FIRE AND AUSTRALIAN BIRDS: A REVIEW

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SUMMARY

The literature concerning the impacts of fire on Australian birds is reviewed. Fire effects are considered for main Australian environments. The methodology of studies is reviewed.

Detrimental fire regimes contributed to the extinction of two of the three bird species, and three of the four subspecies which have disappeared from Australia since European colonisation. Inappropriate fire management is now a factor in the threatened status of at least 51 nationally recognised threatened bird taxa (second in importance only to habitat clearance and fragmentation, which threatens 52 taxa). In many environments (notably heath and mallee), inappropriate fire regime is now the main threat to most declining bird species.

Despite this recognition of the seriousness of fire regime as a process threatening Australian birds, for only a few species has detailed research on the relationship between birds and fire regimes been conducted, and only in exceptional cases has this been translated into management. For many environments, there is no information on the impacts of fire regimes on birds.

Of the threatened species whose relationships with fire regime has been comparatively well documented, almost all show clear preference for much less frequent fire than that currently prevailing. The long-unburnt vegetation favoured by these species is becoming disappearingly rare, and will require concerted management effort to maintain or increase. Most fire-sensitive threatened birds have low reproductive output and limited dispersal ability. The persistence of these species is further jeopardised by habitat fragmentation, which accentuates the handicap of these traits for recolonisation following fire.

In temperate eucalypt forests, control burning is widely used to reduce the probability of extensive wildfire. While the impact of a single control burn upon birds is generally less than that of wildfire, there are few data on the long-term impacts of a sustained regime of control burning. The most detailed long-term study suggests that such frequent mild fires will lead to the decline and loss of some species which are now perceived as common and little affected by mild fires.

INTRODUCTION

Fire has long been recognised as one of the major factors moulding vegetation patterning across Australia (e.g. Mitchell 1838; Jackson 1968). Manipulation of fire, either explicitly or by default, is the main landscape management tool in many environments and most conservation reserves. Inappropriate fire regime is the main threat to many vulnerable and endangered Australian birds (Garnett 1992*a*) and other biota (e.g. plants: Leigh et al. 1984). Yet knowledge of the history and effects of fire is negligible in many environments, and there have been remarkably few long-term studies of the ecological impacts of a range of fire regimes, such that the long-term consequences of fire management are usually very poorly known.

In this essay, I seek to review the relationships between Australian birds and fire. Previous reviews (e.g. Cowley et al. 1969; Christensen & Kimber 1975; Catling & Newsome 1981; Recher 1981; Recher & Christensen 1981; Meredith 1983,1988; Suckling & MacFarlane 1983; Christensen et al. 1985; Smith 1987*a*; Christensen & Abbott 1989; McFarland 1993; Silveira 1993; Arnold et al. 1993; Crowley 1994) have summarised and interpreted studies of fire impacts on birds for broad regions or environments within Australia, and this national overview owes much to these predecessors. The quantity of these reviews is surprisingly out of proportion to the very limited number of detailed primary studies, and the attempt here at a national overview is the only justification for adding yet another review to this unbalanced literature.

Many of the impacts of fire on Australian environments indirectly affect birds, for example by change in nutrient availability, food resources or floristics. References on these subjects are relevant to birds even though birds may not be explicitly mentioned. However, a complete review of the environmental impacts of fire is beyond the scope of this essay, and would be redundant anyway given the excellent recent comprehensive reviews by Gill et al. (1981), Pyne (1991), Williams & Gill (1995), and Whelan (1995), and two recent broad collections of papers (McCaw et al. 1995; DEST 1996). Rather, I attempt here to:

(i) interpret, in terms of consequences for birds, the literature which describes environmental impacts of fires, but which doesn't explicitly mention birds; and

(ii) review, as comprehensively as possible, the literature explicitly concerned with fire and Australian birds.

An annotated bibliography of the relevant literature is compiled as a foundation for the latter goal.

Interpreting the literature is rendered difficult by the variation in fires within and between environments. Individual fires within a given environment vary in seasonal timing, extent, intensity, patchiness, and the temporal pattern of their (re-) occurrence. Their impacts at a particular site are influenced by these diverse factors (and also by landscape context and pre- and post-fire climatic conditions), and different bird species may respond very idiosyncratically to this variation. The search for general pattern in response is further hampered by the very variable and limited research effort, with few long-term studies and little experimentation with a range of fire treatments. In this regard, it is notable that successional responses of Australian mammals have been much more thoroughly documented and subject to far more intensive experimental investigation (e.g. Suckling & MacFarlane 1983; Higgs & Fox 1993).

This document contains a general overview of fire history, an assessment of fire impacts on birds across all main Australian environments, a review of the methodological approaches used in the investigation of impacts, and a concluding section reviewing fire management and bird conservation.

HISTORY OF FIRE REGIMES

Evidence from pollen cores and plant fossil material has demonstrated substantial re-arrangement of Australian vegetation since at least the Tertiary (Hill 1994), notably including a general increase in the extent of *Eucalyptus* open forests and woodlands at the expense of closed forests. Associated with these broad-scale environmental changes, there has been a substantial extinction of Australian fauna, notably rainforest and megafaunal elements, and including many orders and families of birds (Rich 1991).

Environmental change accelerated during the rapid climatic fluctuations of the late Pleistocene (Singh & Geissler 1985; Kershaw 1986), and this was accompanied by extinctions and range changes for much of the fauna. This period saw the end of the line for the massive flightless Mihirungs (Dromornithidae), the disappearance of flamingoes (Phoenicopteridae) from Australia, the extinction of large species of coucal and megapodes, the mainland loss of the flightless Tasmanian Native Hen[1] and further range contractions for groups associated with closed forests (e.g. the logrunners Orthonychidae) (Baird 1991). This change may have been compounded (or precipitated: Merilees 1968; Smith 1977; Flannery 1990, 1994) by the entry of Aboriginal people to Australia, between about 60–100,000 ybp, as Aboriginal use of fire almost certainly led to a fire regime different from that previously prevalent (Jones 1969; Singh et al. 1981; Nicholson 1981; Braithwaite & Estbergs 1985), and consequently re-shaped the Australian landscape. The extent to which Aboriginal land management was responsible for environmental modification remains unclear and contested (e.g. Williams & Gill 1995).

Any sustained change in burning regimes will benefit some components of the ecosystem but disadvantage others. Evidence from early European accounts of firing by Aborigines (e.g. Hallam 1975; Braithwaite 1991; Jones 1995), current accounts of reasonably traditional Aboriginal land management (Haynes 1985, 1991; Lucas & Lucas 1993; Baker et al. 1993; Bradley 1995) and interpretation of vegetation patterning (e.g. Jackson 1968; Price & Bowman 1994) suggests that Aboriginal people generally burnt their lands frequently and purposefully. Most resultant fires appear to have been relatively cool and of limited extent. Hence a fine scale mosaic of vegetation age was maintained, although frequent burning may have favoured early successional species, and savannas and eucalypts generally. Heaths may also have expanded under Aboriginal fire regimes (Jackson 1968; Smith 1977), although shrubbiness under forests and woodlands was probably much diminished (Gill 1981; Recher et al. 1993; Stanton 1995).

Late successional species (and fire-sensitive communities) may have been retained within the managed landscape by the deliberate exclusion of fire from fire-sensitive areas which supported particular resources (e.g. Jones 1995; Lucas & Lucas 1993) or which were otherwise of cultural significance (Latz 1995). Areas (or environments) which were unsuitable for habitation or supported relatively low densities of Aboriginal residents (perhaps such as much of the mallee: Harris 1990) may have avoided the imposition of Aboriginal fire regimes.

Nonetheless, the flammability of much of Australian vegetation (and recurrent drought) must have ensured that there were episodes of catastrophic and extensive wildfires, even under Aboriginal stewardship. The existence of cohorts of Mountain Ash *Eucalyptus regnans* pre-dating European colonisation (Gill 1981) is one demonstration of the extensive, if infrequent, occurrence of such wildfire.

The impacts upon birds of Aboriginal burning regimes were probably very disparate. Directly, Aboriginal people probably used fire as an aid in hunting flightless birds, as they did for hunting macropods and other mammals (Braithwaite 1991). It is possible that the extinction or range contraction of several species of flightless birds in the late Pleistocene was due to Aboriginal hunting (aided by fire), though many other factors may have been involved (e.g. Baird 1984). Aboriginal hunters also used smoke to attract and trap raptors, and the remnants of such traps are still visible in parts of northern Australia (Boekel 1980).

An increase in the frequency and predictability of fires, following Aboriginal entry

[1] Scientific names of all birds mentioned in text or tables are given in Table 1.

to Australia, probably would have led to increased abundance of birds which forage around fires (e.g. raptors, wood-swallows: Braithwaite & Estbergs 1987; Woinarski 1990) or in recently-burnt areas (e.g. granivores). Such fire-associated species probably could not maintain large populations under natural fire regimes of infrequent and unpredictable fires.

However, for birds, the most substantial impacts of Aboriginal fire regimes were probably experienced through resultant vegetation change. An increase in fire frequency would have led to change in floristics, vegetation structure and grain size of vegetation mosaics. Fire-sensitive vegetation (and its associated bird fauna) would have declined, except where this provided desirable resources and could be protected. Probable losers from this re-casting of Australian environments included species associated with conifer forests, with *Casuarina* or *Allocasuarina* woodlands (e.g. Glossy Black-cockatoo: Clout 1989), with closed forests, or with dense shrubby understoreys below *Eucalyptus* forests (e.g. scrub-birds, bristlebirds). Probable winners included species associated with the relatively sparse vegetation of early seral stages (e.g. Richard's Pipit), and those associated with eucalypt open forests and savanna woodlands (e.g. many granivorous finches, doves and parrots; honeyeaters). Nonetheless, the relatively fine scale of burning patterns for lands under Aboriginal management probably maintained relatively high levels of heterogeneity of seral stages and environments generally, and hence supported high diversity of bird species.

Rapidly following European usurpation of land management across much of Australia, the practice and purpose of burning changed. Destructive and extensive burns were used to aid clearing or to demonstrate proprietorship (Gill 1981; Johnson & Purdie 1981). While some changes of incidence (and impacts) were deliberate, others involved a complex interplay of new factors. For example, the introduction and rapid spread of livestock and exotic plants changed fuel characteristics and understorey floristics, thereby constraining options for fire regimes. Other introductions, notably rabbits, interfered with post-fire plant recruitment processes. Clearing and fragmentation of native vegetation changed the scale and extent of fires. More recently, fire has been used as a tool for biodiversity conservation (Good 1981; Garnett & Crowley 1994; Crowley 1995).

FIRE REGIMES AND THEIR IMPACTS ON BIRDS: A REVIEW ACROSS MAIN ENVIRONMENTS

For all main (loosely-defined) Australian environments, I consider (where possible) current and pre-European fire regimes, bird species responses to single fires and fire regimes, relationships of threatened taxa to fire regimes and fire management for bird conservation. The impacts of fire and potential regimes differ appreciably between these environments. In some environments (notably temperate eucalypt open forests), there may be marked differences between mild control fires (which usually affect only the understorey) and wildfire. This distinction is less clearcut in most heaths and mallee communities, where most vegetation occurs near the ground, and the response of birds to control burns may be similar to those following wildfire (Meredith 1983).

COASTAL HEATHS AND THICKETS

Fire regimes

In southwestern Australia, where previously Aboriginal people had burnt coastal heath country with small cool fires at intervals of 5-10 years, early colonists torched the heaths at least once every 2–3 years until grasslands suitable for pastoralism replaced the native bush (Hallam 1975; Smith 1977,1987*a*). Carter (1924) provided a graphic eyewitness account of these changes:

> "*where there had been dense impenetrable scrub, was mostly bare sand drifts caused by fire made to improve the country for cattle grazing*".

By contrast, in southwestern Tasmania, Jones (1995) noted that dense thickets and heaths occurred now in areas where observers in 1829 had recorded open sedgelands, a change attributed to the removal of frequent fires lit by Aboriginal people. This disparity in change reflects both the difficulty of generalising about fire regimes and their effects, and the limited data on, and frailty of interpretations of, pre-European fire regimes.

In coastal heaths of southeastern and eastern Australia, European fire management was initially indiscriminate, unless where directed to conversion of heaths to farmlands. More recently (notably since the 1950s: Luke & McArthur 1978), most heathlands have been managed by high frequency (often with prescribed intervals of <5 years) control burning. Such frequent burning has led to the decline and/or local extinction of several heathland-dependent birds, most notably Ground Parrot and Southern Emu-wren. Over the last two decades, largely in response to research on the requirements of such species, control burning in heathlands has been reduced. In some areas (notably on conservation reserves), fire exclusion or suppression has been recommended (e.g. Cooper 1974) and practised (Meredith et al. 1984). Even in such protected heaths, occasional wildfires have proven difficult to exclude, and have burnt some reserved heaths extensively (notably including the 1994 fire through heathlands at Royal National Park).

Species responses to single fires

Relative to most other Australian environments, the impacts of fire on birds in heaths has been well documented (Table 2). Very high mortality rates have been reported for heathland birds during wildfires (Recher et al. 1975; Fox 1978; Pescott 1983; Wegener 1984*a*,*b*), though Main (1981) suggested that many birds were able to escape such fire. Hawking insectivores (e.g. swallows) and some raptors may be attracted to fire fronts (Main 1981).

In days to months following fire in heaths, the dead or exposed invertebrate and vertebrate prey attracts many predator visitors from adjacent habitats (e.g. Straw-necked Ibis, Torresian Crow, Laughing Kookaburra, raptors, egrets, Pied Currawong, Australian Magpie, Australian Raven, Magpie-lark), and seed shed by plants in response to fire (e.g. *Banksia* spp.) attracts parrots and cockatoos (Roberts 1970; McFarland 1988,1993).

While regrowth vegetation remains relatively open and herb and grass species are relatively abundant (up to about 3 years post-fire), the area is colonised by open-country species such as Richard's Pipit, Brown Quail, Little Button-quail, Elegant Parrot, swallows and martins (Smith 1987*a*; McFarland 1988; Brooker & Rowley 1991; Hopkins & Smith 1996) (Fig. 1). In some heaths, fire may trigger unusually abundant flowering for some plants (notably *Xanthorrhoea*), and some honeyeater and parrot species may respond with increased abundance (Specht 1981; McFarland 1993). Insect abundance may increase rapidly after

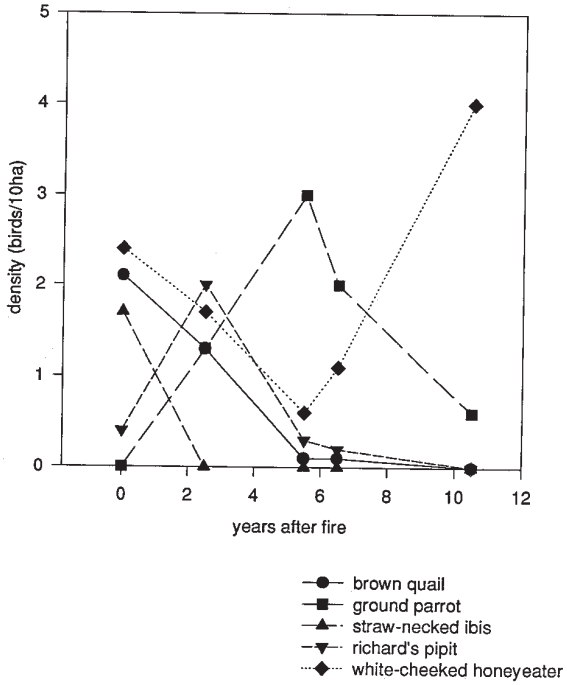


Figure 1: Response of some heathland bird species to fire (after McFarland 1998)

fire, sometimes leading to increased breeding success or rapid increase in some insectivorous birds (Jordan 1987*c*). The total number of bird species may peak at one year post-fire, followed by gradual decline (McFarland 1993). Resident species may change diet, foraging behaviour or nesting behaviour with vegetation and resource changes following fire (Brooker & Rowley 1991).

As the heath structure becomes more closed (after about 3 years post-fire), the bird species composition changes, with loss of the opportunist open-country species and their replacement by species reliant on denser vegetation such as King Quail, Brush Bronzewing, Ground Parrot, Tawny Grassbird, Golden-headed Cisticola, Red-backed Fairy-wren and Southern Emu-wren (in southeastern Queensland: McFarland 1988,1994) and Striated Fieldwren (in southwestern Australia: Smith 1987*a*; Hopkins & Smith in press). In some older heaths (>10–20 years post-fire) there may be a reduction in productivity (or seed availability) and some of these bird species may decline or disappear (McFarland 1993,1994). For example, Smith (1985a) gives a successional pathway in heaths of southwestern Australia from Richard's Pipit to Striated Fieldwren to Western Bristlebird to Western Whipbird, over a period of 50–80 years (although the dynamics in long-unburnt vegetation may be unclear).

The pattern of return of species following fire may vary substantially according to heath floristics (notably affected by moisture availability), the previous occurrence of fire, climate, heath patch size and isolation, and the patchiness of the fire (Recher et al. 1975; Meredith et al. 1984; Jordan 1987*c*; McFarland 1994). For example, one year following a fire that left some small unburnt patches of heath, Recher et al. (1975) reported that all but one species present before the fire were still present (although some were less common). In contrast, 2.5 years after a less patchy fire, Roberts (1970) reported that eight pre-fire resident species (Eastern Whipbird, White-cheeked Honeyeater, Little Wattlebird, Variegated Fairy-wren, Chestnut-rumped Heathwren, Brown Thornbill and Red-browed Finch) either disappeared or had declined substantially. Meredith et al. (1984) noted that Ground Parrots had not recolonised a patch of heath of suitable age, probably because it had previously been burnt at very frequent intervals. Where fire-free intervals are insufficent to allow for maturation of plant species recruiting only through seed, the density of nectarivores may remain low, or particular nectarivore species, such as Crescent Honeyeater (Recher et al. 1975; Recher 1981; Christensen et al. 1981) may not return. McFarland (1994) noted that fragmentation of heaths may prevent recruitment of species with relatively poor dispersal ability (such as Southern Emu-wren) to otherwise suitable heaths.

Species responses to fire regimes

In contrast to the relatively large number of studies which have considered effects of single fires upon birds (or relationship of species with time since fire), there have been remarkably few studies which have considered impacts of repeated fire or sustained fire regimes. The most detailed study of repeated fire on birds is that of Rowley & Brooker (1987), Brooker & Rowley (1991) and Russell & Rowley (1993) on the demography of Splendid Fairy-wren over a long period (to 18 years) in a southwestern Australian heath. During this study, the heath was subjected to at least 6 mild fires (which burnt generally relatively small parts of the study area) and one hot wildfire (which burnt 95% of the study area). This study is remarkable for its length, the detailed monitoring of a large number of resident birds and the precise measurements of a wide range of life history parameters. In general, the birds survived fires relatively well, but showed changes in behaviour and population structure for at least 3–5 years

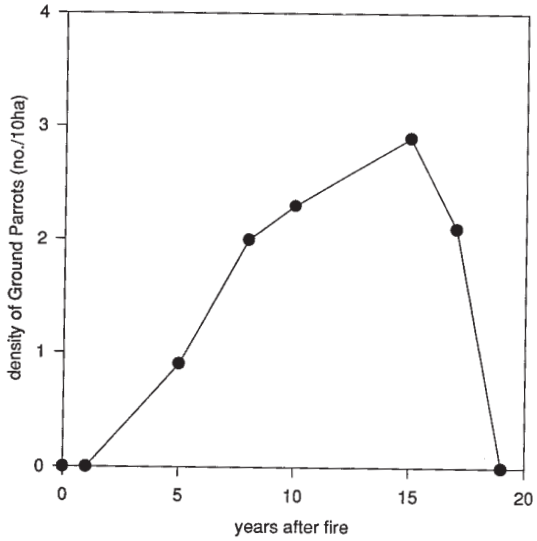
post-fire. All measures of density, productivity and survival increased during fire-free periods. Fire directly affected natality and juvenile survival, and indirectly affected population density, age structure, sex ratio and group composition. The effects of wildfire may have been less than those of mild fires, because of differences in timing with respect to breeding.

The longevity of Splendid Fairy-wrens may mask critical recruitment problems post-fire. The delayed response to fire provides a warning that studies which simply report presence/absence (or even abundance changes) in the short-term after fire are likely to substantially underestimate the actual impacts of fire on populations. Repeated fires clearly threaten this population through their impact on reproductive and life history characters. Without recruitment from adjacent unburnt patches (for example, if this site had been a habitat fragment), this population would have been eliminated by the fire regime. The parameters measured in this study were used to model population responses to a range of fire regimes and habitat fragmentation scenarios by Brooker & Brooker (1994).

Threatened species

An unusually high proportion of threatened bird species occurs in heaths (Garnett 1992*a*), and the conservation of such species is mostly associated with the provision of appropriate fire regimes.

The relationship of the threatened Ground Parrot with fire has been subject to more studies than for any other Australian bird (Table 2). Even so, appropriate fire management of the floristically-rich shrubby or graminoid heaths favoured by this species is still contested (Baker & Whelan 1994). In contrast to early suggestions that fire intervals of 4–5 years were desirable for Ground Parrots (Ridpath 1972), subsequent work in coastal Victoria and southeastern Queensland demonstrated that population densities were low in heaths of <3 years post-fire or >18 years post-fire (Meredith et al. 1984; Meredith 1984*a*,*b*,*c*; Jordan 1984*b*,1987*b*; McFarland 1989, 1991, 1992, 1993: Fig. 2) in accord with production of seeds. Consequently, burning of heaths at intervals of 8–10 years (in Queensland and southwestern Australia) or 10–25 years (in Victoria) was recommended for this species (Smith 1979*b*; Meredith 1983,1984*a*; Meredith & Isles 1980; McFarland 1992; Meredith & Jaremovic 1990). However, no decrease in Ground Parrot abundance



in old heath (or preference for older heaths) was observed by Baker & Whelan (1994) in southeastern New South Wales, Bryant (1991, 1992, 1994) in Tasmania or Watkins (1985), Burbidge et al. (1989,1990) and Cale & Burbidge (1993) in south-western Australia, and these authors suggested that fire exclusion in heaths may be a more appropriate management regime for this threatened species.

Fragmentation of heaths can exacerbate fire management problems for Ground Parrots, as isolation may hinder their dispersal to heaths whose age would otherwise render them suitable (Cale & Burbidge 1993). Ground Parrots also occur in coastal closed sedgelands in southern Australia, but their abundance in these is independent of age, as this environment is not subject to the major structural and floristic changes that characterise heaths of varying age (Meredith et al. 1984; Gill 1996).

In southwestern Victoria and far southeastern South Australia, the threatened Rufous Bristlebird occurs in coastal heaths and thickets that have been unburnt for at least 2 years, and it probably reaches highest densities in far older (>25 years post-fire) heaths and thickets (Reilly 1991*a*; Belcher 1993). Fire is considered to be the major threat to this species in this area and Reilly (1991*a*) recommended that "if fire is to be used as a management tool, frequent pockets of unburnt country of sufficient size are vital". Sufficient cover to protect against predation (of adults and nests) may be the reason

for absence from younger heaths for this insectivorous species. Predation of nests by Foxes *Vulpes vulpes* is considered a main threat for some populations of Rufous Bristlebirds (Garnett 1992*b*).

In heathland populations of the vulnerable Eastern Bristlebird (in eastern New South Wales and southeastern Victoria), abundance increases with age since fire up to at least 9 years, but may then plateau (Jordan 1984*a*; Bramwell et al. 1992; Pyke et al. 1995). Unburnt patches left after fire may be critical for recolonisation (Pyke et al. 1995).

The endangered Orange-bellied Parrot has a complex relationship to seral stages of heath and button-grass at its breeding grounds in south-western Tasmania (Brown & Wilson 1981,1984). In general, it prefers to feed in relatively young heaths and sedgelands (<10 years post-fire), though it changes feeding preferences for successional stages during different months of the breeding season (in response to variation in phenology). As its nesting hollows in adjacent open forests are vulnerable to fire, management of fire is critical, and should involve the maintenance of a range of fire histories.

In southwestern Australia, changed fire regimes and clearing have led to the precipitous decline of four species occurring in heathlands, thickets or swamp/forest margins (Ground Parrot, Western Whipbird, Western Bristlebird and Noisy Scrub-bird) and to the extinction of the Western Australian subspecies of Rufous Bristlebird *D. broadbenti litoralis* (Milligan 1904; Ashby 1921; Carter 1923*a*,*b*, 1924; Whittell 1936; Whitley 1971; Smith 1977, 1985*a*, 1987*a*; How et al. 1987; Garnett 1992*b*; Cale & Burbidge 1993). The endangered Western Bristlebird and Noisy Scrub-bird have persisted only in very localised populations which have escaped frequent burning because of topographic protection from fire, or luck (Smith 1979*a*; Burbidge et al. 1986; Cale & Burbidge 1993). While the habitats of these three species differ somewhat (the Noisy Scrub-bird is not really a heathland species), it is convenient to consider them together because of their co-occurrence in a small number of sites in coastal southwestern Australia, and the detailed research conducted at these sites on relationships between all three species and fire (Smith 1987*a*; Cale & Burbidge 1993; Hopkins & Smith 1996).

Western Bristlebirds require dry heath of at least 6–10 years post-fire or wet heath of at least 3 years post-fire before habitat is suitable (Smith 1977,1985*a*,1987*b*), and density generally declines in very old heath (though some birds persist in heath >45 years post-fire: Cale & Burbidge 1993; Smith 1994), probably because of lowered productvity (Smith 1985*a*,1987*a*,*b*).

For Noisy Scrub-birds, vegetation (thickets and low scrubby eucalypt forests) has to be at least 4–10 years post-fire (depending on floristics and landscape position) before it becomes suitable: vegetation suitability also declines when very old (>30 years post-fire) (Smith & Robinson 1976; Smith 1977, 1979*a*, 1985*a*,*b*,*c*; Smith & Forrester 1981) (Fig. 3).

Where Western Whipbirds occur in heaths, these have to be 4-7 years post-fire before becoming suitable (Smith 1985*a*), and the species persists in long-unburnt thickets (up to 50 years post-fire: Smith 1991).

For all three species, post-fire recruitment or recolonisation is hampered by relatively poor dispersal ability and/or low reproductive rates (Smith 1985*a*) and the very fragmented nature of the habitat (Smith 1979*a*; Cale & Burbidge 1993). Hence managers should aim to prevent entire habitat patches from being burnt (Smith 1987*a*). Fire intervals of <10 years will lead to the local decline and possible extinction of these three taxa. Fire intervals of >50 years may also be disadvantageous. The fire requirements of these three taxa are slightly different, such that an optimum regime for one species will not coincide exactly with that of the others (Smith 1987*a*). Suitability of heaths post-fire can be substantially delayed by grazing pressure by macropods (Smith 1985*a*; Cale & Burbidge 1993; Hopkins & Smith 1996).

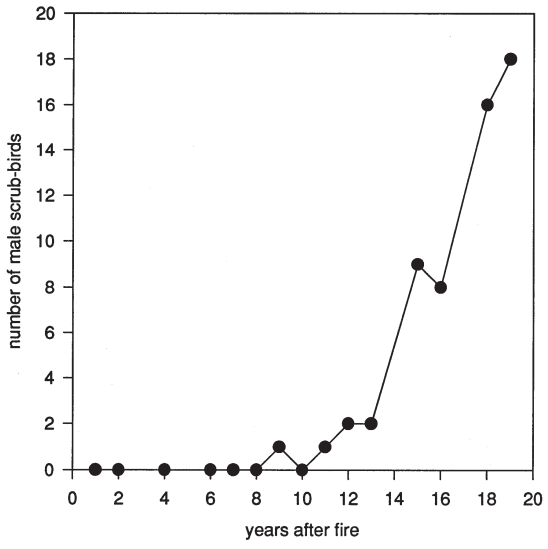


Figure 3: Abundance of male noisy scrub-birds after fire (after Smith 1985c)

Fire management for bird conservation

With rare exceptions, heathlands have generally been burnt more frequently than is desirable for threatened heathland birds. Brooker & Rowley (1991) suggested fire-free intervals of at least 10 years for small heathland passerines generally, and longer intervals (>20 years) are probably preferable for most threatened species (with the exception of Orange-bellied Parrot). A few currently common heathland species (e.g. Striated Fieldwren) may be disadvantaged by infrequent fires, and a mosaic of fire ages should be maintained. Many threatened heathland birds have low reproductive output and limited dispersal abilities. These characteristics suggest that protection of connecting vegetation, or unburnt patches, are critical for post-fire recolonisation (Danks 1991; Du Guesclin et al. 1995).

MALLEE

Fire regimes

In mallee and mallee-heath environments, early European colonists used fire as part of the intrusion and clearing process (Harris 1990). Over the course of the last century, extensive wildfires of high intensity have been frequent, and old (>30 years post-fire) mallee has become extremely scarce and fragmented. In response to such wildfires, fuel-reduction burning in mallee lands has been widely used, though the practice is contentious (Cheal et al. 1979; Gill 1990).

Species responses to single fires

There is little information on mortality directly due to wildfire in mallee habitats, though Benshemesh (1990) noted that at least 10 of 11 marked Malleefowl survived a patchy but intense burn, but within a few months following fire all but 4 had emigrated or died. Chandler (1973) suggested that mortality during mallee fires may be very substantial.

Species common in recently-burnt areas (<1 year post-fire) include mainly widespread opportunists (e.g. Nankeen Kestrel, Australian Magpie) (Meredith 1982,1983). Subsequently (1–10 years post-fire), Chestnut Quail-thrush, Tawny-crowned Honeyeater, Hooded Robin, Red-capped Robin, White-fronted Honeyeater and Shy Heathwren become abundant (Carpenter & Matthew 1986; Woinarski 1989*a*,*b*) (Fig. 4).

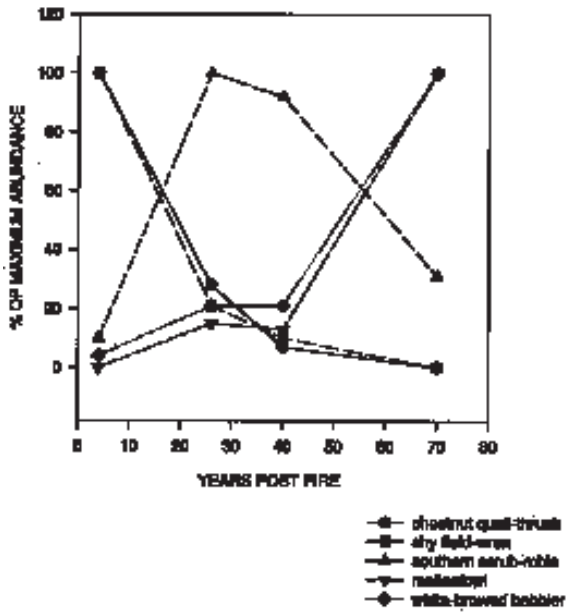


Figure 4: Response of five bird species to fire in mallee-broombush (after Woinarski 1989b)

As the vegetation becomes taller and denser (10–30 years post-fire), vegetation favours the mallee endemic birds (Meredith 1982) and the density of Red-lored Whistler, Crested Bellbird, Purple-gaped Honeyeater and Southern Scrub-robin peaks (Carpenter & Matthew 1986; Woinarski 1987, 1989*a*, *b*).

Older (>30 years post-fire) vegetation (with tall mallees and relatively open understorey) is favoured by Malleefowl, Black-eared Miner, White-browed Babbler, Yellow Thornbill (Carpenter & Matthew 1986; Benshemesh 1988,1990,1992; Woinarski 1989*a*,*b*; Silveira 1993), and some hollow-nesting birds such as Striated Pardalote and Regent Parrot (Cheal et al. 1979; Carpenter & Matthew 1986; Emison & Bren 1989).

This general successional pattern varies in response to the landscape position (e.g. dune crest versus swale, soil type) and spatial context of fires (extent and patchiness of fire, patch isolation, etc.) (Woinarski et al. 1988*a*). The complex floristic mosaic typical of mallee vegetation may provide habitat heterogeneity even after extensive fires, as different dominant plant species regrow at different rates post-fire, thereby providing a range of vegetation structure even across an area with uniform fire history. This allows some species to serially track preferred vegetation structure by moving between floristic communities (Carpenter & Matthew 1986; Woinarski et al. 1988*a*). Weather conditions

following fire may also influence bird responses, with Chandler (1973) noting that drought post-fire may accentuate the fire impact.

Species responses to fire regimes

There is no information on the responses of birds to repeated fire, or particular fire regimes in mallee.

Threatened species

A relatively high proportion of threatened birds in Australia occurs in mallee (Garnett 1992*a*). Fire is one of the most serious threatening processes for threatened mallee birds (Stephens 1992; Silveira 1993; Smith et al. 1994, 1996).

The vulnerable Malleefowl requires a dense and extensive layer of litter to provide material for incubation. This is not available until at least 10–15 years post-fire (Frith 1962; Tarr 1965), then increases in older vegetation. Optimum fire interval for this species is at least 60 years (Benshemesh 1990). Fire intervals of 20 years have been estimated to reduce Malleefowl densities to 6% of the maximum carrying capacity (Benshemesh 1990). Young vegetation (<10 years post-fire) may have a greater density of food resources (notably seeds) for this species, and a mosaic of fire ages may be desirable (Carpenter & Matthew 1986; Brickhill 1987; Priddell 1989,1990). Unburnt patches within extensively-burnt vegetation appear critical for recolonisation post-fire or persistence in a mainly burnt environment (Benshemesh 1988,1990,1992). Another major threatening process, predation, may have increased impact in burnt country (Benshemesh 1992). Suitably old mallee has become rare (Priddell 1990), and maintenance of Malleefowl will require management to protect existing old vegetation and to provide for additional long-unburnt areas in the future (Benshemesh 1990, 1992, 1994).

The endangered Black-eared Miner forages preferentially in decorticating bark of very old (>50 year post-fire) mallee eucalypts (McLaughlin 1992), though may occur in much younger mallee where it adjoins older vegetation (Silveira 1993,1995). The main threat to this taxon is genetic swamping from the related Yellow-throated Miner, a process partly brought about by extensive mallee clearing (Garnett 1992*b*), however the limited area of old mallee is a factor in its threatened status (Starks 1987) and maintenance of patches of old mallee may be an important management requirement.

The vulnerable Mallee Emu-wren is closely associated with *Triodia* hummock grasses under mallee. Silveira (1993) noted that it was absent for 5-6 years post-fire, and then persisted in long-unburnt vegetation. However, Garnett (1992*b*) reported the species bred at high densities within 5 years of fire, and Emison et al. (1987) considered that it was common in young regrowth. Low dispersal ability may limit its recolonisation to isolated patches or following very extensive non-patchy fires. The threatened Striated Grasswren may also be severely disadvantaged by intense and extensive fire (Brickhill 1980; Garnett 1992*b*; Silveira 1993).

The threatened mallee-heath subspecies of Slender-billed Thornbill *Acanthiza iredalei hedleyi* may be vulnerable to frequent fire (Matthew 1994).

Limited data on the rare Scarlet-chested Parrot suggest that this species may prefer recently-burnt (3–5 years post-fire) mallee with hummock-grass understorey (Forshaw 1981; Robinson et al. 1990).

The vulnerable eastern subspecies of Western Whipbird *Psophodes nigrogularis leucogaster* has been recorded from a wide range of post-fire ages, but appears to be most abundant in mallee vegetation 10–25 years old in the Murray Mallee (Woinarski et al. 1988*a*). The western mallee subspecies, *P.n.oberon*, has been recorded only from long-unburnt (>25 years) vegetation in southwestern Australia (Smith 1985*a*,1991; McNee 1986). McNee (1986) recommended that management for this species required long fire-free intervals (at least 30 years and preferably 50 years).

The vulnerable Red-lored Whistler is most abundant in mallee 5-30 years post-fire, and may not persist in very old mallee (Woinarski 1987).

Threatened populations of Major Mitchell's Cockatoo and Regent Parrot may require mallee which is sufficiently old (probably >50 years post-fire) to form suitable nesting hollows (Cheal et al. 1979; Emison & Bren 1989; Silveira 1993).

Fire management for bird conservation

Overviews of the management of mallee birds have recommended fire regimes which maintain a mosaic of vegetation of a range of ages, but with a bias towards retention of older ages (Cheal et al. 1979; Emison & Bren 1989). Meredith (1982) noted that the goal of maintenance of a mosaic of vegetation ages was not equivalent to, and unlikely to be achieved by, unplanned random burns.

Fire management has been complicated by

mallee fragmentation, especially in southwestern Australian and western New South Wales. Individual fragments tend to each have a homogeneous fire history, leading to reduced bird species diversity within fragments (Menkhorst & Bennett 1990; Priddell 1990), though their isolation may offer some fire protection.

TEMPERATE EUCALYPT OPEN FORESTS

Fire regimes

There has been considerable debate about the fire regimes operating in (and understorey characteristics of) temperate eucalypt open forests before European colonisation, and in the early years of settlement (Gill 1981; Nicholson 1981; Williams & Gill 1995). The regimes and their impacts probably showed important differences between forest types (Wakefield 1970), rendering generalisations difficult to draw.

In response to Aboriginal management, the eucalypt forests of temperate southeastern Australia were probably generally characterised by low grassy understoreys (maintained by either frequent cool firing or very rare fires: Benson 1981; Recher et al. 1993). With exclusion of Aboriginal management, these forests rapidly developed shrubby understoreys, probably markedly increasing fuel levels and hence increasing the probability of hot and extensive wildfire (Smith 1979*a*). While bird species diversity at any given point probably increased in response to greater structural complexity of vegetation (Recher 1969), the loss of fine-scale management probably led to increased regional homogenisation of the environment (in terms of floristic variation and seral ages) and hence reduced regional bird species diversity. Change in understorey structure would also have disadvantaged birds reliant upon forests with grassy understorey (Recher et al. 1993), although to an extent some of these species may have been able to substitute the developing mosaic of farmlands and forests.

Frequent wildfires in temperate eucalypt forests were an inevitable consequence of limited European understanding of fire management in these systems. More recently, in response to the human deaths and destruction of property in wildfire, fire suppression and/or frequent and extensive fuel-reduction (or control) burning have been implemented in most temperate eucalypt forests.

Species responses to single fires: wildfire

Bird mortality may be very high in severe wildfires in temperate eucalypt forests (e.g. Hemsley 1967; Christensen et al. 1981; Suckling & MacFarlane 1983; Wegener 1984*a*,*b*). Hood (1941) provided a vivid eye-witness account of birds in a forest wildfire:

> "*As the terrific blast of fire swept along, birds could be seen rising from the ground or leaving the trees in front of it only to be overpowered by the dense smoke and rising scorching heat. In all cases the birds fell exhausted into the flames*".

Some bird species, notably aerial insectivores (e.g. swifts: Lord 1936; McCulloch 1966) and raptors may follow fires, hunting disturbed insects or vertebrates.

Where wildfire has killed the canopy trees, wholesale recomposition of the bird fauna may follow. Recently burnt areas initially have very few birds (Dedman 1983*a*,*b*,*c*,*d*,*e*), or at least a substantial decline (20-65%: Ratkowsky 1979,1985; Hewish 1983; Braithwaite et al. 1984; Loyn et al. 1992*a*) in species richness and abundance. However, even very small birds may survive hot wildfire (Rowley & Brooker 1987), especially where some patches remain unburnt (Smith 1989). Surviving individuals may adopt unusual behaviours or diet, for example Superb Fairy-wrens have been recorded feeding in scorched canopy (Dedman 1983*e*), and the diet of Sooty Owls was found to be much less varied post-fire (Loyn et al. 1986).

Ground-feeding insectivores or carnivores may invade or remain in burnt areas, probably in response to the availability of dead or injured prey, or its greater accessibility (Hewish 1983). Species such as Richard's Pipit, Australian Magpie, ravens, Flame Robin, Scarlet Robin, Laughing Kookaburra, Grey Butcherbird, Nankeen Kestrel and Superb Fairy-wren colonise open burnt areas until regrowth becomes too dense (up to 3 years) (Christensen 1974; Stokes 1975; Chambers 1983; Braithwaite et al. 1984; Loyn 1985*a*,*b*; Reilly 1991*a*,*b*). Granivorous birds (e.g. Red-browed Finch, Blue-winged Parrot, Diamond Dove, Common Bronzewing, Brown Quail, Painted Button-quail) may also invade or become more abundant in recently burnt areas (Recher et al. 1985; Loyn 1985*b*).

In contrast, nectarivorous, frugivorous and foliage-gleaning insectivorous birds (e.g. Brown Thornbill, Striated Thornbill, Yellow-faced

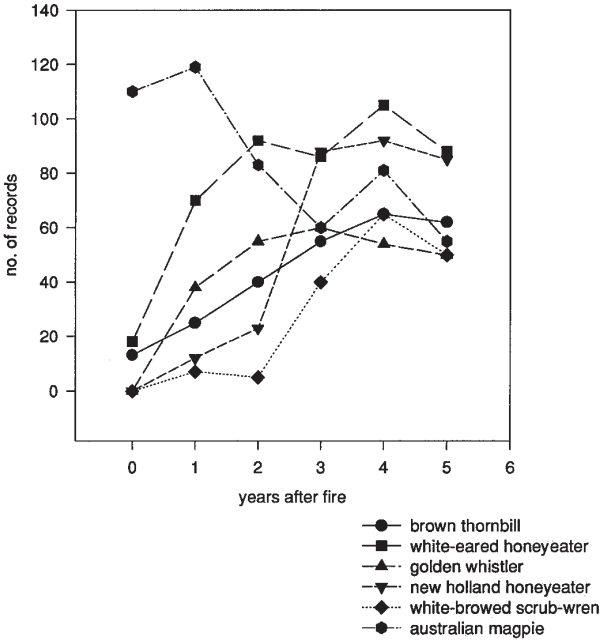


Figure 5: Response of 6 bird species to wildfire in temperate eucalypt open forest (after Reilly 1991a)

Honeyeater, Yellow-tufted Honeyeater, Golden Whistler, Grey Fantail) disappear or are generally much less abundant for at least two years after hot wildfire (Ratkowsky 1979,1985; Hewish 1983; Braithwaite et al. 1984; Recher et al. 1985,1987*a*; Loyn 1985*b*; Loyn et al. 1992*a*; Reilly 1991*a*,*b*) (Fig. 5). However, in some cases, wildfires may stimulate flowering of eucalypts and hence attract greater abundance of some nectarivores (Recher et al. 1985). Declines may be delayed for 2-5 years for some species, such as Eastern Yellow Robin (Marchant 1985; Jordan 1988) and Rufous Whistler (Reilly 1991*b*), possibly because of structural characteristics of regrowth at this period (Suckling & MacFarlane 1983).

Pre-fire total bird abundance may be reached by 2 years post-fire and exceeded 3 years post-fire (Christensen 1974; Loyn et al. 1992*a*). Rapid regrowth of woody vegetation within 2–3 years post-fire allows the return of some foliage-gleaning birds, and the loss of the open-country invaders. Most of the original bird assemblage is then gradually regained (Catling & Newsome 1981). By about 50 years post-fire (Loyn 1985*a*) only species typical of old-growth forest—hollow-nesting birds, honeyeaters, some raptors, trunk-gleaining insectivores, frugivores and some insectivores of the canopy foliage (Scotts 1991; Taylor 1991)—are missing.

Hollow-dependent species are scarce or absent until trees become sufficiently old to form suitable hollows (Milledge & Palmer 1990; Kavanagh 1990,1991). Depending upon the bird and tree species, this may be between 100 and >250 years post-fire (Loyn 1985*a*,*b*; Milledge et al. 1991; Nelson & Morris 1994), and hollow availability may continue to increase with tree ages perhaps up to 1000 years (Mawson & Long 1994). The relationship of fire with hollow formation is complex: fires may kill canopy trees but these (and their hollows) may persist as dead stags; fires may lead to hollow formation (or change in dimensions of existing hollows) in surviving trees or may destroy hollow-bearing trees; and frequent fires may alter recruitment processes and hence dictate future availability of hollows (Cowley 1971; Ashton 1975; Saunders 1979; Saunders et al. 1982; Ambrose 1982; Calder et al. 1983; Inions 1985; Smith & Lindenmayer 1988; Inions et al. 1989; Gibbons 1994; Mawson & Long 1994).

