A Guide to Fire Ecology

on the Mid Coast

This project has been assisted by

Image: Isabelle Strachan. Cool (low temperature) burn reaching scrub height.
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Disclaimer

Contents

Contents

Eco Burn
Education

Definitions

Asset(s)	Anything that is of value to the community that may be at risk from bushfire.[1]
Atmospheric Stability	Refers to the amount of vertical movement of air within the atmosphere. Temperature inversions are an indication of a stable atmosphere.[2]
Backing Fire	"Part of a fire which burns back against the wind or down slope, where the flame height and rate of spread are reduced" [3]. (Not to be confused with the term 'backburn' which is a fire fighting technique.)
Biodiversity	Is the variety of all living things including the different animals and plants, the genetic information they have and the ecosystems they live in and form.[4]
Cultural Burn	Refer to the "First Nations Fire Use in Australia (Cultural Burning)" section or Local Land Services "Aboriginal Land Management" booklet.
Crowning	When a fire reaches the canopy.
Disturbance	Any relatively discrete event in time that removes organisms and opens up space which can be colonised by individuals of the same or different species.[5]
Ecological Burn	A form of prescribed burning that aims to achieve specified ecological objectives; protect species and ecosystems.[3]
Ecological Succession	Refers to the cycle and stages of change to vegetation occurring within an ecological community over time.[6]
Epicormic Buds	Dormant buds that sit beneath bark which grow when exposed to light and air.[7]
Fire Frequency	Over time, how often a specific area burns.
Fire Frequency Guidelines	These guidelines are designed to support ecological fire management using fire frequency intervals. Broad vegetation types have minimum and maximum fire intervals, aimed at conserving plants and threatened animals. These intervals target species which are particularly sensitive to very short or very long intervals between fires.[8]

[1]Mid Coast Bush Fire Management Committee Bush Fire Risk Management Plan. (n.d.). [online] Available at: https://www.rfs.nsw.gov.au/__data/assets/pdf_file/0007/114793/Mid-Coast-BFRMP.pdf.
[2]Bureau of Meteorology. (2017). How weather affects fire. [online] Available at: http://www.bom.gov.au/weather-services/fire-weather-centre/how-weather-affects-fires/.
[3]Bushfire Glossary. (2012). [online] Australasian Fire Authorities Council. Available at: https://www.afac.com.au/docs/default-source/doctrine/bushfire-terminology.pdf.
[4]The Australian Museum. (2020). What is biodiversity? [online] Available at: https://australian.museum/learn/science/biodiversity/what-is-biodiversity/ [Accessed 7 May 2022].
[5]Tierney, D. and Watson, P. (2009). Fire and the Vegetation of the Hunter Central Rivers CMA (Draft).
[6]Johnson, Edward.A. and Miyanishi, K. (2007b). Disturbance and Succession. In: Edward.A. Johnson and K. Miyanishi, eds., Plant disturbance ecology: the process and the response. Amsterdam; Boston: Elsevier/Ap.
[7]Meier, A.R., Saunders, M.R. and Michler, C.H. (2012). Epicormic buds in trees: a review of bud establishment, development and dormancy release. Tree Physiology, 32(5), pp.565–584. doi:10.1093/treephys/tps040.
[8]Conroy, N., Watson, P. and Hinchcliffe, J. (2010). Managing Fire On Your Property: A booklet for landholders in the hunter-central rivers. [online] Available at: https://hotspotsfireproject.org.au/download/landholder-booklet-hunter-central-rivers.pdf [Accessed 8 Jan. 2022].

Definitions

Fire Intensity	Heat energy released from organic matter during a fire.[9]
Fire Regime	The intensity, season and extent of each fire and the frequency at which fires re-occur.[10]
Fire Severity	Effects fire intensity has on the landscape, including plants and animals.
Fuel Arrangement	The spatial distribution and orientation of fuel[3]. Refer to the "Understanding the Ingredients of Fire and Fuel Behaviour" section for a figure demonstrating fuel arrangement.
Hazard Reduction Burn	A form of prescribed burning, that aims to protect assets by reducing the fuel load present.[8]
Hazard Reduction Certificate (HRC)	Issued by the Rural Fire Service, a process that simplifies legal approvals for planned hazard reduction activities.
Head Fire	The part of a fire which spreads the fastest and is the most intense.[3]
Heterogeneity	A term used to describe diversity and variety.
IBRA	Interim Biogeographic Regionalisation for Australia.
Ignition Point	A point where a fire initially starts, either naturally or intentionally.
Incident Controller (IC)	The person defined on scene as in control of the team and situation.
Keetch-Byram Drought Index (KBDI)	The KBDI provides an estimate of how dry the soil is. The number relates to the amount of rainfall in millimetres (mm) that would be required to saturate/wet the soil.[11]
Keith Class	The middle tier in David Keith's vegetation community hierarchy.[12]
Keith Formation	The top tier in David Keith's vegetation community hierarchy.[12]
Lignotuber	A woody swelling at the base of a tree or stem that contains buds and food reserves.[13]
Mineral Earth	A term used to define a control line that has been raked back to bare soil, so there is no vegetative material available.
Mosaic or Patch Burns	Patchiness of burnt and unburnt vegetation in a landscape that creates diversity amongst vegetation (age, structure and distribution.)[8]

[9]Keeley, J.E. (2009). Fire intensity, fire severity and burn severity: a brief review and suggested usage. International Journal of Wildland Fire, [online] 18(1), pp.116–126. doi: https://doi.org/10.1071/wf07049.
[10]Primer on Fire Ecology. (n.d.). [online] Nature Conservation Council of NSW. Available at: https://assets.nationbuilder.com/natureorg/legacy_url/2809/fire-ecology-primer-v2-oct2015.pdf?1630462737 [Accessed 1 May 2022].
[11]'Weather & Bushfire Behaviour' (2006). Bush Fire Bulletin, vol. 28, no. 1, pp. 21–24.
[12]Keith, D. A., & Pellow, B. J. (2015). Review of Australia's Major Vegetation classification and descriptions. Centre for Ecosystem Science, UNSW: Sydney, NSW, Australia.
[13]Fire Ecology and Management in Northern Australia. (n.d.). Fire Ecology: Effects of fire on plants and animals. [online] Available at: http://learnline.cdu.edu.au/units/env207/ecology/individual.html#:~:text=Fire%20acts%20as%20a%20generalist [Accessed 15 Mar. 2022].

Definitions

Plant Type Communities (PCT)	The lower tier in David Keith's vegetation community hierarchy.[12]
Prescribed Burn	The controlled application of fire under specified environmental conditions to a predetermined area and at the time, intensity, and rate of spread required to achieve specific resource management objectives.[14]
Pyric-Carnivory	"The response of carnivorous predators to fire in order to capture prey."[15]
Rhizomes	Are typically underground stems that grow horizontally, and are capable of producing new shoots and roots.[16]
Sclerophyll	A type of vegetation, characterised by hard, thick leaves, that has adapted to drought and long periods of dryness.[17]
Scorch Height	The height above ground level, on vegetation that has been browned by a fire.
Seed Dormancy	The period in which a seed can remain viable within the soil seed bank awaiting germination triggers.
Selective Foraging	A term used to describe the decisions and preferences of herbivores when choosing what to eat. Usually influenced by the level of nutritional content in the plant.[18]
Succession	Usually following a disturbance, succession is a predictable process of community change where several assemblages of species progressively occupy a site, each giving way to it's successor until stable, self-producing community is reached.[6]
Torpor	A short hibernation which involves an animal lowering its body temperature and slowing its metabolism.[19]

[14]AFAC (2015). Overview of prescribed burning in Australasia. Report for the National Burning Project – Subproject 1. Australasian Fire and Emergency Service Authorities Council Limited. March 2015.
[15]Hovick, T.J., McGranahan, D.A., Elmore, R.D., Weir, J.R. and Fuhlendorf, S.D. (2017). Pyric-carnivory: Raptor use of prescribed fires. Ecology and Evolution, 7(21), pp.9144–9150. doi: https://doi.org/10.1002/ece3.3401.
[16]ABC - Gardening Australia. (2009). All About Rhizomes. [online] Available at: https://www.abc.net.au/gardening/factsheets/all-about-rhizomes/9429982.
[17]Hotspots Fire Project. (n.d.). Fire Management Plan - Vegetation Types. [online] Available at: https://hotspotsfireproject.org.au/fire-management-plan/vegetation-types#:~:text=Wet%20Sclerophyll%20Forest%20(grassy%20sub%20formation)&text=Appropriate%20fire%20frequencies%20for%20this [Accessed 29 Mar. 2022].
[18]Huang, Y., Wang, L., Wang, D., Zeng, D.-H. and Liu, C. (2016). How does the foraging behavior of large herbivores cause different associational plant defenses? Scientific Reports, 6(1). doi: https://doi.org/10.1038/srep20561.
[19]Stawski, C., Körtner, G., Nowack, J. and Geiser, F. (2015). The importance of mammalian torpor for survival in a post-fire landscape. Biology Letters, 11(6), p.20150134. doi: https://doi.org/10.1098/rsbl.2015.0134.

1. An Introduction to EcoBurn Education

Introduction

Bushfires have been shaping the landscape for millions of years and are a common, natural component of the Australian environment[20]. Our environment, including plants and animals, has evolved and adapted to fire with a proportion of our vegetation relying on fire for survival and regeneration[21].

In Australia, fire has been used as a land management tool by Aboriginal people to maintain their connection and reciprocal responsibilities to Country through the constant revitalisation of their Aboriginal Cultural Practice. Aboriginal land management, including the use of fire, has shaped ecosystems and landscapes in Australia for at least 60,000 years.

This understanding and practice has been lost in much of modern Western land management practices, and the consequences are impacting our ability to manage biodiversity, ecosystem resilience and risks to human life and assets.

In the 2019/2020 bushfire season, the Mid Coast region was heavily impacted by catastrophic bushfire conditions. It was during this time that Mid Coast 2 Tops Landcare (hereafter MC2T) acknowledged the requests from our community for more engagement on the topic, to increase both understanding and the capacity of landholders to actively manage fire on their property.

Landholders driveway post bushfire. Photo credit Daintry Gerrand

The purpose of this series of resources is *to increase the knowledge, capacity and confidence of private landholders to participate in ecologically responsible fire management, until such time that First Nations led landscape management becomes possible.*

Asset protection zone around house and gardens, nearby bushland in the background. Photo credit - Daintry Gerrand

Importance of Fire Management on Private Land

Around 70% of NSW is owned or managed by private landholders[22]. Because of this, it is vital that all land managers are supported in increasing their confidence and skills to participate in active fire management on their property. Through previous engagement programs, local landholders have repeatedly conveyed their lack of confidence and knowledge as key barriers to applying fire on their property.

Implementing fire management on private property can be difficult to navigate because of both complex ecological considerations and legislative approval pathways. The information given in this booklet is current as at publication date, and aims to offer clarity in these areas. However, it should be noted that both our ecological knowledge and legislation on the topic are likely to evolve quickly over the coming years as our understanding improves.

[20]Deb, P., Moradkhani, H., Abbaszadeh, P., Kiem, A.S., Engström, J., Keellings, D. and Sharma, A. (2020). Causes of the Widespread 2019–2020 Australian Bushfire Season. Earth's Future, [online] 8(11). Available at: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020EF001671.
[21]Government, A. (2018). Bushfire. [online] Ga.gov.au. Available at: https://www.ga.gov.au/scientific-topics/community-safety/bushfire.
[22]State of New South Wales (Biodiversity Conservation Trust). (2024). Private land conservation in NSW. [online] Available at: https://www.bct.nsw.gov.au/private-land-conservation-nsw.

As a landholder, understanding your property and the sort of vegetation present is a great start to fire management planning. This booklet, together with MC2T's online materials, provide resources to improve your understanding and guide your processes in the application of fire on your property. We also encourage you to engage with your local fire brigades and land managers for expert knowledge and support.

Purpose of this Guide

This guide aims to help landholders understand fire behaviour and the effect of fire on the landscape and environment. It further aims to clarify landholder responsibilities and to increase landholder confidence relating to implementing fire as a land management tool.

Specifically, this guide covers:

- fire and fuel behaviour and how this applies in the landscape
- how plants and animals respond to fire
- the difference between types of prescribed burns
- how to apply fire in a way that promotes biodiversity and risk reduction outcomes
- strategies relating to effective property-based fire management.

Understanding the Ingredients of Fire and Fuel Behaviour

Fire itself is a visual result of the combustion process[23]. Combustion is a type of chemical reaction that occurs when oxygen and fuel react to release heat and light[3].

Fires and the way they interact with vegetation, climate and weather are complex. To be successful, a fire needs three things; fuel that can burn, an ignition source and oxygen.

Once established, the way a fire behaves can be impacted by:

- fuel
- weather and climate
- topography.

Fuel

Fires are fuelled by living and non-living vegetation such as wood, leaves, shrubs, trees etc. How fast a fire spreads, and its intensity are determined by the type, size, quantity, arrangement and moisture level of the fuel and the topography of the landscape.

Type

The different types of fuel that you can find in the landscape include:

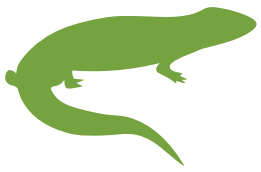
- grass
- forest litter lying on the ground
- small shrubs and scrub
- trees, logs and stumps
- bark.

Size

Fine fuels are any plant material that are smaller than the width of a pencil (or <6mm in diameter). Fuel at this size, dries out, heats up and burns quickly, contributing to the spread and intensity of a bushfire[24]. Coarse fuels, such as stumps, logs and branches will take longer to ignite and burn more slowly, however, they can burn for much longer periods of time.

Amount of fuel

The rate at which fuel can accumulate and build up is dependent on what type of vegetation is present, and how quickly this material decays or is broken down[18].The volume of fine fuel present contributes to fire intensity. Large amounts of fine fuels increase the intensity of bushfires. It is important to note that effective fire management does not require the removal of all fine fuel in the landscape. Fine fuel has an important role in healthy ecosystems as habitat, food provision and in erosion control. For more information on the relationship between fire management and ecology, see the 'Managing Fire and Biodiversity' section.



[23]Science Learning Hub. (2009). What is fire? [online] Available at: https://sciencelearn.org.nz/resources/747-what-is-fire#:~:text=Combustion%20is%20when%20fuel%20reacts,fast%20and%20is%20called%20burning.
[24]Hotspots Fire Project (2021). [online] Available at: https://www.hotspotsfireproject.org.au/download/understandingfuelandfuelaccumulation.pdf [Accessed 3 Mar. 2022].

Moisture Level

The amount of moisture present in fuel determines whether it burns and, if so, how fast. Fuel that is damp or wet may take a longer time to ignite, or may not burn at all. Fuel that is dry can ignite and burn quickly, contributing to how fast a bushfire spreads.

Arrangement

Fuel can be laid out across the landscape between the surface and canopy. The way pieces of fuel are arranged vertically and horizontally, in relation to air flow and one another, will affect how they burn and determine how fast a fire can spread between them.

Fuels that are loosely and continuously arranged are more likely to burn. This is because more oxygen is available to promote combustion[25] which, in turn, results in increased flame contact and radiant heat. Alternatively, fuels that are tightly packed/compacted or non-contiguous are likely to burn less intensely and will smolder due to a lack of oxygen.

A continuous ladder of fuel, including suspended fuel, from the surface to the crown of the vegetation encourages the vertical movement of fire, potentially resulting in crown fires.

Weather

Different weather conditions directly influence fire behaviour and impact fire size, intensity and speed[26].

Wind

Wind provides a continuous supply of oxygen to a fire and may blow flames into fresh, unburnt fuel. It can be unpredictable and difficult to forecast, and a change in wind direction can result in a change to the size of the fire front.

High wind speeds supply more oxygen to a fire, increase how fast it spreads and can create spot fires ahead of the main fire front by carrying burning material[28].

Fuel arrangement - The way fuels are arranged can affect the behaviour of the fire. Credit Hines et al., 2010[27]

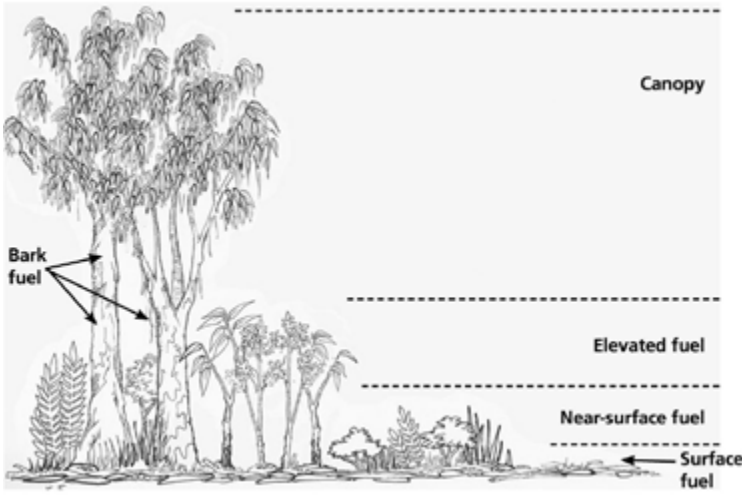
Temperature

High temperatures dry out vegetation, which makes it easier for them to ignite and burn. As a result, bushfires tend to occur in the summer months. Temperature varies over the course of the day and fires are usually at their most intense during the hottest part of the day.

Humidity

The amount of moisture in the air can affect how flammable vegetation is for a fire. Relative humidity (RH) is a measure of this moisture and is expressed as a percentage of the air's maximum water vapour holding capacity at that temperature[23].

Fire intensity usually increases during the day as the temperature rises and relative humidity falls, and reduces at night as relative humidity increases and temperature drops.



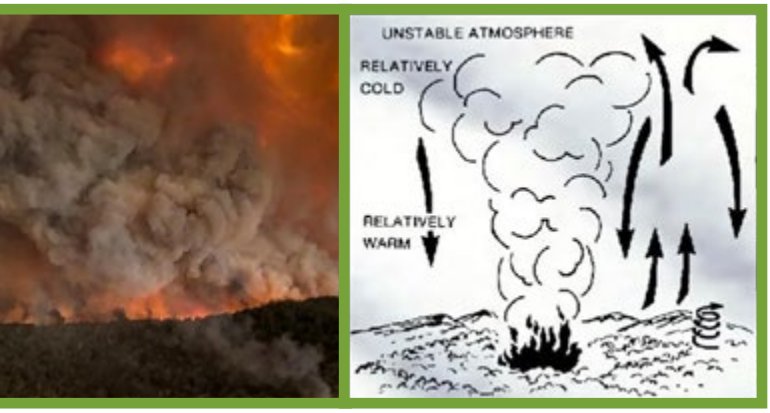
Fuel arrangement in the landscape. Credit Hines et al., 2010

[25]Hotspots Fire Project (2024). Available at: https://hotspotsfireproject.org.au/download/factsheet-understanding-how-fire-behaves.pdf [Accessed 7 Mar. 2024].
[26] Bureau of Meteorology. (2017). How weather affects fire. [online] Available at: http://www.bom.gov.au/weather-services/fire-weather-centre/how-weather-affects-fires/.
[27]Hines, F., Tolhurst, K.G., Wilson, A.A. and McCarthy, G.J. (2010). Fire and adaptive management: Overall fuel hazard assessment guide. [online] 8 Nicholson Street, East Melbourne: Victorian Government Department of Sustainability and Environment Melbourne. Available at: https://www.ffm.vic.gov.au/__data/assets/pdf_file/0005/21110/Report-82-overall-fuel-assess-guide-4th-ed.pdf.
[28]Geoscience Australia (2022). Bushfire. [online] Geoscience Australia. Available at: https://www.ga.gov.au/education/natural-hazards/bushfire.

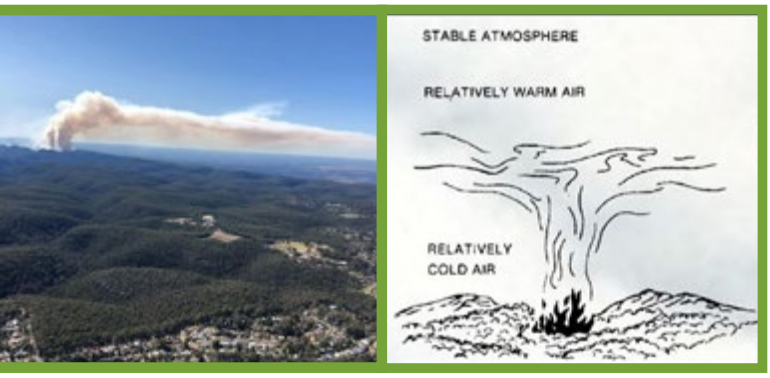
Atmospheric Stability

Atmospheric stability refers to the amount of vertical air movement, which affects local wind patterns[29] and therefore the intensity and spread of a fire.

