FIRE & BIODIVERSITY

Landholder Information Guide

AUGUST 2018

SOUTHCOAST
NATURAL RESOURCE MANAGEMENT

INFORMATION TO HELP BALANCE THE CONSERVATION OF BIODIVERSITY WITH THE NEED TO BE FIRE SAFE

Photo: Sarah Comer, Department Biodiversity, Conservation and Attractions

Photo: Meredith Spencer

ACKNOWLEDGEMENTS

This landholder guide has been comprised using existing research and information produced by a number of sources and expert opinion. While it is primarily focussed on the South Coast region of Western Australia, the research and information is based on broader knowledge bases, and therefore has relevance beyond this region.

We are very grateful to the Cape to Cape Catchment Group of the Margaret River region, who informed the design of this guide and have allowed us to reproduce aspects of their related publication, which in turn was produced with valuable input from Dr Lachie McCaw, Department of Biodiversity, Conservation and Attractions (DBCA).

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Useful additional information and references can be found at the end of the publication.

South Coast NRM has prepared this publication in good faith to provide landholders and managers with information to help balance the conservation of biodiversity with the need to be fire safe. It provides material derived from sources believed to be reliable and accurate at the time of publication. The publication is intended to be a guide only and readers are directed to seek their own independent advice and make their own necessary enquiries as needed.

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Australian Government

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OUR REGION CONTAINS A DIVERSE MOSAIC OF VEGETATION TYPES AND HABITATS THAT SUPPORT MANY UNIQUE SPECIES. IT IS UP TO ALL OF US TO MAINTAIN THESE LANDSCAPES INTO THE FUTURE.

Photo: Meredith Spencer

Photo: Sarah Barrett, Department of Biodiversity, Conservation and Attractions

CONTENTS

1. ABOUT THE LANDHOLDER GUIDE

South Coast NRM has developed this Fire and Biodiversity guide to provide both urban and rural landholders and managers with information to help balance the conservation of biodiversity with the need to be fire safe. Recent changes to legislation and policies have enhanced risk management in relation to fire, and protection of life and property continues to drive fire management decisions. There is, however, a need for further understanding and appreciation of fire and biodiversity and, in particular that:

1. Reducing bushfire risk can often be undertaken while supporting biodiversity values; and
2. There are many excellent opportunities for landholders to contribute greatly to the maintenance of our unique biodiversity through their fire management decisions.

The South Coast region has extremely high levels of biodiversity with more than 20% of the State's plant diversity and numerous unique and threatened flora and fauna species. It is internationally recognised as being part of one of the world's 34 biodiversity "hotspots" and includes significant areas of conservation reserves including iconic areas such as the Fitzgerald River and Stirling Range National Parks and the Two Peoples Bay Nature Reserve. Biodiversity values within privately owned remnant bush are also very high.

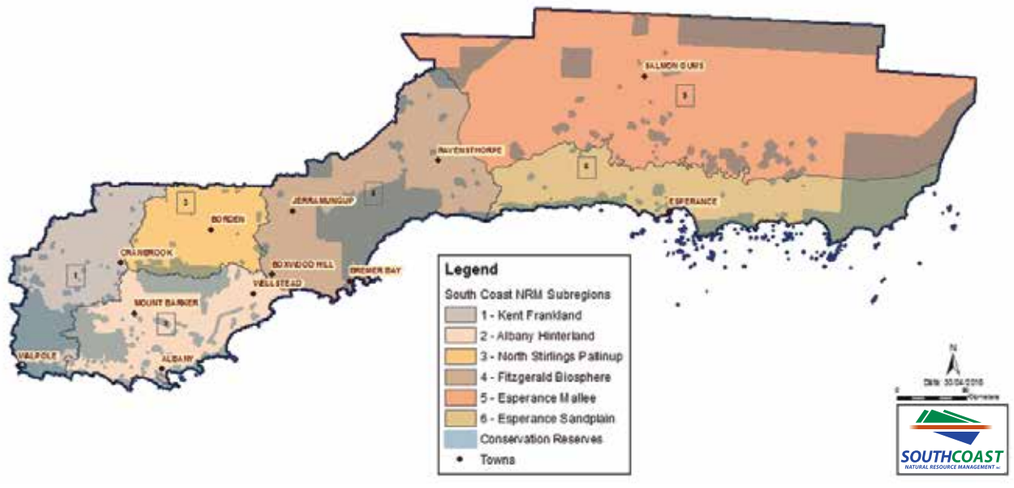
In addition to providing habitat for unique flora and fauna, our natural environment helps to define our region's "sense of place". Natural bushland is valued within the community for its beauty, character and diversity, and people frequently choose to live close to nature to benefit from its many intrinsic values. At the same time, there is recognition that vegetation, as fuel, may also be a fire hazard which needs management in balance with those values.

Therefore, whether you are planning a new development or wanting to manage your existing property, consideration of biodiversity in your decisions relating to fire management should be really important.

Fire can impact biodiversity through direct and indirect influences and is considered a significant threatening process to fire sensitive ecosystems, many of which occur within the South Coast region (Barrett et al, 2009). For example, if the interval between fires is shorter than the time necessary for seed banks to re-establish, vegetation communities and the habitats they support may be significantly changed and species may even be lost.

Fire activity is sensitive to various factors including wind speed, humidity, temperature and drought, and changes in climate may result in more fire events in the region. CSIRO research indicates that extreme fire-weather days have, and will continue to become, more prevalent (Hope et al, 2015). Community appreciation of the risk posed by fire in a drying climate is high, and this guide is designed to extend that understanding to include conservation awareness. Knowledge in this field continues to grow and viewpoints in the community and amongst experts can vary significantly regarding the information presented. This publication is an initial attempt to address the importance of biodiversity considerations in fire planning, and it is intended that it be an evolving document, improved and enriched over time.

SOUTH COAST NATURAL RESOURCE MANAGEMENT REGION



Sections 1 to 3 of the Landholder Guide provide an introduction into general principles and terms in relation to fire, while Sections 4 to 7 include techniques and knowledge for balancing fire and biodiversity values around the home and in remnant bushland. Sections 8 and 9 outline relevant legislation and offer useful links to further information. Appendices 1 and 2 describe the specific ecological considerations for South Coast vegetation and wildlife, respectively.

IMPORTANT

Protection of people and property is a foremost consideration in fire management decisions, particularly near the home. **Compliance with relevant legislation and local government regulations is essential.** Consult your local brigade and/or local government fire notices to ensure compliance with all regulations and directions.

The information presented here is intended to provide knowledge that will allow people to consider biodiversity conservation as a high priority within fire planning.

Every property has unique ecological values, topography, fire history, threats and risks. Land managers and landowners are strongly advised to seek professional assistance to formulate site specific fire management plans.

Photo: Stretch (Darren Little), City of Albany

2. FIRE MANAGEMENT PRINCIPLES

Fires may result from human activity or be naturally occurring, for example lightning strikes.

For many thousands of years before European arrival, Indigenous Australians worked to shape the landscape and to protect and conserve the plants and animals found here. Fire is of great cultural significance to Aboriginal people who have used this extensively to manage the landscape, and many organisms have developed adaptations for living with fire.

There is increasing acknowledgement for the need to understand the influence of past fire regimes on vegetation and to acknowledge traditional Aboriginal land management practices as well as the changes caused by European attempts to create a natural regime to determine modern-day prescribed burns (Kost, 2013). Regional natural resource management (NRM) organisations across Australia are investing in, or interested in, the use of traditional Aboriginal and contemporary fire knowledge as a land management tool. This provides opportunities to both rejuvenate and regenerate native ecosystems and support cultural obligations and economic opportunities for Aboriginal people through environmental services contacts.

There has been considerable discussion around this area of land management in previous years across multiple sectors. Fire risk management in terms of protection of lives, infrastructure and property is currently actively managed at State Government and Local Government (local volunteer brigades) level, however fire manipulation for native ecosystem management has been lacking.

With a changing climate, fire events are predicated to become more frequent and intense. Biological and physical traits may enable some plant communities to be relatively resistant to fire prone environments, while others may be less so.

In relation to fire there are several principles, based on current scientific knowledge, that relate to biodiversity values in Western Australia. These are described by Shedley (2007) below:

Principle 1

Fire is an environmental factor that has influenced, and will continue to influence, the nature of the south-west landscapes and biodiversity.

Principle 2

Species and communities vary in their response to, and reliance on, fire. Knowledge of the life histories of organisms or communities and their relationship to fire should underpin the use of fire in natural ecosystems.

Principle 3

Following fire, ecosystems often form a new, short-lived state with respect to species composition and structure because of environmental factors such as landform, topography and the biology of species, together with random climatic events.

Principle 4

Fire management is required for two primary reasons, and these are not necessarily mutually exclusive:

1. To conserve biodiversity, including encouraging natural regeneration
2. To reduce the occurrence of large intense wildfires.

Fire management should consider both ecological and protection objectives in order to optimise outcomes.

Principle 5

The damage potential, suppression difficulty and direct impact on biodiversity of a fire, and the rate of recovery following a fire, are in direct proportion to the fire's intensity and size.

Principle 6

Fire diversity promotes biodiversity. An interlocking mosaic of patches of vegetation – representing a range of fire frequencies, intervals, seasons, intensities and scales – is needed to optimise the conservation of biodiversity. No single fire regime benefits all organisms or ecosystems.

Principle 7

Fire management should avoid applying the same fire regime over large areas for long periods of time, and also avoid extreme regimes, such as very frequent or very infrequent intervals over large areas.

Principle 8

The scale of the fire-induced mosaic should:

- enable dispersal of young native animals
- optimise boundary habitat
- optimise connectivity or the ability of animals to move through the landscape.

Principle 9

All available knowledge, including life histories, attributes of native plants and animals and knowledge of traditional Aboriginal fire regimes should be used to develop ecologically based fire regimes for a landscape or a vegetation complex.

Principle 10

Fire history, vegetation communities and landscape information should be used to develop the known and ideal intervals of time since last fire.

Principle 11

Wildfire can damage and destroy both conservation and social values. Because of this it is important to develop a systematic and structured approach to identify and manage the consequences of wildfire events.

Principle 12

Fire management should adapt to new knowledge gained through research, monitoring and experience together with changing community expectations.

Photo: Deon Utber, Department of Biodiversity, Conservation and Attractions

Photo: David Mitchell, Department Biodiversity, Conservation and Attractions

3. ECOLOGICAL FIRE MANAGEMENT TERMS

FIRE REGIME

Refers to the frequency, season, intensity and pattern characteristics of fire. These can be influenced by decisions including how, when and under which conditions fires are lit. Fire exclusion can also be classed as a fire regime as plant and animal compositions will continue to change in the absence of fire.

FIRE RESPONSE

Includes the individual response, population response and community response to fire regimes over time and spatially.

The ecosystems of the South Coast have varied responses to fire, with some being fire sensitive, resulting in permanent loss of species diversity, structure and habitat value in the face of inappropriate fire, while others are more fire resilient, composed of species able to re-establish their pre-fire state relatively quickly.

PATCHINESS AND MOSAICS

Ideally the creation of patches of different post fire age and fire regimes is optimal for biodiversity, and no burn areas may be designated, for example along streams. Creation of unburnt sections can provide:

- protection for sensitive communities
- refuge from adjoining fires
- diversity of habitat features.

Within small remnants, however, impacts including disturbance caused through boundary creation and weed invasion can be significant, and these may out-weigh the benefits of creating a mosaic.

FIRE SEASON

Seasonal conditions, for example, patterns of rainfall, temperature, day length, humidity and wind speed can all influence fire behaviour and its effects on plants and animals. The ecological objectives of any burn will dictate within which season – autumn, winter or spring – a burn is undertaken.

FUEL LOAD

Several factors influence the rate of spread and heating effect of a fire including the amount and condition of fuel, together with aspects such as fuel dryness, ground slope and wind speed. It will vary depending on vegetation type and whether in a natural or modified environment. For example, fuel in forests will include the ground fuels such as leaf litter and twigs and aerial fuels such as fine live and dead foliage on shrubs and bark, sometimes referred to as “ladder” fuels. In heath vegetation, live and dead shrub material will carry fire. Cured, dry grasses and annual weeds often account for the predominant fuel on roadsides and in remnant bush within agricultural land.

FIRE BEHAVIOUR

It is essential to have an understanding of fire behaviour for both ecological and fuel reduction purposes.

Slow moving trickle fires can be managed with minimal risk, while more intense fires may result in burning embers being blown downwind of the flames – a process known as “spotting”. Intense fires can cause damage to mature trees and mortality to fauna, leaving few unburnt patches and single aged regrowth. It can also facilitate soil erosion and sediment movement into streams.

HABITAT TREES AND FEATURES

Habitat trees and features include large hollow-bearing trees, patches of scrub, granite outcrops, waterholes and other areas known to be nesting sites or important habitat for species. By clearing fuels from the base and edges of these features and ensuring they are targeted for protection during and following burns, they can be protected from the impacts of fire.

FURTHER INFORMATION

Barrett, S. Comer, S., McQuoid, N., Porter, M., Tiller, C. and Utber, D. (2009) Identification and Conservation of Fire Sensitive Ecosystems and Species of the South Coast Natural Resource Management Region, Department of Conservation and Land Management, South Coast Region, Western Australia

Photo: Meredith Spencer

Photo: Meredith Spencer

4. BUSHFIRE PRONE AREAS

The natural environment provides habitat for unique flora and fauna and often defines a region's "sense of place". Vegetation is valued within the community for its beauty, character and diversity, and people frequently choose to live close to nature to benefit from its many intrinsic values. At the same time, there is recognition that vegetation, as fuel, may also be a fire hazard which needs management in balance with those values.

Many of us have chosen to make our homes amongst the beautiful natural environment of the South Coast region.

Over time, improvements in suppression technology, understanding of fire regimes and building construction methods and materials, together with more fragmented landscapes through urbanisation have helped to reduce fire risks. Having said this, large bushfire events continue to impact communities across Western Australia (AILA, 2016).

Following inquiries resulting from major bushfire events, an online, interactive map of Western Australia was developed to identify areas deemed by the Fire and Emergency Services Commission to be bushfire prone.
https://maps.slip.wa.gov.au/landgate/bushfireprone/

This map indicates that much of the South Coast region has been designated bushfire prone, identified by the presence of and proximity to bush fire prone vegetation. The areas include both the vegetation and a 100 metre buffer zone immediately surrounding it. Areas identified as being bushfire prone may trigger assessment under planning and other regulations.

Reforms to Government regulations and policies enacted in April 2016 require that new buildings, additions and developments be assessed for their bushfire risk level, and specific construction and landscape requirements be implemented, depending on the risk level. It is recommended that these be applied to existing constructions; however, this is not mandatory - the regulations are not retrospective at this stage.

BUSHFIRE ATTACK LEVEL

Bushfire Attack Levels (BALs) are a way to measure the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact. They use increments of heat flux exposure expressed in kilowatts per metre squared, and provide the basis for construction requirements to improve protection of buildings from attack by bushfire.

The Australian Standard 3959 (AS 3959) provides specifications for determining BALs and for building construction in a bushfire prone area. The document breaks down the risk into 6 different levels:

BAL Low
BAL 12.5
BAL 19
BAL 29
BAL 40
BAL Flame Zone

BAL-FZ	BAL-40	BAL-29	BAL-19	BAL-12.5	BAL-LOW
Direct exposure to flames, radiant heat and embers from the fire front.	Increasing ember attack and windborne debris, radiant heat between 29 kW/m2 and 40 kW/m2. Exposure to flames from fire front likely.	Increasing ember attack and windborne debris, radiant heat between 19 kW/m2 and 29 kW/m2.	Increasing ember attack and windborne debris, radiant heat between 12.5 kW/m2 and 19 kW/m2.	Ember attack radiant heat below 12.5 kW/m2.	There is insufficient risk to warrant any specific construction requirements, but there is still some risk.

Image: Courtesy of WA Planning

The BAL rating is influenced by a number of factors including distance to and type of vegetation, and the slope of the land underneath the vegetation. In Western Australia, these factors are applied against a Fire Danger Index of 80 to determine the BAL. Determination of a BAL rating for new developments, alterations and structures such as decks need to be undertaken by accredited BAL assessors. BAL ratings will also influence landscape design.

Generally, a rating of BAL 29 or lower indicates that the bushfire risk is considered manageable. For developments where BAL 40 or Flame zone applies, it must be demonstrated that the risk can be managed to the satisfaction of the decision makers before building or planning approval will be given.

Siting new developments in lower risk or existing cleared areas of the block during planning phases can enhance both safety and biodiversity values. Homes situated at the top of vegetated slopes, for example, are in hazardous positions, as fire moves quickly upslope. They will also require greater modification of native vegetation to reduce fuel loads and subsequent risk.

Enhance protection of biodiversity by reducing the risk of fire.

Manage hazards to life and property by constructing and maintaining homes and having buffer zones to minimise risk of fire.