Species responses to single fires: control burning

Environmental changes, and hence changes in bird species composition, are less pronounced with single control burns (Christensen & Kimber 1975). Where this is managed successfully, fires are relatively limited in extent, leave unburnt patches, and do not consume the canopy or kill trees.

Bird survival during control burns is relatively high (Christensen et al. 1981; Abbott & Christensen 1994). For example, following a control fire in an open forest in southeastern Australia, Cowley found that at least 18 of 27 banded birds living in the understoey remained in pre-fire territories. However, subsequent mortality is unknown and may be high (Christensen et al. 1981).

Short-term changes in bird species composition are relatively minor (Christensen & Kimber 1975; Christensen et al. 1985; Tolhurst 1996) and largely restricted to understorey species (Christensen et al. 1985; Christensen & Abbott 1989; Nichols & Muir 1989; Wardell-Johnson & Nichols 1991; Wardell-Johnson & Christensen 1992). Species which feed from the open ground (such as Flame Robin, Scarlet Robin, Grey Shrike-thrush, Laughing Kookaburra, Superb Fairy-wren, Red-browed Finch, Pied Currawong, White-winged Chough, Australian Magpie, Buff-rumped Thornbill and Painted Button-quail in southeastern Australia and Grey Shrike-thrush,

Western Yellow Robin, Scarlet Robin, Australian Magpie, White-winged Triller, Australian Raven in southwestern Australia: Cowley 1974; Christensen et al. 1985; Christensen & Abbott 1989; Loyn et al. 1992*b*) generally increase post-fire. Species that feed from relatively dense shrubs initially decrease (e.g. Brown Thornbill, White-browed Scrubwren and Olive Whistler southeastern Australia and White-browed Scrubwren and Inland Thornbill in southwestern Australia) or disappear (Red-winged Fairy-wren, White-breasted Robin and Golden Whistler in southwestern Australia: Christensen & Kimber 1975; Christensen et al. 1985), but generally return (and sometimes exceed pre-fire abundance) within 2–3 years post-fire (Christensen & Kimber 1975; Christensen et al. 1985) (Fig. 6). Birds persisting in burnt areas may undergo change in behaviour and diet (Wooller & Calver 1988).

Control fires generally have little impact on canopy birds (Christensen & Kimber 1975; Christensen et al. 1981,1985), but increased numbers of lorikeets and honeyeaters may be attracted to fire-induced flowering of eucalypts (Christensen et al. 1985; Recher et al. 1985; Christensen & Abbott 1989; Loyn et al. 1992*b)*.

The season of burning has some impact on responses (Loyn et al. 1992*b*), but this may be very minor (Christensen et al. 1985). At least some birds raised young post-fire from nests started just pre-fire (Cowley 1974). Where control fires are unusually hot, bird responses may be more substantial and recovery more gradual, possibly because of greater depletion of invertebrates in hot fires (Christensen et al. 1985).

Total bird abundance may decline immediately after fire, then exceed pre-fire levels by 5 months post-fire (Kimber 1974; Christensen & Kimber 1975). However, there may be much variability in such responses: for example, Wooller & Calver (1988) reported a decline in bird abundance that was sustained for at least 3 years post-fire.

Species responses to fire regimes

While relatively minor impacts of control fires have been demonstrated in many studies, these are essentially short-term responses to single (or few) fire events, and may belie more substantial or insidious long-term impacts of a fire regime of frequent control burns (Recher et al. 1985). Consistent and frequent burning is likely to lead

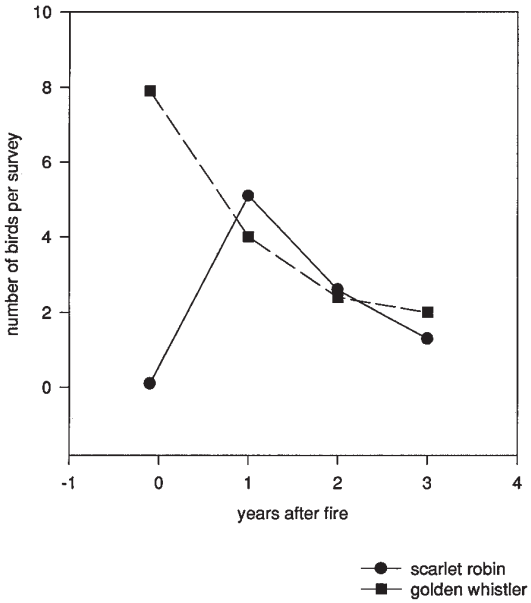


Figure 6: Response of a ground-feeding bird (Scarlet Robin) and shrub-feeding bird (Golden Whistler) to control burn in temperate eucalypt open forest. (after Christensen et al. 1985)

to sustained changes in understorey floristics and structure, including decline in litter and increase in weeds (Cowley 1971; Recher & Serventy 1991), and ultimately to changes in recruitment patterns for canopy trees.

Where fire regimes lead to relatively permanent, rather than short-term, changes in understorey, the bird species composition of the understorey will also be relatively permanently changed. Where frequent control burning is used to reduce fuel loads over sustained periods, birds which favour shrubby undergrowth (e.g. Golden Whistler) or dense leaf litter (e.g. Pilot-bird) will be disadvantaged (Rowley et al. 1988; Recher & Lim 1990; Taylor 1991; Recher & Serventy 1991; Recher et al. 1993). Birds which require relatively open understoreys may be favoured by very frequent fires or very long intervals between fires, but not by intermediate frequencies. For example, Superb Lyrebirds may decline or disappear from forests without frequent control burning because of the spread of wiregrass several years after fires (Cowley et al. 1969; Catling & Newsome 1981; Suckling & McFarlane 1983; Smith 1994), but occur also where long-unburnt forests develop a dense tall shrubby understorey which shades out grass (Loyn et al. 1985*a*,*b*).

Frequent burning may also lead to change in the spatial patterning of eucalypt open forests relative to vegetation dominated by more fire-sensitive plant species (notably rainforest). Such change may be to the disadvantage of birds of rainforests or their margins (Ferrier 1985; Holmes 1988,1989).

While milder fires generally have less impact than hot wildfires on invertebrates (Majer 1984,1985; Christensen et al. 1985) and other resources for birds, the cumulative impacts of repeated mild fires upon these resources, and hence upon birds, may be more severe (Friend 1995), although the limited evidence is not consistent (Springettt 1976; Abbott et al. 1984; Friend 1995).

Forestry

Much of the management of temperate eucalypt forests is associated with forestry. Fire management is a significant component of forestry activities. The impacts upon birds of interactions of fire and forestry practice (or comparisons between the two) have been considered by Cowley (1971), McIlroy (1978), Wilson (1981), Green (1982), Tingay & Tingay (1984), Loyn (1985*a*), Recher et al. (1985,1987*b*), Dickinson et al. (1986), Recher (1991), Curry (1991), Milledge et al. (1991), Taylor (1991), Wardell-Johnson & Nichols (1991), Wardell-Johnson & Christensen (1992) and Abbott & Christensen (1994). In some eucalypt forests (notably *E.regnans* and *E.delegatensis*), hot fire following harvesting is essential for tree regrowth. Such fires may exacerbate harvesting effects for species such as Spotted Quail-thrush (Wilson 1981), though McIlroy (1978) claimed that post-harvest fires had little impact on bird species. Piles of slashed vegetation left after harvesting may attract more birds if left unburnt (Dickinson et al. 1986; Curry 1991). Recher et al. (1987*b*) noted that the effects of wildfire upon birds were more severe in small retained (unlogged) strips than in larger strips or in larger unlogged areas. Regrowth forests following logging showed greater impact of wildfire upon birds than did burnt unlogged forests (Recher et al. 1985), and the combined effects of logging and fire were more serious than either individually. Hollow availability may be more affected by forestry activities than by fire regime (Lindenmayer et al. 1990).

Threatened species

A small proportion of the bird species in temperate open forests is threatened relative to those in other habitats (Garnett 1992*a*). Forestry and clearing, rather than fire, are the primary threatening process for most of these taxa. Most of the threatened bird species occurring in temperate eucalypt open forests (e.g. Sooty Owl, Masked Owl, Powerful Owl, southern subspecies of Red-tailed Black-cockatoo and Long-billed Black-cockatoo) are associated with old vegetation, usually because of their requirement for hollows. The endangered Orange-bellied Parrot nests in hollows in eucalypt open forest fringing heaths and button-grass plains in southwestern Tasmania. Fire management is critical for these species, to ensure protection of existing hollows and to allow the development of sufficient areas of suitable old trees for the future.

The endangered Helmeted Honeyeater is restricted to riparian eucalypt forests near Melbourne. Two small isolated populations disappeared after recent wildfire (Backhouse 1987). While widlfire is a continuing threat to the only remaining population, fire prevention works may create more disturbance than fire (Backhouse 1987).

The endangered Forty-spotted Pardalote occurs in coastal eucalypt open forests in Tasmania. Isolated populations may have been eliminated by wildfire, but mild fires are probably not detrimental to this canopy-feeding bird (Rounsevell & Woinarski 1983), although its requirement for hollows for breeding suggests that fire management may be required for its maintenance.

The rare Rufous Scrub-bird and northern populations of the vulnerable Eastern Bristlebird inhabit ecotones between rainforests and eucalypt open forests, and are threatened by too frequent fires (Ferrier 1985; Holmes 1988,1989), though both may also be disadvantaged by rainforest expansion associated with fire exclusion.

Fire management for bird conservation

A number of studies have recommended that fire management for bird conservation in eucalypt open forests should involve the flexible use of a broad range of fire regimes, with specific attention to threatened bird species (e.g. Recher 1981,1991; Wardell-Johnson et al. 1989). Until more is known about the long-term effects of particular regimes, this is probably the most prudent strategy.

3.4 TEMPERATE WOODLANDS

Fire regimes

Little information is available on the pre-European fire regimes in temperate woodlands, or the impacts of current regimes on birds of this habitat. Hopkins (1985*a*) considered that fires were probably infrequent in temperate woodlands of southwestern Australia under Aboriginal land management. He also noted that single fires in woodlands could have dramatic effects on vegetation structure, that repeated burning could cause permanent structural and floristic changes and that regeneration rates were generally very slow. In contrast, Prober & Thiele (1993) considered that woodlands in a slightly higher rainfall area in southeastern Australia were burnt every year under Aboriginal land management, and this maintained a floristically rich grass/herb understorey dominated by *Themeda*.

Subsequent to European settlement, in both southeastern and southwestern Australia, woodlands have been much affected by clearing, fragmentation, grazing, forestry operations and alteration of ecological processes (including changed fire regimes) (Saunders 1989; Saunders & Curry 1990; Bennett 1993; Robinson 1994; Yates et al. 1994). The age structure of most woodlands has probably markedly changed since European colonisation, with removal of most old trees on public lands and absence of regrowth on private (grazed) lands (Bennett 1993).

Species responses to single fires

Turner (1987,1992) considered short-term (8 months post-fire) and longer-term (8 years post-fire) responses of birds to a single wildfire in a mixed *Callitris-Eucalyptus* woodland in southeastern Australia. In the short-term, bird abundance and richness was much reduced. Crested Pigeon, cuckoos, Rainbow Bee-eater, Speckled Warbler, White-browed Babbler, White-plumed Honeyeater, Little Friarbird, Yellow-faced Honeyeater, Chestnut-breasted Mannikin, White-browed Wood-swallow, Superb Fairy-wren and Mistletoebird declined, while Emu, White-winged Triller and Dusky Wood-swallow were more common in burnt vegetation. At 8 years post-fire, richness and abundance of birds was greater in the regrowth vegetation. Species more common in the burnt area included Galah, Cockatiel, Turquoise Parrot, Rainbow Bee-eater, Black-faced Cuckoo-shrike, White-winged Triller, Superb Fairy-wren, Western Gerygone, Rufous Songlark, Grey Fantail, Brown Treecreeper, Varied Sittella, Grey-fronted Honeyeater, White-naped Honeyeater, Noisy Friarbird and Dusky Wood-swallow. Golden Whistler and Speckled Warbler were more common in the unburnt area.

Open-country bird species invaded *Banksia* woodlands in southwestern Australia soon after fire, but most species present before fire were again recorded within a few months after fire (Bamford 1985*a*,*b*). No species showed a preference for the long unburnt (22 years post-fire) sites.

Species responses to fire regimes

There is very limited information on response of birds to repeated fire, or particular fire regimes, in temperate woodlands. Adam & Robinson (1996) found greatly reduced density of Grey-crowned Babblers in roadside remnants that were annually burnt compared to unburnt strips, in association with greatly reduced shrub cover.

Threatened species

Woodland birds are declining across much of southern Australia (Recher & Lim 1990; Robinson 1991). In many woodlands, hollow-nesting birds (and other fauna) are threatened by current (and/or projected) limited supply of hollows (Saunders et al. 1982; Traill 1993; Bennett 1993), which may be influenced by fire regimes (Webster & Ahern 1992; Quin & Baker-Gabb 1993). Birds which nest or forage on the ground are threatened by introduced predators and floristic or vegetation structural changes associated with grazing or changed fire regimes (Bennett 1993). A recent review of threatened woodland birds (Robinson 1994) did not list inappropriate fire regimes as a major threatening process, but little is known of the fire regimes preferred or required by such species, nor of impacts of the interaction between fire and grazing. Management of fire may be a major concern if grazing is excluded from woodland conservation reserves.

Casuarina or *Allocasuarina* may be a locally prominent component of some woodland communities and provides focal resources for some bird species, notably the endangered Glossy Black-cockatoo. A high frequency of intense fires since European settlement has led to decline in

mature Casuarina, and hence of this dependent bird (for example, its extinction from King Island is associated with extensive hot wildfires around 1920: Green & McGarvie 1971). Its persistence requires management to ensure fire exclusion, or long intervals between intense fire (Joseph 1982; Clout 1989). For example, Joseph (1982) found that woodland areas 22 years post-fire were still unsuitable for Glossy Black-cockatoos.

The extinction of the Paradise Parrot from grassy woodlands of inland northeastern New South Wales and southeastern Queensland has been linked to change in the fire regime following European settlement (Chisholm 1922,1945), although pastoralism, drought or weeds (singly, or in combination) may also have been involved (Forshaw 1981; Garnett 1992*b*).

Fire management for bird conservation

There is an urgent need for data to guide fire management for the conservation of temperate woodland birds. Some fire management actions for Superb Parrot, Turquoise Parrot, Grey-crowned Babbler and Glossy Black-Cockatoo have been described (e.g. Davidson & Chambers 1991; Davidson & Robinson 1992; Webster & Ahern 1992; Quin & Baker-Gabb 1993).

3.5 TROPICAL EUCALYPT OPEN FORESTS AND SAVANNA WOODLANDS

Fire regimes

Fire management by Europeans has varied substantially across the extensive tropical eucalypt open forests and savanna woodlands of northern Australia. In the Top End and Kimberley, the incidence of hot extensive late Dry season fires has increased (Braithwaite & Estbergs 1985; Lewis 1985). This increase has largely been due to pastoral goals, but a high frequency of extensive late Dry season fires occurs across all land tenures, including conservation reserves (Russell-Smith & Bowman 1992; Russell-Smith & Ryan 1994).

Fires in tropical open forests and savanna woodlands are generally relatively mild and immediate impacts are often restricted to the understorey (Braithwaite & Estbergs 1985; Bowman 1988), superficially more similar to control burning than wildfire in temperate systems. Rapid build up of fuel and long dry seasons almost inevitably lead to a high frequency of fires, hence generally denying successional patterns comparable to those in temperate open forests (Bowman 1988).

Species responses to single fires

There may be very marked short-term response by birds to fire in tropical eucalypt open forests and savanna woodlands. Typically, the slow mild fires lead to little direct bird mortality (Braithwaite 1985). Many hawking insectivores (e.g. wood-swallows, swifts) and raptors are attracted to fires.

From hours to months after fire, a wide range of ground-feeding birds (e.g. Torresian Crow, raptors, Pied Butcherbird, Straw-necked Ibis, Red-tailed Black-cockatoo, Little Corella, Galah, Blue-winged Kookaburra, Red-backed Kingfisher, Magpie-lark) is attracted to burnt areas to feed on resources made more accessible by the removal of the dense grass layer (Crawford 1972,1979; Beeton 1985; Braithwaite 1985; Braithwaite & Estbergs 1987; Press 1987; Woinarski 1990) (Fig. 7). Many of these species may track fires or recently-burnt areas across the landscape (Crawford 1972; Woinarski & Tidemann 1991,1992; Woinarski et al. 1992). This attraction may be reduced in intense late Dry season fires, as the hot fires may destroy a far higher proportion of seeds than do the cooler burns of the early dry season (Woinarski 1990). Individual bird species may also differ in their short-term responses to late and early Dry season fires (Woinarski 1990; Tidemann 1993*b*).

Few bird species of tropical open forests and woodlands seem to be clearly disadvantaged in the short-term by fire. Those that do, include the insectivorous Golden-headed Cisticola and Red-backed Fairy-wren, which feed and shelter in dense grass (Crawford 1972,1979; Woinarski 1990) and Purple-crowned Fairy-wren which requires dense grass and pandanus (Rowley 1987,1993; Rowley & Russell 1993). Early dry season fires may also destroy the nests and/or young of birds which nest on the ground or in grass tussocks (notably Partridge Pigeon and Masked Finch: Woinarski 1990; Lucas & Lucas 1993).

In tropical eucalypt open forests and savanna woodlands, hot fires late in the Dry season may destroy hollow-bearing trees, to the detriment of hollow-nesting birds, including Gouldian Finch and Palm Cockatoo (Young 1991; Tidemann 1992; Stanton 1992,1995; Crowley 1995). While this may be a serious threat for Palm Cockatoos, the smaller hollows suitable for Gouldian Finch appear to be relatively abundant and not limiting (Tidemann et al. 1992).

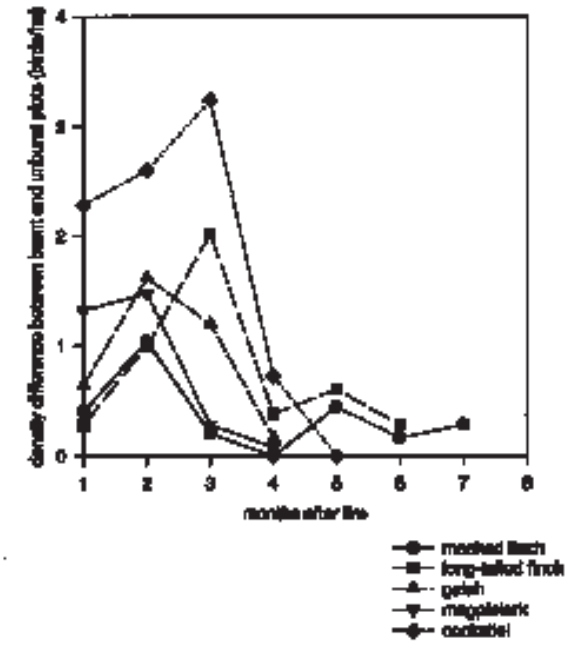


Figure 7: Short-term response of birds to fire: tropical savanna woodland (after Woinarski 1990)

Species responses to fire regimes, and threatened species

The high frequency and intensity of fires late in the Dry season has led to the decline of fire-sensitive vegetation within the tropical eucalypt landscape (notably monsoon rainforests, *Callitris* and some *Acacia* woodlands: Bowman 1988; McKenzie & Belbin 1991; Russell-Smith & Bowman 1992; Bowman & Panton 1993; Price & Bowman 1994) since European settlement, and hence disadvantaged the birds associated with these (Woinarski 1993*b*; Woinarski & Fisher 1995*a*,*b*). Inappropriate fire regimes may have led to the extinction of the subspecies of Northern Scrub-robin from monsoon rainforests and *Acacia* thickets of the Northern Territory, although whether this population ever existed is questionable (Bennett 1983). Evidence from abandoned nesting mounds of the rainforest-dependent Orange-footed Scrubfowl located now in tropical eucalypt open forests suggests that contraction of rainforests, and hence decline of their bird species, occurred also in the period of Aboriginal land management (Stocker 1971; Russell-Smith 1985; Bowman et al. 1994*b*).

Where fire is excluded (generally only possible in areas without long dry seasons, or where fuel levels are kept low by grazing), fire-sensitive vegetation can expand into the open forests and savanna (Russell-Smith & Dunlop 1987; Stanton 1992,1995; Crowley 1995; Harrington & Sanderson 1994). In the Wet tropics of Cape York Peninsula, rainforest expansion has been at the expense of the narrow margin of wet sclerophyll forest, and bird taxa associated with this vegetation (including the vulnerable Southern Cassowary, and isolated populations of Eastern Yellow Robin, Yellow Thornbill, Buff-rumped Thornbill, Crested Shrike-tit, White-naped Honeyeater and Yellow-faced Honeyeater: Crowley 1995; Harrington & Sanderson 1994) are threatened by fire suppression.

In contrast, too frequent burning of the rainforest/eucalypt open forest margins is considered threatening to the vulnerable Black-breasted Button-quail in southeastern Queensland, and fire exclusion has been recommended to maintain the dense leaf litter it requires (Hughes & Hughes 1991).

Presumably as a result of a complex interaction between grazing pressure, burning regime and periods of unusually high rainfall, wet grassland flats on Cape York Peninsula are being invaded by dense *Melaleuca* forests (Stanton 1995). This has severely disadvantaged the endangered Golden-shouldered Parrot (Garnett & Crowley 1994; Crowley 1995; Stanton 1995).

For the tropical eucalypt open forests and savanna woodlands themselves, frequent fires (annual or biennial) decrease structural complexity of the vegetation (Bowman et al. 1988) and the incidence or productivity of shrubs bearing fleshy fruits. Hence, tropical open forests and savanna woodlands protected from fire have different bird species composition to those burnt frequently (Porter & Henderson 1983; Woinarski 1990). The more structurally diverse forests resulting from infrequent fires generally having richer bird assemblages, especially of frugivorous birds and those which forage or nest in shrubs (Porter & Henderson 1983; Woinarski et al. 1988; Woinarski 1990).

Grass species composition may also be determined by the season and frequency of fires (e.g. Smith 1960; Tothill 1992), which may affect granivorous birds, though the evidence is limited (Tidemann 1990; Garnett & Crowley 1995*b*). Fitzherbert & Baker-Gabb (1988) considered six granivorous bird species (Gouldian Finch, Yellow-rumped Mannikin, Chestnut-backed Button-quail, Partridge Pigeon,

Golden-shouldered Parrot and Hooded Parrot) to be threatened by too frequent fires in the tropical savannas. Garnett & Bredl (1985) noted that the threatened Star Finch was largely restricted to long-unburnt patches of grass on Cape York Peninsula. On Cape York Peninsula, pastoral management often involves "storm-burning" after the first rains of the Wet season (Crowley 1995). This may have removed much of the annual sorghum, possibly to the detriment of the endangered Gouldian Finch (Tidemann 1993*a*; Tidemann et al. 1993), though possibly to the advantage of Golden-shouldered Parrots (Garnett & Crowley 1994).

The decline of two trunk-gleaning insectivores, the Black Treecreeper of open forests on Cape York Peninsula and the northern subspecies of Crested Shrike-tit of open forests across northern Australia, has been linked to frequent intense and extensive late dry season fires (Robinson & Woinarski 1992; Garnett & Crowley 1995*a*).

The vulnerable Red Goshawk occurs widely across open forests of northern Australia. Although there are reports of nestlings being killed by fire and nest trees being destroyed by fire (Aumann & Baker-Gabb 1991) and suggestions that high fire frequency is disadvantageous (Debus & Czechura 1988), the evidence to evaluate fire effects is insufficient.

Exclusion of fire has been recommended for the riparian habitat of the threatened Purple-crowned Fairy-wren (Rowley & Russell 1993), and less frequent fire (especially of extensive hot fires) for the threatened Black Treecreeper and Crested Shrike-tit (Robinson & Woinarski 1992; Garnett & Crowley 1995*a*).

Fire management for bird conservation

Fire management for the conservation of birds in the tropical eucalypt open forests and savanna woodlands has emphasized the need for maintenance of a range of burning practices preferably creating a fine-scale mosaic of fire histories (Press 1987; Brooker et al. 1990; Stanton 1992; Crowley 1995; Garnett & Crowley 1995*a*), with emphasis on burning early in the dry season to prevent destructive late Dry season fires (Tidemann 1992; Woinarski 1993*a*) or "storm-burning" in the early Wet season (Garnett & Crowley 1994; Crowley 1995) for the management of particular bird species.

3.6 TUSSOCK GRASSLANDS

There is surprisingly little information on the impact upon birds of fire in tussock grasslands (Fitzherbert & Baker-Gabb 1988; Woinarski 1993*a*). Research on effects of fires in savanna woodlands is at least partly transferable to grasslands. Burning patterns in tussock grasslands across Australia are very variable, ranging from attempted exclusion to frequent firing to promote "green pick" (Walker & Tothill 1992; Pressland et al. 1992). Their impact is almost everywhere regulated or confounded by grazing pressure.

Burning patterns in the floodplain grasslands of northern Australia have now changed from those employed by Aboriginal people, who lit mild early dry season fires to decrease the likelihood of subsequent extensive destructive fire and to manipulate graminoid species composition to favour Magpie Goose, a pivotal food resource (Jones 1980; Lewis 1989; Lucas & Lucas 1993; Lucas & Russell-Smith 1993). Burning patterns now tend to be more erratic, with a higher frequency of wildfire (Press 1988).

In semi-arid Mitchell grasslands, land management usually attempts fire exclusion (Orr & Holmes 1984; Anderson et al. 1988). This leads to change in plant species composition and structure of the grasslands, and, as fire promotes seeding (Scanlan 1980), to decrease in seed availability. The consequences of such habitat and resource changes to birds are unknown (Woinarski 1993*a*).

Fire is also used extensively to maintain semi-arid grasslands under invasion by "woody weeds" (Walker & Tothill 1992; Sullivan et al. 1992), and to aid in the clearance of woody species to create grasslands (Johnson & Purdie 1981; Anderson & Back 1992). Given the correlation of bird species richness with vegetation structural complexity (Recher 1969), this habitat alteration probably reduces local species richness.

In temperate grasslands, burning regimes have also changed appreciably from relatively frequent firing by Aboriginal people (Nicholson 1981) usually to a contemporary regime of attempted fire exclusion with occasional hot wildfire (Fitzherbert & Baker-Gabb 1988). Occasional wildfires in temperate grasslands of the Riverina may have severe impacts on grassland birds, notably the threatened Plains-wanderer (Baker-Gabb et al. 1990). Many grasses and other grassland plant species depend upon specific

burning regimes (Lunt 1991). Plant species diversity is increased by regular burning at about 5 year intervals (McDougall 1989). While these floristic (and vegetation structural) responses to fire regime probably influence grassland bird species composition, there is no substantial information on bird-fire relationships in temperate grasslands.

Early seral grasslands occurring soon after hot fires in heaths and forests attract a wide range of typical grassland birds, such as Richard's Pipit, Blue-winged Parrot, quail and Australian Magpies (Loyn 1985*b*; Dickinson et al. 1986; Brooker & Rowley 1991).

3.7 HUMMOCK GRASSLANDS

Hummock grasslands form a distinctive and extensive environment acoss much of arid and semi-arid Australia and in sandstone ranges of northern Australia. Suijdendorp (1981) summarises prevailing fire regimes in hummock grasslands and their broad ecological impacts. Current fire regimes generally differ from the patch mosaic burns used by Aboriginal people to changed scale of fires with fewer small mild fires but more frequent extensive wildfire (Kimber 1982; Griffin et al. 1983; Griffin 1984; Burbidge 1985; Reid & Fleming 1992; Baker et al. 1993; Russell-Smith & Ryan 1994). Hummock grasslands may be expanding under some current fire regimes at the expense of other vegetation types, such as *Acacia* woodlands and shrublands (Bowman et al. 1994*a*; Latz 1995). Environmental responses to fire in hummock grasslands (and other arid communities) may be particularly influenced by season of fire and rainfall following fire (Noble et al. 1984; Reid et al. 1993*a*).

In contrast to some detailed studies demonstrating successional patterns in mammals and reptiles of hummock grasslands (e.g. Masters 1993), there has been little research on the relationships of birds to fire regimes in hummock grasslands. Reid et al. (1993*a*,*b*) found that short-term effects of fire in hummock grasslands of central Australia include invasion of recently-burnt areas by nomadic open-country birds (including White-winged Triller, Budgerigar, Black Honeyeater, Crimson Chat, Zebra Finch, Banded Whiteface and Masked Wood-swallow). Pioneer plants may provide a rich seed resource soon after fire (Latz 1995), and many granivores are hence attracted to recently-burnt areas (Baker et al. 1993).

Longer-term impacts are less clearcut. The availability of hummock grass seeds generally increases with time since fire up to about 10-20 years but may then decline (Westoby et al. 1988). Invertebrate numbers may be low in the first year after fire (Masters 1993). Several bird species show preference for, or are restricted to, long-unburnt hummock grasslands. These include Rufous-crowned Emu-wren, Spinifexbird and the threatened Striated Grasswren, all insectivores which shelter or nest in large clumps of hummock grass (Pedler 1991; Garnett et al. 1993; Reid et al. 1993*a*,*b*). The threatened Carpentarian Grasswren, of sandstone ranges in the Gulf of Carpentaria hinterland, also requires long-unburnt hummock grasslands or, at least, is severely disadvantaged by the current regime of frequent extensive hot fires (CSIRO 1976; Schodde 1982; McKean & Martin 1985,1989). This may also be the case for the Black Grasswren (in the Kimberley) and White-throated Grasswren (of the Arnhem Land sandstone massif) (Fitzherbert & Baker-Gabb 1988), however, although extensive hot fires are now frequent in this environment (Russell-Smith & Ryan 1994), the evidence of their impact on White-throated Grasswrens is unclear (Noske 1988,1992*a*,*b*: Woinarski 1992).

The threatened Night Parrot formerly occurred in hummock grasslands and other arid habitats across much of inland Australia. Its rapid decline may have been due to increased frequency of extensive fires (Ashby 1924*a*). Recent reports have been from an area where small control burns had led to a mosaic of vegetation ages and had prevented extensive fire (Garnett et al. 1993).

Fine-scale mosaic burning (largely to reduce the likelihood of extensive hot wildfire) has been recommended for the conservation of birds generally in hummock grasslands (Gibson 1986; Pedler 1991; Reid et al. 1993*a*,*b*; Baker et al. 1993).

3.8 ACACIA SHRUBLANDS AND WOODLANDS

There is relatively little information on the birds of *Acacia* woodlands and shrublands, fire regimes operating in them, or the effects of fire regimes on their birds. Aboriginal use of fire in semi-arid and arid *Acacia* communities may have been generally restricted to infrequent burning of many small patches, creating a fine-scale mosaic of successional states (Griffin & Hodgkinson 1986). European colonisers in these environments

initially had no fire strategy, or used fire to clear country. The incidence of extensive wildfire has accordingly increased markedly (Griffin & Hodgkinson 1986).

Some *Acacia* formations, such as Mulga *A. aneura*, are notably fire-sensitive, and are declining under current management (Reid et al. 1993*b*; Bowman et al. 1994*a*). Reid et al. (1993*b*) noted that:

> *"given the importance of this species to the associated rich bird community, it would seem that the destruction of extensive areas of mulga by fire would decimate bird populations, at least until the mulga had regenerated to a certain age".*

Most bird species will recolonise mulga by about 10–15 years post-fire (Reid et al. 1993*a*,*b*), though older mulga may support more mistletoe, and hence the bird species associated with this (e.g. White-fronted Honeyeater: Reid et al. 1993*a*). Recently-burnt mulga contains many generalist nomadic species, such as White-winged Triller and Zebra Finch (Reid et al. 1993*a*).

The loss, through burning and mechanical clearing, of Brigalow *Acacia harpophylla* forests and other trees in inland southeastern Queensland, may have widespread ripple effects, as this area is probably an important wintering base for many bird species migrating from southeastern Australia (Nix 1993).

Increased incidence of intense wildfire is regarded as the major conservation threat to birds of Lancewood *Acacia shirleyi* woodlands (Woinarski & Fisher 1995 *a*,*b*).

Conservation managers have recommended that extensive wildfires in *Acacia* communities should be avoided, and hence biodiversity maintained, by mosaic burning, with small mild fires (Griffin & Hodgkinson 1986).

3.9 OTHER HABITATS

In chenopod shrublands, Brooker et al. (1979) noted that White-winged Fairy-wrens disappeared from a bluebush site for at least 5 years post-fire. Wildfire may be a substantial threat to the Nullabor Quail-thrush, especially as regrowth of chenopods is often prevented (or delayed) by rabbit grazing (Burbidge & Pedler 1993,1996; Pedler & Burbidge 1995).

There is little information on the impact of fire regimes on birds in other Australian environments. In some cases (such as mangroves, saltpans, rainforests), this is because fire may not be a major management issue, at least in the short-term.

3.10 SPECIAL CASE: ISLANDS

Increased use and extent of fire following European colonisation contributed to the extinction of the Kangaroo Island Emu (Ashby 1924*a*) and the Glossy Black-Cockatoo on King Island (Green & McGarvie 1971), although the evidence for its role in the former case is limited.

Birds which nest in colonies on, or close to, the ground may be particularly vulnerable to fire. The most obvious examples of this susceptibility are seabirds, whose island (or, occasionally mainland) colonies have been frequently devastated by fire, often killing many thousands (and/or a large proportion) of the nesting adults, young and/or eggs (MacGillivray 1910; Hull 1922; Whitley 1944; Fowler 1945; Abbott 1981; Lane 1976; White 1979*a*,*b*; Garnett 1987; Chatto 1995), and/or rendering vegetation subsequently less suitable for breeding (Pescott 1976; Paton & Paton 1977; Brothers 1983; Brothers & Skira 1987,1988; Skira & Brothers 1988*a*,*b*; Walker & Hulsman 1993). In many cases, these fires have been deliberately lit by fishermen.

4. RESEARCH ADEQUACY, METHODS AND PRIORITIES

Recher et al. (1985) noted that:

> *"Considering the frequency with which fires occur in eucalypt forests and woodlands and their dramatic impact on the landscape, there is remarkably little information about the effects of fire on fauna or the long-term consequences of burning on forest ecosystems".*

This is a striking feature of this review of the effects of fire on Australian birds. In general, there is insufficient information available to direct management or to evaluate a range of conservation options. Most information is anecdotal or serendipitous. There have been very few long-term studies. There have been few comparisons of different fire regimes, or of treatments with controls. There have been relatively few studies with individually-marked birds. For some environments, and many biogeographic regions, there is effectively no information on responses of birds to current, or alternative, fire regimes (Table 2).

The disparate approaches, and limitations, of research on birds has hampered comparisons, synthesis and overview. A similar problem has recently been described for research on the impacts of fire upon invertebrates (Friend 1995).

Sampling sites across a range of fire ages

A relatively high proportion of studies have considered succession (or change in bird species composition with post-fire age) by comparing bird assemblages at separate sites across a range of ages (e.g. Cheal et al. 1979; Meredith et al. 1984; Loyn 1985*a*; Bamford 1985*a,b*; Carpenter & Matthew 1986; McFarland 1988; Woinarski 1989*b*). Such research provides a broad-brush response to fire ages, and is attractive in that sampling of a range of ages can be undertaken over a short time period. However, the ages sampled are constrained by availability, rendering prediction from beyond the sampled range uncertain (Baker & Whelan 1994). Because different sites are sampled to represent different post-fire ages, it is also likely that fire effects are compounded or confounded by other environmental factors or local site effects (Burbidge et al. 1989). Except where specific searches are made for rare species (e.g. Meredith et al. 1984; McFarland 1988), this approach may also provide too few data to enable statistical analysis of responses of such species.

In most cases, this approach also fails to consider fire regime, concentrating instead on time since last fire. Where more detailed information on fire histories of sites are known (e.g. Russell-Smith & Ryan 1994), systematic sampling of sites should be able to indicate the impacts of a range of fire regime parameters rather than simply period since last occurrence.

Repeated sampling of individual sites

There have been a small number of valuable studies which have monitored bird assemblages at single sites over an extended time following wildfire (Hewish 1983; Smith 1985*a*; Reilly 1991*a,b*; Turner 1987,1992; Brooker & Rowley 1991; Cale & Burbidge 1993). In some cases these have included comparisons with before-fire abundances (Hewish 1983; Recher et al. 1987*b*), or with nearby unburnt vegetation (Hewish 1983; Recher et al. 1987*b*; Turner 1992). More studies have considered short-term (0–2 years post-fire) responses (e.g. Roberts 1970; Ratkowsky 1979,1985; Dedman 1983*a–e*,1984; Recher et al. 1985; Loyn et al. 1992*a*), during which changes may be most rapid. In general, the interpretation (and extrapolation) of these studies is constrained by lack of replication, such that it may be difficult to distinguish idiosyncratic site (or fire) factors and responses from more general responses.

Because control burning is, by definition, more tractable than wildfire, there has been somewhat more systematic sampling of the short-term responses of birds to control fires (Hodgson & Heislers 1972; Cowley 1974; Kimber 1974; Christensen & Kimber 1975; Ratkowsky 1978,1979; Tingay & Tingay 1984; Wardell-Johnson & Christensen 1992; Woinarski 1990; Loyn et al. 1992*b*), usually with before-after comparisons, and occasionally with comparisons with unburnt controls (Kimber 1974; Christensen et al. 1985; Woinarski 1990; Loyn et al. 1992*b*; Tolhurst 1996) or between a range of control burning approaches (notably season of burn: Woinarski 1990; Loyn et al. 1992*b*; Tolhurst 1996). However, these studies cover a remarkably small proportion of the environments in which

control burning is regularly and extensively implemented. Most also report changes in the more common species only (for which more data are compiled), and hence may overlook impacts of fire upon rarer birds (Christensen et al. 1985; Meredith 1988). Again, the extrapolation from these studies is usually hampered by inadequate replication; though generally consistent findings across a range of studies at separate locations suggest that the main conclusions are probably robust.

Sampling sites of known long-term fire regimes

There have been extremely few studies which have examined longer-term effects upon birds of specified fire regimes (Meredith 1988). Exceptional have been studies in tropical eucalypt open forests, where Porter & Henderson (1983) compared bird assemblages in plots of three different fire regimes (unburnt, annually burnt and burnt at 2–5 year intervals) maintained over nearly 30 years; and Woinarski (1990) compared bird assemblages in plots of four regimes (unburnt, burnt annually in the early dry season, burnt annually in the late dry season and burnt biennially) maintained over 14 years. The difficulty of maintaining consistent fire treatments over such long period (and the unreality of assuming that such strictly-enforced regimes could occur beyond experimental sites) has provided a strong disincentive for such studies.

Fire season and breeding

There have also been very few studies which have compared the effects of fires occurring at different seasons. Several authors have advocated that fires should avoid the breeding season, as fires then may destroy a high proportion of the season's reproductive output for birds nesting on the ground or in low vegetation (Bedggood 1980; Reilly 1991*a*,*b*; Baker et al. 1993), and this impact may be compounded when fires are frequent (Lucas & Lucas 1993; Brooker & Brooker 1994). For example, Rowley & Brooker (1987) suggested that a single hot wildfire had less impact on the survival of Splendid Fairy-wrens than did cool control fires, because the wildfire occurred after the breeding season whereas the control fires were earlier. In contrast, Christensen et al. (1985) considered that occasional fires during the breeding season probably have limited and insignificant impact on populations of forest birds. As noted above, a special case may be birds which nest in isolated colonies, where a single fire may destroy many individuals and/or a large proportion of the population.

An unusual relationship between birds and fire is the consumption of ash and charcoal by a range of bird species (Baldwin 1965; Coate 1985; Pescott 1985; Hutchins 1988), which may be related to mineral requirements for breeding, but limited analysis has failed to establish any pattern or compelling explanation of this feature.

Autecological studies

Some detailed long-term autecological studies have revealed important subtleties of fire impacts, such as delayed responses due to reduced breeding success in the years after fire (Marchant 1985; Rowley & Brooker 1987; Brooker & Rowley 1991; Russell & Rowley 1993), the fate of dispersing birds, role of unburnt patches and complex patterns of use of mosaics of different fire age (Smith 1979*a*,1985*a*,1987*a*; Brown & Wilson 1981,1984; Benshemesh 1992), change in population age structure, sex ratio and survivorship (Rowley & Brooker 1987; Brooker & Rowley 1991; Russell & Rowley 1993), and critical requirements for apparently trivial resources (e.g. cobwebs) which may be particularly affected by fire (Brooker & Rowley 1991; Recher 1991). The subtlety but importance of these factors suggests that brief monitoring post-fire may provide misleading assessments of longer-term impacts. It also demonstrates that management of fire for the conservation of individual bird species must be preceded by detailed long-term research (Smith 1987*a*).

Translation of research to management

Such long-term autecological studies are particularly valuable in that they can provide specific information on which to base carefully targetted fire management (e.g. Hopkins 1985*b*; Brooker & Brooker 1994). There has been remarkably little effective translation of research results to evaluated management options - though some exceptions include Meredith (1982), Smith (1987*a*), Benshemesh (1990), McFarland (1992), Cale & Burbidge (1993) and Hopkins & Smith (1996) - possibly because of the paucity of quantitative data.

Brooker & Brooker (1994) provide easily the most detailed assessment of a range of fire management options for any Australian bird

species, using modelling to predict survival/extinction probabilities for a range of fire regimes across a range of habitat patch sizes. However, this case is exceptional, as it is based on data from one of the very few long-term studies of the responses of individual species to fire (Rowley & Brooker 1987; Russell & Rowley 1993). Comparable data are available for very few other species (probably being limited to Noisy Scrub-bird, Western Bristlebird and possibly Western Whipbird, Rufous Scrub-bird and Ground Parrot). Yet such modelling may be vital for management of fire-susceptible threatened species, to decide whether to translocate populations, how to protect populations from fire, whether to provide a range of fire ages in different patches, etc. These studies provide good examples of how research should precede and guide management.

In the absence of a sufficient research history, fire management (especially in conservation reserves) should conservatively include a broad range of regimes, so as not to foreclose options (Recher 1981,1991; Christensen et al. 1985; Brooker et al. 1990). Fire management should be accompanied by ongoing monitoring of impacts upon the fauna, and particularly on the known fire-sensitive species, and assessment of these impacts should then be used to refine, or more precisely target, that management (Wardell-Johnson et al. 1989). Acceptance of the importance of fire management for conservation of fauna is relatively recent. Only 20 years ago, Newsome et al. (1975) considered that:

> "*it is too early to think of utilising fire as a tool for management of fauna in National Parks*".

Landscape context

Relatively little research has been directed at spatial analysis of fire effects, such as the role of unburnt patches, the relationship between fire extent and direct impacts and recolonisation, and the process of recolonisation of burnt isolates. Many experienced field workers have reported that fires which comprehensively burn areas have greater impacts than patchy burns which leave some unburnt areas (e.g. Recher 1981; Smith 1989; Reilly 1991*a*); however there is little quantitative documentation of the role, or required size, of unburnt patches. Using radio-telemetry, Benshemesh (1990) demonstrated the importance of small unburnt patches in the post-fire persistence of Malleefowl. Smith (1989) reported that a forest bird assemblage proved remarkably resilient to a wildfire largely because of small areas (in gullies) that were left unburnt. Rowley & Brooker (1987) noted that Splendid Fairy-wrens that retained some unburnt patches in their territories persisted after fire, whereas those whose territories were completely burnt disappeared. However, Brooker & Rowley (1991) found no apparent preference for unburnt patches of heath among a range of bird species after fire.

Recolonisation of burnt areas is generally quicker if smaller areas are burnt and are surrounded by similar unburnt vegetation (e.g. Reilly 1991*b*), but again the evidence is more anecdotal than analytical. Small burnt areas may attract more concentrated populations of post-fire scavengers than extensively burnt areas (Woinarski 1990).

Small distant isolates which are unlike their surrounds are less quickly recolonised post-fire than are large isolates close to unburnt source areas (Reilly 1991*a*,*b*; McFarland 1991), and unburnt corridors may be important in this recolonisation (Danks 1991; DuGuesclin et al. 1995). Small fragments may also suffer more severe fire impacts than large fragments (Recher et al. 1987*b*), possibly because there is a higher probability of some unburnt areas (or some survivors) in larger fragments. Increased fragmentation of suitable habitat, either through clearing or widespread application of inappropriate fire regimes, may exacerbate local fire effects, especially for species with relatively poor dispersal ability.