In a stable atmosphere, cooler air near the surface prevents the upward movement of air, which results in steady winds and trapping smoke, decreasing the likelihood of intense fires. An unstable atmosphere has a lot of upward and downward movement of air, which often results in increased and erratic winds. Usually, when fires burn under unstable atmospheric conditions, they spread faster, are more intense and tend to have more erratic fire behaviour.



Above: An unstable atmosphere[29] and an example of a fire burning under these conditions.
Below: A stable atmosphere (ref 29 bushfire bulletin) and an example of a fire burning under these conditions.



Rainfall and Soil Dryness

Rainfall and soil moisture impact vegetation growth in the landscape, the amount of water available (for fire-fighting purposes), relative humidity, and fuel moisture, which in turn impact fire and fire behaviour.

Rainfall can:

- directly influence how much vegetation growth occurs in the landscape, therefore contributing to fuel loads[30]
- increase relative humidity, which adds moisture to fuels, making them less flammable[31]
- put out a fire if it's heavy enough[19]. Note: When a bushfire becomes large enough in size, and both the fine and coarse fuels are burning, they generate significant heat and energy to continue increasing in size. The coarse fuels, once burning are difficult to extinguish and can continue to burn even after rain impacts the fireground
- make it difficult for firefighters to access burnt areas, if heavy enough, and can cause erosion issues[19].

Days since last rainfall and underlying soil dryness significantly influence bushfire behaviour. Moisture in the soil transfers to fuels, such as grass and leaf litter, directly touching the surface. These fuels will absorb the moisture from the soil, making them less flammable.

Part of NSW Mid Coast during drought[32]

During drought, the soil dries out and provides no additional moisture for surface fuel to absorb[23]. Many drier than average seasons have resulted in catastrophic bushfires that have been very difficult to control and suppress, as seen in the 2019/2020 Black Summer Bushfires. Therefore, it is important to understand the long-term weather conditions when understanding bushfire risk in the landscape.

[29] "Weather & Bushfire Behaviour' 2006, Bush Fire Bulletin, vol. 28, no. 1, pp. 21–24.
[30] O'Kane, M. and Owens, D. (2023). Fire Season Outlook 2023-2024. [online] Rural Fire Service. Available at: https://www.rfs.nsw.gov.au/__data/assets/pdf_file/0004/257107/Fire-Season-Statement-2023-24-Final-004.pdf.
[31] McCaw, L., Mills, G., Sullivan, A., Hurley, R., Ellis, P., Matthews, S., Plucinski, M., Pippen, B. and Boura, J. (2009). Victorian 2009 Bushfire Research Response - Final Report. [online] Available at: https://www.bushfirecrc.com/sites/default/files/managed/resource/chapter-1-fbit.pdf.
[32] Driscoll, J. (2023). Majority of Mid Coast now officially drought declared. [online] Manning River Times. Available at: https://www.manningrivertimes.com.au/story/8419557/majority-of-mid-coast-now-officially-drought-declared/ [Accessed 19 Mar. 2024].

Drought Index and Drought Factor

There are two ways to assess seasonal dryness in Australia:

- Keetch–Byram Drought Index (KBDI) – a measure of soil moisture loss and volume of rainfall required to saturate the soil
- McArthur's Drought Factor (DF) – a measure of fuel dryness that reflects recent rainfall[23].

Both the KBDI and DF can be used to understand short-term and long-term moisture, or lack thereof, in fuel and soil.

Ignition sources

Ignition sources can be natural (lightning or long-distance spotting) or anthropogenic (prescribed burns, accidental or arson).

Generally, fires occurring over summer are caused by natural ignition sources whereas winter fires are due to anthropogenic ignition sources. Arson ignitions are more likely closer to populated areas[33].

Topography

Topography's influence on fire behaviour is more predictable than the other components in the fire behaviour triangle - fuel and weather. Slope, aspect, elevation and terrain (e.g. gullies) all influence how fast a fire spreads, the type of vegetation that grow there and other fire behaviour.

Slope

Slope is the amount or degree of incline of a hillside. Radiant heat generated by a fire will preheat unburnt fuel upslope, making the fuel easier to ignite. Additionally, on a hillside, a fire's flames are physically closer to the fuels on the uphill side, which will also accelerate fire speed upslope.

The steepness of the slope has a direct correlation to how fast a fire spreads[34]. As a general rule, for every 10° of slope, a fire will double its speed as it travels uphill. Alternatively, fire travels slower downhill as flames lean away from the fuel and there is less preheating of fuel downhill of the fire.

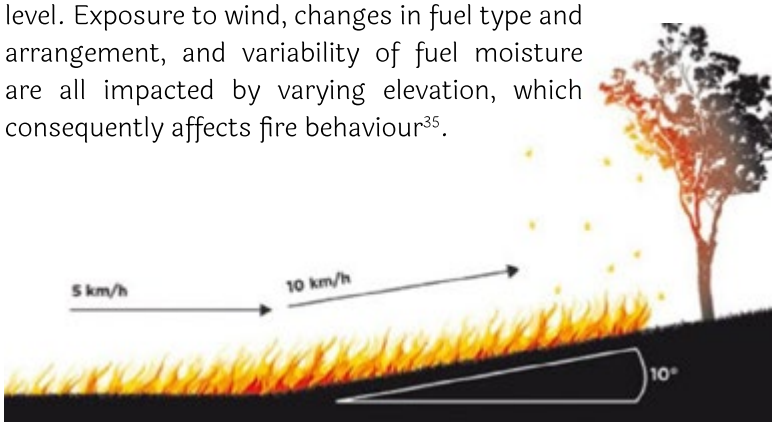
Slope - flames lean into slope so when travelling downhill a fire will travel slower as fuel isn't being pre-heated as quickly ahead of the fire.
Bushfire Front - Bushfire management in Western Australia. (2017). What Happens in a Prescribed Burn - Bushfire Front. [online] Available at: https://www.bushfirefront.org.au/prescribed-burning/what-happens-in-a-prescribed-burn/ [Accessed 27 Aug. 2024].

Aspect

Aspect is the direction a slope is facing. The aspect of a slope influences the amount of sunlight and heat the area receives. This influences the type of plants that grow there and the soil moisture content. In NSW, western and northern facing slopes are exposed to more direct heat from the sun[34]. Weather conditions tend to be warmer and drier meaning vegetation on these slopes is usually more flammable, and there's less of it compared to slopes with different aspects. Conversely, south-facing slopes tend to experience less direct sun, are cooler, hold more moisture and have a more significant amount of vegetation.

Elevation

Elevation is the height of terrain above mean sea level. Exposure to wind, changes in fuel type and arrangement, and variability of fuel moisture are all impacted by varying elevation, which consequently affects fire behaviour[35].



Fire travels faster uphill. The fire can double its speed for every 10 degrees of slope.
Country Fire Authority. (2023). How Fire Behaves. [online] Available at: https://www.cfa.vic.gov.au/plan-prepare/bushfire-basics/how-fire-behaves#:~:text=A%20fire%20will%20burn%20faster.

[33]Vacchiano, G., Foderi, C., Berretti, R., Marchi, E., & Motta, R. (2018). Modeling anthropogenic and natural fire ignitions in an inner-alpine valley. Natural Hazards and Earth System Sciences, 18(3), 935-948.
[34]Government of South Australia - Department for Environment and Water. (n.d.). The science behind fire behaviour. [online] Available at: https://www.environment.sa.gov.au/topics/fire-management/fire-science-and-planning/fire-behaviour#:~:text=bridge%20these%20gaps.-.
[35]Bennett, M., Fitzgerald, S., Parker, R. (Bob), Main, M., Perleberg, A., Schnepf, C.C. and Mahoney, R. (2010). Reducing Fire Risk on Your Forest Property. [online] Oregon State University: Pacific Northwest Extension Publishing. Available at: https://extension.oregonstate.edu/catalog/pub/pnw-618-reducing-fire-risk-your-forest-property.

Terrain/Land Features

The way wind interacts with landscape terrain and features can be quite complex. Land formations can block, direct and/ or influence the speed of wind and one of the best ways to understand these interactions is by looking at specific land features and weather patterns:

- Valleys and gullies can help funnel wind, often increasing its speed[36]
- Exposed hills experience higher wind speeds, compared to sheltered slopes
- Over the course of a day air temperature can impact wind and how it moves through a landscape. In general, cool wind will flow downslope at night, while the heating of air during the day will cause it to rise upslope[34].

The relationship between landscape features and terrain, and wind can make it difficult to predict fire behaviour which can threaten your safety during bush fires.

Parts and Components of Fire

Radiant and Convective Heat

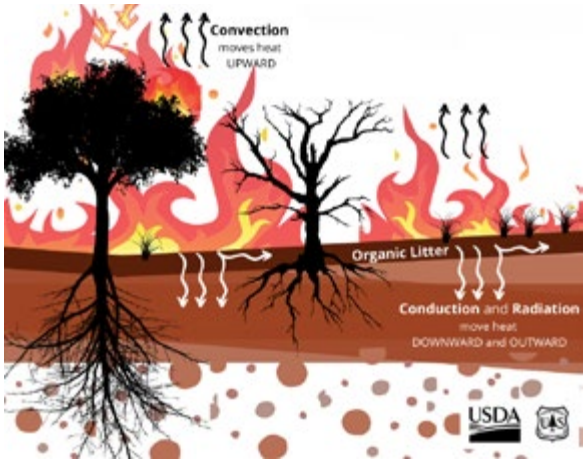
Bushfires generate significant amounts of heat, referred to as 'radiant' or 'convective' heat.

Radiant heat travels in straight lines, radiating out from a fire ahead of the flames and can be blocked by a solid object or barrier such as a concrete wall or building[37]. This type of heat can dry out and ignite fuels, crack or break windows and can be fatal in a bushfire[37].

Embers

Embers are burning or smoldering debris, such as twigs, bark, moss or leaves, which become airborne and transported in a cluster by the wind[37]. During a bushfire, this process can produce a significant number of embers known as an 'ember attack'. When these embers land, they can ignite combustible material around your house and enter the house via roof cavities or gaps, where they start internal house fires.

Another major consequence of embers and ember attacks is the ignition of spot fires. Spot fires occur when embers are carried by prevailing winds or hot, convected air and drop ahead of, or away from, the main fire, thereby spreading the fire further afield[34].



Types of heat a fire produces; convective, radiant and conductive. Parsons, A., Robichaud, P.R., Lewis, S.A., Napper, C. and Clark, J.T. (2010). Field Guide for Mapping Post-Fire Soil Burn Severity. [online] United States Department of Agriculture - Forest Service, pp.1–6. Available at: https://www.fs.usda.gov/rm/pubs/rmrs_gtr243.pdf.

Parts of fire and flame structure

The various parts of a fire will exhibit different characteristics and varying levels of intensity as shown in the figures below. It is important to understand the following:

- The greatest intensity and rate of spread will be at the head of the fire
- The flank of a fire can become a head fire when the wind changes direction
- The use of backing fire is the best way to keep the intensity of the fire as low as possible i.e., backing the fire into the wind or starting at the top of a slope and backing the fire down the slope[38].

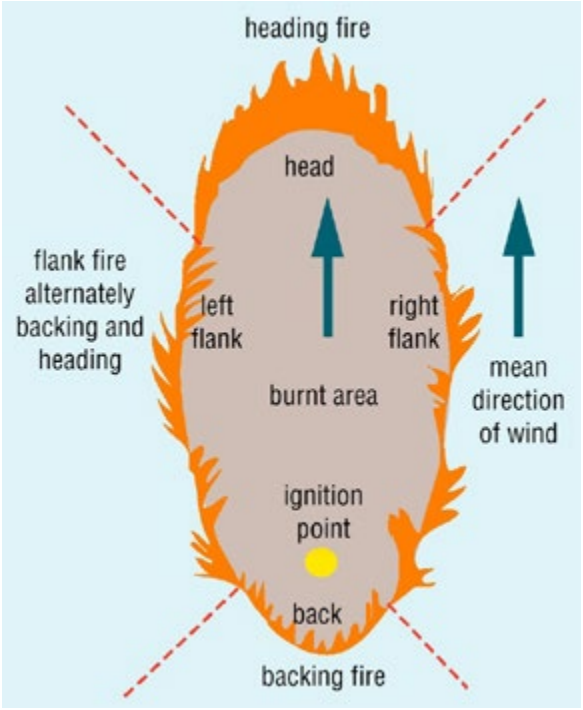
Remember, a backing fire isn't to be confused with the term 'backburn'. A 'backburn' is a fire fighting technique.

Forms of Fire

There are various ways a fire can burn through the landscape, including:

- Ground fire
- Crown fire
- Surface fire
- Firestorm
- Grass fire

[36] Sharples, J., McRae, R., Weber, R. and Wilkes, S. (2010). Wind-terrain interaction and bushfire propagation over rugged terrain. Fire Note, [online] (61). Available at: https://www.afac.com.au/docs/default-source/fire-and-hazard-notes/061.pdf?sfvrsn=12&download=false [Accessed 25 Nov. 2024].
[37] CSIRO - Bushfire best practice guide. (n.d.). How do bushfires spread? [online] Available at: https://research.csiro.au/bushfire/bushfire-basics/how-do-bushfires-spread/#:~:text=Radiant%20heat%20is%20the%20heat [Accessed 20 Mar. 2024].



Parts of a fire and it's flame structure[39].

Ground fires burn organic material in or beneath the soil layer[40]. They are often slow moving and can consume roots and tubers. These fires are common in Bogs and Fens, which are much more common in other countries, than in comparison with Australia because it is not one of our dominant vegetation communities. An example of a recent ground fire in NSW happened in 2020 near Port Macquarie, called the 'Lindfield Park Road Ground Fire' which burned 858 hectares over 210 days[41].

Grass fires are fires that burn through open, grassland areas that contain few or no trees. They can cover great distances in a short amount of due to the availability and flammability of the fuel, and wind speed.

Surface fires are our most common form of bush fire and burn litter, vegetation in the mid storey and suspended fuel. They do not reach or kill the canopy. These fires are slower than grass fires but access more energy due to larger amounts of fuel present and fuel size.

Crown fires are high-intensity fires that burn the canopy of the vegetation. These fires cause long-term disturbance to vegetation communities and have an increased risk of spot fires from embers.

Fire storms are caused by catastrophic crown fires that have surpassed the canopy and have the energy available to generate their own weather. Hot air and smoke rises, mixing with cooler air, causing the plume to broaden, cool and form clouds. Lightning produced by clouds ignites new fires, thus becoming self-seeding across the landscape. Large air pressure differences within the fire storm cause strong winds, increasing spotting and ember risk[42].

Types of Prescribed Burns

In addition to the definitions outlined at the start of the booklet, we can further define prescribed burns, being those that are set intentionally, by the intention of the burn itself. Whilst most burns will meet multiple objectives, the main objective will determine who, when, where and how a burn is conducted.

This becomes important as we discuss planning a burn on your property.

Hazard Reduction Burn - done with the objective of protecting human life and assets

Ecological Burn - done with the objective of supporting ecological processes such as germination, weed management or flowering, in line with known fire regimes

Cultural Burn - Refer to the "First Nations Fire Use in Australia (Cultural Burning)" section or Local Land Services "Aboriginal Land Management" booklet

Agricultural Burn - done with the intention of supporting agricultural outcomes.

For more information on prescribed burning, see later section of this booklet; Planning for fire on your property.

[38]Fire Management. (2020). [online] Wisconsin Department of Natural Resources. Available at: https://cf-store.widencdn.net/.
[39]Fire Ecology and Management in Northern Australia. (n.d.). Fire Fundamentals: Fire behaviour. [online] Available at: https://learnline.cdu.edu.au/units/env207/fundamentals/behaviour.html [Accessed 20 Mar. 2024].
[40]Watts, A. C., & Kobziar, L. N. (2013). Smoldering combustion and ground fires: ecological effects and multi-scale significance. Fire Ecology, 9, 124-132.
[41]Bush and peat fire burning for 210 days in NSW declared out in wake of weekend deluge. (2020). [online] Australian Broadcast Corporation. Available at: https://www.abc.net.au/news/2020-02-12/bush-and-peat-fire-burning-210-days-declared-out/11958192. [Accessed 20 Mar. 2024]
[42]How fires make thunderstorms. (n.d.). [online]. Australian Bureau of Meteorology. Available at: http://www.bom.gov.au/weather-services/fire-weather-centre/how-fires-make-thunderstorms/#:~:text=A%20plume%20of%20hot%2C%20turbulent,and%20cool%20as%20it%20rises. [Accessed 20 Mar. 2024]

An Introduction into Australia's Fire History

First Nations Fire Use in Australia (Cultural Burning)

By Shaun Hooper (Wiradyuri Bularidee)
Aboriginal Land and Sea Hub
University of New England

Aboriginal people around Australia have been using fire in the landscape to maintain our cultural responsibilities and obligations to the Dreaming Law eternally. During the Dreaming, the world was 'put in place' by our Ancestral Beings, who also gave us the Law to maintain and continue the Dreaming. Fire is an essential part of the Dreaming Law and an integral part of Australian ecosystems that have continued shaping the unique flora and fauna species and their habitats as the Dreaming is constantly renewed and revitalised.

Before the colonisation of New South Wales, landscapes were open, grassy forests and woodlands resulting from Aboriginal People maintaining their Cultural Practices like Cultural Burning[43]. However, the continuing aftermath of colonisation, its genocide and removal of Aboriginal people from the land led to the loss of this vital Cultural Practice that cares for Country. The colonisers used higher intensity fires to clear the land for agriculture and forestry, displacing Aboriginal Cultural Burning. As a result, the great Open Forest and Woodlands became cleared pastures for sheep and cattle, native grasses replaced by pasture grasses, and the forests were logged and left to overgrow. As a result, the vegetation structure and composition changed from what had been maintained by Aboriginal people through Cultural Burning eternally. The removal of Aboriginal Cultural Fire Regimes has led to a denser, shrubby understory, increasing fuel loads[15]. This is exacerbated by the decrease and extinction of various ground birds and animals that reduce fuel loads by turning over the soil leading to increased fuel loads that were part of these species' reciprocal obligations[44] were to reduce through turning over the soil and in the process burying the flammable leaf litter.

More recently, Aboriginal People have been gaining greater access to Country through Land Rights and Native Title, we/they have continued to put fire into the landscape as part of the revitalisation of Aboriginal Cultural practice, discussed today as 'Aboriginal Cultural burning'. Aboriginal Cultural Burning is generally described as 'cool' or low-intensity burning. But that's not the whole story. We need to understand the role fire plays in how Aboriginal people maintain their connection and responsibilities to the Country to fully appreciate how Cultural Burning can be beneficial.

Cultural Burn at Rothbury, in the Hunter Valley.
Photo credit Taree Indigenous Development and Employment (TIDE)

MC2T operates within the homelands of the Worimi and the Birpai Aboriginal People, who have cared for and maintained their Country eternally. One of the ways Worimi and Birpai People have been caring for Country is the use of Aboriginal Cultural Burning. Aboriginal Cultural Burning is part of the broader way Worimi and the Birpai Aboriginal People maintain their connection and

[43]GGammage, B., 2013. The biggest estate on earth., Mariani, M., Connor, S.E., Theuerkauf, M., Herbert, A., Kuneš, P., Bowman, D., Fletcher, M.S., Head, L., Kershaw, A.P., Haberle, S.G. and Stevenson, J., 2021. Disruption of cultural burning promotes shrub encroachment and unprecedented wildfires. Frontiers in Ecology and the Environment. And Hooper, S. 2020 Aboriginal Burning in South Eastern Australia: Lessons from Brush Turkey. Master of Philosophy, University of New England.
[44]Hooper, S. 2020 Aboriginal Burning in South Eastern Australia: Lessons from Brush Turkey. Master of Philosophy, University of New England, Hooper, S. 2019 Aboriginal Cultural Burning: Brush Turkey and the Little Furry Fellas: A yarn About Fuel Management. 6th International Fire Behaviour and Fuels Conference, Sydney

reciprocal responsibilities to Country through the constant revitalisation of their Aboriginal Cultural Practice[45].

Some Definitions

Before we move on, we need to understand a few key terms used when talking about Aboriginal Cultural Burning. One crucial element to understand is Country. Country to an Aboriginal person is more than the place you call home; it represents a concept of 'oneness' with the land, you are part of Country, and Country is part of You; this you could think about like a Mother type relationship. It would help your understanding if you considered Country a living entity, having all the same attributes as any living thing. For example, Country can feel, Country can be sad, Country can be happy, and Country can talk with you. Country is vital to understand as more than just land, more than just a resource, but as a living entity that can create and maintain relationships with everything else in the cosmos, including you.