FURTHER INFORMATION

Australian Standard AS3959 – includes assessment methodologies and construction specifications.
http://www.gnowangerup.wa.gov.au/files/9614/4953/7761/20151204112916593.pdf

A Visual Guide for bushfire risk assessment in Western Australia (this document aims to present Western Australian vegetation types in relation to AS3959 vegetation classifications).
https://www.planning.wa.gov.au/dop_pub_pdf/Visual_guide_for_bushfire_risk_assessment_in_Western_Australia.pdf

ASSET PROTECTION ZONES

Bushfire regulations require that Asset Protection Zones (APZs) be developed around habitable buildings to minimise the level of bushfire impact. The guidelines recommend that with AS 3959 constructed homes the APZ be of sufficient size to ensure potential radiant heat from a bushfire does not exceed 29Kw/m² (BAL 29) at all times.

Keeping flammable material to minimum for 20m around buildings is also a requirement of most local government regulations. It is, however, important to know the specific requirements of your local government area, as some Shires have further, particular requirements. For example, the Shire of Denmark regulations require APZs to factor in slope of the land, meaning the APZ will be larger for properties with vegetated slopes.

The APZ should include a defendable space adjacent to the building to allow firefighters or adequately prepared homeowners better access and a safer area from which to defend the building. This should be an area of at least three metres in width where bushfire fuel is kept at an absolute minimum.

An APZ around a home may be achieved with thoughtful plant placement and design of the surrounding landscape – there is no need to clear every stick of vegetation on your property. The environmental, economic and social values of native vegetation can be preserved through measures such as appropriate siting of developments and by taking care and consideration in the design of your garden within the APZ. These can be undertaken with a view to maximising benefit to biodiversity while balancing the need for fire safety.

The following Section 7 is summarised from the Country Fire Association Victoria (2012) document Landscaping for Bushfire: Garden Design and Plant Selection. The full document can be downloaded at:
https://www.cfa.vic.gov.au/documents/20143/72271/landscaping_for_bushfire.pdf/1c6084e1-159e-a820-b0b3-6dc077e661c0

Photo: Meredith Spencer

5. GARDEN PLANNING FOR FIRE AND BIODIVERSITY

When planning a fire wise garden it is important to recognise that three main factors influence bushfire behaviour.

WEATHER

The hot, dry and windy days often experienced in summer increase the flammability of vegetation by drying plant material, allowing it to readily ignite.

The greatest risk to a house is from ember attack, which occurs when small burning leaves, twigs and bark are carried by wind, landing in and around homes and gardens.

TOPOGRAPHY (OR SLOPE)

Slope influences fire behaviour, with fire burning more quickly and intensely upslope than down. Vegetation ahead of the fire is heated by flames and radiant heat, increasing its flammability.

VEGETATION (FUEL)

In a bushfire situation, plants are the primary source of fuel. The amount, type and arrangement of vegetation will affect how easily fire may spread through a garden.

Fine fuels, for example, leaf litter can dry easily and be spread as embers. Shrubs, vines and other high fuels can act as "ladders" for fire, taking it to the canopies of trees and increasing the fire intensity.

By breaking up the continuity of fuel, the spread of fire can be limited. Selective placement and choice of plants within the APZ can also reduce fire risk around homes.

DESIGN

It is possible to achieve appropriate fire safe fuel levels in the asset protection zone while providing for native plants and animals. The following design principles can reduce potential impact to homes from fire:

- create a defendable space
- remove flammable objects
- break up fuel continuity
- carefully select, locate and maintain trees/plants.

DEFENDABLE SPACES

A defendable space is the area immediately around a home (the inner zone) where vegetation should be minimal for approximately 3m - locate non-flammable surfaces such as paths, driveways and paved areas here.

Use non-combustible, moveable containers and plant pots that can be relocated in summer.

REMOVE FLAMMABLE OBJECTS

As far as possible keep flammable objects such as barbecues, gas bottles, wood piles and furniture away from the house.

Lay alternative mulches such as gravel, scoria, pebbles, shells or recycled bricks and use landscaping features such as stone walls, rockeries and pathways.

Photo: Meredith Spencer

BREAK UP FUEL CONTINUITY

Design your garden so as to break up the garden beds with areas of low fuel between. This will reduce the likelihood of garden plants igniting the vegetation around them through radiant heat or direct flames.

Some ways to do this include:

- not planting shrubs under trees – if planted beneath trees, shrubs can act as "ladders" and carry fire to tree canopies
- clump shrubs and trees so that they don't form a continuous canopy
- use gravel paths, non-flammable mulch and mown grass to separate plant groups
- prune tree branches to a minimum of 2m above the ground.

THINGS TO CONSIDER IN GARDEN DESIGN

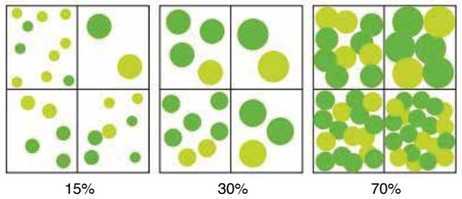
- Paths
- Ponds
- Bird baths
- Rock or masonry walls
- Low plants
- Rock mulch
- Sprinklers
- Rain water
- Fire fighting equipment

Photo: Cherie Kemp

The guidelines Planning in Bushfire Prone Areas Version 1.1 describe the planting standards for Asset Protection Zones:

- **Fences:** within the APZ are constructed from non-combustible materials (e.g. iron, brick, limestone, metal post and wire). It is recommended that solid or slatted non-combustible perimeter fences are used.
- **Objects:** within 10m of a building, combustible objects must not be located close to the vulnerable parts of the building i.e. windows and doors.
- **Fine fuel load:** combustible dead vegetation matter less than 6 millimetres in thickness reduced to and maintained at an average of two tonnes per hectare.
- **Trees (> 5m in height):** trunks at maturity should be a minimum distance of 6m from all elevations of the building, branches at maturity should not touch or overhang the building, lower branches should be removed to a height of 2m above the ground and or surface vegetation, canopy cover should be less than 15% with tree canopies at maturity well spread to at least 5m apart as to not form a continuous canopy.

Figure 16: Tree canopy cover – ranging from 15 to 70% at maturity



- **Shrubs (0.5m to 5m in height):** should not be located under trees or within 3m of buildings, should not be planted in clumps greater than 5m^2 in area, clumps of shrubs should be separated from each other and any exposed window or door by at least 10m. Shrubs greater than 5m in height are to be treated as trees.
- **Ground covers (< 0.5m in height):** can be planted under trees but must be properly maintained to remove dead plant material and any parts within 2m of a structure, but 3m from windows or doors if greater than 100mm in height. Ground covers greater than 0.5m in height are to be treated as shrubs.
- **Grass:** should be managed to maintain a height of 100mm or less.

OTHER IMPORTANT THINGS TO REMEMBER:

- fire is rarely sustained in the canopy without understorey or leaf litter beneath the tree
- keep gutters free of leaves and other material that may burn
- keep grasses below 10 cm in height
- remove dead leaves and branches from around the house and under trees
- keep plants well hydrated through watering and non-flammable mulch. Watering less frequently but for longer encourages deeper roots and reduces moisture loss during dry periods
- remove weeds – these often contribute to fuel loads and can escape into adjacent bush
- replace plants that die or become diseased.

In a fire situation, strong winds may cause branches or trees to fall or catch alight and fall. Correctly selected and located trees can, however, reduce wind speed, absorb radiant heat and filter embers.

CHOOSING SUITABLE PLANTS FOR THE ASSET PROTECTION ZONE (APZ)

Keep landscaping plantings or native vegetation to low growing plants in the APZ. Maintaining native bushland can be achieved through pruning/slashing, pathway placement and fuel reduction through raking or burning.

If planting, choose your plants and design carefully with bushfire prone areas in mind.

All plants will burn under certain conditions depending on the intensity of the fire and amount of ember and flame attack.

Plants with high foliage moisture won't burn as readily as those with low foliage moisture, and those with low foliage moisture will also continue to burn once the ignition source has been removed.

Having said this, it must be noted that all plants, including those with high foliage moisture, that are in the path of bushfire will dry out as a result of radiant heat if they are subjected to this heat for long enough.

Leaves that are soft and fleshy, or wide, flat and thick tend to have greater moisture content compared to their surface area, making them more fire wise.

A higher moisture content means the leaves will take longer to dry out and therefore longer to catch fire.

Fruits and vegetables are useful plants around the home as they can assist protection from fire and will also support biodiversity, including birds and insects.

The placement of plants within a garden, rather than the flammability of individual plants, is of greater importance in restricting the impact of bushfire spread.

Plant fruit trees on the side of the house most at risk - that which receives prevailing summer wind - ensuring tree crowns are a minimum 2m from the building (FESA, 2008).

Agapanthus readily spreads to bushland & is very difficult to eradicate

WEED SPECIES

It is also essential to ensure plants selected do not have the potential to become Environmental Weeds. Some popular garden plants can escape into adjacent bushland and grow rapidly, displacing native species. They also often contribute to high fuel loads.

Further information on controlling specific weeds can be found in Florabase weed notes:
https://florabase.dpaw.wa.gov.au/weeds/

Some common weeds in the region can be found in the following publication:
http://www.denmark.wa.gov.au/Profiles/denmark/Assets/ClientData/Documents/biosecurity/Weed_it_Out_Brochure_Print_Version.pdf

NATIVE PLANTS SUITABLE FOR THE ASSET PROTECTION ZONE

Native plantings will enhance biodiversity value in the garden, providing colour and habitat for birds and other fauna. They are most well suited to local conditions and require less watering than many exotic plants. Many low growing locally native plants can be used within the APZ area.

Principles for low flammability plants include:

- limited potential for growth in height or width
- smooth bark that does not accumulate on the plant or shed in long ribbons
- those that do not accumulate large amounts of dead foliage on the plant
- foliage that decays rapidly once shed from the plant (e.g. some small Allocasuarina species may be suitable for the APZ, while taller species that produce deep needle beds won't be suitable)
- plants that can cope with periodic pruning to remove accumulated foliage or to break the vertical continuity of foliage and reduce the likelihood of fire spreading up through the plant
- plants with foliage that does not have a high content of volatile oils.

Once the principles are understood, plants suitable for your property can be selected from species lists, nurseries or established gardens (L. McCaw, Senior Principal Research Scientist, DBCA, pers. comm, 2017).

Loose, stringy or fibrous bark will ignite easily and may also carry fire up the tree to the canopy. Shreds of flaming bark may also create embers which can spread fire.

Smooth bark or that which is attached firmly is usually less flammable as it is more difficult to ignite.

The native shrubs and low ground covers below will be more able to regenerate following fire and/or can be easily pruned or slashed to keep low and reduce fuel availability.

Images from Western Australian Herbarium (1998 -). FloraBase - the Western Australian Flora. Department of Biodiversity, Conservation and Attractions. https://florabase.dpaw.wa.gov.au/

Anigozanthos (Kangaroo Paw - small varieties)

Conostylis (varieties)

Orthrosanthus

Grevillea (small varieties)

Hibbertia Buttercups

Hemiandra Snake Bush

Scaevola Fan Flowers

Astroloma Cigar Plant

Banksia (low prostrate species)

Adenanthos cuneatus (prostrate form)

Olearia axillaris

Patersonia occientalis

Hovea (small varieties)

Kennedia Coral Peas

Lomandra

Johnsonia Hooded Lily

Sowerbaea Purple Tassles

Chorizema Heart Flame Peas

All photos: Meredith Spencer

6. MANAGING REMNANT BUSHLAND

The South Coast region consists of a variety of landscapes and vegetation types, each with unique ecological characteristics. Soils are often nutrient poor and many vegetation communities have evolved that are both rich in species yet vulnerable to frequent disturbance including fire (McQuoid & McMahon, 2017).

These types of habitats are often found with high numbers of localised rare species and species of ancient ancestry. The communities can, however, show unexpected persistence and resilience even when fragmented (Hopper 2009); even small remnants of bushland on the South Coast are valuable and worth protecting.

Photo: Jane Plant

A unique predator – the Pitcher Plant.

Fire can play an important part in maintaining the diversity of native plants and animals, but this does not mean that even fire-adapted ecosystems will thrive under any burning regime – there are limits. Burning too frequently or not enough can cause species to decline, or even become locally extinct.

Generally landholders may wish to manage bushland remnants to:

1. Manage fuels to reduce wildfire risk
2. Promote regeneration of some vegetation communities.

Managed fire can be used for both of these purposes, however, it should be noted that following fire some vegetation types will regenerate thickly and certain fire responsive species may become more prevalent than they were before the fire.

It is important to remember also that every vegetation patch is different, with its own size, shape and individual species. It may be isolated, surrounded by pasture or connected to other vegetation. All of these factors will influence the type and scale of fuel management that is adopted.

> On small properties it may be preferable to hand clear, rake, slash and remove suspended material from trees & shrubs to reduce fuel loads

HOW DO NATIVE PLANTS RESPOND TO FIRE?

Fire plays a role in the lifecycle of many plants in fire-adapted communities. It can:

- open up the canopy, allowing sunlight to reach ground level
- form ash beds to provide nutrients to help seedlings establish
- eliminate insects and plant diseases which might otherwise slow growth
- stimulate new, vigorous growth to help boost plant health.

Many plants, such as Grass Trees (*Xanthorrhoea spp*) will flower profusely following fire, and some, like Banksia and Hakea release seeds from woody cases after fire.

Heat and the chemicals in smoke can both activate seed germination for many species.

In fire adapted ecosystems, plants may:

- survive the fire by reshooting a short time afterwards. Known as 'resprouters', these include most Eucalypt species. They may shoot from buds protected by bark on branches or from 'lignotubers' at the base of the plant
- be killed by fire, relying on regeneration from seed. Known as "obligate seeders", these species usually produce large quantities of seed which is stored in the soil or woody seed cases on the plant, ready to germinate after fire.

If fires are too frequent, there will not be enough time for seed banks to develop in between, and species may be lost from an ecosystem. To give both seeders and resprouters the time to reproduce, it is recommended that the time between fires should be about twice as long as the period it takes for the slowest growing seeders to mature and set seed.

Appendix 1 details common vegetation types in the South Coast region and provides advice on their biodiversity and recommended fire regimes.

> Where the primary purpose of fire management is for protection of life and property other management approaches may be desirable and a tailored Fire Management Plan is recommended.

LEGAL CONSIDERATIONS

Please note that prior to any bushland modification you should contact local and/or state government authorities to determine any requirements for native vegetation clearing or other permits.
https://www.der.wa.gov.au/images/documents/your-environment/native-vegetation/Fact_sheets/fs1_legislation.pdf

Threatened flora & fauna species and communities and environmentally sensitive areas are protected at State and Commonwealth levels against any action that may be considered to have a significant impact on the species, habitat and/or food resources.

CASE STUDY

Fire management strategies to maintain species population processes in a fragmented landscape of fire-interval extremes. (Tulloch et al, 2016)

Recent research modelled populations of seven Banksia species occurring under varying conditions in the South Coast region against different fire management strategies. This research found that in many areas, including peri-urban remnants, vegetation is burnt too frequently. This can lead to declines in species that rely on long intervals between fire, either for plants to reach maturity or for shelter/food resources for fauna to recover.

Conversely, too infrequent fire may also lead to declines in plant species through senescence (aging) of plants with relatively short life spans or seed longevity, or through being displaced by other species.

Connectivity to other remnant vegetation and unfavourable conditions post fire, e.g. related to lower rainfall as projected to occur with a drying climate, influenced species survival following fire. The researchers found that fires were more frequent and extensive in continuous vegetation compared to fragmented native vegetation remnants in agricultural areas.

Photo: Deon Utber, Department of Biodiversity, Conservation and Attractions

Overall, no one fire regime suited the persistence of all seven species of Banksia across the highly modified and fragmented landscape, although a regime of no fire was always found to result in reduced species persistence compared to managed fire or wildfire.

In unconnected landscapes, managed fire (or managed fire and wildfire) may be beneficial to maintain communities, however, in connected vegetation there is a need to reduce unplanned fire. In these circumstances, methods to reduce fire risk that do not involve burning may be more appropriate.

Photo: Ella Brouwer

TO BURN OR NOT TO BURN

There can be conflicts between managing vegetation to reduce risk to life and property and protecting and enhancing biodiversity values. Generally, higher intervals between fire are required for many plant and animal species. These longer intervals may not be recommended for fuel minimisation for other purposes.

A connected mosaic of vegetation with a range of fire frequencies, intervals, seasons, intensities and scales is optimal for biodiversity. No single fire regime benefits all organisms or ecosystems.

When considering use of fire to lower fuel and reduce impact of intense bushfires, it is important to recognise that there are many factors to take into account, and that opinions differ widely regarding the most appropriate fire regimes to implement.

It is important to remember that burning is restricted to scheduled dates, and these may vary between local government authorities. Permits may also be required.

