FIRE AS A WILDLIFE HABITAT MANAGEMENT TOOL

Land for Wildlife Note No. 14 *July 2000*

Author: Cath Moran & Penny Watson

This technical note deals principally with the effects of fire on native flora and fauna, and the use of fire as a tool to protect their longer term habitat needs. It is not aimed at describing management to reduce risk of property damage, although this element should be incorporated into your fire management planning. Under the *Queensland Fire & Rescue Authority Act (1990)*, landholders have a "duty of care" to undertake "reasonable steps" to reduce fire hazard on their property. Information on ways to protect built assets can be obtained from your local Rural Fire Brigade.

Fire in the Australian environment

(Photograph courtesy Neil Gowley)

Fire has been a formative influence in many natural ecosystems in Australia. Even before Aboriginal people arrived on the continent, fires were a feature of the landscape, with lightning strikes and volcanic activity providing sources of ignition. Many native plants that are familiar to us today evolved during this time. Chief amongst them are the eucalypts, whose many species dominate our open forest and woodland vegetation. Eucalypts are highly flammable, due to the oil content of their leaves, and many are dependent on fire for regeneration. Other fire-adapted species include the wattles, bottlebrushes, tea-trees, and banksias.

When Aboriginal people reached Australia, fire frequency increased. Aboriginal people used fire for many purposes, and managed specific areas differently. Burning regimes were based on an understanding of the responses of vegetation and fauna to fire. For example, some areas were frequently burned to encourage fresh young grass, which in turn would bring animals, which could be hunted. Other areas were managed to encourage the reproduction and fruiting of food plants. Burning was often patchy, and must have allowed some long-unburnt vegetation to survive, as animals and birds, which need this habitat, are still with us today. Wildfire would still have occurred. Lightning strikes would have remained an important source of ignition, as they are now. Intense fires are needed to maintain some vegetation types which are currently found in south-east Queensland, and in other parts of Australia, indicating that this type of burning existed under Aboriginal stewardship. Aboriginal fire management regimes still operate in some parts of Australia, and are being reinstated in others.

Thus when Europeans arrived in Australia, they found themselves in a landscape, which often differed from those they knew in terms of its relationship with fire. Some Australian ecosystems – notably rainforest – resemble European forests in that they do not encourage or tolerate fire. In Australia's open forest, woodland, heath and grassland communities, however, fire is an intrinsic ecosystem component. The key question for these ecosystems is: what fire regimes will allow us to maintain the full range of plants, animals and processes, which have evolved in these fire-adapted vegetation types?

The use of fire as a management tool continued after European settlement in Australia, although the characteristics of fires were fundamentally altered. Initially, the frequency of fire increased in some areas, due to its use in land clearing and in promoting the growth of grasses and other stock feed. Later, a policy of fire suppression in bushland was pursued throughout Australia, often resulting in less frequent but high intensity wildfires. More recently, widespread prescription burning has been used in an attempt to reduce the threat wildfires pose to life and property.

Published with the assistance of Bushcare — a program of the Commonwealth Governments' Natural Heritage Trust

The use of fire in the present landscape

Fire is still one of the major land management tools used in Australia. Planned burning is undertaken for a range of purposes, including protection from unplanned fire. Increasingly, however, the importance of fire in ecosystem composition, structure and function is being recognised. More and more land managers are attempting to use fire in a way, which is consistent with biodiversity conservation.

The major goals of present-day fire management include burning to maintain pasture: in many forest and woodland environments, frequent low-intensity burning reduces shrub vegetation and maintains a grassy understorey. The forestry industry employs fire to encourage the regeneration of timber species, and to protect plantations from wildfire. Fire, in conjunction with other strategies, can be used as a means of controlling some weeds. Prescription or controlled burning for the purpose of reducing the risk of wildfire damage to human life and property continues, although other risk reduction measures are increasingly being implemented, as the limitations of control burning and its ecological consequences are recognised. The use of planned burns for purely conservation purposes is also increasing.