In some cases, fragmentation may also offer some protection from landscape-wide fires (for example, much of the limited long-unburnt mallee exists as small patches isolated by farmland), and possibly more flexibility in manipulating vegetation ages (e.g. because it is relatively easy to impose contrasting regimes on different isolates). However, in general, fragments are probably more prone to homogenising fires than are extensive habitats (Menkhorst & Bennett 1990), support relatively small populations and are less likely to be recolonised post-fire (Brooker & Brooker 1994), with the result that they are less likely to retain environmental diversity (Williams et al. 1994) and sustain, over the long-term, populations of species which are associated with particular seral stages. Fragments, particularly smaller ones, may also be subjected to fire regimes which are

unlike those occurring in extensive habitats, typically being burnt much more frequently or much less frequently (depending upon their surrounds). This disruption of ecological processes is recognised as a major management problem in fragmented habitats (e.g. Abensperg-Traun & Smith 1993; Yates et al. 1994), and is likely to be critically important to fire-susceptible threatened bird species in fragmented habitats.

Fire control

There has been little research on the impacts upon birds of fire control mechanisms other than fuel reduction burning. Adam & Robinson (1996) and Davidson & Robinson (1992) suggested that land managers who must protect property from wildfire should preferably use judicious slashing rather than control burning for roadside remnants used by Grey-crowned Babblers. However, Schulz (1991) noted that slashing also had problems for the conservation of this species. The provision of water sources for fire fighting may locally alter bird community dynamics in arid or semi-arid areas (Cheal et al. 1979; Meredith 1982). Firebreaks and associated road networks are likely to lead to increased penetration of predators, and increased predation post-fire (May 1994).

Interactive effects between fire and other land uses or threatening processes

There has been limited research directed at the impacts upon birds of fire/forestry interactions (e.g. Recher et al. 1985,1987*b*; Dickinson et al. 1986), but many aspects of fire management in forestry operations have not been assessed in terms of impacts upon birds.

Other than preliminary studies by Brooker (1988) and Tidemann (1990), there has been no research investigating the impacts upon birds of interactions between fire and grazing by livestock. Grazing by stock leads to changes in fuel loads, floristic composition, vegetation structure, recruitment of tree species, successional process and, hence, to different fire regimes to those operating in ungrazed areas. Pastoralists may also impose particular fire regimes with the single aim to provide short-term benefit to stock (Head et al. 1992). Removal of stock from woodland fragments is advocated as a conservation measure for woodland birds (Robinson 1994), but the impact of this removal on fire regimes is unclear. Removal of the immediate perceived problem, grazing, may lead to its replacement with another management issue, fire.

Grazing by other herbivores may delay or stall recovery of vegetation after fire, extending or magnifying fire impact. The interaction of rabbits, fire and chenopod shrublands is threatening Nullabor Quail-thrush (Burbidge & Pedler 1996). Grazing by macropods may stall regrowth of heath, to the detriment of Western Bristlebirds (Cale & Burbidge 1993).

Fire management, even in conservation reserves, serves many purposes other than optimising environments for particular bird species. In order to include bird conservation in a multi-purpose fire management plan, it is critical that research be directed at the assessment the consequences for birds of fire/land-use interactions.

There has also been little study of the interaction between fire and predation, although the compounding effects of these two factors has been recognised (e.g. Braithwaite & Estbergs 1987; Benshemesh 1990; Recher 1991). While birds may survive fire, lack of vegetation cover in burnt areas may make them far more susceptible to predation, and predator density may increase in recently-burnt areas.

Multidisciplinary studies

With notable exceptions (e.g. Recher et al. 1985; Tolhurst & Flinn 1992), almost all research on the effects of fire upon birds has been carried out in an ecological vacuum, without synchronous complementary studies of the responses of other components of the ecosystem. However multidisciplinary approaches may provide the mechanisms for explaining why individual bird species respond in particular ways to a given fire or fire regime, and hence provide powerful capability to better guide management.

Representation of biogeographic regions and environments

The research effort directed at the relationships between Australian birds and fire has been very inequitably distributed across habitats and geographic regions (Table 2). While the known occurrence of fire-sensitive threatened birds in heaths and mallee is reasonable grounds for giving these environments high priority attention, other environments where fire is a major management issue have been neglected. Critical gaps occur in the long-term effects of control burning in temperate eucalypt forests, and in the impacts of fire regimes in woodlands (including those dominated by *Acacia*, *Callitris* and *Casuarina* species), tussock grasslands, hummock grasslands and rainforest margins.

5. CONSERVATION OVERVIEW

Of the three species and four subspecies of birds which have become extinct since European settlement, inappropriate fire regimes caused, or contributed to, the loss of two species (Kangaroo Island Emu and Paradise Parrot) and three subspecies (Northern Territory subspecies of Northern Scrub-robin, southwestern Australian subspecies of Rufous Bristlebird and southwestern Australian subspecies of Lewin's Rail). Fire is now recognised as a main threatening process for many rare, vulnerable and endangered Australian birds. Brouwer & Garnett (1990) listed inappropriate fire regime as a threat for 22 of 52 threatened Australian bird species, and Garnett 1992*b* considered it threatened 51 taxa (second only to habitat clearance and fragmentation, which threatened 52 taxa) (Table 3).

This recognition of the significant impact of fire is not recent. For example, in reviewing the status of threatened Australian birds, Ashby (1924*b*) noted:

> *"The most serious factor of all is the destruction of both food supply and shelter; and, of course, breeding haunts, by bush-fires. I consider that these … factors, especially …. bush-fires, account for more than nine-tenths of the disappearance of certain forms … I am confident that the indiscriminate burning of bush, which is the concomitant of all farming and grazing operations, is by a long way the major cause of the disappearance of many of our rarer birds".*

Despite this long-standing appreciation of the problem, there has been very limited research directed at the impacts of fire regimes on birds and little informed management of fire for bird conservation. To a large extent, myth, anecdote and casual observations substitute for detailed knowledge in management advice (Meredith 1982).

However, recent research has served to focus more sharply on the intricacies of fire regime, and away from the perception that occasional catastrophic wildfires are inevitably the most serious fire threats to bird conservation (Recher 1981). Rather, minor changes in fire regime may be critical (Saunders 1985) and lead to almost imperceptibly gradual, but inexorable, bird decline (Brooker & Brooker 1994).

It is striking that, across a broad range of environments, most fire-sensitive threatened species require fire intervals longer than those which have been imposed since European settlement. Too frequent burning has endangered species such as Noisy Scrub-bird, Western Bristlebird, Malleefowl and Ground Parrot. The old-growth (or mid to late seral) vegetation that these species require, or are most abundant in, is now becoming disappearingly rare. The maintenance of suitably-aged vegetation is required to retain such species. The endangerment of so many species reliant on relatively old vegetation is a clear indication that land managers are now generally burning far more extensively or frequently than prior to European settlement, or that fires now are generally more destructive.

The very low fire frequency, or fire exclusion, required by many of these species (e.g. preferred intervals of at least 20 years for most threatened heathland birds (Smith 1985*a*) or at least 60 years for Malleefowl (Benshemesh 1990)) will pose serious management problems, especially where many of these species somewhat paradoxically live in very fire-prone environments (mallee and heath), where potentially competing fire management goals exist, and where adjacent populations of humans lead almost inevitably to uncontrollable increased ignition of fires.

The long fire-free periods that many of these fire-sensitive birds require, and the very old trees (generally centuries to millenia old) required by most of the many hollow-nesting birds, suggests that much of the bird fauna has adapted to an environment which has a long history of little or mild disturbance. The association with, or reliance upon, long-unburnt vegetation by a significant component of the bird fauna is in marked contrast to that shown by other vertebrate groups, where the successional sequence is often played out within 10 to 20 years (e.g. Fox 1982; Masters 1993), other than for hollow-dependent species. This disparity may be because most of the mammal, reptile and frog fauna is terrestrial, and hence responds to the relatively rapid changes in understorey, ground and litter characteristics rather than to the slower changes in taller shrubs and trees. Alternatively, the lesser mobility of mammals, reptiles and frogs may have precluded

the development of species tightly associated with old seral stages.

However, two features generally common to most of the fire-sensitive threatened bird species are low reproductive output and relatively limited dispersal abilities (Smith 1977,1985*a*,*c*,1987*a*,*b*; Reilly 1991*b*): indeed, these features probably partly define why these species are threatened by frequent fire. While these are useful adaptive traits in stable (and often resource-poor) environments, they are profound handicaps where that environment is disturbed. Such species are particularly vulnerable to habitat fragmentation and fire, and their conservation must involve landscape-scale perspective and management, else recovery from fire may be fatally compromised.

Friend (1993) considered the responses to fire of mallee mammals, reptiles and frogs, and sought to compare the ecological characteristics of species according to their preferred seral stages. Following this approach, although close to tautological, it is clear that most fire-sensitive bird species are mainly insectivorous and forage in dense shrubs, shrubby understorey or thick leaf litter.

The broad requirements of some of these threatened fire-sensitive bird species are now reasonably obvious. However, many species now considered reasonably abundant may be more subtly disadvantaged by current fire regimes. The detailed study of the common Splendid Fairy-wren by Rowley & Brooker (1987), Brooker & Rowley (1991), Russell & Rowley (1993) and Brooker & Brooker (1994) has illustrated the danger of small but repeated impacts associated with a regime of frequent control burning. Where such regimes are sustained over long periods (decades to centuries), the bird assemblage within habitats will be gradually re-sorted and species now considered secure may be lost. Over longer periods (decades to millenia), sustained fire regimes will re-arrange spatial relationships between habitats, resulting in decline or extinction of fire-sensitive habitats (and their associated bird fauna). The long period of such change relative to that of most studies on fire impacts suggests great caution should be exercised in interpretation of studies which suggest minor or no changes associated with fire.

In general, currently threatened bird species will benefit from longer intervals between fires. Such change will disadvantage species associated with early seral stages. However, these species (such as Richard's Pipit, Little Button-quail, Blue-winged Parrot, Scarlet Robin, Flame Robin) are generally widespread and common, and typically occur after fire across a broad range of environments. In the first few years post-fire, the presence of such invading generalist species alongside recolonisers may lead to local species richness which is greater than that pre-fire (e.g. Christensen et al. 1985). However, on a landscape scale this is not equivalent to increased biodiversity, as habitat characteristics (and hence bird species composition) of early seral stages of disparate environments tend to be more similar to each other than are later stages. Hence, frequent regular fires across a range of environments will result in a convergence of their bird fauna, and a loss of the late seral species which contribute much of the distinctiveness to different environments.

Such homogenisation may be avoided by planned fine-scale mosaic burning with a range of fire regimes, but with priority protection of current long-unburnt areas (and ensuring future provision of such areas). Such management has been recommended across a very broad range of Australian environments (Recher 1981,1991; Christensen et al. 1985; Braithwaite 1985; Emison & Bren 1989; Brooker et al. 1990). The approach has the advantage of conservatively covering a broad spectrum of fire regime options, until better knowledge of the requirements of individual species is available. Such knowledge will be acquired only when a much more comprehensive, strategic and concerted research effort is established.

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7. TABLES

Table 1. Scientific names of birds mentioned in text (following Christidis & Boles 1994).

ORDER STRUTHIONIFORMES	
Casuariidae	
Casuarius casuarius	Southern Cassowary
Dromaius novaehollandiae	Emu
Dromaius baudinianus	Kangaroo Island Emu
ORDER GALLIFORMES	
Megapodiidae	
Leipoa ocellata	Malleefowl
Megapodius reinwardt	Orange-footed Scrubfowl
Phasianidae	
Coturnix ypsilophora	Brown Quail
Coturnix chinensis	King Quail
ORDER ANSERIFORMES	
Anaseranatidae	
Anseranas semipalmata	Magpie Goose
ORDER PELECANIFORMES	
Pelecanidae	
Pelecanus conspicillatus	Australian Pelican
ORDER CICONIIFORMES	
Threskionithidae	
Threskiornis spinicollis	Straw-necked Ibis
ORDER FALCONIFORMES	
Accipitridae	
Erythrotriorchis radiatus	Red Goshawk
Aquila audax	Wedge-tailed Eagle
Falconidae	
Falco cenchroides	Nankeen Kestrel
ORDER GRUIFORMES	
Rallidae	
Rallus pectoralis	Lewin's Rail
Gallinula mortierii	Tasmanian Native-hen
Otididae	
Ardeotis australis	Australian Bustard
ORDER TURNICIFORMES	
Turnicidae	
Turnix velox	Little Button-quail
Turnix varia	Painted Button-quail
Turnix melanogaster	Black-breasted Button-quail

continued over

Table 1. continued

ORDER CHARADRIIFORMES	
Pedionomidae	
Pedionomus torquatus	*Plains-wanderer*
Burhinidae	
Burhinus grallarius	*Bush Stone-curlew*
ORDER COLUMBIFORMES	
Columbidae	
Phaps chalcoptera	Common Bronzewing
Phaps elegans	Brush Bronzewing
Ocyphaps lophotes	Crested Pigeon
Geophaps smithii	Partridge Pigeon
Geopelia cuneata	Diamond Dove
ORDER PSITTACIFORMES	
Cacatuidae	
Probosciger aterrimus	Palm Cockatoo
Calyptorhynchus banskii	Red-tailed Black-Cockatoo
Calyptorhynchus lathami	Glossy Black-Cockatoo
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo
Calyptorhynchus baudinii	Long-billed Black-Cockatoo
Cacatua roseicapilla	Galah
Cacatua tenuirostris	Long-billed Corella
Cacatua pastinator	Western Corella
Cacatua sanguinea	Little Corella
Cacatua leadbeateri	Major Mitchell's Cockatoo
Nymphicus hollandicus	Cockatiel
Psittacidae	
Polytelis anthopeplus	Regent Parrot
Platycercus icterotis	Western Rosella
Barnardius zonarius	Australian Ringneck
Purpureicephalus spurius	Red-capped Parrot
Psephotus chrysopterygius	Golden-shouldered Parrot
Psephotus dissimilis	Hooded Parrot
Psephotus pulcherrimus	Paradise Parrot
Melopsittacus undulatus	Budgerigar
Neophema chrysostoma	Blue-winged Parrot
Neophema elegans	Elegant Parrot
Neophema chrysogaster	Orange-bellied Parrot
Neophema pulchella	Turquoise Parrot
Neophema splendida	Scarlet-chested Parrot
Pezoporus wallicus	Ground Parrot
Pezoporus occidentalis	Night Parrot

continued over

Table 1. continued

ORDER STRIGIFORMES	
Strigidae	
Ninox strenua	Powerful Owl
Tytonidae	
Tyto tenebricosa	Sooty Owl
Tyto novaehollandiae	Masked Owl
ORDER APODIFORMES	
Apodidae	
Hirundapus caudacutus	White-throated Needletail
Apus pacificus	Fork-tailed Swift
ORDER CORACIIFORMES	
Halcyonidae	
Dacelo novaeguineae	Laughing Kookaburra
Dacelo leachii	Blue-winged Kookaburra
Todiramphus pyrrhopygia	Red-backed Kingfisher
Meropidae	
Merops ornatus	Rainbow Bee-eater
ORDER PASSERIFORMES	
Menuridae	
Menura novaehollandiae	Superb Lyrebird
Atrichornithidae	
Atrichornis rufescens	Rufous Scrub-bird
Atrichornis clamosus	Noisy Scrub-bird
Climacteridae	
Climacteris picumnus	Brown Treecreeper
[*C.p. melanota*	
Maluridae	
Malurus coronatus	Purple-crowned Fairy-wren
Malurus cyaneus	Superb Fairy-wren
Malurus splendens	Splendid Fairy-wren
Malurus lamberti	Variegated Fairy-wren
Malurus elegans	Red-winged Fairy-wren
Malurus leucopterus	White-winged Fairy-wren
Malurus melanocephalus	Red-backed Fairy-wren
Stipiturus malachurus	Southern Emu-wren
Stipiturus mallee	Mallee Emu-wren
Stipiturus ruficeps	Rufous-crowned Emu-wren
Amytornis woodwardi	White-throated Grasswren
Amytornis dorotheae	Carpentarian Grasswren
Amytornis striatus	Striated Grasswren
Amytornis textilis	Thick-billed Grasswren
Pardalotidae	
Pardalotus punctatus	Spotted Pardalote
Pardalotus quadragintus	Forty-spotted Pardalote
Pardalotus striatus	Striated Pardalote
Dasyornis brachypterus	Eastern Bristlebird
Dasyornis longirostris	Western Bristlebird

continued over

Table 1. continued

Dasyornis broadbenti	Rufous Bristlebird
Pycnoptilus floccosus	Pilotbird
Sericornis frontalis	White-browed Scrubwren
Hylacola pyrrhopygia	Chestnut-rumped Heathwren
Hylacola cauta	Shy Heathwren
Calamanthus fuliginosus	Striated Fieldwren
Chthonicola sagittata	Speckled Warbler
Gerygone fusca	Western Gerygone
Acanthiza pusilla	Brown Thornbill
Acanthiza apicalis	Inland Thornbill
Acanthiza inornata	Western Thornbill
Acanthiza reguloides	Buff-rumped Thornbill
Acanthiza iredalei	Slender-billed Thornbill
Acanthiza chrysorrhoa	Yellow-rumped Thornbill
Acanthiza nana	Yellow Thornbill
Acanthiza lineata	Striated Thornbill
Aphelocephala nigricincta	Banded Whiteface
Meliphagidae	
Anthochaera chrysoptera	Little Wattlebird
Philemon corniculatus	Noisy Friarbird
Philemon citreogularis	Little Friarbird
Manorina flavigula	Yellow-throated Miner
Manorina melanotis	Black-eared Miner
Lichenostomus chrysops	Yellow-faced Honeyeater
Lichenostomus melanops	Yellow-tufted Honeyeater
Lichenostomus melanops cassidix	Helmeted Honeyeater
Lichenostomus cratitius	Purple-gaped Honeyeater
Lichenostomus plumulus	Grey-fronted Honeyeater
Lichenostomus penicillatus	White-plumed Honeyeater
Melithreptus lunatus	White-naped Honeyeater
Phylidonyris pyrrhoptera	Crescent Honeyeater
Phylidonyris nigra	White-cheeked Honeyeater
Phylidonyris albifrons	White-fronted Honeyeater
Phylidonyris melanops	Tawny-crowned Honeyeater
Certhionyx niger	Black Honeyeater
Epthianura tricolor	Crimson Chat
Petroicidae	
Petroica multicolor	Scarlet Robin
Petroica goodenovii	Red-capped Robin
Petroica phoenicea	Flame Robin
Melanodryas cucullata	Hooded Robin
Eopsaltria australis	Eastern Yellow Robin
Eopsaltria griseogularis	Western Yellow Robin

continued over

Table 1. continued

Eopsaltria georgiana	White-breasted Robin
Drymodes superciliaris	Northern Scrub-robin
Drymodes brunneopygia	Southern Scrub-robin
Pomatostomidae	
Pomatostomus superciliosus	White-browed Babbler
Cinclosomatidae	
Psophodes olivaceus	Eastern Whipbird
Psophodes nigrogularis	Western Whipbird
Cinclosoma punctatum	Spotted Quail-thrush
Cinclosoma castanotus	Chestnut Quail-thrush
Cinclosoma cinnamomeum	Cinnamon Quail-thrush (includes Nullabor Quail-thrush)
Neosittidae	
Daphoenositta chrysoptera	Varied Sittella
Pachycephalidae	
Falcunculus frontatus	Crested Shrike-tit
Oreoica gutturalis	Crested Bellbird
Pachycephala olivacea	Olive Whistler
Pachycephala rufogularis	Red-lored Whistler
Pachycephala pectoralis	Golden Whistler
Pachycephala rufiventris	Rufous Whistler
Colluricincla harmonica	Grey Shrike-thrush
Dicruridae	
Grallina cyanoleuca	Magpie-lark
Rhipidura fuliginosa	Grey Fantail
Campephagidae	
Coracina novaehollandiae	Black-faced Cuckoo-shrike
Lalage sueurii	White-winged Triller
Aatamidae	
Artamus personatus	Masked Woodswallow
Artamus superciliosus	White-browed Woodswallow
Artamus cyanopterus	Dusky Woodswallow
Cracticus torquatus	Grey Butcherbird
Cracticus nigrogularis	Pied Butcherbird
Gymnorhina tibicen	Australian Magpie
Strepera graculina	Pied Currawong
Corvidae	
Corvus coronoides	Australian Raven
Corvus orru	Torresian Crow
Corcoracidae	
Corcorax melanorhamphos	White-winged Chough
Motacillidae	
Anthus novaeseelandiae	Richard's Pipit
Passeridae	
Taeniopygia guttata	Zebra Finch
Poephila personata	Masked Finch
Neochmia ruficauda	Star Finch
Neochmia temporalis	Red-browed Finch

continued over

Table 1. continued

Lonchura castaneothorax	Chestnut-breasted Mannikin
Erythrura gouldiae	Gouldian Finch
Dicaeidae	
Dicaeum hirundinaceum	Mistletoebird
Hirundinidae	
Hirundo nigricans	Tree Martin
Sylviidae	
Megalurus timoriensis	Tawny Grassbird
Eremiornis carteri	Spinifexbird
Cincloramphus mathewsi	Rufous Songlark
Cisticola exilis	Golden-headed Cisticola

Table 2. Summary table of incidence of subjects in fire-bird references.

This tally is based on references included within the annotated bibliography. Where possible, I have tried to restrict inclusion in this list to subjects which form a substantial component or focus of the paper considered. Note that the same material may be included in several papers (notably in reviews), such that a large tally doesn't necessarily equate to a substantial research effort. A single paper may consider several subjects, so the tallies do not sum to the number of papers included in the annotated bibliography (361). Bioregions are the biogeographic regions defined in Thackway & Cresswell (1995).

BROAD SUBJECTS

No. of references	subject
141	threatened species
127	management
78	wildfire
60	review
46	community
41	control burning
26	historic change; seabirds
24	hollows
21	forestry
20	mortality
17	succession
13	isolate
10	Aboriginal burning
9	old-growth
6	charcoal; Aboriginal knowledge
2	corridors; slash-burn

BIOREGIONS

No. of references	Bioregions
37	Murray-Darling Depression
33	South East Corner
29	South East Coastal Plain
28	Jarrah Forest
22	South Eastern Highlands
19	Esperance Plains, Top End Coastal, Warren
14	Pine Creek-Arnhem Swan Coastal Plain
12	South Eastern Queensland
11	Swan Coastal Plain
10	Cape York Peninsula
9	West and South West
8	Ord-Victoria Plains
7	Gulf Falls and Uplands Victoria Bonaparte
6	Freycinet, NSW North Coast, Victorian Midlands
5	Avon Wheatbelt, Channel Country, Daly Basin, Furneaux, Gulf Coastal, Naracoorte Coastal Plain
4	Great Sandy Desert, Mulga Lands, NSW South western Slopes, Riverina
3	Broken Hill Complex, Central Kimberley, Mt Isa Inlier, Northern Kimberley, Nullabor, Sydney Basin
2	Carnarvon, D'Entrecasteaux, Lofty Block, Mitchell Grass Downs, Simpson-Strezlecki Dunefields, Sturt Plateau, Wet Tropics, Woolnorth
1	Australian Alps, Ben Lomond, Brigalow Belt North, Brigalow Belt South, Central Arnhem, Central Mackay Coast, Darling Riverine Plains, Desert Uplands, Einasleigh Uplands, Eyre & Yorke Blocks, Finke, Flinders and Olary Ranges, Gascoyne, Gawler, Geraldton Sandplains, Gibson Desert, Hampton, Little Sandy Desert, MacDonnell Ranges, Murchison, Nandewar, Pilbara, Stony Plains, Yalgoo

ENVIRONMENTS

No. of references	habitat
116	(temperate) eucalypt open forest
103	heath
48	tussock grassland
47	mallee
25	tropical eucalypt open forest
24	tropical eucalypt savanna woodland
21	hummock grassland
19	rainforest
17	(temperate) eucalypt woodland
15	thicket
10	sedgeland
8	Acacia woodland/shrubland
6	wetlands
5	Callitris woodland, pandanus, (Allo)Casuarina woodland, chenopod shrubland
2	Banksia woodland
1	riparian vegetation

continued over

Table 2. continued

INDIVIDUAL BIRD SPECIES

No. of references	bird species
33	Ground Parrot
15	Western Whipbird
14	Malleefowl
13	Noisy Scrub-bird
8	Eastern Bristlebird, Western Bristlebird
7	Gouldian Finch
6	Rufous Bristlebird, Black-eared Miner
5	Glossy Black-cockatoo, Golden-shouldered Parrot, Carpentarian Grass-wren White-throated Grass-wren
4	Orange-footed Scrubfowl, Sooty Owl, Superb Lyrebird, Splendid Fairy-wren
3	Cassowary, Hooded Parrot, Nullabor Quail-thrush, Striated Grass-wren, Purple-crowned Fairy-wren, Black Honeyeater
2	Red Goshawk, Powerful Owl, Red-tailed Black-Cockatoo, Superb Parrot, Regent Parrot, Turquoise Parrot, Scarlet-chested Parrot, Orange-bellied Parrot, Paradise Parrot, Western Rosella, Ringneck Parrot, Night Parrot, White-throated Needletail, Rufous Scrub-bird, Grey-crowned Babbler, Flame Robin, Red-lored Whistler, Thick-billed Grass-wren, Rufous-crowned Emu-wren, Southern Emu-wren, Mallee Emu-wren, Brown Thornbill, Slender-billed Thornbill, Forty-spotted Pardalote

continued over

Table 2. continued

1	Kangaroo Island Emu Australian Pelican, Magpie Goose, Australian Bustard, Black-breasted Button-quail, Chestnut-backed Button-quail, Little Button-quail, Bush Stone-curlew, Wedge-tailed Eagle, Plains-wanderer, Palm Cockatoo, Pink Cockatoo, Yellow-tailed Black-cockatoo, White-tailed Black-cockatoo, Long-billed Corella Little Corella Red-capped Parrot, Brush Bronzewing, Flock Bronzewing, Partridge Pigeon, Fork-tailed Swift, Tree Martin, Spinifex Bird, Richard's Pipit, Pilot Bird, Spotted Quail-thrush, Northern Scrub-robin, Eastern Yellow Robin, Scarlet Robin, Crested Shrike-tit, Black Grass-wren, White-winged Fairy-wren, Red-winged Fairy-wren, Western Thornbill, Striated Thornbill, Brown Thornbill, Yellow-rumped Thornbill, Black Treecreeper, Helmeted Honeyeater, Mistletoebird, Yellow-rumped Pardalote, Forty-spotted Pardalote, Star Finch, Yellow-rumped Mannikin

Table 3. Threatened bird taxa for which inappropriate fire regime has been listed as a threatening process by Garnett (1992b). Extinct taxa are excluded. Conservation status: R=rare, K=insufficiently known, V=vulnerable, E=endangered.

Casuarius casuarius	Southern Cassowary (V)
Leipoa ocellata	Malleefowl (V)
Botaurus poiciloptilus	Australasian Bittern (K)
Erythrotriorchis radiatus	Red Goshawk (V)
Turnix castanota	Chestnut-backed Button-quail (K)
Turnix olivii	Buff-breasted Button-quail (K)
Turnix varia scintillans	Painted Button-quail (Houtmans Abrolhos subsp) (V)
Turnix melanogaster	Black-breasted Button-quail (V)
Geophaps smithii smithii	Partridge Pigeon (eastern subsp.) (V)
Geophaps smithii blaauwi	Partridge Pigeon (western subsp.) (K)
Probosciger aterrimus	Palm Cockatoo (K)
Calyptorhynchus banskii graptogyne	Red-tailed Black-Cockatoo (southeastern subsp.) (E)
Calyptorhynchus lathami halmaturinus	Glossy Black-Cockatoo (Kangaroo Island subsp.) (E)
Eclectus roratus	Eclectus Parrot (R)
Psephotus chrysopterygius	Golden-shouldered Parrot (E)
Neophema chrysogaster	Orange-bellied Parrot (E)
Neophema splendida	Scarlet-chested Parrot (R)
Pezoporus wallicus flaviventris	Ground Parrot (western subsp.) (E)
Pezoporus occidentalis	Night Parrot (K)
Ninox rufa queenslandica	Rufous Owl (eastern subsp.) (R)
Ninox rufa meesi	Rufous Owl (Cape York Peninsula subsp.) (K)
Tyto tenebricosa	Sooty Owl (R)
Tyto novaehollandiae melvillensis	Masked Owl (Melville Island subsp.) (K)
Atrichornis rufescens	Rufous Scrub-bird (R)
Atrichornis clamosus	Noisy Scrub-bird (E)

continued over

Table 3. continued

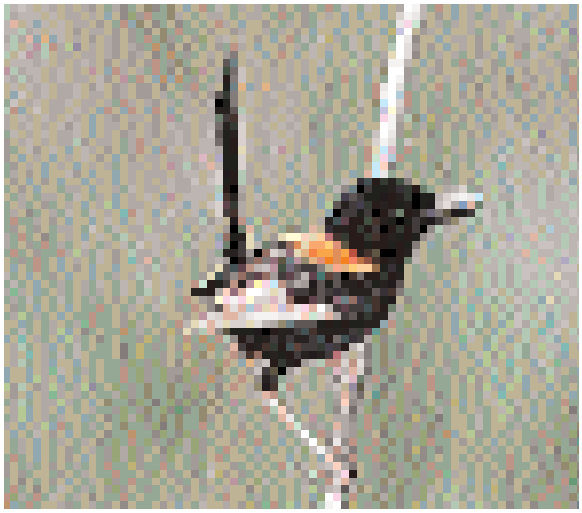
Malurus coronatus coronatus	Purple-crowned Fairy-wren (western subsp.) (V)
Stipiturus malachurus intermedius	Southern Emu-wren (Mt Lofty Ranges subsp.) (E)
Stipiturus malachurus parimeda	Southern Emu-wren (Eyre Peninsula subsp.) (V)
Stipiturus mallee	Mallee Emu-wren (V)
Amytornis dorotheae	Carpentarian Grasswren (K)
Amytornis striatus striatus	Striated Grasswren (sandplain subsp.) (K)
Amytornis striatus merrotsyi	Striated Grasswren (Flinders Ranges subsp.) (K)
Pardalotus quadragintus	Forty-spotted Pardalote (E)
Dasyornis brachypterus	Eastern Bristlebird (V)
Dasyornis longirostris	Western Bristlebird (E)
Dasyornis broadbenti broadbenti	Rufous Bristlebird (Victorain subsp.) (R)
Dasyornis broadbenti whitei	Rufous Bristlebird South Australian subsp.) (K)
Acanthiza pusilla arcibaldi	Brown Thornbill (King Island subsp.) (K)
Acanthiza iredalei hedleyi	Slender-billed Thornbill eastern subsp.) (K)
Manorina melanotis	Black-eared Miner (E)
Lichenostomus melanops cassidix	Helmeted Honeyeater (E)
Psophodes nigrogularis nigrogularis	Western Whipbird (western heath subsp.) (E)
Psophodes nigrogularis oberon	Western Whipbird (western mallee subsp.) (R)
Psophodes nigrogularis lashmari	Western Whipbird (Kangaroo Island subsp.) (R)
Psophodes nigrogularis leucogaster	Western Whipbird (eastern subsp.) (V)
Falcunculus frontatus whitei	Crested Shrike-tit (northern subsp.) (K)
Pachycephala rufogularis	Red-lored Whistler (V)
Erythrura gouldiae	Gouldian Finch (E)
Cisticola juncidis normani	Zitting Cisticola (Normanton subsp.) (K)
Zoothera lunulata halmaturina	Bassian Thrush (South Australian subsp.) (R)

Mallee Fowl. Fires in the mallee country may create flushes of food resources for the Mallee Fowl, but generally long-unburnt country is most favourable, especially for breeding. A complex fire mosaic is probably optimal for this species, with special management effort directed to maintaining the most vulnerable long-unburnt patches. /K Thaler © ANBG. Inset photo /Joe Benshemesh

Noisy Scrub-bird. The range and abundance of this unusual bird has declined catastrophically over the last 150 years. It is now restricted to a very few populations in south-western Australia. Much of this decline has been due to the imposition of an inappropriate fire regime. Despite living in highly flammable heath and thicket vegetation, the Noisy Scrub-bird is dependent upon vegetation which has remained unburnt for long periods, typically greater than 40 years. /Ray Smith

Splendid Fairy-Wren. The Splendid Fairy-wren is a small bird found in heathlands in southwestern Australia. If heathland patches are totally burnt by fire, local extinctions may occur, and the Fairy-wren's poor dispersal ability renders recruitment and recolonisation difficult. Cooler fires may also affect habitat suitability through impacts upon prey abundance, nest site availability, nest parasitism and predation. /Tom & Pam Gardner © Nature Focus

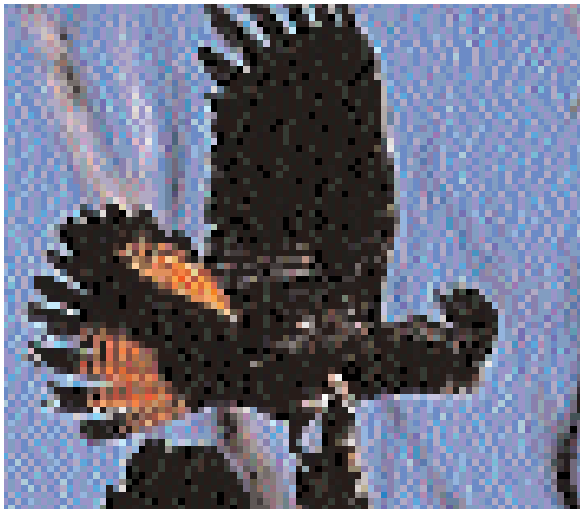
Gouldian Finch. The endangered Gouldian Finch has complex relationships with fire. In its tropical savanna woodland habitat, dry season fires remove the dense grass layer, allowing it easier access to grass seeds on the ground. Hence, it seeks out recently burnt areas and in the short term is favoured by frequent (annual) fires. However, fires may change the seed productivity and timing in the subsequent seeding period, and little is known of the longer-term consequences of a frequent fire regime upon grass species composition and hence food resources. Fire management for this species should aim to maximise environmental variability. /Ian Morris



Red-backed Fairy-wren. The Red-backed Fairy-wren occurs in dense ground layer vegetation across northern Australia. Fires remove most of this vegetation, and may knock out local populations. A consistent regime of frequent fires over extensive areas will greatly suppress populations of this species. /Tom & Pam Gardner © Nature Focus

Magpie Goose. Aboriginal people have a long tradition of burning the northern floodplains once the waters have receded during the dry season. The purpose of burning is to increase the suitability of the area for Magpie Goose feeding and nesting. Where Aboriginal fire management of the floodplains has been removed, Magpie Geese have become disadvantaged. /G O'Neill © ANPWS

Eastern Bristlebird. The Eastern Bristlebird is one of a group of species restricted to heathlands and coastal thickets in temperate southern Australia. Recently-burnt areas are unsuitable, with population densities increasing as vegetation density builds up, for at least 15 years post-fire. Its persistence in an area may require careful management, aimed principally toward fire suppression. However, some fire is almost inevitable in this habitat, and remaining unburnt patches are then critical for re-establishment of populations. / Norman Chaffer Estate © Nature Focus



Red-tailed Black Cockatoo. Like many parrots and a range of other birds, Red-tailed Black Cockatoos require hollows for nest sites, typically formed in very old trees. Intense fires may destroy such important trees, although fire may have a role in hollow formation. In northern Australia, Red-tailed Black-cockatoos also track fires, as food is most readily available in recently-burnt areas.
/ Babs & Bert Wells © Nature Focus

Ground Parrot. The Ground Parrot is generally severely disadvantaged by frequent fires in heathlands. In some habitats and areas it may also decline in long-unburnt (>15 years) vegetation, but elsewhere fire exclusion is recommended. The impacts of fire may be compounded by habitat fragmentation, which is probably appreciably greater now for heathlands than it was before European colonisation. Such fragmentation may decrease the probability of recolonisation of isolates where fire (and unsuitable post-fire habitat) has destroyed local populations. / John Gray © Nature Focus

FIRE AND AUSTRALIAN BIRDS
An annotated bibliography

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INTRODUCTION

This annotated bibliography compiles all (361) references I could locate which relate to fire and Australian birds. It is based on systematic searches of the journals:

Emu (1960–1995)
Corella (1977–1995)
Australian Bird Watcher (1970–1994)
South Australian Ornithologist (1968–1994)
Australian Bird Bander (1969–1976)
Sunbird (1992–1995)
Australian Journal of Ecology (1980–1995)
(Australian) Wildlife Research (1984–1995)
Proceedings of the Ecological Society of Australia (1980–1995)
Northern Territory Naturalist (1978–1994)
Australian Forestry (1977–1995)
Australian Forest Research (1981–1987)
Victorian Naturalist (1975–1992)

and less comprehensive searches through other journals, reports, theses and other publications, notably including the general bibliography of Gill *et al*. (1994) on fire ecology in Australia, as well as publications indicated to me by a range of authorities in most States and Territories.

All entries are stored on the bibliographic data base **Endnote Plus**. For each reference, I list keywords and bioregion(s) in italics. Keywords include the (broad) vegetation formation to which the article refers, the main bird taxa considered, whether the article deals with threatened taxa, whether the article describes responses of a whole bird community, whether it deals with management issues, etc. Bioregions follow Thackway and Cresswell (1995). No bioregions are listed for most review articles or where the observations reported are relatively trivial (e.g. birds seen feeding on charcoal). A map of the locations of primary sources reported is presented as an appendix.

The annotations given are my own summaries of relevant sections of the articles, except where material is presented in quotation marks.

Much of the material presented here is discussed in the accompanying review.

Although I have made every attempt to be comprehensive, many studies of the relationship between birds and fire are presented in the grey literature. I would be grateful for notification of any papers I may have missed, or any comment on my interpretation of any articles.

Gill, A.M., Moore, P.H.R., and Martin, W.K. (1994). Bibliography of fire ecology in Australia (including fire science and fire management). Edition 4. NSW National Parks and Wildlife Service, Hurstville.

Thackway, R. and Creswell, I.D. (1995). An interim biogeographic regionalisation for Australia: a framework for setting priorities in the National Reserves System Cooperative Program. Version 4.0. Australian Nature Conservation Agency: Canberra.

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REFERENCES

Abbott, I. (1981). Seabird Islands: No. 106. Mondrain Island, Archipelago of the Recherche, Western Australia. *Corella*, 5, 60–61.
seabirds; heath; tussock grassland; mortality
Bioregion: Esperance Plains
Fires since 1801 have repeatedly consumed much of the vegetation, destroying many breeding seabirds.

Abbott, I., & Christensen, P. (1994). Application of ecological and evolutionary principles to forest management in Western Australia. *Australian Forestry*, 57, 109–122.
management; control burning; eucalypt open forest
Bioregion: Jarrah Forest
Reviews some studies of the impacts of fuel reduction burning on birds in Jarrah forests, suggesting limited effect.

Adam, P., & Robinson, D. (1996). Negative effects of fuel-reduction burning on the habitat of the Grey-crowned Babbler *Pomatostomus temporalis*. *Victorian Naturalist*, 113, 4–9.
Grey-crowned Babbler; threatened species; management; control burning; eucalypt woodland
Bioregions: Victorian Midlands; South Eastern Highlands
Frequent (annual) fuel-reduction burning (in remnant vegetation along roadside verges) is having a considerable impact on the habitat (and hence numbers) of the threatened Grey-crowned Babbler. Warns that findings of little impact of fuel-reduction burning on birds should be treated with caution. Alternative mechanisms of fire protection (e.g. slashing) should be considered in order to safeguard these populations.

Arnold, G. W., Smith, G. T., Rowley, I. C. R., & Brooker, M. G. (1993). The effects of fire on the abundance and distribution of animals in Australian ecosystems, with emphasis on Mediterranean ecosystems. In L. Trabaud & R. Prodon (Eds.), *Fire in Mediterranean ecosystems* (pp. 237–257). Brussels: Commission of the European Communities.
review; heath; mallee; eucalypt open forest; isolate
Reviews studies of effects of fire on birds (and other fauna) in Mediterrean ecosystems (heath, mallee and open forest) in southwestern and southeastern Australia. More studies are required on the influence of fire mosaic or patchiness. Mammals (at least in eastern Australia) show pronounced seral responses to fire. Lizards and frogs are generally not greatly affected by fire. Fauna of mediterranean systems shows less clear seral responses to fire than those in temperate ecosystems, as the fauna of mediterranean ecosystems has adapted to substantial climatic variability. There are substantial differences between bird species in response to fire, for example the Ground Parrot is fire dependent whereas Noisy Scrub-bird is fire sensitive. Long-term demographic studies are needed to comprehend and predict responses to fire. Fire management is an essential component of the management of conservation reserves: this may be complicated by fragmentation.

Ashby, E. (1921). Notes on the supposed "extinct" birds of the south-west corner of Western Australia. *Emu*, 20, 123–124.
Ground Parrot; Western Whipbird; succession; heath; threatened species.
Bioregion: Swan Coastal Plain
Frequent fires (lit by farmers) had changed heathlands to grasslands at a site in southwestern Australia eliminating Ground Parrots and Western Whipbirds.

Ashby, E. (1924a). Notes on extinct or rare Australian birds, with suggestions as to some of the causes of their disappearance. Part I. *Emu*, 23, 178–183.
review; threatened species; Night Parrot; hummock grassland; Ground Parrot; heath; wetlands; Kangaroo Island Emu.
Speculates that Night Parrots persist only where hummock grasses are "unswept by fires". Disappearance of Ground Parrot due to frequent fires. Extinction of Kangaroo Island Emu was due to hunting and excessive burning.

Ashby, E. (1924b). Notes on extinct or rare Australian birds, with suggestions as to some of the causes of their disappearance. Part II. *Emu*, 23, 294–298.
review; threatened species
Review of decline of Australian birds. "The most serious factor of all is the destruction of both food supply and shelter, and, of course, breeding haunts, by bush-fires. I consider that these … factors, especially … bush-fires, account for more than nine-tenths of the disappearance of certain forms … I am confident that the indiscriminate burning of bush, which is the concomitant of all farming and grazing operations in bush country, is by a long way the major cause of the disappearance of many of our rarer birds."

Aumann, T., & Baker-Gabb, D. J. (1991). *The ecology and status of the Red Goshawk in northern Australia. RAOU Report No. 75*. Royal Australasian Ornithologists Union.
Red Goshawk; tropical eucalypt open forest; threatened species; management.
Fires have been reported to burn out the nests of Red Goshawk, killing young. In the long term, a combination of grazing and frequent fires may result in reduction of prey and loss of nest trees, however short-term results show little clear indication of differences in density or breeding success related to burning history.

Australian Biological Research Group Pty. Ltd. (1987). *Management Plan for the Ground Parrot in the Orbost Region*. Australian Biological Research Group Pty Ltd.
Ground Parrot; heath; sedgelands; threatened species; management.
Bioregion: South east Corner
Fire regimes proposed for heathlands to maintain suitability for Ground Parrots.

Backhouse, G. N. (1987). Management of remnant habitat for conservation of the Helmeted Honeyeater *Lichenostomus melanops cassidix*. In D. A. Saunders, G. W. Arnold, A. A. Burbidge, & A. J. M. Hopkins (Eds.), *Nature conservation: the role of remnants of native vegetation* (pp. 287–294). Chipping Norton: Surrey Beatty.
Helmeted Honeyeater; eucalypt open forest; wildfire; management; threatened species; isolate
Bioregion: South Eastern Highlands
The sites of two small isolated populations of Helmeted Honeyeaters were severely burnt by bushfire, destroying much of the habitat. Both populations disappeared after fire. At the site of the remaining population (a narrow riparian strip) fire prevention works may create more disturbance than fire.

Baird, R. F. (1986). Historical records of the Glossy Black Cockatoo *Calyptorhynchus lathami* and Red-tailed Black Cockatoo *C. magnificus* in south-eastern Australia. *South Australian Ornithologist*, 30, 38–45.
Glossy Black-Cockatoo; historic change; threatened species; review; Casuarina woodland
Bioregion: Woolnorth
Considers historic change in the distributions of Glossy Black-Cockatoo and Red-tailed Black-Cockatoo. Declines initially as a result of climate change, more recently exacerbated by clearing and fire (at least for Glossy Black-Cockatoo on King Island)

Baker, J., & 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.
Ground Parrot; threatened species; heath.
Bioregion: South East Corner
Some previous studies have suggested that suitability of heaths for Ground Parrots (and hence Ground Parrot abundance) peaks at around 10 years post-fire, and hence have recommended fire intervals of 8-10 years. In contrast, this study suggests that there is little evidence for a decline in suitability, but rather that abundance plateaus (at c 0.25birds/ha) after around 5 years. This was based on a series of censuses of the same locality from immediately after fire to 10.7 years post-fire. Few studies have examined abundance in heaths >15 years. No single fire regime is typical of all areas where Ground Parrots occur.

