HOTSPOTS FIRE PROJECT

MANAGING FIRE ON YOUR PROPERTY

A booklet for landholders in the Hawkesbury-Nepean Region

NSW RURAL FIRE SERVICE

Nature Conservation Council The voice for nature in NSW

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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.

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The Hotspots Fire Project is jointly delivered by the
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Hawkesbury-Nepean Region

1 INTRODUCTION TO THE HAWKESBURY-NEPEAN REGION

The Hawkesbury-Nepean Region covers approximately 22,000 square kilometres of NSW extending from Tarago, south of Goulburn to the Putty Valley in the north, and west from Lithgow to Palm Beach on the coast. The region is home to the second oldest national park in the world – the Royal National Park, and the World Heritage Listed Blue Mountains National Park. The region has a significant international value because it provides the majority of the drinking water for over five million people living in Sydney. A defining natural feature of the region are the mountains, which represent over 70% of the catchment, while 10% consist of flat terrain [1].

The region is home to approximately one million people living mostly in the major population centres of Western Sydney, Goulburn, Southern Highlands, Lithgow and the Blue Mountains. Land-uses include urban and residential development, mining, power generation, tourism and recreation, forestry, aquaculture and a wide range of agricultural industries [2].

The topography of the region and its proximity to the coast result in a variety of climates. The areas near the coast as well as the Blue Mountains are relatively wet. During winter, the region experiences cold days, particularly in more elevated parts. The temperatures are milder along the coast with warmer winters. There are some seasonal differences in rainfall with more rainfall occurring in summer and autumn.

The Hawkesbury-Nepean catchment's natural landscapes are incredibly varied, from rainforests to open woodlands, heathlands to wetlands, and highland freshwater streams to the magnificent Hawkesbury River estuary. Over 70 % of the vegetation of the catchment is considered intact, that means native vegetation in which the structure has not been substantially altered by human activities, or has been altered and has since recovered [3].

Although many of these landscapes have been altered by development and agriculture, almost half of the catchment is allocated to national parks and water catchment reserves. Despite this, the region includes some of the most critically endangered wildlife, plants and ecological communities in NSW.

The region is rich in cultural heritage, and overlies several First Nations including the Dharug, Eora, Tharawal (Dharawal), Wiradjuri, Darkinung (Darkinjung), Kuring-gai and Gundungurra[4]. In the region there are many areas and landscape features that have important social, spiritual, historical, and commemorative significance.

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[1]NSW Government, Department of Primary Industries, Water, Hawkesbury-Nepean catchment: http://www.water.nsw.gov.au/water-management/basins-and-catchments/hawkesbury-catchment (September 2016)

[2]State of the Catchments 2010, Hawkesbury-Nepean Region, Overview (2010) Published by: Department of Environment, Climate Change and Water NSW, now Office of Environment and Heritage.

[3]State of the Catchments 2010, Hawkesbury-Nepean Region, Native vegetation (2010) Published by: Department of Environment, Climate Change and Water NSW., now Office of Environment and Heritage.

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

2 LIVING WITH FIRE

Fire in the Hawkesbury-Nepean Region

Fire is part of life on the land in the Hawkesbury-Nepean 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 in recent years.

Large fires moving from west or east during spring and summer have been recorded regularly with devastating impacts. The Linksview Road Springwood and State Mine Fires in 2013 are recent examples before Black Summer where the massive Mt Gosper and other fires were experienced. The warming climate, topography and vegetative cover facilitates the formation of intense fire events such as Pyrocumulonimbus (pyroCb) bush fires.

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

Knowledge about the nature of fire and its effects on the landscape will help provide 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 already in the know, this information will add to existing knowledge and hopefully prompt some important new insights into fire management.

© C. Wade, 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 lead 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 lead to the contraction of fire sensitive areas such as rainforest to more naturally fire protected and wetter locations[5].

First Nations Australians 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 bush fire 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 Hawkesbury-Nepean 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 bush fires.

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.

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[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 high intensity 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 seeder *Petrophile pulchella* stores seed in woody capsules. Fire triggers release of this seed © P. Watson, Hotspots Fire 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 serrated tussock (*Nassella trichotoma*). 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 their 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 factor. In the Hawkesbury-Nepean 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. 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 be required from the NSW Rural Fire Service.

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 that leave 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 a base from which animals 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.