Other factors including prevailing weather conditions also need to be considered.

IDENTIFY YOUR OBJECTIVE

The first step is to identify why you want to burn - is it to manage fuels to reduce wildfire risk or to promote regeneration of some vegetation communities?

The presence of flammable material does not, of itself, constitute a fire hazard. The hazard will only exist if there is something of value requiring protection, for example, a property or fence which may be burnt, and also that there is a chance of ignition taking place (Hussey & Wallace, 1993).

ABATEMENT OF FIRE HAZARD

If the remnant is considered a fire hazard, you can consider:

- removing heaps of flammable material
- removing grass fuel with herbicides
- mowing or slashing to reduce fuel density
- widening the firebreak in the cleared land around the remnant
- burning to remove the fuel load.

In many instances multiple objectives can be gained from a planned burn. These can include reducing fuel hazards, encouraging regeneration of certain species, the creation of ash beds and the germination of soil stored seed.

KNOW YOUR VEGETATION

Where reducing risk to life and property is not the primary objective, burning with ecological considerations can be undertaken. The fire response of different vegetation communities and species varies, and is described in more detail for common South Coast region vegetation types in Appendix 1.

It is important to understand the type of vegetation you have, and whether it would benefit or not from burning. If you're not sure, discuss your vegetation with a biodiversity conservation expert in your local community, such as local or state government conservation officers, local natural resource management group or private ecological consultants.

What plants are in your bush and how are they adapted to fire?

The Department of Biodiversity, Conservation and Attraction's NatureMap database can provide some general information regarding plant species in your area and their response to fire: https://naturemap.dpaw.wa.gov.au/

1. Access the database as a registered (no cost) or guest user, and search for species by area
2. Customise the map with Biodiversity features (e.g. remnant vegetation), Infrastructure (roads) and other useful features and use the "zoom in" tool to locate your area
3. In Section Type, select "user-defined area" and drop down list to select "rectangle". Alternatively, select a pre-defined area
4. Select group results by "Response to fire"
5. Use the "select species" (top tool on the map) to draw a rectangle around the area of interest
6. Create a report to show list of species and known fire response data of species in your area.

These species have been recorded around your area and will give you a starting point as to what may be on your property. Take a look in your bush and record any plants you know – your local Herbarium, good flora identification books and knowledgeable people in the community may also be able to assist.

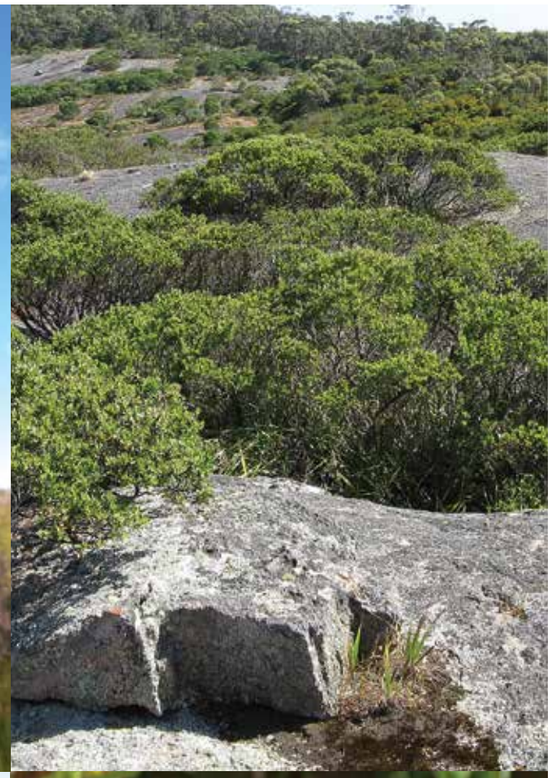
See Florabase https://florabase.dpaw.wa.gov.au/

Photos: Meredith Spencer (image 1 & 2), David Deeley (image 3)

PLANNING – THINGS TO CONSIDER

Good planning can help to reduce risk and uncertainty. Useful actions to consider include:

1. Preparation of a long term ecological fire plan. Collate all the knowledge you can of your site including fire history, different vegetation communities and species and any special areas of value that should be excluded from fire. Call on expert assistance available in our community
2. Each individual burn should have a plan including a checklist of before and after actions
3. Include in your plan any post burn follow up activities such as weed control, grazing control e.g. reducing kangaroo/rabbit impact on new regenerating shoots and fox and cat control - native wildlife can be particularly vulnerable following fire
4. Keep records about the burn – weather conditions, the pattern of lighting, flame heights and how easy it was to control
5. Monitor the outcome – take photographs from designated points and notes about the responses of the



Flower photos: 'Pimelea species' and 'Banksia praemorsa'. Meredith Spencer

Landscape photos: 'Banksia heath' and 'Granite outcrops'. Department of Biodiversity, Conservation and Attractions, South Coast.

Eco burn. Photo: David Mitchell, Department of Biodiversity, Conservation and Attractions

animals and plants, whether any values were affected (e.g. hollows, old trees, granite outcrops)

6. Review your plan and whether your objectives were achieved and modify as required.

FREQUENCY – HOW OFTEN TO BURN

The time between fires is a key consideration for encouraging the range of plants and animals in fire-adapted ecosystems. Too frequent fire can deplete seed banks of obligate seeders, as new plants don't have time to reach maturity and set seed, ultimately resulting in the loss of species. Plant growth is generally much slower in drier areas and so longer periods between fire may be required in these regions (Hussey and Wallace, 1993).

Resprouters will also suffer with frequent fire, as plants become weakened and young individuals are burned before reaching a stage where they can withstand fire. If there are no adult plants or viable seed, plant species cannot regenerate and persist in an ecosystem.

Frequent burning can encourage grasses while reducing shrub cover, which may not benefit animal species that need understorey for nesting and shelter. Those animals that require flowers and seeds for food will also be impacted.

Long term fire exclusion can also pose problems for ecosystems as plant habitat becomes old and dies.

Variability in the intervals – and no extremes of frequency – is a key principle for managing fire for biodiversity

Variability in the intervals between fire in fire-adapted ecosystems is key for managing biodiversity because, even in the one community, there will be different plants and animals with different life strategies for coping with fire. A single fire event will not usually have an effect on species composition as most species will regenerate, however, using the same fire regime repeatedly can be detrimental to vegetation communities.

Some vegetation communities are fire sensitive and fire in these ecosystems should be avoided or very rarely implemented (see Appendix 1).

FIRE SEASON - AUTUMN, WINTER OR SPRING BURN?

The season during which fire occurs can influence not only how fire behaves, but also its impact on plants, animals and other environmental features.

Some things to think about include:

- breeding times of birds and animals – you may want to wait until young birds have the ability to fly well
- insect dormancy – many invertebrates are vulnerable to fire during winter months while they are dormant
- seed availability – Fires in late winter/early spring will impact that season's flowering and seed set for some shrub species. This will have greater impact if fire frequency intervals have been short, and seed banks have not yet replenished
- many geophytes, such as orchids, are known to be killed by fire occurring between May to November, while the leaf is green but the tuber not yet fully formed (Watson and Tran, 2002).

SPRING? - Burns area likely to affect young wildlife

WINTER? - Perhaps the safest? May kill orchids

AUTUMN? - Consider weeds.

- Not all native plants flower in Spring and not all juveniles are born in Spring…
- Every site is unique and must be looked at in that way.
- **Variability of seasons is recommended. Always burning in the same season can diminish numbers of some plants & animals.**

Photos: David Deeley (image 1), Liz Tanner (image 2)

Events such as rainfall, before and after the fire, can influence the effect on natural communities

FIRE BEHAVIOUR AND INTENSITY

To safely and effectively implement a burn, regardless of whether the objective is for ecological purposes or to reduce fuel, it is critical to have an understanding of fire behaviour.

A planned, slow moving trickle fire through low growing plants can be managed with minimal risk. More intense fires may pose greater risk, spreading by embers – often bark fragments – with wind and creating new "spot fires".

Fire movement and behaviour can be described by its rate of spread, the duration of heating, the size of flames and the height to which vegetation is affected by convective heating (i.e. scorch).

Ecologically, there is no one answer as to the most appropriate fire intensity. Hot fires can be destructive, killing more individual plants and animals, while cool burns remove less leaf litter but also cause less erosion. Cool burns may not, however, be sufficient to break seed dormancy for species that require hot fire. A fuel reduction burn usually involves low intensity fires (Watson and Tran, 2002).

Intensity is related to the frequency and season of the burn

Hot fires are easier to undertake in larger natural areas away from human habitation than on properties where residential or farming assets exist (Watson and Tran, 2002).

Input from experts is essential when planning and carrying out any controlled burn (see Assistance section).

Cool burn. Photo: David Deeley

SEASONAL FIRE EFFECTS ON BIODIVERSITY VALUES

SEASON	EFFECT
Midsummer/ Autumn	Hot and intense Fires don't go out overnight Likely to burn mature trees Will break seed dormancy of buried seeds May result in high fauna mortality Good regeneration may result from follow up winter rains
Winter	Low intensity Fires usually go out overnight Patchy – some unburnt areas Will not crack dormancy of buried seed Encourages grass weeds Disrupts some fauna breeding cycles Survived by most adult fauna More beneficial for fuel reduction than regeneration purposes
Spring/Early Summer	Low/Moderate intensity, some canopy scorch Patchy – some unburnt areas Will destroy current year seed production Will stimulate surface seed germination Young fauna may be killed, adults often survive and recolonise from nearby unburnt patches Will encourage perennial weed growth Favours resprouting plants to grow over summer
The burning technique is ALWAYS constrained by what can be done safely. Contact your local government for details of restrictions and technical matters that may apply prior to undertaking any burn.	

(derived from: Hussey and Wallace, 1993)

FUEL LOADS

Any decision regarding when and how to burn needs to take into account the specific ground conditions of the site, including the time since last burn and fuel characteristics.

Forest, woodland and shrubland fuels accumulate with time since last fire for at least a decade, often longer, before reaching equilibrium.

The rate of spread and heating effects of fire are influenced by several factors including fuel type and amount, but also slope, wind speed and the dryness of the fuel. For example, forest and woodland fuels often consist of leaf litter (leaves/ twigs), fine live and dead foliage on shrubs, and bark on tree stems. During heathland fires, live and dead foliage on shrubs provides greatest fuel. Dry grasses and annual weeds are a major fuel source in road reserves and remnant bushland, particularly around the edges of native vegetation blocks.

Mosaic burning can slow down wildfires by breaking up fuel loads.

HABITAT TREES AND FEATURES

These should be identified and mapped prior to burning to enable protection. For example:

- bushland with known nesting sites for significant species
- large hollow bearing trees
- granite outcrops
- wetlands, creeklines and water holes
- other significant features.

Carefully clear (e.g. rake) fuel from the base/edge of these features and make sure fire is extinguished from them quickly post-burn to reduce fire impact.

NATURAL MULCH

It is important to recognise that natural mulch and leaf litter is an important part of the ecology of your bushland. It is home to micro-organisms, fungi and invertebrates that are critical for recycling of nutrients, impedes weed growth and protects native seed banks. The natural mulch provides habitat and food resources, and helps to suppress fire. This important feature will be lost through repeated, frequent fire.

Photo: Meredith Spencer

POST-FIRE FLARE UPS

It is vital to plan to ensure that any burning is undertaken so that the burnt area does not reignite, especially in the event of hot, dry and windy weather. A secure perimeter should be burnt around the area, with any fire or heat in logs and trees extinguished. In small patches of bush it may be necessary to burn out most of the area for security. It should be noted that fires in peat can be difficult to extinguish and these areas should always be excluded from burning (see Appendix 1).

Photo: David Mitchell, Department Biodiversity, Conservation and Attractions

Photo: Meredith Spencer

UNBURNT PATCHES

If burning larger remnants it may be possible to leave unburnt patches within the area by using weather conditions and time of day to vary fire intensity and spread. Unburnt patches are important to provide:

- protection for fire sensitive communities
- refuge areas for animals to shelter and recolonise the burnt area when recovered
- food sources in early months following fire
- seed sources for plant regeneration
- diversity of habitat features including long unburnt areas.

Try also to leave a few years before burning areas adjacent to unburnt patches.

A mosaic of areas of different fire histories is optimal for biodiversity, however, this should be weighed against the potential for weed invasion in smaller remnants.

If you have a large bushland area, work with neighbouring landholders if you can to provide a mosaic of vegetation at different stages of post-fire regeneration which will provide a range of habitats on a landscape scale (Watson and Tran, 2002).

Corridors of vegetation that allow movement of animals during a fire and recolonization avenues post fire also provide significant benefits to wildlife.

UNPREDICTABLE EVENTS

Particularly if the remnant is isolated from other bushland, it is better not to burn the entire block in one fire. Unpredictable events can have an enormous impact on the recovery of bush following fire. For example:

- heavy rain can cause severe erosion if it occurs before plant cover has re-established. Ash, mineral nutrients and seed may be removed from the site, hampering regeneration and impacting waterways. Steep slopes and hard soils may be most affected
- drought occurring in the year following fire will impact on the survival of seedlings
- insect plagues, for example, locusts, can devastate recovering bushland, removing key habitat species and potentially changing the structure of the post burn bushland (Hussey and Wallace, 1993).

RISKS INVOLVED IN BURNING

Planned burning of specific areas to either reduce fuel or for biodiversity objectives like regeneration, habitat creation or modification can be achieved with good planning. Because natural vegetation has evolved with fire, there is the potential to achieve these objectives while maintaining natural values (Australian Institute of Landscape Architects [AILA], 2016).

There are, however, some issues that need to be considered before undertaking a small burn, including your own experience. For example:

- there is always a risk, particularly where fuel loads are high, that burning may get out of control and threaten the very values you are seeking to protect. Situations can also change and a cool burn if not properly extinguished can turn into a wildfire when remaining fuels dry
- there is often a very small "window of opportunity" – when the weather and soil conditions are right to achieve your burn and meet all of its objectives
- often small burns that focus on protecting particular outcomes/infrastructure can be more resource intense than larger burns
- planned burns are complex, and require both skill levels and expertise. If you're not experienced, you need to have people with experience there
- be aware that frequent low intensity burns can actually favour growth of grasses, which in turn create even more flammable vegetation
- smoke from burns can drift quite long distances and may impact on people's health or industries such as wine grape growing (AILA, 2016).

ASSISTANCE

If you would like assistance or advice regarding undertaking a small burn on your property, contact the Department of Biodiversity, Conservation and Attractions or your local government authority emergency management services team. They may be able to provide advice, come to your property and make a site assessment or direct you to your local Fire Brigade who may be able to assist with your burn. There are also private companies involved in Bushfire mitigation who may be able to advise or support your small burn.

Note also that prior to burning there may be a requirement for a permit. Again, contact your local government authority.

REMEMBER, FIRE DEMANDS RESPECT.

Ensure you get expert input when planning and implementing a burn.

Local rural fire brigades may be able to assist with your planned burn.

Written permits may also be necessary.

Community safety is everyone's responsibility.

Photo: Sarah Barrett
Department of Biodiversity, Conservation and Attractions

NOTE: Nothing said in this document changes Landholder responsibilities under any relevant legislation. Ensure you are compliant at all times and seek advice from professionals where necessary.

ACKNOWLEDGEMENTS

This section has been derived from the Cape to Cape Catchment Landholder Fire and Biodiversity Kit, developed from information provided by Dr Lachie McCaw, DBCA, Parks and Wildlife Service, unless otherwise referenced.

CASE STUDY - The role of fire as a regeneration tool

By Cherie Kemp, DBCA

In any discussion about Fire and Biodiversity management of the land, we need to firstly acknowledge this land and its original inhabitants, their knowledge and use of fire in the landscape.

Methods that landowners can use to trigger regeneration in their bushland:

- rake and pile burns
- ash bed creation - larger piles of vegetation
- mosaic burning
- individual remnants of vegetation burnt at varying intensity, timing with the aim of obtaining "patchiness" within that remnant.

Very good vegetation.

Degraded/poor vegetation on the edge of very good vegetation.

Where the vegetation is degraded, a trigger mechanism may be required to encourage new regeneration.

Recommendation: rake and pile burns so that existing vegetation is not disturbed by machinery.

Managing ashbed remnants.

Regenerating ashbed.

continued on following pages...

CASE STUDY - The role of fire as a regeneration tool... continued

Ashbed creation:

- rake up leaves, gather larger twigs, branches and form into a long, narrow shape. Do not use hollow logs (these are potential den sites for fauna)
- place in a cleared area or degraded area over weeds, away from overhanging canopy/trees. Do not place over healthy, native ground flora
- make heap no more than 50 cm high
- choose a cool fine day in Winter to light these
- plenty of water on hand
- natural regeneration should occur in these ash beds the following Spring/Summer
- note that seeds held in fruits on branches will be also be burned – if there are viable seeds on some branches, don't include them in the heap. Rather, retain these and spread so that they will fall into the ashbed afterwards.