Baker, L., Woenne-Green, S., & Mutitjulu Community (1993). Anangu knowledge of vertebrates and the environment. In J. R. W. Reid, J. A. Kerle, & S. R. Morton (Eds.), *Uluru fauna. The distribution and abundance of vertebrate fauna of Uluru (Ayers Rock-Mount Olga) National Park, N.T.* (pp. 79-132). Canberra: Australian National Parks and Wildlife Service.
management; Aboriginal knowledge; mallee; hummock grassland; Acacia woodland.
Bioregion: Central Ranges
Describes Aboriginal knowledge of wildlife. Many granivores are favoured by fire, but Emu dislike freshly-burnt country. Burning in spring can disrupt their breeding and cause them to move away. Fires lit in strong winds can kill many small animals. Discusses traditional Aboriginal burning regimes.

Baker-Gabb, D. J., Benshemesh, J. S., & Maher, P. N. (1990). A revision of the distribution, status and management of the Plains-wanderer *Pedionomus torquatus*. *Emu*, 90, 161-168.
Plains-wanderer; tussock grassland; wildfire; management; threatened species.
Bioregions: Murray Darling Depression; Channel Country; Riverina; Victorian Volcanic Plain
Plains-wanderers are sedentary in sparse grasslands unless these are overgrazed, burnt or cultivated. It is likely that most young and many adults at one site perished when an extensive fire swept through the area, and wildfire may have severe impact on this species. This was the first such fire recorded from this area for 70 years.

Baldwin, M. (1965). Bird eating charcoal. *Emu*, 64, 208.
charcoal
Four species (Fairy Martin, Dusky Wood-swallow, Double-barred Finch and Zebra Finch) recorded eating charcoal.

Bamford, M. J. (1985a) *The dynamics of small vertebrates in relation to fire in banksia woodland near Perth, Western Australia*. PhD, Murdoch University.
Banksia woodland; succession; community
Bioregion: Swan Coastal Plain
Bird communities were assessed at six sites across a range of ages (0-22 years) since fire. Soon after fire in Banksia woodland, bird richness decreased, but the site was colonised by open-country birds from surrounding farmlands.

Bamford, M. J. (1985b). The fire-related dynamics of small vertebrates in Banksia woodland: a summary of research in progress. In J. R. Ford (Ed.), *Fire ecology and management in Western Australian ecosystems* (pp. 107-110). Perth: Western Australian Institute of Technology.
Banksia woodland; community.
Bioregion: Swan Coastal Plain
Six Banksia sites with a range of fire histories were monitored for vertebrates. Birds were more affected by fire than reptiles but less than mammals. Most bird species were recorded within a few months of fire. At one site, the number of bird species was dramatically lower soon after a fire, but returned to pre-fire levels within 1 year, although total number of individuals remained low for at least 2 years. No species showed a preference for the long unburnt sites. A few species were more common in the most recently burnt sites. These were mainly species typical of the surrounding farmlands.

Bates, R. (1980). After the fire: some observations on the effect of the February 20, 1980 (Ash Wednesday) bushfires on wildlife in the Adelaide Hills. *South Australian Naturalist*, 54, 77-79.
wildfire; eucalypt open forest
Bioregion: Lofty Block.

Bedggood, G. W. (1980). Birdlife between Lake Tyers and Marlo, Victoria. *Australian Bird Watcher*, 8, 147-162.
heath; eucalypt open forest; control burning.
Bioregion: South east Corner
Suggests that the widespread spring fuel reduction burns result in heavy toll of young birds and eggs, excessive loss of hollows suitable for breeding, loss of protective undergrowth, loss of ground-nesting birds, and reduced germination for spring-flowering plants.

Beeton, R. J. S. (1985). The little corella: a seasonally adapted species. *Proceedings of the Ecological Society of Australia*, 13, 53-63.
Little Corella; tussock grassland; tropical eucalypt savanna woodland
Bioregions: Ord-Victoria Plains; Victoria-Bonaparte
At a season when food is generally limited (March-April), Little Corellas flock to small areas recently burnt, presumably because such fires increase accessibility to seeds.

Belcher, C. (1993). *Rufous Bristlebird survey and habitat analysis, Port Campbell National Park 1992*. Department of Conservation and Natural Resources.
Rufous Bristlebird; heath; thicket; threatened species; isolate
Bioregion: South East Coastal Plain
At Port Campbell National Park optimal habitat for Rufous Bristlebird is climax heathland more than 25 years post-fire. Isolated populations are susceptible to elimination by fire, and the poor dispersal ability of the species may limit subsequent recolonisation

Bennett, S. (1983). The Northern Scrub-robin *Drymodes superciliaris* in the Northern Territory. *Emu*, 83, 105-107.
Northern Scrub-robin; rainforest; threatened species
Bioregion: Gulf Coastal
If records from the Roper River earlier this century are valid, the Northern Scrub-robin has become extinct in the NT, most likely because of change in fire regimes leading to decline in the extent of rainforest thickets.

Benshemesh, J. (1988). *Report on a study of malleefowl ecology*. Department of Conservation, Forests and Lands.
mallee; Malleefowl; threatened species; wildfire
Bioregion: Murray Darling Depression
A detailed case study of the response of Malleefowl to an intense but patchy fire. Results are summarised in Benshemesh (1990). Small unburnt patches were vital for the persistence of the species. Long fire-free intervals (>60 years) are optimal.

Benshemesh, J. (1990). Management of Malleefowl - with regard to fire. In J. C. Noble, P. J. Joss, & G. K. Jones (Eds.), *The mallee lands: a conservation perspective* (pp. 206-211). Melbourne: CSIRO.
mallee; Malleefowl; threatened species; wildfire
Bioregion: Murray Darling Depression
Optimal fire frequency for Malleefowls is >60 years. Broad-scale fires eliminate Malleefowl in the short-term, and even 20-30 years post-fire, breeding densities are only about one third of those in long-unburnt mallee (based on four matched pairs of 20-30 year old and >40 year old sites). Patchy burns provide some refuges from which recolonisation can occur. Sufficient litter for nesting is generally unavailable until 10-15 years post-fire. Previous authors had suggested that food resources were more abundant in younger mallee and that periodic fire was needed for their maintenance. Modelled densities were 6% of maximum carrying capacity for 20 year fire interval, 30% at 40 year intervals, and 54% at 60 year intervals.

At least 10 of 11 radio-marked and banded birds survived a patchy but intense fire, but in the months following the fire all but 4 had emigrated or died. Dispersing birds used corridors of unburnt vegetation rather than traversing extensive burnt areas. The remaining birds bred in the season following fire in small unburnt patches. These birds foraged extensively in burnt areas, using the rich pulse of herbs growing after fire.

Benshemesh, J. S. (1992) *The conservation biology of Malleefowl, with particular regard to fire*. PhD, Monash University.
Malleefowl; mallee; Callitris woodland; wildfire; old-growth; threatened species.
Bioregion: Murray Darling Depression
Detailed study of habitat requirements and biology of the Malleefowl, particularly in response to a wildfire. Malleefowl requires long-unburnt mallee to provide the extensive litter needed for breeding. Such old-growth has become extremely limited. Malleefowls may survive fires if unburnt patches occur.

Benshemesh, J. S. (1994). *Malleefowl Leipoa ocellata*. Department of Conservation and Natural Resources.
Malleefowl; mallee; threatened species; wildfire; management
Bioregion: Murray-Darling Depression
Reviews information on Malleefowl (in Victoria). "The extent and frequency of fires pose a serious threat to the conservation of Malleefowl as remaining populations may be destroyed and habitat quality reduced for 40 years or more … the effect of fire is exacerbated by the fragmentation due to clearing, as isolated reserves that are entirely burnt are unlikely to be recolonised … more effective fire control may be the single most important factor in improving the conservation status of the species." The scale of fire in mallee lands is a problem, as it may be comparable to that of the largest reserves. Birds may survive and breed after patchy fires.

Bill, M. E. (1932). Lyre-birds and bushfires. *Victorian Naturalist*, 49, 24.
Superb Lyrebird; wildfire

Blakers, M., Davies, S. J. J. F., & Reilly, P. N. (1984). *The atlas of Australian birds*. Melbourne: Melbourne University Press.
review
Distributional information on all Australian birds, but includes information on threatening processes. Notes Orange-bellied Parrot prefers heaths and button-grass plains <15 years post-fire for feeding. Increase in fire frequencies or intensities may have led to decline in Gouldian Finch and Pictorella Mannikins. Notes references to fire for other species (e.g. Emerald Dove, Partridge Pigeon, Paradise Parrot, Scarlet-chested Parrot, Golden-headed Cisticola, White-throated Grass-wren, Eastern Bristlebird).

Boekel, C. (1980). Birds of Victoria River Downs Station and of Yarralin, Northern Territory. Part 1. *Australian Bird Watcher*, 8, 171-193.
tropical eucalypt savanna woodland; hunting
Bioregion: Ord-Victoria Plains
Describes the use of smoke and traps by Aboriginal people for catching eagles and kites.

Bowman, D. M. J. S., Woinarski, J. C. Z., & Russell-Smith, J. (1994). Environmental relationships of Orange-footed Scrubfowl *Megapodius reinwardt* nests in the Northern Territory. *Emu*, 94, 181-185.
Orange-footed Scrubfowl; historic change; rainforest.
Bioregions: Top End Coastal; Pine Creek
Arnhem; Central Arnhem
Environmental changes, probably including historic changes in fire regime, have led to some contraction of rainforests, as evidenced by the occurrence of old scrubfowl mounds in areas which are now eucalypt open forests.

Braithwaite, L. W., Clayton, M., MacLean, L., & Parker, B. S. (1984). *Vertebrate fauna of a 144-ha water catchment within eucalypt forest being harvested for woodpulp at Eden, south-eastern New South Wales*. CSIRO Wildlife and Rangelands Research.
eucalypt open forest; wildfire; community
Bioregion: South East Corner
Birds were surveyed at a site for 15 months before and 2 months after January wildfire. Parts of the site were logged during this period. Species richness declined after fire. Laughing Kookaburra, Grey Butcherbird, Flame and Scarlet Robins increased after fire. Striated Thornbill, Red Wattlebird, Crescent Honeyeater and Pied Currawong decreased.

Braithwaite, R. W. (1985). Fire and fauna. In R. W. Braithwaite (Ed.), *Kakadu Fauna Survey. Final report to Australian National Parks and Wildlife Service.* (pp. 634-650). Darwin: CSIRO.
management; tropical eucalypt open forest; tropical eucalypt savanna woodland; rainforest
Bioregions: Pine Creek Arnhem; Top End Coastal
A wide range of carnivorous and hawking birds are attracted to fire. Soon after fire, many carnivorous and granivorous birds move into burnt areas to take advantage of greater abundance or accessibility of resources. Some nests (of Brown Honeyeater, Mistletoebird, White-throated Honeyeater) were found to be destroyed by fire.

Braithwaite, R. W. (1996). Biodiversity and fire in savanna landscapes. In O. Solbrig, E. Medina, & J. F. Silva (Eds.), *Biodiversity and savanna ecosystem processes: a global perspective* (pp. 121-140). Berlin: Springer-Verlag.
tussock grasslands; tropical eucalypt savanna woodland; tropical eucalypt open forest; review
Reviews some previous studies from northern Australia. In general, there is little succession, but increase in bird abundance soon after fires.

Braithwaite, R. W., & Estbergs, J. (1987). Fire-birds of the Top End. *Australian Natural History*, 22, 299-302.
community; tropical eucalypt open forest; tropical eucalypt savanna woodland.
Bioregions: Top End Coastal; Pine Creek Arnhem
Several species (notably Brown Falcon, Black Falcon, Whistling Kite, Black Kite, woodswallows, Tree Martin) are attracted to fires, often in large aggregations. Torresian Crow, raptors, butcherbirds, Straw-necked Ibis, Black-faced Cuckoo-shrike, nightjars, Red-tailed Black-cockatoo, Little Corella, Galah, quail, Northern Rosella, Blue-winged Kookaburra, Red-backed Kingfisher, Forest Kingfisher, Partridge Pigeon and Magpie-lark forage in the burnt area immediately (to several months) after fire, consuming carrion, more accessible animal food or fallen seeds. In the months following fire, vegetation regrowth attracts herbivorous insects and birds feeding on them (e.g. Straw-necked Ibis). In the wet season, many of these species migrate into more arid areas where fires continue to occur, though most are then no longer associated with burnt areas but rather open country around waterholes. The short-term attraction of many mobile species to burnt areas is in contrast to the succession described in temperate areas.

Bramwell, M., Pyke, G., Adams, C., & Coontz, P. (1992). Habitat use by Eastern Bristlebirds in Barren Grounds Nature Reserve. *Emu*, 92, 117-121.
Eastern Bistlebird; threatened species; heath; eucalypt woodland.
Bioregion: South east Corner
Eastern Bristlebird population density was greater in heath/woodland 9 years after fire than 6 years after fire.

Brickhill, J. (1980). Striated Grasswren *Amytornis striatus*. In C. Haigh (Ed.), *Endangered animals of New South Wales* (pp. 68). Sydney: NSW National Parks and Wildlife Service.
threatened species; mallee; hummock grassland; Striated Grass-wren
Extensive wildfires in mallee have severe and long-term impacts on Striated Grass-wren.

Brickhill, J. (1987) *The conservation status of malleefowl in New South Wales*. M.Nat.Res.Sc., University of New England.
mallee; Malleefowl; threatened species
Bioregion: Murray Darling Depression
Periodic fire may be needed to maintain the food resources on which the Malleefowl depends. A fine-scale fire-age mosaic benefits Malleefowl through provision of a diversity of food types.

Brooker, L. C., & Brooker, M. G. (1994). A model for the effects of fire and fragmentation on the population viability of the Splendid Fairy-wren. *Pacific Conservation Biology*, 1, 344-358.
Splendid Fairy-wren; isolate; management; wildfire; control burning; heath; long-term study
Bioregion: Swan Coastal Plain
Based on 17 years breeding, parasitism and survival data, a model of the effects of fire (both wildfire and controlled burning) on populations of Splendid Fairy-wrens is developed and explored. The frequency and extent of fire can readily drive isolated populations to extinction. This

probability increases with smaller population size (=smaller area of isolate), and increase in probability of fire. In this case, the main effect of fire is manifested through increase in subsequent nest predation.

Brooker, M. G. (1988). Some aspects of the biology and conservation of the Thick-billed Grasswren *Amytornis textilis* in the Shark Bay area, Western Australia. *Corella*, 12, 101-108.
Thick-billed Grass-wren; succession
Bioregion: Carnarvon
Increased tourism and de-stocking could lead to changes in fire regime. Evidence of past severe fires, but current frequency of fires is low. Thick-billed Grasswrens can occur in vegetation within a few years post-fire, but fire is likely to be a main management consideration.

Brooker, M. G., & Rowley, I. (1991). Impact of wildfire on the nesting behaviour of birds in heathland. *Wildlife Research*, 18, 249-263.
heath; eucalypt open forest; wildfire; long-term study; Western Thornbill; Splendid Fairy-wren; Yellow-rumped Thornbill; breeding; control burning
Bioregion: Swan Coastal Plain
An intense wildfire burnt almost all of the study site half-way through a nine-year study: three wildfires burnt the rest of the study area over the next 3 years. Birds changed their nest siting after fires. In contrast to pre-fire locations, Splendid Fairy-wrens nested only in resprouter plant species in the first year post-fire. By the second year post-fire, they used some seeding shrubs. They had difficulty attaching nests to post-fire substrate, with several nests falling to the ground. Western Thornbills were unable to nest in preferred Hakea in the year post-fire but nested instead in holes of eucalypts and under shedding bark. They changed their placement of nests in Xanthorrhea. Very small unburnt patches were not used selectively by any of the three main bird species considered. The height distribution of nests generally changed in burnt vegetation. Breeding of Splendid Fairy-wren was delayed by 3-5 weeks in the year after fire, and the number of nests built per group had almost doubled by the second year (probably due to high rate of nest failure). Western Thornbills also delayed breeding by up to 5 weeks in burnt areas (cf unburnt) in the year after fire, and only 59% of females attempted to breed. The delay was due to shortage of nesting material (e.g. cobwebs) and/or inadequate food for egg production. Yellow-rumped Thornbills used novel nest sites post-fire, but used only 2 species of plant as nest sites, compared to 11 pre-fire.

Of 26 species which bred in the site in the year preceding the fire, 21 nested in burnt areas in the year following fire. White-browed Scrubwren vacated the area and did not nest for 2 years post-fire (possibly due to limited food resources through lack of litter). White-cheeked Honeyeater did not nest until 4 years post-fire. Inland Thornbill became rare and had failed to nest by 5 years post-fire. Fantailed Cuckoo remained abundant at the site but did not breed until its hosts (White-browed Scrubwren and Inland Thornbill) returned to breed. Little Button-quail and Elegant Parrot were recorded nesting only after the fire (attracted to the temporary conversion of heath to grassland), and White-winged Triller and Dusky Wood-swallow were more numerous breeders post-fire.

Although most species appeared to have some individuals which survived fire and showed adaptable behaviour in subsequent nesting, less obvious effects (such as increased mortality, lowered productivity and altered age structure) may be more critical in determining the ultimate viability of populations.

"For small heathland passerines, control burns at any time of year and even five years apart could make an area uninhabitable." Suggests intervals of perhaps as long as 10 years are needed to maintain these populations.

Brooker, M. G., Ridpath, M. G., Estbergs, A. J., Bywater, J., Hart, D. S., & Jones, M. S. (1979). Bird observations on the north-western Nullabor Plain and neighbouring regions, 1967-1978. *Emu*, 79, 176-190.
chenopod shrubland; wildfire
Bioregion: Nullabor
A widespread fire followed by drought may have led to local loss (for at least 5 years) of White-winged Fairy-wren from a bluebush site.

Brooker, M. G., Braithwaite, R. W., & Estbergs, J. A. (1990). Foraging ecology of some insectivorous and nectarivorous species of birds in forests and woodlands of the Wet-Dry tropics of Australia. *Emu*, 90, 215-230.

tropical eucalypt open forest; tropical eucalypt savanna woodland; community

Bioregions: Pine Creek Arnhem; Top End Coastal

Study of foraging behaviours of insectivorous and nectarivorous birds across a range of habitats. "… controlled burning and the prevention of previously frequent wildfires are but a few examples of disturbances which may change … the abundance and diversity of birds." More than half of the insectivorous species forage from the ground or from shrubs and grass. "The lower strata are the most affected by fire … (and) the needs of this large ground and shrub-foraging guild should therefore be considered in the formulation of fire management plans. A range of fire types throughout the year might increase the habitat diversity … with a positive effect on the diversity of bird species."

Brothers, N. P. (1983). Seabird Islands: No. 136. Actaeon Island, Tasmania. *Corella*, 7, 89-90.

seabirds; heath; tussock grassland

Bioregion: D'Entrecasteaux

"The vegetation on the island has been frequently burnt for many years and … this may have significantly affected the habitat suitable for burrowing" for nesting seabirds.

Brothers, N. P., & Skira, I. J. (1987). Seabird Islands: No. 173. Chappell Island, Furneaux Group, Tasmania. *Corella*, 11, 81-82.

seabirds; tussock grassland

Bioregion: Furneaux

Firing and grazing has substantially modified the vegetation, considerably reducing the distribution and abundance of breeding shearwaters.

Brothers, N. P., & Skira, I. J. (1988). Seabird Islands: No. 185. Little Dog Island, Furneaux Group, Tasmania. *Corella*, 12, 85-86.

seabirds; tussock grassland

Bioregion: Furneaux

Repeated fires have changed vegetation patterning, probably affecting suitability for shearwaters.

Brouwer, J., & Garnett, S. (Ed.). (1990). *Threatened birds of Australia: an annotated list*. Melbourne: Royal Australasian Ornithologists Union.

review; threatened species

Of 52 threatened bird species, inappropriate fire regime is a factor affecting status for 22 species.

Brown, P. B., & Wilson, R. I. (1981). *A survey of the Orange-bellied Parrot Neophema chrysogaster in Tasmania, Victoria and South Australia*. National Parks and Wildlife Service, Tasmania.

Orange-bellied Parrot; threatened species; management; eucalypt open forest; sedgelands; hollows

Bioregion: West and South West

Uncontrolled burning of button-grass plains in southwestern Tasmania extend to the breeding sites of Orange-bellied Parrots in fringing open forest, to the extent that, when nesting, they "are constantly at risk from wildfires". However, the Parrots feed in the button grass plains, sedgelands and heaths, and prefer relatively young vegetation (albeit in a seasonally rotating order: in October and November they fed mainly in 7-8 year old regrowth, in December they mainly fed in 1-4 year old regrowth, in January and February they mainly fed in regrowth >8 years post-fire). A fire management plan is required.

Brown, P. B., & Wilson, R. I. (1984). The Orange-bellied Parrot. In R. H. Groves & W. D. L. Ride (Eds.), *Species at risk* (pp. 106-116). Canberra: Australian Academy of Science.

Orange-bellied Parrot; heath; sedgelands; threatened species; management.

Bioregion: West and South West

Fire management is critical for the maintenance of Orange- bellied Parrot at their breeding grounds. Relatively young regrowth heath (7 years post-fire) is preferred for feeding, and is probably unsuitable by 10-12 years. In its breeding area it roosts in thick regrowth of 7-10 years post-fire.

Bryant, S. L. (1991). *The Ground Parrot, Pezoporus wallicus, in Tasmania: distribution, density and conservation status. Scientific report no. 91/1*. Parks, Wildlife & Heritage, Tasmania.
Ground Parrot; threatened species; heath; sedgelands.
Bioregion: West and South West
Provided density estimates of Ground Parrots at 185 sites of varying ages post-fire. No clear peak in abundance at a particular age. Did not recommend prescribed burning on current information.

Bryant, S. L. (1992). The Ground Parrot and age of vegetation in Tasmania. In L. Joseph (Ed.), *Issues in the conservation of parrots in Australasia and Oceania: challenges to conservation biology.* (pp. 42-45). Melbourne: Royal Australasian Ornithologists Union.
Ground Parrot; threatened species; heath.
Bioregion: West and South West
Ground Parrots occur in heath across a very broad range of ages after fire, though are least abundant in early regrowth.

Bryant, S. L. (1994). Habitat and potential diet of the Ground Parrot in Tasmania. *Emu*, 94, 166-171.
threatened species; heath; sedgelands; Ground Parrot.
Bioregion: West and South West
Recorded in vegetation from 1 to 90 years post-fire. Minimum vegetation cover required is achieved in most situations in Tasmania within 12 months post-fire. Growth rates (and phenology) of moorland plant species are very variable, leading to wide range of vegetation ages used.

Burbidge, A. A., Folley, G. L., & Smith, G. T. (1986). *The Noisy Scrub-bird. Western Australian Wildlife Management Program 2*. Department of Conservation and Land Management.
Noisy Scrub-bird; eucalypt open forest; heath; threatened species; management.
Bioregion: Esperance Plains
The former frequent burning and drainage of swamps would have led to decline of this species. Management requires fire control.

Burbidge, A. H., & Pedler, L. (1993). *Conservation status of the Nullabor Quail-thrush*. World Wide Fund for Nature.
Nullabor Quail-thrush; threatened species; chenopod shrubland; management
Bioregion: Nullabor
Hot fires may make areas unsuitable for Nullabor Quail-thrush, and this effect may be exacerbated by grazing preventing regrowth.

Burbidge, A. H., & Pedler, L. (1997). Habitat of the threatened Nullabor Quail-thrush. *Wildlife Research*, 24.
Nullabor Quail-thrush; chenopod shrublands; threatened species; management
Bioregion: Nullabor
Interacting with grazing by rabbits and livestock, and weed invasion, fire is a main threat to the Nullabor Quail-thrush. Habitat should be managed to decrease risks (or frequency) of extensive fire (especially hot wildfire).

Burbidge, A. H., Watkins, D., & McNee, S. (1989). *Conservation of the Ground Parrot in Western Australia. Final report (Project 118)*. World Wildlife Fund.
Ground Parrot; threatened species; heath; management; control burning
Bioregion: Esperance Plains
Ground Parrots in WA prefer long-unburnt heath, but it is not clear at what age heaths become suitable. "The major approach for the management of Ground Parrots in these areas at this time must be one of total fire exclusion". If fuel reduction burning must be done (for buffer strips) this should be done in autumn, to avoid disruption of breeding). Describes floristics and results of radio-tracking.

Burbidge, A. H., McNee, S., Newbey, B., & Rolfe, J. (1990). *Conservation of the Ground Parrot in Western Australia. Supplementary report: project 118*. World Wildlife Fund.
Ground Parrot; heath; management; threatened species.
Bioregion: Esperance Plains
Results of some censuses and floristic associations for Ground Parrot in southwest Australia. The western subspecies appears to have very different habitat and management requirements to the eastern subspecies. Monitoring of sites following wildfire is outlined.

Cale, P. G., & Burbidge, A. H. (1993). *Research plan for the Western Ground Parrot, Western Whipbird and Western Bristlebird*. Australian National Parks and Wildlife Service.
Ground Parrot, Western Whipbird, Western Bristlebird; threatened species; management; heath; mallee.
Bioregions: Esperance Plains; Jarrah Forest; Warren
Reviews conservation status, research priorities and responses to fire for three threatened species (Western Whipbird, Western Bristlebird and Ground Parrot). Fire management of these three species (and also Noisy Scrub-bird) should be integrated at sites of co-occurrence, although this may be complicated by somewhat different responses to fire. For Ground Parrot, cautions against correlative studies of abundance and time since fire (other factors may be involved). Limited data from WA suggest response may differ to that recorded from eastern Australia: birds in WA use long-unburnt vegetation (>20, and maybe >30 years post-fire), and are more abundant in a long-unburnt area than an adjacent 6-year post-fire area. This difference may reflect slower growth rates of heath in WA. "Determining the age after fire at which vegetation becomes suitable for Ground Parrots and the length of time for which it remains suitable is essential for the proper long-term management of the species": this can only be done by monitoring existing populations and/or determining the time after fire at which colonisation occurs. "Fire has been identified as the greatest threat to P.n. nigrogularis … (but) little is known about the responses to fire of P.n. oberon". Management and research for the former subspecies should consider whether there is an upper limit on the age of vegetation used; for the latter subspecies research should examine more comprehensively long-term responses of known populations to vegetation age and hence derive fire management plans. For Western Bristlebirds, research has indicated that heaths older than c45 years become less suitable (due to decrease in productivity and floristic/structural changes). Research and management should continue long-term monitoring of population size with heaths of increasing age, and examination of the impacts of fire breaks.

Calver, M. C., Hobbs, R. J., Horwitz, P., & Main, A. R. (1996). Science, principles and forest management: a response to Abbott and Christensen. *Australian Forestry*, 59, 1-6.
management; control burning; eucalypt open forest
Bioregion: Jarrah Forest
Disputes claims (made by Abbott and Christensen) of limited impacts of fuel reduction burning in jarrah forests; no new data are presented.

Campbell, A. G. (1937). Birds of Wilson's Promontory. *Emu*, 37, 157.
eucalypt open forest
Bioregion: South east Coastal Plain
Birds in the Wilson's Promontory area have been much less common because of fire, and are likely to be further affected. "The forests of the west coast are gone and the forests of the east are doomed owing to the ravages of fire … the utterly senseless waste of the natural assets of this national park can only be termed a satire upon the methods of those in control".

Carpenter, G., & Matthew, J. (1986). The birds of Billiatt Conservation Park. *South Australian Ornithologist*, 30, 29-37.
mallee; Callitris woodlands; community; hollows
Bioregion: Murray Darling Depression
Vegetation of several ages since fire was sampled. "Fire has an important influence on bird populations within the Park due to its effect on vegetation. For example, hollows suitable for nesting are occasionally produced by fires. Elsewhere, suitable hollows exist only in long-unburnt eucalypts and Callitris." Areas burnt <10 years before were unsuitable for Gilbert's and Red-lored Whistlers, Southern Scrub-robin and Western Whipbird, but suitable for Hooded and Red-capped Robins. Relationship of birds with age since fire may be changed with varying floristics: Callitris is slower-growing than eucalypts and maintains shrubbiness longer, therefore species requiring shrubby vegetation may persist in Callitris longer than in eucalypts. Southern Scrub-robin, Shy Heath-wren, Crested Bellbird and Purple-gaped Honeyeater were common in areas burnt 23 years previously, or older areas that had shrubby understorey. Mallee-fowl mounds were most common in areas older than 23 years post-fire with open understorey, but recently burnt areas may offer

rich food supplies for this species. Several species showed no apparent relationship with fire (Grey Shrike-thrush, Golden Whistler, Splendid and Variegated Fairy-wrens, White-browed Babbler, Weebill, Inland Thornbill, Yellow-rumped Pardalote, Grey Butcherbird, and Brown-headed, Yellow-plumed, White-eared and Spiny-cheeked Honeyeaters).

Carter, T. (1923a). Birds of the Broome Hill district. Part I. *Emu*, 23, 125-142.
Malleefowl; mallee; heath; threatened species
Bioregion: Avon Wheatbelt
In 1902 the Malleefowl was common in coastal vegetation, but its population had diminished by 1920 because of burning of the coastal vegetation to improve grazing for cattle.

Carter, T. (1923b). Birds of Broome Hill district. Part II. *Emu*, 23, 223-235.
Western Whipbird; heath; threatened species
Bioregion: Avon Wheatbelt
Repeated fires have destroyed much of the heath and thickets that the Western Whipbird requires, and it is becoming rarer.

Carter, T. (1924). Birds of the Broome Hill District. Part III. *Emu*, 23, 306-318.
Rufous Bristlebird; heath; threatened species
Bioregions: Warren; Avon Wheatbelt
Repeated burning of heaths had severe impact on Rufous Bristlebird.

Catling, P. C., & Newsome, A. E. (1981). Responses of the Australian vertebrate fauna to fire. In A. M. Gill, R. H. Groves, & I. R. Noble (Eds.), *Fire and the Australian biota* (pp. 273-310). Canberra: Australian Academy of Science.
review
Considers a series of propositions that the Australian vertebrate fauna is fire-adapted. In eucalypt forests, the greatest bird diversity occurs in forests 5-6 years post-fire then mature forests declines as habitat. There is little evidence of distinct seral stages, but simply gradual changes in abundance. All species in eucalypt forests have the capacity to survive fires and recover quickly. There are very few fire specialists. It is difficult to ascribe life history traits to adaptation to fire as opposed to other features of the Australian environment. Primitive birds are mainly in least fire-prone environments (rainforests). Fire-prone environments tend to be species-poor overall. Ground Parrots may be fire-specialists, requiring heath of a certain range of ages post-fire. Superb Lyrebird and Common Bronzewing may require fire to eliminate wiregrass and enhance production of Acacia seeds respectively. White-browed Scrubwren decreased after fire in a eucalypt forest.

In eucalypt forests, bird numbers in the understorey and ground layers decline with long periods after fire, and more frequent burning may be required for these lower layers.

Chaffer, N. (1954). The Eastern Bristle-bird. *Emu*, 54, 153-162.
Eastern Bristlebird; threatened species; heath; wildfire
Bioregion: South East Corner.
Repeated bushfires may have reduced the numbers of Eastern Bristlebirds, although they have survived in areas of frequent fire.

Chambers, W. (1983). Birds at Urquhart's Bluff: before and after the fire. *Geelong Naturalist*, 20, 50-51.
eucalypt open forest; wildfire
Bioregion: South east Coastal Plain
Anecdotal notes of species before fire and then gradually recolonising after fire. By six weeks post-fire, Australian Magpie, Grey Shrike-thrush, Crimson Rosella, Pied Currawong, Grey Currawong, Australian Raven, Welcome Swallow, Masked Lapwing, Sulphur-crested Cockatoo and Yellow-tailed Black Cockatoo had been recorded. Within weeks after that, first returns of White-eared Honeyeater, Eastern Spinebill and Flame Robin.

Chandler, L. G. (1973). In the wake of a bushfire. *Wildlife in Australia*, 10, 140-141.
wildfire; mallee
Bioregion: Murray Darling Depression
General notes, suggesting high mortality of small birds during mallee wildfire. Malleefowl may be particularly disadvantaged, with eggs lost, young killed and regrowth vegetation unsuitable. Effects may be accentuated if drought follows fire.

Chatto, R. (1995). The effects of fire on a breeding colony of Australian Pelicans. *Corella*, 19, 70.
Australian Pelican; mortality
Bioregion: Top End Coastal
In two of the last four years, fire burnt through an island colony of Australian Pelicans killing at least 1000 young birds (=most of the population). Fires were probably deliberately lit.

Cheal, P. D., Day, J. C., & Meredith, C. W. (1979). *Fire in the national parks of north-west Victoria*. National Parks Service.
threatened species; mallee; heath; management; hollows
Bioregion: Murray-Darling Depression
Bird communities were censused in a range of vegetation types (mallee and heath) across a range of regrowth ages. "After a fire in mallee vegetation, virtually no birds will breed in the burnt area in the first three to four years". Some birds (mainly granivores) will forage in such burnt areas, but generally at low abundance. When regrowth trees begin to emerge, bird diversity and densities increase rapidly (to peak at about 15 years post-fire, though richness may continue to increase). No bird species appears to be restricted to young regrowth, but several are restricted to mallee of >15-20 years post-fire. These include hollow-nesting species (e.g. Striated Pardalote, parrots), some canopy species and many ground-foraging species. Most of the "typical" mallee species favour old vegetation. However very old mallee may become unsuitable, even for these species. Malleefowl may prefer vegetation around 15-25 years post-fire, as food resources probably decline with increasing time since fire.

In heaths, few species occur in very young regrowth, richness probably peaks at c15-20 years post-fire, and older heaths tend to be species-poor.

Predation on birds may be high in the immediate aftermath of fire. In general, old mallee had more stable bird assemblages (greater similarity in species composition between geographically separated sites compared to younger regrowth), and their bird assemblages included more insectivores and greater stratification of foraging zones. The restriction of most mallee specialists to old vegetation (and the generalist nature of transient species occurring in young regrowth) argues for a relative stability of old mallee and the adaptation of most mallee birds to long intervals between fire.

Chisholm, A. H. (1922). The "lost" Paradise Parrot. *Emu*, 22, 4-17.
Paradise Parrot; threatened species; eucalypt woodland.
The Paradise Parrot may have declined (now to extinction) over the last century because grazing and frequent firing led to loss of its seed resource.

Chisholm, A. H. (1945). Birds of the Gilbert diary, Part 2. *Emu*, 44, 183-200.
Paradise Parrot; eucalypt woodland; threatened species.
Altered fire regimes since European settlement may have contributed to the extinction of the Paradise Parrot.

Christensen, P. (1974). The concept of fauna priority areas. In *Third Fire Ecology Symposium* (pp. 66-73). Melbourne: Forests Commission, Victoria.
eucalypt open forest; wildfire
Bioregion: Warren
Bird abundance and richness increases sharply in Karri forest up to at least 2 years after a very hot burn. Some species of open formations (e.g. Scarlet Robin) can invade wetter forests after hot fires. Other species (e.g. Red-winged Fairy-wren) decline but then increase within 2 years.

Christensen, P., & Abbott, I. (1989). Impact of fire in the eucalypt forest ecosystem of southern Western Australia: a critical review. *Australian Forestry*, 52, 103-121.
review; community; management; eucalypt open forest; succession
Bioregions: Jarrah Forest; Warren.
Current periods between fuel-reduction burns are 5-6 years for Jarrah forest and 7-9 years for Karri forest, other than in conservation reserves. Limited evidence suggests that Aboriginal burning in these forests may have been more frequent (3-5 year cycles) or much less frequent. Reviews research on effects of fire on soil nutrients, floristics, structure, invertebrates and vertebrates. Most studies report an initial short-term decrease in understorey birds followed by an increase above pre-fire levels following fuel-reduction burns in Jarrah and Karri forests, with little change in canopy species. Some species (e.g. White-winged Chough, Western Yellow Robin, Scarlet Robin) invaded or increased in abundance in recently-burnt areas. Honeyeaters also became more common in association with

fire-induced flowering. Fire intensity is the major factor influencing the impact of fire on bird populations.

Christensen, P. E., & Kimber, P. C. (1975). Effect of prescribed burning on the flora and fauna of south-west Australian forests. *Proceedings of the Ecological Society of Australia*, 7, 85-107.
review; eucalypt open forest; control burning; community; succession
Bioregions: Jarrah Forest; Warren
Birds showed surprisingly small changes following cool fire. Birds were sampled at two sites (one unburnt for 40 years and one subject to an intense prescribed fire) in dry sclerophyll forest. There was little difference in the bird communities before fire. From one month to one year post-fire there was a very slight decline of ground and understorey species. By 2 years post-fire the population of understorey and ground-dwelling species (e.g. Rufous Treecreeper, Inland Thornbill, Western Thornbill, Western Yellow Robin, Golden Whistler) had surpassed pre-fire levels, and that of canopy species was unchanged. Following a fire in wet sclerophyll forest, bird numbers decreased initially, but by 5 months post-fire abundance was higher than pre-fire (due especially to more Western Yellow Robin, Inland Thornbill, Scarlet Robin, Rufous Treecreeper and Grey Shrike-thrush). In the second year after fire there was an increase in birds of the shrub layer (particularly of Inland Thornbill and White-browed Scrubwren), and of White-naped Honeyeater (which foraged in epicormic growth). Some species (e.g. Red-winged Fairy-wren and Golden Whistler) disappeared for the first year post-fire, but returned in 2-3 years post-fire. White-browed Scrubwren changed foraging behaviour after fire. Extensive hot fires or frequent cool fires would produce a homogenisation of the landscape to the detriment of bird species diversity.

Christensen, P., Recher, H., & Hoare, J. (1981). Responses of open forests (dry sclerophyll forests) to fire regimes. In A. M. Gill, R. H. Groves, & I. R. Noble (Eds.), *Fire and the Australian biota* (pp. 367-393). Canberra: Australian Academy of Science.
review; eucalypt open forest; widlfire; mortality
In very hot wildfires, bird mortality in fires may be high. With cooler fires, mortality is usually low, however post-fire mortality may be substantial. Noisy Scrub-bird requires a late seral stage and cannot survive frequent fires. The nectarivorous Crescent Honeyeater may disappear from heaths for several years after fire. Post-fire changes in forests are most pronounced for birds of ground and understorey layers. In general these birds decline in abundance after fire, but then increase to at least pre-fire levels within 2-3 years post-fire Recolonisation and increased populations may be due to greater insect numbers on regrowth vegetation.

Christensen, P. E. S., Wardell-Johnson, G., & Kimber, P. (1985). Birds and fire in southwestern forests. In A. Keast, H. F. Recher, H. Ford, & D. Saunders (Eds.), *Birds of eucalypt forests and woodlands: ecology, conservation, management* (pp. 291-299). Chipping Norton: Surrey Beatty.
eucalypt open forest; management; community; control burning; wildfire; succession
Bioregion: Jarrah Forest
Reports two studies of birds and fire in Jarrah forests. A hot prescribed fire burnt the site in the third year of a 5 year study (a control site remained unburnt). Bird species richness increased in the burnt site. 13 species (including White-winged Triller, Australian Magpie, Australian Raven) appeared after fire that had not been recorded before, and others (e.g. Dusky Wood-swallow, Tree Martin, Scarlet Robin, Western Yellow Robin, Inland Thornbill, Western Thornbill) became more abundant (for varying periods post-fire). Some nectarivorous species (Purple-crowned Lorikeet, Silvereye, Red Wattlebird, Western Spinebill) increased post-fire, because of fire-induced flowering in the eucalypt overstorey.
Canopy-feeding insectivores showed no or little effect of fire. Golden Whistler, White-breasted Robin and White-browed Scrub-wren declined after fire (the latter two did not reappear until 2 years post-fire).

A second study considered long-term impacts of fire regimes, comparing bird assemblages in 3 areas with different fire regimes (unburnt for 14 years, burnt in a severe wildfire 1 year before study, and burnt in a mild fire 6 months before study). The unburnt and mildly burnt sites had more species and individuals than the site which had been burnt by wildfire. Golden Whistler, Inland Thornbill, Western Yellow Robin and White-breasted Robin were most common in the unburnt forest (and least common in the wildfire site). Scarlet Robin was least common in the wildfire site. Western Thornbill was least common in the unburnt site. The abundance of small insectivores of the canopy showed little variation.

Rapid response of birds to mild fire compared to more substantial impact of hot wildfire may be due to a delayed recovery of invertebrates in the latter. As a general rule, the effect of mild or moderate fires on birds is inversely proportional to their main foraging height. However responses of species are somewhat idiosyncratic, and the individual responses of rare species in particular need to be considered.

Fire intensity is the major factor determining impact of fire on birds. Season of burn may be relatively unimportant, other than through its impact on intensity: this view is contrary to popular belief that spring burning is especially detrimental due to its alleged disruption of breeding. A diverse burning pattern may be the most appropriate management.

Clout, M. N. (1989). Foraging behaviour of Glossy Black-cockatoos. *Australian Wildlife Research*, 16, 467-473.

Glossy Black-cockatoo; Allocasuarina woodland; hollows; eucalypt open forest; threatened species; management

Bioregion: South eastern Corner

Glossy Black-cockatoos are reliant on seeds of Allocasuarina. These species are fire-sensitive, requiring heat to open cones, but are easily killed by intense fire. Post-European changes in fire regime have reduced abundance of Allocasuarina and the large dead trees in which Glossy Black-cockatoos nest. Conservation of this species depends upon appropriate fire management.

Coate, K. (1985). Black Honeyeaters feeding on ash. *Western Australian Naturalist*, 16, 51-52.

charcoal; Black Honeyeater

Up to 4 Black Honeyeaters were feeding simultaneously in old fireplaces, consuming ash. Analysis showed this had high levels of calcium, and the behaviour may be explained by female birds seeking calcium before egg-laying.

Cooper, R. P. (1972). The occurrence of the Pilot-bird on Wilson's Promontory. *Australian Bird Watcher*, 4, 137-143.

Pilot-bird; eucalypt open forest; wildfire

Bioregion: South east Coastal Plain

From being common last century in densely vegetated gullies of the Strzelcki Ranges, the Pilot-bird has now been largely wiped out of the area by clearing and wildfire, particularly the disastrous fires of 1939.

Cooper, R. P. (1974). The avifauna of Wilson's Promontory. Part 1. *Australian Bird Watcher*, 5, 137-174.

heath; eucalypt open forest; management

Bioregion: South east Coastal Plain

Substantial changes to vegetation (increased scrubbiness) of Wilson's Promontory over the last century were due to changes in fire regime. This must have changed bird species composition. A very large wildfire in 1951 (during the breeding season) probably resulted in massive mortality of birds. Argues against fuel reduction burning and burning of heathlands. "Fire has a most detrimental effect on the avifauna of any area."

Cooper, R. P. (1975). The avifauna of Wilson's Promontory. Part 4. *Australian Bird-watcher*, 6, 17-34.

heath; Ground Parrot; threatened species

Bioregion: South east Coastal Plain

Ground Parrots reported to flee just ahead of fire front. The species disappeared from an area for at least four years post-fire.

Cowley, R. D. (1971). Birds and forest management. *Australian Forestry*, 35, 234-250.
review; eucalypt open forest; management; forestry
In eucalypt forests, birds which feed or nest on the ground (e.g. Superb Fairy-wren, White-browed Scrubwren, Spotted Quail-thrush, Brown Thornbill and White-eared Honeyeater) may be those most affected by fire. Birds which nest within 1.5m of the ground may be vulnerable to fuel-reduction fire during the breeding season. Food (e.g. seed) is generally more available after a fire. Cool burns generally leave unburnt patches, typically in gullies, and regrowth of grasses and shrubs is usually rapid after fire. Frequent fires can change shrubby understorey to grass, to the advantage of species such as Spotted Quail-thrush and Buff-rumped Thornbill but to the disadvantage of species associated with shrubs (e.g. White-browed Scrubwren, Brown Thornbill, Common Bronzewing). Frequent fires in wetter forest may result in a dense cover of wire grass, to the detriment of species foraging in litter (such as Superb Lyrebird, Bassian Thrush, Eastern Yellow Robin, Superb Fairy-wren). Some honeyeaters are advantaged by frequent light fires, because these promote profuse flowering.

