HOTSPOTS FIRE PROJECT

MANAGING FIRE ON YOUR PROPERTY

A booklet for landholders in the Southern Rivers Region

NSW RURAL FIRE SERVICE

Nature Conservation Council The voice for nature in NSW

HOTSPOTS FIRE PROJECT

MANAGING FIRE ON YOUR PROPERTY

A booklet for landholders in the Southern Rivers Region

The Hotspots Fire Project acknowledges that the preparation and implementation of this guide occurs on the traditional lands of First Nations peoples and that this management has and continues to shape the landscape we see today.

Version 5, February 2024

The Hotspots Fire Project is jointly delivered by the
Nature Conservation Council of NSW and the NSW Rural Fire Service

WHAT DOES THIS BOOKLET COVER?

1. Introduction to the Southern Rivers Region 5

2. Living with fire 6

3. Managing fire for biodiversity conservation 8

4. Fire in the landscape: putting the science into context 14

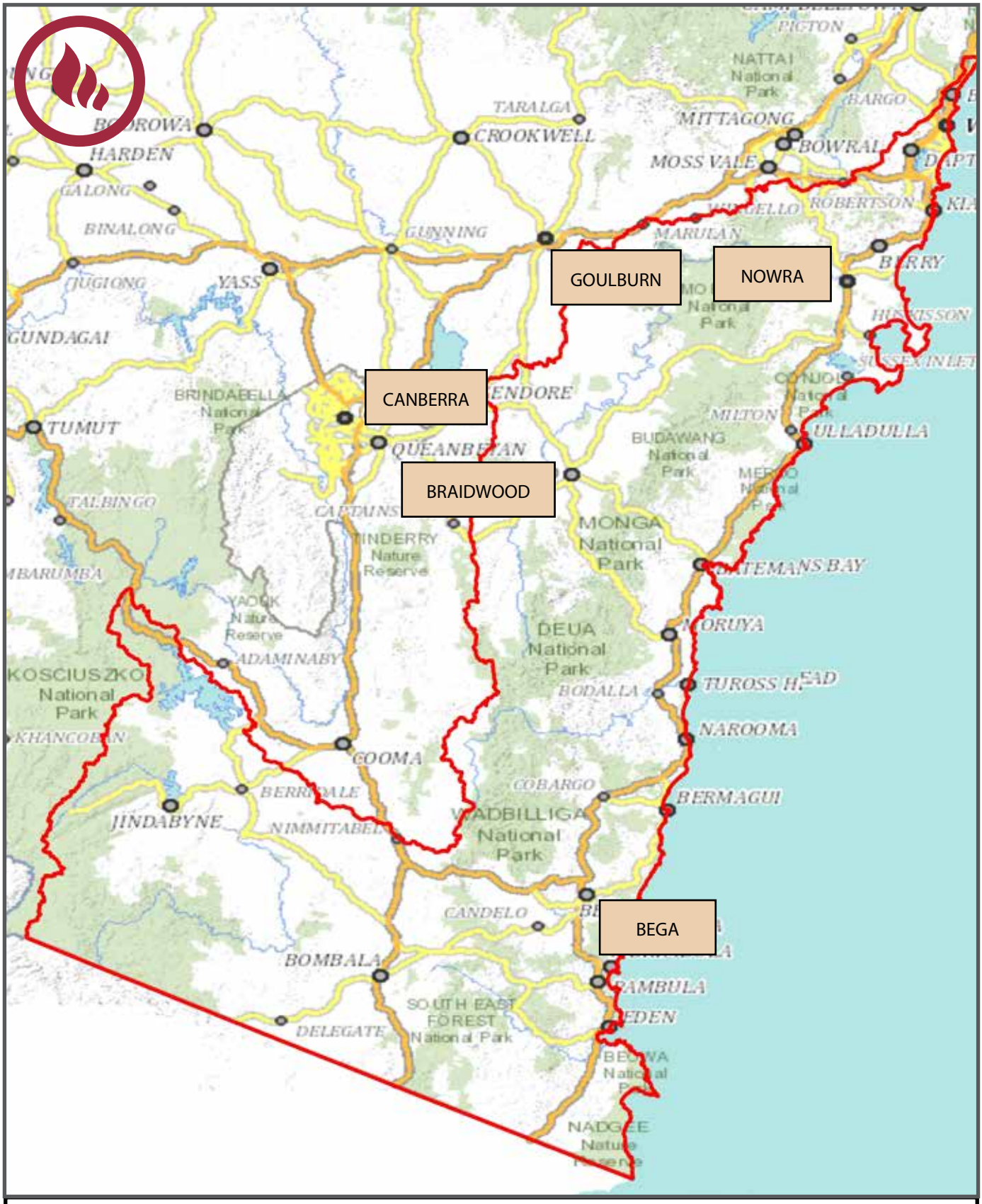
5. Managing fire for different vegetation types 19

6. Fire management planning 24

7. Preparing a property fire management plan 29

8. Fire and Climate Change 31

9. Working together to manage fire across the landscape 33



Southern Rivers Region

1 INTRODUCTION TO THE SOUTHERN RIVERS REGION

The Southern Rivers Region covers approximately 32,000 square kilometres of south-east NSW, ranging from Stanwell Park, north of Wollongong, down to the Victorian border and extends west towards Goulburn and out to Cabramurra in the south. Landscapes range from coastal shores and estuaries to alpine and sub-alpine areas, including the legendary plains and the high country of the Monaro. It contains unique and varied river, estuary, groundwater systems and marine wetlands. Defining natural feature of the region are the major waterways - the Shoalhaven, Snowy, Genoa Rivers and lake Illawarra.

The region is located within the temperate and warm-temperate coastal lowlands, escarpment and undulating highlands and tablelands. These areas are characterised by complex patterns of terrain and geology. The forest types of the region vary from sclerophyll forests to woodlands but heathlands are more common along the coast.

The natural resources of the region support a variety of land uses including agriculture (sheep, beef, dairy and cropping), horticulture, aquaculture, commercial and recreational fishing, forestry, mining, and tourism. There are areas of national park and state forests and the major population centres are Wollongong, Shellharbour, Kiama, Nowra-Bomaderry and Batemans Bay, which are primarily located along the coast.

The south east region generally experiences a diverse climate ranging from alpine environments to coastal areas. In the north, rain is uniformly distributed among seasons but is slightly more dominant in summer and autumn on the south coast and dominant in spring and winter in the Snowy Mountains, Monaro and southern slopes and plains. Winter snowfall in the Alps is essential for the ecology and economy of the region.

The introduction of exotic plants and animals, the clearing and disturbance of native vegetation and changes to fire regimes are some of the major pressures on the ecosystems in NSW. The region's rivers, estuaries, marine environment, wetlands and groundwater support unique and complex aquatic flora and fauna like the threatened iconic green and golden bell frog[1]. A total of 297 threatened species and entities occur, or did occur, within the Southern Rivers Region[2]. While many national parks have been created, not all vegetation communities or habitat types are well represented.

The region is rich in cultural heritage and is home to 17 traditional First Nations including the Bidwell, Yuin, Tharawal, Jaitmalang and Ngarigo[3]. In the region there are many areas and landscape features that have important social, spiritual, historical, and commemorative significance.