Heaps recommended to be used here.

This is the outcome 5 years later with kangaroo proof fencing, weed control, feral animal control, ashbed creation, rake and pile burns together with some additional tubestock planting.

Note – ongoing weed control is essential.

Mosaic burning:

- section the bushland into a mosaic pattern
- burn one section at a time
- where possible, leave creeklines and wetland areas unburnt
- ensure wildlife have habitats to escape into
- different bushland blocks have different issues and biodiversity values - specific fire management is required for each bush block.

Landowner burnt different sections every 8-10 years for 30 years – vegetation is in very good condition.

This property was burnt in different sections every 5-6 years over 30-40 years and is described as being in excellent condition with high conservation values.

continued on following page...

CASE STUDY - The role of fire as a regeneration tool... continued

Whole remnant burning/patchiness:

- when burning whole remnants attempt to have fire in some areas trickle slowly through the vegetation and other areas that will burn a little warmer - the aim of this is to create "patchiness" within the remnant

- patchiness leaves refuges for plants and animals
- leave creeklines out of burning where possible
- leave granite outcrops out of burning where possible
- undertake weed and feral animal control before and after.

Feral animals and weeds need to controlled before and after any fire/burn.

Photos and text by Kemp, C. © Off Reserve Conservation Officer, Dept. Biodiversity, Conservation and Attractions

References: Abbott/Burrows (2003). Fire in ecosystems of South West Western Australia - Impacts and Management.

Acknowledgements: Thank you to all the private landowners for the use of their properties and their knowledge and experience..

Photo: Sarah Comer, Department of Biodiversity, Conservation and Attractions

Photo: Meredith Spencer

Wildlife Notes

No.17, January 2006

Information Notes for the *Land for Wildlife* Scheme in Western Australia

The Use of Fire in Small Remnants

Keywords:	fire, regeneration, remnant bushland
Location:	south-west Western Australia
Authors:	Penny Hussey and Avril Baxter

INTRODUCTION

Many landowners see a need to "clean up" their bushland by putting a fire through it to reduce the fire hazard and hopefully cause regeneration. However, in these altered landscapes the result may not be what we expect.

With flammable vegetation, dry summers and sources of ignition, it is not surprising that fires are an important component of ecosystems in south-west Australia. Over millions of years, native plants and animals have evolved various strategies to cope and persist in this fire-prone environment.

> If we wish to use fire for any reason at all, but especially for nature conservation, we need to be aware that the bush community's response to that fire may be very different to the response which would have occurred prior to European settlement.

Today, however, trying to manage fire in small isolated remnants of native vegetation, while at the same time trying to conserve that bushland and all its native flora and fauna, presents an enormous challenge.

In this Wildlife Note we explore some of the issues and consequences of using fire in small remnants and provide a checklist to help you in your decision-making.

WHY BURN BUSHLAND?

Planned fire may be prescribed to remove a perceived fire hazard or to promote regeneration ('ecological renewal').

Removing a perceived fire hazard

In areas where there is danger to life and property from wildfire, for example adjoining houses, fuel reduction for safety is a vital consideration. For example, burning sections during the cooler months of the year when the fire can be more easily contained and may go out overnight could be a suitable regime.

Nevertheless, conservation of the values of the natural community should be included in the fire management plans and compatible strategies considered, such as burning sections in rotation, and having permanent low fuel zones adjacent to the infrastructure being protected.

Promoting regeneration

Nothing lives for ever. All living things must reproduce a new generation; in vegetation communities we call this 'regeneration'. Without regenerative processes, a gradual decline of mature plants will eliminate them from an area, leaving no replacement seedlings. Work done in almost all south-west Australian vegetation communities shows that a 'disturbance factor' induces regeneration. One such disturbance factor could be fire.

There are two ways in which trees and shrubs respond to fire:

a) the whole plant is killed and a new generation grows from seed (reseeders) or
b) only parts of the plant are killed, and new growth arises from stem or rootstock (resprouters).

Fig. 1: Very soon after a fire, Kingias can be seen resprouting. No seedlings have yet germinated.
Photo: N. Burrows.

On extremely infertile and difficult soils, the most important role of fire may be in recycling nutrients. Without rapid decomposition by fungi or termites, or extensive leaf herbivory where the fauna recycle nutrients in their wastes, the nutrients remain held in living and dead plant material, so there is little left in the soil to fuel new growth. Both reseeder and resprouter plants take advantage of this release of nutrients to grow rapidly after fire.

EFFECTS OF FIRE ON NATURAL COMMUNITIES

The effect of fire on natural communities depends on many factors. Some of the most important are the frequency between fires, the season, its intensity, climatic events before and after the fire, the patchiness of the fire, the condition, size and connectivity of the bushland and the fauna present.

Fig. 2: Fire can change the composition of a plant community. The wandoo woodland in Wyalkatchem Nature Reserve had not burnt for over 60 years, and the ground layer consisted of perennials, grass-like plants and everlastings, as can be seen in the front of the photo. A very hot fire in the summer of 1999 through part of the reserve caused a massive germination of shrubs, which dominate the regeneration area. This change in community structure can clearly be seen in the centre of the photograph. Photo: P. Hussey

EFFECT OF FIRE ON NATIVE PLANT COMMUNITIES

Fire frequency

Fig. 3: Fire frequencies can affect vegetation communities. A fire in the 1960s led to the regeneration of sheoaks throughout this area. However, a fire four years later, which was stopped at the roadway, killed the regenerating sheoaks which had not been able to set seed, leaving room for powderbark wandoos, from a mature stand at the top of the ridge that had not been affected by the fire, to colonise the area.
Photo: A. Baxter.

For many plants to persist after a fire, they must be able to reach maturity and set seed (the reseeders). Since plants vary in the length of time they take to do this, it follows that the frequency of the fires will have a distinct effect on the composition of the vegetation community. For example, in woodlands, the understorey follows a cyclical pattern of growth / decline / renewal, often on a shorter timescale than the tree species.

As a general rule of thumb fire intervals should be at least twice as long as it takes the slowest maturing plant to flower and produce seed, and before older plants are no longer able to reproduce.

Fire season

The time of the year in which the fire occurs will make a considerable difference. There are three possible fire seasons: midsummer/autumn, winter, spring/early summer.

Midsummer / early autumn fires

These fires are usually intense and difficult to control, they will consume most of the above ground material and most likely burn down mature trees. In doing so they remove herbivores (eg sap sucking insects) and parasites (eg mistletoe or dodder) from the population. Heat penetration of the dry soil is maximised, which will break the dormancy for some buried seeds such as wattles and peas. The chemicals produced by the fire will also encourage germination (see Fig. 2).

If the season is kind, then seeds which are stimulated to germinate by these fires will be supported by winter rain and plants that resprout from lignotubers will have water available to manufacture new food, using the released mineral nutrients to fuel the new growth. In adverse seasons the soil surface is exposed to potential wind and water erosion both from the bushland and into it from surrounding paddocks.

Winter fires

These low intensity fires will leave patches of unburnt vegetation. However, the new seed crop within the burnt patches may be destroyed before maturity, and plants such as everlastings and orchids, which have not evolved adaptations to survive fire during their growing season, will be damaged. Also, the fire may not trigger germination of the native seed stored in the soil, but could encourage the growth of grass weeds if they are present in the system.

Fig. 4: A winter burn in weedy bushland encouraged the growth of exotic grasses. Photo: A. Baxter

Spring/early summer

These fires are low to moderately intense, depending on the air temperature and humidity, the amount and moisture content of the fuel and soil, and the wind strength. Some of the tree crowns will be scorched and some patches may be left unburnt. They will destroy that year's seed crop for many plants. Seeds on the surface will be stimulated to germinate, but the fire may not be hot enough to crack the dormancy of buried seed. They also encourage the growth of already established perennial grass weeds such as veldt grass. Germinating plants may not survive until the autumn break of the season. However plants that resprout will grow well over summer and out-compete seeders.

We recommend autumn burning for most regeneration burns, especially where regrowth of wattle and pea thickets is important. If, however, the potential intensity of the fire is a management concern, then the fire can be timed for after the first winter rains, which will reduce the fire intensity, but be prior to the active plant growth.

Climatic events

The impact of unpredictable climatic events is enormous. Heavy rain after a fire can remove the ash, its mineral nutrients and germinating seed from the site. Weed seeds and artificial fertilisers can also be blown or washed in from surrounding paddocks. Regenerating plants can be affected by prolonged dry periods or frost, especially on granites and sandy soils.

Patchiness of fire

Burning small patches at a time creates an uneven aged bushland which has many advantages for both plants and animals. Seeds from unburnt patches can reinvade the burnt areas and recently burnt patches can be used as a break for the next planned fire. This more diverse environment generally makes it more resilient to fire – a case of not putting all your eggs in one basket!

A 'safe' plan is to use only small patches of fire within a remnant, to create a mosaic of vegetation of different ages which maximises the resources for fauna and makes the remnant more resilient to fire.

EFFECT OF FIRE ON NATIVE FAUNA

Fire may kill some animals, whilst those that survive by sheltering in burrows may die of starvation or predation soon afterwards. If the remnant is connected to or near other bushland, then recolonisation can occur. If the whole block is burnt and migration is not possible, the animal may go locally extinct. Hence, burning small patches within a remnant to create a mosaic of different ages will allow animals to persist in an area.

The fire frequency that favours particular animals varies considerably from animal to animal. Some animals require long unburnt vegetation, for example, mallee fowl which require leaf litter for nest building are more common in mallee and broombush which has not been burnt for more than 40 years. A study in the Fitzgerald River National Park found that capture rates of honey possums were low for four to five years after a fire and peaked at 30 years - this pattern follows the amount of cover available.

Winter fires will disrupt the breeding cycle of some animals and spring fires may kill some young animals, for example nesting birds.

Hollows are also very important. Ironically, fire consumes hollows in trees and logs on the ground, and it creates them. Many animals including bats and 18% of Australian birds have been shown to use tree hollows for nesting or cover; numbats and some lizards need hollow logs on the ground. For these animals, the effects of fire can improve or destroy the habitat that they require. To save hollows, you may need to remove any debris that has accumulated against the trunks of favoured trees and around logs on the ground.

EFFECT OF FIRE ON SMALL REMNANTS

Disturbance is a key factor in opening up the bush to change, and fire is a major disturbance.

Small bush remnants are very often isolated and subject to far more disturbing factors than they would have suffered prior to European settlement, putting the natural communities under great stress. They are less resilient and often degrade to a simpler community.

Generally, the greater the 'edge-to-area ratio', the more effect the stress factors will have and the more quickly the bush is likely to degrade. Linear strips such as roadsides are the classic example.

Weeds

Having opened up the bushland it is very easy for weed invasion to occur at the edges and quickly cover the whole patch. Many introduced plants – especially pasture and crop weeds – enjoy disturbance and will displace native disturbance opportunists such as everlasting daisies. Similarly perennial/woody weeds, such as tagasaste, will displace shrub species.

This leads to a change in community structure, which will provide different resources for fauna and in turn respond differently to fire.

Many weeds will change the fire's characteristics including its readiness to burn, how easily it will spread, and the temperature at ground level. Bunch grasses which evolved in southern Africa under a regime of annual burning (eg African love grass, tambookie, veld grass), cause a massive change in the fire response when they come to dominate the ground layer of Western Australian communities. Veld grass in banksia woodland is a good example of this bad problem.

You can use the period immediately after a fire, (whether the fire was planned or unplanned) to undertake control of some difficult perennial weeds such as African love grass or bridal creeper. They will respond to the fire with rapid growth from underground reserves, often before native plants have started to resprout or seeds to germinate. Thus they can be hit immediately with a knock-down herbicide, without danger of damaging desirable native plant regeneration. In addition, because the fire opens up an area, it is easier to reach dense infestations, and to locate all sites for control work.

WHEN NEVER TO USE FIRE FOR REGENERATION

When the soil is buried by wind-deposited material

Sometimes the natural soil surface (including rootstocks) is covered by a non-wetting layer of soil (usually sand), straw, weed seeds and sheep droppings blown in from an adjoining paddock. This prevents heat cracking the buried seeds and the chemicals leached from combustion products from reaching seeds and so stimulating germination. Buried rootstocks will often not regrow. Such a site, very common along sandplain roadsides, is gone for ever.

During or immediately after a severe drought

In this case, the plants are already under extreme stress and being forced to regenerate could totally exhaust those that resprout from lignotubers and so lead to death. Similarly there may not have been good seed set in previous years. Give the bush a couple of years of average conditions in which to recover.

When a locust plague is predicted for the following year!

SOME MANAGEMENT PRINCIPLES

The correct use of fire can stimulate regeneration and regrowth in bushland, thus creating habitats for fauna.

There is no need to "tidy up" the bush; some standing dead vegetation is beneficial in your bushland, providing habitat for many animals. As a general rule, if more than fifty percent of the understorey shrubs are dying or dead, the area is ready for a regeneration fire.

Successful regeneration of reseeder species is dependent on the availability of viable seed. Before burning an area of bushland, monitor the plants over the previous year to ensure that they have produced viable seed. Not all plants produce seed each year and this can affect the success of the regeneration. Other species may be able to regenerate from soil seed stores. Knowing your plants can help to plan a successful regeneration burn.

If all the shrubs are gone (eg after a long period of grazing or a long period without fire) some of the small seeds which could have been stored in the soil may be absent. You may need to introduce more seed into the system, preferably from a similar site nearby. The best way to test this out is to set up a small trial area and monitor regeneration.

A cautionary tale - fires can be deceptive. A landholder reported:

"On a cool May morning I lit a small fire on a 2.5ha block of bush. It burnt slowly and gradually went out. Thinking this was a very good result, I went off to town for about three hours. On returning, I found a blaze that required neighbours and the volunteer fire brigade to attend."

Similarly, if there is not sufficient woody debris on the bushland floor, it may not carry a fire of sufficient intensity to promote regeneration of seeds such as wattles or peas, which are stored in the soil seed bank for many years.

A mosaic of small patch burns will create a greater variety of habitats for animals and allow them to recolonise an area as it regenerates. It will also prevent major losses to the bushland's resource if detrimental climatic events occur after the fire. If this is not possible, a combination of 'heap burns' (bonfires) and direct seeding is recommended, on-going in different locations every year (see Fig 5).

Aboriginal people used to burn bushland to *attract* grazing animals. Heavy grazing pressure can undo all the good the regeneration burn has done! Therefore after using fire, check immediately to ensure that fences are intact and stock excluded. Rabbits need to be controlled and in some instances (and under a specified management plan) kangaroos culled.

Follow the prohibited and restricted burning times for your area. Remember, nothing said here can override a landholder's responsibility under the Bushfires Act and the Fire and Emergency Services Act. You are obliged to keep the fire under control and on your property. If it escapes you could be answerable for the damage caused.

Essentially, to keep your bushland healthy, planned fire is a management tool you may need to consider. But before you get out the matches, work through the attached checklist.

Whatever strategy is chosen, there will inevitably be gains and losses. Though we may plan as well as we can, the result of fire in your small remnant is in the lap of the gods!

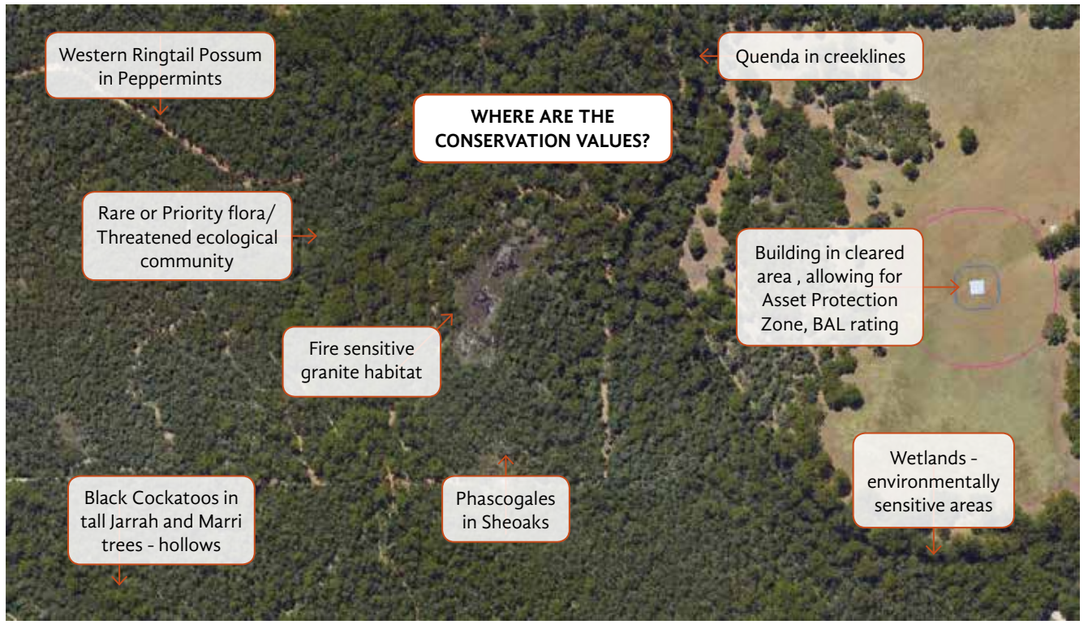
'Hot' fires severely damage existing trees and can affect fauna. In relatively small remnants they are neither practical nor desirable. Piling dead material into low heaps and then burning them can create the same effect in a manageable way.