Fire management for conservation recognises that fire has long been a component of natural systems in Australia. Those concerned with effective management of flora and fauna must consider the role of fire in:

- maintaining biological diversity;
- stimulating the regeneration of particular plant species;
- the development of vegetation structural characteristics; and
- the abundance and distribution of wildlife habitat resources.

It is increasingly being recognised that total exclusion of fire from the Australian environment is unrealistic, as well as unnatural. Natural ignition, arson, and accidental fires will occur. Wildfires perform a valuable function in some natural systems, however some systems, such as rainforest, need to be protected from burning. The picture is of course complicated by the fact that we now have houses in bushland, and so must consider ways to protect life and property in areas, which we want to manage primarily for conservation. It is important that landholders in bushland areas take appropriate measures to protect the buildings on their properties. Where this is done through strategies such as appropriate siting and housing design, using landscape features such as driveways, lawns and paved areas to provide a fire break, and vigilant clean-up of gutters and rubbish, then areas away from the house can more confidently be managed for conservation purposes.

Because of dramatic alteration to the Australian landscape and changed management objectives, it is impractical to suggest replication of historical burning regimes. In any case, our knowledge of the past is far from complete. However, we can get some idea of how we should manage fire for conservation purposes by considering the responses of local plants and animals to fire. While we still have much to learn in this area, we know enough to draw out some basic guiding principles. These principles will no doubt be developed and refined as our understanding grows.

It is important to recognise that different ecosystems are adapted to different regimes of fire, and thus need to be managed differently. The fire regime consists of four components: frequency, intensity, spatial extent and season. These factors, which are obviously variable, determine the effects of fire on individual species and communities, and will be discussed in turn. But first, what do we know about the different ways plants and animals may respond to fire in general?

The impacts of fire on native flora and fauna

Ecological systems are dynamic. Periodic changes can be caused by a disturbance, such as fire, flood, wind, or tree fall. These disturbances alter conditions of light, water and nutrient availability, area of bare soil, and soil depth, and make an important contribution to maintaining biological diversity. Fire is one of the most pervasive natural disturbance agents in the Australian environment.

Heat from fires can cause the opening of protective woody seed cases, such as those of the Banksia spp. *(Photograph couresty Penny Watson)*

Fire and native flora

Since fire has featured as a significant evolutionary force over such a long time period, many native plant species have adapted to the effects of burning. A well known example of adaptation to fire is that of coastal wallum heathland species which flower, seed, and/or germinate more readily following the passage of fire. *Xanthorrhoea* (grass tree) species, for example flower profusely following fire, and in fact rarely flower without burning. Heat from fires can cause the opening of protective woody seed cases, such of those of *Banksia* and *Hakea* species. Heat and smoke are important in activating the seed of many species: legumes such as *Acacia* species and the many pea flowers are examples. Many ephemeral plant species germinate and flower following fire.

Furthermore, fire tends to volatise organic nitrogen, creating conditions that are well suited to nitrogen fixers, such as *Acacia* species and some species of she oak. Fire opens the canopy allowing seedlings access to sunlight, and creates an ashbed, which includes nutrients for seedling growth.

Eucalypts are one of the most widely recognised representatives of fire-adapted native plants. Eucalypts accommodate fires in a variety ways, depending on the characteristics of the fire, as well as on those of the species and the vegetation association. The bark of most eucalypts is densest at the base where the fire burns, and conducts heat poorly. Lower intensity fires char the exterior but do not wound the living cambium* beneath it. Bark also protects epicormic buds*, from which new shoots arise following the death of branches. Seeds encased in woody capsules also tend to survive fire. Many eucalypt species possess a lignotuber* in which critical nutrients are stored and from which new shoots can emerge following the scorching of seedlings during fire.