[1]Local Land Services, South East, Regional profile: http://southeast.lls.nsw.gov.au/our-region/region-profile

[2]NSW BioNet Atlas, Department of Planning, Industry and Environment, 2021

[3]AIATSIS, Map of Indigenous Australia, http://aiatsis.gov.au/explore/articles/aiatsis-map-indigenous-australia

2 LIVING WITH FIRE

Fire in the Southern Rivers Region

Fire is part of life on the land in the Southern Rivers Region of New South Wales. Some landholders use fire as a land management tool. Others are concerned about the impact of fire on their properties, given the number of major fire events in the region over the last century.

This booklet provides an introduction to how fire can be managed for protection of life and property, and for healthy, productive landscapes. Developed specifically for the Southern Rivers, this booklet also presents a framework for incorporating fire into property management planning activities.

Knowledge about the nature of fire and its effects on your landscapes will give you greater confidence in managing fire, both for the protection of life and property, and as a land management tool in building healthy land systems.

For some landholders, this information will stimulate a new understanding of the role of fire in shaping and sustaining local landscapes and the plant and animal species they contain. For those of you already in the know - this information will add to your existing knowledge and hopefully prompt some important new insights into fire management.

Fire management planning for protection of life, property & environment © P. Neil, NSW Rural Fire Service

Fire and the Australian continent

Fire has shaped the character and biodiversity of Australian landscapes for millions of years prior to the arrival of people. Many plant and animals species evolved strategies for coping with fire with the ability to survive fire directly and/or taking advantage of the post-fire environment.

Changes to ancient fire regimes were accelerated as Australia drifted north over the last 70 million years which led to the gradual drying of the continent along with fire in the vegetation being ignited from lightning strikes and volcanoes. On a continental scale, this process contributed to the expansion and dominance of fire tolerant and drought resistant species such as Eucalyptus and sclerophyllous vegetation. This in turn led to the contraction of fire sensitive areas such as rainforest to more naturally fire protected and wetter locations[5].

First Nations Australian's have a long history over thousands of years of using fire as a land management tool and cultural practice. These practices helped shape a cultural landscape that left the legacy of Australia's unique biodiversity and ecosystems prior to European colonisation. Fire sensitive vegetation communities such as rainforest were protected from wildfire where possible by carefully burning fire tolerant areas as a firebreak on the perimeter. This ensured the health of these rainforest areas and the plants and animals that people depended on for food and resources. Countless pathways or walking tracks across the region between different areas were often kept open and grassy with cultural burning to allow for better access and to encourage animals to forage on the regrowth.

In more recent times, several First Nations groups have been working to reintroduce cultural burning practices back on to Country in the Southern Rivers region. The most important principle of cultural burning is having the right First Nations people involved for each area being considered. Other common principles of cultural burning include only burning small areas in calm, cooler conditions to create low intensity fires that do not impact the tree canopy and just burn the ground layer. This leaves unburnt patches and promotes habitat and resources for native animals. In some areas where knowledge and cultural practices of fire have been interrupted by colonisation, knowledge is now being renewed through regional collaboration, practicing the principles of cultural burning and observing the change and ecological health of the landscape over time. In turn this supports the strengthening of connection and knowledge between First Nations people and country and the skills and experience to manage these areas for future generations.

The changes to our landscapes since 1788 have been profound and ongoing. We are now faced with fragmented vegetation and the combined impacts of invasive plants and animals as well as extensive and frequent wildfires.We need to draw on both old and new knowledge about fire in order to protect people, natural and built assets and cultural values, and so manage for healthy and productive landscapes.

Much of our new knowledge and our current understanding of how fire might best be managed comes from looking at the way plant and animal species in different communities respond to fire. This topic is the focus of the next section.

---

[5] Bowman, D. M. J. S. (2000). *Australian rainforests : islands of green in a land of fire*. Cambridge : New York : Cambridge University Press, http://www.loc.gov/catdir/toc/cam025/99024978.html

3 MANAGING FIRE FOR BIODIVERSITY CONSERVATION

Science based management

Scientists and land managers have long recognised the relationship between biodiversity (the variety of different plant and animal species) and healthy land systems.

It wasn't until fairly recently that scientists gained a much better understanding of the significant role that fire plays in shaping these land systems and the biodiversity within them. Fire ecology is now an important area of scientific study.

For landholders, the most useful information to come out of this research relates to how different aspects of fire affect vegetation and wildlife, and how different plant and animal species respond to fire.

Plant responses to fire

Many Australian plant species have developed reproductive strategies in close association with fire. Since fire is such a powerful disturbance force, changes in fire patterns can quickly influence which species (and reproductive strategies) will persist in an area and which won't.

Different plant species respond differently to fire: some do not tolerate fire, some can tolerate fire and others rely on it for reproduction. For many Australian plants one or more of their reproduction processes (flowering, seed release or germination) occur exclusively, or most abundantly, in the months or years after a fire.

Scientists describe two broad post-fire regeneration strategies that occur in areas with a long history of fire which are of particular relevance to fire managers: *obligate seeding and resprouting.*

In the absence of fire, *Banksia ericifolia* can competitively exclude other plant species from available space and sunlight © W. Parker, Hotspots Fire Project

Obligate Seeders

When obligate seeder species are exposed to a fire, all, or almost all, plants are killed. These species can persist, however, by regenerating from seed (they're *obliged* to regenerate from seed if they are to survive). This seed may be stored in the soil, on the plant (e.g. in cones), or brought in from nearby unburnt patches of vegetation by wind, water, birds or other animals.

Land managers implementing fire management strategies need to consider the frequency of burning if they wish to ensure the survival of these obligate seeder species.

Obligate seeders reliant on seed dispersal from other areas may also be threatened by extensive fires. This is because no, or few, seed supply areas escape being burnt and the likelihood of animals (or other dispersers) bringing in new seed is reduced.

Fire intensity can also affect obligate seeders because specific temperatures may be necessary to trigger seed release and/or germination.

Fire frequency needs to take account of the life span of obligate seeders; including the amount of time it takes for these plants to experience their first flowering and to produce seeds. If the interval between two fires is too short, the second fire may wipe out an entire generation of young obligate seeders before they have reached reproductive maturity (i.e: before they have started producing seed). On the other hand, if fire is excluded from an area for too long, a whole generation of obligate seeders may move beyond reproductive age and die off before a fire has had a chance to trigger germination. While some seeds can survive in the soil for very long periods, others are relatively short-lived.

Obligate seeders may store seed on the plant in woody capsules © W. Parker, Hotspots Project

Resprouters

Resprouters are able to resprout after fire from woody underground lignotubers or epicormic buds protected underneath their bark. Some can tolerate frequent fire, and some can live for a long time without fire. However, it is important to note that even resprouter populations may be affected by very frequent fire or by fire exclusion, and may rely on seed to ensure healthy, diverse gene pools.

Not surprisingly, in the absence of fire, those plants which come to dominate the landscape include long-lived species and those which are able to regenerate without fire. These plants may competitively exclude other species from available light and space. A fire can help to open up the bush so light can reach ground level triggering resprouting, germination, and plant growth.

Planchon's stringybark (*Eucalyptus planchoniana*) resprouting from buds © P. Donatiu, QFBC

Fire regimes

Fire regime is the term used to describe aspects of fire that are important for managing vegetation and wildlife.