The term 'Aboriginal Cultural Practice' recognises that Aboriginal Knowledge Systems should be thought of as a process[46] more than a body of knowledge or data. The vital underlying processes bring or emerge knowledge out of Country and allow Aboriginal people to continue maintaining the Dreaming Law, such as Cultural Burning. These processes are part of Aboriginal Cultural Practice. These knowledge creation processes are essential to protect as knowledge is not considered universal as with Western Knowledge, but relational, situational, and contextual, relevant only to the situation. It is the process of renewing, reactivating, and revitalising the Dreaming Law and hence Country through, in this case, processes like Cultural Burning that continually protect Aboriginal Knowledge processes.

The 'Dreaming' provides the context for how Aboriginal people are to maintain their connections to Country and the reciprocal obligations that exist for the ongoing maintenance of the balance of life in the cosmos. The Dreaming is not static but created through the Ancestors' actions and constantly reactivated and revitalised through Aboriginal Cultural practices such as Aboriginal Cultural Burning. Country is the manifestation of the relationships between everything in the Cosmos and needs to be maintained and nurtured through Aboriginal Cultural Practices to sustain life, such as Aboriginal Cultural Burning, which we understand through the Dreaming Law.

Cultural burn. Credit Mal Ridges, NSW Office of Environment, Energy and Science.

How does Cultural Burning work to maintain life?

Aboriginal Cultural Burning is part of Cultural Practices that maintain and renew the Ancestors' Dreaming Law. Aboriginal People practice Cultural Burning by 'talking' with Country. As we discussed earlier, Country is like a person to Aboriginal People, like our Mother. Sometimes this is referred to as 'Reading Country', but it is more than reading. It is being in a relationship with Country, a two-way conversation about the status of relationships and what is needed to fulfil the mutual and reciprocal obligations between species, Ancestors, Sacred sites and other Beings and things that live in Country. Aboriginal Burning was a geographically diverse cultural practice, men and women burnt in the right times and across different parts of Country[47].

[45]The Royal Commission into National Natural Disaster Arrangements 'Background Paper: Cultural burning practices in Australia' https://naturaldisaster.royalcommission.gov.au/system/files/2020-06/Cultural%20burning%20practices%20in%20Australia%20-%20Background%20Paper.pdf

[46]Goodall, H. (2008). "Riding the tide: Indigenous knowledge, history and water in a changing Australia." Environment and History 14(3): 355-384. and Hooper, S. 2020 Aboriginal Burning in South Eastern Australia: Lessons from Brush Turkey. Master of Philosophy, University of New England

[47]Hallam, S.J., 2014. Fire and hearth: a study of Aboriginal usage and European usurpation in south-western Australia. Apollo Books.

Unlike Western fire management, everything plays a role in undertaking Cultural Burning. Some of these beings have specific obligations set out in Aboriginal Dreaming Law. Aboriginal Law tells us that we are burning to maintain the relationships between things, and all things are important and equal in Country. Brush Turkeys' story can help us understand how this works. Brush Turkey and her relationship with fire is a familiar association across Aboriginal Communities in NSW and Australia. The story varies, but a common NSW story goes that Brush Turkey was very jealous of the beauty of all other birds in the bush, and her jealousy drove her to try and kill them by setting fire to the bush. This great fire produced the vegetation associations that in modified forms exist today. Being part of the Dreaming Law, Aboriginal People must maintain this story or Dreaming Law through Aboriginal Culture practice, here, the Aboriginal Cultural Practice of Aboriginal Cultural Burning[48].

In this story of the Dreaming Law, Brush Turkeys' indiscriminate use of 'wrong fire' explains the origin of the landscape and the consequences for Brush Turkey's actions today. As a result of Brush Turkey's indiscretion, the Ancestors placed her in charge of hazard reduction, destined to turn over leaf litter and reduce fuel loads by creating soil. It tells us that our Ancestor Brush Turkey instigated part of the world, and Aboriginal people must maintain it[49] through the Aboriginal Cultural Burning, that is 'right fire'. This obligation of Aboriginal to burn Country is part of the ongoing renewal of the eternal Dreaming, which makes the Dreaming the 'everywhen'[20], by the obligation of Aboriginal People to maintain and renew the Dreaming Law. Coming from the past, in the origin stories of Dreaming Law created by the Ancestors, through the present in Aboriginal Peoples' ongoing renewal and revitalisation of Cultural practices and on into the future by maintaining relationships that provide life to continue in the beauty and variance that exists.

Cultural burn demonstration at Wuppinguy TSR Upper Hunter in Box Gum Woodland. Credit Catherine Conroy and Hunter Local Land Services

As an example of one species' reciprocal obligations, we will let Bandicoot explain the shared responsibility in fire. Fire is a shared process in Country; Aboriginal people and Bandicoot work together with other species in Country to maintain the Dreaming Law. Cultural Burning maintains Bandicoot's habitat. As part of this reciprocal relationship, Bandicoot turns over the soil, reducing fuel loads and changing the vegetation structure, benefiting everything else by reducing fire intensity[50]. In the web of relationships between everything in Country, there is a multiplying effect with everything contributing; Brush Turkey, Porcupine, Lyrebird, Bettong, Kangaroo, Wombat all contributing and being supported. Things become sick, threatened, or extinct when this reciprocal relationship is ignored or unable to be fulfilled.

What is the difference between Aboriginal and Western approaches?

As suggested in the previous discussion, there are striking differences between Aboriginal and Western approaches to fire. The most significant difference is the conceptualisation of fire in the west as 'catastrophic', an agent of destruction.

The view of fire as catastrophic is the opposite of how Aboriginal Culture sees fire as an agent of cleansing and renewal; larger fires are seen as having a role in resetting the status quo.

[48]Hooper, S. 2020 Aboriginal Burning in South Eastern Australia: Lessons from Brush Turkey. Master of Philosophy, University of New England
[49]Stanner, W.E.H., 2014. On Aboriginal Religion. Sydney University Press.
[50]Hooper, S. 2020 Aboriginal Burning in South Eastern Australia: Lessons from Brush Turkey. Master of Philosophy, University of New England, Hooper, S. 2019 Aboriginal Cultural Burning: Brush Turkey and the Little Furry Fellas: A yarn About Fuel Management. 6th International Fire Behaviour and Fuels Conference, Sydney and Foster, C.N., Banks, S.C., Cary, G.J., Johnson, C.N., Lindenmayer, D.B. and Valentine, L.E., 2020. Animals as agents in fire regimes. Trends in Ecology & Evolution, 35(4), pp.346-356.

The Western vision of fire as destructive has led to an approach that prioritises suppression of fire in the landscape with quick response tools such as firefighters, fire trucks and aircraft, and that more strategic tool, hazard reduction. Hazard reduction is applied to a small percentage of the landscape, generally related to asset protection, to reduce the progression and intensity of fire by removing fuel, allowing firefighters to contain the fire. The effectiveness of hazard reduction reduces over time, as the fuel accumulates and its ability to stop or slow a fire reduces. Hazard reduction is implemented within a 'prescription', a window of opportunity dictated by variables such as weather, fuel moisture or time of year. All of which achieve certain fire behaviour outcomes, generally resulting in the reduction of on ground and standing fuel to some designated percentage, hence reducing fire intensity and forward rate of spread of future wildfires.

People sometimes struggle with the fundamentals of how Aboriginal Cultural Fire Practitioners implement a Cultural Burn; it does not look like a hazard reduction because it is not. A prescription does not guide an Aboriginal Cultural Burn; it is guided by the close relationship and conversation the Aboriginal Cultural Fire Practitioner is having with Country and everything in it. Aboriginal approaches to fire are based on a cultural understanding of the need for fire and its role in the landscape.

Aboriginal Peoples' close connection to Country ensures that the regular spirals of seasons and everything talking in Country are part of the 'discussion' in deciding when and where to burn. Aboriginal Cultural Burning is often referred to as 'cool' burns, which refers to the low intensity, low flame height burns that move slowly through the bush. When you see an area that has been burnt, you can tell a lot about the people that burnt it. You should not see fire scars running up trees; you should only see the very bases of the tree trunks a bit burnt; you should not just see gray ash on the ground; you should see the logs not burnt to ash; you should see only grass shooting; you should see shrubs dead, and you should never see the canopy burnt. These are some of the things that you should and should not see after a Cultural Burn, but sometimes the fire might need to be a 'clean up' or 'reset' fire which might be a bit bigger. These may be more common than the old days, as there is a lot of sick Country that needs looking after and 'Cleaning up'.

Cultural burn. Credit Mal Ridges, NSW Office of Environment, Energy and Science

Science is discovering that Cultural Burning is different too. A 2019 scientific study[51] compared the fire severity of Cultural and Prescribed Burning, finding that Cultural Burning has a lower fire severity. Cultural Burning temperatures did not get hot enough to trigger germination of shrubby species, unlike Prescribed Burning. Shrub mortality was more significant in Cultural Burning, showing that Cultural Burning had an unexpected influence on vegetation with a significant reduction of species diversity, particularly within the shrub layer, which prescribed burns tend to increase.

This mechanism led to the open grassy forests and woodlands that resulted from generations of Aboriginal People practising their Aboriginal Cultural Practices[52].

Prescribed burning and the tendency to restrict

[51]Selvey, M. 2019. The effects of contemporary and cultural prescribed burning on post-fire above ground and below ground shrub dynamics. Honours Thesis, University of Wollongong.

[52]Gammage, B., 2013. The biggest estate on earth., Mariani, M., Connor, S.E., Theuerkauf, M., Herbert, A., Kuneš, P., Bowman, D., Fletcher, M.S., Head, L., Kershaw, A.P., Haberle, S.G. and Stevenson, J., 2021. Disruption of cultural burning promotes shrub encroachment and unprecedented wildfires. Frontiers in continued 24 Ecology and the Environment. And Hooper, S. 2020 Aboriginal Burning in South Eastern Australia: Lessons from Brush Turkey. Master of Philosophy, University of New England.

fire in the landscape has produced higher intensity fires reducing grassy understory and replacing it with denser shrub understory increasing fuel loads[24].

Cultural Burn at Rothbury, in the Hunter Valley. Credit Taree Indigenous Development and Employment (TIDE).

Another vital consideration is that Cultural Burning potentially contradicts ecological approaches to fire, such as the Fire Interval Threshold approach used in NSW fire management to determine maximum and minimum fire return. Cultural Burning fire regimes are also potentially thought of as a threatening process, with "High-frequency fire resulting in the destruction of life-cycle processes in plants and animals and loss of vegetation structure and composition"[53] is listed as a threatening process under the Biodiversity Conservation Act 2016. Cultural Burning reduces understory species composition and diversity in vegetation communities over time, to increase the diversity of fauna species and their habitat, considered a threatening process and contradictory to ecological approaches of Fire Interval Threshold and Vital Attributes Theory[54]. This is at the root of the threatened and extinct status of fauna species in Australia through the prioritisation of all biodiversity over the habitat of specific species. This would indicate a conflict between the outcomes of Western approaches in New South Wales and the Aboriginal cultural approaches that emerge out of the application of the Aboriginal Cultural Practice of Aboriginal Cultural Burning.

Protection of Aboriginal Cultural Burning

Aboriginal People, in revitalising their Traditional Cultural practice of Burning, have been acutely aware of the fact that their cultural practices have been ignored and even devalued. Now when Aboriginal People choose to revitalise this practice in the face of growing impacts from the years of mismanagement of fire in the Australian landscape, that they wish to protect the cultural integrity of and their ability to practice this way of fire. Some fire professionals want to identify Aboriginal Cultural Burning as a form of Prescribed Burning, this is incorrect as it is based on the maintenance of relationships within the cosmos, not reduction of the environment down to 'variables' which have no reference back to the status of specific relationships. It is necessary to eliminate the risk of Cultural Burning being reduced to a series of prescriptions that can be falsely utilised in Western fire management.

Fire prescription considers specific environmental conditions of the site on which the burning will be undertaken, But, other cultural understandings are embedded in the way Aboriginal people exist in and relate to the world. These understandings cannot be reduced to a prescription but need to be practiced in a whole-of-Culture way. Aboriginal Cultural Burning as an essential Cultural practice can and needs to be protected through the continued implementation by Aboriginal People.

The Local Aboriginal Community generally undertakes Aboriginal Cultural Burning; the area's local people have a specific connection to the Country and the required understanding of the reciprocal responsibilities that need to be maintained. As a Cultural Practice, Aboriginal Cultural Burning cannot be reduced to a set of guidelines or prescriptions as they are Aboriginal people practicing their Culture and driven by the implicit understandings within the local Aboriginal Community's relationship with Country. The values that we see in Aboriginal Cultural Burning are emergent qualities that come out of the continued maintenance of this Cultural Practice by the local Aboriginal Community.

[53]Biodiversity Conservation Act 2019
[54]Noble, I.R. and Slatyer, R.O., 1980. The use of vital attributes to predict successional changes in plant communities subject to recurrent disturbances. Vegetation, 43(1), pp.5-21.

What are the benefits of using Cultural Burning to care for my land?

As an alternative to current Western approaches to fire management, Aboriginal Cultural Burning offers a process that can restore the bush to a functioning ecosystem that provides for the maintenance of Aboriginal People's reciprocal relationships with all the other species, Spirits and Beings in the landscape. This means nothing less than the continuance of Aboriginal Culture. Aboriginal Cultural Burning has an emergent outcome of producing habitat species that work with Aboriginal People in maintaining Country, and other emergent benefits such as fuel reduction, supporting Aboriginal people maintain their Cultural Practice through business development and economic opportunities and reinstating a land management system that has been inherent in the Australian landscape since the Beginning eternally.

For further advice engage with your local Traditional Owners, found through Local Aboriginal Land Councils, Local Land Services or Taree Indigenous Development and Employment (TIDE) to connect with local First Nations Fire Practitioners.

Post Colonisation Fire History

Since the arrival of Europeans, the Australian landscape has undergone drastic changes. European settlement brought widespread land clearing, the introduction of non-native species, and disruptions to natural fire patterns and Indigenous land management practices. Over the past 200 years, fire has often been perceived as a threat, leading to a suppression-focused approach to bushfire management. This shift has resulted in some vegetation communities experiencing fire too frequently or not frequently enough, affecting ecosystem resilience and increasing bushfire risk.

Early European colonisers documented the rapid impacts of these changes on the landscape. Whilst often difficult to read in the light of modern culture, their journals do provide valuable insights into the first observations of the environmental impacts of colonization in Australia. For instance, Thomas Mitchell in 1848 noted;

"Fire, grass, kangaroos, and human inhabitants, seem all dependent on each other for existence in Australia; for any one of these being wanting, the others could no longer continue."

"The omission of the annual periodical burning by natives, of the grass and young saplings, has already produced in the open forest lands nearest to Sydney, thick forests of young trees, where, formerly, a man might gallop without impediment, and see whole miles before him. Kangaroos are no longer to be seen there; the grass is choked by underwood; neither are there natives to burn the grass, nor is fire longer desirable there amongst the fences of the settler."

Thomas Mitchell, 1848[55]

In recent decades, the consequences of a suppression-focused fire management approach have become better understood by western land managers. Today, fire management is recognized as crucial for protecting and working with the landscape, especially under the pressures of climate change. Appropriate fire regimes now play a significant role in present-day fire management and bushfire preparedness, but it is vital we engage all land managers in this process for landscape-scale benefits.

Recent Fire History of the Mid Coast

The recent fire history of the Mid Coast region can be seen in Appendix 2, which demonstrates the degree and regularity of burning across our region over the last two decades. This mapping includes both bushfires, and prescribed burns done to protect life and assets.

In the Mid Coast, most native vegetation formations except rainforests, freshwater wetlands and estuarine/saline wetlands require fire to some degree to regenerate and remain healthy. For more information on the fire requirements of these vegetation formations found on the Mid Coast, see "Vegetation Formations and their Fire Regimes."

Smiths Lake after bushfire - Photo credit Jöel Dunn

[55]Mitchell. T.L. (1848) Of the Aborigines. Journal of an Expedition into the Interior of Tropical Australia. 1876154276.

Climate Change and Fire

Climate drives natural variation in fire regimes through weather, fuel amount and condition and ignition patterns[56]. Fire regimes will be altered by climate change[57] and in ways that worsen the threat of bushfires and the intensity of bushfire events[58]. The exact effects of climate change on fire regimes are not known and are difficult to forecast. Some examples of predictions include:

- increased lightning strikes
- changes to rainfall patterns and potential increase in drought length/ dryness
- altered composition and amount of fuel loads
- altered species distributions because of temperature increase.

Specifically for the region, an increase in the number of higher temperature days is predicted[59].

Appropriate fire regimes can help increase ecosystem resilience which will be helpful to reduce the effects of climate change on native vegetation. In comparison, inappropriate fire regimes may create fragmentation within areas of native vegetation and this will reduce the resilience that the landscape has against climate change. The relationships between fire regimes, climate change and biodiversity are complex and will vary between areas and vegetation formations.

Overall, the potential impacts climate change will have on fire regimes presents landholders with great challenges. It is important to recognise and understand this to manage your property in an appropriate way.

For more information on climate change in the Mid Coast region, see the Climate Change Snapshots in Appendix 1.

Natural ignitions like lightning strikes are predicted to increase with climate change.
Bushfire Front. (n.d.). Bushfire Basics. [online] Available at: https://www.bushfirefront.org.au/about-fire/bushfire-basics/.

[56]NSW Environment and Heritage. (2021). Fire regimes and climate change. [online] Available at: https://www.environment.nsw.gov.au/topics/fire/research/fire-regimes [Accessed 5 May 2022].
[57]Primer on Fire Ecology. (n.d.). [online] Nature Conservation Council of NSW. Available at: https://assets.nationbuilder.com/natureorg/legacy_url/2809/fire-ecology-primer-v2-oct2015.pdf?1630462737 [Accessed 1 May 2022].
[58]AFAC (2015). Overview of prescribed burning in Australasia. Report for the National Burning Project – Subproject 1. Australasian Fire and Emergency Service Authorities Council Limited. March 2015.
[59]North Coast Climate change snapshot. (2014). [online] Office of Environment and Heritage. Available at: https://www.climatechange.environment.nsw.gov.au/sites/default/files/2021-06/North%20Coast%20climate%20change%20snapshot.pdf?la=en&hash=2F4230DDA994155970B93869764CE637CC5BAE12#:~:text=The%20North%20Coast%20Region%20is [Accessed 5 May 2022].

2. Fire Ecology

Vegetation Responses to Fire

Plant species in Australia have evolved to have different adaptive responses to fire. Vegetation, and therefore our landscape, experience both immediate and long-term changes because of fire. Any changes to fire frequency and intensity in an area can dramatically impact the plants that live there and what will continue to survive after a fire.

Fire-related characteristics classify how plants respond to fire. These characteristics include:

- For individual responses
  - regeneration mode
    - resprouters
    - obligate seeders
  - seed storage and dispersal
  - fire or smoke dependent recruitment[33]
- For community response to multiple fires
  - reaching maturity and other life history stages[33]
  - ecological succession
  - weeds.

Overall, how a plant responds to fire is dependent on the individual species and the fire regime it is adapted to, as well as environmental factors like climate change and other types of disturbance

Regeneration Mode

The regeneration mode of plant species refers to the response of an individual plant after a fire[60].

Resprouters

A resprouter is a type of plant that regrows from shoots after a fire[33]. There are three types of resprouting above ground resprouting split into aerial and basal, and below-ground resprouting[61]. Above ground resprouting forms from epicormic buds located under the bark of a tree, or near the base of the plant in the form of lignotubers and basal stems, or near the roots of the plant by sprouting from horizontal rhizomes and root suckers[33]. Generally, resprouters can be relatively tolerant of frequent fire as long as they have time to recover afterwards. They can also survive without fire because most resprouting species utilise seed dispersal to survive as well, although this isn't the case for all resprouting species.

Epicormic growth (type or resprouting) after bushfire. Photo credit Isabelle Strachan.

An example of a resprouter is *Eucalyptus acmenoides* (White Mahogany), which produces epicormic shoots along it's trunk postfire.

Obligate seeder regenerating after bushfire. Photo credit Daintry Gerrand

Obligate Seeders

An obligate seeder is a type of plant that is sensitive to fire and relies on seeds found on the plant or in the soil to germinate after a fire[33]. They do not resprout after fire, which may result in loss of mature seeding plants in the ecosystem. Obligate seeders, compared to resprouters tend to produce large quantities of seed to help their population recover. However, frequent fires can deplete a species seedbank and not allow individual plants time to reach reproductive maturity from seed, leading to decline or local species extinction[62].

An example of an obligate seeder is *Eucalyptus oreades* (Blue Mountain Ash).

Seed Storage and Dispersal

After fire, an ecosystem experiences reduced competition for water and nutrients, and

[60]Community Bushfire Connection. (n.d.). Effects of fire on plants. [online] Available at: https://www.communitybushfireconnection.com.au/ecology/effects-of-fire-on-plants/.
[61]Thomsen, A.M. and Ooi, M.K.J. (2022). Shifting season of fire and its interaction with fire severity: Impacts on reproductive effort in resprouting plants. Ecology and Evolution, 12(3). doi: https://doi.org/10.1002/ece3.8717.
[62]Knox, K.J.E. and Clarke, P.J. (2004). Post-fire response of shrubs in the tablelands of eastern Australia: do existing models explain habitat differences? Australian Journal of Botany, 50(1), pp.348–353. doi: https://doi.org/10.1071/bt01055.