Fig 5: Brushing on ashbed trial, Muresk College of Agriculture. A 'tidy-up' bonfire was burnt on this site, then a week or so later, a seed-bearing branch from a nearby York gum was placed onto the ashbed. Three years later, this vigorous young tree is the result.
Photo: P. Hussey

THINGS TO CONSIDER

CONSIDER ALL ASPECTS OF BUSHLAND MANAGEMENT	CONSIDER ALL ASPECTS OF BUSHFIRE SAFETY
• What is worth protecting, and how?	• Protection of life and property
• Consider a holistic management Plan	• Build to Australian Standard 3959
• Take a landscape design approach	• Bushfire attack level (BAL) assessments
• Identify rare flora and fauna	• Fire fighting equipment
• Identify biodiversity values e.g. habitats	• Safety plan and equipment
• Threatened/Priority Ecological Communities	• Sprinklers
• Environmentally Sensitive Areas	• Stay or go principle
• Wetlands	• Asset Protection Zone design
• Aboriginal heritage registered sites	• Bushfire management plan
• Identify weeds, pests and disease issues/areas	• Firebreak notice requirements
• Identify other natural resource values	• Consider your own capabilities to undertake burns

The needs and balance will vary for every property. Embrace differences and design your fire management plan accordingly.



SMALL REMNANT FIRE MANAGEMENT BIODIVERSITY CHECKLIST

1 WHAT DO YOU HOPE TO ACHIEVE BY BURNING THIS BUSHLAND?

☐ Protection of human property from wildfire?
☐ Promote regeneration of the vegetation or community?
☐ Or both?

2 DOES THE WHOLE REMNANT NEED TO BE BURNT, OR WILL A SMALLER BURN SATISFY THE OBJECTIVE?

☐ Whole remnant ☐ Smaller burn

A smaller burn minimises the possibility of irreversible ecological failures (e.g. should a severe drought occur in the seasons following the fire).

3 CAN SMALL AREAS BE BURNT OVER SEVERAL YEARS TO CREATE A MOSAIC OF VEGETATION OF DIFFERING AGES?

☐ Yes ☐ No

Vegetation at different stages of growth is ideal for the maintenance of resources for fauna.

4 IS THE REMNANT CONNECTED TO OTHER REMNANTS BY A SUITABLE BUSH CORRIDOR?

☐ Yes ☐ No

This will influence how fauna can get away from the fire, or return to regenerating areas.

5 IF IT IS NOT CONNECTED, CAN A BUSH CORRIDOR BE PLANTED PRIOR TO ANY BURN BEING UNDERTAKEN?

☐ Yes ☐ No

Consider the needs of, for example, small birds and design the corridor to facilitate their movement.

6. ARE THE MAJOR PLANT SPECIES SETTING SEED?

☐ Yes ☐ No

If not, regeneration will be impeded. Allow twice the length of time to first seeding of the slowest growing plants for an appropriate interval between fires.

7. ARE THERE WEEDS IN THE BUSH?

☐ Yes ☐ No

Control prior to and post burn.

8. IS THERE A NEARBY SOURCE OF WEED SEED?

☐ Yes ☐ No

Leave a buffer between the source of the seed and the area to be burnt.

9. IS SPREAD OF PHYTOPHTHORA DIEBACK OR OTHER PLANT DISEASES POSSIBLE?

☐ Yes ☐ No

Take appropriate precautions.

10. IS DECLARED RARE FLORA, THREATENED FAUNA OR A THREATENED ECOLOGICAL COMMUNITY PRESENT?

☐ Yes ☐ No

Consult the Department of Biodiversity, Conservation and Attractions.

11. ARE THERE SPECIAL FLORA/FAUNA HABITAT FEATURES PRESENT, E.G. A WETLAND, OR HOLLOWS IN LOGS & TREES?

☐ Yes ☐ No

These may need to be specially protected.

12. ARE FERAL PESTS LIKELY TO PRESENT E.G. FOX, CAT?

☐ Yes ☐ No

Control post burn. Feral animals return quickly after fire and prey on small animals.

Acknowledgements:
This note is updated and reproduced from Land for Wildlife Note 17 and Balancing Safety and Biodiversity presentation, Cherie Kemp, DBCA.

Photo: Deon Utber, Department Biodiversity, Conservation and Attractions

7. FIRE INTERACTIONS – DISEASE, WEEDS, GRAZING AND FERAL ANIMALS

The interactions between fire and other types of disturbance including weed invasion, plant diseases, grazing, fragmentation and climate change can be significant, impacting both the vegetation's susceptibility to fire and post fire regeneration success.

FIRE AND PLANT DISEASE

Phytophthora Dieback is an introduced soil borne plant pathogen widespread on the South Coast that can devastate plant communities. It affects up to 40% of native plant species, killing susceptible species, many of which are both iconic and fundamental to the ecosystems they support. It can irreversibly change plant communities. These changes can also facilitate further land degradation including erosion as vegetation structure is lost.

Any activities involving movement of soil and vegetation, including fire break creation and fire management activities, have the potential to spread the disease with devastating consequences.

Further to this, research (Moore 2005 cited in Barrett et al 2009) has found fire in Dieback infested bushland can exacerbate the severity and extent of the disease and impinge on regeneration capacity of the bushland.

More information regarding Phytophthora Dieback is available through the Dieback Working Group at www.dwg.org.au and South Coast NRM at www.dieback.net.au

FIRE AND WEEDS

Because many privately owned bushland remnants are fragmented patches, often near roadsides or agricultural land, they are generally more susceptible to environmental weeds than larger reserves.

Fire can be a useful tool in managing weeds, however, careful planning and monitoring are needed to ensure its effective use. Without management, fire can exacerbate weed infestation within bushland.

Fire can provide the opportunity to:

- access areas previously restricted, for example, blackberry thickets, as the understorey is removed
- promote the germination of weed seed, which can then often be controlled with herbicide prior to native species germination. Generally seedlings require less herbicide to control than mature plants
- stimulate entire weed seed banks, e.g. Sydney golden wattle, which might otherwise germinate gradually over time.

It is also important to watch for weeds that weren't present before the fire, as seed that has been dormant for a long time may germinate, or birds may carry weed seeds to the site.

It is useful to have an idea of where and what type of weeds are in your bush, so that you can treat them quickly following a fire. Assessing the bush and making a weed map before burning will also help you to identify weed and native seedlings post fire, as you will have some understanding of what species to expect. Determining the difference between weed and native seedlings following fire can be difficult – make sure you know what you are targeting.

Photo: Jeremy Spencer

Photo: Meredith Spencer

CASE STUDY – Fire management in Banksia woodland bushland remnants

By Ben Miller, Department of Biodiversity, Conservation and Attractions, Botanic Gardens and Parks Authority

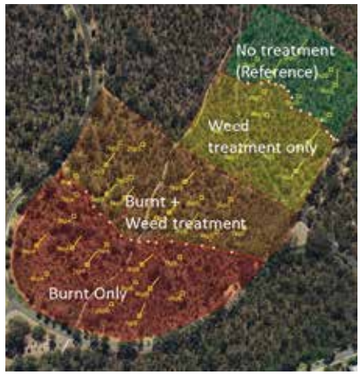
Kings Park's scientists and managers are undertaking research on the effects of different management regimes on the persistence of native species, weed loads and bushfire risk in bushland remnants. The research intends to compare the effects of managed fire – prescribed burning – at short and moderate rotations, with fire exclusion, and combining each of these with the presence or absence of standard weed management programs.

The study is necessarily long-term, planned to span several decades at least. Burns have been implemented at three sites across the Perth metro area. Initial results from the Kings Park fire in 2015 show that prescribed burning in an area of moderate-low weed cover led to a more than 10 times increase in weed species abundance by the second spring after fire.

The combination of fire with post-fire grassy and bulbous weed management resulted in little change in weed abundance pre- to post-fire. Veld grass tripled in density and freesias increased by 7 times after fire with no weed management. Even with follow up weed treatment, freesia abundance doubled after the fire. Native plant abundance increased after fire, a result of post-fire germination of stored seed, but this regeneration response was halved in sites where weed cover was not managed.

Burning in areas with even low-moderate weed loads can result in increased weed problems. These have negative consequences for native species, including regenerating seedlings of native plants. Like other grassy bushland weeds, veld grass is itself a fire hazard, and its increase enhances fire risk.

Managed fire implemented in urban bushland remnants must be accompanied by weed management programs, often over several years. Fire in these systems without weed management contributes to the degradation of bushland, by enhancing weed spread and, perversely, may even result in increased fire hazard.



Study area and treatments.

Veld grass cover after fire with (foreground) and without (background) weed management.

FIRE AND GRAZING

Grazing of newly regenerating seedlings and plants by stock, feral and native animals (e.g. rabbits, kangaroos) and insects such as grasshoppers can pose a significant threat to plant communities recovering post fire. This is particularly an issue in fragmented reserves and remnant bushland due to greater exposure to grazing pressures.

To reduce post fire grazing it is recommended to:

- restrict stock access to regenerating areas
- assess kangaroo and rabbit numbers prior to burns and undertake control activities for at least two years following burns
- consider fencing of small remnant patches of vegetation.

FIRE AND FERAL ANIMALS

Always at risk from feral predators, native species are particularly vulnerable following fire because of reduced habitat protection and access to food resources. Predators can also travel beyond typical range extents to recently burnt areas to feed on animals affected by fire. Feral fox and cat numbers will require control for at least two years post burn to help protect wildlife.

ACKNOWLEDGEMENTS

The section has been developed from the Cape to Cape Catchment Landholder Fire and Biodiversity Kit (2017) with reference to Barrett et al (2009).

FURTHER INFORMATION

Cape to Cape Catchment Group: "A Guide to Fox and Feral Cat Control" https://www.natureconservation.org.au/nature-conservation-publications/

Department of Biodiversity, Conservation and Attractions florabase Weed Notes https://florabase.Parks and Wildlife.wa.gov.au (for treatment advice when identification known)

Dieback Working Group: Range of information available on line via www.dwg.org.au

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Hussey, BMJ, Keighery, GJ, Cousens, RD, Dodd, J and Lloyd, SG (2007) "Western Weeds: A guide to the weeds of Western Australia", second edition, Weed Society of WA

South Coast NRM www.dieback.net.au

Both photos: Department of Biodiversity, Conservation and Attractions, South Coast

Photo: Angus Spencer

8. LEGISLATION

Where do I start? It can be very confusing for a small landholder that wants to do the right thing in managing fire and looking after biodiversity. A first good step is in reading this guide and to start thinking about some of the considerations discussed. A good second step is to contact your local Bush Fire Brigade or local Bushfire consultants.

Legislation and policy frameworks regarding fire management can be complex and confusing, relating to building design and location while also including environmental and other considerations.

As described in the Guidelines for Planning in Bushfire Prone Areas (2017), landholders and land managers need to consult with relevant authorities during planning to manage risks associated with bushfire. Responsibilities include:

- being aware of potentials risks, but also that *bushfire threat can never be fully controlled*
- using accredited specialists to prepare bushfire assessments for development applications
- consulting with Department of Water and Environment Regulation regarding any requirement for clearing of native vegetation
- consulting with Department of Biodiversity Conservation and Attractions Parks and Wildlife Service regarding any activity which may impact Environmentally Sensitive Areas or those with significant conservation values including critical habitat for flora and fauna species or communities
- consulting with Department of Water and Environment Regulation for proposals which may impact waterways or have other water related implications
- ensuring any Bushfire Management Plan is implemented accordingly
- ensuring that contingency measures in relation to bushfire have been prepared and are implemented during a bushfire event
- ensuring any local government fire protection or hazard management notice is responded to and complied with.

Key legislation and policies are summarised below. This list is provided for guidance only and may not address every aspect of relevant legislation. **It is recommended that advice from government authorities and/or bushfire professionals should be sought prior to undertaking development or bushfire management**. The onus is on landholders and managers to ensure compliance with local, state and federal legal requirements.

- Bush Fires Act (1954)
- Environmental Protection Act (1986)
- Environmental Protection Regulations (1987)
- Environmental Protection (Clearing of Native Vegetation) Regulations (2004)
- Biodiversity Protection and Biodiversity Conservation Act (1999)
- Wildlife Conservation Act (1950) (soon to be replaced with Biodiversity Conservation Act (2016)
- Fire and Emergency Services Act (1998)
- Planning and Development Act (2005)
- Planning and Development (Local Planning Schemes) Regulations (2015)
- Planning and Development (Local Planning Schemes) Amendment Regulations (2015)
- State Planning Policy 3.7: Planning in Bushfire Prone Areas and accompanying "Guidelines for Planning in Bushfire Prone Areas Version 1.1" (2017)
- Building Act 2011
- Building Regulations 2012
- Building Code of Australia
- Australian Standards AS3959 "Construction of buildings in bushfire prone areas"

Further information sources can be found in Section 9 "Additional Information".

Photo: Tilo Massenbauer


Photo: Meredith Spencer

9. ADDITIONAL INFORMATION

Planning and construction:

- Map of bush fire prone areas – https://maps.slip.wa.gov.au/landgate/bushfireprone/
- Australian Standard 3959 - http://www.gnowangerup.wa.gov.au/files/9614/4953/7761/20151204112916593.pdf
- A Visual Guide for bushfire risk assessment in Western Australia https://www.planning.wa.gov.au/dop_pub_pdf/Visual_guide_for_bushfire_risk_assessment_in_Western_Australia.pdf
- Western Australian Planning Commission - Planning for Bushfire Protection www.planning.wa.gov.au
- Western Australia Department of Commerce - Designated bush fire prone areas – Frequently asked questions https://www.commerce.wa.gov.au/building-commission/designated-bush-fire-prone-areas-frequently-asked-questions

Regulations:

- Local government Fire Management Notices – see your LGA website
- Department of Environment Regulation – a guide to burning under the native vegetation clearing provisions https://www.der.wa.gov.au/component/k2/item/3986-burning-under-the-native-vegetation-clearing-provisions
- Department of Environment Regulation – clearing for fire protection (building protection zones) https://www.der.wa.gov.au/images/documents/your-environment/native-vegetation/Fact_sheets/fs20-Clearing_for_fire_protection_Building_Protection_Zones.pdf
- Department of Environment Regulation - exemptions and regulations for clearing native native vegetation https://www.der.wa.gov.au/images/documents/your-environment/native-vegetation/Guidelines/Guide_1_-_Exemptions_and_regulations_for_clearing_native_vegetation-1.pdf

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- Country Fire Association Victoria (2012) Landscaping for Bushfire http://www.cfa.vic.gov.au/fm_files/attachments/plan_and_prepare/landscaping/landscaping_for_bushfire.pdf

Information notes:

- Cape to Cape Catchment Group Landholder and Community Information Notes http://www.capetocape.org.au/publications-resources/landholder-community-info/
  - Fire and Biodiversity Landholder Information Kit
  - Plant this Instead
  - "Weed it Out"
  - Weed Alert in the Capes Region
  - Feral Animal booklet
- Department of Fire Emergency Services information notes including: https://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/Pages/allpublications.aspx
  - Winter Burning Guide
  - Fuel Load Guide
  - 'Guide to Preventing and Suppressing Bushfires on Organic Soils'
  - In preparation: 'A Guide to Constructing and Maintaining Fire-breaks'
  - The Homeowner's Bush Fire Survival Manual
  - Prepare. Act. Survive. Your guide to preparing for and surviving the bushfire season
- Land for Wildlife notes: https://www.dpaw.wa.gov.au/management/off-reserve-conservation/107-land-for-wildlife/187-publications
  - Fire in small remnants
  - Requirements for native animals
  - Dead wood and wildlife
  - Bushland regeneration

Weeds:

- Department of Primary Industries and Regional Development App MyWeedWatcher https://www.agric.wa.gov.au/myweedwatcher

Plant Diseases:

- Phytophthora Dieback hygiene http://www.dieback.net.au/images/user-images/documents/dieback_hygiene_2_email_version2013.pdf
- Dieback Information Delivery Management System (DIDMS) - an online platform for the storage, viewing, basic mapping and sharing of spatial Phytophthora Dieback information https://didms.gaiaresources.com.au/disclaimer/
- Department of Parks and Wildlife Myrtle rust note https://www.Parks and Wildlife.wa.gov.au/images/documents/conservation-management/pests-diseases/20120201-myrtle-rust-2-2-1.pdf