Vegetation subject to very small isolated burns may suffer negative impacts. 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 grazing pressure is high from native, feral or domestic animals. 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:

A fire varies in intensity 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

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 millions 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'.

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.

PLANT RESPONSES TO FIRE FREQUENCY IN A SHRUBBY VEGETATION COMMUNITY

Fire is important in allowing a diverse mixture of shrubs to continue living together. The following example illustrates the need for variability in fire frequency to cater for plant species with different responses to fire. The two banksia species in this story occur in heath and woodland communities along the New South Wales coast and Blue Mountains.

The saw banksia *(Banksia serrata)* is one of the largest banksia species. This plant can live for a century and can survive in frequently burnt areas. This is because adult plants have access to more than one strategy for surviving fire. They can resprout from protective buds underneath their bark and from woody underground lignotubers. In addition, a new generation of saw banksias can emerge from seed after fire.

Banksia ericofolia, obligate seeder
© W. Parker, Hotspots Fire Project

The heath-leaved banksia *(Banksia ericifolia)* on the other hand, is almost always an obligate seeder. This means the adult plant has only one fire survival strategy - seed release. Most seeds are released from the woody cones only after the parent plant has been killed by fire. It takes 5 to 8 years for this dense shrub to reach maturity, so if the heath and shrubby woodlands in which it occurs are burnt at intervals of less than 7 or 8 years, this plant can become locally extinct.

At the same time, intervals that are too long can impact on heath banksia, as this shrub lives for decades rather than centuries. Once adult plants die, seeds in cones quickly lose viability. Fire while adult plants are still alive triggers seed release, provides a nutritious ash bed for young seedlings, and reduces competition for sunlight, space, and moisture.

By 15 years after fire, heath banksias grow very large and thick, shading out smaller plants. They will have also stored massive amounts of seed. If all of the fires are spaced 15-30 years apart, new generations of heath banksia will dominate the landscape. Ensuring some fire intervals of 7-10 years, interspersed with some longer intervals, will therefore allow other smaller plant species to grow and build up new generations of seed.

FIRE FREQUENCY IN TEMPERATE GRASSY WOODLANDS

Grassy Woodlands once covered much of the Cumberland Plain, as well as parts of the tablelands and western slopes of the Great Divide. Attractive to settlers, these woodlands have been extensively cleared and used for pasture. Patches of good quality Grassy Woodland where native species still dominate are therefore very valuable from a conservation point of view.

Grassy woodland
© P. Watson, Hotspots Fire Project

Fire frequency can affect the balance between woody species and grasses in some 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 Woodland is concentrated in the ground layer. Here, tussock grasses such as kangaroo grass (*Themeda australis*), snowgrass (*Poa sieberiana*) and wallaby grasses (*Austrodanthonia* sp.) dominate. Smaller grasses and herbs grow in the spaces between these tussocks. Fire burns the dense tussocks back, making space for smaller species. Many grasses and herbs flower rapidly after fire, producing seeds that 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 soil stored seed is stimulated to germinate. Some shrubs, however, can regenerate between fires – blackthorn (*Bursaria spinosa*) is an example. 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, shading out some grass and herb species. Thus, relatively frequent fire may be important for maintaining vibrant populations of grasses and herbs as well as the animals that feed on them.

Both ground layer plants and shrubs form part of the rich diversity of grassy woodlands. 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 Hawkesbury-Nepean provide a significant refuge for several nationally vulnerable fauna species.

Although there will always be exceptions, areas which are often burnt tend to be less dense and have more open spaces. Infrequently burnt areas may naturally be thicker. These differences affect the animals that live in the bush.

Hollows as Habitat

There are extensive areas of hollow-bearing forest in the Hawkesbury-Nepean, mostly shrubby Dry Sclerophyll Forest which can be found in areas surrounding Sydney such as in the Ku-ring-gai, Marramarra, and Royal National Parks.

Hollows as habitat
© M. Graham, Hotspots Fire Project

These magnificent forests have numerous hollows and provide habitat for an abundance of fauna. Many fauna species 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 significant hollow-bearing trees and cause them to fall.

This leads to a loss of valuable habitat and causes increased competition for remaining hollows. Maintenance of hollow-bearing trees and enhancement of these valuable habitats wherever possible, is needed to ensure the survival of many native species.