Some orchid species can be classed as fire stimulated or fire dependent, and *Diuris flavescens*, commonly known as the Pale Yellow Doubletail Orchid is a fire stimulated species found in the Mid Coast region.

increased levels of light getting to the ground. These conditions are ideal for plants to flower or germinate and establish if there are seeds available in the soil.

There are a few ways plants can recover using seed after a fire, including:

- germinating from soil or canopy seed banks
- seeds coming in from outside the burnt area by wind, water, animals or insects like ants
- species creating seeds quickly through fire-cued flowering.

Seed banks have been developed as an adaptive strategy for plants growing in areas with high disturbance and stress[63]. Soil seed banks can be described as seeds that are stored in the soil for a minimum of one year, sometimes decades. Alternatively, canopy seed banks involve storing seed on the plant in 'cones' within the canopy, for an extended period of time[41]. The strategy of on-plant seed storage and delayed release of mature seed triggered by disturbance is called serotiny[64]. There is variation amongst serotinous species which relates to how long seeds are stored in the canopy and when they are released[65]. For weakly serotinous species, some seeds will be released and some will be stored each year, and for strongly serotinous species seeds are stored and only released when the plant experiences disturbance, in this case fire[42].

Hakea sericea, commonly known as Needlebush, is a serotinous species found in heath and dry schlerophyll forest. Credit: John Tann

Fire or Smoke Dependent Recruitment

Fire can impact seeds and their germination in positive and negative ways. Seeds in the soil seed bank can be killed or damaged by high intensity fires[66]. Alternatively, for plants adapted to fire-prone environments, cues like smoke or heat are often required to end seed dormancy and trigger germination[67]. There are two types of seed dormancy; physical and physiological[68].

For physically dormant seed species, their hard seed coating requires a high level of heat to be cracked or melted which then creates an opportunity for germination[44]. For physiologically dormant seed species, the chemical compounds in smoke are a trigger for germination or help increase germination and germination success[44].

Fire and Ecological Succession

Vegetation communities are in a constant state of change due to varying disturbances

[63]Su, W., Yu, J., Zhang, G., Shi, Z., Wang, L., Zhao, G. and Zhou, R. (2019). Comparison of the canopy and soil seed banks of Pinus yunnanensis in central Yunnan, China. Forest Ecology and Management, 437, pp.41–48. doi: https://doi.org/10.1016/j.foreco.2019.01.002.
[64]Bond, W.J. (1985). Canopy-stored seed reserves (serotiny) in Cape Proteaceae. South African Journal of Botany, 51(3), pp.181–186. doi: https://doi.org/10.1016/s0254-6299(16)31669-6.
[65]Martìn-Sanz, R.C., Callejas-Dìaz, M., Tonnabel, J. and Climent, J.M. (2017). Maintenance costs of serotiny in a variably serotinous pine: The role of water supply. PLoS ONE, [online] 12(7), p.e0181648. doi: https://doi.org/10.1371/journal.pone.0181648.
[66]Zirondi, H.L., Silveira, F.A.O. and Fidelis, A. (2019). Fire effects on seed germination: Heat shock and smoke on permeable vs impermeable seed coats. Flora, [online] 253, pp.98–106. doi: https://doi.org/10.1016/j.flora.2019.03.007.
[67]Penman, T.D., Binns, D., Allen, R., Shiels, R. and Plummer, S. (2008). Germination responses of a dry sclerophyll forest soil-stored seedbank to fire related cues. Cunninghamia, 10, p.547.
[68]Mahboube Zahed and Bczek-Kwinta, R. (2023). The Impact of Post-Fire Smoke on Plant Communities: A Global Approach. Plants, 12(22), pp.3835–3835. doi: https://doi.org/10.3390/plants12223835.

and environmental factors[69] and are therefore never 'stable'. Fire is one of the possible natural disturbances. Different vegetation communities have varying responses to disturbance, but the process is often predictable and sequential in any given plant community (stages of ecological succession)[70].

Each stage of the succession of an ecosystem in response to disturbance is defined by different species, habitats and resources, and as such, a landscape is at its most diverse when different patches are experiencing different stages of succession at the same time. For example, where annual grasses are the first to germinate in an area following disturbance they may be later shaded out by a recovered canopy. In this ecosystem, annual grasses and the habitat they provide, would cease to be part of the diversity of the landscape without regular disturbance providing opportunity for them to germinate and reseed. Further, regular disturbance ensures that patches are continuously regenerating, ensuring age diversity of the species within a landscape and increasing the resilience of the ecosystems to extreme events.

Regardless of whether a vegetation community needs periodic disturbance or not, the factors that impact and guide a vegetation communities' response and recovery are:

- what viable seeds are available in the soil and canopy seed banks or dispersed from an area nearby
- changes to competition for resources and space. Following a disturbance, there's a burst in seedling recruitment and regrowth in response to increased light, space and other resources. After this initial flush of plant establishment and regrowth, seedling recruitment slows down as competition for space, light, water and other resources increases
- life history timing including primary and secondary juvenile periods
- prior occupancy of the plants in the area before the disturbance occurred
- a plant's ability to establish without further disturbance[71].

Understanding the relationship between plant survival and dispersal strategies, life history stages and the potential need for disturbance can help predict the successional changes that may occur within vegetation communities and plant species. This is important for fire management because for species where fire naturally occurs, active fire management is critical to keeping that ecosystem in balance. The exclusion of fire from these ecosystems will lead to the loss of some species, and potential transition in vegetation community type over time.

Reaching Maturity and Other Life History Stages

For plants, the time it takes to reach crucial life history stages is important because without reaching these, plants can't regenerate and survive multiple disturbances, such as reoccurring fire. There are two crucial life history stages for plants:

- primary juvenile period – time between germination from seed until the plant is reproductively-mature adult
- secondary juvenile period – time taken for plant to produce viable seed[72].

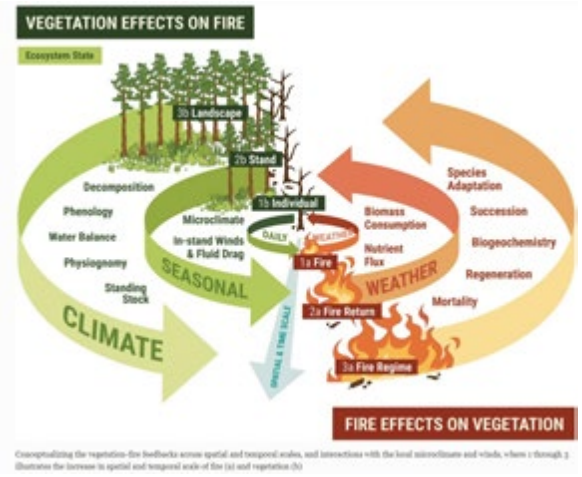
The length of the juvenile periods varies between species and can vary between the same species, pending the location[50]. In terms of the timing of a fire, if a species hasn't reached the primary juvenile period when a fire occurs then that population in that area may go extinct. Alternatively, if a species has reached the primary juvenile period and not the secondary juvenile period then the population may survive but can't recruit new individuals. This may impact the longevity of the population over time[50]. The life history timing of plants is used as a guide (in the form of fire intervals) to help land managers understand how they need to manage their natural assets to protect biodiversity. This

[69]Johnson, Edward.A. and Miyanishi, K. (2007b). Disturbance and Succession. In: E.A. Johnson and K. Miyanishi, eds., Plant disturbance ecology: the process and the response. Amsterdam; Boston: Elsevier/Ap.
[70]Community Bushfire Connection. (n.d.). Disturbance ecology. [online] Available at: https://www.communitybushfireconnection.com.au/ecology/disturbance-ecology/.
[71]Noble, I.R. and Slatyer, R.O. (1980). The use of vital attributes to predict successional changes in plant communities subject to recurrent disturbances. Vegetation, 43(1-2), pp.5–21. doi: https://doi.org/10.1007/bf00121013.
[72]Morrison DA, Buckney RT, Bewick BJ & Cary GJ (1996) Conservation conflicts over burning bush in south-eastern Australia. Biological Conservation 76: 167-175

is particularly important when managing and protecting threatened species and ecological communities.

Fire Regimes

The interaction between fire and vegetation works in a feedback cycle. Fire is an important natural process that drives vegetation structure and type including plant community and species, and how it functions within the landscape i.e. habitat, food sources etc. While fire behaviour is influenced by vegetation relating to the moisture levels, distribution and amount of fuel[73]. The interaction between fire and vegetation are complex because of other influences like climate and weather.



The relationship between fire and vegetation, and how they impact each other can be can be broken down into different levels of scale and amounts of time. Loudermilk, E.L., O'Brien, J.J., Goodrick, S.L., Linn, R.R., Skowronski, N.S. and Hiers, J.K. (2022). Vegetation's influence on fire behavior goes beyond just being fuel. Fire Ecology, [online] 18(1). doi:https://doi.org/10.1186/s42408-022-00132-9.

The way fire impacts a landscape on a long-term basis can be referred to in Western Land Management as a fire regime[68]. Fire regimes are made up of four main characteristics:

- frequency – how often an area experiences fire
- intensity – how hot a fire is
- season – what time of year a fire occurs
- extent – the total area that experiences fire[74].

The relationships between each characteristic listed above and how they vary between each fire event is complicated. The variation between these characteristics then affects how the landscape responds to fire[75]. For example, a fire that occurs in Summer (season), in an area with lots of dry fuel (high intensity), that hasn't burnt in over 20 years (frequency) will be a severe fire and take the landscape years to recover.

Frequency

Out of the characteristics that make up fire regimes, fire frequency is usually the most important factor determining how the landscape responds to fire events. Good fire management is therefore based predominantly on fire frequency and aims to maintain all naturally occurring species within a local community based on their fire response and life history stages[11].

To sustain all, or as many species (plants and animals), as possible, fire interval guidelines were developed to help guide management. Fire intervals are specific to vegetation formations and are based on species response to fire (resprouter or obligate seeder), and how long it takes for the species to reach reproductive maturity[76]. The lower thresholds (shorter time interval) are set for species vulnerable to a lack of fire and upper thresholds (longer time interval) are set to allow species vulnerable to frequent fire to reproduce and recover[11]. Species like the Slender Rice Flower (Pimelea linifolia), which are found throughout the Mid Coast region in forests and woodlands, flourish when their environment is disturbed, and therefore survive in areas which are exposed to more frequent fires (lower fire intervals).

Frequent fires can be detrimental to an ecosystem, especially when they occur too often in the same area. These fires can kill individual plants before they reach reproductive maturity. If all individuals of an obligate seeder species are destroyed by repeated fires before producing viable seeds, the seed bank may become depleted,

[73]Loudermilk, E.L., O'Brien, J.J., Goodrick, S.L., Linn, R.R., Skowronski, N.S. and Hiers, J.K. (2022). Vegetation's influence on fire behavior goes beyond just being fuel. Fire Ecology, 18(1). Doi https://doi.org/10.1186/s42408-022-00132-9.
[74]Murphy, B.P., Bradstock, R.A., Boer, M.M., Carter, J., Cary, G.J., Cochrane, M.A., Fensham, R.J., Russell-Smith, J., Williamson, G.J. and Bowman, D.M.J.S. (2013). Fire regimes of Australia: a pyro geographic model system. Journal of Biogeography, 40(6), pp.1048–1058.
[75]Kenny, B., Sutherland, E., Tasker, E. and Bradstock, R. (2004). GUIDELINES FOR ECOLOGICALLY SUSTAINABLE FIRE MANAGEMENT. [online] NSW Biodiversity Strategy and the NSW National Parks & Wildlife Service. Available at: https://www.environment.nsw.gov.au/resources/biodiversity/FireGuidelinesReport.pdf [Accessed 23 Mar. 2022].
[76]Knox, K.J.E. and Clarke, P.J. (2004). Post-fire response of shrubs in the tablelands of eastern Australia: do existing models explain habitat differences? Australian Journal of Botany, 50(1), pp.348–353. doi: https://doi.org/10.1071/bt01055.

potentially leading to the loss of that species in the area. Additionally, frequent fires can create more open landscapes by reducing the number of shrubs, while infrequent fires can lead to more shrubby and less grassy areas. Each local landscape requires a specific balance between frequent and infrequent fires to maintain ecological health. For example, recurrent, intense fires in the Victorian Central Highland has decimated Mountain Ash (*Eucalyptus regnans*) forests, which have a low fire tolerance. As a result of fires happening in quick succession over large areas, these forests are now being considered for International Union for Conservation of Nature (ICUN) listing.

Infrequent fires can be problematic for species commonly found in heathland and some woodlands that require fire to spread seed. The intensity of a fire also can impact these species, like banksias and *Allocasuarinas*, as some require certain temperatures (heat cues) to release seed and/ or germinate.

To achieve this balance, we aim to burn within our established upper and lower fire intervals, which vary for each vegetation formation based on the needs of the threatened and protected species in those areas. It is important not to burn continuously at the lower interval limit, as there may be species that benefit from the reduced fire frequency of the longer interval limit. As in all aspects of environmental management, promoting diversity in fire frequency within the intervals is recommended.

It is important to remember fire intervals are to be used as a guide, only, as there is emerging science that will likely refine the recommendations around fire frequency which will impact fire intervals and fire management.

Intensity

Fire intensity is influenced by the amount of fuel burned, the energy value of the fuel, and the rate at which the fire spreads. All of these factors influence the temperature of the fire and the degree of disturbance caused. Generally, indicators of fire intensity include flame length and flame height, which can vary based on how much the flames are leaning over.

Fire intensity also impacts the extent of the area burned. High-intensity fires typically leave few unburned patches, eliminating refuge areas for surviving animals. Conversely, lower-intensity fires often leave unburned patches that provide food and shelter, facilitating the maintenance of local floristic diversity which in turn enables fauna to survive and return to the burned areas once they recover.

Season

Season refers to the time of year that the fire should occur naturally and is often similar for vegetation formations in similar climates. Over time this will have had influence on the flowering and seeding season of species present, especially those that are not fire dependent. Fires that occur out of season can diminish the soil seed bank.

Variation between fire regimes, including each component; fire frequency, intensity, season and extent, as well as human disturbance, may create inappropriate fire regimes. Inappropriate fire regimes are classified as a Key Threatening Process in the Biodiversity Conservation Act (2016). It is important to manage fire regimes appropriately to prevent negative impacts.

Yellow-throated Scrub Wrens are found in rainforests and wet gullies. Frequent fire in rainforests can remove their habitat and threaten species like these. Photo credit Isabelle Strachan.

Vegetation Formations and their Fire Regimes

Looking after our landscape including the native vegetation within our region is important. As mentioned earlier, one way to do this is through managing fire regimes for each vegetation formation and class.

In order to understand what fire regime your local landscape might need you will need to identify what types of vegetation you have on your property. To do this, use the summarized information after Table 1 which includes a guide for vegetation class distribution, habitat and common species listed. The information is sourced from the 'Bionet – threatened species – find by habitat' webpage on the NSW Office of Environment & Heritage website[77]. Variations within vegetation communities are common. For more information on other species to look for use Bionet or the Trees Near Me app.

Scan QR code for Trees Near Me app

Managing fire regimes within the landscape isn't just important for biodiversity, but also because within NSW, high frequency fire that results in the loss of vegetation arrangement and disruption of life cycle processes in plants and animals is a Key Threatening Process under the Threatened Species Conservation Act 1995.

Areas extensively burnt can take time to recover after fire. Photo credit Isabelle Strachan.

To avoid issues associated with high frequency fire or the absence of fire, use the recommended fire intervals outlined below. It's important to note fire intervals are best viewed as a guide, as research into some vegetation formations and their fire regimes is still in its early stages[78]. As a result of emerging research make sure to check for updated versions of the fire intervals. They usually change every 3 to 5 years.

Table 1: As per RFS' Bush Fire Environmental Assessment Code - Fire Intervals for Land Management Zones for the vegetation classes within the Mid Coast region.

Vegetation Formation	Vegetation Class	Fire Intervals
Rainforests	Cool Temperate Rainforest	N/A; fire should be excluded from these vegetation classes
	Dry Rainforest	
	Subtropical Rainforest	
	Littoral Rainforest	
	Northern Warm Temperate Rainforest	
Wet Sclerophyll Forest (Grassy Subformation)	Northern Hinterland Wet Sclerophyll Forests	Min. 15 years Max. 50 years
	Northern Tableland Wet Sclerophyll Forests	

[77] NSW Environment, Energy and Science (n.d.). Threatened species - View species by habitat. [online] Bionet. Available at: https://threatenedspecies.bionet.nsw.gov.au/Habitat.
[78]Conroy, N. and Watson, P. (2024). Managing fire on your property - A booklet for landholders in the Namoi Region. [online] Hotspots Fire Project. Available at: https://hotspotsfireproject.org.au/download/landholder-booklet-namoi.pdf.

Table 1 (continued): Fire intervals for each vegetation class within the Mid Coast region.

Vegetation Formation	Vegetation Class	Fire Intervals
Wet Sclerophyll Forest (Shrubby Subformation)	North Coast Wet Sclerophyll Forests	Min. 30 years Max. 60 years
	Northern Escarpment Wet Sclerophyll Forests	
Dry Sclerophyll Forest (Shrub-grass Subformation)	Hunter-Macleay Dry Sclerophyll Forests	Min. 8 years Max. 50 years
	Northern Gorge Dry Sclerophyll Forests	Min. 8 years Max. 50 years
	New England Dry Sclerophyll Forests	
	North-west Slopes Dry Sclerophyll Woodlands	
Dry Sclerophyll Forest (Shrubby Subformation)	Coastal Dune Dry Sclerophyll Forests	Min. 10 years Max. 30 years
	North Coast Dry Sclerophyll Forests	
	Sydney Coastal Dry Sclerophyll Forests	
	Northern Escarpment Dry Sclerophyll Forests	Min. 10 years Max. 30 years
Grassy Woodlands	Coastal Valley Grassy Woodlands	Min. 8 years Max. 40 years
	Subalpine Woodlands	
	New England Grassy Woodlands	
	Tableland Clay Grassy Woodlands	
Grasslands	Western Slopes Grasslands	Min. 3 years Max. 10 years
	Maritime Grasslands	
Heathlands	Coastal Headland Heaths	Min. 10 years Max. 30 years
	Northern Montane Heaths	
	Wallum Sand Heaths	
Forested Wetlands	Coastal Swamp Forests	Min. 10 years Max. 35 years
	Coastal Floodplain Wetlands	
	Eastern Riverine Forests	
Freshwater Wetlands	Montane Bogs and Fens	Fire should be excluded from these vegetation classes
	Coastal Freshwater Lagoons	
	Coastal Heath Swamps	Min. 10 years Max. 35 years
Saline (and Estuarine) Wetlands	Mangrove Swamps	Fire should be excluded from these vegetation classes
	Saltmarshes	

Left: *Backhousia myrtifolia* (Grey myrtle) flowers. © Nicholas Fisher – Flickr.
Right: *Backhousia myrtifolia* (Grey myrtle) trunk and bark. Credit – Harry Rose – Flickr.

Rainforests

Rainforests usually occur in areas that have fertile soil, are moist and free of fire[79]. This formation has closed and continuous tree canopy, and is dominated by broad-leaved evergreen trees with vines, ferns and palms in the understory.

Within the rainforest formation there are 5 vegetation classes, and 24 Plant Community Types for the Mid Coast. Understanding what vegetation class(es) and Plant Community Type(s) you have on your property is useful because it helps inform what appropriate land management strategies are applicable. Usually, this would also involve fire, however rainforests don't recover well after fire, particularly medium to high intensity fire. As a result, fire should be excluded from this formation.

To identify rainforest vegetation classes, use the dominant species found within them. Different classes of rainforest are the differ dominant species found within them. These include:

Dry Rainforests

Dominated by canopy species like *Backhousia sciadophora* (Shatterwood), *Backhousia myrtifolia* (Grey myrtle), *Streblus brunonianus* (Whalebone tree), *Tristaniopsis laurina* (Water gum) and *Waterhousea floribunda* (Weeping lilly pilly) and other species like *Jasminum volubile* (Scrambling jasmine), *Platycerium superbum* (Staghorn) and *Adiantum aethiopicum* (Common maidenhair).

Dry Rainforests are typically found in rough terrain on rocky substrates, around Maitland and northern parts of the Barrington Tops National Park.

Subtropical Rainforests

Dominated by canopy species like *Argyrodendron actinophyllum* (Black booyong), *Argyrodendron trifoliolata* (White booyong), *Baloghia inophylla* (Brush bloodwood), *Dendrocnide excelsa* (Stinging tree) and other species like *Polyosma cunninghamii* (Featherwood), *Piper novae-hollandiae* (Giant pepper vine), *Asplenium australasicum* (Birds nest fern) and *Platycerium bifurcatum* (Elkhorn).