A few eucalypt species, however, are killed in a hot fire. These species belong to one of the two major categories of plant fire response: they are obligate seeders. Obligate seeder species die if all their leaves are burned, and regenerate from seedlings. These species tend to be generous seed producers, and may depend on fire to "change generations". The other major category of fire response amongst plants is the "resprouter" category. Adults of these species tend to survive fire even when all their leaves are burned, often resprouting from ground level from lignotubers. These species generally produce less seed than obligate seeders, their seedlings tend to grow more slowly and they may take some years to reach fire tolerance.

A generalised response to fire is that resprouting species tend to dominate the environment immediately after fire. Vegetation structure is open, light is plentiful. Once rains arrive, seedlings grow in the gaps between resprouting trees and shrubs. Herbs such as orchids and short-lived annuals often thrive, providing a wonderful display at ground level. As the time since the fire increases, so does vegetation cover. Over time, smaller plants may be shaded out. Some species may come in to the system: where plants are not able to germinate from on-site seed banks, recolonisation from surrounding areas may occur. In the modern landscape, the intrusion of introduced weed plants into this recovery process can restrict the regeneration of native plants.

Thus a fire-adapted plant community consists of a wide variety of species whose abundance changes over time and space as a result of fire. The species in each community will exhibit a wide variety of adaptations to fire. Some will tolerate a wide range of fire regimes; others will have more narrow requirements. **Variability within limits** determined by the needs of species with specific requirements is thus a primary principle of fire management for biodiversity conservation.

Fire and native fauna

Native fauna exhibit a parallel range of strategies for maintaining their presence in fire-adapted communities to those exhibited by plants. Some species are "avoiders", staying alive either by leaving the area, or by taking shelter, for example under rocks or in hollow logs. Some species are more likely to lose individuals in the fire path through death as a result of burning or smoke inhalation, as well as from injuries caused by these factors. These species depend on recolonisation from unburned areas to maintain their presence in fire-prone communities.

The direct effects of fire on wildlife are closely related to mobility. In general, birds and other flying fauna can relatively easily escape fire, compared with, for example, a koala. Obviously, aquatic or semiaquatic fauna, such as amphibians, can often shelter in non-combustible areas such as dams, billabongs, and waterways. However some relatively immobile fauna can also find shelter from the direct impacts of fire. Ground dwelling animals often use hollow logs. Before undertaking controlled burning, fuel can be raked away from habitat features like this that could provide refuge. Patchiness in fires provides wildlife with opportunities to escape into unburned areas.

The displacement of fauna from the burned area is thus a direct effect of fire on wildlife. In a fragmented landscape, the capacity of fauna to move safely from burning areas can be seriously impeded. Displacement can have adverse consequences for fauna, particularly territorial species. However, some species, for example some small Australian mammals, have been found to alter their behaviour in response to fire, by occupying territories that are of reduced size compared with pre-fire territory sizes.

The effects of fire on native fauna are not necessarily negative and some species make use of fire. For example Black (or Fork Tailed) Kites in drier regions of Australia

have been known to actively employ fire as a tool to facilitate hunting. These birds collect burning twigs and use them to ignite additional areas of vegetation, presumably making it easier to locate and/or access prey species. Other birds of prey also take advantage of fire, although they may not actively employ fire as a tool. Many raptors and other opportunists and scavengers respond to burning by flocking to the fire to hunt small mammals and other prey.

Fire can affect animals indirectly through its effects on vegetation and other habitat features. Nesting hollows can be created or destroyed by fire. Reshooting vegetation provides "green pick" for herbivores such as kangaroos, wallabies and insects. Fire releases phosphorus, which is taken up by reshooting grasses and is then made available to herbivorous fauna. The Ground Parrot (*Pezoporus wallicus*), which occurs in coastal heathland, appears to depend upon the increased levels of flowering and seeding following fire, as well as needing access to the denser vegetation that develops some years after fire, for nesting. This species is scheduled under the *Nature Conservation* (Wildlife) *Regulation* as Vulnerable and active management of the remaining habitat of this species necessarily incorporates the use of fire.