Photo: Sarah Comer, Department Biodiversity, Conservation and Attractions


Photo: Meredith Spencer

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Photo: Meredith Spencer

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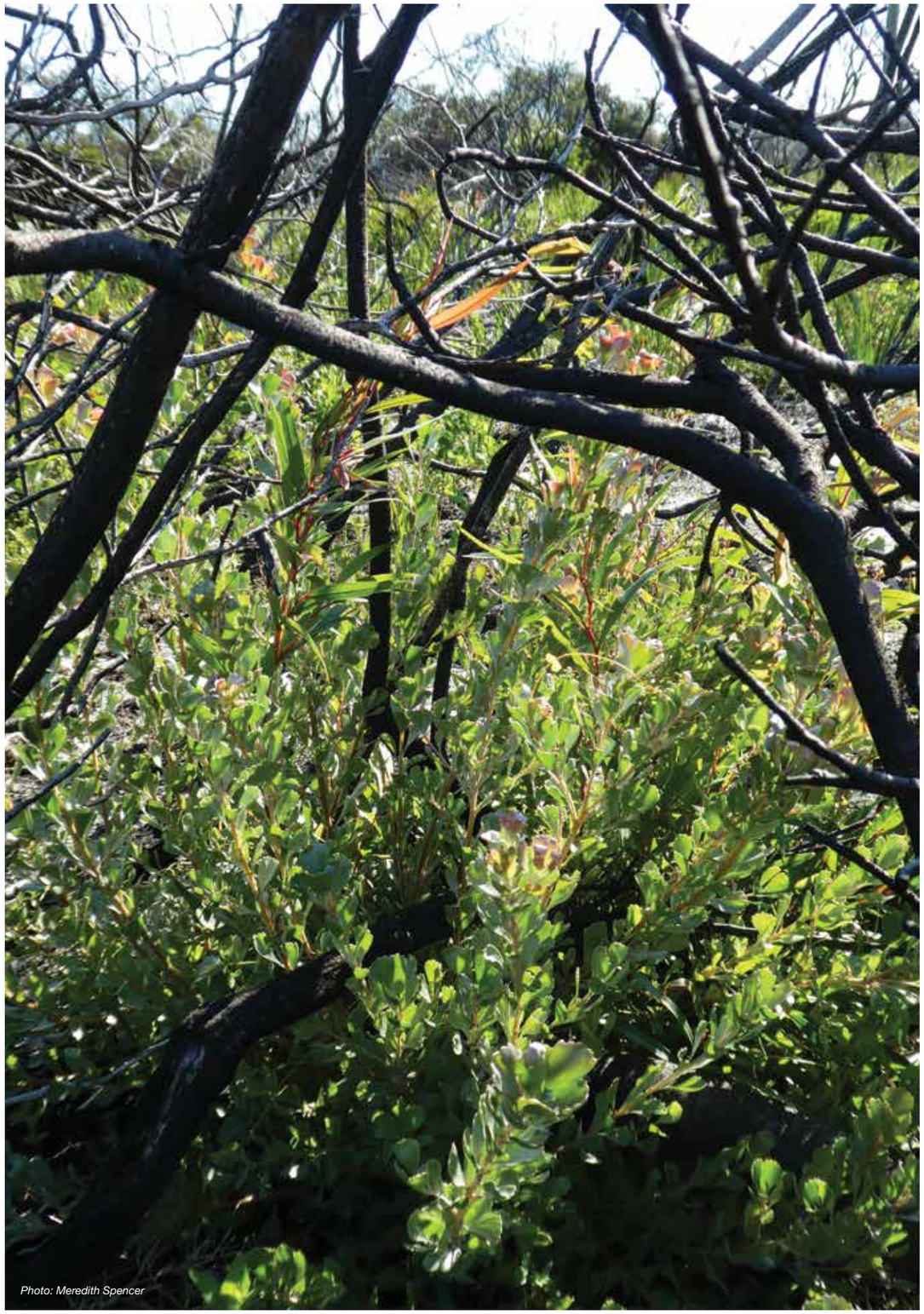

Photo: Meredith Spencer

APPENDIX 1.
SOUTH COAST VEGETATION FIRE REGIMES

The South Coast region consists of a variety of landscapes and vegetation types, each with unique ecological responses to fire. Some of these are described below, with ecological burning considerations. This information is provided for use where biodiversity considerations can be the major driver in fire management. There may be situations where protection of life and property dictate other fire management approaches. This may lead to conflicting considerations.

Generally, low fire frequency will be optimal for some plants and animals, however longer intervals between fire may increase risk of high intensity and extensive wildfire that can only be managed through appropriate mosaic and perimeter fuel management.

The higher fire frequencies suggested are recommended only where fuel loads need to be minimised due to other risk considerations (life and property).

KARRI FOREST is distinguished by Eucalyptus diversicolor often over dense shrub understorey. It is common in the west of the region with the eastern limit occurring around Mount Manypeaks. An outlying population occurs in the Porongurup Range to the north. Often containing tree hollows and long unburnt understorey, Karri forest provides habitat for a range of significant mammal and bird species. 	Frequency: Low * Season: Autumn Intensity: Low	Long unburnt Karri tends to lose its thick shrub layer. Because deep leaf litter may not dry sufficiently, there may be limited opportunities to burn safely. Large old trees e.g. with hollows have habitat value and can be protected by raking fuel from around the base of trees. Trees with hollow butts that catch alight may be at risk of falling. Trapdoor spider species need long unburnt habitat. These species may nest in the bark of Karri, and leaf litter is important for creating microclimates.
JARRAH, MARRI AND SHEOAK vegetation communities are widespread in the region, found on well drained, shallow, loamy/sandy soils. The structure varies from low woodland to forest, with quite open understorey. Some areas may be impacted by Phytophthora Dieback, with a resulting reduced floristic diversity. Sydney Golden Wattle infestations are also often present.	Frequency: Medium Season: Autumn and Spring Intensity: Low	The fuel present in these communities will depend on understorey height and density. This will also influence the rate at which it dries. Some remnant Jarrah Marri Sheoak vegetation has been subjected to grazing which has altered the understorey and introduced weed species that can exacerbate fire risk. Short fire intervals can promote species which contribute to high fuel loads.

*High: 7-15 years interval, Medium: 15- 25, Low: 25 + years interval

		Longer intervals can break this cycle if slower-growing, less fire promoted, understorey species are encouraged. Some wildlife rely on long unburnt patches and ideally these and stream zones should be protected from fire as much as possible. If possible, surround these areas with regions of lower fuel to minimise risk of extensive fire during wildfire situations. Large old trees with hollows may be susceptible to falling following fire and can be protected by raking fuel from around the base. Fallen woody debris can be heaped and burnt to create ashbeds for regeneration of Eucalyptus and some shrubs. This habitat is important for black cockatoos both for habitat (hollows) and foraging (larvae). The Critically endangered Western Ringtail Possum may be found in this habitat. They are sensitive to frequent fire and require protection of hollows and dreys within trees. A range of other important flora and fauna species also make use of this habitat.
BANKSIA HAKEA SHRUBLANDS AND HEATH Dominated by shrub species from the Proteaceae family (e.g. Banksia, Grevillea, Hakea, Adenanthos, Isopogon and Lambertia), occurrences of this diverse community are found on the coastal plains of the South Coast. Highly susceptible to Phytophthora Dieback, occurrences may form part of the Nationally listed Threatened Ecological Community, Proteaceae Dominated Kwongkan Shrubland. 	Frequency: Medium Season: Autumn/early winter Intensity: Moderate mosaic burn if possible.	These communities contain a diversity of species and support a suite of birds, mammals, reptiles and other fauna species, many of which may be threatened. Dominant flowering plants of the Banksia Hakea shrublands and heath are largely serotinous seeders, which are species killed by fire with reliance on seed to regenerate. In these communities, frequent fire may impact the dynamics and persistence of the community. If fire intervals are shorter than the time necessary for seed banks to re-establish, vegetation and the habitats they support may be significantly altered. Many of these vegetation communities may be identified as occurrences of the threatened Proteaceae Dominated Kwongkan shrublands, protected under Federal legislation. Further information can be found at: http://www.environment.gov.au/system/files/resources/4b2a6210-af44-4672-871c-75a8cdc58f56/files/kwongkan-ec-info-guide-faweb.pdf

*High: 7-15 years interval, Medium: 15- 25, Low: 25 + years interval

PEPPERMINT (AGONIS FLEXUOSA) LOW FOREST/WOODLAND is common along the south west coastline. Understorey species typically include tall shrublands over sedges. Sydney Golden Wattle infestations are often present in this habitat. This community is also important habitat for the critically endangered Western Ringtail Possum which is sensitive to widespread hot fires. 	Frequency: Low Season: Autumn, Spring Intensity: Low – moderate. Flames less than 1m	Intense fires will kill mature trees and result in dense thickets of young trees. These young trees will then be sensitive to fire for several decades. Mature Peppermint forest and woodlands can be maintained by mild fires that do not scorch tree crowns.
GRANITE OUTCROPS include unique species able to withstand both inundation and extreme drying during summer months. They are important habitat for reptiles and a number of unique and threatened flora species, some of which are threatened by Phytophthora Dieback and/or aerial canker. 	Not recommended	Granite outcrops can be refuge areas for plant and animal species, as they have sparse vegetation cover and hold little leaf litter to carry fire. With shallow soils and moss beds, these fragile areas are threatened by weed invasion, rabbit grazing, foot and vehicle traffic. Periodic low intensity burning of vegetation around granite outcrops may reduce the potential risk of intense summer bushfire impacting these communities. Several threatened flora and fauna species including refugial invertebrate species may occur within granite outcrop habitats. Cryptograms (moss, lichens and algae) associated with these areas are considered to be fire intolerant.

*High: 7-15 years interval, Medium: 15- 25, Low: 25 + years interval

WETLANDS AND DAMPLANDS occur in the region along larger drainage lines and valleys and upon varying soil types from sand to sandy loam and sandy peat. These communities can be very diverse, particularly with sedge species. Fire greatly influences the structure of the communities, with species decline or loss occurring following fire 	Not recommended	Fire may negatively impact water quality for water dependent species and result in soil loss, sulphur and nutrient release. Organic peat soils may degrade and fires in these soils may be difficult to extinguish. Fire will also make wetlands and damplands more vulnerable to weed invasion. It is recommended that these areas be subject to infrequent fire at greater than at least 20 year intervals.
EUCALYPTUS WOODLANDS SUCH AS SALMON GUMS, WANDOO, YORK AND YATE are typically slow growing and not well adapted to frequent disturbance. The western occurrences often persist as remnants in a highly fragmented landscape, while those in the east tend to be more connected landscapes. This directly affects fire impact and extent. Eucalyptus woodlands offer important habitat for fauna including the endangered Carnaby and Baudin cockatoos. 	Frequency: Low Season: Late Autumn, Winter Intensity: Low	These vegetation communities have minimal understorey and are susceptible to intense, hot fire. They are slow growing – suitable hollows in trees can take over 150 years to form. They also include many obligate seeders, species killed by fire. Some smooth bark species will be killed by even mild fire, and any epicormic regrowth will occur more slowly than on species such as Jarrah and Marri. Eucalyptus woodlands provide important Cockatoo nesting habitat and their long established leaf litter supports other faunal species including reptiles.

*High: 7-15 years interval, Medium: 15- 25, Low: 25 + years interval

MALLET WOODLANDS occur on specific soils types, and are often endemic to regions on the South Coast. Their ranges are restricted, typically less than 1 ha. Mallet and moort stands provide habitat for a range of fauna including Malleefowl, hollow nesting mammals, and reptiles. 	Not recommended	Mallet and moort taxa develop slowly over many decades where fire is excluded. The Eucalyptus species comprising Mallet woodlands are killed by fire. Long intervals between fire are required to allow seed banks to develop, as the species are slow to flower and set seed. Dense stands may result after fire if adequate rainfall occurs post fire. These will thin out over time. Spring fires are likely to result in high mortality of post fire seedlings due to summer drought. Mallet woodlands provide important habitat for Malleefowl and hollow using fauna such as phascogales, birds and bats. Their long established leaf litter supports other faunal species including reptiles.
MALLEE OVER MELALEUCA VEGETATION communities feature in the Ravensthorpe Range and Yilgarn East ecodistricts. They include many species endemic to those regions. 	Frequency: Low Season: Autumn Intensity: Low/moderate	The dense Melaleuca mid storey includes many species killed by fire. Therefore, long intervals between fire are required to allow seed banks and habitat structure to develop. Spring fires are likely to result in high mortality of post fire seedlings due to summer drought. This vegetation community provides habitat for Malleefowl and Tammar wallabies, species that prefer long unburnt bushland.
ORGANIC-RICH SOILS (PEATLANDS) can be found in a variety of ecosystems including marshes, swamps, bogs and coastal wetlands. Around Albany they are usually associated with Callistemon glaucum swamp drainage lines but are more common and within other systems to the west of the region. Organic-rich soils are rare ecosystems that have great biodiversity value. They provide habitat for unique and often restricted species, including relictual species. Most peatlands in WA formed over the late Pleistocene to Holocene eras.	Not recommended	Fires in organic rich soils may cause serious environmental harm. Organic rich soils are very slow to form, a deep organic soil profile may represent many thousands of years of accumulation which can be lost in a single fire event. The loss of the organic soil profile will have long-lasting effects on the biodiversity of the affected area. Fires in organic soils are becoming more common in Western Australia as the climate dries and ground water is depleted. These factors make it more likely that organic soils will dry out and become available to burn.

		Any ground disturbing earthworks undertaken in areas of organic soil will allow oxygen to enter the soil profile and may trigger the reaction that creates acid sulfate soil. Fire exclusion may be achieved by prescribed burning surrounding vegetation when organic rich soils are saturated and will not readily ignite. This will typically be in winter or early spring. Never undertake a prescribed burn within or adjacent to areas of organic rich soil unless those soils are saturated. Bushfires should also be prevented from entering organic soils wherever possible.

*High: 7-15 years interval, Medium: 15- 25, Low: 25 + years interval

ACKNOWLEDGEMENTS

The table above and regime recommendations were developed with expert opinion of the Department of Biodiversity, Conservation and Attractions, Parks and Wildlife Service, Albany ecological staff, the Cape to Cape Catchment Landholder Fire and Biodiversity Kit and Barrett et al (2014).

Photos were provided by Sarah Barrett, Department of Biodiversity, Conservation and Attractions, Parks and Wildlife Service.

FURTHER INFORMATION

Barrett, S., Comer, S., McQuoid, N., Porter, M., Tiller, C. and Utber, D., (2009). Identification and Conservation of Fire Sensitive Ecosystems and Species of the South Coast Natural Resource Management Region, Department of Conservation and Land Management, South Coast Region, Western Australia.

APPENDIX 2.
SOUTH COAST FAUNA – SPECIAL ECOLOGICAL CONSIDERATIONS

The ecology of the South Coast is diverse and complex, and not always fully understood. Interactions between the many plants, animals and habitats can vary with the environmental cues of a given area. Further, the appropriate fire regime for one species may be inappropriate for another species or community. This highlights the importance of landholder and manager understanding of all of the components of an ecosystem or landscape. Things to consider include plants, animals and their habitat needs, the capacity of the vegetation to regenerate, hydrology of the site, erosion potential and weed and feral animal threats. Gaining the detailed knowledge of how to reduce the potential for damaging bushfires while understanding which fire regime is optimal for biodiversity will take time (Cape to Cape Group, 2017, Leighton and Gilfillan, 2012).

When designing ecological fire management guidelines for fauna in an area, it is important to consider the conservation status of species, their distribution and habitat needs. Impact of fire will include the immediate response of species to fire but also their ability to recolonise suitable habitat and their resilience to threats including predation and lack of food resources. Behavioural patterns may also affect fire response – for example species that nest in hollows may not be impacted greatly by low intensity fires, and those with greater mobility may be able to migrate to unburnt patches for food and shelter more readily than sedentary species. Species may also be seasonally vulnerable/resistant to fire (Leighton and Gilfillan, 2012).

The following summaries contain information to assist with the planning of fire regimes that will help to maintain biodiversity values, keeping in mind the specific vegetation/habitat characteristics of the property and locality. It is important to use this information in conjunction with other information provided in this guide, and to ensure that risk is minimised and mitigated at all times. In terms of fauna, a remnant or reserve should be managed for the most fire sensitive, threatened species.

Generally, species considered fire sensitive are typically those that are late successional species. They often occur in isolated populations and have a limited capacity to disperse or produce offspring. They may be a threatened or restricted species (Barrett, et al 2009). Some specific examples are provided below.

LEGAL CONSIDERATIONS

Species with a listed conservation status at either or both state and commonwealth levels are protected by legislation, and any action being considered that may have a significant impact on animals, habitat and,or food resources needs to be undertaken in consultation with relevant government authorities.