Subtropical rainforests are often found on fertile soils, with warm temperatures around coastal lowlands in valleys and riparian areas. Barrington Tops National Park, south of Forster and north west of Taree are areas where this vegetation class can be found.

Littoral Rainforests

Recognised as an Endangered Ecological Community (EEC) under the Threatened Species Conservation Act 1995.

Dominated by canopy species like *Acmena hemilampra* (Common lilly pilly), *Banksia integrifolia* (Coastal banksia), *Cupaniopsis anacardioides* (Tuckeroo), *Drypetes deplanchei* (Yellow Tulipwood), *Elaeocarpus*

Left: Moreton Bay Fig in Subtropical Rainforest, located in Wingham Brush.
Right: *Platycerium bifurcatum* (Elkhorn) located in Old Bar Littoral Rainforest.
Credit Kate Jarzabek.

[79]NSW Environment, Energy and Science. (n.d.). Rainforests. [online] Available at: https://www.environment.nsw.gov.au/threatenedspeciesapp/VegFormation.aspx?formationName=Rainforests [Accessed 18 Apr. 2022].

Left: *Asplenium australasicum* (Birds Nest Fern). © Chris Burn – Flickr (https://www.flickr.com/photos/67627528@N04/36508138042)
Right: *Dicksonia antarctica* (Soft tree fern). Credit John Jennings – Flickr.

obovatus (Hard Quandong), *Ficus fraseri* (Sandpaper fig), *Ficus rubigonosa* (Rusty fig), *Planchonella australis* (Black Apple), and other species like *Breynia oblongifolia* (Coffee bush), *Diosporys australis* (Black Plum), *Elaeodendron australe* (Red Olive Berry), *Guioa semiglauca* (Guioa), *Pandorea pandorana* (Wonga wonga vine), *Platycerium bifurcatum* (Elk Horn Fern) and *Pittosporum revolutum* (Rough fruit pittosporum)[80,81].

These rainforests can be found within a kilometre of the sea, where vegetation can gain nutrients from the sea spray, on coastal sand plains and headlands. Littoral Rainforest is found along the coastline, in patches between Nelsons Bay and Crowdy Bay.

Locally, littoral rainforest supports threatened species such as:

- *Cynanchum elegans* (White Wax Flower)
- *Rhodomyrtus psioides* (Native Gauva)
- *Senna acclinis* (Native Senna)

Cool Temperate Rainforests

Dominated by canopy species like *Acacia melanoxylon* (Blackwood), *Nothofagus moorei* (Antarctic beech)[82], *Cryptocarya nova-anglica* (Mountain laurel), and other species like *Dicksonia antarctica* (Soft tree fern), *Hedycarya angustifolia* (Native mulberry), *Histiopteris incisa* (Bats wing fern), *Hydrocotyle pedicellosa* (Large pennywort) and *Smilax australis* (Sarsaparilla).

Cool Temperate Rainforests are found above 800 to 900 m elevation on fertile soils. These rainforests are found in the Barrington Tops National Park, west of Gloucester.

Left: Cool Temperate Rainforest containing Antarctic Beech, located in Gloucester Tops. ©Poyt – Flickr
Right: *Guioa semiglaucac* (Wild Quince) found in Littoral Rainforest. Credit Kate Jarzabek

Northern Warm Temperate Rainforests

Dominated by canopy species like *Acmena smithii* (Lilly Pilly), *Ceratopetalum apetalum* (Coachwood), *Doryphora sassafras* (Sassafras), and other species like *Dianella caerulea var. producta* (Blue flax lily), *Lomandra spicata* (Rainforest mat rush), *Marsdenia rostrata* (Common milk vine) and *Tasmannia insipida* (Brush pepperbush).

Scattered across the whole of the Mid Coast region, these rainforests are found in sheltered gullies and slopes, including areas above 1000m elevation.

[80]Manning Coastcare Group (2022). Littoral Rainforests of the Mid Coast. [online] Mid Coast 2 Tops Landcare. Available at: https://midcoast2tops.org.au/littoral-rainforests-of-the-mid-coast/ [Accessed 6 Sep. 2024].
[81]Floyd, A.G. (1990). Australian Rainforests in New South Wales. 2nd ed. Chipping Norton, NSW: Surrey Beatty & Sons.
[82] Tolsma, A., Hale, R., Sutter, G. and Kohout, M. (2019). Post-fire dynamics of Cool Temperate Rainforest in the O'Shannassy Catchment. [online] Available at: https://www.ari.vic.gov.au/__data/assets/pdf_file/0030/429618/ARI-Technical-Report-298-Post-fire-dynamics-of-Cool-Temperate-Rainforest.pdf.

Threatened Animal: Manning River Turtle, *Myuchelys purvisi.*

The Manning River Turtle is a medium sized, freshwater turtle that is only found in the middle and upper reaches of the Manning River catchment.

The turtle prefers shallow, fast-flowing channels which are sandy and rocky. This species of turtle is known to eat Lilly Pilly berries as well as other terrestrial fruit and insects. Species of Lilly Pilly are commonly found in the Rainforest formation.

Managing the Rainforest formation appropriately, including keeping a range of fire intervals that support the growth of Lilly Pillies is important to support these threatened turtles.
This species occurs in areas that are not highly fire tolerant, and in catastrophic conditions, will be quite fire naive. In times of fire, deep refuge pools are a critical habitat resource for this species.

Manning River Turtle. © Gary Stephenson – Manning River Times.

Threatened species which can be found in these vegetation classes include:

Arthropteris palisotii (Lesser Creeping Fern)
Cynanchum elegans (White-flowered Wax Plant)
Marsdenia longiloba (Slender Marsdenia)

Wet Sclerophyll Forest (all subformations)

Wet sclerophyll forests are characterised by an open, tall tree canopy made up of sclerophyllous tree species and an understory of rainforest type ferns, shrubs, herbs and grasses[83]. These types of forests occur in high rainfall areas and can be divided into two subgroups; grassy and shrubby. These subgroups outline what type of understorey the formation has.

Within this vegetation formation in the Mid Coast region there are 4 vegetation classes and 36 PCTs (see Appendix 3 for PCT list). For Wet sclerophyll forests, fire intervals are specific to the sub formation and plant community type. See specific intervals below.

To identify wet sclerophyll forest vegetation classes, use the dominant species found within them. These include:

Grassy Subformation

The general recommended fire intervals for this sub formation are 15 to 50 years[84,85]. It is important to note that appropriate fire frequencies for this vegetation formation are still in debate and require more research.

Northern Hinterland Wet Sclerophyll Forests

Dominated by canopy species like *Eucalyptus microcorys* (Tallowwood), *E. pilularis* (Blackbutt), *E. propinqua* (Grey gum), *E. siderophloia* (Grey ironbark), *Syncarpia glomulifera* (Turpentine) and other species like *Allocasuarina torulosa* (Forest oak), *Geranium homeanum* (Crane's bill), *Imperata cylindrica var. major* (Blady grass), *Oplismenus aemulus* (Creeping beard grass) and *Pittosporum revolutum* (Yellow pittosporum).

Scattered across the region, concentrated more towards the coast, Northern Hinterland Forest can be found below 600m elevation on slopes and ridges in coastal foothills.

[83]NSW Environment, Energy and Science. (2017). Wet sclerophyll forests (grassy sub-formation). [online] Available at: https://www.environment.nsw.gov.au/threatenedSpeciesApp/VegFormation.aspx?formationName=Wet+sclerophyll+forests+(grassy+sub-formation) [Accessed 20 Apr. 2022].
[84]Conroy, N. and Watson, P. (2024). Managing fire on your property - A booklet for landholders in the Namoi Region. [online] Hotspots Fire Project. Available at: https://hotspotsfireproject.org.au/download/landholder-booklet-namoi.pdf.
[85]Bush Fire Environmental Assessment Code - Supporting Document: Fire Intervals for Strategic Fire Advantage Zones and Land Management Zones. (2022). [online] NSW Rural Fire Service. Available at: https://www.rfs.nsw.gov.au/__data/assets/pdf_file/0005/212927/CMR1504-BFEAC-Fire-Intervals-for-SFAZs-and-LMZs.pdf.

Clockwise from top left:
Northern Hinterland Wet Sclerophyll Forests. © Ian Brown - BMNature., Northern Tableland Wet Sclerophyll Forests. © Russell Cumming – Flickr., *Syncarpia glomulifera* (Turpentine). Credit Margaret Donald – Flickr., *Guioa semiglauca* (Wild quince), Black Head Flora Reserve. © Janis Laraine Cossill – Flickr., *Eucalytpus microcorys* (Tallowwood). © Nicholas Fisher - Flickr., *Eucalytpus microcorys* (Tallowwood). © Nicholas Fisher - Flickr.

Northern Tableland Wet Sclerophyll Forests

Dominated by canopy species like *Eucalyptus campanulata* (New England blackbutt), *E. obliqua* (Messmate), *Allocasuarina littoralis* (Black sheoak), *Banksia integrifolia subsp. monticola* (White mountain banksia) and other species like *Indigofera australis* (Hill indigo), *Rubus parvifolius* (Native raspberry), *Dichondra repens* (Kidney weed), *Microlaena stipoides var. stipoides* (Weeping grass) and *Pteridium esculentum* (Bracken fern). Northern Tableland Forests are located more inland, west of Gloucester on elevated plateau and escarpments above 800m elevation.

Shrubby Subformation

The recommended fire intervals for this subformation range between 30 and 60 years[84,85]. This range aims to balance eucalyptus regeneration with a less fire tolerant understorey.

Threatened Animal: Long-Nosed Potoroo, *Potorous tridactylus.*

The long-nosed potoroo plays a critical role in ecosystem diversity and soil health through their role as ecosystem engineers. Their digging habits, similar to bandicoots, plays a critical role in fungi and soil health, by turning over new materials into the humus layer. As part of this process, this reduces fine fuel loads by encouraging decomposition. This digging habit also aids in seed dispersal into areas following fire as they seek out their next meal.

Proper fire management practices help maintain the dense understorey vegetation that the long-nosed potoroo relies on for food, shelter, and protection from predators. By creating a mosaic of burned and unburned patches, fire management can ensure the availability of suitable habitats and food resources, thus supporting the population stability of this species.

Photo credit: Aussie Ark.

Threatened Animal: Spotted-tail Quoll, *Dasyurus maculatus.*

This species of quoll can be found living in rainforest, woodland, coastal heathland and riparian forest. The Spotted-tail Quoll requires fallen logs, small caves, hollow-bearing trees, other animal burrows orrock outcrops for den sites. The Wet Sclerophyll formation typicallycontains fallen logs and other habitat requirements that quolls use for dens. Maintaining an appropriate fire regime and managing it correctly is important because this will retain habitat, like fallen logs, that quolls need to live and breed in.

Spotted-tail Quoll. Credit Pierre Pouliquin – Flickr

North Coast Wet Sclerophyll Forests

Dominated by canopy species like *Lophostemon confertus* (Brush box), *Syncarpia glomulifera* (Turpentine), *Eucalyptus deanei* (Mountain blue gum) and other species like *Cryptocarya rigida* (Forest maple), *Guioa semiglauca* (Wild quince), *Clematis glycinoides* (Headache vine), *Plectranthus parviflorus* (Cockspur flower) and *Doodia aspera* (Prickly rasp-fern).

North Coast Wet Sclerophyll Forests can be found across the region, specifically around Stroud and Monkerai. They are located along coastal ranges, foothills and creek flats below 500 m elevation.

Northern Escarpment Wet Sclerophyll Forests

Dominated by canopy species like *Eucalyptus campanulata* (New England blackbutt), *E. microcorys* (Tallowwood), *E. saligna* (Sydney blue gum), *Caldcluvia paniculosa* (Soft corkwood) and other species like *Eustrephus latifolius* (Wombat berry), *Tasmannia insipida* (Brush pepperbush), *Sticherus lobatus* (Spreading shield fern) and *Calochlaena dubia* (Common ground fern).

These types of forests are located above 600m elevation on sandy soils around the Barrington Tops National Park and Gloucester.

Threatened species which can be found in these vegetation classes include:

Eastern Australian Underground Orchid

Chiloglottis platyptera (Barrington Tops Ant Orchid)

Eucalyptus largeana (Craven Grey Box)

Rhodamnia rubescens (Scrub Turpentine)

Dry Sclerophyll Forest (all subformations)

Of all vegetation formations in NSW, Dry Sclerophyll Forest takes up one quarter of the state. Dry Sclerophyll Forests are found in areas with poor to moderate soils and moderate rainfall. They contain plants that have hard, short and often spikey leaves which is an adaptation to a low soil fertility environment[86]. This vegetation formation is one that requires fire for plant regeneration and biodiversity balance. This formation contains a mix of obligate seeders and resprouters, and has a diverse range of shrub-grass combinations which influence fire behaviour.

The Mid Coast region contains 8 Dry Sclerophyll Forest vegetation classes. These classes are divided into two sub-formations which are categorized by their different vegetation structures; grass/shrub or shrubby.

[86]NSW Environment, Energy and Science. (n.d.). Dry sclerophyll forests (shrub/grass sub-formation). [online] Available at: https://www.environment.nsw.gov.au/threatenedspeciesapp/VegFormation.aspx?formationName=Dry+sclerophyll+forests+(shrub%2Fgrass+sub-formation)#:~:text=Shrub%2Fgrass%20dry%20sclerophyll%20forests [Accessed 21 Apr. 2022].

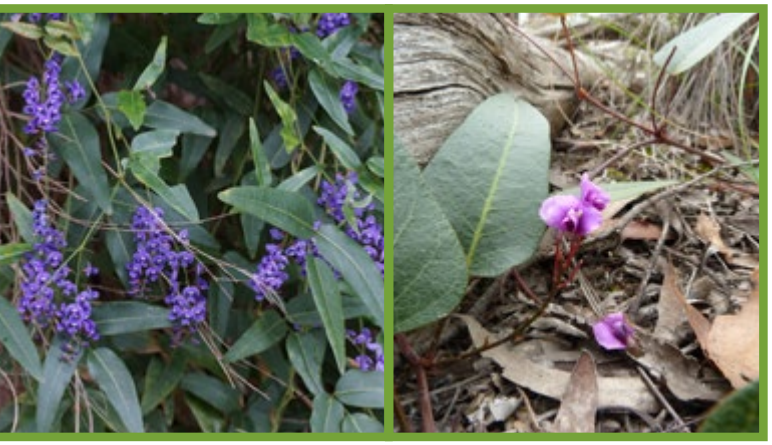
These two sub-formations have different fire regime requirements because of the different structure.

To identify Dry Sclerophyll Forest vegetation classes, use the dominant species found within them. These include:

Shrub/Grass Subformation

For this subformation there is a greater range for fire intervals because of the presence of both grass and shrub components. The fire interval range is between 8 and 50 years[84,85].

(The grassier open forests may require slightly more frequent fire with an occasional longer interval between fires. The grass component is likely to be best maintained by short intervals, while the shrub component is predicted to increase with longer intervals. occasional intervals of greater than 25 years in some areas, have been recommended for these forests).



Left: *Hardenbergia violacea* (False sarsaparilla). Credit Anne-Marie Ladegaard - Flickr
Right: *Hardenbergia violacea* (False sarsaparilla). Credit Donald Hobern – Flickr.

Hunter-Macleay Dry Sclerophyll Forests

Dominated by canopy species like *Eucalyptus crebra* (Narrow-leaved ironbark), *E. maculata* (Spotted gum), *E. moluccana* (Grey box), *E. siderophloia* (Grey ironbark) and other species like *Bursaria spinosa* (Blackthorn), *Allocasuarina torulosa* (Forest oak), *Notelaea longifolia* (Large mock-olive), *Calotis lappulacea* (Yellow burr-daisy), *Cymbopogon refractus* (Barbed wire grass) and *Themeda triandra* (Kangaroo grass).

These forests are found below 400m elevation in valleys and foothills. Hunter-Macleay Dry Sclerophyll Forests are concentrated around the Karuah and Clarence Town area and are scattered across the region as well.

Left: *Acacia filicifolia* (Fern-leaved wattle). Credit Myall Lakes National Park – Flickr.
Right: *Acacia filicifolia* (Fern-leaved wattle). Credit Tony Rodd – Flickr.

Northern Gorge Dry Sclerophyll Forests

Dominated by canopy species like *Eucalyptus canaliculata* (Grey gum), *E. microcorys* (Tallowwood), *E. propinqua* (Grey gum), *E. tereticornis* (Forest red gum) and other species like *Acacia implexa* (Hickory wattle), *Exocarpos cupressiformis* (Native cherry), *Lomandra confertifolia* (Mat rush), *Imperata cylindrica var. major* (Blady grass) and *Hardenbergia violacea* (False sarsaparilla).

Northern Gorge Dry Sclerophyll Forests can be found west of Taree and scattered across the Mid Coast region. They are located on escarpments and gorges on moderately fertile soil.

New England Dry Sclerophyll Forests

Dominated by canopy species like *Eucalyptus acaciiformis* (Wattle-leaved peppermint), *E. caliginosa* (Broad-leaved stringybark), *E. dalrympleana subsp. heptantha* (Mountain gum) and other species like *Acacia filicifolia* (Fern-leaved wattle), *Brachyloma daphnoides* (Daphne heath), *Opercularia hispida* (Hairy stinkweed), *Dichelachne micrantha*

Left: *Callitris glaucophylla* (White cypress pine). Credit David Carr – Flickr.
Right: *Callitris glaucophylla* (White cypress pine). Credit Tony Rodd – Flickr.

Left: *Eucalyptus signata* (Northern scribbly gum). Credit John Tann – Flickr.
Right: *Eucalyptus signata* (Northern scribbly gum). Credit John Tann – Flickr.

(Shorthair plumegrass) and *Poa sieberiana* (Blue tussock grass).

Located in the northern west part of the region near Curricabark, this class is found in areas of low fertility and high elevation (900 to 1300m) where rugged cliffs meet flat tableland.

North-west Slopes Dry Sclerophyll Woodlands

Dominated by canopy species like *Brachychiton populneus subsp. populneus* (Kurrajong), *Callitris glaucophylla* (White cypress pine), *Eucalyptus albens* (White box) and other species like *Acacia decora* (Western golden wattle), *A. implexa* (Hickory wattle), *Dodonaea viscosa subsp. angustifolia* (Sticky hopbush), *Elymus scaber var. scaber* (Common wheatgrass), *Microlaena stipoides var. stipoides* (Weeping grass) and *Arthropodium milleflorum* (Vanilla lily).

The North-west Slopes Dry Sclerophyll Woodlands are found on hilly terrain with moderately fertile soils. Within the region this vegetation class is located in the Nowendoc National Park, parts of the Barrington Tops National Park and near Curricabark area.

Shrubby Subformation

The range of fire intervals for this vegetation class is between 10 to 30 years[84,85]. The different vegetation structure of this sub-formation; shrubby, means that it doesn't need high frequency fire to maintain diversity within grass species present.

Sydney Coastal Dry Sclerophyll Forests

Dominated by canopy species like *Eucalyptus costata* (Sydney red gum), *E. gummifera* (Red bloodwood) and other species like *Banksia serrata* (Old man banksia), *Ceratopetalum gummiferum* (Christmas bush), *Grevillea sericea* (Pink spider flower), *Hakea dactyloides* (Broad-leaved hakea), *Leptospermum trinervium* (Flaky-barked tea tree) and *Patersonia glabrata* (Leafy purple flag).

Eucalyptus maculata (Spotted gum). © Tony Rodd – Flickr.

Threatened Animal: Glossy Black Cockatoo, *Calyptorhynchus lathami.*

The The Glossy Black Cockatoo lives in woodlands and open forests. These birds rely heavily on Allocasuarina littoralis (Black Sheoak) and Allocasuarina torulosa (Forest Sheoak) for food. These species are commonly found within the Dry Sclerophyll formation. Glossy Black Cockatoos require large hollow-bearing eucalypts which can also be found within the Dry Sclerophyll formation.

Managing the Dry Sclerophyll formation appropriately, including keeping a range of fire intervals that support the growth of Sheoaks and retain hollow-bearing trees is important to support these threatened cockatoos.

Glossy Black Cockatoo, captured in Crowdy Bay National Park. Credit David Cook – Flickr.

Sydney Coastal Dry Sclerophyll Forests occurs on sandstone ridges, slopes and gullies below 700m elevation. Within the region this vegetation class is only found in the Karuah River catchment and National Park area.