Mammals and Birds

Many iconic threatened species are known to use hollows in the region including the glossy black cockatoo (*Calyptorhynchus lathami*), the gang-gang cockatoo (*Callocephalon fimbriatum*) and large forest owls such as the Vulnerable powerful owl (*Ninox strenua*), Australia's largest owl at 60 cm in height.

The yellow-bellied glider (*Petaurus australis*) and the spotted-tailed quoll (*Dasyurus maculatus*) inhabit the Dry and Wet Sclerophyll Forests of the region. These species are favoured prey of the powerful owl, which lives in wet and dry forest in coastal regions and on the tablelands and western slopes of northern New South Wales. 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 masked owl (*Tyto novaehollandiae*) is another vulnerable large owl found in the region. 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.

Some small mammals such as the brown antechinus (*Antechinus stuartii*) require dense and shrubby vegetation as habitat. Birds such as 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. This shrub-dependent species will generally return to regenerating shrubby areas within two or three years after a single fire; but by increasing the frequency of fires and removing shrub thickets across the landscape, there is a risk of losing these animals.

The scarlet robin (*Petroica multicolor*) for example, takes advantage of the open spaces provided by frequent fire. The lack of dense undergrowth makes it much easier to see and pounce on their ground dwelling prey. Some species like the new holland mouse (*Pseudomys novaehollandiae*) prefer the habitat that is created soon after a fire. This mouse likes open forest and heath in the early and middle stages of post-fire regeneration. It begins to recolonise burnt areas about one year after fire, and drops in abundance when litter and understorey vegetation build up. By excluding fire from woodland and forest landscapes, animals that rely on open spaces tend to be replaced by species adapted to more shrubby environments.

Some species, like the parma wallaby (*Macropus parma*) need both open and closed habitat created by fire. This wallaby has a strong association with moist eucalypt forest with a thick, shrubby understorey in which to take shelter during the day, traveling quickly through runways they make through the bush. They also need nearby open grassy areas to feed on the herbs and grasses at night.

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.

Powerful owl
© Deptartment of Planning and Environment

Yellow-bellied gllider
© D. Cook

Invertebrates

Giant dragonfly
© Huw Evans, Dept. Planning and Environment

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. The giant dragonfly (*Petalura gigantea*) is listed as Endangered, with habitat loss and degradation identified as the main threats. The egg and early larval stages are identified as the critical phases, where climatic and fire effects may significantly reduce reproductive success. 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.

Some plant-eating beetles, flies and spiders can take advantage of recent fires, while ants that 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 some animals need access to both open areas and denser cover and a mosaic of patches can fulfil this requirement.

Where native vegetation covers large areas it is likely that bush fires will meet this requirement. 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

© P. Warson, 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 22,000 square kilometres covered by the Hawkesbury-Nepean Region includes a wide array of environments. Altitude ranges from sea level to over 1000 m in the Blue Mountains, while average annual rainfall varies from 1300 mm on the coast to 600 mm over parts of the tablelands. Cumberland Plain summers are hot while those in the mountains are mild (24° C western Sydney, 18° C in Blue Mountains). Frosts, which hardly ever occur on the coast, are common in the mountains and on the tablelands. While soils in many parts of the region are sandy and low in nutrients, some places, like the Cumberland Plain and the Central Gorges, have relatively fertile clay loam soils. All these factors affect which plants grow where, and how fast they grow. They also affect the way fire behaves. 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 Hawkesbury-Nepean are listed on the following pages.

Vegetation types of the Hawkesbury-Nepean

Rainforests

© E. Geraghty, Hotspots Fire Project

Rainforests are dominated by soft leaved trees with vines, ferns and palms in the understorey. These forests grow on moist sites with 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), rainforests are very sensitive to recurring fires. Fire should therefore be excluded where possible.

Wet Sclerophyll Forests (shrubby subformation)

© P. Watson, Hotspots Fire Project

Wet Sclerophyll Forests (shrubby subformation) are tall eucalypt forests with a dense understorey of ferns, herbs and shrubs with broad soft leaves. These forests grow on relatively fertile soils in high rainfall areas.

In the Hawkesbury-Nepean, stands occur on the tablelands east of Oberon and in the Watagan Mountains. 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. Shrubby subformation Wet Sclerophyll Forests are likely to experience occasional intense bush fires, perhaps every 40 to 100 years. Intense fire may be needed for eucalypts to regenerate. Less intense but more frequent understorey fires may have a role in maintaining shrubs, ferns and herbs in some of the forests in this category.