ACKNOWLEDGEMENTS

These summaries are gratefully reproduced from the Cape to Cape Catchment Group's Fire and Biodiversity Landholder Kit (2017), with minimal amendments reflecting South Coast knowledge, referenced accordingly.

BLACK COCKATOOS

All three black cockatoo species – Baudin's, Carnaby's and the Red-tailed black cockatoo, are known on the South Coast. Threats to all of these long lived birds include habitat loss and fragmentation, and the plant disease Phytophthora Dieback, which impacts food and nesting habitat (Gilfillan and Leighton, 2012).


Photo: Kathy Ashby

NGOOLARK (BAUDIN'S BLACK-COCKATOO)

Calyptorhynchus Baudinii

Status - Endangered at WA State level
- Vulnerable at Commonwealth level

Extensive, intense summer wildfire can devastate and dislocate cockatoo populations throughout a region due to loss of seed sources for several years and long term loss of nesting hollows.

Conservation of habitat trees with suitable hollows is especially important. These are formed in 100-200 year old trees of Marri, Jarrah, Karri or Wandoo through termite and fungal activity. Nest trees with hollows can be lost in wildfire, controlled burns and post-fire 'clean-up' of old trees that are considered a risk. During intensive wildfires, the trees burn from the top down (burning leaves falling into hollows etc.) and the best protection of an area is management to contain intense fires.

For milder, controlled burns, dragging all deadfall and raking litter away from the base of all veteran and stag trees with hollows and potential hollows has been shown to work well in open woodland, such as Wandoo. Saving nesting trees may be less achievable in dense forests of high rainfall areas. Here, protecting patches of old growth Marri and Karri from intense fire should be the priority.

It should also be noted however that fire plays a part in the formation of hollows in Eucalypts. Fire damage (fire scarring) can facilitate fungal and termite degradation of heartwood which leads to hollow formation (Sandra Gilfillan pers.com).

FURTHER INFORMATION

Johnstone, R. (2010). Baudin's Cockatoo *Calyptorhynchus baudinii*. Information Sheet, Western Australian Museum November 2010.


Photo: Angus Spencer

NGOOLARK (CARNABY'S COCKATOO)

Calyptorhynchus Latirostris

Status - Endangered at WA State level
- Endangered at Commonwealth level

Ngoolark, Carnaby's Cockatoo is an endemic species of southwest Western Australia.

During the cooler months, the birds nest largely in the Wandoo and Salmon Gum, moving closer to the South Coast in the drier part of the year (November – May) to feed in shrublands, banksia woodland and eucalypt woodlands.

Eucalyptus woodlands with Jarrah, Marri and Tuart of 100-200 years age provide suitable tree hollows for nesting. Nest trees with hollows can be lost in wildfire, controlled burns and post-fire 'clean-up' of old trees that are considered a risk. During intensive wildfires, the trees burn from the top down (burning leaves falling into hollows etc.). The best conservation measure is management to contain the extent of wildfires and especially to protect patches of old growth.

For milder, controlled burns, dragging all deadfall and rake litter away from the base of all veteran and stag trees with hollows and potential hollows works well in the open woodland habitat of Carnaby's Cockatoo.

For a site to be suitable for breeding, foraging habitat and access to water need to be within usable distance from nest sites, with loss of feeding grounds within 12km posing a considerable threat to reproductive success. Small prescribed burns and patchy burns will leave unburnt areas providing seed food resources and help prevent extensive, intense wildfires.

Carnaby's Cockatoo readily utilises artificial nest sites where suitable hollows are not available. Installing nesting boxes to increase availability may be useful where suitable trees are not present, for example as a result of a destructive fire history.

It should also be noted that fire plays a part in the formation of hollows in Eucalypts. Fire damage (fire scarring) can facilitate fungal and termite degradation of heartwood which leads to hollow formation (Sandra Gilfillan pers.com).


Photo: Laslo Varga

Banksia seed is a major food resource for Carnaby's Cockatoo, with the Candlestick Banksia, (Biara) *B. attenuata* being a favoured pick. Candlestick Banksia resprouts after a fire but is not productive for seed until 10-30 years. Long unburnt stands are therefore required for species persistence, however, these are susceptible to wildfires which will kill adult trees. Low intensity (Spring), patchy and buffer burns can reduce risk of extensive, intense wildfire but need to be undertaken with great care to achieve the intended result.

FURTHER INFORMATION

Carnaby's Cockatoo *Calyptorhynchus latirostris*. Information Sheet, Western Australian Museum November 2010.

KARRAK (FOREST RED-TAILED BLACK COCKATOO) ***Calyptorhynchus Banksii Naso***

Status - Vulnerable at WA State level
- Vulnerable at Commonwealth level

One of three West Australian sub-species of Red-tailed Black Cockatoo, the forest sub-species is endemic to the wetter regions of the southwest.

Karrack nest in hollows formed as a result of termite and fungal activity in very old trees - 200 to 500 years age - particularly Marri. Such trees are readily lost to wind, wildfire, controlled burns and post-fire 'clean-up' of old trees that are considered a risk.

During intensive wildfires, the trees burn from the top down (burning leaves falling into hollows etc.) and the best protection of an area is management to contain such fires.

For milder, controlled burns, dragging all deadfall and raking litter away from the base of all veteran and stag trees with hollows and potential hollows has been shown to work well in open woodland. Saving nesting trees may be less achievable in dense forests of high rainfall areas of the south west. Here, protecting patches of old growth Marri, Jarrah, Bullich and Karri from fire should be the priority.

Forest Red-tailed Black Cockatoo nests are typically clustered in the landscape, likely related to social interactions within groups. Protection of all veteran trees in areas known to support nesting is highly important. Forest Red-tailed Black Cockatoos are also particularly vulnerable to bushfires that disrupt breeding. While breeding has been recorded in all months, peak breeding occurs in autumn (April-June) and spring (August-October). Peak months and years of breeding coincide with fruiting of either of the principal feed trees, Jarrah or Marri.

Ninety percent of forest Red-tailed Black Cockatoo diet consists of seeds of Marri and Jarrah, supplemented by seed of a range of other tree and understorey species including Blackbutt, Karri, Sheoak and Snotty-gobble. Red-tailed Black Cockatoos in the south west are also utilising seed of cultivated Lemon-scented and Spotted Gum, and Bushy Yate. Land owners should use their own observations on how cockatoo are utilising their area to customise conservation measures at this time of changing dynamics.

FURTHER INFORMATION

Johnstone, R. (2010). Forest Red-tailed Black Cockatoo *Calyptorhynchus banksia naso*. Information Sheet, Western Australian Museum November 2010.


Photo: JJ Harrison


Photo: JJ Harrison


Photo: Patrick Kavanagh

SHRUB FORAGING AND NESTING BIRDS

In general, small bird species are resilient to single, patchy fires of small spatial scale and low to moderate intensity.

Most individual small birds are able to survive low intensity burns by seeking refuge in trees or by flying ahead of the fire front to adjacent unburnt patches. Many return once the fire has past but survival can be low in the more open understorey post-fire. Landscape connectivity can provide routes for re-colonisation post fire from unburnt pockets once the burnt area has regained sufficient habitat resources.

In contrast, the response to extensive and intense fires is often a significant reduction in numbers, taking many years for populations of some species to recover. Recovery is successional, with species that prefer more open vegetation moving back earlier than those that need denser understorey. Repeat burning will prevent some species re-establishing.

Generally, the abundance of insectivores will increase following fire, and may exceed pre-fire levels for several years, while nectorivore abundance typically declines, due to reductions in flowering plants post burn. It is, however, the intensity of fire that has greatest impact on bird species richness and abundance post fire, with low intensity burns having least impact (Leighton and Gilfillan, 2012).

Given that each species responds individually to fire and that the ecology of each site will be unique, there is no one fire regime that will achieve the requirements of all species. Rather than rely solely on fuel age for guiding management, it is important to identify key biodiversity values in areas to be managed, take into consideration the local fire history and local conditions, and maintain as much patchiness as the site allows. This table provides observations on fire response for some bird species of the South Coast region to demonstrate the variety of responses possible.

COMMON NAME	SCIENTIFIC NAME	VEGETATION TYPE	OBSERVATION OF SPECIES PRESENCE IN RESPONSE TO FIRE EVENT
White-fronted Chat	*Epthianura albifrons*	Low open scrub	Benefit post intense fires, present for 2-3 years after fire, may still be present 6 years later.
Tawny-crowned Honeyeater	*Phylidonyris melanops*	Heath	Seems to benefit post fire, present 1-6 years after fire event, with abundance at its highest 2 post burn.
White-cheeked Honeyeater	*Phylidonyris nigra*	Heath	Present between 3-6 years after a fire event.
New Holland Honeyeater	*Phylidonyris movaehollandiae*	Heath	Minimum of 6 years since fire event.
Scarlet Robin	*Petroica multicolor*	Forest and woodland	Colonise new areas or become more abundant in areas that are more open post fire, varying responses at different study sites have been observed.
Grey Shrike-Thrush	*Colluricincla harmonica*	Woodland	Remained in unburnt pockets adjacent to burnt areas for more than 2 years. Began to move back into burnt areas 3 years post fire.
Western Thornbill	*Acanthiza inornata*	Forest and woodland	Varied response to fire at different sites with no strong trend identified.


Photo: Hannah Leadbetter


Photo: Cas Liber

JOOR-JAL (SPLENDID) AND JEER-JILL (RED-WINGED) FAIRY-WRENS

Malurus Splendens* and *M. Elegans

Status - Not listed at WA State or Commonwealth levels

Splendid and Red-winged Fairy-wrens (Joor-jal and Jeer-jill), two of the most characteristic and much loved birds of the south west, require dense understory for nesting and roosting and an adequate supply of invertebrates as a source of food.

Both establish family groups for maintaining territories and raising young. With limited capacity to move long distances across open ground between remnants, Fairy-wren populations are at risk from frequent and extensive fire. Assuming recruits from survivors or other groups in the vicinity can recolonise a burnt area, a population will not re-establish in a burnt patch until the understorey recovers sufficiently to protect adults, eggs, nestlings and fledglings from predation. Numbers build up slowly as family groups establish and grow.

The Splendid Fairy-wren prefers more open vegetation with patchier understorey than the Red-winged Fairy-wren. Splendid Fairy-wrens can have a high survival rate of adults during low to moderate intensity fires. Although breeding success and survival of juveniles is very depressed over subsequent years, populations generally recover several years post fire. Some understorey species that support wrens such as bracken, grass-trees, and many acacias and peas respond rapidly and vigorously to fire.

For example, a study in the Perth Hills found that a population of Splendid Fairy-wrens rapidly recovered after fire which promoted germination of Prickly Moses (*Acacia pulchella*), with 50% of nests located within this species 3 years post fire.

The Red-winged Fairy-wren is associated with dense stream vegetation in Jarrah-Marri forest and the dense understorey of Karri forest. The biology of Red-winged Fairy-wrens is focussed on quality, rather than quantity of vegetation, attuned to stable, predictable conditions. Compared with Splendid Fairy-wrens, adults have higher survival rates from year to year, are longer lived, have lower clutch size, a shorter breeding season and lower incidence of repeat breeding in a season. When their habitat does burn, adult survival is low and re-establishment of a population takes many years as vegetation recovers and recruits re-establish family groups. A population in Karri forest at Manjimup took over 10 years to recover to pre-fire numbers after an intense fire event.

To maintain Fairy-wren populations, particularly Red-winged Fairy-wrens, the best burning strategy is not to burn. Patchy low intensity fuel reduction burns around the periphery may be a means of protecting 'no burn' core areas of stream lines and Karri as habitat for Red-winged Fairy-wrens and a suite of other wildlife with similar requirements. Even low intensity burns in such habitat can be harmful given that half the Red-winged Fairy-wren nest sites in the Manjimup study were in dead brush on the forest floor.

Maintaining connectivity between areas of habitat is particularly important for species such as Fairy-wrens with limited capacity to disperse over open ground. In isolated remnant bushland less than 120 ha in area, Fairy-wren populations may not be sustainable even without fire. Vegetation corridors are used with some success to enable dispersal through cleared farmland. Larger gardens such as those in peri-urban or rural lots can support Fairy-wren populations and provide connectivity between natural vegetation remnants.


Photo: Sally Forbes

NGWAYIR (WESTERN RINGTAIL POSSUM) ***Pseudocheirus occidentalis***

Status - Critically Endangered at WA State level
- Critically Endangered at Commonwealth level

The Ngwayir (pronounced n-w-ear) is a nocturnal possum with a leaf diet restricted to a limited group of plants. Formerly distributed over a much greater range of southwest Western Australia, Ngwayir are found in coastal and forest vegetation from Mandurah to Albany.

The South Coast population occurs from West Cape Howe in the west to Mt Manypeaks in the east, extending approximately 16 km inland. Recent records (Bronte Van Helden unpub. data) have extended its known inland range in the east to Lake Pleasant View Nature Reserve. An outlying population in the Porongurup National Park to the north was present prior to an extensive fire in the park in 2007. It is unknown if this population still persists (Sandra Gilfillan, pers. comm, 2017).

The preferred habitat for the Western Ringtail Possum in the South Coast population is not well understood, but the species has been recorded in a wide variety of habitats, including; coastal heath, Jarrah/Marri woodland and forest, Jarrah/Sheoak woodland, Peppermint woodlands, myrtaceous heaths and shrublands, Bullich (*Eucalyptus megacarpa*) dominated riparian zones and Karri forest (*Eucalyptus diversifolia*), granite communities (*Gastrolobium bilobum/Hakea elliptica*), and sedgelands (comprising a total of 26 vegetation units identified and mapped in the Albany Region (35km radius from Albany) (Sandiford and Barrett 2010) (Sandra Gilfillan, pers. comm, 2017).

The possums have a particular preference for the Peppermint, *Agonis flexuosa*, areas that also tend to have dense canopies of trees that provide shelter for 'dreys' - nests comprising a ball of woven twigs and leaves - and capacity to move from tree to tree with minimal descent to the ground. Skirts of grasstrees (*Balga*) are also favoured nest sites. These structures benefit from thick, more mature vegetation rather than younger, regenerating vegetation (Cape to Cape Catchment Group, 2016, Leighton and Gilfillan, 2012).

Ngwayir are considered to be highly fire sensitive, particularly populations occurring in fragmented areas with limited connectivity (Leighton and Gilfillan, 2012).

They are most abundant in suitable habitat that has remained unburnt for more than 20 years or that have only experienced low intensity fire (flame height <2m up trees in Jarrah and Peppermint forest). Moderate-high intensity burns may be appropriate for bush regeneration and tree hollow development but only when the mid-story quality deteriorates at 20 to 50 years.

Long fire intervals will potentially result in high fuel loads that place the Ngwayir population at risk from wildfire. Where low-lying areas such as riparian zones support highest densities of Ngwayir, these can be protected by more frequent prescribed burns up slope.

For small remnants of high quality habitat, it may be necessary to create a mosaic with buffer and low-fuel patches to prevent total loss to wildfire. When burning small sections, as much of the remaining habitat should be left unburnt for at least 10 years. Movement between habitat remnants to repopulate and maintain gene flow, particularly following fire, is highly dependent on vegetation connectivity due to the limited capacity of Ngwayir to cross open ground.

Prescribed burns in Ngwayir habitat must take into consideration intensity and seasonality to reduce stress on populations from reduced food and shelter resources. Prescribed burns should therefore:

- be low intensity
- aim to retain the dead leaf skirts of Balga and dense mid-storey vegetation as nesting sites
- be conducted in mid-spring, particularly in Jarrah forest, prior to the conclusion of the fresh spring leaf growth - the leaf quality over winter is often low in nutrient value and a mid-spring burn allows time for additional fresh leaf production before growth slows in summer
- be avoided in wetlands. Ngwayir can also nest on the ground in large sedges and these should not be burnt. Burning around these areas should only occur in winter, and no burning should occur in partially inundated areas.

Summer and autumn seasons are not a good time to burn. Summer fires are generally intense with greater loss of understorey and mid-storey cover, exposing possums to hot weather conditions and predation. In autumn, leaves lost won't be adequately replaced until the following spring, further reducing already low food resources over winter. If an autumn burn is unavoidable, keep the burn as small as possible whilst retaining large unburnt areas within the burn mosaic.

Predator control is critical, particularly where burning has been intense and in fragmented habitat - immediately prior to a burn and for about 3 years until the mid-story has properly recovered.


Photo: JJ Harrison

KOOMAL (WESTERN BRUSHTAIL POSSUM) ***Trichosurus vulpecula hypoleucus***

Status - Not listed at WA State or Commonwealth levels

The Koomal, a small, West Australian sub-species of Brushtail Possum, inhabits a wide variety of vegetation types, with the main requirement being adequate refuge and nesting sites. They use tree hollows for nesting, with preference for hollows deeper than 1m.

Refuge sites on the ground include hollow logs, rock piles and burrows constructed by other animals.