Cowley, R. D. (1974). Effects of prescribed burning on birds of the mixed species forests of West Central Victoria. In *Third Fire Ecology Symposium* (pp. 58-65). Melbourne: Forests Commission, Victoria.
eucalypt open forest; control burning; community
Bioregion: Victorian Midlands
Short-term effects of a (fairly hot) prescribed burn in open forest were examined, partly through observation of changed distribution of banded birds. Of 27 banded birds (of 7 species: White-browed Scrubwren, Superb Fairy-wren, Straited Thornbill, Brown Thornbill, White-throated Treecreeper, Eastern Yellow Robin, White-eared Honeyeater) regularly using the site pre-fire, 18 were known to have survived (all species other than White-eared Honeyeater). Home ranges changed little. Birds appeared more wary after fire (and logs were used as refuge). Several species with nests started before the fire successfully raised young after the fire. Only one species (Olive Whistler, which prefers dense understorey) apparently disappeared. Several species characteristic of open areas (Australian Magpie, Buff-rumped Thornbill, Painted Quail) invaded after fire.

Cowley, R. D., Heislers, A., & Ealey, E. H. H. (1969). Effects of fire on wildlife. *Victoria's Resources*, 11, 18-22.
mallee; Malleefowl; Superb Lyrebird; eucalypt open forest; review
Malleefowl require abundant litter for nesting. This may not be available for at least 10 years post-fire. In contrast, Superb Lyrebird may require periodic fires to remove wire grass.

Crawford, D. N. (1972). Birds of Darwin area, with some records from other parts of Northern Territory. *Emu*, 72, 131-148.
tropical eucalypt open forest; tussock grassland; hummock grassland.
Bioregions: Top End Coastal; Pine Creek Arnhem
Burning of grasslands during the dry season leads to local shifts in habitat use by Golden-headed Cisticola and Red-backed Fairy-wren (both may occur in monsoon rainforest fringes when most of the open forests and grasslands have been burnt). Barn Owl concentrates in cleared areas early in the dry but disperses to extensive burnt areas later in the season (presumably because hunting over unburnt grasslands is difficult). In contrast, there does not appear to be a concentration of Pheasant Coucals in unburnt patches of grassland later in the season (possibly suggesting seasonal movement). White-throated Grass-wren recorded only in long-unburnt hummock grassland.

Crawford, D. N. (1979). Effects of grass and fires on birds in the Darwin area, Northern Territory. *Emu*, 79, 150-152.
tropical eucalypt open forest.
Bioregion: Top End Coastal
Monitored bird populations in 24 sites (1.6ha) in wet and dry seasons over 28 months. All sites were burnt at some stage over the study period. Red-backed Fairy-wren was disadvantaged by fire, and its persistence appears to depend on some cover remaining after fire. Within 2 weeks of burning, there is an increase in migratory ground- and mid-level foragers, and Pied Butcherbird, Black-faced Cuckoo-shrike, Magpie-lark and Red-tailed Black-cockatoo. Their numbers declined slightly at >2 months post-fire.

Crowley, G. M. (1995). *Fire on Cape York Peninsula*. Cape York Peninsula Land Use Study.
review; tropical eucalypt open forest; rainforest; hollows; Cassowary; Golden-shouldered Parrot; threatened species; management
Bioregion: Cape York Peninsula
Birds that are advantaged by fire in the short-term, or by a high frequency regime, tend to be nomadic granivores, carnivores or omnivores. Of particular concern is the effect of fires on tree hollows used for nesting by birds. Fires may lead to hollow formation, or to destruction of hollows and nests. Ecotone between rainforest and wet eucalypt forest may be the preferred habitat for Cassowary, and this species may require fire for its maintenance. Widespread late dry season fires have probably led to the decline of the Brown Treecreeper. Lack of burning after the first storms of the wet season is considered a threat to the Golden-shouldered Parrot. A wide variety of burning histories is likely to maximise bird diversity.

CSIRO Wildlife Research (1976). *A survey of the fauna of the Lower McArthur River Region, Northern Territory*. Mimets Development Pty Ltd.
tropical eucalypt open forest; tropical eucalypt savanna woodland; hummock grassland; tussock grassland; Carpentarian Grass-wren; Bush Stone-curlew; Australian Bustard.
Bioregions: Gulf Falls and Uplands; Gulf Coastal
Increased frequency of fire, particularly in hummock grasslands, must have a deleterious effect on the survival of such terrestrial species as Carpentarian Grass-wren, quail, Bush Stone-curlew and perhaps Bustard.

Cummings, B., McDonald, B., & Taplin, A. (1993). Knowledge of birds in Queensland biogeographic regions and threats to their conservation. In C. P. Catterall, P. V. Driscoll, K. Hulsman, D. Muir, & A. Taplin (Eds.), *Birds and their habitats: status and conservation in Queensland* (pp. 178-186). St Lucia: Queensland Ornithological Society Inc.
review
Bioregions: Mitchell Grass Downs, South East Queensland, Einasleigh Uplands, Cape York Peninsula, Wet Tropics, Channel Country, Mulga Lands, Brigalow Belt, Mount Isa Inlier, Gulf Plains, Desert Uplands, Central Mackay Coast.
The relative importance of fire as a factor affecting bird conservation is discussed for every Queensland bioregion. Existing fire regimes may be a management problem for birds in Mitchell Grass Downs, South East Queensland, Einasleigh Uplands, Cape York Peninsula, Wet Tropics, but are not a problem (or there is insufficient information) for other bioregions.

Curry, G. N. (1991). The influence of proximity to plantation edge on diversity and abundance of bird species in an exotic pine plantation in north-eastern New South Wales. *Wildlife Research*, 18, 299-314.
management; slash-burn; forestry
Windrows in plantations allow the entry or persistence of many bird species. These are usually burnt to reduce fire risk to the plantation, but it would be preferable (for bird conservation) not to burn these windrows, but rather to reduce fire hazard by careful positioning of windrows.

Curry, P. J. (1986). Habitat characteristics of the Thick-billed Grasswren *Amytornis textilis* in grazed shrublands in Western Australia. In P. J. Joss, P. W. Lynch, & O. B. Williams (Eds.), *Rangelands: a resource under siege* (pp. 566). Canberra: Australian Academy of Science.
Thick-billed Grasswren; chenopod shrubland; Acacia shrubland
Bioregion: Carnarvon
The western subspecies of Thick-billed Grasswren had previously been considered to be possibly on the verge of extinction and reliant on saltbush and bluebush. Instead, the subspecies was found to be widespread in seral shrublands that replace Acacia shrublands for at least 40 years after wildfire.

Danks, A. (1991). The role of corridors in the management of an endangered passerine. In D. A. Saunders & R. J. Hobbs (Eds.), *Nature conservation 2: the role of corridors* (pp. 291-296). Chipping Norton: Surrey Beatty.
Noisy Scrub-bird; eucalypt open forest; thicket; corridors; management; threatened species.
Bioregion: Jarrah Forest
Dispersal of Noisy Scrub-bird is assisted by corridors which are unburnt (and protected from other disturbance).

Davidson, I., & Chambers, L. (1991). *Vegetation management for Superb Parrot foraging habitat in Victoria*. Victorian Department of Conservation and Environment.
Superb Parrot; threatened species; management
Bioregion: Riverina
Some corridors used by Superb Parrots may be enhanced by the cessation of burning; landowners may be reluctant to increase or maintain suitable habitat patches because of their perception that this increases the risk of wildfire.

Davidson, I., & Robinson, D. (1992). *Grey-crowned Babbler Pomatostomus temporalis*. Department of Conservation and Natural Resources.
Grey-crowned Babbler; eucalypt woodland; threatened species; management; control burning
Bioregions: Victorian Midlands; South Eastern Highlands
Reviews information on this species. Threats to declining Grey-crowned Babblers include fire protection works (e.g. firebreaks and fuel reduction burning) and collection of firewood.

Davies, S. J. J. F., Smith, G. T., & Robinson, F. N. (1982). The Noisy Scrubbird in Western Australia. In R. H. Groves & W. D. L. Ride (Eds.), *Species at risk: research in Australia* (pp. 117-127). Canberra: Australian Academy of Science.
Noisy Scrub-bird; threatened species; heath; eucalypt open forest; management.
Bioregion: Jarrah Forest
The Noisy Scrub-bird disappeared from areas where eucalypt forests fringing swamps had been burnt. With strict fire control populations have built up.

Debus, S. J. S., & Czechura, G. V. (1988). The Red Goshawk *Erythrotriorchis radiatus*: a review. *Australian Bird Watcher*, 12, 175-199.
Red Goshawk; historical change; threatened species; tropical eucalypt open forest
Since the Miocene, Australia's rich raptor community has declined, possibly because of climate change and perhaps Aboriginal fire regimes. Currently, the most serious threats to the Red Goshawk are mismanagement of tropical rangelands (overstocking and too frequent burning), vegetation destruction and wetland drainage.

Dedman, V. (1983a). G.F.N.C. Otway Regeneration Survey - Progress report. *Geelong Naturalist*, 20, 52-56.
eucalypt open forest; heath; wildfire
Bioregion: South east Coastal Plain
By six months after hot fire in heath and eucalypt open forest, birds were returning slowly. Larger species (Australian Raven, Currawongs, Laughing Kookaburra, Sulphur-crested Cockatoo) are conspicuous. Smaller birds were not seen regularly until bracken was high enough to provide cover, but by 6 months post-fire Brown and Striated Thornbills were being seen regularly. Welcome Swallows were common over the burnt heathland.

Dedman, V. (1983b). G.F.N.C. Otways regeneration survey - 2nd progress report. *Geelong Naturalist*, 20, 98-100.
eucalypt open forest; wildfire
Bioregion: South east Coastal Plain
Almost one year after hot fire, bird numbers and species were increasing. Honeyeaters were attracted to flowering Xanthorrhoea. Superb Fairy-wrens were foraging in regrowth bracken. Some species were probably breeding. Pied Currawongs, Sulphur-crested Cockatoos and Red Wattlebirds were noted frequently.

Dedman, V. (1983c). Mammals and birds after the fires: Forest Road, Anglesea. *Geelong Naturalist*, 20, 27.
eucalypt open forest; wildfire
Bioregion: South east Coastal Plain
List of 13 bird species observed in severely burnt eucalypt open forest two weeks after fire.

Dedman, V. (1983d). Moggs Creek: eight days later. *Geelong Naturalist*, 20, 22-25.
eucalypt open forest; wildfire
Bioregion: South east Coastal Plain
Eight days following severe fire in eucalypt open forest, few birds were seen. These included Crimson Rosella, Red Wattlebird, White-throated Treecreeper and Scarlet Robin.

Dedman, V. (1983e). Notes on the effects of the Ash Wednesday fire on the Ironbark Basin, Point Addis. *Geelong Naturalist*, 20, 25-26.
eucalypt open forest; wildfire
Bioregion: South east Coastal Plain
Bird lists from 3 weeks and 6 weeks after hot fire in eucalypt open forest. Superb Fairy-wrens were observed in scorched tree-tops. Commonest birds in the burnt area were Eastern Yellow Robin and White-throated Treecreeper. Other species present included White-browed Scrubwren, Crimson Rosella, Brown Thornbill and Striated Thornbill.

Dedman, V. (1984). Otways regeneration survey. Third progress report. *Geelong Naturalist*, 21, 89-92.
wildfire; eucalypt open forest
Bioregion: South east Coastal Plain
One year after a hot wildfire, large birds (Yellow-tailed Black-cockatoo, Crimson Rosella, Red Wattlebird, Pied Currawong) appear more obvious in burnt forest.

Dickinson, K. J. M., Wall, L. E., & Wilson, R. I. (1986). Birds in a partly clearfelled dry eucalypt forest on dolerite in southeastern Tasmania. *Papers and Proceedings of the Royal Society of Tasmania*, 120, 39-49.
eucalypt open forest; slash-burn; forestry; community; management
Bioregion: Freycinet
Bird assemblages were sampled in unlogged forest, forest clearfelled and slash burnt, and forests clearfelled without subsequent burning. Species typical of open areas (e.g. Blue-winged Parrot, Superb Fairy-wren) invaded the cut and burnt sites. Flame Robin, Dusky Robin, Superb Fairy-wren and Grey Shrike-thrush were more common in the slash-burnt area than the unburnt logged forest: Crescent Honeyeater and Eastern Spinebill were more common in the unburnt cut forest. Prescribed burning under regenerating forests may disadvantage some species which depend on ground habitats (e.g. Spotted Quail-thrush).

Disney, H. J. d. S. (1968). Bushfires and their effect on fauna and flora. *Australian Natural History*, 16, 87-89.
review
Banded birds returned to their pre-burn territories following fire. Backburns may be particularly dangerous to small birds.

Du Guesclin, P., Smith, S., O'Shea, B., & Debbis, C. (1995). "Brushing for bristles": habitat corridors for the Rufous Bristlebird. In A. Bennett, G. Backhouse, & T. Clark (Eds.), *People and nature conservation: perspectives on private land use and endangered species recovery* (pp. 163-165). Chipping Norton: Surrey Beatty.
Rufous Bristlebird; heath; corridors; isolate
Bioregion: South East Coastal Plain
Recolonisation after fire is a problem for Rufous Bristlebirds because of their poor dispersal ability. Corridors may provide effective means for recolonisation.

Emison, W. B., & Bren, W. M. (1989). Common birds of the mallee, northwestern Victoria. In J. C. Noble & R. A. Bradstock (Eds.), *Mediterranean landscapes in Australia: mallee ecosystems and their management* (pp. 221-242). Melbourne: CSIRO.
mallee; heath; eucalypt woodland; Callitris woodland; Casuarina woodland; hollows; management
Bioregion: Murray-Darling Depression
Many species are dependent on hollows in woodlands, and the maintenance of these requires active management (including of fire regimes). In the previous decade, wildfires have burnt much of the mallee shrublands such that long-unburnt patches are now very rare. Species associated with such habitat include those nesting in hollows, and those which require dense litter. The management of mallee for fauna probably requires maintenance of a mosaic of vegetation of a range of ages, but with a bias towards retention of older ages.

Emison, W. B., Beardsell, C. M., Norman, F. I., & Loyn, R. H. (1987). *Atlas of Victorian birds*. Melbourne: Department of Conservation, Forests and Lands, and Royal Australasian Ornithologists Union.
review
Describes habitat and distribution for Victorian birds. The Mallee Emu-wren attains highest densities in early years after fire. The Southern Emu-wren is "able temporarily to colonise ephemeral habitats such as … scrubs regenerating after fire."

Ferrier, S. (1985). Habitat requirements of a rare species, the Rufous Scrub-bird. In A. Keast, H. F. Recher, H. Ford, & D. Saunders (Eds.), *Birds of eucalypt forests and woodlands: ecology, conservation, management* (pp. 241-248). Chipping Norton: Surrey Beatty.
Rufous Scrub-bird; management; eucalypt open forest; rainforest; threatened species.
Bioregion: NSW North Coast
Fire has played a major role in the Rufous Scrub-bird's current distribution and, in particular, its close association with rainforest. High intensity wildfires are known to have destroyed territories. Prescribed burning probably has little direct effect (though habitat suitability was low 10 months after a prescribed fire), and may prevent destruction through wildfire (though most are naturally buffered by their dampness or proximity to rainforests). However long-term influence of prescribed burning may be complex. Suitable habitat in eucalypt forests is probably associated with a particular post-fire seral stage. With long absence of fire, the eucalypt forests may develop into rainforests, to the detriment of Rufous Scrub-birds (due to reduction in ground cover density).

Fitzherbert, J. C., & Baker-Gabb, D. J. (1988). Australasian grasslands and their threatened avifauna. In P. D. Goriup (Ed.), *Ecology and conservation of grassland birds* (pp. 227-250). Cambridge: International Council for Bird Preservation.
review; tussock grasslands; hummock grasslands; tropical eucalypt savanna woodland; management; threatened species; Gouldian Finch; Yellow-rumped Mannikin; Chestnut-backed Button-quail; Partridge Pigeon; Golden-shouldered Parrot; Hooded Parrot; Carpentarian Grass-wren; White-throated Grass-wren; Black Grass-wren
Carpentarian, White-throated and Black Grass-wrens are threatened by fire in hummock grasslands, and require aging (>6 years) Triodia. In tropical grasslands, fire frequency has increased since European settlement. "Large areas are burnt each year … The decline of six bird species - the Gouldian Finch, Yellow-rumped Mannikin, Chestnut-backed Button-quail, Partridge Pigeon, Golden-shouldered Parrot and Hooded Parrot - is probably related to the changed fire regime and associated grazing pressure." After habitat destruction (by over-grazing and conversion of grasslands to agriculture) "fire is undoubtedly the next most significant threat". In tropical savannas, fire effects are poorly understood, but changed phenology or floristics have probably affected some birds. In some central and southern grasslands, a decrease in fire frequency (but increase in intensity) "has had an equally destructive effect".

Fitzherbert, K., McLaughlin, J., & Baker-Gabb, D. (1992). *Black-eared Miner Manorina melanotis*. Department of Conservation and Environment.
Black-eared Miner; threatened species; mallee; management; wildfire.
Bioregion: Murray-Darling Depression
Reviews information on the species. Black-eared Miners inhabit areas that have not been burnt for more than 60 years, a limited and declining habitat. Suppression of wildfires and reduction in fire frequency will assist this species.

Ford, H. A. (1989). *Ecology of birds: an Australian perspective*. Chipping Norton: Surrey Beatty.
review; eucalypt open forest; Ground Parrot; heath
Includes a brief review of the effect of fires in eucalypt forest. Changes are not dramatic and, except after severe or extensive fire, the bird assemblage will have recovered its original composition within 1-2 years post-fire. Ground Parrot cannot survive in habitat where fires occur at intervals of less than every few years or greater than 20 years.

Forshaw, J. M. (1981). *Australian Parrots*. Melbourne: Lansdowne Press.
review; Golden-shouldered Parrot; Ground Parrot; Scarlet-chested Parrot; tropical eucalypt open forest; heath; mallee; hummock grassland; threatened species
Fire regime is contributing to the decline of Golden-shouldered Parrot. The Ground Parrot is dependent on a regime of mosaic burning at 8-10 year intervals. Scarlet-chested Parrot is associated with recently-burnt mallee with hummock grass.

Fowler, S. (1945). The fire on Mondrain Island. *Emu*, 44, 334-335.
seabirds; tussock grassland; heath; mortality
Bioregion: Esperance Plains
Deliberately lit fire burnt 60% of Mondrain Island, leading to seabird deaths.

Fox, A. (1978). The '72 fire of Nadgee Nature Reserve. *Parks & Wildlife*, 2, 5-24.
heath; eucalypt open forest; mortality; wildfire
Bioregion: South East Corner
After fire, 609 birds were found dead on beach. Most (89%) came from a backburn area rather than from the original fire. 49 bird species were recorded as killed: the most common dead birds were Little Wattlebird and New Holland Honeyeater.

Frith, H. J. (1962). Conservation of the Mallee-fowl (*Leipoa ocellata*, Gould). *CSIRO Wildlife Research*, 7, 33-49.
Malleefowl; threatened species; management; mallee.
Bioregion: Murray Darling Depression
Malleefowl requires adequate litter for breeding. This is not available until at least 10-15 years post-fire.

Garnett, S. (1987). Seabird Islands: No. 171. Kusamet Island, Torres Strait, Queensland. *Corella*, 11, 77-78.
seabirds; tussock grassland; thicket; mortality
Bioregion: Cape York Peninsula
The grass on the island is often burnt during October and November which is likely to destroy nests and chicks of the breeding Bridled and Black-naped Terns.

Garnett, S. (1992a). *The action plan for Australian birds*. Canberra: Australian National Parks and Wildlife Service.
review; threatened species; management
Describes the former and current threats to all threatened Australian birds, and research and management requirements. Altered fire regimes are currently threatening 51 taxa (16 confirmed, 35 speculative). Only one other threatening process is affecting more taxa (habitat clearance and fragmentation which affects 54 taxa).

Garnett, S. (1992b). *Threatened and extinct birds of Australia*. Melbourne: Royal Australasian Ornithologists Union.
review; threatened species; management
Reviews (including previously unpublished information) the status of Australian threatened birds. Altered fire regimes are a current confirmed or speculated threat to 51 Australian bird taxa, second only to clearing and fragmentation (affecting 52 taxa). The most serious fire effects are increase in frequency of late dry season fires in tropical woodlands and all fires in the mallee. Discusses the threat of fire (or relationship with fire) for Kangaroo Island Emu, Australasian Bittern (reports desertion of a swamp for 2 years after burning), Red Goshawk, MalleeFowl (habitat should be protected against too frequent burning), Buff-breasted Button-quail (where late dry season fires during the nesting season are regarded as the major threat), Chestnut-backed Button-quail, Painted Button-quail, Black-breasted Button-quail (control burns on rainforest margins at intervals of less than 4 years render the habitat unsuitable), Lewin's Rail, Partridge Pigeon (early dry season fires may destroy the ground nests and eggs), Red-cheeked Parrot (main threat is fire in the late dry season which may destroy nest trees), Eclectus Parrot (nests have been destroyed by management fires), Golden-shouldered Parrot, Partridge Pigeon,

Orange-bellied Parrot, Scarlet-chested Parrot, Ground Parrot (fire continues to be the main threat), Night Parrot, Palm Cockatoo (the hollow trees used for nesting are particularly vulnerable to fire, and many have been destroyed by recent fires, including destruction of eggs and young), Red-tailed Black-cockatoo, Masked Owl, Sooty Owl, Rufous Owl (the hollow trees used for nesting are particularly vulnerable to fire), Rufous Scrub-bird, Noisy Scrub-bird, Purple-crowned Fairy-wren, Southern Emu-wren (where fragmentation exacerbates the threat of fire due to decreased possibility of recolonisation), Mallee Emu-wren, Striated Grass-wren (the major threat is extensive fire), Carpentarian Grass-wren, Black-eared Miner, Helmeted Honeyeater, Forty-spotted Pardalote, Rufous Bristlebird, Eastern Bristlebird (the main threat to the species appears to be change in fire regime), Western Bristlebird (fire is the main threat), Brown Thornbill, Slender-billed Thornbill, Northern Scrub-robin (possible extinction of the NT subspecies has been attributed to changed fire regime), Western Whipbird (fire appears to be the main threat), Crested Shrike-tit, Red-lored Whistler (in remnant habitat the effects of fire may be critical), Bassian Thrush and Zitting Cisticola.

Garnett, S., & Bredl, R. (1985). Birds in the vicinity of Edward River Settlement. Part II. Discussion, references, list of passerines. *Sunbird*, 15, 25-40.
tropical eucalypt open forest; tussock grassland; historic change; Star Finch; community; threatened species
Bioregion: Cape York Peninsula
"Hunting, introduction of plants and animals, and burning are the effects of people most likely to be detrimental to the birds of the Edward River area." Grass around the crocodile breeding lagoon is never burnt, and Star Finch is now restricted to this area, suggesting that the prevailing fire regime in the region has become unsuitable for this species.

Garnett, S. T., & Crowley, G. M. (1994). *The ecology and conservation of the Golden-shouldered Parrot*. Cape York Peninsula Land Use Strategy.
Golden-shouldered Parrot; threatened species; management; tropical eucalypt savanna woodlands; tussock grasslands; historic change; control burning
Bioregion: Cape York Peninsula
Fire regimes determine boundaries (and relative extent) of grassland flats and Melaleuca woodlands. Use of fire to control Melaleuca and early wet season burning (to increase food resources) are required to conserve Golden-shouldered Parrots.

Garnett, S., & Crowley, G. (1995a). The decline of the Black Treecreeper *Climacteris picumnus melanota* on Cape York Peninsula. *Emu*, 95, 66-68.
historical change; tropical eucalypt open forest; Black Treecreeper; management
Bioregion: Cape York Peninsula
Marked decline in Black Treecreeper on Cape York Peninsula over the period 1920 to 1995. Principal reason thought to be change in fire regime, with larger hotter fires now. Remnant populations are now mainly in areas with natural fire breaks (rivers etc). Conservation of the species depends upon reintroduction of fine-grained mosaic burning.

Garnett, S., & Crowley, G. (1995b). Feeding ecology of Hooded Parrots *Psephotus dissimilis* during the early wet season. *Emu*, 95, 54-61.
Hooded Parrot; tropical eucalypt open forest; tropical eucalypt savanna woodland
Bioregion: Pine Creek Arnhem
Detailed foraging study of Hooded Parrots. Fire and grazing may affect plant species composition and hence food availability for this species.

Garnett, S., Crowley, G., Duncan, R., Baker, N., & Doherty, P. (1993). Notes on live Night Parrot sightings in north-western Queensland. *Emu*, 93, 292-296.
Night Parrot; tussock grassland; hummock grassland; Spinifex-bird; Rufous-crowned Emu-wren; threatened species
Bioregion: Mt Isa Inlier
Night Parrot may be present in this area due to favourable fire management (small control burns leading to seral mosaic and preventing extensive wildfire). Rufous-crowned Emu-wrens and Spinifex-birds are also favoured by this management, as both prefer spinifex which has remained unburnt for long periods.

Gibbons, P. (1994). Sustaining key old-growth characteristics in native forests used for wood production: retention of trees with hollows. In T. W. Norton & S. R. Dovers (Eds.), *Ecology and sustainability of southern temperate ecosystems* (pp. 59-84). Canberra: CSIRO.
forestry; old-growth; hollows; management; review; eucalypt open forest
Reviews use of hollows by birds (and other fauna); hollow-formation; relationship between fire (and forestry operations) and hollow formation.

Gibson, D. F. (1986). *A biological survey of the Tanami Desert in the Northern Territory*. Conservation Commission of the Northern Territory.
hummock grassland; Little Button-quail; Richard's Pipit; Rufous-crowned Emu-wren
Bioregion: Tanami
Little Button-quail and Richard's Pipit occur mostly in recently burnt country. Rufous-crowned Emu-wren is particularly common in long-unburnt hummock grass.

Gill, A. M. (1990). Fire management of mallee lands for species conservation. In J. C. Noble, P. J. Joss, & G. K. Jones (Eds.), *The mallee lands: a conservation perspective* (pp. 202-205). Melbourne: CSIRO.
mallee
Bioregion: Murray Darling Depression
Describes characteristics of mallee fires. Species such as Malleefowl and Mallee Emu-wren are threatened by high frequency of fires.

Gill, A. M. (1996). How fires affect biodiversity. In DEST (Ed.), *Fire and biodiversity: the effects and effectiveness of fire management. Proceedings of the conference held 8-9 October 1994, Footscray, Melbourne* (pp. 47-55 (&123-124)). Canberra: Department of the Environment, Sports and Territories.
Ground Parrot; Mistletoebird; threatened species; heath; eucalypt open forest
Description of some impacts upon biodiversity of a range of fire regimes. Hot fires in open forests may eliminate mistletoe (and hence lead to decline in mistletoebirds). Briefly reviews Queensland and Victorian studies of Ground Parrot response to fire, noting that associations with vegetation age of graminoid heaths seem to be related to different responses of shrubs and sedges to fire. Differences between Queensland and Victoria in preferred ages may be due to faster processes in the north. Hence, it is misleading to extrapolate results to different areas or habitats.

Green, R. H. (1982). The activity and movement of fauna in compartment 2, Maggs Mountain, Tasmania, in the first five years of forest regeneration. *Records of the Queen Victoria Museum*, 75, 1-31.
forestry; eucalypt open forest; succession; control burning
Bioregion: Ben Lomond
Mainly concerned with recovery of bird populations after intensive logging, but considers interaction with burning.

Green, R. H., & McGarvie, A. M. (1971). The birds of King Island. *Records of the Queen Victoria Museum*, 40, 1-42.
historic change; wildfire; Glossy Black-Cockatoo; Forty-spotted Pardalote; eucalypt open forest; Casuarina woodland; threatened species
Bioregion: Woolnorth
Clearing for agriculture and wildfire (especially major fires around 1920) led to the extinction on King Island of Glossy Black-Cockatoo and Forty-spotted Pardalote, as well as decline in other species.

Hadlington, P., & Hoschke, F. (1959). Observations on the ecology of the phasmatid *Ctenomorphodes tessulata* (Gray). *Proceedings of the Linnaean Society of New South Wales*, 84, 146-159.
eucalypt open forest; management
Bioregion: South Eastern Highlands
While some fire regimes may decrease the abundance of phasmatids, others may lead to increases, presumably because they decrease the number of egg parasites or the abundance (or predation pressure) of predatory birds.

Harrington, G. N., & Sanderson, K. D. (1994). Recent contraction of wet sclerophyll forest in the wet tropics of Queensland due to invasion by rainforest. *Pacific Conservation Biology*, 1, 319-327.
tropical eucalypt open forest; management; rainforest.
Bioregion: Wet Tropics

Fire suppression has led to contraction of ecotonal wet sclerophyll forests at the expense of expanding rainforest. The eucalypt forests are important for isolated populations of Eastern Yellow Robin, Yellow Thornbill, Buff-rumped Thornbill, Crested Shrike-tit, White-naped Honeyeater and Yellow-faced Honeyeater, and these populations may require the establishment of a more frequent burning regime.

Haynes, C. D. (1985). The pattern and ecology of *munwag*: traditional Aboriginal fire regimes in north-central Arnhemland. *Proceedings of the Ecological Society of Australia*, 13, 203-214.
Hooded Parrot; tropical eucalypt open forest
Bioregions: Top End Coastal, Pine Creek Arnhem.
Changes from Aboriginal fire regimes may be implicated in the decline of Hooded Parrot and some grass finches.

Hemsley, J. H. (1967). *Bushfire - S.E. Tasmania 7th February, 1967. Some aspects of the fire in relation to animal and plant life*. Tasmanian Forestry Commission.
wildfire; mortality
Bioregions: Freycinet, D'Entrecasteaux, Tasmanian Midlands
931 birds of 60 species were found dead on beaches adjacent to areas burnt by wildfire. 25 species were recorded from burnt area during the first two months after the fire.

Hewish, M. (1983). The effect of a wildfire on birdlife in a eucalypt forest: a preliminary report on the Lerdederg Gorge seven weeks after the Wombat State Forest fire. *Geelong Naturalist*, 20, 3-16.
eucalypt open forest; wildfire; community; succession
Bioregion: Victorian Midlands
Censuses in open forest before, 3 weeks and 7 weeks after severe bushfire, including some census points that were unburnt and others that were burnt only mildly. The fire caused an immediate reduction in bird species diversity (25-26 species pre-fire falling to 19-20 species post-fire). Unburnt sites maintained species richness. Mildly burnt sites were intermediate in richness. Some species (Eastern Yellow Robin, Grey Shrike-thrush, Superb Fairy-wren, White-browed Scrubwren, White-throated Treecreeper) were more common (or more obvious) in burnt areas. Four of these species are insectivorous ground-feeders. Recolonisation of burnt areas occurred very quickly, even before the smoke had cleared. Previously common species which were rarer or absent in burnt areas included Golden Whistler, Rufous Whistler, Grey Fantail, Yellow-faced Honeyeater, Yellow-tufted Honeyeater, Spotted Pardalote and Striated Pardalote, though Rufous Whistler and Yelow-faced Honeyeater may have migrated from the area. Most of these species forage in shrubs or canopy, most of which was destroyed in the fire.

Hodgson, A., & Heislers, A. (1972). *Some aspects of the role of forest fire in South-eastern Australia*. Forests Commission, Victoria.
eucalypt open forest; review
Few birds are killed directly in fuel reduction fires. Lyrebirds recolonised forest within 2 years of an extensive wildfire. Frequent burning of forests may favour species which forage in open ground (e.g. Spotted Quail-thrush, Buff-rumped Thornbill) but disadvantage those using shrubs (e.g. White-browed Scrubwren, Brown Thornbill) or eating Acacia seeds (Common Bronzewing).

Holmes, G. (1988). *Eastern Bristlebird: summary conservation statement for northern populations*. QNPWS.
Eastern Bristlebird; threatened species
Bioregion: NSW North Coast
Inappropriate fire regimes threaten Eastern Bristlebird.

Holmes, G. (1989). *Eastern Bristlebird. Species management plan for northern populations*. Queensland NPWS and NSW NPWS.
Eastern Bristlebird; rainforest; eucalypt open forest; threatened species; management.
Bioregions: South Eastern Queensland; NSW North Coast.
Eastern Bristlebird in northern NSW and southeastern Queensland uses ecotones between rainforest and open forest. Suitability is determined by time since fire. Fire management is required.

Hood, J. B. (1941). Birds and bushfires. *South Australian Ornithologist*, 15, 125-127.
mortality; wildfire.
Bioregion: Naracoorte Coastal Plain
Effects of wildfire on birds depend on weather conditions. In relatively mild fires, some species (e.g. Fork-tailed Swift, Australian Raven) are attracted to fire fronts to feed on disturbed or dead insects. In very hot fires (such as the extensive wildfire of 1939), few birds were observed to survive. Species noted to have been killed included Emu, Stubble Quail, Masked Lapwing, Bush Stone-curlew, Sulphur-crested Cockatoo, Long-billed Corella, Eastern Rosella, Crimson Rosella, Red-rumped Parrot, Wedge-tailed Eagle, Australian Magpie, ravens and Laughing Kookaburra. "As the terrific blast of fire swept along, birds could be seen rising from the ground or leaving the trees in front of it only to be overpowered by the dense smoke and rising scorching heat. In all cases the birds fell exhausted into the flames".

Hopkins, A. J. M. (1985). Planning the use of fire on conservation lands in south-western Australia. In J. R. Ford (Ed.), *Fire ecology and management in Western Australian ecosystems* (pp. 203-208). Perth: Western Australian Institute of Technology.
review; Noisy Scrub-bird; management; Western Whipbird; Western Bristlebird; heath; thicket; eucalypt open forest; threatened species
Bioregion: Jarrah Forest
Outlines a fire management plan for Two Peoples Bay Nature Reserve, with major aims to conserve Noisy Scrub-bird, Western Whipbird and Western Bristlebird

Hopkins, A. J. M., & Smith, G. T. (1996). Fire: effects and management implications. In A. J. M. Hopkins & G. T. Smith (Eds.), *The natural history of Two Peoples Bay Nature Reserve* Perth: Department of Conservation and Land Management (CALMScience Supplement).
heath; threatened species; thicket; eucalypt open forest; succession
Bioregion: Jarrah Forest
Following fire in dense closed heath, Richard's Pipit initially colonised (to maximum density at 2 years post-fire) then declined to absence at 6 years post-fire. Striated Fieldwren increased post-fire to replace Pipits. As the regrowth heath proceeded from open to closed the Heath-wren was replaced by Western Bristlebird (this change may be delayed by macropod grazing). Three congeneric honeyeaters showed contrasting post-fire responses. Tawny-crowned Honeyeater was recorded 1 year post-fire and peaked at 3 years post-fire then declined to reach the unburnt heath abundance at 6 years post-fire. White-cheeked Honeyeater was first recorded 3 years post-fire, and remained at low levels for the next 3 years. New Holland Honeyaeter was not recorded until 6 years post-fire.

How, R. A., Dell, J., & Humphreys, W. F. (1987). The ground vertebrate fauna of coastal areas between Busselton and Albany, Western Australia. *Records of the Western Australian Museum*, 13, 553-574.
heath; historic change; eucalypt open forest; Malleefowl; Western Whipbird; Rufous Bristlebird; Noisy Scrub-bird; threatened species
Bioregion: Warren
Decline over this century in several birds in the Warren district was due to changes in fire regime, particularly affecting heath. Species which declined as a result included Malleefowl, Western Whipbird, Rufous Bristlebird and Noisy Scrub-bird.

Hughes, P., & Hughes, B. (1991). Notes on the Black-breasted Button-quail at Widgee, Queensland. *Australian Bird Watcher*, 14, 113-118.
Black-breasted Button-quail; eucalypt open forest; rainforest
Bioregion: South eastern Queensland
The Black-breasted Button-quail is dependent on deep leaf-litter, and occurs in vine thickets and adjacent scrubby eucalypt open forest. The widespread practice of frequent burning may be detrimental to it. It can recover with absence of fire, and fire exclusion is recommended.

Hull, A. F. B. (1922). A visit to the Archipelago of the Recherche S.W. Australia. *Emu*, 21, 277-289.
seabirds; mortality; tussock grassland; heath
Bioregion: Esperance Plains
Noted repeated intense deliberate burns: "so many times have fires been put through the scrub that only possibly birds such as the Mutton Bird could survive".

Hunt, T. J., & Kenyon, R. F. (1970). The rediscovery of the Mallee Whipbird in Victoria. *Australian Bird Watcher*, 3, 222-226.
Western Whipbird; mallee; heath; threatened species.
Bioregion: Murray Darling Depression
Western Whipbirds may have left parts of the Big Desert and Sunset Country this century because the vegetation was too old (and hence understorey too open). Recorded here in 9 year old regrowth. Fires about a decade previously suggest that many areas would now be suitable. A previous record of this species was in "recently burnt" vegetation, though there are also records from more mature regrowth.

Hutchins, B. R. (1988). Black Honeyeaters feeding among charcoal and ash. *South Australian Ornithologist*, 30, 160.
charcoal; Black Honeyeater
A number of Black Honeyeaters visited old campfires and fed on charcoal and ash. As the birds included males, the explanation that ash was eaten to provide calcium for egg-laying is insufficient.

Jones, R. (1980). Hunters in the Australian coastal savanna. In D. R. Harris (Ed.), *Human Ecology in Savanna Environments* London: Academic Press.
Aboriginal knowledge; Aboriginal burning; tussock grasslands; management; wetlands
Bioregion: Top End Coastal
Describes the traditional use of fire for hunting and other resource management, including burning of floodplains to maintain waterfowl populations.

Jordan, R. (1984a). The Eastern Bristlebird. Effects of fire on a population. *RAOU Report*, 11, 30.
Eastern Bristlebird; threatened species; heath; wildfire
Bioregion: South East Corner
Before a wildfire in coastal heathlands, Eastern Bristlebirds were common. Following fire, no birds were detected for 2 months. Population numbers then built up to approach pre-fire levels at 2 years post-fire. All were occupying patches of relatively dense regrowth.

Jordan, R. (1984b). The Ground Parrot - Effect of fire on a population. *RAOU Report*, 11, 28-29.
Ground Parrot; threatened species; heath; wildfire
Bioregion: South East Corner
Populations in 5yr. post-fire coastal heath were c. 0.2birds/ha. For c10 months after wildfire, no Ground Parrots were recorded. Then birds became resident: these were most probably immatures.

Jordan, R. (1987a). The Barren Grounds rolling bird survey. *RAOU Report*, 27, 15-18.
heath; eucalypt woodland; wildfire; community
Bioregion: South East Corner
Four year survey of heathland with some woodland following fire. Four species (Grey Shrike-thrush, Crimson Rosella, Brown Thornbill, Rufous Whistler) showed no change. Four species (Golden Whistler, Flame Robin, Australian Magpie, Australian Raven) showed immediate post-fire increase, followed by decline. Four species (White-browed Scrubwren, Beautiful Firetail, White-eared Honeyeater, Eastern Spinebill) showed post-fire decline followed by increase. Two species (Southern Emu-wren, Tawny-crowned Honeyeater) showed post-fire population explosion (1-2 years post-fire) then decline.

Jordan, R. (1987b). The Ground Parrot in Barren Grounds Nature Reserve. *RAOU Report*, 27, 19-23.
Ground Parrot; heath; threatened species
Bioregion: South East Corner
Population density of Ground Parrots reaches a peak at 4-8 years post-fire in heathland, then declines to virtually absent by 12 years post-fire.

Jordan, R. (1987c). The Southern Emu-wren in Barren Grounds. *RAOU Report*, 27, 24.
Southern Emu-wren; heath; wildfire
Bioregion: South East Corner
Following fire in coastal heathland, a few emu-wrens moved in during the first year, but recolonisation became rapid after about 12 months. Birds were presumably moving in from unburnt patches (mostly within 100m.). Then recruitment was rapid, in response to large post-fire increases in insect numbers.

Jordan, R. (1988). Population changes of some common insectivore species in woodland near the wardens house. *RAOU Report*, 51, 16-18.
eucalypt woodland; wildfire; community
Bioregion: South East Corner
Relatively small changes in abundance that could be attributable to wildfire (based on banding results before and up to five years post-fire) in coastal woodland. Brown Thornbill and White-bowed Scrubwren showed short-term increases, possibly due to increased numbers of insects. No change for Striated Thornbill, which foraged in the canopy (which remained relatively unaffected by fire). Eastern Yellow Robin declined for several years post-fire possibly because of the increased density of ground-layer vegetation. Eastern Spinebill increased for several years post-fire, possibly because of increased nectar availability.

Joseph, L. (1982). The Glossy Black-cockatoo on Kangaroo Island. *Emu*, 82, 46-49.
Glossy Black-cockatoo; Casuarina woodland; eucalypt open forest; threatened species
Bioregion: Lofty Block
Glossy Black-cockatoo is dependent on Casuarina seeds and prefers to feed in taller, mature trees. Areas burnt 22 and 11 years prior to this survey were still unsuitable for Glossy Black-cockatoos.

Joseph, L., Emison, W. B., & Bren, W. M. (1991). Critical assessment of the conservation status of Red-tailed Black-Cockatoos in south-eastern Australia with special reference to nesting requirements. *Emu*, 91, 46-50.
Red-tailed Black-Cockatoo; hollows; eucalypt open forest; management
Bioregions: Murray Darling-Depression; Victorian Midlands
Feeding habitat (Eucalyptus baxteri open forests) of Red-tailed Black-cockatoos in this area is threatened by fuel-reduction burning. Nesting trees are being lost by lack of regeneration and clearing (including for firewood).

Kavanagh, R. P. (1990). *Survey of Powerful and Sooty Owls in south-eastern New South Wales*. Final report (Project 120). World Wildlife Fund (Australia).
Sooty Owl; Powerful Owl; eucalypt open forest; rainforest; old-growth; forestry; hollows; management; threatened species
Bioregions: South East Corner; South Eastern Highlands.
Powerful Owl requires old-growth forests (across a broad floristic range); Sooty Owl requires old-growth forest, especially where there are rainforest elements in the understorey. Too frequent fire or logging will seriously disadvantage these species.

Kavanagh, R. P. (1991). The target species approach to wildlife management: gliders and owls in the forests of southeastern New South Wales. In D. Lunney (Ed.), *Conservation of Australia's forest fauna* (pp. 377-383). Mosman: Royal Zoological Society of NSW.
hollows; Sooty Owl; Powerful Owl; eucalypt open forest; forestry; management; old-growth; threatened species
Bioregions: South East Corner; South Eastern Highlands
Sooty Owls and Powerful Owls are associated with old-growth forests, and provide good indicators for conservation planning.

Kimber, P. C. (1974). Some effects of prescribed burning on Jarrah Forest birds. In *Third Fire Ecology Symposium* (pp. 49-57). Melbourne: Forests Commission, Victoria.
eucalypt open forest; control burning; community; succession
Bioregion: Jarrah Forest
Short-term effects of (hot) control fire were limited, with slight reduction in the number of birds immediately following fire and extending to the first spring after fire. After 2 years numbers increased to 25% above pre-fire levels. The greatest increase was for species occurring in low to mid canopy levels (Western Gerygone, Brown-headed Honeyeater, White-naped Honeyeater, Grey Shrike-thrush, Inland Thornbill, Western Thornbill, Golden Whistler). Bird populations in a forest which had been unburnt for 40 years were appreciably less than in regularly burnt forests. This is so particularly for species occurring in understorey and lower canopies (e.g. Rufous Treecreeper, Western Yellow Robin, Western Spinebill, Golden Whistler, Brown Thornbill).

King, B., & King, D. (1983). Moggs Creek: Ash Wednesday plus nineteen days. *Geelong Naturalist*, 20, 19-21.
eucalypt open forest; wildfire
Bioregion: South east Coastal Plain
General notes on a brief visit to an intensively-burnt open forest at 19 days following fire. The only birds seen were a single Black-faced Cuckoo-shrike, a woodswallow, Australian Raven and Australian Magpie.