A fire regime includes the following factors:

- **Fire Frequency:** the number of fires in a given time
- **Fire Season:** what time of year the fire occurs
- **Fire Extent:** the area covered by the fire
- **Fire Intensity:** how hot the fire is

More on fire frequency:

It is important to consider the sequence of fire events. Long term effects on landscape and biodiversity are generally the result of a pattern of fires over time, rather than of just a single fire. Although this is not to say that a single fire doesn't have the potential to significantly impact on a given area, like in a rainforest for example.

The amount of time between fires (fire interval) and the frequency with which fires occur in a given area are important in the conservation of our plant and animal species.

Frequent burning tends to reduce shrub cover and increase grassiness in some vegetation types resulting in more open landscapes. However, too frequent burning may also favour highly invasive perennial grass species such as African lovegrass (*Eragrostis curvula*), Chilean needle grass (*Nassella neesiana*) and Phalaris. Infrequently burnt areas may naturally be shrubbier. These differences in vegetation structure affect the animals that live in the bush. Some animals need shrub cover to shelter and breed, while others need open, grassy areas to find food.

Different vegetation types are adapted to different fire frequencies.

Variability in the interval between fires is important for maintaining species diversity. Repeated fire intervals of similar length are not always good news for plants or animals.

Acacia resprouting from buds under the bark © P. Donatiu, QFBC

More about fire season:

Climate and weather influence fire season more than any other factors. In the Southern Rivers, bush fires generally occur in the summer but the danger period can begin as early as October and extend through to March. Weather conditions associated with bush fire season include moderate to high daytime temperatures and low relative humidity with winds from the north-west. Dry lightning storms are also common during this period. Along the coastal regions in summer sea breeze patterns can create instability in the atmosphere, which can result in erratic and more destructive fire behaviour. In some areas, frosts in winter can dry out fuels so that ignition is easier and fire intensity may be hotter (low fuel moisture content).

The window of opportunity for planned burns varies across the region and is usually limited to autumn, late winter or spring. The implementation of any planned burn is dependent on the exact weather conditions on the days leading up to and on the day of the burn. If the burn is to occur within the official fire danger period, the burn can still proceed if the weather conditions are appropriate, however, a permit will need to be obtained from the NSW RFS.

From an ecological point of view, some variability in the season in which fires occur is likely to be best. While the season appears to affect some individual species, scientific findings do not point to a particular season being 'better' for a whole community of plant and animal species. Where possible, it is probably better to avoid always burning at the same time of year.

More on fire extent:

Within a fire perimeter, patches will often remain unburnt. Extensive fires with few unburnt patches may limit the ability of animals to find refuge during the fire, and food and shelter after it has passed. Unburnt patches provide native animals protection from predation by feral species and a base from which they can slowly move back into burnt areas as these recover.

Those undertaking planned burns should aim to leave unburnt patches, a process called mosaic burning. Creating internal patchiness within the fire area is a key objective of hazard reduction burns.

Small burns may also have a down side. Animals can easily move into small burnt patches from surrounding unburnt country and may place too much grazing pressure on the recovering vegetation. This problem may be particularly prevalent where animals such as kangaroos are abundant. If a greater area is burnt, grazing pressure is more likely to be spread, reducing impacts on regenerating vegetation.

Landholders wanting to burn with biodiversity in mind may therefore want to aim for burns of varying size, while still ensuring unburnt bushland patches remain for fauna. Burning a number of different patches at around the same time is another way to spread grazing pressure over a larger area. Previously burnt patches can provide boundaries for later patch burns.

More on fire intensity:

Fire intensity varies depending on factors such as wind speed, temperature, humidity,slope, fuel load and the structure of the vegetation. The most intense fires tend to occur during times of high temperatures, low humidity and strong winds, especially when the vegetation has been preconditioned after several days of extreme heat or in periods of drought.

Fires also burn faster and more intensely when running uphill, as the available fuel is preheated by the flames and ignites more easily.

Generally:

- Fires tend to be more intense when there is more available dry fine fuel. 'Fine fuel' is material less than a pencil width (6 mm).
- High intensity fires are more destructive and will kill more plant and animal species, but they also have an important role in some plant communities.
- After a high intensity fire, lots of seed germination may occur. Areas opened up by a high intensity fire will provide increased areas of sunlight and space for young plants to develop.
- Variation in fire intensity plays a role in keeping a greater number of species in the community (i.e. maintaining biodiversity).

Severely burnt areas affect the ability of plants to recover after fire © M. Graham, Hotspots Fire Project

Low intensity burn at Jaaningga Nature Reserve © S. Hemer, NPWS

Unburnt patches will provide animals with a refuge during and after fire © W. Drake

Fire regimes: implications for management

In some parts of the landscape bush fire is inevitable due to fuel accumulation, climatic conditions and likely ignition sources such as arson and lightning. Prevailing weather conditions and natural landscape patterns will often influence fire season, intensity and extent. Management planning needs to be flexible enough to accommodate bush fires.

Over many thousands of years, much of the Australian bush has evolved ways to live successfully with fire and to use it for reproductive advantage. Many vegetation types have also developed an ability to 'bounce back' from different fire regimes. This bouncing back is often termed 'resilience'.

A warming and drying climate in the Southern Rivers region has contributed to fires becoming more frequent and severe, and this is projected to continue. This may test the resilience of some ecosystem types, which is why adaptive management is important.

The best approach is to vary your fire management actions over time. Talk to people with knowledge in your region, and try different things based on your own observations of vegetation responses to fire on your property.

Biodiversity is more likely to be sustained when fire management extremes are avoided. Excluding all fire from your property, or burning as soon as vegetation has sufficient fuel to support a fire, will eventually see the loss of species adapted to a more moderate or variable regime.

High intensity fire © G. Walker, NSW Rural Fire Service

4 FIRE IN THE LANDSCAPE: PUTTING THE SCIENCE INTO CONTEXT

Like many natural processes, the relationship between vegetation and fire regime is complex. However, there are some simple principles that emerge in the following stories about fire in particular plant and animal communities.

FIRE FREQUENCY IN TEMPERATE GRASSY WOODLANDS

Grasslands and Grassy Woolands once covered extensive areas of eastern Australia. Today, remnant areas of Temperate Grassy Woodlands are still found on the Monaro Tableland and around Braidwood.

Kangaroo grass
© P. Watson, Hotspots Fire Project

Fire frequency can affect the balance between woody species and grasses in these grassy vegetation types. Frequent burning tends to produce open, grassy landscapes, whereas in places where fire has been excluded or is rare, shrubs and young trees may increase in number.

Plant diversity in Grassy Woodlands are concentrated in the ground layer. Here, tussock grasses such as kangaroo grass (*Themeda triandra*), snowgrass (*Poa sieberiana*) and wallaby grasses (e.g. *Austrodanthonia species)* dominate the ground layer. Smaller grasses and herbs grow in the spaces between these tussocks. Fire burns the dense tussocks back, making space for the smaller species. Many grasses and herbs flower rapidly after fire, producing seeds which germinate while gaps between resprouting grass tussocks are still available. Some native tussock grasses, particularly kangaroo grass, are encouraged by fire. Thus fire provides a way for large native grasses, small grasses and herbs to live together.

Where fire has been excluded from grassy areas, shrubs may increase or decrease depending on whether or not the species present rely on fire for regeneration. Shrubs that depend on fire to regenerate will die off after a long fire-free interval, producing a more open understorey than in the years following fire. When a fire next comes along, these shrubs may reappear in large numbers as seed stored in soil is stimulated to germinate. Some shrubs, however, can regenerate between fires. Where this is the case, the density of these shrubs will increase in the absence of fire. Where fire frequency is low, and environmental conditions are right, these species may progressively come to dominate the landscape.