In fact many fauna species in fire-adapted systems appear to exhibit a preference for a particular stage of post-fire regeneration. For example the early years post-fire provide bountiful resources for ground-feeding birds. Some bird species may be attracted to plants with fire-stimulated flowering, or to the seeds of grasses that flourish post-fire. In a few years, as the vegetation becomes more dense, the bird species composition changes. Open-country species are replaced by species, which need cover for nesting or shelter. Species, which feed on the fruits of the regenerating trees and shrubs come in. In long-unburned heath, aging vegetation may lose its productivity, and some species move elsewhere. Similar successional preferences have been observed in some small mammals, and in invertebrates.

This observation leads to another principle of fire management for biodiversity: where possible, it is good practice to **maintain a range of post-fire age-classes** in the vegetation, thus providing habitat for fauna species with different needs.

The suitability of the post-fire environment for breeding and ongoing recruitment will influence the longer-term impact of fire on fauna. Fire may differentially affect particular age groups or individuals of one gender. For example, a study of fire effects on populations of the Bush Rat *Rattus fuscipes* found that burnt areas were first recolonised by males and juveniles while females were restricted to unburnt patches, or areas with more advanced regeneration (Recher & Christensen, 1981). Again, maintaining a range of post-fire age-classes may assist this species to breed successfully, and thus to survive long-term.

The fire regime

As mentioned earlier, the most pertinent characteristics of fire - frequency, intensity, extent, and season - are incorporated into what is termed the **fire regime**.

Fire-adapted ecosystems include eucalypt forests and woodlands, wet and dry heaths, grasslands, and melaleuca forests. Each of these communities is adapted to a somewhat different regime of fire: what's appropriate for one community may not be appropriate for another.

Even within a fire-adapted ecosystem, different species will prefer somewhat different regimes. As a result, no community will benefit from a rigid regime of fire. This is because, as we have seen, different species have different adaptions to fire. These adaptations are part of what distinguishes the species "niche". To maintain the full range of species in a community, we therefore need variability in fire regimes, and in particular, in the frequency of fire.

Fire Frequency

Fire adapted ecosystems can suffer from too-frequent, or too infrequent, burning. Frequent burning may result in the loss of obligate seeder plant species, ie those whose

(Photograph courtesy Mark Peacock – DNR)

(Photograph courtesy Neil Gowley)

adults are killed by fire. If a second fire takes place before seedlings have reached reproductive maturity, these species may become locally extinct due to lack of seeds to germinate after the fire. Even resprouting species may be at risk under a frequent burning regime. Seedlings of these species may take several years to grow big enough to survive a fire, and bud supplies on mature plants may become exhausted. Frequent fire may also pose a risk for species, which need heat to break seed dormancy, as frequent fire is generally of relatively low intensity. From a fauna point of view, frequent fire can simplify vegetation structure, reducing the abundance of understorey shrubs, which provide shelter for many species. The decrease in shrubs will also reduce food resources for some fauna species. There is also evidence that ecosystem functionality can be disrupted by frequent fire – for example some wet sclerophyll sites in south-east Queensland have been found to lose nitrogen at a rapid rate.

Fire-adapted systems can also lose species if fire is excluded for long periods. Many plant species in these systems can only regenerate in the years immediately post-fire, as they need the open canopy and bare ground of the post-fire environment to get established. If fire is excluded for too many years, adult plants die without replacing themselves. Fauna species, which rely on early and mid-successional post-fire vegetation, cannot survive in long-unburned vegetation. Some vegetation types may be taken over by a different vegetation type if fire is excluded: the classic example in Queensland is wet sclerophyll forest, which needs fire to open up the canopy and burn off the rainforest understorey plants if it is to survive. If we lose our wet sclerophyll forests, then plants and animals which rely on this "ecotone"* between dry open forest and rainforest will be left without habitat.

What fire frequencies are appropriate for different ecosystems? The Gold Coast City Council has developed a Bushfire Management Strategy that provides some guidance as to appropriate fire regimes for different ecological communities and these are summarised below. These guidelines provide a starting point, and will no doubt be refined as we learn more about our regional ecosystems and the needs of the plants and animals within them. Some figures given here represent speculative **average** inter-fire intervals for fire-adapted systems: variability around these means should further encourage biodiversity.