Currently, variable fire intervals in the range 30 to 60 years are recommended for shrubby subformation wet sclerophyll forests across the state. However as research into the effects of fire frequency in shrubby Wet Sclerophyll Forests in NSW is still in its infancy, these recommendations may best be viewed as a first approximation which can be refined as we learn more.

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.

Wet Sclerophyll Forests (grassy subformation)

© P. Watson, Hotspots Fire Project

Grassy subformation Wet Sclerophyll Forests are dominated by straight trunked eucalypts, with a grassy understorey and sparse shrubs which may have hard or soft leaves. This tall forest type also grows on fertile soils in high rainfall areas.

These forests are similar to Wet Sclerophyll Forests (shrubby subformation) but have a more open canopy, less shrubs and a greater grassy or herbaceous groundcover.

In the Hawkesbury-Nepean, remnants occur on the tablelands, in the Watagan Mountains, and on shale soils in north-west Sydney. 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.

Dry Sclerophyll Forest (shrubby subformation)

© W. Parker, Hotspots Fire Project

This vegetation type covers forests and woodlands 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, whose flowers colour the bush in spring. The cover of grasses and sedges is sparse.

Dry Sclerophyll Forests (shrubby subformation), which grow on poor soils in moderate rainfall areas, are the dominant vegetation of the Hawkesbury-Nepean Region. Examples include the forests of the sandstone country which stretches from the coast up into the Blue Mountains, the sand flat forests around Castlereagh on the Cumberland Plain and the stringybark forests around Goulburn. Variable fire intervals between 10 and 30 years are recommended to maintain diversity in this vegetation type.

Dry Sclerophyll Forest (shrub/grass subformattion)

© P. Watson, Hotspots Fire Project

Dry Sclerophyll Forests (shrub/grass subformation) consist 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.

Several rather different forms of shrub/grass Dry Sclerophyll Forest are found in the Hawkesbury-Nepean. The forests of the gorges south-west of Katoomba occupy precipitous slopes, while on the low rolling hills of the Cumberland Plain shrub/grass forests occur in a mosaic with grassy woodlands.

Across the state, intervals in the 8 to 50 year range have been recommended. The grass component is likely to be best maintained by short intervals, while the shrub component is predicted to increase with longer intervals.

Heathland

© P. Watson, Hotspots Fire Project

Heathlands are dominated by hard-leaved shrubs, many of which are obligate seeders. Heath grows in high rainfall areas, on infertile soils, often in exposed positions.

In the Hawkesbury-Nepean heaths are found in coastal areas and also inland on sandstone ridges and slopes where soils are not deep or fertile enough to support trees. Fires at a range of intervals between 10 and 30 years are recommended for maintaining biodiversity in heathlands.

Within this range, variability in inter-fire interval is important. Research in heaths in the Sydney region has found that plant species diversity is maximized through diversity in inter-fire intervals. Further studies have clarified why this is so: fire creates the space for large and small species with a range of responses to fire to live together (see page 14).

Grassy Woodland

© P. Watson, Hotspots Fire Project

These are open eucalypt woodlands with an understorey of grasses, herbs and scattered shrubs. Grassy Woodlands grow on rolling terrain with fertile soils and moderate rainfall.

In the Hawkesbury-Nepean, Grassy Woodlands once occupied most of the Cumberland Plain where the suburbs of Western Sydney now sit, and also occurred on the tablelands north and south of Goulburn. Grassy Woodlands have been heavily cleared and grazed.

Across the state, a variable fire frequency of between 8 to 40 years has been recommended. On the Cumberland Plain where plants grow relatively quickly because of higher rainfall and warmer temperatures, 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 and snow gums are sometimes found, somewhat longer intervals are likely to be appropriate.

Grassland

© G. Basnett, Hotspots Fire Project

Grasslands are notable for their 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 native Grasslands are easily missed; some may not even be visible through autumn or winter, but re-emerge to flower in spring.

Grasslands once occurred south of Goulburn, as well as on some coastal headlands. Grazing and pasture improvement have extensively modified the Grasslands, so remnants where native species continue to thrive are places to be cherished.

Across the state, fires at intervals between 3 and 10 years are recommended to keep dominant grasses from overwhelming smaller herbs and to open up gaps for seedlings to germinate and grow.