Coastal Dune Dry Sclerophyll Forests

Dominated by canopy species like *Eucalyptus costata* (Sydney red gum), *E. pilularis* (Blackbutt), *E. racemosa* (Northern scribbly gum) and other species like *Pteridium esculentum* (Bracken fern), *Acacia longifolia* (Sydney golden wattle), *Ricinocarpus pinifolius* (Wedding bush), *Acacia terminalis* (Sunshine wattle) and *Lomandra longifolia* (Spiny-headed mat-rush).

This vegetation class can be found scattered along the entire coastline of the region and is concentrated around Seal Rocks and the Myall Lakes areas.

North Coast Dry Sclerophyll Forests

Dominated by canopy species like *Eucalyptus gummifera* (Red bloodwood), *E. racemosa* (Northern scribbly gum) and species like *Banksia oblongifolia* (Fern-leaved banksia), *B. spinulosa var. collina* (Hairpin banksia), *Leptospermum trinervium* (Flaky-barked tea tree), *Pimelea linifolia* (Slender rice flower) and Imperata cylindrica var. major (Blady grass).

North Coast Dry Sclerophyll Forest occurs only in the Coorabakh National Park area for the Mid Coast region. This vegetation class is found on sandy soils, at altitudes up to 400m.

Northern Escarpment Dry Sclerophyll Forests

Dominated by canopy species like *Eucalyptus acaciiformis* (Wattle-leaved peppermint), *E. caliginosa* (Broad-leaved stringybark), *E. campanulata* (New England blackbutt), *E. codonocarpa* (Bell-fruited mallee), *E. dalrympleana* (Mountain gum), and other species like *Acacia buxifolia subsp. buxifolia* (Box-leaved wattle), *Allocasuarina littoralis* (Black sheoak), *Leptospermum brevipes* (Slender tea-tree), *Persoonia cornifolia* (Broad-leaved geebung) and *Entolasia stricta* (Wiry panic grass).

Left: *Leptospermum brevipes* (Slender Tea-tree). © Janis Laraine Cossill Flickr.
Right: *Eucalyptus costata* (Sydney red gum). Credit Kirsty Komuso – Flickr.

Located near Barrington Tops, this vegetation class occurs in areas with low nutrient soils and visible boulders. They occur in areas of elevation between 800m and 1400m.

Threatened species which can be found in these vegetation classes include:

Acacia courtii (North Brother Wattle)

Allocasuarina defungens (Dwarf Heath Casuarina)

Corybas dowlingii (Red Helmet Orchid)

Cynanchum elegans (White-Flowered Wax Plant)

Grassy Woodlands

Spread across most of eastern NSW, this vegetation formation is found on moderate to highly fertile soils. Grassy woodlands like flat to hilly terrain and are made up of grasses, herbs, scattered shrubs and an open canopy containing different species of Eucalypts.

Grassy Woodlands have unfortunately been exposed to extensive modification due to agriculture. Land clearing, overgrazing and weed invasion have reduced the health of these woodlands across NSW. It is important to maintain and protect the remaining Grassy Woodland vegetation left in the Mid Coast region. One way to do this is to make sure the vegetation is exposed to appropriate fire intervals. The recommended fire intervals for this formation are between 8 and 40 years[84,85].

4 different Grassy Woodland vegetation classes can be found within the Mid Coast region. To identify these vegetation classes, use the dominant species found within them. These include:

Coastal Valley Grassy Woodlands

Dominated by canopy species like *Eucalyptus floribunda* (Rough-barked apple), *E. paniculata* (Grey ironbark), *E. tereticornis* (Forest red gum) and other species like *Melaleuca nodosa* (Prickly-leaved paperbark), *Leptospermum polygalifolium subsp. montanum* (Tantoon), *Microlaena stipoides var. stipoides* (Weeping grass), *Dichelachne micrantha* (Plumegrass), *Entolasia stricta* (Wiry panic grass) and *Hydrocotyle laxiflora* (stinking pennywort).

Coastal Valley Grassy Woodlands are found in areas of altitude up to 350m, on moderately fertile soils on hills and plains. Within the region, this vegetation class is found in small patches near Forster, Upper Myall, Gloucester and Bundook.

Left: *Banksia spinulosa var. collina* (Hairpin Banksia). Credit John Tann – Flickr.
Right: *Banksia spinulosa var. collina* (Hairpin Banksia). Credit Nicholas Turland – Flick.

New England Grassy Woodlands

Dominated by canopy species like *Eucalyptus blakelyi* (Blakelys red gum), *E. bridgesiana* (apple box), *E. caliginosa* (broad-leaved stringybark), *E. laevopinea* (silver-top stringybark), *E. melliodora* (yellow box) and other species like *Cassinia quinquefaria* (Native rosemary), *Aristida ramosa* (purple wiregrass), *Sorghum leiocladum* (wild sorghum) and *Poa sieberiana* (Grey tussock grass).

For the Mid Coast region, this vegetation class is found scattered between Mernot and Woko National Park. They usually occur on moderately fertile soils, above 600m elevation

Tableland Clay Grassy Woodlands

Dominated by canopy species like *Eucalyptus pauciflora* (White sally), *E. stellulata* (Black sally), *E. viminalis* (Ribbon gum) and other species like *Acacia dealbata* (Silver wattle), *Wahlenbergia stricta subsp. stricta* (Tall bluebell), *Austrostipa scabra*

(Rough speargrass), *Elymus scaber* (Wheatgrass), *Poa labillardieri* (Common tussock grass) and *Themeda triandra* (Kangaroo grass).

Tableland Clay Grassy Woodlands are found on fertile, clay soils at altitudes between 700 and 1300m. This vegetation class is scattered within Barrington Tops National Park.

Subalpine Woodlands

Dominated by canopy species like *Eucalyptus pauciflora* (White sally), *E. dalrympleana* (Mountain gum), *E. rubida subsp. rubida* (Candlebark), *E. debeuzevillei* (Snow gum) and other species like *Podolobium alpestre* (Alpine shaggy pea), *Poa sieberiana var. sieberiana* (Snowgrass) and *Stylidium graminifolium* (Grass triggerplant).

Subalpine Woodlands are found at elevations between 1000 and 1800m. They exist on mountain summits and slopes exposed to cold winds. This vegetation class only occurs in the higher areas of Barrington Tops National Park.

Threatened species which can be found in these vegetation classes include:

Haloragis exalata subsp. Velutina (Tall Velvet Sea-berry)

Melaleuca biconvexa (Biconvex Paperbark)

Pterostylis elegans (Elegant Greenhood)

Grasslands

Grasslands, as suggested in the name, contain few woody plants, and instead are predominantly made up of grasses, herbs and some small shrubs. This vegetation formation is usually used by animals for foraging only, as it offers little protection. Unfortunately, most grasslands have been extensively modified because of grazing, leaving only fragmented small patches of remnant native grassland.

To help manage remnant native and modified grasslands, they should be exposed to appropriate fire intervals. These are recommended to be between 3 and 10 years[84,85].

Within the Grasslands vegetation formation there are 2 vegetation classes found within the region. To identify these, use the dominant species found within them:

Western Slopes Grasslands

Dominated by forbs and grass species like *Cullen tenax* (Emu-foot), *Solanum esuriale* (Quena), *Aristida leptopoda* (White speargrass), *Austrodanthonia bipartita* (Bandicoot grass), *Paspalidium constrictum* (Knotty But grass) and *Sporobolus caroli* (Fairy grass).

This vegetation class can be found on

Threatened Animal: Koala, *Phascolarctos cinereus.*

Koalas can be found in woodlands and forests. They spend most of their lives in trees and feed on around 70 different species of eucalypts and 30 other species. Eucalypts are commonly found in the Grassy Woodland formation, and their abundance is obviously very important to koala populations. It is therefore crucial to manage Grassy Woodlands including implementing appropriate fire regimes. Appropriate fire regimes involve keeping a range of fire intervals to support the growth of eucalypts.

Koalas are notoriously fussy eaters, preferring specific ages of specific eucalyptus species at different times. For this reason, ensuring a high degree of age diversity through small mosaic burning is a vital part of good fire management in areas where koalas are present.

Koala captured in the Mid Coast region. Credit Peter Goonan, MidCoast Council.

clayey soils between altitudes of 200 and 400m. Within the Mid Coast region, Western Slopes Grasslands can be found around Rawdon Vale, Cobark, Bretti, Curricabark and Cooplacurripa (identification and location within the region as per Upper Hunter Mapping by NSW Office of Environment and Heritage data, 2018).

Maritime Grasslands

Dominated by shrubs and grass species like *Banksia integrifolia subsp. integrifolia* (Coast banksia), *Leucopogon parviflorus* (Coastal bearded-heath), *Pultenaea maritima* (Coastal headland pea), *Spinifex sericeus* (Hairy spinifex), *Sporobolus virginicus* (Marine couch) and *Themeda triandra* (Kangaroo grass).

Maritime Grasslands habit areas exposed to strong winds and sea spray, usually on exposed coastal headlands and beach areas. This vegetation class occurs in small coastal patches along our coastal cliffs in Hawks Nest, Mungo Brush, Pacific Palms, Forster and Crowdy Head.

Threatened species which can be found in these vegetation classes include:

Prostanthera densa (Villous Mint-bush)

Pultenaea maritima (Coast Headland Pea)

Chamaesyce psammogeton (Sand Spurge)

Thesium australe (Austral Toadflax)

Heathlands

Located on infertile, shallow, sandy soils, Heathlands are found on exposed positions in coastal areas and further inland. They are made up of hard-leaved shrubs and almost no trees or grasses. This vegetation formation is highly fire prone, and relies on fire for balance. The differences in fire regime for this formation determine the differences in vegetation structure and composition[87]. The recommended fire intervals for Heathlands are 10 to 30 years[84,85].

There are three Heathlands vegetation classes found in the Mid Coast region. To identify the different classes, use the dominant species found within them:

Wallum Sand Heaths

Dominated by Mallee and small forms of *Eucalyptus gummifera* (Red bloodwood), *Banksia aemula* (Wallum banksia) and other species like *Melaleuca nodosa* (Prickly-leaved paperbark), *Leptospermum trinervium* (Flaky-barked tea tree), *Isopogon anemonifolius* (Broad-leaved drumsticks), *Monotoca scoparia* (Prickly broom-heath), *Schoenus ericetorum* (Heath bog-rush) and *Gonocarpus teucrioides* (Raspwort).

From left: Coastal Valley Grassy Woodlands. © Ian Brown, BMNature. , *Eucalyptus blakelyi* (Blakelys Red Gum). © Lorraine Oliver, NSW Grassy Ecosystems - Flickr., *Eucalyptus blakelyi* (Blakelys Red Gum). Credit Nathanael Coyne – Flickr., Subalpine Woodlands. © Ian Brown, BMNature.

[87]NSW Environment, Energy and Science. (n.d.). Heathlands. [online] Available at: https://www.environment.nsw.gov.au/threatenedSpeciesApp/VegFormation.aspx?formationName=Heathlands [Accessed 7 Apr. 2022].

This vegetation class is found scattered on dune crests or sand plains along the coast of the region. Specifically, near Diamond Beach, Crowdy Head to Crowdy Bay and Mungo Brush.

Northern Montane Heaths

Dominated by Mallee and small forms of *Eucalyptus andrewsii* (Gum-topped peppermint), *E. prava* (Orange gum), *Callitris endlicheri* (Black cypress pine) and other species like *Cheilanthes distans* (Bristly cloak fern), *Entolasia stricta* (Wiry panic), *Lepidosperma gunnii* (Little sword-sedge), *Lomandra longifolia* (Spiny-headed mat-rush) and *Schoenus apogon* (Common bog-rush).

Northern Montane Heaths are located on ridges and sandy soils with altitudes between 400 and 1500m. These Heaths (to date) have only been found around the Tiona and Regatta Island areas within the region.

Coastal Headland Heaths

Dominated by shrubs and grass species like *Acacia sophorae* (Coastal wattle), *Leptospermum laevigatum* (Coast tea tree), *Westringia fruticosa* (Coastal rosemary), *Banksia integrifolia subsp. integrifolia* (Coast banksia), *Entolasia stricta* (Wiry panic) and *Polymeria calycina* (Slender bindweed).

Areas around Mungo Beach and Hawkes Nest are where you can find this vegetation class within the region.

Coastal Headland Heaths are found on exposed headlands and coastal areas which are exposed to maritime sea spray.

Threatened species which can be found in these vegetation formations include:

Melaleuca groveana (Grove's Paperbark)

Allocasuarina defungens (Dwarf Heath Casuarina)

Forested Wetlands

Forested Wetlands are associated with floodplains, riparian corridors and poorly drained areas. They contain fertile soils and consist of hard leaved trees and shrubs and water loving understorey plants. Periodic flooding within this vegetation formation helps sustain the high nutrient level within the soil[88].

The role of fire hasn't been studied yet for this type of vegetation formation. The suggested fire intervals are between 10 and 35 years[84,85], aiming to balance the fire-sensitive understorey and sclerophyllous canopy layer.

Within the Forested Wetlands formation there are 3 vegetation classes for the Mid Coast.



From left: *Themeda triandra* (Kangaroo Grass) © Lorraine Oliver, NSW Grassy Ecosystems – Flickr., *Themeda triandra* (Kangaroo Grass) © Lorraine Oliver, NSW Grassy Ecosystems – Flickr., Maritime Grasslands. © Nicholas Fisher – Flickr.

[88]NSW Environment, Energy and Science. (n.d.). Forested wetlands. [online] Available at: https://www.environment.nsw.gov.au/threatenedspeciesapp/VegFormation.aspx?formationName=Forested+wetlands [Accessed 9 Apr. 2022].

To identify these vegetation classes, use the dominant species found within them. These include:

Coastal Swamp Forests

Dominated by canopy species like *Eucalyptus robusta* (Swamp mahogany), *Melaleuca quinquenervia* (Broad-leaved paperbark), *M. linariifolia* (Flax-leaved paperbark) and other species like *Leptospermum juniperinum* (Prickly tea tree), *Chorizandra cymbaria* (Heron bristle rush), *Gahnia clarkei* (Tall saw-sedge), *Blechnum indicum* (Swamp water fern) and *Hypolepis muelleri* (Harsh ground fern).

Coastal Swamp Forests, except for around Forster, occur along most of the coast of the Mid Coast region. This vegetation class likes to habit waterlogged soils on coastal sand plains and flood plains that sit below 50 m elevation.

Coastal Floodplain Wetlands

Dominated by canopy species like *Casuarina glauca* (Swamp oak), *Eucalyptus amplifolia* (Cabbage gum), *E. grandis* (Flooded gum), *E. tereticornis* (Forest red gum), *Lophostemon suaveolens* (Swamp mahogany) and other species like *Melaleuca ericifolia* (Swamp paperbark), *Lomandra filiformis subsp. filiformis* (Wattle mat rush), *Juncus usitatus* (Common rush) and *J. kraussii subsp. australiensis* (Sea rush).

This vegetation class can be found on coastal floodplains that have fertile soils and that are inundated periodically. Coastal Floodplain Wetlands are scattered along the entire coast of the region.

Eastern Riverine Forests

Dominated by species like *Casuarina cunninghamiana* (River oak), *Melicytus dentatus* (Tree violet), *Tristaniopsis laurina* (Water gum), *Persicaria hydropiper* (Water pepper), *Carex appressa* (Tussock sedge), *Entolasia marginata* (Bordered panic) and *Oplismenus aemulus* (Australian basket grass).

Eastern Riverine Forests are found in riparian corridors, in open terrain with altitudes of around 800m. For the region, this class is found in isolated pockets around the Gloucester area (identification and location within the region as per Mid-Coast Council mapping, 2021).

Threatened species which can be found in these vegetation formations include:

Alexfloydia repens (Floyd's Grass)
Eucalyptus parramattensis subsp. decadens

From left: *Banksia aemula* (Wallum banksia). © Nicholas Fisher - Flickr., *Banksia aemula* (Wallum banksia). © Nicholas Fisher - Flickr., *Leptospermum laevigatum* (Coastal tea-tree). Credit Margaret Donald - Flickr., *Leptospermum laevigatum* (Coastal tea-tree). Credit Margaret Donald - Flickr.

Clockwise from left: *Lophostemon suaveolens* (Swamp Mahogany). © Nicholas Fisher - Flickr., *Melaleuca quinquenervia* (Broad-leaved Paperbark). Credit Harry Rose – Flickr., *Melaleuca quinquenervia* (Broad-leaved Paperbark). Credit Harry Rose – Flickr., *Melaleuca quinquenervia* (Broad-leaved Paperbark) Forested Wetlands. © Chris Burns - Flickr. (https://www.flickr.com/photos/67627528@N04/19483664808/in/album-72157658295547363/)

Freshwater Wetlands

This vegetation class is dominated by sedges and rushes, and contains a wide range of shrubs as well. Freshwater Wetlands are permanently or temporarily covered by water and occur in association with inland rivers and along the coast. These wetlands help regulate water flow in catchments and provide valuable refuge for threatened animals in general, and especially during periods of drought[89].

Most wetlands rarely require fire, if at all, to balance biodiversity within them. This means that it's recommended to exclude fire for most of the vegetation classes within the Freshwater Wetland formation[90] except Coastal Heath Swamps. Coastal Heath Swamps do need fire to remain healthy and resilient and the suggested fire intervals are 10 to 35 years years[84,85].

Within this vegetation formation in the Mid Coast region there are 3 vegetation classes. To identify Freshwater Wetland vegetation classes, use the dominant species found within them. These include:

Montane Bogs and Fens

Dominated by species like *Grevillea acanthifolia* (Acanthus-leaved grevillea), *Leptospermum myrtifolium* (Myrtle tea-tree), *L. obovatum* (River tea-tree), *Callistemon pityoides* (Alpine bottlebrush), *Gonocarpus micranthus ssp. Micranthus* (Creeping raspwort), *Hypericum japonicum* (Matted St John's wort), *Carex appressa* (Tall sedge) and *Geranium neglectum* (Crane's bill).

Montane Bogs and Fens occur scattered within the Barrington Tops National Park. They are found in poorly drained headwater valleys with moderately fertile peats and soils.

Coastal Heath Swamps

Dominated by species like *Hakea teretifolia subsp. teretifolia* (Dagger hakea), *Leptospermum juniperinum* (Prickly tea-tree), *Banksia oblongifolia*

[89]NSW Environment, Energy and Science. (n.d.). Freshwater wetlands. [online] Available at: https://www.environment.nsw.gov.au/threatenedspeciesapp/VegFormation.aspx?formationName=Freshwater+wetlands [Accessed 8 Apr. 2022].
[90]Hotspots Fire Project. (n.d.). Fire Management Plan - Vegetation Types. [online] Available at: https://hotspotsfireproject.org.au/fire-management-plan/vegetation-types#:~:text=Wet%20Sclerophyll%20Forest%20(grassy%20sub%20formation)&text=Appropriate%20fire%20frequencies%20for%20this [Accessed 29 Mar. 2022].

Clockwise from left: Montane Bog. © Ian Brown BMNature., Coastal Heath Swamp. © Ian Brown BMNature., *Hakea teretifolia subsp. teretifolia* (Dagger Hakea). Credit Margaret Donald – Flickr., Coastal Freshwater Lagoon. © Ian Brown BMNature.

(Fern-leaved banksia), *Callistemon citrinus* (Crimson bottlebrush), *Dampiera stricta* (Blue dampiera), *Bauera rubioides* (River rose), *Baumea articulata* (Jointed twig-rush), *Xanthorrhoea fulva* (Grass tree) and *Lepyrodia scariosa.*

Occurs on the coast south of Old Bar and between Hawks Nest and Blueys Beach. Like Montane Bogs and Fens, Coastal Heath Swamps are found in poorly drained head water valleys and dune swales. These swamps are found on infertile peats and soils, unlike Montane Bogs.

Fire intervals minimum 10 years and maximum 35 years[84,85]

Coastal Freshwater Lagoons

Dominated by species like *Melaleuca quinquenervia* (Broad-leaved paperbark), *Viminaria juncea* (Golden Spray – native broom), *Lepidosperma concavum* (Sandhill sword-sedge), *Villarsia exaltata, Carex fascicularis* (Tassle sedge), *Philydrum lanuginosum* (Frogsmouth), *Eleocharis sphaecolata* (Tall spike sedge) and *Hypolepis muelleri* (Ground fern).

Coastal Freshwater Lagoons are found in low lying areas in coastal sand sheets and floodplains with water consistently present. In the Mid Coast region, this vegetation class occurs in patches near Forster, Mungo Brush and Myall Lakes, Myall River near Wanderrabah Beach and Booral.

Threatened species which can be found in these vegetation formations include:

Euphrasia ciliolate (Polblue Eyebright - only found around the Barrington Tops National Park for the Mid Coast region)

Lindernia alsinoides (Noah's False Chickweed)

Maundia triglochinoides

Estuarine and Saline Wetlands

Like Freshwater Wetlands, Saline Wetlands are permanently or temporarily flooded with water. The difference between the two vegetation formations is that Saline Wetlands (as the name suggests) contain varying levels of salt. Most plants can't survive salt concentrations in soil above 0.1% by weight. Saline Wetlands can experience soil concentrations between 3 and 27%[91]. The plants present in this formation have adapted these concentrations to survive, as well as having features that help reduce water loss to prevent the need to uptake saline water.