In some situations, shrub density may increase to the point where grasses and herbs are shaded out. Heavy litter which accumulates as time goes by after a fire may also leave little room for small ground layer species. Thus, relatively frequent fire may be important for maintaining vibrant populations of grasses and herbs as well as the animals which feed on them.

Both ground layer plants and shrubs form part of the rich diversity of Grassy Woodlands in the Southern Rivers. Varying fire frequency over time and space is important for maintaining this diversity. Patchy fires help to ensure enough space for all species including shrubs, grasses and herbs.

ANIMAL RESPONSES TO FIRE FREQUENCY AND FIRE EXTENT

Variability in fire frequency over time and across the landscape plays an important role in providing the habitat that bushland animals need. Fire alters the structure and density of vegetation layers and can change the species composition of bushland areas. Some birds, mammals and invertebrates may even disappear if fires occur too often or are excluded completely. Landscapes in the Southern Rivers Region provide a significant refuge for several nationally Vulnerable fauna species.

Hollows as Habitat

Hollow-bearing trees were once abundant in grassy woodlands and wet and dry sclerophyll forests across the region but clearing, dieback, frequent burning and intense bush fires have greatly reduced their availability as a resource. In particular, areas of high productivity on the Tablelands and coastal river valleys have been substantially modified for agriculture or expansion of urban and rural residential areas. Other less fertile areas still have large forested areas but the loss of hollows from logging and inappropriate fire regimes continues to impact many species which are dependent on hollows for key parts of their life-cycle. Specifically, providing places for animals to feed, shelter and breed.

Hollows can take many centuries to develop or be replaced when lost from a landscape. Fires can burn through and cause the tree to fall. This leads to a loss of valuable habitat and causes increased competition for the remaining hollows. Maintenance of hollow-bearing trees and enhancement of these habitats wherever possible, is needed to ensure the survival of many native species.

Hollows as habitat
© M. Graham, Hotspots Fire Project

Mammals and Birds

Many iconic threatened fauna species are known to use hollows in the region. The vulnerable yellow-bellied glider (*Petaurus australis*), inhabits fertile and productive forests along the coast and escarpment of the region but becomes scarce on the heavily cleared Tablelands and low fertility sandstone forests. The Vulnerable eastern pygmy-possum (*Cercartetus nanus*) has a patchy distribution mainly along the coast but may also be present in more remote unsurveyed areas. Populations of the greater glider (*Petauroides volans*) have become isolated and endangered in areas such as Eurobodalla and the Seven Mile Beach National Park.

Good populations of powerful owls (*Ninox novaehollandiae*) live in wet and dry forests in coastal regions and eastern part of the southern Tablelands. This bird has a strong association with long-unburnt areas of forest for its nesting and roosting locations. However, it is known to forage in open forest areas. Patchy, frequent fires provide the open, accessible forest areas in which small birds and mice become easy prey. The barking owl (*N. connivens*) is also present in some areas, but in much fewer numbers.

Other Vulnerable large owls known in the region include the masked owl (*Tyto novaehollandiae*), and sooty owl (*Tyto tenebricosa*), they are mainly found in the wetter coastal forests but have also have been recorded on the Tablelands. To ensure the survival of these sensitive species, large hollows must be maintained in the landscape. This will ensure that breeding pairs can successfully maintain their large home range and reproduce.

Glossy black-cockatoos (*Calyptorhynchus lathami*) and Gang-gang cockatoos (*Callocephalon fimbriatum*), found throughout the area, rely on large hollows for breeding. Other birds such as the brown thornbill (*Acanthiza pusilla*) and the white-browed scrubwren (*Sericornis frontalis*) forage for insects on the foliage and bark of shrubs or feed amongst the leaf litter under sheltered thickets. These shrub dependent species will generally return to regenerating shrubby areas within three years after a single fire.

On the other hand, the flame robin (*Petroica phoenicea*) and the scarlet robin (*Petroica multicolor*) for example, take advantage of the open spaces provided by frequent fire. The lack of shrubby undergrowth makes it easier to catch their ground-dwelling prey. The Critically Endangered smoky mouse (*Pseudomys fumeus*) lives in heathy areas in the far south of the region and appears to be vulnerable to frequent fire which reduces the cover of logs for shelter and the variety of food available. Long periods without fire however, may also result in the domination of some plant species by reducing the variety of seed and fungi available.

In frequently burnt areas, there tends to be less shrub cover and more open spaces. Animals that rely on a dense, shrubby environment for their food and shelter are displaced by species adapted to more open habitat. In heath communities, for example, some birds and small mammals, like sugar gliders and eastern pygmy possums, rely on *Banksia ericifolia* thickets for nectar and shelter. By increasing the frequency of fires and removing these thickets across the landscape, there is a risk of losing these animals. Thus both open and dense patches are important in conserving the range of animal species found in the bush. Variable fire intervals across time and space help ensure the habitat needs of the full range of species are met somewhere in the landscape.

Yellow-bellied glider
© D. Cook

Smoky mouse
© L. Broome, Dept. Planning and Environment

Invertebrates

Different fire regimes will also affect invertebrates like ants, beetles, dragonflies and spiders. Numbers of these invertebrates can be reduced immediately post-fire, but can quickly recover. Although overall diversity can be the same between areas, the frequency of fires will affect the features of the habitat and therefore which species live there. Excess nutrients from bush fire debris can reduce aquatic macro-invertebrate (e.g. insect, crustacean and mollusc) populations post-fire, however they can also be quick to recover.

Wolf Spider © G. Gowing

Some plant-eating beetles, flies and spiders can take advantage of recent fires, while ants which feed in the litter layer can be more common in longer unburnt areas. Wolf spiders (family Lycosidae) for example are ground hunters, preferring more open habitats to hunt while jumping spiders (family Salticidae) hunt for food in understory vegetation, trees and logs provided by more complex habitats.

Bush Fire, Mosaics and Variability

Maximisation of biodiversity, creating refuges and allowing breeding cycles are only a few factors that will be improved by mosaic burning. In some places, fire needs to happen often enough to maintain open, grassy forest environments rich in grasses and herbs, where early-successional animal species can thrive. Other places need to support good-sized patches of thicker vegetation where broadleaf shrubs and late-successional fauna can flourish. It is also important to remember that some animals need access to both open areas and denser cover, and a mosaic of patches can fulfil that requirement.

Where native vegetation covers large areas it is likely that bush fires will fulfil this prescription. Where remnants have been isolated by clearing and urbanisation, or where fire suppression has been unusually effective, some prescribed burning may need to occur. Hot fires have their place, as well as cool winter burns. A further point is the importance of topography in providing refuge areas from which re-colonisation of the post-fire environment can occur. Not only do unburnt areas serve this function, places where fire is less severe also play this role. When thinking about the effects of fire and how best to manage it, it is instructive to consider landscape patterns: how does vegetation change with topography? How does topography affect fire behaviour and how does this enable plant and animal species to survive and thrive together in a fire-prone environment?

5 MANAGING FIRE FOR DIFFERENT VEGETATION TYPES

© G. Basnett, Hotspots Fire Project

If different vegetation types are adapted to different fire frequencies, how do landholders know whether their fire management actions are good for biodiversity?