King, B. R., Limpus, C. J., & Walker, T. A. (1991). Seabird islands: No. 210. Fife Island, Great Barrier Reef, Queensland. *Corella*, 15, 59-61.
seabirds; tussock grassland
Bioregion: Cape York Peninsula
Several fires have been recorded from the island, affecting nesting seabirds.

King, D. F. (1987). Further fauna surveys at Moggs Creek - post Ash Wednesday wildfire. *Geelong Naturalist*, 23, 81-84.
eucalypt open forest; wildfire; community
Bioregion: South east Coastal Plain
List of bird species recorded during one visit three years post-fire. Part of ongoing survey (see Dedman 1984).

Lane, S. G. (1976). Seabird islands: No. 18. Broughton Island, New South Wales. *Australian Bird Bander*, 14, 10-13.
seabirds; tussock grassland; mortality
Bioregion: NSW North Coast
Fishermen frequently set fire to the grasslands on this island. Burning may have interfered with the breeding storm-petrels, but apparently not with shearwaters (which nest in deep burrows). Burnt areas may assist the shearwaters taking off or landing.

Lane, S. G. (1982). Seabird Islands: No. 119. Frederick Island, Archipelago of the Recherche, Western Australia. *Corella*, 6, 61-62.
seabirds; heath; tussock grassland
Bioregion: Esperance Plains
Much of the vegetation was extensively burnt by fire, probably in the year preceding this report. If this fire occurred during the breeding season it would probably have destroyed many nesting birds.

Lewis, H. T. (1989). Ecological and technological knowledge of fire: Aborigines versus park rangers in northern Australia. *American Anthropologist*, 91, 940-961.
Aboriginal knowledge; Aboriginal burning; management; tussock grasslands; review; historic change; Magpie Goose; wetlands
Bioregion: Top End Coastal
Reviews burning practices of Aboriginal people and park rangers. Aboriginal people note that burning is important for Magpie Geese (and other waterfowl), as they prefer to feed in burnt areas around their nest sites. Last fires of the year in floodplains are always set before waterfowl begin to nest.

Lindenmayer, D. B., Norton, T. W., & Tanton, M. T. (1990). Differences between wildfire and clearfelling on the structure of montane ash forests of Victoria and their implications for fauna dependent on tree hollows. *Australian Forestry*, 53, 61-68.
hollows; forestry; review
Bioregion: South Eastern Highlands
Fire and clearfelling affect hollow availability very differently (age range of trees, spatial patterning, abundance and longevity of hollow-bearing trees), and hollow-nesting birds (such as owls and cockatoos) are more affected by clearfelling than by fire.

Lord, E. A. R. (1936). Notes on swifts. *Emu*, 35, 216-218.
White-throated Needletail; wildfire
White-throated Needletail (=Spine-tailed Swift) feeds on insects in smoke over bushfires. Flocks of swifts followed fires for several days.

Loyn, R. H. (1985a). Bird populations in successional forests of Mountain Ash *Eucalyptus regnans* in central Victoria. *Emu*, 85, 213-230.
eucalypt open forest; wildfire; hollows; forestry; succession; management
Bioregion: South Eastern Highlands
Mountain Ash forests are rarely dry enough to burn, but when they do, trees are killed over extensive areas. Little regeneration occurs naturally in absence of fire. Bird abundance was estimated at a series of sites of varying age since fire (including 39, 73, 90 and 223 years post-fire)

or logging. Young regrowth (after clear-felling) had a very different bird fauna to mature forests, including many species typical of open areas (e.g. Nankeen Kestrel, Richard's Pipit, Australian Magpie, Blue-winged Parrot, Flame Robin) or low shrubbery (Superb Fairy-wren, Red-browed Finch). The bird species composition changed little between 50 to about 200 years post-fire. The abundance of some birds that were associated with particular plants (e.g. Correa lawrenciana, Acacia dealbata) changed with the successional increase and then decrease of these. Hole-nesting birds were more abundant in forests >100 years than 39-80 years, although dead trees left after the 1939 fire offered a reasonable number of hollows. A few species were largely restricted to forests >200 years. These included Powerful Owl, Sooty Owl, Australian Owlet-Nightjar and Sulphur-crested Cockatoo (all hollow-nesters), Mistletoebird, Australian King-Parrot, Lewin's Honeyeater and Satin Bowerbird (all at least partial fruit-eaters) and Varied Sittella. The immediate effects on birds of wildfire in Mountain Ash forests must be profound. After the 1939 fires, flocks of Gang-gang Cockatoos were reported from many suburban areas from which they were normally absent.

Loyn, R. H. (1985b). Ecology, distribution and density of birds in Victorian forests. In A. Keast, H. F. Recher, H. Ford, & D. Saunders (Eds.), *Birds of eucalypt forests and woodlands: ecology, conservation, management* (pp. 33-46). Chipping Norton: Surrey Beatty.

eucalypt open forest; community; hollows

Bioregions: South east Coastal Plain; South Eastern Highlands; Australian Alps; Victorian Midlands; Riverina

Discusses effects of fire in a range of forests in southeastern Australia. Compares densities of hole-nesting birds in a range of mature and regrowth forests. Highest proportion of hollow-nesters is in mature River Red Gum forests. Mistletoe is more common in older forests (and hence density of Mistletoebirds is greater). Some honeyeaters, foliage-gleaning insectivores and bark-foraging birds are more common in mature than in regrowth forests. In mixed foothill forests, birds that feed from bare open ground (e.g. Scarlet Robin, Buff-rumped Thornbill, Spotted Quail-thrush, White-throated Nightjar, Painted Button-quail) are more common on ridges than in gullies and in more recently burnt areas. In Mountain Ash forests, a few open-country birds (Richard's Pipit, Nankeen Kestrel, Blue-winged Parrot) occur for about 3 years post-fire, but regeneration is rapid and regrowth is soon colonised by bird species typical of the understorey of mature forests.

Loyn, R. H. (1987). Effects of patch area and habitat on bird abundances, species numbers and tree health in fragmented Victorian forests. In D. A. Saunders, G. W. Arnold, A. A. Burbidge, & A. J. M. Hopkins (Eds.), *Nature conservation: the role of remnants of native vegetation* (pp. 65-77). Chipping Norton: Surrey Beatty.

eucalypt open forest; community; isolate

Bioregion: South east Coastal Plain

Bird assemblages were recorded from 56 forest fragments, and the distribution of individual species, and assemblage parameters, were related to a number of environmental factors (including fire history). Patch size, grazing history and presence of Noisy Miners accounted for most variation: fire history was not strongly correlated with assemblage parameters, but this was possibly because fire history showed little variation between patches.

Loyn, R. H., Traill, B. J., & Triggs, B. E. (1986). Prey of Sooty Owls in East Gippsland before and after fire. *Victorian Naturalist*, 103, 147-149.

Sooty Owl; threatened species; rainforest; eucalypt open forest

Bioregion: South East Corner

Diet of Sooty Owl was restricted 4 months after fire to one terrestrial rodent species, in contrast to varied diet pre-fire. Owls were observed in burnt forests, and contraction in diet may have been due to greater ease of catching rats in burnt areas.

Loyn, R. H., Cameron, D. G., Traill, B. J., Sloan, J. F., Malone, B. S., Schulz, M., Earl, G. E., & Triggs, B. E. (1992a). *Flora and fauna of the Cooaggalah Forest Block, East Gippsland, Victoria. Ecological Survey Report 20*. Department of Conservation and Environment.
wildfire; eucalypt open forest; rainforest; community.
Bioregion: South East Corner
A very intense bushfire burnt the study area during survey. The fire had burnt especially fiercely in some rainforest gully vegetation. Sampling continued 1-4 months, 1 year and 2 years post-fire. In the 1-4 months post-fire, bird numbers were reduced to 57% of pre-fire levels. Honeyeaters departed, and little food remained for them. Numbers of granivorous and frugivorous birds were also greatly reduced. Bark-foraging and ground-foraging (e.g. Superb Lyrebird, which were observed to forage in ash) birds showed little change, and some carnivorus birds and Flame and Scarlet Robins increased. Treecreepers and Laughing Kookaburra were the only conspicuous birds in heavily-burnt stands. Pre-fire abundance was reached 2 years post-fire, and marginally exceeded at 3 years post-fire, though some honeyeaters (e.g. Crescent and New Holland Honeyeaters) and Beautiful Firetail were still well below pre-fire levels. Most localised species (e.g. Southern Emu-wren, Beautiful Firetail) had returned to the sites that they had occupied pre-fire.

Loyn, R. H., Hewish, M. J., & Considine, M. (1992b). Short-term effects of fuel reduction burning on bird populations in Wombat State Forest. In K. Tolhurst & D. Flinn (Eds.), *Ecological impact of fuel reduction burning in dry sclerophyll forest: first progress report* (pp. 5.1-5.11). Melbourne: Department of Conservation and Environment (Research Report no. 349).
eucalypt open forest; control burning; community
Bioregion: Victorian Midlands
Over 3 years, bird populations were assessed before and after fuel-reduction burns at 3 areas (each with control, spring burn and autumn burn sites) in eucalypt open forest. Scarlet and Flame Robins were substantially more common in autumn-burnt areas. Birds which fed to some extent on bare ground (Laughing Kookaburra, Grey Shrike-thrush, Superb Fairy-wren) generally increased post-fire; those that fed in shrubby understorey (Brown Thornbill, White-browed Scrubwren) generally decreased. Nectarivorous birds (lorikeets and honeyeaters) were more common in burnt areas, attracted to what appeared to be fire-induced high-quality flowering in some eucalypts. Three species which were rarely recorded before fires, became abundant post-fire (Red-browed Finch, White-winged Chough, Pied Currawong). In general, there was little change in total bird richness or abundance, and most individual species showed no significant change. Notes that the study areas were small, and no burnt site was >300m from unburnt forest. Also, the area had relatively few shrubs before burning, so impacts may be more profound in forests of different structure. The study deals with changes over 2 years only, and monitoring is needed to detect longer-term changes.

Lucas, D., & Russell-Smith, J. (1993). *Traditional resources of the South Alligator floodplain: utilisation and management*. Australian Nature Conservation Agency.
wetlands; tussock grasslands; Aboriginal knowledge.
Bioregion: Top End Coastal
Some traditional burning was aimed at increasing the abundance of foodplants for people and important birds (Magpie Goose, Brolga). Early dry season burning had to be undertaken carefully out of consideration for ground-nesting birds, such as Partridge Pigeon.

Lucas, K., & Lucas, D. (1993). *Aboriginal fire management of the Woolwonga wetlands in Kakadu National Park*. Australian Nature Conservation Agency.
wetlands; tussock grasslands; Aboriginal knowledge.
Bioregion: Top End Coastal
The grasslands should be burnt annually at appropriate times of year. One aim of burning is to maintain or increase abundance of wild rice Oryza because it is an important food for Magpie Goose. Prefer not to burn too early in the dry season because some birds (notably Partridge Pigeon, White-throated Grasswren, quails, finches and whistle-ducks) are nesting then on the ground or in grass. Small fires may be relatively safe then, and may prevent very large destructive fires later.

Lyndon, E. (1977). Aftermath of fire at Waratah Bay - and Lyrebirds. *Victorian Naturalist*, 94, 18-19.
Superb Lyrebird; heath; eucalypt open forest
Bioregion: South east Coastal Plain
Anecdotal report of lyrebirds occurring in regrowth 2-3 years post-fire.

MacGillivray, W. D. K. (1910). Along the Great Barrier Reef. *Emu*, 10, 216-233.
seabirds
Bioregion: Cape York Peninsula
Fire reported from Fife Island, killing breeding seabirds.

Main, A. R. (1981). Fire tolerance of heathland animals. In R. L. Specht (Ed.), *Ecosystems of the World. 9B. Heathlands and related shrublands. Analytical studies.* Amsterdam: Elsevier.
review; heath
Birds tend to flee in advance of smoke and flame front, in contrast to mammals, reptiles and amphibians which burrow or re-enter burnt areas through gaps in fire front. Ravens, crows, magpies and currawongs forage in recently burnt areas. Swallows and kestrels may feed in front of the fire.

Marchant, S. (1985). Breeding of the Eastern Yellow Robin. In A. Keast, H. F. Recher, H. Ford, & D. Saunders (Eds.), *Birds of eucalypt forests and woodlands: ecology, conservation, management* (pp. 231-240). Chipping Norton: Surrey Beatty.
Eastern Yellow Robin; eucalypt open forest; eucalypt woodland; wildfire.
Bioregion: South East Corner
An 8 year study of banded population of Eastern Yellow Robin at two plots, both of which were burnt (to various degrees) in the sixth year. Fire had little immediate effect on Robins, with all birds apparently surviving. In the year after fire, nests were generally higher and clutches smaller, but breeding success was similar to pre-fire. At two years post-fire, fewer birds nested and some territories were deserted. This was assumed to be because a dense grass layer had developed which hindered foraging. Fire effects may have been more serious if the fire was during the breeding season.

Matthew, J. (1994). The status, distribution and habitat of the Slender-billed Thornbill *Acanthiza iredalei* in South Australia. *South Australian Ornithologist*, 32, 1-19.
Slender-billed Thornbill; heath; mallee.
Bioregion: Murray Darling Depression
The subspecies of Slender-billed Thornbill occurring in mallee heath (Acanthiza iredalei hedleyi) may be considered vulnerable to fires, but fire is not a threatening process for subspecies occurring in samphire.

Mawson, P. R., & Long, J. L. (1994). Size and age parameters of nest trees used by four species of parrot and one species of cockatoo in south-west Australia. *Emu*, 94, 149-155.
hollows; eucalypt woodland; eucalypt open forest; Regent Parrot; Red-capped Parrot; Western Rosella; Port Lincoln Ringneck; Western Long-billed Corella
Bioregions: Avon Wheatbelt; Jarrah Forest
Hot fires may create, enlarge or destroy hollows. Dimensions of hollows (and size and age of trees) used by Regent Parrot, Red-capped Parrot, Western Rosella, Port Lincoln Ringneck and Western Long-billed Corella are given. Trees used are very old (minimum 73 years, maximum >1300 years). Clearing is main cause of reduction in hollow availability, but frequent burning of roadside verges prevents seedling establishment and hence tree recruitment. In some remnant patches, complete absence of fire may also prevent germination.

McAllan, I. A. W. (1996). The Flock Bronzewing *Phaps histrionica* in New South Wales, with comments on its biology. *Australian Bird Watcher*, 16, 175-204.
Flock Bronzewing; review; tussock grasslands
Bioregions: Mitchell Grass Downs; Channel Country; Darling Riverine Plains; Mulga Lands; Broken Hill Complex
Although exclusion of fire by pastoralists in Mitchell grasslands may have reduced seed availability, this can "be only a minor problem" for Flock Bronzewings.

McCaw, L., Maher, T., & Gillen, K. (1992). *Wildfires in the Fitzgerald River National Park, Western Australia, December 1989*. Department of Conservation and Land Management.
wildfire; mortality
Bioregion: Esperance Plains
The remains of a large number of small birds were found in a woodland burnt by relatively low intensity wildfire. Following a patchy wildfire, unburnt vegetation was important as refuge for less mobile species. Large flocks of granivorous birds were observed well within an extensively-burnt area within days following wildfire.

McCulloch, E. M. (1966). Swifts and bushfires. *Emu*, 65, 290.
White-throated Needletail; Fork-tailed Swift; wildfire
Both White-throated Needletail and Fork-tailed Swifts flocks fed in insects in smoke over bushfires.

McFarland, D. C. (1988). The composition, microhabitat use and response to fire of the avifauna of subtropical heathlands in Coloola National Park, Queensland. *Emu*, 88, 249-257.
heath; community; succession; management
Bioregion: South Eastern Queensland
Bird species composition and richness was determined at sites 0,2.5,5.5,6.5 and 10.5 years post-fire. Older heaths had fewer "inconsistent" species (irregular visitors, migrants, etc.). Post-fire recolonisation depends upon extent and intensity of fire and availability of unburnt patches. Species richness was higher (39 spp.) in the first year after fire than in the oldest site (14 species), although many of the species in the young site were migrants or visitors from nearby habitats. These latter were attracted by post-fire flowering or seeding or exposed and dead invertebrates and vertebrates immediately after fire (e.g. for raptors, Laughing Kookaburra, Torresian Crow, Straw-necked Ibis). Responses to fire age were related to food and shelter. Most structural attributes either peaked or reached a plateau by 3-6 years post-fire. Brown Quail used seeding grasses in open regeneration. King Quail, Brush Bronzewing and Ground Parrot preferred thicker vegetation of middle-aged heathlands (which also held greatest abundance of their seed resources). Swallows, martins and Richard's Pipit preferred open young sites. Tawny Grassbird, Golden-headed Cisticola, Red-backed Fairy-wren and Southern Emu-wren were most abundant in mid to late ages. Pheasant Coucal and Eastern Grass Owl showed no relationships with age. Past practice of burning every c3 years has advantaged opportunistic species, but disadvantaged most of the resident species. Longer intervals between burns (e.g. 7-8 years) and mosaic burns are recommended to maintain resident species.

McFarland, D. C. (1989). *The Ground Parrot Pezoporus wallicus (Kerr) in Queensland: habitat, biology and conservation*. Department of Conservation, Parks & Wildlife, Queensland.
Ground Parrot; threatened species; heath; isolate
Bioregion: South Eastern Queensland
Ground Parrots were most abundant in heaths from 5-8 years post-fire, and are threatened by fire intervals of less than this. This threat is exacerbated by fragmentation.

McFarland, D. C. (1991). The biology of the Ground Parrot, *Pezoporus wallicus*, in Queensland. III. Distribution and abundance. *Wildlife Research*, 18, 199-213.
Ground Parrot; heath; threatened species; sedgeland; isolate
Bioregion: South Eastern Queensland
Describes distribution and habitat preferences for Ground Parrot in subtropical heaths. Although Ground Parrots were recorded at a site 2 months post-fire, they were not recorded regularly until >9 months post-fire. Densities peaked at 5-8 years post-fire, when the number of food plants, and standing crop of food, is maximum, and when these are most stable seasonally. Decline of numbers of Ground Parrots in older heath reflects reduced seed availability. High intensity fires may be more deleterious than fuel-reduction burns. Ground Parrots recolonise rapidly after either summer or winter fires. Increasing heathland isolation increases the possibility of complete burns with catastrophic fire and reduces the chance of recolonisation.

McFarland, D. C. (1992). Fire and the management of ground parrot habitat. In B. R. Roberts (Ed.), *Fire Research in rural Queensland* (pp. 483-495). Toowomba: University of Southern Queensland.
Ground Parrot; heath; management; threatened species
Bioregion: South Eastern Queensland
Densities of the fire-sensitive and fire-dependent Ground Parrots in subtropical heaths peak at 5-8 years post-fire, with no birds recorded at >15 years post-fire. A management plan for Ground Parrots in heathlands of southern Queensland is described: it involves moderate to low intensity burning at 8-10 years during winter. Impacts of this regime on other heathland biota are considered. Of 12 species of breeding resident birds, 7 reach peak densities at or >6 years post-fire.

McFarland, D. C. (1993). Fire and bird conservation. In C. P. Catterall, P. V. Driscoll, K. Hulsman, D. Muir, & A. Taplin (Eds.), *Birds and their habitats: status and conservation in Queensland* (pp. 41-44). St Lucia: Queensland Ornithological Society Inc.
review; Ground Parrot; heath; threatened species; community; management
Bioregion: South Eastern Queensland
In southeastern Queensland, Ground Parrots nest only in dry heaths that are at least 3-4 years post-fire. Fire is the main factor affecting density. Ground Parrots can recolonise burnt heaths within 12 months, densities peak at 5-8 years post-fire, and no birds have been recorded in heaths >15 years post-fire (but few such areas occur or have been searched). This pattern correlates with seed availability and cover. Other declining species in Queensland affected by fire regime include Golden-shouldered Parrot, Eastern Bristlebird, Rufous Scrub-bird, Carpentarian and Striated Grass-wrens. In heathland, raptors, egrets and ibis move in during and just after fires. Within 1 year of fire, there is usually massive flowering of Xanthorrhoea, which attracts many honeyeaters. Granivores colonise somewhat later. The total number of species is highest within 1 year post-fire, but then declines. The number of breeding species peaks between 3-8 years post-fire, followed by decline, especially for granivorous species.

Controlling fire to benefit one bird species may have deleterious impact on other species. In heathlands of southeastern Queensland, mosaic winter burning at intervals of 8-10 years is recommended.

McFarland, D. C. (1994). Notes on the Brush Bronzewing *Phaps elegans* and Southern Emu-wren *Stipiturus malachurus* in Cooloola National Park. *Sunbird*, 24, 14-17.
heath; Brush Bronzewing; Southern Emu-wren; isolate
Bioregion: South Eastern Queensland
Heaths of 0-10.5 years post-fire were searched. No Brush Bronzewings were recorded from heaths younger than 2 years or older than 10.5 years. Southern Emu-wrens occurred in heaths of age 1.5 to 9 years, with highest density in sites of 6-8 years. Fragmentation and generally high past fire frequency may have eliminated Emu-wrens from what now appears suitable heaths.

McIlroy, J. C. (1978). The effects of forestry practices on wildlife in Australia: a review. *Australian Forestry*, 41, 78-94.
review; eucalypt open forest; management; forestry
Most Australian fauna is fire-adapted. High intensity fires and frequent low intensity fires homogenise forests, leading to elimination of species dependent on shrubs, litter and logs. Of 48 bird species in a native forest, 12 occurred following clear-felling. All of these remained after the felled area was burnt.

McKean, J. L., & Martin, K. C. (1985). *Distribution and status of the Carpentarian Grasswren Amytornis dorotheae*. Conservation Commission of the Northern Territory.
Carpentarian Grass-wren; hummock grasslands; management; threatened species
Bioregion: Gulf Fall and Uplands
Hot extensive wildfires are the most serious threat to the Carpentarian Grass-wren.

McKean, J. L., & Martin, K. C. (1989). Distribution and status of the Carpentarian Grass-wren *Amytornis dorotheae*. *Northern Territory Naturalist*, 11, 12-19.
Carpentarian Grass-wren; hummock grassland; management; threatened species
Bioregion: Gulf Fall and Uplands
Extensive wildfires are the most severe threat to Carpentarian Grass-wren, and recent fires have led to its decline and contraction

McLaughlin, J. (1992). The floristic and structural features of Black-eared Miner Manorina melanotis habitat. *RAOU Report No. 84*. Royal Australasian Ornithologists Union.
Black-eared Miner; threatened species; old-growth.
Bioregion: Murray-Darling Depression.
Mallee of at least 55-60 years post-fire is required, with younger mallee possessing few of the structural features (decorticating bark) preferred by this species.

McLaughlin, J. (1994). *Searches for the Black-eared Miner Manorina melanotis in the Victorian Murray Mallee. RAOU Report No. 93*. Royal Australasian Ornithologists Union.
Black-eared Miner; mallee; threatened species
Bioregion: Murray-Darling Depression
The endangered Black-eared Miner is restricted to long-unburnt mallee remote from edges.

McNamara, E. (1946). Field notes on the Eastern Bristlebird. *Emu, 45*, 260-265.
Eastern Bristlebird; heath; threatened species
Bioregion: South East Corner
The causes of the rarity of Eastern Bristlebirds are obscure. Bushfires may be the chief reason, as heaths are vulnerable to fire, and birds would have trouble surviving in burnt areas. But much of the heath where they occur now has been burnt in the past. Unburnt patches may be the key to their survival.

McNee, S. (1986). *Surveys of the Western Whipbird and Western Bristlebird in Western Australia. RAOU Report No. 18*. Royal Australasian Ornithologists Union.
Western Whipbird; Western Bristlebird; heath; mallee; threatened species; management.
Bioregions: Esperance Plains; Warren; Jarrah Forest
The range and abundance of the Western Whipbird and Western Bristlebird have been substantially reduced by clearing and too frequent fires. Management of these species will require long intervals without fire (at least 30 years and preferably 50 years for Western Whipbird). Western Whipbird is known to survive fire, but then not persist in burnt areas.

Menkhorst, P. W., & Bennett, A. F. (1990). Vertebrate fauna of mallee vegetation in southern Victoria. In J. C. Noble, P. J. Joss, & G. K. Jones (Eds.), *The mallee lands: a conservation perspective* (pp. 39-53). Melbourne: CSIRO.
mallee
Bioregion: Murray Darling Depression
Mallee vegetation is highly flammable and for some birds certain seral stages in the post-fire succession offer a higher quality habitat. Species favouring climax vegetation include Black-eared Miner and Malleefowl. Fire management since European settlement has reduced habitat heterogeneity and especially the extent of old-growth mallee. This is especially so in isolated patches which fire can reduce to a single age class.

Meredith, C. W. (1982). The research input to fire management in natural areas with particular reference to wildlife research in the semi-arid lands of Victoria and New South Wales. In A. Heislers, P. Lynch, & B. Walters (Eds.), *Fire ecology in semi-arid lands* (10pp). Deniliquin: CSIRO.
mallee; community; management
Bioregion: Murray Darling Depression
Comprehensive studies are required for input into management, else casual observations and myth substitute for knowledge. Notes that fire regime includes season, intensity, pattern and area affected, as well as frequency; that fire frequency should be a statistical distribution rather than an inflexible repetition of a mid-point; that "optimum" fire regimes vary between species and even between short- and long-term within species; and that unplanned random burning is not the same as mosaic burning. Mallee woodland endemic birds are most common in areas >20-25 years post-fire. Specialist species with restricted distributions tend to be found in older vegetation while widespread generalists are typical of early regeneration. However some specialists may favour early regrowth. While Malleefowl require long period between fires, it may be that very old vegetation has a declining food supply. Shy Heath-wren, Red-lored Whistler, Western Whipbird and Striated Grass-wren may be associated with early stages of regeneration. Research needs include study of fire relationships of other mallee endemic birds, and the effect of fire on hollow formation and seed and nectar production.

Meredith, C. W. (1983). Fire and birds. The result of two studies and their relevance to fuel reduction burning. In E. H. M. Ealey (Eds.), *Fighting fire with fire* (pp. 193-202). Melbourne: Graduate School of Environmental Science Monash University.
mallee; community; Ground Parrot; heath; sedgelands; control burning; threatened species
Considers two examples: bird communities of mallee and Ground Parrot in coastal heathlands. In both habitats, there is little functional difference between wildfire and fuel reduction burns. Burning frequency in mallee of <20-30 years would result in 25% or more reduction in bird species richness. Habitat endemic species would be those most likely to be lost. These include those requiring abundant litter (e.g. Malleefowl), hollows (Chestnut-rumped Thornbill, parrots) or dense large spinifex (Striated Grass-wren, Mallee Emu-wren). Bird numbers may be greatest at about 15 years post-fire. Species common in early regrowth include mainly widespread opportunists (Kestrel, Australian Magpie, White-fronted Honeyeater, some thornbills). Management should concentrate on localised burning at borders. Ground Parrot can survive in sedgelands for indefinite period, but in heathlands it requires fire every 20-25 years. Currently, fuel-reduction burning is too frequent, and may eliminate this species from graminoid heathlands.

Meredith, C. W. (1984a). The Ground Parrot. *RAOU Conservation Statement*, 1.
Ground Parrot; heath; sedgeland; threatened species
Inappropriate fire regimes, compounded by fragmentation of populations, are the main threats to the Ground Parrot

Meredith, C. W. (1984b). *Management of the Ground Parrot Pezoporus wallicus in Victoria*. Fisheries & Wildlife Division, Victoria.
Ground Parrot; heath; sedgelands; threatened species; management
Detailed recommendations for fire management at sites of varying floristics in Victoria, in order to conserve Ground Parrot populations.

Meredith, C. W. (1984c). Recent records of the Ground Parrot *Pezoporus wallicus* in western Victoria. *Geelong Naturalist*, 21, 3-4.
Ground Parrot; heath; threatened species; control burning
Bioregion: South east Coastal Plain
The disappearance of Ground Parrot from some sites was related to old age of the heaths. The low numbers in another site were a result of extensive and frequent fuel reduction burns.

Meredith, C. W. (1988). *Fire in the Victorian environment - a discussion paper.* Conservation Council of Victoria.
review; management
Short-term effects of fire on bird communities vary with fire intensity (and the extent of vegetation change). However if fire regimes lead to long-term change in vegetation characteristics, there will be long-term change in bird communities. If fire frequency is too great, birds dependent on older stages will be lost. These are often specialist species with restricted distributions. Notes that no long-term studies of the relationships between birds and fire have been conducted in any Australian habitat; and that previous studies (e.g. Kimber 1974, Christensen & Kimber 1975) have restricted analysis to common species in the communities they studied.

Meredith, C. W., & Isles, A. C. (1980). *A study of the Ground Parrot (Pezoporus wallicus) in Victoria. report No. 304*. Environmental Studies Division of the Ministry for Conservation, Victoria.
Ground Parrot; heath; threatened species.
Bioregions: South East Corner; South east Coastal Plain; Naracoorte Coastal Plain
Ground Parrot abundance peaks at 5-10 years post-fire; heaths then eventually become unsuitable.

Meredith, C. W., & Jaremovic, R. (1990). *Current status and management of the Ground Parrot in Victoria*. Arthur Rylah Institute for Environmental Research.
Ground Parrot; heath; wildfire; control burning; threatened species; management
Bioregions: South East Corner; South east Coastal Plain
Hot fire in a coastal heathland reduced the Ground Parrot population at this site by 75%. Elsewhere, widespread and frequent fuel-reduction burns in heathland led to substantial and lasting reductions in Ground Parrot densities. A model is developed to predict population changes post fire, and hence to design management burning regimes.

Meredith, C. W., Gilmore, A. M., & Isles, A. C. (1984). The Ground Parrot (*Pezoporus wallicus* Kerr) in south-eastern Australia: a fire-adapted species? *Australian Journal of Ecology*, 9, 367-380.
Ground Parrot; heath; sedgeland
Bioregions: South east Corner; South east Coastal Plain; Naracoorte Coastal Plain.
Examined Ground Parrot abundance at a series of sites of known age since fire. Fire age is the major determinant of abundance in heathlands, mainly through its influence on food resources. The production of seeds eaten by Ground Parrot remains relatively constant over time in sedgelands but varies in heathland with time since burning. Long unburnt (>20 years) and very frequently burnt (<6-8 years) heathlands are unsuitable for Ground Parrot. Fires are uncommon in sedgelands, and Ground Parrots show no relationship with sedgleland age. Ground Parrots may disperse to unusual habitats after fire, and immatures may move long distances. Ground Parrots are not fire-adapted, but rather they are adapted to a diet dominated by the seeds of graminoid sedges. In habitats where the availability of these seeds is unrelated to fire (e.g. sedgelands) Ground Parrot abundance is also unrelated to fire, but in heathlands, the Ground Parrot is a fire-requiring species because of its adaptation to a particular diet.

Milledge, D. R., & Palmer, C. L. (1990). *The Sooty Owl in Mountain Ash forests in the Victorian Central Highlands*. Department of Conservation and Environment.
Sooty Owl; hollows; eucalypt open forest; old-growth; management; threatened species
Bioregion: South Eastern Highlands
Sooty Owls are virtually confined to forests that are at least 150 years old, because of requirements for high density of hollows (for their own nesting and that of their prey).

Milledge, D. R., Palmer, C. L., & Nelson, J. L. (1991). "Barometers of change": the distribution of large owls and gliders in Mountain Ash forests of the Victorian Central Highlands and their potential as management indicators. In D. Lunney (Ed.), *Conservation of Australia's Forest Fauna* (pp. 53-65). Sydney: Royal Zoological Society of NSW.
eucalypt open forest; old-growth; hollows; threatened species
Bioregion: South Eastern Highlands
Survey of owls at four age classes (50 to >250 years). Sooty Owl was associated with large areas of old-growth (>250 years) forest, though did occur in 50-80 year forests (where fire-killed stags remained).

Milligan, A. W. (1904). Notes on a trip to the Wongan Hills, Western Australia. *Emu*, 4, 2-11.
Western Whipbird; threatened species; heath.
Bioregion: Avon Wheatbelt
Repeated fires probably led to the disappearance of Western Whipbirds from the Wongan Hills area.

Mollison, B. C., & Green, R. H. (1962). Mist-netting Tree-Martins on charcoal patches. *Emu*, 61, 277-280.
Tree Martin; charcoal
Tree Martins observed to collect and maybe consume charcoal and ash.

Morton, S. R., & Brennan, K. G. (1991). Birds. In C. D. Haynes, M. G. Ridpath, & M. A. J. Williams (Eds.), *Monsoonal Australia: landscape, ecology and man in the northern lowlands.* (pp. 133-149). Rotterdam: Balkema.
review; tropical eucalypt open forest; management
Little doubt that changed fire regimes have affected birds. If current burning regimes have higher frequency of late dry season hot fires (as is likely) then birds associated with shrubby understorey may have declined considerably. Research into the management of fire for birds needs high priority.

Nelson, J. L., & Morris, B. J. (1994). Nesting requirements of the Yellow-tailed Black-cockatoo, *Calyptorhynchus funereus*, in *Eucalyptus regnans* forest, and implications for forest management. *Wildlife Research*, 21, 267-278.
Yellow-tailed Black-cockatoo; hollows; management
Bioregion: South eastern Highlands
The mean estimated age of trees used for nesting by Yellow-tailed Black-cockatoos was 221 years (with youngest at 162 years). Live trees are better nesting sites than dead stags as they are better able to withstand fire.

Newsome, A. E., McIlroy, J., & Catling, P. (1975). The effects of extensive wildfire on populations of twenty ground vertebrates in south-east Australia. *Proceedings of the Ecological Society of Australia*, 9, 107-123.
wildfire; heath; eucalypt open forest
Bioregion: South East Corner
Tracks of large vertebrates were counted before and after an extensive hot wildfire. No changes were detected for Superb Lyrebird (the only bird considered), though there were few records to compare. Fire may reset fauna succession in dry sclerophyll forests, but "it is too early to think of utilising fire as a tool for management of fauna in National Parks". Wildfire is not necessarily the bogey widely imagined.

Nichols, O. G., & Muir, B. (1989). Vertebrates of the jarrah forest. In B. Dell, J. J. Havel, & N. Malajczuk (Eds.), *The Jarrah Forest* (pp. 133-153). Dordrecht: Kluwer.
eucalypt open forest; review
Bioregion: Jarrah Forest
Understorey birds are affected for 1-2 years by cool burns in Jarrah forests; canopy species show little response. The Jarrah forest fauna is adapted to a great variety of fire regimes, many irregular and unpredictable.

Noske, R. (1988). *The status and biology of the White-throated Grass-wren*. Australian National Parks & Wildlife Service.
White-throated Grasswren; hummock grassland
Bioregion: Pine Creek Arnhem
Fire may decrease some populations of White-throated Grass-wrens, but the status of the species is probably secure. Fires affect populations for two reasons: Grass-wrens rely on living vegetation both directly and indirectly for plant and insect food; and they may be killed by fire because of their ground-dwelling habits and poor flying ability. Fire frequency may be more important than intensity.

Noske, R. A. (1992a). Do Grasswrens have the numbers? Reply to Woinarski (1992). *Northern Territory Naturalist*, 13, 5-8.
White-throated Grasswren; hummock grassland
Bioregion: Pine Creek Arnhem
Most sites where White-throated Grasswrens were recorded had been burnt in the previous few years. "Indeed I was impressed by the ability of Grasswrens to survive in areas of recent severe fires." Long-term absence of fire may be disadvantageous.

Noske, R. A. (1992b). The status and ecology of the White-throated Grasswren *Amytornis woodwardi*. *Emu*, 92, 39-51.
White-throated Grasswren; hummock grassland
Bioregion: Pine Creek Arnhem
Fire is important in the ecology of White-throated Grasswrens, but information on its effects is inconclusive. Regular burning may benefit this species through maintenance of hummock grasslands at the expense of more fire-sensitive plants. The species was recorded across the range of fire ages studied (6 months

post-fire to "many years" post-fire). Fire may have immediate impacts of reduction in food resources and nest sites. Absence from some sites may be due to high frequency of fires. Recent changes in fire regime may suggest that its secure status cannot be assumed.

Paton, J. B., & Paton, D. C. (1977). Seabird Islands: No. 52. Wright Island, South Australia. *Corella*, 1, 68-69.
seabirds
Bioregion: Eyre and Yorke Blocks
A fire lit to control exotic Boxthorn spread through all vegetation. The resultant vegetation loss caused erosion and damage to penguin burrows, and discouraged Silver Gulls from breeding, but probably had little impact on Fairy Terns.

Pattemore, V. (1980). *Effects of the pulpwood industry on wildlife in Tasmania*. National Parks and Wildlife Service, Tasmania.
forestry; management; eucalypt open forest
Mainly concerned with effects of forestry practices, but considers interaction with fire regimes.

Pedler, L. (1991). *Rare bird survey: implications for fire management for Uluru National Park*. Australian National Parks and Wildlife Service.
hummock grassland; mallee; Striated Grasswren; threatened species; management
Bioregion: Great Sandy Desert
Examines distribution of rare bird species around Uluru. Striated Grasswren requires mature spinifex. Recommends a fire management strategy which produces a fine-grained diversity of fire ages in hummock grassland and mallee, and the retention of long-unburnt patches.

Pedler, L., & Burbidge, A. H. (1995). The range and status of the Nullabor Quail-thrush. *South Australian Ornithologist*, 32, 45-52.
Nullabor Quail-thrush; chenopod shrubland; management; threatened species
Bioregion: Nullabor
Fire is a threat to Nullabor Quail-thrush as its preferred bluebush is killed in severe fires, and subsequent regeneration may be affected by herbivore grazing.

Pescott, T. (1983). Beach-washed birds after the Ash Wednesday fire. *Geelong Naturalist*, 20, 17-19.
eucalypt open forest; wildfire; mortality
Bioregion: South east Coastal Plain
Large numbers of bush birds were washed up on the beach following hot fire. The birds generally did not show any signs of having been burnt. A total of 2183 individuals of 66 species were recorded. The most numerous dead birds were Crimson Rosella (984 individuals), New Holland Honeyeater, Red Wattlebird, Currawongs, Sulphur-crested Cockatoo, White-eared Honeyeater, Ravens, Australian Magpies and White-naped Honeyeater.

Pescott, T. (1985). Black Honeyeaters and charcoal. *Geelong Naturalist*, 22, 37-39.
charcoal; Black Honeyeater
Black Honeyeaters observed to repeatedly collect and consume charcoal.

Pescott, T. W. (1976). Seabird Islands: No. 27. Lady Julia Percy Island, Victoria. *Australian Bird Bander*, 14, 29-31.
seabirds; tussock grassland
Bioregion: South east Coastal Plain
Occasional fires have had considerable impact on vegetation, at times leading to rapid degeneration of petrel and penguin burrows.

Porter, J. W., & Henderson, R. (1983). Birds and burning histories of open forest at Gundiah, southeastern Queensland. *Sunbird*, 13, 61-69.
eucalypt open forest; historic change; management
Bioregion: South Eastern Queensland
Bird communities were sampled in forests which had been subjected to three fire regimes over 29 years: burnt annually, burnt periodically at 2-5 year intervals, and unburnt. The annually burnt forest had developed a grassy understorey and the unburnt forest had a shrubby understorey. Four species (Pheasant Coucal, Willie Wagtail, Brown Treecreeper and Australian Magpie) were most abundant in the annually burnt forest. Two species (Forest Kingfisher, White-throated Honeyeater) were most abundant in the forest burnt at longer intervals. Six species (Eastern Yellow Robin, Golden Whistler, Variegated Fairy-wren, White-throated Treecreeper, Little

Wattlebird and Yellow-faced Honeyeater) were most abundant in the unburnt forest. 15 of 37 common species showed no apparent preference. The total abundance and richness of birds did not differ appreciably between treatments. The current periodic burning of these forests is probably restricting encroachment of rainforests and their associated birds.

Press, A. J. (1987). Fire management in Kakadu National Park: the ecological basis for the active use of fire. *Search*, 18, 244-248.
management
Bioregions: Pine Creek Arnhem; Top End Coastal
In the absence of management, up to 80% of the area can be burnt annually. Fires attract falcons, kites and Tree Martin, which hawk in front of the fire. Immediately after fire, Grey Butcherbird, Magpie-lark, Straw-necked Ibis, Torresian Crow, Red-tailed Black-cockatoo, owls and nightjars feed in the burnt area.

Priddel, D. (1989). Conservation of rare fauna: the Regent Parrot and the Malleefowl. In J. C. Noble & R. A. Bradstock (Eds.), *Mediterranean landscapes in Australia: mallee ecosystems and their management* (pp. 243-249). Melbourne: CSIRO.
Malleefowl; mallee; threatened species; management
Bioregion: Murray Darling Depression
Active management of mallee habitat is required for the maintenance of its biota. Important food sources for the Mallee-fowl are available only after the plants reach a certain age. Homogeneous habitat (such as following extensive fire) may be detrimental to it.

Priddel, D. (1990). Conservation of the Malleefowl in New South Wales: an experimental management study. In J. C. Noble, P. J. Joss, & G. K. Jones (Eds.), *The mallee lands: a conservation perspective* (pp. 71-74). Melbourne: CSIRO.
Malleefowl; mallee; threatened species; isolate; management
Bioregion: Murray Darling Depression
One of four given threats to the long-term survival of Malleefowl is fire. There is a correlation between breeding density and age since fire. Almost all extensive stands of mallee in NSW have been burnt within the last 30 years, many repeatedly. Extensive areas of long-unburnt mallee are now rare in NSW. Fire threatens mallee remnants in a different way to extensive stands, with the isolation of remnants offering some protection, but when fires occur in them they are likely to homogenise the remnant completely.

Priddel, D., & Wheeler, R. (1990). Survival of Malleefowl *Leipoa ocellata* chicks in the absence of ground-dwelling predators. *Emu*, 90, 81-87.
Malleefowl; mallee; threatened species
Bioregion: Murray Darling Depression
Habitat quality may be the most critical element in the recruitment and survival of Malleefowl. This may be related to rainfall. "Alternatively, the age of the mallee community (i.e. time since last fire) may be the critical determinant of habitat suitability".

Pyke, G. H., Saillard, R., & Smith, J. (1995). Abundance of Eastern Bristlebirds in relation to habitat and fire history. *Emu*, 95, 106-110.
Eastern Bristlebird; eucalypt open forest; heath; management
Bioregion: South East Corner
Sampled Eastern Bristlebirds in vegetation at sites (forest, woodland, "mallee-heath" and heath) from 0-14 years post-fire (all fires were control burns). Bristlebird numbers increase with increasing time since fire up to about 9 years and then remain relatively constant for at least 4 years. Bristlebirds occurred in recently burnt areas, but these were mostly small and close to unburnt areas, Fire management is essential for the conservation of Bristlebirds. Numbers can be maintained if the interval between fires is at least 10 years, and if unburnt patches are retained during control burning.

Pyne, S. J. (1991). *Burning bush: a fire history of Australia*. New York: Henry Holt and Company.
review
Provides a broad review of the history and character of fire in Australia, with a few review examples of responses of birds to fire.

Quin, B. R. (1990) *Conservation and status of the Turquoise Parrot (Neophema pulchella, Platycercidae) in Chiltern State Park and adjacent areas*. M.Sc., Department of Zoology, LaTrobe University.
Turquoise Parrot; threatened species; management.
Bioregion: South Eastern Highlands
Fires (wildfire and control burns) destroy the stumps often used by nesting Turquoise Parrots.

Quin, B. R., & Baker-Gabb, D. (1993). *Conservation and management of the Turquoise Parrot Neophema pulchella in north-east Victoria*. Department of Conservation and Environment.
Turquoise Parrot; eucalypt woodland; threatened species; management; control burning; hollows
Bioregions: South Eastern Highlands; NSW Southwestern Slopes
Dead trees and stumps, favoured for nesting by Turquoise Parrots, are susceptible to destruction by fire. These should be protected from control burning (or if burning must occur, the vicinity of all nest sites should be first slashed). Management may be able to impose a fire regime which increases the dominance of native perennial grasses.