[91]NSW Environment, Energy and Science. (n.d.). Saline wetlands. [online] Available at: https://www.environment.nsw.gov.au/threatenedspeciesapp/VegFormation.aspx?formationName=Saline+wetlands [Accessed 1 May 2022].



From left:
Very mature Grey and River Mangrove Forest. Photo credit Jessica Leck.
Burn impacted mangrove system. The system is regenerating through seedlings that have come in on the tide and are covering the ground, and through epicormic growth on the mature Grey Mangroves. Photo credit Jessica Leck.
Saltmarsh at Port Stephens. Credit Hunter Local Land Services.

Saline Wetlands provide important habitat and breeding grounds for aquatic and bird life, including numerous threatened species. This vegetation formation is sensitive to fire, and it is recommended that fire should be excluded where possible[84,85].

For the Mid Coast, there are two Saline Wetland vegetation classes that can be found. To identify Saline Wetland vegetation classes, use the dominant species found within them. These include:

Mangrove Swamps

Dominated by species like *Avicennia marina* (Grey mangrove), *Aegiceras corniculate* (River mangroves), *Excoecaria agallocha* (Milky mangrove), *Samolus repens* (Creeping brookweed), *Sporobolus virginicus* (Sand couch), *Suaeda australis* (Seablite) and *Sarcocornia quinqueflora ssp. quinqueflora.*

Mangrove Swamps can be found around Old Bar, Forster and Hawkes Nest. They occur in areas subject to frequent tidal flooding on mudflats in coastal estuaries.

Saltmarshes

Dominated by species like *Sclerostegia arbuscula, Zoysia macrantha* (Prickly couch), *Sporobolus virginicus* (Sand couch), *Sarcocornia quinqueflora ssp. Quinqueflora, Apium prostratum* (Sea celery), *Baumea juncea* (Bare twig-rush) and *Triglochin striata* (Streaked arrowgrass).

Small soaks that receive salt spray on exposed headlands or hypersaline estuarine mudflats subject to occasional tidal flooding are areas where you can find Salt Marshes. Within the region, Salt Marshes are found around Old Bar, Forster and Hawks Nest.

Currently, within the Mid Coast there are no threatened plants listed in these vegetation classes and formation.

Threatened Animal: Eastern Curlew, *Numenius madagascariensis.*

This critically endangered bird is easily identified with its long, down curved black bill. The Eastern Curlew is found in intertidal mudflats, saltmarsh, coastal lakes and estuarine habitats. It roosts amongst coastal vegetation like mangroves and low salt marsh, making this vegetation formation important to the survival of this bird. Excluding fire from Saline Wetlands as recommended is very important and will allow coastal vegetation to continue to grow and survive, supporting the Eastern Curlew in the process.

Eastern Curlew. © Chris Burn – Flickr.

Fire and Threatened Plant Species

Much like general plant responses to fire, threatened plant species and Endangered Ecological Communities (EECs) can have mixed responses to fire. These responses are driven by species or community sensitivity to fire, whether fire and disturbance is required for germination, or particular fire aspects of a fire regime like frequency and the season in which a fire occurs. The timing of a fire is potentially critical to flowering, germination and seedling establishment, which is particularly important for threatened species.

Understanding what threatened plants and communities are in your area will help guide how you conduct fire management your property. By exploring resources like the Trees Near Me app to identify what vegetation formations are on your property, or by speaking with a local threatened species specialist, you can work out what threatened species or EECs may occur on your property. From here you can begin to understand the fire requirements or sensitivities of those species and EECs in your area.

In the Mid Coast, there are the following Endangered Ecological Communities (not including individual threatened plant species some of which are listed in the 'Vegetation Formations and their Fire Regimes' section):

Sub-tropical Lowland Rainforest
- Littoral Rainforest
- Lowland Rainforest
- Coastal Saltmarsh
- Swamp Sclerophyll Forest on Coastal Floodplains.

For more information on what threatened species and EECs are in the Mid Coast region, use 'Bionet' on the NSW Office of Environment & Heritage website or contact Mid-Coast Council.

Refer to the 'Planning to use Fire as a Land Management Tool' section for information on how to protect threatened species during prescribed burns.

Weeds and Their Response to Fire

Invasive plant species impact the biodiversity and health of ecosystems and threaten the survival of plants and animals[92]. Weeds are opportunistic and take advantage of the increase in resources and space after a fire, placing more pressure on the recovering native vegetation. They also can alter nutrient cycling, fire regimes, fauna movements and soil health[93].

Whilst fire can contribute to the establishment weeds, it may also be advantageous for the landscape and land managers when used as a tool or opportunity.

Advantages of fire for weed management include:
- improved site access
- flushing weed seed banks to allow for treatment (many weeds are sensitive to fire)
- suppressing growth or killing weeds
- trigger native seed bank and regeneration
- many weeds germinate more quickly than natives, and this can be used to carefully control them prior to native germination (timed control)
- exposing underground tubers to make them easier to treat[92].

The potential impact of invasive species in response to fire varies based on environmental and landscape factors. These include:
- fire regime
- weather and climate of the area
- the condition of the vegetation and area before a fire occurs – how healthy or resilient is the native vegetation
- wildlife movements – animals can help spread seeds around
- the diversity and number of weeds present in the landscape
- whether weed control is conducted or not[94].

Weed control can incorporate prescribed burns or targeting an area post bushfire, however a combination of different, targeted techniques is required to achieve good restoration outcomes[94], and is referred to as Integrated Weed Management.

[92]Australian Association of Bush Regenerators. (2020). Assisting recovery of weed-affected native vegetation. [online] Available at: https://drive.google.com/file/d/1brmYBCKoiNTyVius4-p8PZvos63k4eNm/view?usp=sharing [Accessed 11 Apr. 2024].
[93]Weidlich, E.W.A., Flòrido, F.G., Sorrini, T.B. and Brancalion, P.H.S. (2020). Controlling invasive plant species in ecological restoration: A global review. Journal of Applied Ecology, 57(9), pp.1806–1817. doi: https://doi.org/10.1111/1365-2664.13656.
[94]Graham, M., McShea, K., Taylor, K., Foreman, K. and Cramp, J. (2017). The interaction between fire and weeds: A booklet for NSW landholders. 2nd ed. [online] Available at: https://nrmregionsaustralia.com.au/wp-content/uploads/2020/01/fire-and-weeds-landholders-bookletfinallr.pdf.

When considering fire as a weed management tool, it is important to remember for long term success you must consider all reproductive structures, both vegetative (tubers, crowns, nodes) and sexual (seed bank), whilst being mindful that fire too frequently will cause additional management issues, such as erosion and loss of native seed bank.

Annual weeds commonly regerminate en masse after fire. They typically produce copious volumes of seed and are fast growing. For annual weeds, it's good to aim to reduce the re-establishment of them by depleting the seedbank and reducing the volume of weedy plant material. Ongoing restoration of the native ecosystem will be necessary, such as establishing a healthy canopy, to avoid future establishment. Remember, annuals will often die off on their own when the native ecosystem is healthy, and in the meantime they may provide erosion control. Post-fire control of annual weed flush may however, be necessary to enable native species to re-establish an area. It is important to assess each situation and adapt your post fire management accordingly. Prioritisation of weed control efforts will be necessary on large sites.

For perennial weeds, we aim to remove the existing seedbank, remove vegetative mass and prevent new seed sets. Fire can be a useful tool in the removal of vegetative mass and allow access for ongoing control of these species, however the intensity needed to kill established plants (Lantana) may be higher than preferred in typical prescribed ecological burns.

If you have problematic weed loads on your property and are interested in control options, get in touch with your Local Landcare Coordinator, Council Weeds Officer or Local Land Services team for specific advice.

Post fire vines, Cooplacurripa.

3. Animals and Fire

Animal Responses to Fire

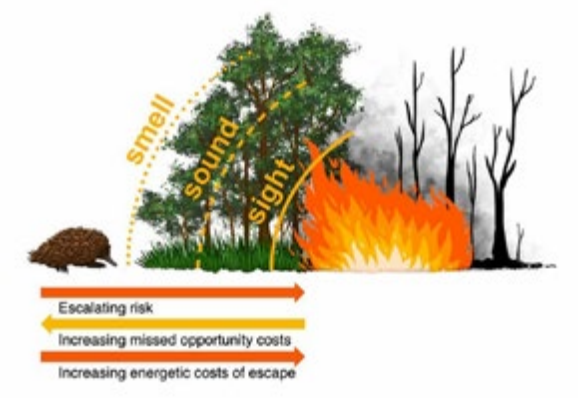
Following fires, the welfare of wildlife is often a common concern and common headline. Whilst it is true wildlife carers experience an influx following fire, research shows that in normal conditions (not catastrophic), animals are far more resilient to fires that we have previously thought. The ways animals respond to fire depends on:

- the availability of their habitat requirements, such as refugia, resources and shelter
- the natural fire regimes they have evolved with in preferred habitat types
- the behavioural, physiological and morphological traits of the animal[95].

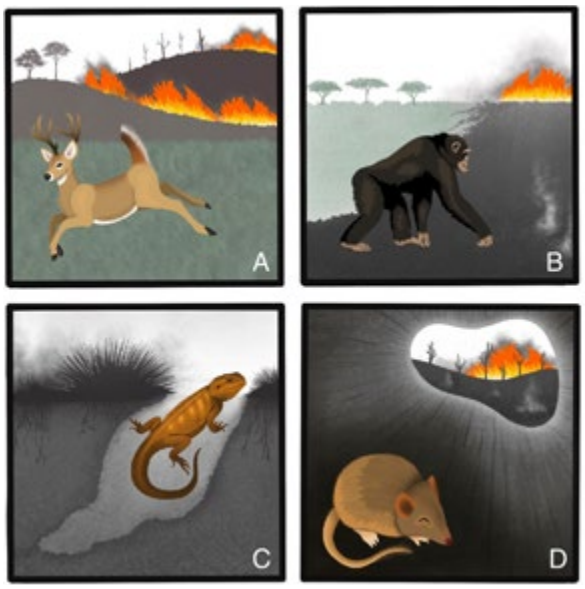
Considering these, it is clear that the healthier and undisturbed and ecosystem is, the more resilient native fauna populations will be to fire disturbance. Saying that, fire can be a significant driver of population dynamics in animals, and therefore understanding how animals respond to fire is important.

Fire Avoidance Behaviours

Animals can use a range of cues that a fire produces, like the visual smoke cloud or plume, the sound of the fire crackling or the smell of smoke, to help them sense a fire early. These cues relate to their senses; smell, hearing and sight, and trigger them to respond to ensure their survival. These survival responses can be called "fire-avoidant behaviours". In many cases, wildlife will signal an approaching fire long before humans could naturally know about it.



Cues animals use to respond to fire and how that impacts their chance of survival[95].



Types of fire-avoidance behaviours in animals[96].

In line with the National Environmental Science Program (NESP) Threatened Species Recovery Hub's Research finding factsheet (2021), the most common fire-avoidance behaviours are:

- immediate evacuation - from a fire front
- doubling back into a fire front - to find refuge in the safety of burned areas
- delayed evacuation – finding refuge temporarily and then evacuating (leaving in the days following a fire, once the risk had passed)
- sheltering in place - whereby animals find long-term refuge within the fire area until the landscape begins to recover.

When practicing burning on private property, it is important to be aware of these potential behaviours, and plan for wildlife being present in any burn. This should be a consideration not only for the wildlife and their ease of access, but the WHS risks associated with encountering stressed wildlife.

[95]NESP Threatened Species Recovery Hub. 2021. Animal behaviour and mortality during fire, Project 8.3.4 Research findings factsheet. [online] Available at: https://www.nespthreatenedspecies.edu.au/media/5qilomfo/8-3-4-animal-behaviour-and-mortality-during-fire-findings-factsheet_v2.pdf [Accessed 26 Mar. 2024].
[96]Nimmo, D.G., Carthey, A.J.R., Jolly, C.J. and Blumstein, D.T. (2021). Welcome to the Pyrocene: Animal survival in the age of megafire. Global Change Biology, 27(22), pp.5684–5693. doi: https://doi.org/10.1111/gcb.15834.

The Use of Fire Refuges

For species that choose to either delay evacuation, or those that choose to shelter in place, they require fire and temperature resilient habitat features, called refugia. Short and long-term refuges found in fire-prone landscapes are described as habitat features throughout an area that facilitate survival and/or the persistence of animals in the face of a fire that would otherwise result in displacement or mortality[97]. Fire refugia can be separated into two categories:

non-flammable – eg. rock crevices, burrows, creeks or deep pools

flammable – eg. large logs, hollows and wet gullies.

Prey species use torpor (defined at the front of the booklet), an energy saving mechanism, when there is low food availability and during winter. This survival strategy has recently been found to be used as a response to fire[98]. Stawski et al. (2015) state that terrestrial mammals like the brown antechinus (Antechinus stuartii), found in NSW and the Mid Coast, use torpor to reduce foraging requirements and to moderate their predator risk[98].

These key habitat features in any landscape are becoming increasingly scarce as humans continue to modify the landscape. Ensuring habitat features are protected on your property is a key action you can take in your fire preparation to aid wildlife in the event of a fire.

Mortality

The mortality of animals during a fire is a result of their mobility, the intensity of the fire and how well adapted to fire they are. Higher proportions of animals die in high intensity fires, compared with low intensity fires[99]. Globally, a meta-analysis of animals monitored during wildfires found an average mortality of less than 3% during normal fire conditions[100].

Animals using fire-avoidant behaviours and heat refugia often survive fire initially. However, when exposed to intense, fast-moving bushfires that burn into the canopy and produce extreme levels of heat, animals have lower survival rates.

Animals that live in landscapes that rarely experience fire lack traits that help them detect and respond to an approaching fire. This lack of understanding around fire risk is called "fire naivety"[95]. Climate change is impacting how animals respond in this way, as fire is occurring in landscapes that aren't fire prone which means these species won't have evolved with fire.

Post Fire Response

Surviving a fire front is only part of the challenge for animals when it comes to responding to a fire event. Immediately following a fire, depending on the intensity, animals may face reduced amount or lack of water, food and shelter, whilst concurrently exposed to increased predation risk[101].

If species responses are considered past the immediate impact of fire and for more than a few years following it, it is clear that different species may benefit at different time points after a disturbance like fire[99]. Fire can trigger new plant growth as the landscape recovers. This may provide food for herbivores. Fire may also alter habitat structure which can influence predation patterns[100].

Post Fire Predation Response

For predators in a landscape, fires are an excellent feeding opportunity. Fires can affect predator-prey interactions, either by:

providing enhanced foraging opportunities for predators

reducing the number of predators through injuring or killing them

altering and reducing habitat for prey which impacts predation rates – less areas to hide often results in higher predation

[97]Leonard, S. W. J., Robinson, N. M., Bassett, M., Chia, E. K., Ritchie, E., Buckingham, S., Murphy, N., Gibb, H., Schofield, J., Gibson, M., Bennett, A.F. & Clarke, M. F. (2014). Refuges for flora and fauna in fire-prone landscapes. La Trobe University, Melbourne.
[98]Stawski, C., Körtner, G., Nowack, J. and Geiser, F. (2015). The importance of mammalian torpor for survival in a post-fire landscape. Biology Letters, 11(6), p.20150134. doi: https://doi.org/10.1098/rsbl.2015.0134.
[99]Community Bushfire Connection. (n.d.). Effects of fire on animals. [online] Available at: https://www.communitybushfireconnection.com.au/ecology/effects-of-fire-on-animals/ [Accessed 26 Mar. 2024].
[100]Jolly, C. J., Dickman, C. R., Doherty, T. S., van Eeden, L. M., Geary, W. L., Legge, S. M., ... & Nimmo, D. G. (2022). Animal mortality during fire. Global Change Biology, 28(6), 2053-2065.
[101]Doherty, T.S., Geary, W.L., Jolly, C.J., Macdonald, K.J., Miritis, V., Watchorn, D.J., Cherry, M.J., Conner, L.M., Gonzàlez, T.M., Legge, S.M., Ritchie, E.G., Stawski, C. and Dickman, C.R. (2022). Fire as a driver and mediator of predator-prey interactions. Biological Reviews of the Cambridge Philosophical Society, [online] 97(4). doi: https://doi.org/10.1111/brv.12853.

altering how prey species forage and source food and water – less resources available and more competition for them will change how prey move around[100].

The abundance of a predator species in burnt areas can be determined by their hunting[102]. Species that rely on cover and habitat for stalking and ambushing prey are likely to be less common in burnt areas, whereas pursuit-type species i.e. fire hawks, that rely on open areas to hunt benefit from fire and resulting burnt areas.

Fire hawks, named by Indigenous Australians, are drawn to fire and use it as a way to capture their prey[103].

Herbivory Response Post Fire

Post fire landscapes, often have increased levels of nutrients, increased access to sunlight and less competition, and therefore promote germination and resprouting responses from plants when supported by sufficient post fire precipitation[104]. Plant growth following a fire is often more palatable, of high nutritional quality and the species that herbivores like tend to be more common[105]. For this reason, herbivores are often drawn to freshly burnt areas and this pattern of behaviour is called the "magnet effect[104]."

Herbivores have been shown to have positive and negative impacts on a post fire landscape. Selective foraging can alter the diversity and structure of a vegetation community, increasing heterogeneity which is needed for a healthy ecosystem[104]. Alternatively, increased foraging in an already disturbed and recovering landscape puts more pressure on plants and may prolong their recovery[106].

Response of Pest Species to Fire

After a fire, pest species can place a greater strain on the recovering landscape and associated native species that are already experiencing challenges.

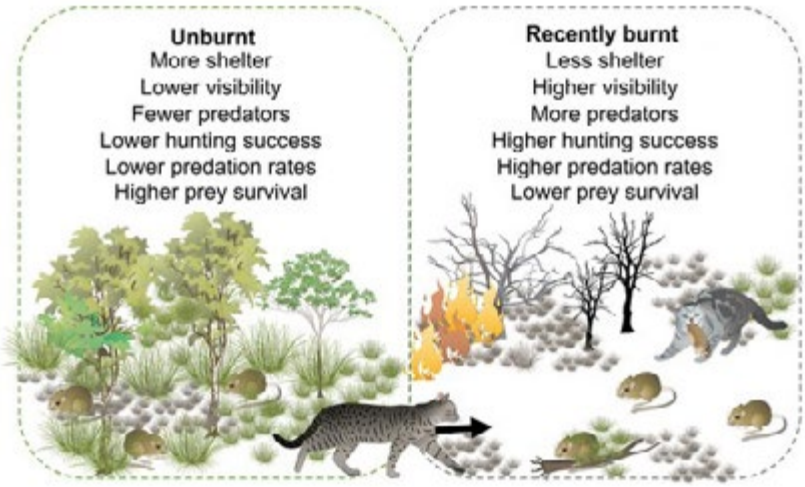
Feral cats and foxes are drawn to recently and severely burnt areas[107] to take advantage of reduced vegetation cover and stressed or fatigued prey. Therefore, native prey species, small mammals in particular, are threatened by this increased predation risk after a fire.

Introduced herbivores like rabbits can put added strain on recovering vegetation in a post firelandscape because they can prevent successful regrowth and help to spread weeds[108]. Also, these pests can out compete our native herbivores for resources putting pressure on these already impacted populations[106].

[102]Hovick, T.J., McGranahan, D.A., Elmore, R.D., Weir, J.R. and Fuhlendorf, S.D. (2017). Pyric-carnivory: Raptor use of prescribed fires. Ecology and Evolution, 7(21), pp.9144–9150. doi: https://doi.org/10.1002/ece3.3401.
[103]John, J. (2018). Australian 'firehawks' use fire to catch prey. [online] The Wildlife Society. Available at: https://wildlife.org/australian-firehawks-use-fire-to-catch-prey/.
[104]Westlake, S.M., Mason, D., Adrià Làzaro-Lobo, Burr, P., McCollum, J.R., Chance, D.M. and Lashley, M.A. (2020). The magnet effect of fire on herbivores affects plant community structure in a forested system. Forest Ecology and Management, 458, pp.117794–117794. doi: https://doi.org/10.1016/j.foreco.2019.117794.
[105]Cherry, M.J., Warren, R.J. and Conner, L.M. (2017). Firemediated foraging tradeoffs in whitetailed deer. Ecosphere, 8(4). doi: https://doi.org/10.1002/ecs2.1784.
[106]NESP Threatened Species Recovery Hub. 2021. Managing herbivore impacts after mega-fires Project 8.4.3 Research findings factsheet. [online] Available at: https://www.nespthreatenedspecies.edu.au/media/z5ldwkop/8-4-3-managing-herbivore-impacts-after-mega-fires-ff_v2.pdf [Accessed 1 Apr. 2024].
[107]NESP Threatened Species Recovery Hub. 2021. Conserving Australia's threatened native mammals in predator-invaded, fire-prone landscapes, Project 1.3.2 research findings factsheet. [online] Available at: https://www.nespthreatenedspecies.edu.au/media/aazhfkta/1-3-2-conserving-australia-s-threatened-native-mammals-in-predator-invaded-fire-prone-landscapes-ff_v5.pdf [Accessed 1 Apr. 2024].
[108]Department of Energy, Environment and Climate Action. (2021). Managing invasive species after fire. [online] Available at: https://www.environment.vic.gov.au/invasive-plants-and-animals/managing-invasive-species-after-fire.

