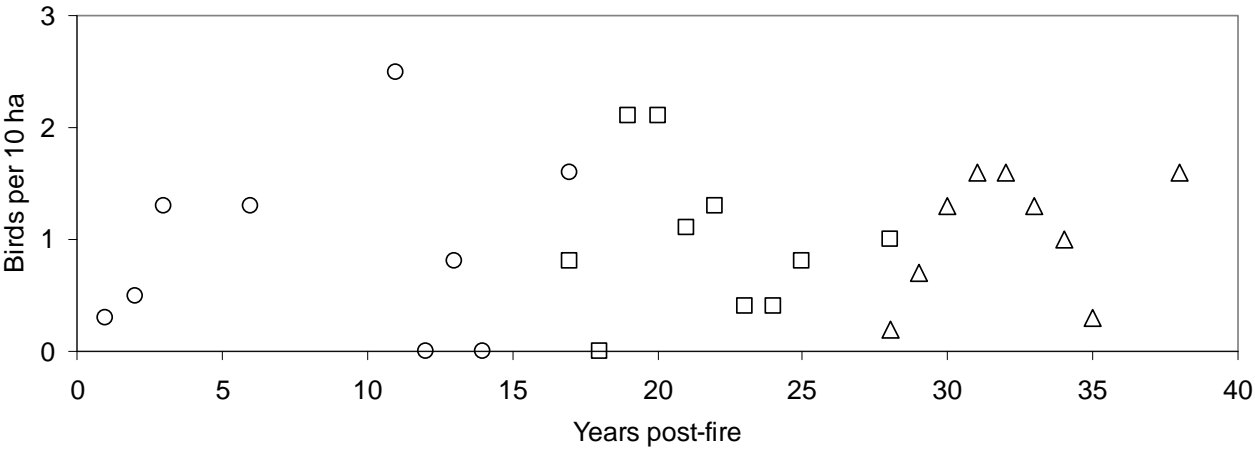


Figure 3 Density estimates of Ground Parrots at Nadgee: □ Endeavour Moor, ○ Impressa Moor, Δ Nadgee Moor and ◇ Upland Heath.