Ratkowsky, A. V. (1978). The effect of a spring fire on the number of bird species. *Tasmanian Naturalist* (53), 11-12.
eucalypt open forest; wildfire; community
Bioregion: Freycinet
Birds were counted in burnt and unburnt dry eucalypt forest (either side of a road) from 5 days to 13 weeks after a moderate intensity October wildfire (foliage up to about 8m was destroyed). In the first 11 weeks post-fire, there was an average of 2.7 species. Then this suddenly increased to 7.0 species, equal to that in the unburnt area. During the first week post-fire, Fantailed Cuckoo, Black-headed Honeyeater and Black-faced Cuckoo-shrike remained in the burnt area, but they then disappeared from it. After 11 weeks, Black-headed Honeyeater, Brown Thornbill, Superb Fairy-wren and, to a lesser extent, Dusky Wood-swallow, Black-faced Cuckoo-shrike, and Striated Pardalote returned to the burnt area. At this period there was considerable regrowth at the base and trunks of eucalypts and recovery of other plants. There was no change observed for Forest Raven, Yellow-throated Honeyeater, Grey Shrike-thrush, Grey Currawong, Blackbird or Dusky Robin.

Ratkowsky, A. V. (1979). The bird species of Mt. Nelson in relation to microhabitat and recent bushfires. *Tasmanian Naturalist* (57), 12-18.
eucalypt open forest; wildfire; community; control burning
Bioregion: Freycinet
No. of bird species declined from 11.6 before a November controlled burn in dry eucalypt forest to an average of 6.9 in the 3 months after fire.

For 19 weeks after a hot October fire, bird richness in burnt areas was far less (5.7) than in adjacent unburnt areas (16.2 species). Species absent from, or rarer in, the burnt areas included Swift Parrot, Green Rosella, Fantailed Cuckoo, Shining Bronze-cuckoo, Olive Whistler, Golden Whistler, Satin Flycatcher, Superb Fairy-wren, Brown Thornbill, Yellow Wattlebird, Yellow-throated Honeyeater, Strong-billed Honeyeater, Black-headed Honeyeater, Crescent Honeyeater, New Holland Honeyeater, Spotted Pardalote, Silvereye, Grey Butcherbird and Forest Raven. Species more common in the burnt area were Common Bronzewing and Dusky Wood-swallow. Common species showing little difference included Black-faced Cuckoo-shrike, Blackbird, Grey Shrike-thrush and European Goldfinch. More prolonged impact of this fire, compared to the milder fire considered by Ratkowsky (1978), were because this severe fire had consumed much more of the vegetation, including tree canopies. This "indicates clearly that intensity of fire is a very important factor in determining the rate at which avifauna will repopulate a burnt area".

Ratkowsky, A. V. (1985). The effect of a severe fire on the number of bird species in a wet sclerophyll environment. *Tasmanian Naturalist*, 8-9.
eucalypt open forest; community; wildfire
Bioregion: Freycinet
Following hot fire in January, more bird species were observed in unburnt area (17.5 spp.) than in burnt area (6.5 spp) in October-December. Species absent from the burnt area included Shining Bronze-cuckoo, Olive Whistler, Golden Whistler, White-browed Scrubwren and Strong-billed Honeyeater. Species less common in burnt area included Peregrine Falcon, Yellow-tailed Black-cockatoo, Black-faced Cuckoo-shrike, Black-headed Honeyeater, Silvereye, Swift Parrot, Green Rosella, Blackbird,

Yellow-throated Honeyeater, Crescent Honeyeater and Spotted Pardalote. The Striated Pardalote was the only species common in the burnt area (though not more common than in the unburnt area). Results generally similar to those reported following severe fire in drier eucalypt open forest (Ratkowsky 1979).

Recher, H. F. (1981). Death of an Australian myth: fire and its effects on wildlife. In P. J. Stanbury (Ed.), *Bushfires: their effect on Australian life and landscape*. (pp. 39-48). Sydney: Macleay Museum, University of Sydney.
review; wildfire
"The effects of fire on animals … have been neglected by Australian scientists … There are few long term studies." In mild fires, birds easily avoid flames. Some species are attracted to the fire front. In a mild burn, birds were observed in the still smoking forest within moments of the flame passing. In extensive wildfires, immediate effect is more severe. But birds respond rapidly because of their high mobility and high reproductive potential. Within a year of burning, birds are numerous in forest. Many will have survived in small unburnt patches but others probably move in from distant areas unaffected by fire. Birds may respond to flush of insects on regrowth vegetation. Forest canopy birds are generally less affected than ground-dwelling birds or birds of the shrub layer. Nectarivorous birds may be affected if fire frequency leads to decline in nectariferous plants. A diversity of fires (rather than regular prescriptive burns) is needed to maintain the greatest range of bird species.

Recher, H. F. (1991). The conservation and management of eucalypt forest birds: resource requirements for nesting and foraging. In D. Lunney (Ed.), *Conservation of Australia's forest fauna*. (pp. 25-34). Sydney: Royal Zoological Society of NSW.
eucalypt open forest; management; forestry
Many bird species have very idiosyncratic requirements for nesting or foraging (e.g. spiders webs, dead limbs). Fire (and logging) simplifies forest environments to the detriment of many bird species. Loss of shrubby understorey may result in greater nest predation or removal of species which forage in particular shrub species. Effects of logging may be compounded if they are associated with fire. Relatively inflexible imposed fire regimes may be particularly detrimental to birds.

Recher, H. F., & Christensen, P. E. (1981). Fire and the evolution of the Australian biota. In A. Keast (Ed.), *Ecological biogeography in Australia* (pp. 135-162). The Hague: Junk.
review
Birds easily survive mild fires: in a controlled fire in shrub woodland, birds avoided the flames and moved into an adjacent unburnt heath, then returned to their original sites immediately after the fire had passed. However, there may be appreciable mortality in extensive wildfire. Because of their greater mobility and higher reproductive potential, birds respond to the effects of fire more rapidly than do mammals. Changes are most pronounced for birds of the ground and understorey vegetation. After mild fires, bird numbers decline initially but then (1-3 years post-fire) quickly return to or exceed pre-fire levels. Reproductive output of birds may be increased in the year following fire (probably due to greater insect availability).

Recher, H. F., & Lim, L. (1990). A review of current ideas of the extinction, conservation and management of Australia's terrestrial vertebrate fauna. *Proceedings of the Ecological Society of Australia*, 16, 287-301.
review; management
Some birds (such as grass-wrens and scrub-birds) which were restricted to specialised habitats, have been affected by habitat change through alteration of fire regimes or grazing. Of 13 bird species which declined in King's Park over the previous 60 years, 10 were ground-foragers. This change was due to alteration of ground vegetation and litter caused by spread of weeds and changed fire regimes. Frequent fuel-reduction burns in forests are a concern, as they change understorey and litter characteristics and lead to reduction in available energy. These fire-induced changes will have long-term effects on many insectivorous birds.

Recher, H. F., & Serventy, D. L. (1991). Long term changes in the relative abundance of birds in Kings Park, Perth, Western Australia. *Conservation Biology*, 5, 90-102.
historic change; eucalypt open forest; management
Bioregion: Swan Coastal Plain
Over nearly 60 years of intermittent survey, change in ground cover (development of dense understorey, loss of eucalypt canopy and proliferation of weeds), associated with fire regime, has led to marked change in the bird assemblage of Kings Park. Nine of 16 species which declined (Western Spinebill, Pallid Cuckoo, Grey Butcherbird, Laughing Kookaburra, Golden Bronze-cuckoo, Scarlet Robin, Indian Turtledove, Western Yellow Robin, Senegal Dove, White-tailed Black-cockatoo, Golden Whistler, Sacred Kingfisher, Tree Martin, Purple-crowned Lorikeet, Whistling Kite, Willie Wagtail) were ground-foraging birds. Prescription burning from the 1930s to 1960s has exacerbated problems (spread of weeds and debilitation of remaining eucalypts).

Recher, H. F., Lunney, D., & Posamentier, H. (1975). A grand natural experiment - the Nadgee wildfire. *Australian Natural History*, 18, 150-163.
wildfire; heath; eucalypt open forest; mortality
Bioregion: South East Corner
Around 70,000 ha (including almost all of Nadgee reserve) of heath and open forest were burnt in a wildfire, the first major fire in the area for 40 years. The beach was littered with dead small birds. One year after fire, all pre-fire bird species were present except for Crescent Honeyeater, although some were less common than previously. Multiple nesting was evident for some insectivorous birds. Management should ensure that fires do not burn the whole reserve, and that a diversity of fires occurs.

Recher, H. F., Allen, D., & Gowing, G. (1985). The impact of wildfire on birds in an intensively logged forest. In A. Keast, H. F. Recher, H. Ford, & D. Saunders (Eds.), *Birds of eucalypt forests and woodlands: ecology, conservation, management* (pp. 283-290). Chipping Norton: Surrey Beatty.
eucalypt open forest; community; wildfire; management; forestry
Bioregion: South East Corner
One year after an intense and extensive wildfire, bird populations (and invertebrate numbers) were censused in 12 burnt and unburnt sites, including some which had been logged, across a range of forest types. Invertebrates were generally more abundant in foliage in burnt forests. Burnt and logged forests had fewer bird species and individuals than unburnt and unlogged forests. The combined effect of these two disturbances was greater than either alone. Brown Thornbill, Striated Thornbill, White-throated Treecreeper, Golden Whistler and Grey Fantail were less abundant in burnt forests. Nectarivores (Musk Lorikeet, Yellow-faced Honeyeater, Yellow-tufted Honeyeater, White-naped Honeyeater), granivores (Diamond Dove, Common Bronzewing, Forest Bronzewing, Brown Quail, Painted Quail, Red-browed Finch, Beautiful Firetail) and Spotted Pardalote were generally more abundant in burnt forest.

"Considering the frequency with which fires occur in eucalypt forests and woodlands and their dramatic impact on the landscape, there is remarkably little information about the effects of fire on fauna or the long-term consequences of burning on forest ecosystems." Generally fire effects are most substantial on species occurring in lower substrates, and the timing of their responses is related to vegetation recovery. Proposes a model that nutrients released after fire promote growth of nutrient-rich foliage and hence an increase in invertebrates (and thus insectivorous birds). However, following this intense fire, the relatively sparse foliage in burnt areas may have led to increased predation and to lower density of invertebrates per land area (cf. per area of foliage), and hence birds were relatively less common.

Recher, H. F., Davis, W. E., & Holmes, R. T. (1987a). Ecology of Brown and Striated Thornbills in forests of south-eastern New South Wales, with comments on forest management. *Emu*, 87, 1-13.
Brown Thornbill; Striated Thornbill; eucalypt open forest; wildfire; forestry; management
Bioregions: South east Corner; South eastern Highlands
Brown and Striated Thornbills were more abundant in unburnt open forest than in forest burnt 1 year previously, regardless of logging history.

Recher, H. F., Shields, J., Kavanagh, R., & Webb, G. (1987b). Retaining remnant mature forest for nature conservation at Eden, New South Wales: a review of theory and practice. In D. A. Saunders, G. W. Arnold, A. A. Burbidge, & A. J. M. Hopkins (Eds.), *Nature conservation: the role of remnants of native vegetation* (pp. 177-194). Chipping Norton: Surrey Beatty.
eucalypt open forest; community; isolate; management; forestry
Bioregion: South Eastern Corner
Six creek reserves (retained strips post-logging) and two sites in unlogged areas were censused for birds over 8 years. The widest reserve was burnt in the fourth year and four others were burnt in the seventh year. The fire had little effect on bird numbers in the widest strip, but total bird population and number of forest birds declined precipitously in the year post-fire for the four smaller burnt strips. The decline was only partly due to fire, but may have been compounded by drought. Open country birds increased in the strips post-fire.

Recher, H. F., Hutchings, P. A., & Rosen, S. (1993). The biota of the Hawkesbury-Nepean catchment: reconstruction and restoration. *Australian Zoologist*, 29, 3-41.
historic change
Bioregion: Sydney Basin
Describes environmental change since European colonisation. Many bird species have declined, associated with a complex mix of factors including change in fire regimes. Increased fire frequencies and more frequent wildfires of human origin are probably the major causes of decline of Rock Warbler and Ground Parrot.

Reid, J., & Fleming, M. (1992). The conservation status of birds in arid Australia. *Rangelands Journal*, 14, 65-91.
review; management; historic change; hummock grasslands; mallee
Suggests that fire regime and extent of long-unburnt patches have changed in arid environments generally since European settlement, though evidence is equivocal. There is more convincing evidence of changed fire regime in hummock grassland deserts, to the possible detriment of species such as Striated Grass-wren. However, pastoralism is regarded as a more serious threat for most birds and most environments (e.g. riparian habitats, tussock grasslands and chenopod shrublands).

Reid, J. R. W., Kerle, J. A., & Morton, S. R. (1993a). Birds. In J. R. W. Reid, J. A. Kerle, & S. R. Morton (Eds.), *Uluru fauna: the distribution and abundance of vertebrate fauna of Uluru (Ayers Rock - Mount Olga) National Park, N.T.* (pp. 36-57). Canberra: Australian National Parks and Wildlife Service.
mallee; hummock grassland; Acacia woodland; community; wildfire
Bioregion: Great Sandy Desert
Recently burnt areas are favoured by nomadic birds (e.g. Budgerigar, White-winged Triller, Black Honeyeater, Crimson Chat, Zebra Finch, Masked Wood-swallow) and the rarer Banded Whiteface. A few species (e.g. Striated Grass-wren, Rufous-crowned Emu-wren) are largely restricted to mature hummock grasslands. By 10 years post-fire, mulga woodlands were recolonised by most sedentary mulga birds, though much older woodlands support more mistletoe and hence greater numbers of White-fronted Honeyeaters. Recommends a patch-burn strategy as advocated by Aboriginal residents. Extensive fires probably have a more homogenising effect. Rainfall after fires may substantially influence the rate of regrowth and bird responses.

Reid, J. R. W., Kerle, J. A., & Morton, S. R. (1993b). Ecological patterns and processes of importance. In J. R. W. Reid, J. A. Kerle, & S. R. Morton (Eds.), *Uluru fauna: the distribution and abundance of vertebrate fauna of Uluru (Ayers Rock - Mount Olga) National Park, N.T.* (pp. 133-148). Canberra: Australian National Parks and Wildlife Service.

hummock grasslands; mallee; Acacia woodland; management

Bioregion: Great Sandy Desert

"Mulga is killed by fire, and given the importance of this species to the associated rich bird community, it would seem that the destruction of extensive areas of mulga by fire would decimate bird populations, at least until the mulga had regenerated to a certain age." However, a mulga stand 11-14 years post-fire supported birds typical of tall old mulga, as well as many nomadic species characteristic of early regrowth. This may be because the site was close to old mulga. Management should aim to avoid very extensive fires, and fires in regrowth mulga not old enough to have produced seed (c15 years). In spinifex, Striated Grasswren is confined to mature vegetation, while Banded Whiteface (and a range of nomadic species) are associated with recently burnt areas. Management require a fine-scale patch-burn strategy, but with special attempt to maintain old vegetation.

Reilly, P. (1991a). The effect of wildfire on bird populations in a Victorian coastal habitat. *Emu*, 91, 100-106.

eucalypt open forest; wildfire; community; management; isolate; succession

Bioregion: South east Coastal Plain

Bird censuses were conducted in coastal vegetation from several months before a hot and extensive wildfire (with very few unburnt patches) to nearly six years post-fire. There were marked differences between species in responses. A group of species were not or little affected (including Crimson Rosella, Rufous Whistler, Grey Shrike-thrush, Grey Fantail, Striated Pardalote and Pied Currawong). Another group showed an initial decline with recovery after one or more years (including Golden Whistler, Superb Fairy-wren, Striated Thornbill, Crescent Honeyeater, New Holland Honeyeater, Spotted Pardalote for recovery after one year, and Eastern Yellow Robin, White-throated Treecreeper and Eastern Spinebill for recovery after 2-3 years). Seed-eating Bronzewings did not appear until 2 years post-fire. Another group showed an initial increase, generally followed by decrease (Flame Robin, Scarlet Robin, Australian Magpie, ravens). Breeding was recorded within the first year post-fire for Flame Robin, Buff-rumped Thornbill, Grey Currawong and Australian Magpie. By two years post-fire all species present pre-fire had been recorded, though abundance was generally still slightly less. Some species changed foraging behaviours in burnt areas. Rufous Bristlebirds began returning 2 years post-fire, possibly from refuges in town gardens (where they had been unreported before the fire). Fire probably poses the greatest threat to this species. "If fire is to be used as a management tool, frequent pockets of unburnt country of sufficient size are vital … The time of burning ought also to be considered so that its impact on breeding populations is minimal."

Reilly, P. (1991b). The effect of wildfire on bush bird populations in six Victorian coastal habitats. *Corella*, 15, 134-142.

heath; thicket; eucalypt open forest; community; wildfire; management; succession

Bioregions: South eastern Highlands, South east Coastal Plain

Six sites across a range of habitats were monitored at 6-monthly intervals from 14 months after a severe bushfire to 56 months post-fire. No unburnt controls were available in the area. For some species, return showed considerable variation between sites. Rufous Whistlers initially did not appear to be greatly affected by the fire, but became extremely rare or absent 32-56 months post-fire. Southern Emu-wrens recolonised heath 38 months and 56 months post-fire, possibly from a nucleus in a small patch that was unburnt. Rufous Bristlebirds returned at 14 months post-fire at one site (near an unburnt patch), but had not returned to another site (of former occurrence) 7.5 years post-fire. White-throated Treecreepers recolonised sites at 15, 27 and 39 months post-fire. Tawny-crowned Honeyeaters were absent until 56 months post-fire. For some species, colonisation was not from unburnt refuges to burnt margins to interior of burnt areas, but rather they first appeared deep in the burnt forests. Fire effects are greatest for ground-dwelling birds, especially those with restricted distributions, narrow habitat ranges and limited dispersal ability (e.g. Rufous Bristlebird,

Southern Emu-wren). Too frequent fires alter vegetation and change bird assemblages. If fire is to be used as a management tool, pockets of unburnt country are vital. Burning during the breeding season should be avoided.

Ridpath, M. G. (1972). The effects of fire on fauna. In R. J. Hooper & M. Rowell (Eds.), *Proceedings of the 1971 Tropical and Arid Fire Symposium*. (pp. 64-66). Darwin: NT Government Printer.
historical change; review; Orange-footed Scrub-fowl; Wedge-tailed Eagle; Ground Parrot
Fire regimes change habitat configurations and relative extent. For example, abandoned mounds of Orange-footed Scrubfowl indicate that rainforests have declined over the last 8,000 years because of Aboriginal burning and/or climate change. In arid environments, burning may reduce the number of rabbits, leading to local decline in Wedge-tailed Eagle population. Ground Parrots need heaths burnt every 4-5 years.

Ridpath, M. G. (1974). The ecological consequences of fire for animal communities. In R. E. Fox (Ed.), *Report on the use of fire in national parks and reserves.* (pp. 48-53). Darwin: Department of the Northern Territory.
review

Roberts, P. E. (1970). Some effects of a bushfire on heathland birdlife. *Proceedings of the Royal Zoological Society of New South Wales*, 89, 40-43.
heath; wildfire
Bioregion: Sydney Basin
Up to 2.5 years after fire, eight previously resident bird species disappeared or declined: Eastern Whipbird, White-cheeked Honeyeater (occasional visits to flowering Xanthorrhoea since fire), Little Wattlebird, Eastern Spinebill (occasionally feeding in regrowth heath), Variegated Fairy-wren, Chestnut-rumped Heath-wren (one pair returned to regrowth heath 1 year after fire), Brown Thornbill (declined in abundance in heath), Red-browed Finch (completely disappeared from the locality). Several birds from adjacent woodlands temporarily moved into the heath immediately (and up to 3 months) after fire: Laughing Kookaburra, Pied Currawong, Australian Magpie, Australian Raven, Magpie-lark, Eastern Rosella, Crimson Rosella. These fed on the seeds shed after fire (the rosellas) or invertebrate and vertebrate prey killed or exposed by the fire. White-eared Honeyeaters increased in the burnt heath from occasional visitors to nesting residents about 1 year post-fire.

Robertson, B. I. (1981). Seabird Islands: No. 102. Chalky Island, Furneaux Group, Tasmania. *Corella*, 5, 49-52.
seabirds; tussock grasslands; heath
Bioregion: Furneaux
The island was burnt by quail-shooters in 1968, affecting breeding seabirds.

Robinson, A. C., Casperson, K. D., & Copley, P. B. (1990). Breeding records of the Malleefowl (*Leipoa ocellata*) and Scarlet-chested Parrot (*Neophema splendida*) within the Yellabinna Wilderness area, South Australia. *South Australian Ornithologist*, 31, 8-12.
Scarlet-chested Parrot; mallee; hummock grassland.
Bioregion: Great Victoria Desert
Scarlet-chested Parrot may show some association with young regrowth (3-5 years post-fire).

Robinson, D. (1992). Habitat use and foraging behaviour of the Scarlet Robin and the Flame Robin at a site of breeding-season sympatry. *Wildlife Research*, 19, 377-395.
Flame Robin; Scarlet Robin
Bioregion: South eastern Highlands
Wildfire or fuel reduction burning may change the relative competitive ability of these two similar species.

Robinson, D., & Woinarski, J. C. Z. (1992). A review of records of the Northern Shrike-tit *Falcunculus frontatus whitei* in northwestern Australia. *South Australian Ornithologist*, 31, 111-117.
Crested Shrike-tit; tropical eucalypt open forest; threatened species
Crested Shrike-tits favour old forests in temperate Australia. Frequent burning of tropical eucalypt forests may be one reason for the rarity of this subspecies, through loss of large trees. More data

are needed on the long-terms effects of fire on arthropods and hence bark-foraging birds.

Rounsevell, D. E., & Woinarski, J. C. Z. (1983). Status and conservation of the Forty-spotted Pardalote, *Pardalotus quadragintus* (Aves: Pardalotidae). *Australian Wildlife Research*, 10, 343-349.

Forty-spotted Pardalote; threatened species; eucalypt open forest; isolate

Bioregion: Freycinet

Wildfire may threaten all populations of Forty-spotted Pardalote. One small isolated population may have disappeared after fire. However, population numbers at another site were similar 2 years post-fire to pre-fire levels (possibly because of proximity of unburnt areas with relatively large populations). Fuel-reduction burns are probably not detrimental.

Rowley, I. (1987). *Conservation of the Purple-crowned Fairy-wren Malurus coronatus in northern Australia*. World Wildlife Fund (Australia).

Purple-crowned Fairy-wren; riparian vegetation; threatened species; pandanus; tussock grassland; tropical eucalypt savanna woodland

Bioregions: Victoria Bonaparte; Ord-Victoria Plains; Central Kimberley; North Kimberley; Gulf Fall and Uplands; Gulf Coastal

Fire may destroy or degrade some of the riparian strips on which this species depends, though the main threat is degradation of this habitat by cattle.

Rowley, I. (1993). The Purple-crowned Fairy-wren *Malurus coronatus*. I. History, distribution and present status. *Emu*, 93, 220-234.

Purple-crowned Fairy-wren; pandanus; tussock grassland; threatened species; tropical eucalypt savanna woodland

Bioregions: Victoria Bonaparte; Ord-Victoria Plains; Central Kimberley; North Kimberley; Gulf Fall and Uplands; Gulf Coastal

The Purple-crowned Fairy-wren is found in riparian vegetation (Pandanus and cane-grasses) in northern Australia. Heavy grazing by cattle and burning by pastoralists removes both shelter and foraging substrate for this species, forcing them to abandon this habitat at critical times of the year, leading to local declines and extinction.

Rowley, I., & Brooker, M. (1987). The response of a small insectivorous bird to fire in heathlands. In D. A. Saunders, G. W. Arnold, A. A. Burbidge, & A. J. M. Hopkins (Eds.), *Nature Conservation: the role of remnants of native vegetation* (pp. 211-218). Chipping Norton: Surrey Beatty.

Splendid Fairy-wren; heath; wildfire; isolate; management

Bioregion: Jarrah Forest

Six fires (one of which was intense) burnt parts of the study area over a 12 year study of colour-banded Splendid Fairy-wrens. In most cases, unburnt patches were left. But in both territories that were completely burnt out, most of the previous occupiers disappeared (and were presumed to have perished). The incidence of parasitism in the years following fire was low. With the exception of adult survival, all measures of density, productivity and survival increased during fire-free periods. The major change occurred in the fourth year post-fire and was sustained thereafter. High adult survival allows population maintenance despite several years of low productivity post-fire. However, frequent fires eliminated some populations at the site, with subsequent restoration of territories arising from recruitment from beyond the site.

This study also reports short-term (9 months) response to an intense wildfire which consumed 95% of the vegetation. The population survived the very hot (>600oC at 10cm above ground) fire well, showed remarkable site tenacity, and showed similar or even reduced mortality in the months post-fire than in previous years. The better short-term survival after a hot fire than after cooler burns may have been due to the timing of the hot fire, which was several months after breeding season.

Frequent burns had a deleterious effect on this population. If the site had been a remnant, the Fairy-wrens may well have been eliminated by this fire regime. Optimum density may be maintained with at least 12 year intervals between fires, which should not be during the breeding season.

Rowley, I., & Russell, E. (1993). The Purple-crowned Fairy-wren *Malurus coronatus*. II. Breeding biology, social organisation, demography and management. *Emu*, 93, 235-251.
Purple-crowned Fairy-wren; tussock grassland; pandanus; management; threatened species
Bioregions: Victoria Bonaparte; Ord-Victoria Plains; Central Kimberley; North Kimberley; Gulf Fall and Uplands; Gulf Coastal
Purple-crowned Fairy-wrens require riparian habitat which is easily damaged by stock or fire. This habitat should be protected from fire at all times.

Rowley, I., & Russell, E. (1995). The breeding biology of the White-winged Fairy-wren *Malurus leucopterus leuconotus* in a Western Australian coastal heathland. *Emu*, 95, 175-184.
White-winged Fairy-wren; heath; wildfire
Bioregion: Swan Coastal Plain
All White-winged Fairy-wrens from a 32ha study site (77 adults banded in the 4 years before fire) could not be relocated shortly after a wildfire, and only one wren was seen there 3 months after the fire.

Rowley, I., Russell, E., Brown, R., & Brown, M. (1988). The ecology and breeding biology of the Red-winged Fairy-wren *Malurus elegans*. *Emu*, 88, 161-176.
Red-winged Fairy-wren; control burning; eucalypt open forest
Bioregion: Warren
In the long term, fuel-reduction burns must have severe effects on populations of Red-winged Fairy-wren, because nearly half of the nest sites in this study were in "dead brush", the fuel that such burns seek to reduce. This species occurs in a very stable environment and has very low reproductive output: it may be a very poor recoloniser.

Russell, E. M., & Rowley, I. (1993). Demography of the cooperatively breeding Splendid Fairy-wren, *Malurus splendens* (Maluridae). *Australian Journal of Zoology*, 41, 475-505.
Splendid Fairy-wren; wildfire
Bioregion: Swan Coastal Plain
Studied a population for 18 years, which included a number of minor wildfires and one which burnt 95% of the study area. Annual survival decreased in the two years after fire. Females laid more clutches when predation or brood-parasitism was high, particularly in the 2 years post-fire, but productivity was low for several years post-fire. Territories were not vacated initially after fire, but by 3-5 years post-fire some territories were vacant and group sizes decreased. Population decline occurred 3-5 years post-fire due to decreased reproductive output and replacement of older breeding birds by less productive novices. Fire directly affected natality and juvenile survival and indirectly affected population density, age structure, sex ratio and group composition.

Russell-Smith, J. (1985). A record of change: studies of Holocene vegetation history in the South Alligator Region, Northern Territory. *Proceedings of the Ecological Society of Australia.*, 13, 191-202.
Orange-footed Scrubfowl; historic change; rainforest
Bioregion: Top End Coastal
Historic changes in fire regime have led to contraction of monsoon rainforests, as evidenced by old scrubfowl mounds occurring in eucalypt open forests.

Russell-Smith, J. (1995). Fire management. In T. Press, D. Lea, A. Webb, & A. Graham (Eds.), *Kakadu: natural and cultural heritage and management* (pp. 217-237). Darwin: Australian Nature Conservation Agency and North Australia Research Unit.
management; review; tropical eucalypt open forest; tussock grassland; Aboriginal knowledge; Aboriginal burning
Bioregions: Pine Creek - Arnhem; Top End Coastal
Reviews burning regimes used traditionally by Aboriginal people and currently by park managers; and some studies of the effects of fire on birds in this region.

Saunders, D. A. (1979). The availability of tree hollows for use as nest sites by White-tailed Black Cockatoos. *Australian Wildlife Research*, 6, 202-216.
hollows; White-tailed Black-cockatoo

Saunders, D. A. (1985). Human impact: the response of forest and woodland bird communities. Whither the future? A synthesis. In A. Keast, H. F. Recher, H. Ford, & D. Saunders (Eds.), *Birds of eucalypt forests and woodlands: ecology, conservation, management* (pp. 355-357). Chipping Norton: Surrey Beatty.

review; eucalypt open forest; management

Much more research is needed on the role of fire in bird conservation and management. "Minor changes in the fire regime may be as damaging as the widespread clearing for agriculture."

Saunders, D. A., Smith, G. T., & Rowley, I. (1982). The availability and dimensions of tree hollows that provide nest sites for cockatoos (Psittaciformes) in Western Australia. *Australian Wildlife Research*, 9, 541-556.

hollows

The smallest trees suitable for nesting by any of 5 species of cockatoos considered was at least 130 years old. Such trees are becoming scarcer due to vegetation clearing and prevention of regeneration (due to stock trampling or grazing).

Schodde, R. (1982). *The Fairy-wrens. A monograph of the Maluridae*. Melbourne: Lansdowne.

Mallee Emu-wren; Carpentarian Grass-wren; threatened species; management; hummock grasslands; review.

The Mallee Emu-wren and Carpentarian Grass-wren are probably threatened by fire. Both may recover very slowly after fire has consumed their highly flammable hummock grassland habitat. This may be especially threatening where populations are highly fragmented. Southern Emu-wren and Striated Grass-wren may also be adversely affected by wildfire, though this does not yet threaten the species existence. Both may take many years to recolonise. The Southern Emu-wren is reported to fly well before the fire front.

Schodde, R., Mason, I. J., & Wood, J. T. (1993). Geographical differentiation in the Glossy Black-Cockatoo *Calyptorhynchus lathami* (Temminck) and its history. *Emu*, 93, 156-166.

Glossy Black-Cockatoo; threatened species; management; hollows

Management for the Glossy Black-Cockatoo should include developing a fire regime that prevents severe wildfires (and hence elimination of food sources), and maintaining availability of hollows.

Scotts, D. (1994). Sustaining sensitive wildlife within temperate forest landscapes: regional systems of retained habitat as a planning framework. In T. W. Norton & S. R. Dovers (Eds.), *Ecology and sustainability of southern temperate ecosystems* (pp. 85-106). Canberra: CSIRO.

old-growth; forestry; management; eucalypt open forest

Mainly concerned with management of forestry, but provides a review of old-growth characteristics and the association of birds with these.

Scotts, D. J. (1991). Old-growth forests: their ecological characteristics and value to forest-dependent vertebrate fauna of south-east Australia. In D. Lunney (Ed.), *Conservation of Australia's forest fauna* (pp. 147-159). Sydney: Royal Zoological Society of NSW.

eucalypt open forest; old-growth; forestry; hollows

Bioregions: South Eastern Highlands; South East Corner

Old-growth forests are characterised by abundant litter, logs and hollows, and distinctive floristic composition. 17 bird species are listed as finding optimum habitat in old-growth forests. These include hollow-nesting species, honeyeaters, trunk-gleaning insectivores, frugivores and some insectivores of the canopy foliage.

Silveira, C. E. (1993). *Recovery plan for threatened mallee birds - addressing fire regimes*. Royal Australasian Ornithologists Union.
mallee; heath; threatened species; management; review; Malleefowl; Pink Cockatoo; Regent Parrot; Mallee Emu-wren; Striated Grass-wren; Black-eared Miner; Slender-billed Thornbill; Western Whipbird; Red-lored Whistler.
Bioregions: Murray-Darling Depression; Mallee
Provides a review of the observed association of threatened mallee birds (Malleefowl, Pink Cockatoo, Regent Parrot, Mallee Emu-wren, Striated Grass-wren, Black-eared Miner, Slender-billed Thornbill, Western Whipbird and Red-lored Whistler) with fire, and research and management requirements. For the Malleefowl, a high frequency of fire is a confirmed threat in mallee of eastern Australia, but has not been established in western mallee. For the Pink Cockatoo, primary threats are the loss of suitable hollows through natural attrition and the prevention of formation of new hollows due to increased frequency of fire. The Mallee Emu-wren and Striated Grass-wren are absent in mallee with hummock grassland understorey for 5-6 years post-fire, but persist then until the vegetation is long-unburnt. Recolonisation may be a problem for these species with poor dispersive ability following large-scale fires which eliminate populations. Black-eared Miners apparently prefer long-unburnt mallee for breeding, though may feed in younger regrowth. In southwestern Australia, Western Whipbirds prefer mallee-heath older than 14 years, and may prefer much older vegetation.

Silveira, C. E. (1995). The Black-eared Miner. *Australian Bird Watcher*, 16, 96-109.
Black-eared Miner; threatened species; mallee
Bioregion: Murray-Darling Depression
In contrast to previous claims (McLaughlin 1992) that the Black-eared Miner is restricted to mallee at least 55 years post-fire, this paper reports foraging by Black-eared Miners in mallee of 3-11 years post-fire (though these birds apparently nested in adjacent long-unburnt mallee).

Skira, I. J., & Brothers, N. P. (1988a). Seabird Islands: No. 183. Little Green Island, Furneaux Group, Tasmania. *Corella*, 12, 80-81.
seabirds; tussock grassland
Bioregion: Furneaux
The island is regularly fired, and burning and grazing by sheep have caused much deterioration of vegetation and soil, affecting breeding shearwaters.

Skira, I. J., & Brothers, N. P. (1988b). Seabird Islands: No. 184. Great Dog Island, Furneaux Group, Tasmania. *Corella*, 12, 82-84.
seabirds; tussock grassland
Bioregion: Furneaux
Frequent burning has caused fewer areas to be used by breeding shearwaters, however burning is now less frequent due to management control by state conservation agency.

Smith, G. T. (1977). The effect of environmental change on six rare birds. *Emu*, 77, 173-179.
review; historic change; Aboriginal burning; Noisy Scrub-bird; Rufous Scrub-bird; Western Bristlebird, Eastern Bristlebird, Rufous Bristlebird; Western Whipbird; threatened species; management
Examines status, habitat requirements and history of Noisy Scrub-bird, Rufous Scrub-bird, Western Bristlebird, Eastern Bristlebird, Rufous Bristlebird and Western Whipbird. The Scrub-birds and Bristlebirds are Tertiary relicts, more common in closed forests of the Tertiary, and now largely restricted to very narrow specialised habitats. Aboriginal entry to Australia had a major impact on the fauna during the Pleistocene and Recent by "prolonged, constant and widespread use of fire". One consequence was a possible increase in the area of heath (to the advantage of several heath-favouring birds, including Western Bristlebird and Eastern Bristlebird). However, burning regime of heaths became much more frequent with European colonisation and led to the decline of bristlebirds and scrub-birds. Western Bristlebirds require heath of at least 8-10 years post-fire before habitat is suitable. For Noisy Scrub-birds fire intervals of <5 years or >30 years render heath/thicket unsuitable.

Smith, G. T. (1979a). The Noisy Scrub-bird. In M. J. Tyler (Ed.), *The status of endangered Australasian wildlife* (pp. 117-121). Adelaide: Royal Zoological Society of South Australia.
Noisy Scrub-bird; heath; thicket; isolate; threatened species; eucalypt open forest; management; historic change; Aboriginal burning
Bioregion: Jarrah Forest
Aboriginal use of fire probably had little impact on Noisy Scrub-bird habitat (as such fires were probably small and lit after the breeding season). After European colonisation, heaths were burnt every 2-3 years to provide grass for cattle, while attempts made to exclude fire in forests probably resulted in higher frequency of occasional hot wildfires. These changes would have led to the decline and local extinction of Noisy Scrub-birds, and these losses would have further fragmented populations and made recolonisations after fires less likely. Recent increases are due to absence of fire. However, lack of fire may allow successional changes that render gullies unsuitable for Scrub-birds (this has already happened at two small sites).

Smith, G. T. (1979b). The status of Australian parrots. In M. J. Tyler (Ed.), *The status of endangered Australasian wildlife* (pp. 101-108). Adelaide: Royal Zoological Society of South Australia.
Ground Parrot; review; heath; threatened species; management
Too frequent burning renders heath unsuitable for Ground Parrot, and heath over-protected from fire also becomes unsuitable as it becomes too tall and dense. Management needs to mosaic burn at 8-10 year intervals.

Smith, G. T. (1985a). Fire effects on populations of the Noisy Scrub-bird (*Atrichornis clamosus*), Western Bristle-bird (*Dasyornis longirostris*) and Western Whip-bird (*Psophodes nigrogularis*). In J. R. Ford (Ed.), *Fire ecology and management in Western Australian ecosystems* (pp. 95-102). Perth: Western Australian Institute of Technology.
Noisy Scrub-bird; Western Bristlebird; Western Whipbird; heath; thicket; eucalypt open forest; management; historic change; threatened species; Aboriginal burning
Bioregions: Esperance Plains; Warren; Swan Coastal Plain; Jarrah Forest
There have been few studies of the effects of fire on birds, and most are opportunistic and short-term. Western Whipbird, Western Bristlebird and Noisy Scrub-birds are all poor dispersers. Change in fire regime from that used by Aborigines to that used by settlers resulted in severe contraction of range. These three species survive at Two Peoples Bay, largely through topographic protection from fire. Recent fire control in this area has led to the expansion of populations of all three species. Vegetation has to be 4-10 years post-fire before being suitable for Noisy Scrub-birds (being faster in wet gullies where dominant eucalypts have not been destroyed). Reproductive output is low, hence recruitment after fire may be very gradual. Wet heath may be suitable for Western Bristlebirds 3 years post-fire and dry heath by 6-10 years post-fire, though grazing pressure from Grey Kangaroos (especially if burnt areas are limited) may extend these periods. For Western Whipbirds, minimum periods before vegetation was suitable were 4-6 and 7 years post-fire. In heath, there is a bird succession from Richard's Pipit to Striated Field-wren to Western Bristlebird to Western Whipbird. The long-unburnt part of this succession is fairly speculative as there are few very old heaths. Some >45 year post-fire heaths retain Bristlebirds, but at densities less than those in 20 year old heaths. Less is known of later succession in the low eucalypt forests used by Noisy Scrub-birds. A fire interval of at least 20 years (and possibly of the order of 50 years) should be maintained, and accompanied by considered monitoring.

Smith, G. T. (1985b). The Noisy Scrub-bird *Atrichornis clamosus*. Does it's past suggest a future? In A. Keast, H. F. Recher, H. Ford, & D. Saunders (Eds.), *Birds of eucalypt forests and woodlands: ecology, conservation, management* (pp. 301-308). Chipping Norton: Surrey Beatty.

Noisy Scrub-bird; threatened species; eucalypt open forest; wetlands; heath; management; Aboriginal burning; historic change

Bioregions: Jarrah Forest; Warren

Compares Aboriginal fire regimes (small, patchy) with settler fire regimes (frequent in wet heaths and swamp margins; hot summer fires and more frequent occurrence of bushfires in open forest) in the restricted habitat of Noisy Scrub-bird. Topographic protection has resulted in low frequency of fire at one site and hence the survival of one relict population. Minimum age of vegetation to be suitable is known, but there is also indication that long-term fire exclusion may result in reduction of habitat suitability.

Smith, G. T. (1985c). Population and habitat selection of the Noisy Scrub-bird, *Atrichornis clamosus*, 1962-83. *Australian Wildlife Research*, 12, 479-485.

Noisy Scrub-bird; heath; thicket; eucalypt open forest; threatened species

Bioregion: Jarrah Forest

Exclusion of fire has led to substantial vegetation change and marked increases in populations of Noisy Scrub-bird. Six years after a hot fire, regeneration was suitable in some, if not all, areas for Noisy Scrub-bird. But the first male to recolonise was not recorded until 9 years post-fire, suggesting problems of dispersal from unburnt areas. Nothing is known about how long vegetation remains suitable, but it is likely to be greater than 40 years.

Smith, G. T. (1987a). The changing environment for birds in the south-west of Western Australia; some management implications. In D. A. Saunders, G. W. Arnold, A. A. Burbidge, & A. J. M. Hopkins (Eds.), *Nature Conservation: The role of remnants of native vegetation* (pp. 269-277). Chipping Norton: Surrey Beatty.

historic change; eucalypt open forest; heath; thicket; Noisy Scrub-bird; Western Whipbird; Western Bristlebird; management; threatened species; Aboriginal burning

Bioregions: Esperance Plains; Jarrah Forest; Warren

Change from Aboriginal burning regimes to those associated with Europeans led to epidemic of intense fires in the early years of settlement. In coastal areas, early pastoralists fired the heaths every 2-3 years. Clearing and fragmentation have left the remnants more vulnerable to catastrophic fire. Changes in burning regime are thought to be the main cause of decline for Noisy Scrub-bird, Western Bristlebird, Western Whipbird and possibly Ground Parrot; and probably for the regional extinction of Rufous Bristlebird. Discusses management of Two Peoples Bay for the threatened Noisy Scrub-bird, Western Bristlebird and Western Whipbird. Recent large wildfires in nearby areas severely reduced or wiped out populations of Western Bristlebird. Notes the importance of natural firebreaks (rocky hills, dissescted gullies) in providing protection from fire for these remnant populations. Recolonisation period post-fire depends on a number of factors (edaphic, proximity of source populations, refuge areas). Fine scale habitat manipulation of old areas may maintain their suitability for Noisy Scrub-birds. Older heaths (45 years post-fire) may have decreased productivity and hence lowered suitability for Western Whipbirds and Western Bristlebirds. Fire intervals of <10 years will lead to local decline and possible extinction for these 3 species. Fire intervals of >50 years may also be deleterious. Fire management should maintain firebreaks and prevent one fire burning the whole reserve. Long intervals between fires will disadvantage some other early successional birds (e.g. Richard's Pipit, Striated Fieldwren). Long-term fire exclusion may also change the relative extent of heaths and thickets to the disadvantage of one or other of the threatened species. The longevity of many Australian birds means that many which survive fire may live long enough to recolonise. Describes three requirements

for management: detailed information on habitat requirements, data on type and rate of vegetation change post-fire, and information on the relationship of birds with fire regime.

Smith, G. T. (1987b). Observations on the biology of the Western Bristlebird *Dasyornis longirostris*. *Emu*, 87, 111-118.
Western Bristlebird; heath; thicket; threatened species; historic change
Bioregions: Esperance Plains; Jarrah Forest
Western Bristlebirds have disappeared from much of their range over the last 100 years, due to past practice of burning the coastal heaths and thickets every two or three years to provide cattle feed. Clearing and draining swamps have also contrubuted to the decline. Home ranges were established 9 years post-fire (adjacent to gullies) and 11-14 years post-fire (drier areas) at sites relatively distant from existing populations, and 4-6 years post-fire at sites adjacent to or within 2km of existing populations. The preferred short closed heaths are suitable 3 years after fire (in wet areas) or 6-10 years after fire (drier areas). Oldest suitable age is not known, but birds are present in 45 year heath (although less abundant than in 20 year old heath). While old heaths are probably structurally suitable, their productivity may have declined. Thickets and more swampy vegetation may be less vulnerable to fire and provide important refuges after fire.

Smith, G. T. (1991). Ecology of the Western Whipbird *Psophodes nigrogularis* in Western Australia. *Emu*, 91, 145-157.
Western Whipbird; mallee; heath; thicket
Bioregions: Esperance Plains; Jarrah Forest
Western Whipbirds in southwestern Australia are most abundant in dense coastal thickets. Population increases at some sites are due to absence of fire (up to at least 50 years). In general fire intervals of less than 10 years will lead, or has led, to extinction of local populations. Notes that fire effects will differ according to vegetation type (for example between Victorian mallee and southwestern Australian heath).

Smith, G. T., & Forrester, R. I. (1981). The status of the Noisy Scrub-bird *Atrichornis clamosus*. *Biological Conservation*, 19, 239-254.
Noisy Scrub-bird; heath; eucalypt open forest; thicket; threatened species; management
Bioregion: Jarrah Forest
Fire suppression at remaining colony sites has helped to increase the numbers of Noisy Scrub-birds.