To help make these decisions, the Department of Planning and Environment (DPE) has developed fire frequency guidelines for broad vegetation types around NSW. These guidelines are periods of time (in years) bounded by 'thresholds'. Thresholds refer to the upper and lower limitations to survival for species that are particularly sensitive to very short or very long, intervals between fires. The fire frequency guidelines aim to ensure fire intervals are long enough to let vulnerable obligate seeders grow to maturity, while also ensuring fire happens often enough to keep short lived species around.

The 32,000 square kilometres covered by Southern Rivers Region include a wide range of environments from the Illawarra where the climate is warm and moist to the cooler, drier Tableland plateau. Rainfall increases again in the Alps where temperatures drop and snow becomes a factor. Season of rainfall also varies throughout the region. Plant growth responds to all of these factors, as does fire behaviour. Where it is warm and wet, plants may take less time to mature and competition between canopy and understorey plants may be more intense.

The bush in these areas may be able to handle fairly regular fire. Where plants grow more slowly, their survival may depend on longer fire-free intervals. All these factors affect which plants grow where, and how fast they grow. They also affect the way fire behaves, and fire frequency guidelines aim to reflect these differences.

The recommended fire frequency intervals are based on what scientists currently know about fire ecology, and will continue to be refined as more information comes to hand. Upper thresholds in particular are currently based on very limited data.

Fire frequency intervals for broad vegetation types found in the Southern Rivers are listed on the following pages.

Vegetation types of the Southern Rivers

Wet Sclerophyll Forests (shrubby subformation)

© G. Basnett, Hotspots Fire Project

Wet Sclerophyll Forests (shrubby subformation) are tall eucalypt forests with a dense understorey of broad soft leaved shrubs, ferns and herbs. These forests grow on relatively fertile soils in high rainfall areas. Although it is understood that fire is important in these forests, the fire intervals needed to preserve the dominant eucalypts and safeguard other biodiversity values are still unclear.

These forests are likely to experience occasional intense bush fires, perhaps every 50 to 100 years, or sometimes even less often. Some Southern Rivers Wet Sclerophyll Forest eucalypts, notably alpine ash (*Eucalyptus delegatensis*), unusually for eucalypts, are obligate seeders. High severity crown fires in these forests will kill the alpine ash trees, which must then regrow from seedlings, significantly changing the forest structure. If another fire occurs before the saplings mature to produce seed, these magnificent trees will be lost. However, low intensity understorey fires may have a role in maintaining shrubs, ferns and herbs in both alpine ash and other South Coast forests in this category. Currently, variable fire intervals in the range 30 to 60 years are recommended for shrubby Wet Sclerophyll Forests across the state.

Wet Sclerophyll Forests (grassy subformation)

© W. Parker, Hotspots Fire Project

Wet Sclerophyll Forest (grassy subformation) is dominated by straight trunked eucalypts, with a grassy understorey and sparse shrubs, which may have hard or soft leaves. This tall forest type grows on fertile soils in high rainfall areas. It is similar to Wet Sclerophyll Forest (shrubby subformation) but has a more open canopy, less shrubs and a greater grassy or herbaceous groundcover.

Appropriate fire frequencies for this forest type are still being debated. Variable fire intervals in the range 15 to 50 years are recommended. Several NSW studies have found that fire frequency has a profound effect on vegetation structure in wet grassy forests. Frequently burnt areas are open and grassy, with a diverse herbaceous ground layer, while infrequent burning is associated with an increased abundance of shrubs and small trees. Each environment provides habitat for a distinct suite of plants, insects and small mammals. To provide for the full range, it is probably important to keep some parts of the landscape open with relatively frequent fire, while other places are burnt less often to allow thicker habitat to develop.

Grassy Woodlands

© G. Basnett, Hotspots Fire Project

This is open eucalypt woodland with a dry understorey of grasses, herbs and scattered shrubs. Grassy Woodland grows on rolling terrain with fertile soils and moderate rainfall, and has been extensively used for grazing. In the Southern Rivers Region, Grassy Woodlands are found across a wide range of environments, from coastal valleys to subalpine highlands. Across the state, a variable fire frequency of between 8 to 40 years has been recommended.

Near the coast, intervals compatible with retaining a diverse, grassy understorey along with some shrubs are likely to lie towards the lower end of this range. In the higher country of the Tablelands, where plants grow more slowly, longer intervals are likely to be appropriate. Here, minimum intervals of 10 years have been suggested. An experimental study of the effects of a wide range of fire frequencies in snow gum woodland at 1,280m found considerable stability in plant species richness.

Dry Sclerophyll Forests (shrubby subformation)

© W. Parker, Hotspots Fire Project

This vegetation type includes low forest and woodland dominated by eucalypts, with a hard leaved shrubby understorey. The term sclerophyll refers to the hard, leathery leaves of many distinctly Australian trees and shrubs. In the shrubby understorey of these forests there are many obligate seeders and resprouting shrubs. The cover of grasses and sedges is sparse. Variable fire intervals mostly in the to 30 year range are recommended to maintain diversity.

Dry Sclerophyll Forests (shrub/grass subformation)

© G. Basnett, Hotspots Fire Project

Dry Sclerophyll Forest (shrub/grass subformation) consists of open eucalypt forest with a sparse hard leaved shrub layer and continuous grassy groundcover. These forests occur on moderately fertile soils in moderate rainfall areas. Like Grassy Woodland, these forests have also been used for pasture. Across the state, intervals in the 8 to 50 year range have been recommended for these forests. The grass component is likely to be best maintained by short intervals, while the shrub component is predicted to increase with longer intervals.

Heathlands

© P. Watson, Hotspots Fire Project

Heathland is dominated by hard leaved shrubs, many of which are obligate seeders. Heath grows in high rainfall areas, on infertile soils, often in exposed positions. Different types of heath occur in the Southern Rivers Region, including the heathlands found in coastal areas where the soil may be moist, and those growing in drier rocky inland areas. In coastal heath, fires at a range of intervals between 10 to 30 years are recommended for maintaining overall biodiversity.

Within this range, variability in inter-fire interval is important. Research in heaths in other regions has found that plant diversity is maximised through diversity in inter-fire intervals, because fire creates the space for large and small species with a range of responses to fire to live together.

Heathland in rocky inland areas is probably adapted to a range of fire regimes depending on its relationship to the surrounding vegetation and climate. Intervals between 15 to 50 years are suggested.

Grasslands

© G. Basnett, Hotspots Fire Project

Grassland is notable for its lack of woody plants, although a few low shrubs can sometimes be found in these communities. A wide variety of herbs grow in the spaces between tussocks of perennial native grasses such as kangaroo grass (*Themeda australis*), snowgrass (*Poa sieberiana*) and wallaby grasses (*Austrodanthonia* species). Many plants in these native grasslands are subtle; some may not even be visible through autumn or winter, but re-emerge to flower in spring.

Grassland once covered an extensive area in the Southern Rivers Region, particularly on the Monaro Tablelands where rainfall is relatively low. Grazing and pasture improvement have modified grasslands, so remnants where native species continue to thrive are places to be cherished.

Across the state, fires at intervals between 3 to 10 years are recommended to keep dominant grasses from overwhelming smaller herbs and to open up gaps for seedlings to germinate and grow. Regular burning keeps kangaroo grass healthy and in some situations, along with other strategies, can help keep weeds in check.