Forested Wetland

© W. Parker, Hotspots Fire Project

These forests typically feature hard leaved trees (paperbarks, casuarinas, eucalypts), 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. Scientists have not yet studied the role of fire in this vegetation type in any detail; however variable intervals between 10 and 35 years are suggested.

Freshwater Wetland

© E. Geraghty, Hotspots Fire Project

Freshwater Wetlands include heath swamps and high country bogs and fens. They usually have a dense ground-cover of sedges, and may also contain a wide range of shrubs. Freshwater Wetlands occur on peaty soils with reduced drainage and may be either periodically or permanently inundated. As in drier heathlands, variable fire regimes play an important role in creating space for the full range of plant species. Intervals between 10 and 35 years have been suggested for this vegetation.

Because these communities are vulnerable to peat fires when the substrate is dry, planned fires are best conducted when the soil is wet.

Note that freshwater wetlands are areas of great 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.

Estuarine and Saline Wetlands

© E. Geraghty, Hotspots Fire Project

Estuarine and Saline Wetlands include the mangroves and salt marshes that occur along the edge of coastal estuaries.

These communities are not fire prone and excluding fire is appropriate.

6 FIRE MANAGEMENT PLANNING

Introduction

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.

Property planning at Hotspots workshop © M. Rose

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 in the Hawkesbury-Nepean 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, fromer 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*.

Landholders exchange local fire knowledge and experience © Never Never Resources

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.

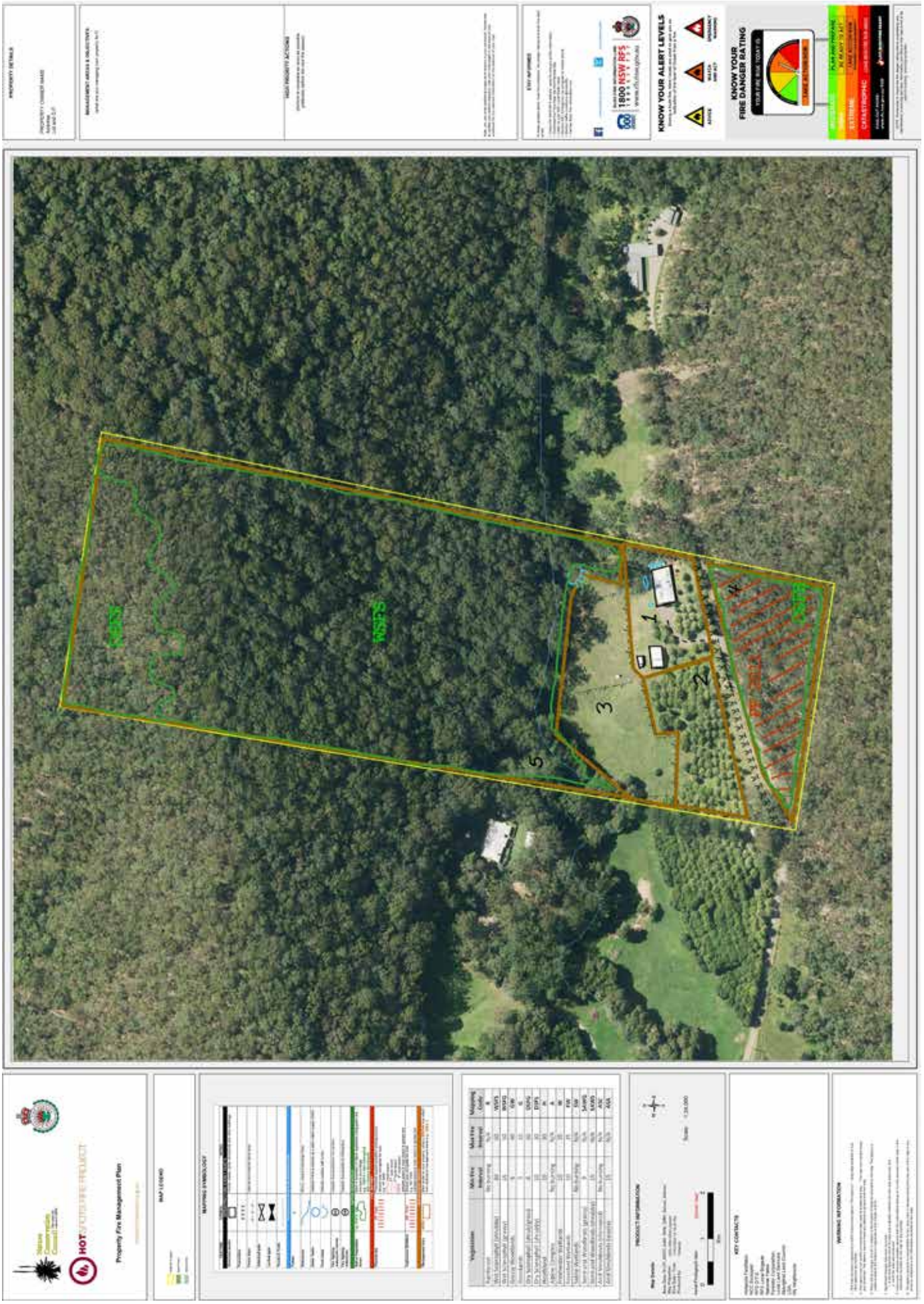
- Make a note of the fire frequency intervals recommended for the vegetation types on your property.
- How often have these vegetation types burned in the past? Note when and where fires have occurred. What is the fuel load?
- Are past fire regimes consistent with recommended regimes? Make a note of 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.