The frequency of burning is related to the intensity of fire when it does occur, due mainly to the accrual of fuel over time. In general, the longer the inter-fire period, the more leaf litter, fallen branches, sticks and twigs will accumulate, and thus the hotter the next fire will be.

Vine forest associations, including riparian forest	*Exclude fire. Rainforest species unable to tolerate burning.*
Eucalypt emergents with rainforest understorey ('wet eucalypt' forest)	• *Infrequent (no more than once per 15 – 20 years) in developed areas. In less developed areas, unplanned fires should fulfil ecological imperatives.*
Dry open eucalypt forest/woodlands	• *Once per 7 – 12 years in developed areas.* • *Undertake controlled burns at intervals varying from 7 to 20 years in less developed areas.*
Paperbark open forest	• *Undertake prescribed burns at intervals of approximately 15 years.*
Freshwater wetlands	• *Permanent wetlands generally unable to support a fire.* • *Ephemeral wetlands may burn when dry.*
Estuarine complexes	• *Mangroves generally unable to support fire. Avoid scorching.* • *Salt marsh and she-oak associations will tolerate occasional fire.*
Coastal Complexes	• *Occasional (once per 8 – 10 years) high intensity fires will maintain diversity in heathland associations.*

Table 1 Fire management objectives for major ecological associations (Source: Gold Coast City Council (1998))

Fire Intensity

As noted above, some plant species and communities need relatively high intensity fire for regeneration. However, high intensity fire will kill more plants and animals. Generally, controlled burning regimes promote low intensity burns. From the perspective of encouraging ecological diversity, variability in frequency is recommended and this usually results in variable fire intensity, which is probably also desirable from an ecological point of view.

A lower intensity fire will usually result in a more 'patchy' burn, which is a plus (see next section). However continued low-intensity burns can favour a particular vegetation composition and structure. For example, regular low intensity burning will tend to encourage the maintenance of a grassy understorey in open forest vegetation, whereas less frequent and more intense fires produce a more diverse understorey, including shrub species.

It is, of course, much easier to incorporate a relatively high intensity fire in large natural areas with no human habitation than it is in rural residential and farming districts where life and property issues are salient. Expert input is a must when planning and carrying out any control burn.

Fire Extent

A patch-burning, or mosaic, approach is recommended, particularly in the context of the modern, fragmented landscape. It is not recommended that the whole area of a particular vegetation type be burnt at once. This will maintain a mosaic of patches at different stages of post-fire regeneration, providing a diversity of habitat opportunities for both flora and fauna. Mosaic burning can maintain seed sources in adjoining patches for the regeneration of native plants in the burnt area. This approach also maintains areas of variable fuel load and helps prevent wildfires. The size of each patch will be determined by topography, surrounding landscape, and the location of fire breaks which can be used to confine the fire. It has been recommended that adjoining patches be burnt at intervals of no less than 2 years.

When planning a controlled burn, consider the need for fauna to escape the fire and move to unburnt areas. Making provisions for the movement requirements of fauna can enable the safe passage of wildlife from the area of burning to a refuge area. In highly fragmented areas, particularly in coastal lowlands, this can obviously be very difficult. Co-ordinating controlled burning with adjoining property owners and with other land managers whose property may incorporate escape routes is encouraged.

Fire season

Various factors are worth considering when deciding when to burn.

Think about the breeding needs of fauna species, particularly those that are vulnerable to the effects of fire, such as ground dwelling or young fauna. Removal of understorey vegetation during times when young birds

Monitoring site established 30 March 1994. Vegetation type: Tall open forest with dense mid-stratum of low trees and lower stratum of grasses and forbes. *(Photographs courtesy Queensland Parks and Wildlife Service)*

Stage 1: 3/3/94 Tall open forest prior to a fire

Stage 2: 9/2/95 Tall open forest immediately after a fire

use it to reach nests and take shelter can have significant effects. 'Cool' winter burns coincide with the dormancy period of many invertebrates when they are likely to be burnt by fire.