Smith, G. T., & Robinson, F. N. (1976). The Noisy Scrub-bird: an interim report. *Emu*, 76, 37-42.
Noisy Scrub-bird; eucalypt open forest; threatened species; thicket; heath; historic change
Bioregion: Jarrah Forest
The dramatic disappearance of the Noisy Scrub-bird soon after European colonisation certainly resulted from frequent devastating fires and the clearing and burning of eucalypt forests. However total fire exclusion may eventually render habitat unsuitable.

Smith, L. H. (1994). A critical analysis of the factors responsible for the decline of the Superb Lyrebird *Menura novaehollandiae* in Sherbrooke Forest, Victoria. *Australian Bird Watcher*, 15, 238-249.
Superb Lyrebird; eucalypt open forest; control burning; management
Bioregion: South eastern Highlands
Population of Superb Lyrebirds has declined, partly through fox predation and through understorey change (reduction in open leaf litter and increase in grass cover), during a period when former frequent burning was replaced by fire exclusion. A firebreak maintained by burning and slashing was abandoned by Lyrebirds when it became overgrown following cessation of burning.

Smith, P. (1989). Changes in a forest bird community during a period of fire and drought near Bega, New South Wales. *Australian Journal of Ecology*, 14, 41-54.
eucalypt open forest; community; rainforest; wildfire; succession
Bioregion: South East Corner
A forest bird community was monitored for 3 years, during which it was partly burnt by wildfire and affected by severe drought. The fire affected mainly the undergrowth, especially on ridges:

gullies were mainly left unburnt. Changes in the bird community were limited. Differences in species were restricted to rare visitors. The distribution of insectivorous birds contracted (and the species declined) in the year following fire; nectarivorous and frugivorous species expanded and became more abundant (due to prolific flowering and fruiting in the second year of the study, possibly because of the fire). 10 species (Eastern Yellow Robin, Crested Shrike-tit, Golden Whistler, Rufous Fantail, Superb Fairy-wren, White-browed Scrubwren, Brown Gerygone, Brown Thornbill, Lewin's Honeyeater, Silvereye) declined in burnt areas in the 2 years following fire: all, other than Crested Shrike-tit, were birds which feed, nest or shelter in dense shrubby understorey. For seven resident species, colour-banding allowed assessment of changes in territory. For 6 of these species (especially Brown Thornbill), the number of territories declined post-fire, with loss of colour-banded birds from the site and/or contraction to unburnt patches. In the year post-fire many species bred at atypical times, possibly related to flush of resources. Recovery of populations had not reached pre-fire levels two years after fire, which is slower than that reported in other studies. This may have been because of drought, and suggests that a range of variables may affect recolonisation. The resilience of the community was related to the role of unburnt areas, particularly wet gullies.

Smith, P. J., Pressey, R. L., & Smith, J. E. (1994). Birds of particular conservation concern in the Western Division of New South Wales. *Biological Conservation*, 69, 315-338.

threatened species; review; mallee; eucalypt woodland; Acacia woodland; management

Bioregions: Murray Darling Depression; Broken Hill Complex; Mulga Lands; Channel Country; Simpson-Strzelecki Dunefields

Reviews change in abundance and threats for bird species in the Western Division of New South Wales. The most frequently-mentioned threats are overgrazing, introduced predators, clearing and altered fire regimes (in that order). Fire is a threat particularly to mallee birds, especially the frequent occurrence of extensive wildfires. Altered fire regime is listed as a threat for 15 taxa (Black-eared Miner, Malleefowl, Red-lored Whistler, Regent Parrot, Scarlet-chested Parrot, Striated Grass-wren, Glossy Black-cockatoo, Turquoise Parrot, Southern Scrub-robin, Shy Heath-wren, Chestnut Quail-thrush, Black-winged Currawong, Gilbert's Whistler, Jacky Winter and Golden Whistler).

Smith, P. J., Smith, J. E., & Pressey, R. L. (1995). *Birds of particular conservation concern in the Western Division of New South Wales: distribution, habitats and threats*. NSW National Parks and Wildlife Service.

threatened species; review; mallee; eucalypt woodland; Acacia woodland; hummock grassland; tussock grassland; management

Bioregions: Murray-Darling Depression; Broken Hill Complex; Mulga Lands; Channel Country; Simpson-Strzelecki Dunefields.

Reviews the threatening processes for threatened bird taxa in the Western Division of NSW. Fire is one of the major threats, particularly for mallee birds.

Smith, S., & Baker-Gabb, D. (1993). *Rufous Bristlebird Dasyornis broadbenti*. Department of Conservation and Natural Resources.

Rufous Bristlebird; threatened species; thicket; control burning; wildfire.

Bioregions: Naracoorte Coastal Plain; South east Coastal Plain

Reviews information on the species (in Victoria). Wildfire or inappropriate (control) burning regimes are a threat throughout its range. Management requires determination and implementation of a preferred fire regime, however this may conflict with protection of property (or current legislation).

Sonter, C. (1984). The Yellow-rumped Pardalote - a declining bird in Sunraysia? *Australian Bird Watcher*, 10, 234-235.

Yellow-rumped Pardalote; wildfire; mallee; eucalypt woodland

Bioregion: Murray-Darling Depression

Combination of bushfires, clearing and drought may have led to the decline of this species.

Specht, R. L. (1981). Responses to fires in heathlands and related shrublands. In A. M. Gill, R. H. Groves, & I. R. Noble (Eds.), *Fire and the Australian biota* (pp. 395-415). Canberra: Australian Academy of Science.
heath; review
Yellow-tailed Black-cockatoos visited a heathland soon after fire to feed from grubs attracted to the fire-induced flowering of Xanthorrhoea. Honeyeaters recolonised when woody plants replaced the more herbaceous short-lived plants. Black cockatoos returned to mature heaths to tear apart Banksia flowers.

Stanton, J. P. (1992). J.P. Thomson oration. The neglected lands: recent changes in the ecosystems of Cape York Peninsula and the challenge of their management. *Journal of the Queensland Geographical Society*, 7, 1-18.
Cassowary; management; threatened species; tropical eucalypt open forest; rainforest; hollows.
Bioregion: Cape York Peninsula
The maintenance of the preferred habitat of the Cassowary (ecotone between rainforest and wet eucalypt open forest) requires a regime including frequent fire. Preservation of trees bearing hollows suitable for nesting birds may require control burning at times when fuel moisture is high.

Stanton, P. (1995). A tropical Queensland perspective. In D. B. Rose (Ed.), *Country in flames. Proceedings of the 1994 symposium on biodiversity and fire in North Australia* (pp. 71-76). Canberra: Department of the Environment, Sport and Territories, and North Australia Research Unit.
tropical eucalypt open forest; rainforest; tussock grassland; management; threatened species; Golden-shouldered Parrot; Palm Cockatoo; Cassowary.
Bioregion: Cape York Peninsula
Present fire regime is leading to expansion of rainforest at the expense of wet eucalypt forests, to the detriment of Palm Cockatoo and Cassowary. It is also leading to invasion of grassy flats by Melaleuca, threatening the Golden-shouldered Parrot.

Starks, J. (1987). *The status and distribution of the Black-eared Miner (Manorina melanotis) in Victoria. Technical report no.49*. Arthur Rylah Insitute of Environmental Research.
Black-eared Miner; mallee; threatened species
Bioregion: Murray Darling Depression
The endangered Black-eared Miner is associated with long-unburnt mallee, and the limited extent of such old vegetation is a factor in its threatened status.

Stephens, S. (1992). *Endangered species and communities and threatening processes in the Murray Mallee*. Australian National Parks and Wildlife Service.
mallee; review; management; threatened species
Bioregion: Murray Darling Depression
Altered fire regime has contributed to the decline of 8 (sic) bird species (Beautiful Firetail, Black-eared Miner, Chestnut Quail-thrush, Chestnut-rumped Heath-wren, Crested Shrike-tit, King Quail, Mallee Emu-wren, Mallee-fowl, Night Parrot, Orange-bellied Parrot, Red-lored Whistler, Red-tailed Black-cockatoo, Rufous Bristlebird and Rufous Field-wren) in the Murray Mallee (the fourth-ranking threat after overgrazing, introduced predators and clearing). Includes discussion of management and research options and priorities.

Stocker, G. C. (1971). The age of charcoal from old jungle fowl nests and vegetation change on Melville Island. *Search*, 2, 28-30.
Orange-footed Scrubfowl; charcoal; historic change; rainforest; Aboriginal burning
Bioregion: Top End Coastal
Recent changes in fire regimes have led to retreat of rainforests, marked by the occurrence of abandoned mounds of scrubfowl in areas which are now eucalypt open forests.

Stokes, T. (1975). The effect of a bushfire on the banding of Flame Robins in the Brindabella Ranges. *Australian Bird Bander*, 13, 75-76.
Flame Robin; wildfire; eucalypt open forest
Bioregion: South Eastern Highlands
In 28 months following hot wildfire in montane eucalypt forest, Flame Robins were far more abundant in burnt than unburnt areas.

Suckling, G. C., & MacFarlane, M. A. (1983). The effects of fire on fauna - a review. In E. Ealey (Ed.), *Fighting fire with fire*. (pp. 107-128). Melbourne: Monash University.
review; eucalypt open forest; wildfire; control burning; management
Few studies of effects of fire on fauna other than mammals. Summarises existing data for birds, in terms of effect of fire intensity, frequency and season. Few birds are killed by low intensity fires, but many may subsequently die through predation or starvation. In contrast, immediate mortality may be high with intense fires. Fire intensity affects vegetation structure, which has more important long-term implications for birds. More refuge areas may be left by low intensity fires. Some birds (e.g. Flame Robin) prefer severely burnt areas to unburnt forests. Return of bird communities is probably quicker after low-intensity fires. In open forests, understorey may require more frequent fires than overstorey, and the number of birds in the understorey may decline in old forests. Ground-feeding birds (e.g. Superb Lyrebird, Superb Fairy-wren, Bassian Thrush, Eastern Yellow Robin) may require periodic fires. Other species (e.g. Noisy Scrub-bird) cannot survive frequent fire. There are no data on the time of year at which birds are most susceptible to fire, though effects may be greatest during the breeding season.

Swanson, N. M. (1976). Seabird Islands: No. 32. Mutton Bird Island, New South Wales. *Australian Bird Bander*, 14, 88-91.
seabirds; tussock grassland
Bioregion: NSW North Coast
Fires have led to erosion and spread of exotic grasses. Nesting birds took about 4 years to fully re-use a site that had been severely burnt.

Tarr, H. E. (1965). The Mallee-Fowl in Wyperfeld National Park. *Australian Bird Watcher*, 2, 140-144.
Malleefowl; threatened species.
Bioregion: Murray-Darling Depression
Mallee may be unsuitable for Malleefowl for up to 10-20 years post-fire.

Taylor, R. J. (1991). *Fauna conservation in production forests in Tasmania*. Hobart: Forestry Commission Tasmania.
review; forestry; eucalypt open forest; control burning; management
Reviews impacts of control burning and wildfire on birds (and other fauna) in eucalypt forests. In general, effects of mild control fires are short-term and minor, though long-term changes in understorey as a result of frequent control fires may lead to more substantial changes in the bird assemblage. Regeneration of wet sclerophyll eucalypt forests may require hot burns. Species such as Grey Goshawk and hollow-nesting species require, or are more abundant in, old-growth forests.

Tidemann, S. C. (1990). Relationships between finches and pastoral practices in northern Australia. In J. Pinowski & J. D. Summers-Smith (Eds.), *Granivorous birds and agriculture* (pp. 305-315). Warsaw: PWN-Polish Scientific Publishers.
tropical eucalypt savanna woodland; tussock grassland; management
Bioregions: Victoria Basin; Ord-Victoria Plains; Sturt Plateau
Across 21 trapping sites, there was no relationship between number of finches and a general measure of fire extent on pastoral properties (although this measure was not related closely to the fire history of the actual site); in contrast, there was a significant negative relationship with cattle density.

Tidemann, S. C. (1992). *Conservation of the Gouldian Finch, N.T.* World Wide Fund for Nature.
Gouldian Finch; threatened species; tropical eucalypt savanna woodland; management; control burning
Bioregions: Daly Basin; Victoria-Bonaparte; Ord-Victoria Plains
Management of the Gouldian Finch should require controlled burning of the breeding sites early in the dry season, to prevent late dry season destructive fires.

Tidemann, S. C. (1993a). Management of a threatened species: the Gouldian Finch example. In C. P. Catterall, P. V. Driscoll, K. Hulsman, D. Muir, & A. Taplin (Eds.), *Birds and their habitats: status and conservation in Queensland* (pp. 123-131). St Lucia: Queensland Ornithological Socity Inc.
Gouldian Finch; tropical eucalypt savanna woodland; tropical eucalypt open forest; threatened species; management; control burning
Sorghum seeds are important in the diet of the threatened Gouldian Finch, but their abundance is reduced by early dry season burning, and early wet season burning can eliminate annual Sorghum.

Tidemann, S. C. (1993b). Where are Gouldian Finches after the breeding season? *Victorian Naturalist*, 110, 238-243.
Gouldian Finch; tropical eucalypt savanna woodland; threatened species; control burning; wildfire
Bioregion: Daly Basin
Within weeks of a hot fire, Gouldian Finch activity was monitored in a cool burnt (April) and a hot burnt (October) area. Early in the morning, birds tended to feed in the hot burnt area (where fallen seeds were less hidden by regrowth), but would fly to the cool area (which had more foliage in canopies) when disturbed. Later in the morning, birds moved to feed in the cool burnt area. Temperatures on the ground were hotter in the hot burnt area (to 56°C). Cool fires occur during the nesting season, but the hollow-nesting Gouldian Finches are unaffected.

Tidemann, S. C., McArtney, J., & Smith, I. (1993). Queensland Gouldian Finches *Erythrura gouldiae* and air-sac mite *Sternostoma tracheacolum*. *Sunbird*, 23, 36-40.
Gouldian Finch; tropical eucalypt savanna woodland; threatened species; management; control burning
Bioregion: Mount Isa Inlier
Pastoralists burning during the early Wet season may have reduced the availability of Sorghum, reducing the survival of Gouldian Finch.

Tingay, A., & Tingay, S. R. (1982a). Seabird Islands: No. 113. Middle Island, Archipelago of the Recherche, Western Australia. *Corella*, 6, 49-50.
seabirds; tussock grassland; heath; eucalypt open forest
Bioregion: Esperance Plains
A fire burnt uncontrolled on the Island for nearly 4 weeks in January-February 1977, destroying most vegetation. "The effect of the holocaust on breeding seabirds is not known."

Tingay, A., & Tingay, S. R. (1982b). Seabird Islands: No. 118. Hood Island, Archipelago of the Recherche, Western Australia. *Corella*, 6, 59-60.
seabirds; heath
Bioregion: Esperance Plains
"Fire is an everpresent threat" to seabirds breeding on Hood Island.

Tingay, A., & Tingay, S. R. (1982c). Seabird Islands: No. 120. Sandy Hook Island, Archipelago of the Recherche, Western Australia. *Corella*, 6, 63-64.
seabirds; tussock grassland; heath
Bioregion: Esperance Plains
The main threat to the breeding seabirds is the risk of fire caused by human visitors.

Tingay, A., & Tingay, S. R. (1984). *Bird communities in the karri forest of Western Australia*. Australian Conservation Foundation.
eucalypt open forest; community; forestry; control burning; management
Bioregion: Warren
Bird distributions were monitored in a series of plots of varying age in Karri forests, especially relating to forestry. Cool burns in mature forest initially cause a short-term decrease in total abundance of birds, followed by an increase of small insectivores occurring in low vegetation. These then decline as the shrubs regenerate. Species richness and abundance peaked at 6 years post-fire. However some species were more common in long-unburnt forests. The bird communities in mature forests showed more seasonal stability than those in 50-year old regeneration.

Tolhurst, K. (1996). Effects of fuel reduction burning on fauna in a dry sclerophyll forest. In DEST (Ed.), *Fire and biodiversity: the effects and effectiveness of fire management. Proceedings of the conference held 8-9 October 1994, Footscray, Melbourne* (pp. 113-121 (&129)). Canberra: Department of the Environment, Sports and Territories.
control burning; eucalypt open forest
Describes experiment with 15ha treatments and replicates, with range of controlled fire regimes. Only results following 1 year of treatment are presented. "Bird abundance and species composition remained remarkably stable on burnt and unburnt areas. The main changes observed after burning were influxes of some species inhabiting understorey, and influx of some species (e.g. scarlet robin, flame robin) which fed on eucalypt nectar. The latter is of some interest, as such influxes have not been reported in previous studies of prescribed burning". Notes the caveat that the study area was small, and no part of any burnt site was more than 300m from unburnt forest. Also notes that the pre-fire understorey was relatively open - hence the responses may be more pronounced in forests with denser understorey.

Trickett, T. (1983). Geelong garden birds on the days of dust-storm and bushfire. *Geelong Naturalist*, 20, 28-29.
wildfire
Bioregion: South east Coastal Plain
Lorikeets and some other birds were behaving strangely in a garden on the day of extreme winds, smoke and nearby fire.

Turner, R. J. (1987). Effect of fire on birds - Weddin Mountain. In *Disappearing islands. Proceedings of a seminar on conservation and co-operation in the Central West* (pp. 66-86). Bathurst: National Parks and Wildlife Service, NSW.
Callitris woodland; eucalypt woodland; wildfire; community; succession
Bioregion: NSW South western Slopes
Burnt and unburnt vegetation was surveyed 8 months, and 8 years 8 months, after an intense wildfire. At 8 months post-fire, the abundance and richness of bird species was significantly less in burnt than in unburnt vegetation. Species which were more abundant in unburnt vegetation included: Crested Pigeon, cuckoos, Rainbow Bee-eater, Speckled Warbler, White-browed Babbler, White-plumed Honeyeater, Little Friarbird, Yellow-faced Honeyeater, Chestnut-breasted Mannikin, White-browed Wood-swallow, Superb Fairy-wren and Mistletoebird. Species more common in the burnt areas included Emu, White-winged Triller and Dusky Wood-swallow. At 8 years 8 months post-fire, the abundance and richness of birds was greater in burnt area (7.3 birds per observer-hour) than unburnt (3.8 birds per observer-hour). Species more common in burnt area included: Galah, Cockatiel, Turquoise Parrot, Rainbow Bee-eater, Black-faced Cuckoo-shrike, White-winged Triller, Superb Fairy-wren, Western Gerygone, Rufous Songlark, Grey Fantail, Brown Treecreeper, Varied Sittella, Grey-fronted Honeyeater, White-naped Honeyeater, Noisy Friarbird and Dusky Wood-swallow. Golden Whistler and Speckled Warbler were more abundant in the unburnt forest. These differences were considered to be due to release of nutrients after fire, which allowed vigorous regrowth of wattles, other shrubs and eucalypts and which probably supported greater abundance of insects.

Turner, R. J. (1992). Effect of wildfire on birds at Weddin Mountain, New South Wales. *Corella*, 16, 65-74.
eucalypt woodland; Callitris woodland; wildfire; community; succession
Bioregion: NSW South western Slopes
Birds were surveyed 8 months and 8.7 years after wildfire, including comparison with adjacent unburnt areas. At 8 months post-fire there were fewer species and individuals in burnt (50 spp, 225 individuals) than unburnt (59 spp, 400 individuals) areas. At 8.7 years post-fire, there were more species and individuals in the burnt area (87 spp, 660 individuals) than unburnt (63 spp, 340 individuals) area. Ground-foraging, foliage-gleaning, aerial, nectarivorous, granivorous, trunk-gleaning and frugivorous birds increased significantly from 8 months to 8.7 years post-fire. Recruitment may have been limited because the site was largely surrounded by cleared farmlands. The intense fire at this site led to increase in the dominance of eucalypts at the expense of Callitris. By 8 years post-fire, Rufous Songlark, parrots, Black-faced Cuckoo-shrike, Superb Fairy-wren, Grey Fantail, Varied Sittella and Apostlebird were more common in the burnt area than unburnt sites.

Venn, D. R., & Fisher, J. (1993). *Red-tailed Black-Cockatoo Calyptorhynchus banksii graptogyne*. Department of Conservation and Natural Resources.
Red-tailed Black-Cockatoo; eucalypt woodland; wildfire; management; threatened species; hollows.
Bioregions: Naracoorte Coastal Plain; Murray-Darling Depression.
Reviews information on this species. Wildfire can have a devestating effect on this species, leading to death of River Red Gum and Yellow Gum, and hence removing food sources and nesting trees. Impacts of fuel reduction burning are not known, but hot fires may reduce the availability of fruits (of Brown Stringybark) for up to 3 years. These factors should be further researched. Firewood collection is likely to be detrimental to this species.

Verbeek, N. A. M., Braithwaite, R. W., & Boasson, R. (1993). The importance of *Pandanus spiralis* to birds. *Emu*, 93, 53-58.
pandanus; community
Bioregion: Top End Coastal
Disturbance due to increasingly intense fires may have reduced pandanus thickets and their associated birds, though little evidence is available.

Walker, T. A., & Hulsman, K. (1993). Seabird Islands: No. 221. Wilson Island, Great Barrier Reef, Queensland. *Corella*, 17, 155-157.
seabirds; pandanus; tussock grassland
Bioregion: South Eastern Queensland
Previous dominance by Pandanus has been much reduced by burning. This reduction has led to decline of Wedge-tailed Shearwaters. The island was set on fire in the 1960s and 1970s, which would have caused mortality to breeding seabirds. Bridled Terns were probably most affected.

Wall, C. A. (1989) *Post-fire dynamics of the vegetation, habitat and population of the Ground Parrot at Barren Grounds Nature Reserve, New South Wales*. B.Sc. (Hons.), University of New South Wales.
Ground Parrot; heath; threatened species
Bioregion: South East Corner

Wardell-Johnson, G., & Christensen, P. (1992). A review of the effects of disturbance on wildlife of the karri forest. In *Research on the impact of forest management in south-west Western Australia* (pp. 33-57). Perth: Department of Conservation and Land Management (Occasional Paper 2/92).
eucalypt open forest; management; review; control burning
Bioregion: Warren
Historic changes in the bird community in south-western Australia were mainly from heaths as a result of frequent burning. Reviews studies on the effects upon birds of fuel-reduction burning in Karri forests. Generally, small decrease in abundance of understorey birds for a few months after burning, followed by increase to above pre-burn levels within 1-2 years post-fire. Many individuals remain in the same locality after fire.

Wardell-Johnson, G., & Nichols, O. (1991). Forest wildlife and habitat management in southwestern Australia: knowledge, research and direction. In D. Lunney (Ed.), *Conservation of Australia's forest fauna* (pp. 161-192). Mosman: Royal Zoological Society of NSW.
eucalypt open forest; review; control burning; wildfire; management
Bioregions: Jarrah Forest; Swan Coastal Plain; Warren
Reviews studies dealing with fire, bird communities and their relationship in forests of southwestern Australia. Describes an ongoing study of birds in 67 plots, of which nearly half have been burnt.

Wardell-Johnson, G., McCaw, W. L., & Masey, K. G. (1989). Critical data requirements for the effective management of fire on nature conservation lands in south Western Australia. In N. Burrows, L. McCaw, & G. Friend (Eds.), *Fire management on nature conservation lands* Perth: Department of Conservation and Land Management.
eucalypt open forest; heath; review; management; threatened species; control burning
Bioregions: Jarrah Forest; Warren; Swan Coastal Plain
Fire management plans need to be associated with monitoring of threatened and key species.

Watkins, D. (1985). *Report of the R.A.O.U. Ground Parrot survey in Western Australia*. Royal Australasian Ornithologists Union.
Ground Parrot; heath; threatened species
Bioregions: Esperance Plains; Jarrah Forest; Warren
Ground Parrots were recorded only in diverse shrub-heathlands unburnt for at least 16 years.

Watkins, D., & Burbidge, A. H. (1992). Conservation of the Ground Parrot in Western Australia. In L. Joseph (Ed.), *Issues in the Conservation of Parrots in Australasia and Oceania: Callenges to Conservation Biology. Proceedings of the RAOU/WWF Scientific Day and Workshop, Sydney, 22-23 September 1990.* (pp. 46-49). Melbourne: RAOU.
Ground Parrot; threatened species; management; heath; wildfire
Bioregion: Esperance Plains
In WA, the Ground Parrot has been recorded from heaths of 15-35 years after fire, though individuals may sometimes forage in the edge of adjacent areas that have been burnt more recently. These preferred ages are appreciably greater than those reported for mainland eastern Australia. Wildfire is the major threat to this subspecies. Recent extensive wildfires have probably greatly reduced populations, including in national parks.

Webster, R., & Ahern, L. (1992). *Management for conservation of the Superb Parrot (Polytelis swainsonii) in New South Wales and Victoria*. Department of Conservation and Natural Resources.
Superb Parrot; threatened species; eucalypt woodland; control burning; management
Bioregion: Riverina
For the Superb parrot, the impacts of control burning are unclear, but may include reduction in food availability during the breeding or post-breeding period (and hence reduced breeding success), change in vegetation structure or composition (possibly including invasion by exotic plants), and damage or destruction of nest sites. However, control burning may provide a tool for increasing food resources or other habitat characteristics. Recommends that nest sites be given priority protection during fire suppression, that control burns not occur around nest sites (unless slashing is done first), that extensive control burns not occur in major feeding sites, that planned burning within the breeding range should occur between May and July, and that more research be directed at the effects of fire.

Wegener, A. (1984a). Animals killed by bushfires in coastal Victoria, February 1983. *Australian Bird Watcher*, 10, 248-250.
mortality; wildfire
Bioregions: South east Coastal Plain; South Eastern Highlands
Dead birds found on the beach following the Ash Wednesday bushfires were counted. 55 species were recorded, the most common being Crimson Rosella, Red Wattlebird and New Holland Honeyeater. Many were badly burnt, but others showed no signs of burns. The northerly winds blew the fire towards the coastline and many birds had tried to escape by flying out to sea.

Wegener, A. (1984b). Survey of animal species killed by the Ash Wednesday fires along the Great Ocean Road. *Geelong Naturalist*, 21, 13-16.
mortality; eucalypt open forest
Bioregion: South east Coastal Plain
Count of 55 bird species washed up along the beach immediately after hot wildfire. The most common dead birds were Crimson Rosella, New Holland Honeyeater and Red Wattlebird. Many were badly burnt, but some appeared undamaged and were presumably asphyxiated.

Whelan, R. J. (1995). *The ecology of fire*. Cambridge: Cambridge University Press.
review
Reviews many aspects of fire ecology. For birds, recommends more long-term studies with banded birds and research into possible ecological disadvantages of control burning.

White, G. (1979a). Seabird islands: No. 75. Louisa Island, Tasmania. *Corella*, 3, 61-62.
seabirds; mortality; tussock grassland
Bioregion: West and South West
"A very severe fire was lit on the island in recent years and burnt for several weeks extending over most parts and reportedly killing countless thousands of breeding shearwaters."

White, G. (1979b). Seabird Islands: No. 76. De Witt Island, Tasmania. *Corella*, 3, 63-65.
seabirds; eucalypt open forest; heath; tussock grassland; mortality
Bioregion: West and South West
Fishermen frequently set fire to the vegetation causing heavy casualties among the penguin colonies. Three fires in 1975 and 1976 reduced the population of breeding penguins by almost one thousand, with even greater toll of chicks.

White, G. (1979c). Seabird Islands: No. 77. Flat Witch Island, Tasmania. *Corella*, 3, 66-67.
seabirds; mortality; heath; tussock grassland
Bioregion: West and South West
Fires are occasionally lit during the seabird nesting season and undoubtedly kill many seabirds.

White, G. (1979d). Seabird Islands: No. 79. Flat Island, Tasmania. *Corella*, 3, 70-72.
seabirds; tussock grassland; mortality
Bioregion: West and South West
Fires are uncommonly lit during the seabird breeding season, leading to some losses of breeding birds.

Whitley, G. P. (1944). Fire and Petrels: the mystery of Mondrain Island. *Emu*, 44, 6-7.
seabirds; tussock grassland; heath; mortality
Bioregion: Esperance Plains
Many breeding shearwaters were killed on Mondrain Island in an extensive fire.

Whitley, G. P. (1971). Field notes on birds by Thomas Carter. *Western Australian Naturalist*, 12, 41-44.
Western Whipbird; heath; threatened species; historic change.
Bioregion: Warren
Frequent firing of heaths probably led to the local extinctions of Western Whipbirds.

Whittell, H. M. (1936). The Bristle-birds of Western Australia. *Emu*, 35, 197-201.
Western Bristlebird; Rufous Bristlebird; heath; wildfire; threatened species
Bioregion: Warren
Reports from Whitlock that Western Bristlebird disappeared from an area after severe fire.

Williams, J. E., & Gill, A. M. (1995). *The impact of fire regimes on native forests in eastern New South Wales*. NSW National Parks and Wildlife Service.
review; eucalypt open forest; management; control burning; wildfire; forestry; historic change; Aboriginal burning
Bioregions: South East Corner; South Eastern Highlands; Sydney Basin; NSW North Coast; New England Tableland
Broad review of ecological impacts of fire in eastern NSW. For birds, responses "depend to some extent on fire intensity … Unburnt patches provide important resources … Species occupying the lower vegetation strata are … likely to be most affected by the changes in vegetation structure caused by fire … Following fire of low to moderate intensity, a rapid recovery in both numbers and species composition is generally observed, whereas the recovery process after more intense fires is usually slower."

Wilson, B. A. (1996). Fire effects on vertebrate fauna and implications for fire management and conservation. In DEST (Ed.), *Fire and biodiversity: the effects and effectiveness of fire management. Proceedings of the conference held 8-9 October 1994, Footscray, Melbourne* (pp. 131-147). Canberra: Department of the Environment, Sports and Territories.
review
Reviews studies on responses of birds (and other vertebrates) to fire. Recommends increased synthesis and modelling (across a range of scales); longer-term studies; effects of fire interacting with other factors (e.g. predation); and improved communication between researchers and managers. Also, notes far more studies for plants than for animals.

Wilson, R. I. (1981). The woodchip industry and Tasmanian birds. *Tasmanian Bird Report*, 11, 11-14.
forestry; eucalypt open forest; Spotted Quail-thrush; management; control burning
Fire regimes may exacerbate or ameliorate forestry effects. For example, the Spotted Quail-thrush may better tolerate logging if the forest is allowed to regenerate without use of fire.

Wilson, S. J. (1995). Survival of Brown and Striated Thornbills in the Brindabella Range, Australian Capital Territory. *Corella*, 19, 138-146.
Brown Thornbill; Striated Thornbill; eucalypt open forest; wildfire.
Bioregion: South Eastern Highlands
Wildfire burnt about half of a study site in the middle of a 20-year study. Banding and survival data are presented on a year-by-year basis, though the effects of fire are not analysed.

Woinarski, J. C. Z. (1987). Notes on the status and ecology of the Red-lored Whistler *Pachycephala rufogularis*. *Emu*, 87, 224-231.
Red-lored Whistler; mallee; heath; threatened species
Bioregion: Murray Darling Depression
Red-lored Whistlers prefer mallee vegetation of 5-30 years post-fire, probably because they require dense low cover under relatively open mallee canopies. Consequently, long intervals of fire exclusion may lead to the loss of this species.

Woinarski, J. C. Z. (1989a). Broombush harvesting in southeastern Australia. In J. C. Noble & R. A. Bradstock (Eds.), *Mediterranean landscapes in Australia: mallee ecosystems and their management* (pp. 362-378). Melbourne: CSIRO.
mallee; heath; management; community; succession
Bioregion: Murray Darling Depression
Although few bird species were restricted to particular age classes of vegetation, for 18 of 26 commonly-recorded species, there was significant variation in density between sites with different post-disturbance age. Shy Heath-wren, Tawny-crowned Honeyeater and Chestnut Quail-thrush favoured young (<10 years) regrowth; Yellow Thornbill, White-browed Babbler and Malleefowl favoured old (>30 years) vegetation.

Woinarski, J. C. Z. (1989b). The vertebrate fauna of broombush *Melaleuca uncinata* vegetation in north-western Victoria, with reference to effects of broombush harvesting. *Australian Wildlife Research*, 16, 217-238.
mallee; heath; community; succession; management
Bioregion: Murray Darling Depression
Bird assemblages were sampled in mallee broombush stands 4,8,26,40 and 60-80 years post-fire, 3 years after a severe frost, and 1-2,3,4-5 and 6-10 years after vegetation harvesting. Invertebrates were least abundant in old vegetation. There was substantial change in bird species composition from young to old vegetation. Species characteristic of areas burnt recently (<10 years) included Chestnut Quail-thrush and Shy Heath-wren. Species most common in intermediate ages (10-30 years post-fire) included Southern Scrub-robin and Red-lored Whistler. Species most common in older vegetation included Malleefowl and Gilbert's Whistler. There were some differences in bird species composition between sites regrowing for comparable periods after fire, frost and cutting (with burnt sites having fewest species and individuals, possibly because more trees were retained with frost and cutting disturbances).

Woinarski, J. C. Z. (1990). Effects of fire on the bird communities of tropical woodlands and open forests in northern Australia. *Australian Journal of Ecology*, 15, 1-22.
tropical eucalypt open forest; tropical eucalypt savanna woodland; community; succession
Bioregions: Top End Coast; Daly Basin.
Two studies are reported: a short-term response to fires at 3 times during the dry season, and longer-term responses to four fire regimes maintained over 14 years. Of 11 common species, 6 showed significant differences between long-term fire treatments (fire exclusion, annual early dry season burn, annual late dry season burn, biennial early burn): White-throated Honeyeater, Weebill and Lemon-bellied Flycatcher were all significantly more common in unburnt plots and then in plots burnt biennially, and Pied Butcherbird, Blue-winged Kookaburra and Magpie-lark were absent in unburnt plots. In general, granivores were most common in the early burnt plots, carnivores were least common in unburnt plots, and foliage-gleaners, branch-gleaners and nectarivores were most common in unburnt plots. These differences were

related to variation in extent and composition of understorey. With short-term responses, early dry season burns were relatively cool and localised, and a wide range of bird species (Gouldian Finch, Long-tailed Finch, Masked Finch, Galah, Cockatiel, Magpie-lark, Grey-crowned Babbler, Pied Butcherbird, Black-faced Wood-swallow and Black-tailed Treecreeper) were more common in burnt areas from 3 days to 4 months after fire. This attraction was less pronounced beyond 4 months post-fire, possibly because of greater extent then of burnt areas outside the study site. Several other species (Tree Martin, White-breasted Wood-swallow, Black Kite, Torresian Crow and Brown Falcon) moved into the study site when fires were burning. Only one species (Red-backed Fairy-wren) showed short-term decline in burnt areas. There was little short-term response to the late fire, either because it destroyed more of the seed resources, or because of the greater regional extent of burnt areas. Many species in this region probably track fires to take advantage of the consequent rich food resources or greater access to food (through clearing of the dense grass layer). In comparison to temperate forests, there appears to be a greater positive response of birds to cool burns, and a less obvious long-term successional response. The latter may be because the prevalence of fire prevents any substantial vegetation succession in tropical eucalypt open forests.

Woinarski, J. C. Z. (1992). The conservation status of the White-throated Grasswren *Amytornis woodwardi*, an example of problems in status designation. *Northern Territory Naturalist*, 13, 1-5.
White-throated Grasswren; hummock grassland
Bioregion: Pine Creek Arnhem
White-throated Grasswren densities were less in recently burnt (<1yr) sites, and some populations may have been eliminated by repeated hot fires. The fire regime of the Arnhem Land massif is undergoing substantial change, probably to the detriment of this species, and its existence may be threatened by the current regime.

Woinarski, J. C. Z. (1993a). Australian tropical savannas, their avifauna, conservation status and threats. In C. P. Catterall, P. V. Driscoll, K. Hulsman, D. Muir, & A. Taplin (Eds.), *Birds and their habitats: status and conservation in Queensland* (pp. 45-63). St Lucia: Queensland Ornithological Socity Inc.
tropical eucalypt savanna woodland; topical eucalypt open forest; tussock grassland; hummock grassland; review; management
Fire regimes in monsoonal savannas have changed markedly since European colonisation. Limited research in savanna woodlands suggests that early dry season fires attract many birds, those later in the dry season are more detrimental. Fire exclusion may benefit species which feed or nest in shrubby understorey. No research has been undertaken on fire and birds in floodplains. Fire is usually excluded from Mitchell grasslands, which may be disadvantageous for granivorous birds. Recommends more research on fire and birds, particularly in Mitchell and floodplain grasslands.

Woinarski, J. C. Z. (1993b). A cut-and-paste community: birds of monsoon rainforests in Kakadu National Park, Northern Territory. *Emu*, 93, 100-120.
rainforest; community
Bioregion: Pine Creek Arnhem
Relative to larger patches, small rainforest patches tend to be more disturbed by fire (and other factors), and have fewer obligate rainforest bird species. The abundance of several open forest or rainforest margin species (e.g. Pied Butcherbird, Bar-shouldered Dove) within monsoon rainforests was positively correlated with recent extent of fire in rainforest patches.

Woinarski, J. C. Z., & Fisher, A. (1995a). Wildlife of lancewood (*Acacia shirleyi*) thickets and woodlands in northern Australia: 1. variation in vertebrate species composition across the environmental range occupied by lancewood vegetation in the Northern Territory. *Wildlife Research*, 22, 379-411.
Acacia woodlands; community; wildfire
Bioregions: Sturt Plateau; Gulf Fall and Uplands; Ord-Victoria Plains
Many lancewood patches showed impact of fire, and wildfire is the major threat to lancewood. The abundance of 11 bird species (including Peaceful Dove, Singing Honeyeater, Double-barred Finch

and Pied Butcherbird) was significantly negatively associated with fire impact, whereas only 2 species showed positive correlations.

Woinarski, J. C. Z., & Fisher, A. (1995b). Wildlife of lancewood (*Acacia shirleyi*) thickets and woodlands in northern Australia: 2. comparisons with other environments of the region (*Acacia* woodlands, *Eucalyptus* savanna woodlands and monsoon rainforests). *Wildlife Research*, 22, 413-443.
Acacia woodland; rainforest; tropical eucalypt savanna woodland; historic changes
The distributions of bird species offers some support to a formerly extensive continuum from monsoon ranforests to Acacia thickets. Climate change and/or changes in fire regime may have fragmented this vegetation, with consequent expansion of Eucalyptus savanna woodlands.

Woinarski, J. C. Z., & Tidemann, S. C. (1991). The bird fauna of a deciduous woodland in the wet-dry tropics of northern Australia. *Wildlife Research*, 18, 479-500.
tropical eucalypt savanna woodland; community
Bioregion: Daly Basin
Fire, rain, flowering and seeding produce a dynamic patchwork of environments, to which bird species respond by mobility and shifting composition at any site.

Woinarski, J. C. Z., & Tidemann, S. C. (1992). Survivorship and some population parameters for the endangered Gouldian Finch *Erythrura gouldiae* and two other finch species at two sites in tropical northern Australia. *Emu*, 92, 33-38.
Gouldian Finch; tropical eucalypt savanna woodland; threatened species
Bioregions: Daly Basin; Victoria-Bonaparte
Extensive nomadism in Gouldian Finch may be a response to environmental heterogeneity caused by fire, rainstorms, floristic and substrate patterning.

Woinarski, J. C. Z., Eckert, H. J., & Menkhorst, P. W. (1988a). A review of the distribution, habitat and conservation status of the Western Whipbird *Psophodes nigrogularis leucogaster* in the Murray mallee. *South Australian Ornithologist*, 30, 146-153.
Western Whipbird; mallee; heath; threatened species; management
Bioregion: Murray Darling Depression
Previous studies have differed in characterising the preferred age of vegetation used by the Western Whipbird. This study also shows no consistent pattern, with records from 2 years post-fire to at least 40 years post-fire. However, intermediate (10-25 years) ages seem most suitable, but this may change with different floristic associations, or with localised idiosyncracies (such as insect outbreaks). Other terrestrial bird species showing association with seral stages in mallee include Shy Heath-wren and Chestnut Quail-thrush (<10 years post-fire), Southern Scrub-robin (10-30 years), Malleefowl and White-browed Babbler (>30 years). Habitat fragmentation may exacerbate fire effects, reducing chances of refuge and recolonisation. Small-area mosaic burning to maintain a diversity of fire ages is recommended.

Woinarski, J. C. Z., Tidemann, S. C., & Kerin, S. (1988b). Birds in a tropical mosaic: the distribution of bird species in relation to vegetation patterns. *Australian Wildlife Research*, 15, 171-196.
tropical eucalypt open forest; community
Bioregion: Top End Coastal
Tropical eucalypt open forests with a dense shrubby understorey have far richer bird assemblages than those without. This structural complexity is probably related to fire regime, though may also be influenced by moisture availability.

Woinarski, J. C. Z., Whitehead, P. J., Bowman, D. M. J. S., & Russell-Smith, J. (1992). Conservation of mobile species in a variable environment: the problem of reserve design in the Northern Territory, Australia. *Global Ecology and Biogeography Letters*, 2, 1-10.
Gouldian Finch; threatened species; management; tropical eucalypt savanna woodland; tussock grassland
The endangered Gouldian Finch (and other more common species) may exploit landscape patchiness

by following episodic fires or occasional Dry season rainstorms. Changes in distribution related to fire constrain reservation options for this species and conservation planning generally.

Wooller, R. D., & Brooker, K. S. (1980). The effects of controlled burning on some birds of the understorey in Karri forest. *Emu*, 80, 165-166.
eucalypt open forest; control burning; community
Bioregion: Warren
Birds were mist-netted and banded in Karri forest in the year before and after a fuel-reduction burn. The species and number of birds caught were very similar before and after fire. Some species showed quantitative changes. Fairy-wrens were less common, possibly because of changed food resources or less cover. Black-faced Cuckoo-shrike and Rufous Treecreeper increased, possibly because of more open understorey. Six individuals (of 5 spp) were retrapped at the same location after fire.

Wooller, R. D., & Calver, M. C. (1988). Changes in an assemblage of small birds in the understorey of dry sclerophyll forest in south-western Australia after fire. *Australian Wildlife Research*, 15, 331-338.
eucalypt open forest; control burning
Bioregion: Jarrah Forest
Mist-netting and banding of understorey birds was conducted 2 months before a cool burn, then 2,7,10,22 and 34 months post-fire in a Jarrah forest. Although the fire was mild, limited in extent and left much surrounding vegetation unburnt, the total number of birds caught after the fire was about half that of before fire. 22% of marked birds were recaptured after fire. After the fire, birds ate relatively more ants but fewer beetles, than before fire. Prey size was smaller after the fire than before. Dietary diversity of insectivorous birds declined post-fire. Abundance of all prey types (including ants) decreased after fire. One common species (Splendid Fairy-wren) pre-fire disappeared for 10 months post-fire. One species absent before fire (Scarlet Robin) became common within 2 months of the fire. Otherwise most changes were of relative abundance rather than change in species presence.

Wouters, M. (1996). Developing fire management planning and monitoring. In DEST (Ed.), *Fire and biodiversity: the effects and effectiveness of fire management. Proceedings of the conference held 8-9 October 1994, Footscray, Melbourne* (pp. 235-239). Canberra: Department of the Environment, Sports and Territories.
control burning; heath; Ground Parrot; management; threatened species
Bioregion: South East Corner
Outlines a fire management plan for far East Gippsland, which sets out the fire management required to maintain the ecology of coastal heathland, in particular Ground Parrot habitat, and how this can be accommodated within high protection priority zones (where ecological values may need to be compromised). Also notes that some mallee communities should have a fire exclusion management for conservation of Malleefowl, but such straightforward cases are rare - in most cases, management generally has to be conservative, adopt a range of fire management regimes and monitor consequences.

Young, J. (1991). Dealing with fire in parks and protected areas. In *Tropics under fire: fire management on Cape York Peninsula* (pp. 43-45). Cairns: Cairns and Far North Environment Centre.
hollows; tropical eucalypt open forest; rainforest; management
Bioregion: Cape York Peninsula
Hot fires (including control burns) can destroy the hollows important for nesting birds (especially owls and parrots), and have been reported destroying nests and young.

LOCATION (AND NUMBER) OF PRIMARY STUDIES OF EFFECTS OF FIRE ON BIRDS.

Numbers are based on a 1° x 1° grid. Studies extending over more than 5 cells were not counted. In some cases where study areas were not clearly defined, there may be some minor imprecision in my attempt to locate them.