Example Hotspots Property Fire Management Plan

© Hotspots Fire Project

8 Fire and Climate Change

It is now 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].

> "The greatest increase in the Hawkesbury-Nepean Region is projected for Western Sydney with an additional 5-10 days in the near future." [2]

Climate Change in the Hawkesbury-Nepean Region

Temperatures have been increasing in the Hawkesbury-Nepean Region since about 1960. The future climate is projected to continue to warm on average about 0.7 °C in the near future (2020-2039). Fewer cold nights are projected to occur in the Blue Mountains and inland.

Such warming tendency would increase evaporation, heat waves, extreme wind, and fire weather risk. Despite a considerable increase in autumn rainfall, the spring rainfall will decrease in the near future. The greatest increase in hot days is expected around Western Sydney and the Hawkesbury, mainly during spring and summer. Four additional hot days and 5 fewer cold nights are expected on average for the near future in the catchment. 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 has already experienced an increase in the severity and frequency of fire weather[4]. Although these changes won't affect the region in autumn due to projected increases in seasonal rainfall, they are projected to occur in spring during prescribed burning periods and in summer, which is the peak fire risk season. During spring, the north-west and south-west of the region will be more affected. The impacts of climate change in this area are most likely to be felt through extreme weather events. There will also be long-term consequences for the region from changes in average temperature, rainfall and evaporation[3].

Changes in 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’ bushfire season is rapidly changing, as bush fires are increasing in number and burn for longer.” [5]

© 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) Metropolitan Sydney Climate change snapshot, Produced by NSW and ACT Regional Climate Modelling (NARCliM) project.

[4]https://www.csiro.au/en/research/natural-disasters/bushfires/2019-20-bushfires-explainer

[5]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 Hawkesbury-Nepean Region

Fire management planning to protect life, property and the environment requires collaboration within communities, between agencies and across tenures. Bush Fire Management Committees are responsible for Bush Fire Risk Management Plans. There are 13 committees in the Hawkesbury-Nepean region covering the Blue Mountains, Chifley, Cumberland Zone, Central Coast, Hawkesbury, Hornsby/Ku-ring-gai, Hunter Valley, Illawarra, Lithgow, Macarthur, Southern Tablelands, Northern Beaches, and Wingecarribee/ Wollondilly.

By working together, individual landholders can be part of a 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 at Hotspots Bowen Mt workshop © M. Graham, Hotspots Fire Project

Community members listen to a presentation in Canyonleigh. © K. Taylor, 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 contributions from Waminda Parker, Mark Graham, Kevin Taylor, Kate McShea, Jeremy Gonthier, Richard Geddes and Lucy Tremain 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.

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The Nature Conservation Council of NSW
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The following agencies have useful websites and may be of assistance:

Hotspots Fire Project
www.hotspotsfireproject.org.au

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

Greater Sydney Local Land Services
www.lls.nsw.gov.au/regions/greater-sydney

Nature Conservation Council of NSW Bushfire Program
www.nature.org.au/bushfire_program

Forestry Corporation of NSW
http://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

Landholders and Forest NSW staff at Glen Innes. © Never Never Resources.

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HOTSPOTS FIRE PROJECT

Nature Conservation Council
The voice for nature in NSW