The timing of the fire can have implications for the composition of the vegetation, which regenerates following burning. Consider potential seed sources for the recolonisation of the area being burnt.

As well as the year to year changes in seasons, the broader, El Nino-induced cycle of drought and flooding will influence the effects of fire, as well as wildfire risk.

Again, variation in the timing of fire is encouraged, so that some plants and animals are not favoured over others. In south-east Queensland, controlled burning is generally **not** recommended from September to December, due to wildfire risk. However summer, autumn and winter burns are used flexibly by a number of local land managers.

Developing a fire management plan for your property

This Note has focussed on providing basic information on fire ecology and its broad implications for management. The following points highlight some key elements of successful fire management plans. Supplementary material to assist property owners to develop individual property plans is currently being developed.

- Plans should be based on **long term management objectives.** Consider the different sorts of vegetation communities on your property, and their relative tolerance of and resilience to fire. Mapping vegetation types, particular habitat features (eg hollow trees), the location of 'significant' plants and animal species, topography, aspect, fire history, infrastructure, fire breaks and access tracks will help assess fire risk and develop a management strategy.
- Background information may be valuable. Discuss the fire history of your property and the local area with local residents. As far as possible, **assess** the success of the existing fire regime. Do not necessarily assume that current practices are optimal for native wildlife protection – or that they are destructive. Do seek to understand the reasoning behind current fire regimes.
- **Co-ordinate** with neighbouring landholders to maintain a mosaic of vegetation at different stages of development.
- **Vary** the timing and frequency of burning. This will result in fires of different intensity, help maintain a diversity of vegetation types and species, and avoid problems of consistently burning when particular kinds of fauna are most vulnerable.
- **Monitor** the responses of flora and fauna to fire and incorporate this feedback into your management plan. Also monitor the rate of fuel load accumulation in different areas and after different fires. Adapt your burning regime to these observations and to accommodate new information.

Stage 3: 3/5/95 Evidence of natural regeneration approximately 3 months after the fire

Stage 4: 31/3/98 Further natural regeneration with the occurrence of early successional species such as Acacia spp.

- The weather doesn't necessary conform to human plans! Fire management plans must be **flexible** to accommodate particular seasonal characteristics and other variable factors.
- If you do decide to burn, obtain a **permit** and consider seeking advice. Under the *Fire Service Act*, 1990 a **written permit from a Fire Warden** is required any time vegetation is to be burnt off (excepting the routine burning of sugar cane). In accordance with the Act, **neighbours must be advised** of your intention to apply for a permit to light a fire. Your **local council** may also require that you obtain a permit or at least consult with relevant officers. The local Rural Fire Brigade may be to assist with burns, on a "donation" basis.

Glossary

Cambium: a sheath of dividing cells that lies between wood and bark and gives rise to these two tissues.
Ecotone: a plant community that is in transition between two adjacent but different plant communities.
Epicormic buds: lying buried and protected beneath the bark of the trunk and branches of various trees and shrubs.
Lignotuber: a woody swelling covered in dormant buds, situated at the base of the trunk of various trees and shrubs.

References and further reading

Gill, A.M., R.H. Groves and I.R. Noble (eds). (1981). Fire and the Australian Biota. Canberra: Australian Academy of Science. See particularly the chapters by: Gill, "Adaptive responses of Australian vascular plant species to fire," pp. 243-72; Ashton, "Fire in tall open forests (wet sclerophyll forests)," pp. 339-66; and Christiensen et al., "Responses of open forests (dry sclerophyll forests) to fire regimes," pp. 367-93.

McFarland, D. (1988). "The composition, microhabitat use and response to fire of the avifauna of subtropical heathlands in Cooloola National Park, Queensland." *emu* 88:249-257.