Freshwater Wetlands

© G. King, Department of Planning and Environment

Freshwater Wetlands include swamp heath, floodplain shrublands and sedgeland. These wetlands usually have a dense groundcover of sedges. They occur on peaty soils with reduced drainage and may be either periodically or permanently inundated with fresh water.

A fire frequency between 10 to 35 years has been suggested for this vegetation type. This community is vulnerable to peat fires when the substrate is dry. Because of this, planned fires are best conducted when the substrate is wet.

Note that Freshwater Wetlands are areas of environmental sensitivity, and need to be treated with care. Fire should be excluded from some classes of Freshwater Wetland. Most coastal wetlands are covered by protective legislation, such as SEPP (Coastal Management) 2018, Biodiversity Conservation Act 2016 (as endangered ecological communities), or Development Control Plans.

Forested Wetlands

© W. Parker, Hotspots Fire Project

These forests typically feature hard leaved trees (eucalypts, casuarinas, paperbarks), scattered shrubs and a continuous groundcover of water loving sedges and herbs. They grow in high rainfall areas on coastal dune swales, flood plains and riparian zones, principally along the coast and inland rivers. Scientists have not yet studied the role of fire in this vegetation type in any detail; however variable intervals between 10 to 35 years are suggested for this vegetation type.

Rainforests

© G. Basnett, Hotspots Fire Project

Rainforest is dominated by soft leaved trees with vines, ferns and palms in the understorey. These forests grow on moist sites on fertile soils. The moist environment shades out the more flammable species that fuel fires, thereby protecting most of the forest from fire events. Although a bush fire may occasionally go through a Rainforest (and the community may be able to recover slowly), Rainforest is very sensitive to recurring fire events. Fire should therefore be excluded where possible.

Estuarine and Saline Wetlands

© R. Dick, Department of Planning and Environment

Estuarine and Marine Wetlands include the mangroves and salt marshes that occur along the edge of coastal estuaries. They are not fire prone communities and excluding fire is appropriate.

Creek-side vegetation

© W. Parker, Hotspots Fire Project

Creek-side or riparian vegetation includes all vegetation within the riparian zone. The vegetation in the riparian zone protects these environments from erosion and maintains water quality.

Burning riparian vegetation may destroy bank stability, disturb nutrient cycling, increase sedimentation in the creek, and alter light levels and temperature in the creek environment. These communities are generally not prone to fire and excluding fire is appropriate.

The vegetation types are classified according to a statewide assessment made in 2003 by Dr David Keith. (Keith, D., 2003. *Ocean shores to desert dunes*: *the native vegetation of New South Wales and the ACT.* Department of Environment and Conservation NSW, Hurstville, NSW.) The groupings can be recognised by specific combinations of plant species, in some cases, these include plant species found nowhere else. The vegetation types are also based on factors such as the height and spacing of the dominant plants as well as geographic indicators of rainfall and soil type.

6 FIRE MANAGEMENT PLANNING

Introduction

Tanja Wapengo Bunga workshop © M. Rose

If you live in a fire prone landscape, eliminating fire from your property is not a practical solution. Managing fire is an important part of living with fire, both to protect life and property and to respond to the ecological needs of the bush.

Many landholders see their assets as being their house and property as well as the productivity of their land. In addition to this, the natural and cultural values of a property are also valuable assets. Effective planning will be essential to meeting the challenges associated with fire management in the Southern Rivers Region.

This planning needs to address two goals: (1) protection of life and property and (2) protection of environmental and cultural values. Each goal requires its own particular management strategies which can be developed and implemented at the property level. However, in particular areas of your property, these two goals may come into conflict. In these instances, the relative advantages and disadvantages need to be weighed up and tradeoffs are often inevitable.

> “Hotspots is a way of returning the community back to the land, with a new range of training programs and education that can provide the community with the skills and knowledge to be in the drivers seat for managing their own land. They can now set their own direction.”
>
> – Claude McDermott, former Aboriginal Heritage Officer, Department of Planning and Environment

PROTECTING *ALL* YOUR ASSETS

The bush fire risk management planning process applies a zoning approach to fire management planning. Zones are a way of identifying areas in the landscape for planning and risk management purposes. There are five types of zones which have different intents.

- **Asset Protection Zones** (APZs) are fuel reduced areas surrounding a built asset or structure which is managed progressively to minimise fuel loads in order to reduce the potential radiant heat levels, flame contact, ember and smoke attack. Vegetation within these zones should be managed to ensure it does not provide a path for the transfer of fire from unmanaged vegetation to the asset either from the ground level or through the tree canopy. Refer to the NSW RFS Standards for APZs and seek NSW RFS advice to determine the recommended width of your APZ. Environmental approval to undertake vegetation clearance may be required.

- **Strategic Fire Advantage Zones** (SFAZs) are large scale, strategically determined areas which are regularly burnt to reduce fuel loads. These fuel reduced areas are designed to slow a fire, reduce its intensity in the landscape and provide a valuable opportunity for active firefighting during a bush fire. They can be located in areas of known fire paths or adjacent to APZs. These zones are determined by each Bush Fire Management Committee during the development of a Bush Fire Risk Management Plan.

- **Ignition Management Zones** (IMZs) are an area in the landscape that is maintained at a reduced fuel level in order to minimise the propagation of ignitions and limit the rapid escalation of fires, often along ridgetops. IMZs are similar to Strategic Fire Advantage Zones but are treated more regularly and thoroughly than a SFAZ.

- **Land Management Zones** (LMZs), the main focus of the Hotspots Fire Project, are areas that are managed to maintain or enhance land management objectives, including biodiversity. Fire history, vegetation type and fire frequency are important considerations in these areas. The NSW RFS recommends burning in these zones to maintain a mosaic of areas with varying fuel loads.

- **Fire Exclusion Zones** (FEZs) are areas where fire is actively excluded. These areas may include rainforest and other fire sensitive vegetation and some cultural or historic heritage sites and production areas. Planning decisions with respect to these zones should be heavily guided by the NSW RFS.

When planning for a prescribed burn it is important to define your objectives, acknowledging that there is a greater focus on hazard reduction works closer to assets (e.g. APZs and SFAZs) and a better balance between land management objectives (e.g. biodiversity conservation) and fire management in LMZs.

Burning native vegetation on your property requires environmental assessment and consent. Landholders need to apply to the NSW RFS for a Bush Fire Hazard Reduction Certificate (HRC) before planning and implementing a burn. Applications for a HRC are assessed under the Bush Fire Environmental Assessment Code for NSW. Assessments are made on biodiversity, threatened species, cultural heritage, and other potential impacts on waterbodies and soil erosion.

In processing a HRC application to carry out a burn in a SFAZ or LMZ the NSW RFS will consider the vegetation type in which the burn is to be carried out, the fire history and the

recommended fire frequency intervals for that vegetation type. The SFAZ minimum intervals represent an absolute minimum (i.e. their intent is to minimise environmental harm in areas where fire is managed primarily for fuel reduction). LMZ minimum intervals represent a more sustainable minimum (considered more appropriate where biodiversity management is the primary goal).