In the Albany region, much Koomal habitat has been lost to clearing and, while they are not perceived to be under threat, they are not frequently seen. On occasion, Koomal may find refuge in the roof space of houses. They have been recorded in the reserves of Mount Clarence and Mount Adelaide, however their distribution is restricted to specific woodland and forest tree habitat with suitable hollow formations (Leighton and Gilfillan, 2012). Their preferred hollows (1m or more deep) take an average of 300 years to form in Jarrah and 200 years in Marri trees.

Population recovery can be quite rapid after an intense summer-autumn fire as Koomal can cross long distances of open ground (up to 400m) between areas of suitable habitat and are therefore less susceptible to local extinction in connected vegetation remnants that have been burnt than might be supposed. However, the loss of tree hollows from intense fires is a significant threat.

In one study, a minimum of 3 habitat trees was required per square hectare to support Koomal populations.

Flammable material should be raked away from the base of all old trees with hollows prior to a burn, especially for those known to be used by possums. Saving nesting trees may be less achievable in dense forests of high rainfall areas. Here, protecting patches of old growth Marri and Karri from fire should be the priority.

Fires of low intensity appear to have very little impact on Koomal and they are regarded as post fire opportunistic (Leighton and Gilfillan, 2012). It should also be noted that fire plays a part in the formation of hollows in Eucalypts. Fire damage (fire scarring) can facilitate fungal and termite degradation of heartwood which leads to hollow formation (Sandra Gilfillan pers.com).

FURTHER INFORMATION

Department of Conservation and Land Management (2005). Living with Possums. Land for Wildlife, Department of Conservation and Land Management, https://www.dpaw.wa.gov.au/images/documents/conservation-management/off-road-conservation/LFW/2005346_possum_bro_2005.pdf

The Western Ringtail Possum – a threatened species in our backyards, Western Ringtail Action Group, https://geocatch.asn.au/wp-content/uploads/2018/01/Final-WRP-brochure-2011.pdf

Photo: David Tunbridge

Photo: Ry Beaver

NOOLBENGER (HONEY POSSUM)

Tarsipes rostratus

Status - Not listed at WA State or Commonwealth levels

The Noolbenger (ngool-boon-gor) is a small marsupial endemic to the south-west. It is reliant on pollen and nectar as a food source and as such, their recovery post fire is dependent on flower productivity. While listed as common, they are limited in their occurrence on the South Coast. Noolbenger have specific, nectar reliant diets and therefore favour vegetation composed of many nectar-rich plant species.

The main plant groups favoured for food are the Proteaceae (Banksia family), Myrtaceae (Eucalypt family) and Epacridaceae (heaths). Frequent and/or extensive fires can be significantly detrimental if flower production is reduced and landscape fragmentation limits their capacity to move into and return from suitable habitat adjacent to the burnt patch.

Noolbengers are considered fire sensitive, being most at risk when exposed to large, intense fires and frequent fire. They may return to suitable habitat 2-4 years post fire, initially to feed each night and eventually to re-establish breeding populations (D. Bradshaw pers. comm.). However, peak abundance is not reached for 20-30 years. Abundance has been observed to decline in areas unburnt for more than 36 years.

Management of Noolbenger habitat in a mosaic of recently burnt and long unburnt patches with connective corridors is advisable for areas of vegetation sufficiently large to be managed in this way. Burn areas that are as small as 2 ha are quite feasible, although the establishment of tracks to help conduct burns around such small areas as these may not be desirable. For remnant vegetation too small to break up into a mosaic, the core habitat can be protected from fire by maintaining low fuel around the periphery through cool burns or other means, whilst maintenance of connectivity between habitat patches provides for re-colonisation when a bushfire eventuates.

Low intensity, frequent and patchy burns (intervals of 5-15 years) may help reduce wildfire risk without damaging or killing trees. However, great care is needed to ensure these types of fire remain controlled and that prevention is not as damaging as the cure.

CHUDITCH (WESTERN QUOLL)

Dasyurus geoffroii

Status - Vulnerable at WA State level
- Vulnerable at Commonwealth level

The range of the Chuditch, Western Australia's largest remaining marsupial carnivore, has been significantly reduced since European settlement.

The densest populations are in Jarrah forest along waterways which provide the necessary shelter from introduced predators, opportunity to establish dens underground and in logs, and adequate food.

On the South Coast, monitoring research has recorded mild improvements in abundance within important populations in the Ravensthorpe Range and the northern sandplain of the Fitzgerald River National Park. As a result, animals from these areas have been used in translocations of the species to the Flinders Range in South Australia (Spencer et al, 2016)

Prescribed burns of less than 4000 ha are considered to be ecologically beneficial to Chuditch as a means of building a mosaic of varying fuel ages in the landscape and with that a variety of food sources. Conversely, hot summer wildfires are detrimental as they destroy log dens and promote uniformity of vegetation in the landscape.

Protection of log den resources requires consideration in planning a prescribed burn. This can be achieved by raking dead leaf and tree material away from hollow logs (and hollow dead standing trees) prior to burning and taking effort to extinguish any burning logs after the burn.

Chuditch prey on large invertebrates, reptiles and small mammals which may be in limited supply in the initial post burn stages. Connectivity with other patches to enable an enlarged foraging range will assist them during this time, although the species is capable of crossing open ground. Chuditch are vulnerable to fox predation, which increases with loss of habitat cover and need to shift or extend the foraging range post fire. Fox management is therefore important immediately prior to and during burn recovery periods.

Saving den logs and trees may be less achievable in dense forests of high rainfall areas of the south west. Excluding fire from the preferred habitat of stream vegetation within forest may be the best way to maintain Chuditch. In these circumstances, management may be needed for surrounding areas to reduce fuel levels and the risk of extensive, intense bushfire.

Photo: Greg Schechter

QUOKKA ***Setonix brachyurus***

Status - Vulnerable at WA State level
- Vulnerable at Commonwealth level

The Quokka (Kwok-a) is a small, stocky, highly distinctive wallaby between 2.7g – 4.2g.

Predominantly known for the Rottnest Island populations, mainland Quokka all occur in areas receiving over 600 mm rain per year, although most are within regions of higher rainfall about 1000 mm/yr. This is likely to correlate with the availability of leafy, green and digestable vegetation and habitat cover provided by these high rainfall areas.

From Nannup, Quokka occur within the Southern Jarrah, Marri and Karri forests to around Denmark, and on the South Coast east to Green Range. There are sub-populations of Quokka on Bald Island and within the Stirling Ranges. They most commonly occupy forest and riparian habitats with sedge dominated understorey. The South Coast populations require wider ranges of vegetation types, both floristically and structurally, than the more northern populations. For example, the Two Peoples Bay population occurs within coastal heath and thickets with swamps and riparian vegetation (Bain et al, 2015a).

Quokka move in response to the seasons, shifting to the outer when winter rains inundate the centre of their swamp. They will be exposed to less predation if the outer areas of wetland habitat provide sufficient refuge (Bain et al, 2015a).

Fire regimes that impact preferred habitat, such as long unburnt riparian or swamp vegetation, are likely to be detrimental to Quokkas. Further, low intensity fire that burns only swamp edges can result in reduced swamp vegetation, and does not create the mosaic of vegetation structure required by Quokkas (Bain et al, 2015b).

Quokkas appear to require a landscape mosaic of vegetation structures including swamps with dense understory for refuge, interspersed between areas of more recent fire with an open structure and greater supply of food. Uniform old growth may limit Quokka feeding habitat and shelter through accumulation of dead material and mid-storey vegetation senescence. However, long unburnt (120 years) vegetation at Bald Island and, until 2015 on Mount Gardner (60 years) both supported thriving populations (Bain et al, 2015b).

Research indicates that maintaining vegetation structure and multiple unburnt patches across over 20% of the area, associated with slow fire rate of spread and low soil dryness are important for Quokka habitat. Intense wildfire will result in complete loss of vegetation structure and unburnt areas, which are not re-colonised by Quokkas (Bain et al, 2015b).

In regions where feral pigs occur, control following fire is essential as they will impact recovering vegetation structure. Feral cat and fox control should also be considered (Bain et al, 2015b).

Quokkas move between swamps in response to vegetation change in the years following a fire event. Maintaining vegetation connectivity between suitable patches of habitat is therefore important to conserving Quokkas in a fragmented landscape (Bain, et al 2015b).

Both photos: South Coast NRM

KWOORA (WESTERN BRUSH OR BLACK-GLOVED WALLABY) *Macropus irma*

Status - Priority 4 (requires regular monitoring) at WA State level
- Not listed at Commonwealth level

The Kwoora is a medium sized wallaby (7-9 kg) endemic to south-west Western Australia. A grazer rather than browser, the Kwoora favours open forest and woodland, particularly seasonally-wet flats with low grasses and open, scrubby thickets. It is uncommon in Karri forests which have dense undergrowth.

In the South Coast region, Kwoora are known from the Forest to Stirlings and Stirlings to Fitzgerald vegetation corridors in both private remnants and reserves. The species relies on habitat with a medium–dense understorey of about 1-1.5m high interspersed with open areas for feeding. These refuges also require suitable linkages between patches to facilitate movement of animals and population connectivity (Gilfillan 2016).

Kwoora numbers are reported to have increased in abundance in areas where foxes have been controlled and prescribed burning programs conducted across much of its forest habitats are considered to favour this species.

The primary considerations for retaining Kwoora are therefore to retain areas of forest, particularly with seasonally-wet flats, with connectivity where the vegetation is fragmented. The Kwoora's preference for dense understorey often associated with drainage lines and wetlands mean they often do best in a fire mosaic with a moderate burn regime of 4-10 year rotation. This ensures a scrubby thicket to provide shelter and the capacity to avoid fox predation.

YONGA (WESTERN GREY KANGAROO) *Macropus fuliginosus*

Status - Not listed at WA State or Commonwealth levels

Yonga, the Western Grey Kangaroo is a large kangaroo of southern Australia with a range from southwest Western Australia to western Victoria.

Yonga has greatly benefited from an increase in suitable habitat and water supply associated with agriculture. The open, grassy understorey of frequently burnt forest can also carry high kangaroo numbers and native vegetation on the edge of farmland provides day-time shelter as well as roughage to supplement greener feed provided in pasture and crops.

Western Grey Kangaroos are generally a threatening factor when considering conservation aspects of fire management. Selective grazing by kangaroos on seedlings and resprouting shoots contributes towards shaping the vegetation composition post fire. Grazing can therefore not only reduce density of regrowth but cause decline and loss of targeted plant species and overall floristic diversity.

Post fire management of bushland may require the exclusion of kangaroos for several years if numbers in the area are high, particularly where sheltering vegetation has been retained adjacent to patch burns.

However, large herbivores have a preference toward grass-like plants and may target some weed species and assist with post fire biomass control on the forest floor. Therefore, management decisions should be based on site specific ecological values and vegetation composition.

Photo: Sally Forbes

Photo: Dane McMillan

QUENDA (SOUTHERN BROWN BANDICOOT) *Isoodon obesulus fusciventer*

Status - Priority 4 (requires regular monitoring) at WA State level
- Not listed at Commonwealth level

Quenda is a subspecies of Bandicoot endemic to the southwest. They are relatively widespread in the south-coast across Karri, Jarrah and coastal vegetation, occurring in reserves and private land remnants across the region.

Quendas are typically nocturnal though may sometimes be active during the day. They are omnivores, feeding on insect larvae, fungi, seeds and some plant matter. When searching for food they leave distinctive cone shaped diggings (Leighton and Gilfillan, 2012).

Quendas prefer swampy and creekline areas with very dense understory that provides protection and shelter from predators. With a weight of between 400 g to 1.6 kg, they fall within the critical weight range (50 g to 5.5 kg) that is particularly vulnerable to foxes, dogs and cats. Monitoring at Cape Arid following cat baiting trials indicated a significant improvement in numbers, though trends in Frankland where fox and cat presence persists show a species in decline (Spencer, et al 2016).

Low intensity, high frequency fire regimes help support the dense vegetation required by Quendas. They will benefit from a landscape mosaic of varying fuel ages that provides shelter in dense vegetation and food resources in neighbouring patches that have been more recently burnt.

The combination of fragmentation of suitable habitat across the landscape and extensive, frequent fire is a threat to Quendas. Landscape connectivity is vital and can be promoted through the conservation and restoration of connective corridors between areas that provide suitable nesting habitat with dense understorey and patches burnt more frequently, ideally in a patchy burn mosaic.

MARDO (YELLOW-FOOTED ANTECHINUS) *Antechinus flavipes leucogaster*

Status - Not listed at WA State or Commonwealth levels

The Mardo is a distinct southwest Western Australian subspecies of antechinus.

This small, carnivorous marsupial is considered common, with a stable but sparse distribution in forest and woodland habitats. They are omnivorous, eating invertebrates, small birds and mice as well as flowers and nectar. When young become too big for the mother to carry around, they rest in nests made of leaf litter.

Mardo prefer forested areas that have remained unburnt for more than 10 years where deep leaf litter provides nest sites and a high abundance of invertebrate food. Following fire in upland dry areas, Mardo populations may take 20 years to reach pre-fire population levels.

Retention of areas of live grass-trees (Balga) with long skirts and fallen dead trunks can provide shelter for foraging and nesting within burnt areas to help maintain Mardo populations.

Photo: Jeremy Spencer

Photo: Cooper Bullock

REPTILES

A range of reptiles from large goannas to small skinks and geckoes, and snakes occur within the ecosystems of the South Coast region. Some reptiles prefer granite outcrop areas for thermal qualities and shelter, while others may require logs and leaf litter habitat (Gilfillan and Leighton, 2012).

Because of their use of burrows and open areas, many species of snakes and lizards are fairly resilient to the immediate impacts of low-medium intensity fire, though arboreal or surface dwelling species will be more at risk. High intensity fire, or frequent fire, may restrict habitat regeneration for reptiles (Leighton and Gilfillan, 2012).

Studies in Kings Park determined the greatest diversity of reptiles within long unburnt sites, however, at some sites species numbers and abundance were largely at pre-fire levels two years following fire, with migration from unburnt areas apparent (Leighton and Gilfillan, 2012). This again suggests the importance of mosaic burns and connectivity to unburnt areas, and that older aged habitat is important for many reptile species.

AMPHIBIANS

Understanding of the effects of fire on frog species in the South Coast region is quite low. A number of frogs have invertebrate diets and so require leaf litter habitats, while others, such as Crinea species, are attracted to moist environments such as those created by granite outcrops pooling and shedding water during winter months. This is particularly important where water is required during the breeding phases. Granite outcrop ecosystems are themselves sensitive to fire (Appendix 1), and many small frogs may also rely on the mosses and lichen occurring upon them (Leighton and Gillfilan, 2012).

Burrowing frogs such as moaning and banjo frogs may be protected by the insulating properties of soil, however, tree frogs may be vulnerable to fire (Leighton and Gilfillan, 2012).

Photo: Meredith Spencer

All photos: Department of Biodiversity, Conservation and Attractions, South Coast

INVERTEBRATES

Invertebrate diversity is rich in the South Coast, including species such millipedes, scorpions, worms, beetles, land snails and spiders. They may be found in leaf litter, soil, debris, rock piles, on trees and beneath bark and may be impacted by fire directly and indirectly through habitat modification. Species may survive fire through patches of unburnt vegetation or by soil insulation or other refugia (Leighton and Gilfillan, 2012).

Generally invertebrates will recolonise an area through adjacent unburnt areas, dense crowns of plants, thick bark on trees and soil from rocks and burrows. How quickly invertebrates recolonise will depend on their ability to disperse, and the intensity, patchiness, extent and season of fire will all affect re-colonisation capacity (Leighton and Gilfillan, 2012).

SHORT RANGE ENDEMIC (SRE) INVERTEBRATE FAUNA

The South Coast region is also significant for its short-range endemic invertebrate fauna species. These are species that have extremely limited distributions, for example, they may be restricted to only one mountain peak. Therefore, separate mountain peaks in the same Range may have unique communities of invertebrate species.

Seven taxa of SRE spider occurring within the mid-west, wheatbelt and South Coast, and two taxa of millipede on the South Coast are Specially Protected (Schedule 1) fauna.

SRE taxa typically have:

- limited capacity to disperse
- are confined to fragmented habitats
- usually have highly seasonal activity patterns, for example being active only during cooler, wetter times and
- low reproduction capacity.

Some examples include millipedes, velvet worms, land snails and spiders. In the South Coast they occur in localised and specialised habitats that include isolated hills and other landforms, vegetated gullies and freshwater habitats that are relicts of ancient habitats, or mimic historic habitat, e.g. Stirling Range, Ravensthorpe Range. SRE are particularly sensitive to fire and changed fire regimes.

FIRE & BIODIVERSITY

Landholder Information Guide

SOUTHCOAST NATURAL RESOURCE MANAGEMENT

Australian Government

Photo: Meredith Spencer