Queensland Department of Housing, Local Government and Planning. (1995). *Bushfire Prone Areas - Siting and Design of Residential Buildings*. Brisbane: DHLGP in conjunction with the Rural Fire Division of the Queensland Fire Service.

Whelan, R.J. (1995). *The Ecology of Fire*, Cambridge University Press: Cambridge.

References

Benson, J.S. and P.A. Redpath. (1997). "The nature of pre-European native vegetation in south-eastern Australia: a critique of Ryan, D.G., Ryan, J.R. and Starr, B.J. (1995). *The Australian Landscape - Observations of Explorers and Early Settlers." Cunninghamia* 5:285-328.

Benwell, Andrew S. (1998). "Post-fire seedling recruitment in coastal heathland in relation to regeneration strategy and habitat." *Australian Journal of Botany* 46:75-101.

Department of Environment and Heritage. (1991). *Management Information: Fire Management*. Pamphlet.

Fire and Biodiversity Kit Working Group. (1999). *How to plan for fire safety and biodiversity*. Victoria: Department of Natural Resources and Environment.

Gill, A.M. and R. Bradstock. (1995). "Extinction of biota by fires." Pp. 309-22 in *Conserving Biodiversity: Threats and Solutions*, R.A. Bradstock, T.D. Auld, D.A. Keith, R.T. Kingsford, D. Lunney, and D.P. Sivertsen (eds). Chipping Norton: Surrey Beatty and Sons.

Gold Coast City Council . (1998). *Bushfire Management Strategy*. Gold Coast City Council.

Hannah, D.S., G.C. Smith and G. Agnew. (1998). "Reptile and amphibian composition in prescribed burnt dry sclerophyll production forest, southern Queensland." *Australian Forestry* 61:34-39.

Keith, D. (1996). "Fire-driven extinction of plant populations: a synthesis of theory and review of evidence from Australian vegetation." *Proceedings of the Linnean Society of New South Wales* 116:37-77.

McFarland, D.C. (1988). "Fire and the vegetation composition and structure of subtropical heathlands in south-eastern Queensland." *Australian Journal of Botany* 36:533-46.

Pyne, S.J. (1991). *Burning Bush: A Fire History of Australia*. New York: Henry Holt.

Queensland Fire Service. *Fire Service Act: some notes for landholders*. Pamphlet.

Tasker, E., R. Bradstock, and C. Dickman. (1999). "Small mammal diversity and abundance in relation to fire and grazing history in the eucalypt forests of northern New South Wales." *Conference Proceedings, Australian Bushfire Conference, Albury*, July 1999. http://life.csu.edu.au/bushfire99/papers/tasker/index.html.

Thomas, A. (1999). "Fire Management in Noosa National Park", Eco Echo, 58.

Recher, H.F. & Christensen, P.E. (1981)."Fire and the evolution of the Australian Biota." Pp.137-62 in *Ecological Biogeography of Australia*: Volume 1, Keast. A. (ed.) The Hague: Dr. W. Junk.

Williams, J.E., R.J. Whelan, and A.M. Gill. (1994). "Fire and environmental heterogeneity in southern temperate forest ecosystems: implications for management." *Australian Journal of Botany* 42:125-37.

Woinarski, J.C.Z. (1999). "Fire and Australian birds: a review." Pp. 55-180 in *Australia's Biodiversity - Responses to Fire. Plants, Birds and Invertebrates*, A. M. Gill, J. C. Z. Woinarski, and A. York. Canberra: Department of the Environment and Heritage.

The Queensland Fire & Rescue Authority (QFRA) provides advice and has a range of documents available that outline fire hazard assessment and management methods. Contact your local QFRA office for further information.

Information compiled by Land for Wildlife Officer Cath Moran, and SEQ Fire and Biodiversity Consortium Coordinator Penny Watson. Comments and suggestions provided by Darryl Larsen and Paul Donatiu are sincerely appreciated. The Fire and Biodiversity Consortium is funded by the National Heritage Trust through the Bushcare Program.