A range of NSW RFS brochures and standards are available that provide detailed information about how to undertake a low intensity burn safely and how to maintain Asset Protection Zones. Most of these are available on the NSW RFS website, or from local district offices. For details on how to safely conduct a low intensity prescribed burn, refer to *Standards for Low Intensity Bush Fire Hazard Reduction Burning*, and for details on how to maintain a suitable Asset Protection Zone, refer to *Standards for Asset Protection Zones.*

Malua Bay Guerilla Bay workshop © B. Kenny

Some key messages in planning for biodiversity conservation

The relationship between fire and biodiversity is complex, and there is still much for scientists and fire managers to learn.

However fire management planning for biodiversity conservation and cultural values need not be a complex or difficult process. You can take the information in this book away with you, think about it and decide for yourself how you might be able to apply it on your own property.

Based on existing knowledge, and on the information contained in this book, the following key messages provide simple guidelines for fire planning to protect biodiversity on your property.

When making decisions on issues such as fire frequency it helps to be very clear about what your land management objectives are in different areas of your property.

You should anticipate the need for flexibility with regards to your management actions. For many landholders, this forms part of an overall adaptive management approach to biodiversity on their property.

When your objective is biodiversity protection:

1. Think about the key messages listed here; and
2. Use the recommended fire frequency intervals for the different vegetation types on your property as a guide.

THE KEY MESSAGES

Simple principles for management

- Both too frequent and too infrequent fire can trigger negative impacts that throw systems 'out of balance' e.g. loss of species, weed invasion.
- Even within a single vegetation type, different species have different needs in relation to fire. To address this, vary fire frequency over time and space to allow for the full range of species.
- The bush at each stage of growth after fire looks different. Each stage provides different habitat, each has value.
- Don't burn entire vegetation types at once. Patchiness provides refuges for animals and a seed source for plants to recolonise burnt areas.
- Fires occur in a landscape context. It's useful to think about how the different vegetation types in a landscape are related in terms of fire.
- Coordinate fire activities with neighbours to provide a mosaic of vegetation in different stages of post-fire development, as different animals use different stages. Remember that fire management is a shared responsibility.
- When planning how often to burn, think about unplanned as well as planned fire. Unplanned fires may happen often enough to fulfil the needs of the bush.
- Understanding how fire behaves in different vegetation types and the influence of weather and topography will help you to better prepare for fire.

© A. Miller, Hotspots Fire Project

"Before Hotspots we were an isolated community, we felt we had to fight fire by ourselves, we were alone. But since the training, we feel part of a larger community now that we manage for fire as a community."

– Hotspots workshop participant

7 PREPARING A PROPERTY FIRE MANAGEMENT PLAN

The following information can help you prepare a property fire management plan:

Think about how you manage your property, what you want to achieve and how this might affect your fire management goals. Consider: risk, production, conservation and cultural values.

1. Identify your property and productivity assets and map them.

- Most properties will benefit from at least one Asset Protection Zones (APZ), based around your main property asset/s. The NSW Rural Fire Service have resources which can assist you in determining the size, placement and management of these.

2. Identify and map the vegetation types on your property as well as any known fire history.

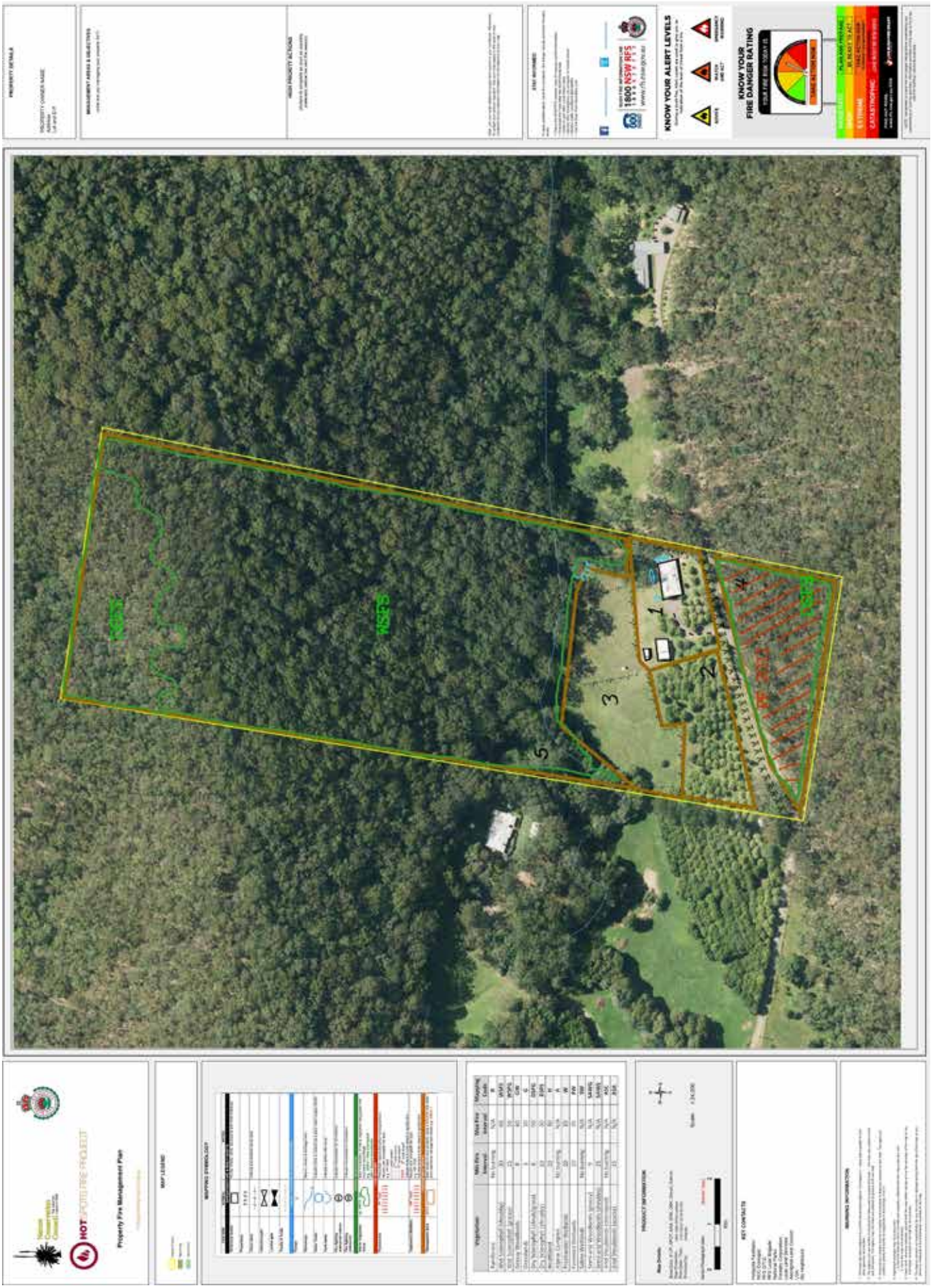
- Make a note of the fire frequency intervals recommended for the vegetation types on your property.
- How often have these vegetation types burned in the past? Note when and where fires have occurred. What is the fuel load?
- Are past fire regimes consistent with recommended regimes? Make a note of vegetation areas on your property that don't meet recommended fire regimes.
- Think about actions you could take to bring fire frequency into line with the recommendations, as well as to reduce fuel in strategic areas.

3. Develop and maintain a mosaic of different stages of post-fire development.

- Do you have the resources to maintain parts of your property at different stages of development after fire?
- Could you work with your neighbours to make this happen?

4. Monitor and review.

- Keep a record of when fires occur and what areas they cover.
- Observe changes to vegetation and different species. Like all land management planning, fire planning is partly a matter of observation and responding to the needs of the land.
- Review your plan as you learn more.



© Hotspots Fire Project

8 Fire and Climate Change

It is now widely accepted that the world is undergoing a significant change in climate.

The full impacts of climate change in Australia are not yet clear although an increase in extreme weather events including drought, storms, floods as well as changes in rainfall (increase or decrease in different places and in different seasons) are anticipated.

The frequency and intensity of bush fires is projected to increase in many parts of Australia as conditions for fire (such as hot, dry conditions) increase [1].

> "A warming of 1.0 °C and a 5% decrease in rainfall (a moderate scenario for 2030) would make the climate of Nowra similar to the current climate of Parramatta in Western Sydney." [2]

Climate Change in the Southern Rivers Region

The region's average temperatures have been increasing since about 1950, with the largest increases in temperature in the most recent decade.

The future climate of the region is likely to continue to be warmer with temperatures increasing by about 0.6 °C in the near future (2020-2039) and 2 °C in the far future (2060-2079).There will be hotter days (above 35 °C) and fewer cold nights below (2 °C).

The Southern Rivers Region currently experiences considerable rainfall variability however spring rainfall is projected to decrease in the future. Such trends toward drier conditions would increase fire weather risk. Maximum temperatures are projected to increase the most during spring and summer. Despite this, autumn rainfall should potentially increase. The region as a whole will see a decrease in cold nights, but less dramatically in coastal regions. These climate projections take into account a broad range of assumptions about future greenhouse gas emissions and differences in various climate models [3].

The region is expected to experience an increase in severity and frequency of fire weather conditions in summer and spring and decrease in autumn. Although the increase in severe fire weather are relatively small in magnitude (up to two more days every five years by 2030), they are projected to occur in prescribed burning periods (spring) and the peak fire risk season (summer), increasing the risk of bush fires. Change to extreme temperatures, both hot and cold, as well as changes in average temperatures will have long-term consequences for the region.

Changes in the fire regime are likely to impact plants and animals in the region. An increase in fire frequency is likely to alter some ecosystems, affecting species composition and structure. For example, if intense crown-scorching fires increase in frequency in inland areas this is likely to increase mortality rates in mature trees, resulting in younger stands and a reduction in hollow-bearing trees. More frequent fire also enhances recruitment of some weed species. In many eucalypt and casuarina species, fire and drought conditions also reduce seed production, decreasing food for birds such as glossy black cockatoos.

It is not just climate change that will influence future fire regimes and subsequent fire management planning. Human development, settlement patterns and the changing landscape will also play an important role.

> "The concept of a 'normal' bush fire season is rapidly changing, as bush fires are increasing in number and burn for longer." [3]

© M. Graham, Hotspots Fire Project

[1]CSIRO (2007a) *Bushfire Weather in South-East Australia: Recent Trends and Projected Climate Change Impacts*. Updated 2013.

[2]CSIRO (2007), *Report Climate Change in Central West Catchment. Prepared for the New South Wales Government.*

[3]NSW Office of Environment and Heritage (2014), *South East and Tablelands Climate change snapshot*, Produced by NSW and ACT Regional Climate Modelling (NARCliM) project.

[4]Hughes, Lesley, (2014) *Be prepared: Climate Change and the NSW Bushfire Threat*. Climate Council of Australia.

9 WORKING TOGETHER TO MANAGE FIRE ACROSS THE LANDSCAPE

Cooperation in the Southern Rivers Region

Fire management planning to protect life, property and the environment requires collaboration within communities, between agencies and across tenures.

In the Southern Rivers Region, this is already happening. Fire management planning is being undertaken across parts of the landscape; not only on private properties, but in national parks, state forests and public lands. Fire management planning, using a risk management approach, is also being undertaken across the wider landscape in each Fire Control District.

Individual landholders and groups of landholders can be part of this much broader process of fire management, whilst being able to make independent choices about fire management on their own land.

This process has a number of individual and potentially far reaching benefits. Among other things, it encourages landholders to:

- Plan and talk together about assets and how best to protect them;
- Listen to others with knowledge and ask them challenging questions; and
- Protect all of the aspects of the landscape most valued by landholders.

Landholders on site at Tarraganda workshop © K. McShea

Cultural Burn © M. Graham, Hotspots Fire Project

About the Hotspots Fire Project

Based on best available science and operational knowledge, the Hotspots Fire Project delivers workshops and resources to landholders and land managers to provide them with the skills and knowledge they need to participate in fire management planning.

Hotspots operates on a core belief that well-informed and well-prepared communities complement the roles of land managers and fire agencies and that a shared approach to fire management is critical to any form of planning.

Under the guidance of the nine project partners in the Advisory Committee, Hotspots is delivered through the coordinated efforts of the NSW Rural Fire Service and the Nature Conservation Council of NSW.

> “The workshop really brought the community together to implement not just individual property level planning but also a far reaching and coordinated approach to managing fire risk as well as biodiversity.”
>
> – Hotspots workshop participant

Partners and collaborators

This booklet has been compiled for the Hotspots Fire Project, with input from and in consultation with a wide range of stakeholders. The information contained herein reflects our understanding at the time of publication. We are learning more about fire and the environment every day and anticipate that some recommendations may change as new information comes to hand.

This booklet was written by Nicole Conroy, Penny Watson, Grahame Collier and Julie Hinchliffe with assistance from Waminda Parker, Mark Graham, Kevin Taylor, Kate McShea, Lucy Tremain and Jeremy Gonthier for the Hotspots Fire Project. The Hotspots Fire Project is jointly managed by the Nature Conservation Council of NSW and the NSW Rural Fire Service.

Thanks to the many others who took the time to comment on the drafts. Thank you to our project partners for their technical input, photos and continuing support of the project: The NSW Department of Planning and Environment, NSW Local Land Services, NSW Farmers, The Queensland Fire and Biodiversity Consortium, Forestry Corporation of NSW, Local Government NSW, National Parks and Wildlife Service, and the University of Wollongong's Centre for Environmental Risk Management of Bushfires.

For further information on the Hotspots Fire Project contact:

The NSW Rural Fire Service
(02) 8741 5555
Email: hotspots@rfs.nsw.gov.au

The Nature Conservation Council of NSW
(02) 9516 0359
Email: info@hotspotsfireproject.org.au

The following agencies have resources that may be of assistance:

Hotspots Fire Project
www.hotspotsfireproject.org.au

NSW Rural Fire Service
www.rfs.nsw.gov.au

South East Local Land Services
http://southeast.lls.nsw.gov.au

Nature Conservation Council of NSW Bushfire Program
www.nature.org.au/healthy-ecosystems/bushfire-program

Forestry Corporation of NSW
www.forestrycorporation.com.au

NSW National Parks & Wildlife Service
www.nationalparks.nsw.gov.au

Queensland Fire and Biodiversity Consortium
www.fireandbiodiversity.org.au

NSW State Emergency Services
www.ses.nsw.gov.au

Demonstration property owner at Nerriga workshop © K. McShea

Version 4, October 2023
Front cover image © N. Conroy, Hotspots Fire Project. Internal cover top image ©Flickr smalljude. Internal cover bottom image © Hotspots. Back cover image © L. Andrews, Hotspots Fire Project

HOTSPOTS FIRE PROJECT

Nature Conservation Council
The voice for nature in NSW