Patch or Mosaic Burning for Animal Diversity

Small-scale mosaic burning is the term used to burn small patches throughout a landscape over time, rather than a single, large-scale fire. For wildlife, this practice maintains a high degree of habitat variability, such as vegetation age diversity, species diversity and supports the development of habitat features such as logs and hollows.



The success of introduced species like feral cats usually increases after a fire[101].

For some species, access to this age diversity, and the resources it provides, can be critical for the life history of an individual. For example, the desert hopping mouse utilizes multiple post fire resources. They may need fresh germinating grasses for bedding; the seed from flowering grasses 1-2 years post burn; the hummus layer for both shelter and access to invertebrate prey. For all of these resources to be found within an individual's home range, patch diversity becomes a vital aspect of the ecology of this habitat. This single example demonstrates the importance of patch diversity in an individuals home range, suggesting the complexity needed to support whole ecosystems.

Further, age class variation is critical to support the full species diversity of an area. One species may prefer the open canopy and dense midstory of a mid-succession ecosystem, while another may prefer the mature forest formation, with a closed canopy and sparse midstory typical of a climax community at the end of its succession process. For both species to continue to exist within an area, habitats in both stages of recovery are required to be present at all times. Mosaic burn patterns ensure the presence of both species continuously, rather than local extinctions experienced in large scale burn regimes when suitable habitat is outgrown through the succession process[109].

Squirrel gliders (Petaurus norfolcensis) require old growth forest including tree hollows. Consider the habitat and food requirements of your local animals, particularly threatened species like these two when carrying out fire management actions like prescribed burns and bushfire preparation. (Threatened Species - NSW Environment, Energy and Science. (2017). Squirrel Glider - profile. [online] Available at: https://threatenedspecies.bionet.nsw.gov.au/profile?id=10604# [Accessed 12 Sep. 2024].)

[109]Kelly, L. T., Nimmo, D. G., SpenceBailey, L. M., Taylor, R. S., Watson, S. J., Clarke, M. F., & Bennett, A. F. (2012). Managing fire mosaics for small mammal conservation: a landscape perspective. Journal of Applied Ecology, 49(2), 412-421.

Fire and Threatened Animal Species

The impacts of fire and needs of our threatened animal species are important to understand so we can factor these into our prescribed burning process and bushfire response. Fire behaves differently during a planned burn and usually spreads slowly enough that it allows animals to move away or seek refuge elsewhere.

Examples of how some of our threatened species interact with fire (bushfire and prescribed burns) includes:

- Quolls need woody debris for nesting so we should exclude or protect these when carrying out a prescribed burn, and bushfires can assist in creating this habitat
- Koalas need age and species diversity in eucalyptus feed trees and weed loads can limit movement. Prescribed burns influence both factors
- Some threatened birds need small patch mosaics to stimulate flowering/seed/fruiting in feed species. Insectivores benefit from the gaps in the canopy (increases light/flowering/insect activity) from small fires.

Using tools such as the Atlas of Living Australia can be useful to understand what species you have on your property and allow you to better research the needs of these specific species.

Scan QR code for Atlas of Living Australia

Parma wallabies (Notamacropus parma) like to shelter in thick, shrubby understorey and feed on nearby open, grassy areas (Threatened Species - NSW Environment, Energy and Science. (n.d.). Parma Wallaby - profile. [online] Available at: https://threatenedspecies.bionet.nsw.gov.au/profile?id=10501)

4. Planning for Fire on Your Property

The Mid Coast is a fire prone region. Trying to exclude fire from the area and your property is not practical. Using fire strategically to manage the protection of both property and local biodiversity is the best approach we can take to living with fire in this region.

Landholders have traditionally identified their property's assets as their houses and other buildings, the productivity of the space, and the land itself. This way of thinking does not, however, consider the native vegetation and wildlife that live there to also be assets. Effective fire management that addresses fire related challenges involves recognising wildlife and native vegetation as assets.

A Fire Management Plan is a good way for landholders to address objectives to protect all assets; life, property and biodiversity. When done correctly, fire management can be used for both bushfire preparedness and as a land management tool.

To do this effectively, it is critical to understand your property's vegetation, weather, climate, topography and history before burning. Generally speaking, good land management incorporates both bushfire preparation and active fire management, rather than trying to exclude fire.

This section covers general fire planning and using fire as a land management tool. For information on preparing for bush fire, use the NSW Rural Fire Service website, your local Fire Control Centre and/or refer to Appendix 6. By the end of this module, you should have a greater understanding of how to plan and conduct a prescribed burn and who to speak to if you need help.

General Fire and Planning

Identifying your Assets

An asset is a built, environmental or cultural item or part of your property that you'd like to protect.

For example:

- Built assets include:
  - A house, shed or other building
  - Power Lines
  - Fence lines
  - Gates
  - Fire trails, tracks or driveways
- Environmental assets include:
  - Water features like tanks, pumps or waterways
  - Areas with threatened species in them
- Cultural assets include:
  - Aboriginal places and items of significance.

Overall Fuel Hazard and Assessment Guide – 4th Edition (2010)

One of the most useful pieces of information you can use to help guide your decisions when planning for fire is understanding the Overall Fuel Hazard (OFH) across the different vegetation formations and classes. This can be done by reading and using the OFH Assessment Guide by Hines et al. (2010)[110].

The Stuttering Barred Frog (Mixophyes balbus) is associated with rainforest and wet sclerophyll forest and prefers areas that are undisturbed with thick canopy*. As a result, the Stuttering Frog is very sensitive to fire, so identifying whether you have threatened species like this on your property is important. That way you know what areas to exclude or protect when conducting your fire management actions. Credit: Aussie Ark.
*Clark, C. (2015). Stuttering Barred Frog. [online] Aussie Ark. Available at: https://www.aussieark.org.au/stuttering-barred-frog/.

[110]Hines, F., Tolhurst, K. G., Wilson, A. G., and McCarthy, G, J. (2010). Overall fuel hazard assessment guide. Victorian Government Department of Sustainability and Environment. https://www.ffm.vic.gov.au/__data/assets/pdf_file/0005/21110/Report-82-overall-fuel-assess-guide-4th-ed.pdf

Hines et al. (2010)[110] describes the purpose of the guide is to:

> Make a rapid, visual assessment of fuel arrangement; and
> Gain an understanding of how this will affect the chances of controlling a bushfire.

As explained in the guide, *"Each fuel layer is assessed simply and visually. Assessing the fuel takes only a few minutes and is based on the premise that the eye is better able to integrate local variations in fuel than systematic measurement. Each fuel layer is assessed in turn and given a hazard rating. Particular emphasis is placed on how the fuel is arranged within each of these layers. The hazard ratings are then combined to produce an Overall Fuel Hazard Rating that ranges from Low to Extreme".* (Hines et al., 2010, page 2).

Using the guide to help determine areas of greatest risk due to fuel hazard will assist you to make informed decisions about strategies and actions that will provide the most effective outcomes. For example, if you have an area of high value koala habitat trees that is surrounded by areas with very high or extreme fuels loads without any mineral earth break, then there is an increased risk of these assets burning in a destructive bushfire.

Therefore, you may decide to focus time and resources in your fire management plan to reduce this risk by establishing mineral earth breaks around the area and/or reducing the overall fuel hazard in targeted areas using mechanical mulching and/or planned burning.

Fuel Moisture

As we know, fire and the associated risks are determined, in part, by the volume, arrangement and moisture content of the fuel on the fire ground. The Fuel Moisture or the Crunch Tests are helpful ahead of prescribed burns, and ahead of bushfire season to see just how dry the vegetation is on your property.

The leaf moisture method involves:
A sample leaf or piece of bark (dead) should be taken from above and below the surface of the litter layer. Shelteredfrom any wind, light the end of each leaf, starting with pointing the tip of the leaf or bark down (be careful when lighting the leaf or bark). Rotate the leaf from pointing down to pointing upright and observe how the flame behaves.

The aim is to discover the angle at which a small flame either goes out or flares up – holding the leaf or bark at different angles simulates slope.

This exercise informs you about the availability of the fuels on your property and how a fire may behave in your landscape.

The other way to test the moisture in your fuel or its flammability is a scrunch test. Scrunch or grind a leaf in your hand. If the leaf is:

> dry and crumbly, and leaves your hand dusty, this indicates the fuel is dry and has a high flammability
> flexible and moist leaving your hand feeling a bit wet or dirty, this indicates a higher moisture level and lower flammability.

This information, coupled with your new knowledge on fire regimes, your property's vegetation formations and your assets, ensures you are well equipped to begin your bushfire planning and preparation in the most informed and ecologically sensitive way.

Planning to use Fire as a Land Management Tool

While preparing and responding to bush fires is a critical part of land management, it is only one part. In Australian landscapes which have evolved with 'regular' fire, present day land management requires facilitating 'regular' fire to continue. We can do this through prescribed burning, which can help to reduce parts of bush fire risk, whilst supporting biodiversity and land management goals. (Note: the specifics of 'regular' fire are based on the objective for management and the species present.)
For many landholders, the concept of burning on their property can be an intimidating step to take in active land management and as a result, fire suppression continues to be the preference. Given the preparation, skills and challenges of navigating legislation, this is understandable.

This information booklet, and local land management agencies like the Rural Fire Service, Landcare, Council and Local Land Services are available to support landholders in this process.

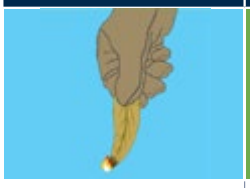
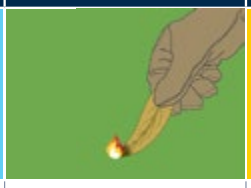
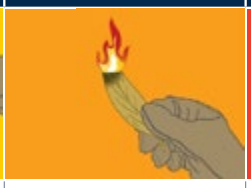
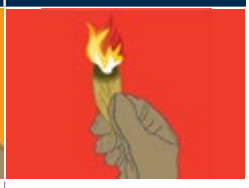
Types of Prescribed Burns

When thinking about planned burns, the types of burns can be separated into two categories; Indigenous and Western Land Management.

- Aboriginal Land Management
  - Cultural burning
- Western Land Management
  - Ecological burning
  - Hazard reduction burns
  - Agricultural burns

When considering these burns, it is critical to understand that the difference between the types of prescribed burns comes down to the objective, not always the process or the outcomes of the burn. A burn can have overlapping outcomes but the ***objective*** is what drives the burn and the prescription. For example, an ecological burn has an ecological objective, like using fire as part of weed management. The burn however will likely achieve some fuel reduction, therefore meeting some hazard reduction outcomes.

Landholders discussing with a bushfire consultant, the risk of high fuel loads, particularly hanging bark, and how that may impact the containment line of a prescribed burn.

Wet	Damp	Moist	Dry	Very dry
				
Leaf burns only when pointed straight down or does not burn at all	**Leaf burns when angled down but not when level**	**Leaf burns when level but not when angled up**	**Leaf burns when angled up, but not if vertical**	**Leaf burns when angled straight up**
If in the area to be burnt, the fuel is too moist to burn	If the leaf sample is from the: **Top layer** The fire will burn slowly **Bottom layer** The fuel moisture is okay Fires with damp fuels tend to need the wind and/or a slope to spread	If the leaf sample is from the: **Top layer** The fire will burn at the upper level of intensity for a burn **Bottom layer** The fuel moisture is okay	If the leaf sample is from the: **Top layer** The fire will burn at too high an intensity for a burn **Bottom layer** The fuel is too dry to perform a burn	The fuel is too dry to burn
Recommendations				
Postpone planned burn until moisture levels drop	Proceed with planned burn	Proceed with planned burn, but exercise caution	Do not proceed with planned burn	Do not proceed with planned burn

Fuel Moisture Leaf Test diagram[11]

[11]Burn SMART Leaf moisture method. (2021). Bushfire Centre of Excellence, Department of Fire and Emergency Services. https://www.dfes.wa.gov.au/documents/BurnSmart_LeafMoistureMethod_2021.pdf

Aboriginal Land Management – Cultural Burning

The earlier section in this workbook explains the concept of Cultural Burning as part of Aboriginal Land Management, written by First Nations man Shaun Hooper. Please refer to this section for an in-depth explanation of the importance, intricacies and definitions of the practice.

For Western land managers, it is important to understand that Cultural Burning is not necessarily a pathway for you to achieve your ecological objectives. Where Western land managers engage cultural leaders to conduct a burn, this may be referred to a Cultural Informed burn.

Cultural burns are instigated and delivered by First Nation community members for any number of cultural reasons. This may have overlapping outcomes to other types of burns, but is independent in purpose, managers and practice.

Cultural Burning in the Hunter

As per Hunter Local Land Services 'Supporting Aboriginal Land Management' information booklet, their unique Cultural Fire Management Program is demonstrating the opportunities provided by cultural burning at various scales, locations, vegetation types and land tenures. This program is the first of its kind and is unique as it is tailored to the Hunter vegetation types whilst also restoring knowledge and practices that have been missing from the landscape for over 200 years.

As part of the program, Hunter Local Land Services supports the local Aboriginal community.

For more info on the program and Aboriginal Land Management, scan the QR code.

Ecological Burns

Traditionally, when we think about fire management we think about hazard reduction and fire fighting techniques like back burning[112]. While some hazard reduction burns will have ecological benefits for an area, most don't, and their planning is based around safety rather than biodiversity conservation. This is why good fire management is made up of components including ecological burns or hazard reduction burns planned with ecological needs considered. The aim of ecological burns is to restore fire in ecosystems where it has been absent, where fire regimes haven't been appropriate and to protect fire-sensitive flora and fauna[113].

It's important to not confuse ecological burns with Cultural Burning. While many of the ecological burning techniques are adapted from cultural burning practices, it is important to clarify the difference between the two. Cultural Burning is burning conducted by people of culture on Country for a range of cultural practices and priorities. These may include ecological outcomes but this is not the sole objective.

Ecological burns are designed with botany and ecological priorities in mind. They range in intensity, because different ecological objectives require different temperatures and intensities. In vegetation classes where it's required, these burns can be hot enough to trigger fire dependent plant species[27], or mitigate weed incursions.

Whereas in other cases, ecological burns can reduce fuel loads to protect fire sensitive animals and plants. To protect structural integrity and diversity of an area, ecological burns are carried out in mosaic, or patch, type fashion to mimic natural fire regimes[114].

A prescribed burn occurring on private property. Burn is low in temperature as indicated by the scorch height on the trees. Credit Isabelle Strachan.

[112]AFAC (2015). Overview of prescribed burning in Australasia. Report for the National Burning Project – Subproject 1. Australasian Fire and Emergency Service Authorities Council Limited. March 2015.
[113]Primer on Fire Ecology. (n.d.). [online] Nature Conservation Council of NSW. Available at: https://assets.nationbuilder.com/natureorg/legacy_url/2809/fire-ecology-primer-v2-oct2015.pdf?1630462737 [Accessed 1 May 2022].
[114]Kenny, B., Sutherland, E., Tasker, E. and Bradstock, R. (2004). GUIDELINES FOR ECOLOGICALLY SUSTAINABLE FIRE MANAGEMENT. [online] NSW Biodiversity Strategy and the NSW National Parks & Wildlife Service. Available at: https://www.environment.nsw.gov.au/resources/biodiversity/FireGuidelinesReport.pdf [Accessed 23 Mar. 2022].

The frequency of ecological burns in an area is dependent on the individual plant and animal species that are present there. For example, Mid-Coast Council has recently worked with NSW Department of Environment to undertake burning on a Council-managed reserve to improve habitat for the critically endangered Pale Yellow Doubletail Orchid (*Diuris flavescens*).

Some orchid species can be classed as fire stimulated or fire dependent, and *Diuris flavescens*, commonly known as the Pale Yellow Doubletail Orchid is a fire stimulated species found in the Mid Coast region.

Hazard Reduction Burns

The primary objective of hazard reduction burns is to protect lives, property, and other critical assets. Landholders conducting burns on private property are generally required to obtain a Hazard Reduction Certificate (HRC). Currently, this is the standard process for all Western land management burns; however, it was originally designed with hazard reduction burns in mind.

This approach to fire management is evolving as the natural environment is increasingly recognised and valued as an asset that also requires protection. This shift has introduced some confusion, particularly regarding approval pathways, which will be discussed in a later section. Given the rapidly advancing knowledge of western land managers in this field, related policies and procedures are expected to continue evolving in the coming years.

Factors to Consider in your Planning

Patch Size

Ideal size of patch is a common question landholders have when planning an ecologically sensitive prescribed burn. Whilst there is no single answer, two key considerations are:

What is your level of comfort and experience? Start as small as you are comfortable with. If you have not applied fire on your property before, there is no minimum size. One square metre will build your confidence in understanding how applied fire moves when applied to your property and is a fine place to start. For those more comfortable, a guide of not burning more than 30% of any one vegetation formation at a time and allowing one third of the maximum fire regime period between patches burnt, can be a good guide, but is highly dependent on the vegetation formation, overall patch size and fire history of the area.

Control Lines

Control lines are a break in vegetation and fuel to prevent the continuous spread of fire. They aim to provide access to a burn, a perimeter from which to light a burn and/or an opportunity to contain a burn. They may consist of natural features such as water courses and waterbodies, constructed features such as driveways or may need to be specifically constructed. The maximum width of a control line must not be wider than 4m, unless the vegetation is classed as 'Heathland' (as per vegetation formation classifications), where controls lines can be up to 6m in width.

When planning a burn, we want to utilise the lines we already have, such as driveways, roadways, tracks and trails, fence lines. We are not trying to further fragment our vegetation, so wherever possible, utilizing these existing assets saves both resources and potential future impacts. If control line construction involves the removal of native vegetation, make sure appropriate environmental approvals have been given. Check with RFS, Local Land Services and Council before implementing or for more information on control lines.

Water Supply

Make sure you have an appropriate water supply on the fire ground, 2 units/vehicles for each burn edge at a minimum. You can use portable sources like a 1 cubic metre pod on a trailer or ask your local brigade and they may bring some water sources. Large tanks and dams can also be used as refill points during the burn.

Only light what you can extinguish with the vehicles and water resources you have on the fire ground. Burn like you don't have any water – you can always add more fire, but can't take it away.

Weather Conditions as recommended by RFS 'Standards for low intensity hazard reduction burning for private landholders'

Weather conditions are likely to fluctuate over the course of the day, and, the conditions to aim for during a burn will vary depending on the vegetation community within the prescribed burn area. Here are some weather conditions to help guide your planning:

Temperature should be **< 25C**. Remember usually peak between 2-3pm in afternoon.

Relative humidity should be at **50% and increasing.**

Wind speed should not go **over 15km** and aim for **wind direction** to be **consistent**

Prescribed burns **require stable atmospheric conditions**. Note – these conditions can lead to smoke being trapped and accumulating within the lower atmosphere, resulting in smoke haze and reduced visibility.

If you're unsure about what weather conditions you should be aiming for speak with your local fire brigade or Fire Control Centre.

Ignition and Fire Spread Patterns

When planning prescribed burns, it's crucial to consider both where the fire is ignited and how it will spread.

Spot Ignition: Using spot ignition with widely spaced spots allows for a slower build-up of fire intensity. However, when two separate fires meet, such as when two spot fires converge, a junction zone is created. This zone can significantly increase fire intensity at point[115].

Strip or Line Ignition: Igniting a planned burn using strips or lines of fire results in a much faster build-up of maximum fire intensity. This method can make the fire more difficult to control.

Assuming you have checked weather conditions (refer above for a guide) and relevant approvals have been granted (see Pathway for Burning on Private Property below for more guidance), you can begin. Take your time when burning, use spot ignition to burn a few metres along the uphill edge, then gradually work towards both sides, allowing the fire to burn inward toward the original edge. The goal is to burn the edges first, creating breaks or buffer zones that help confine the fire within the planned burn area.

Key Points to Remember:

Avoid igniting fires from the bottom of a hill upwards.

Ensure everyone involved is within your line of sight to prevent anyone from becoming trapped in the burn area.

WHS and Safety Considerations

See Appendix 5 for a QR code that outlines extensive WHS and safety considerations for conducting a prescribed burn.

Biodiversity (& Heritage) Conservation

When planning your burn, identify your environment (and heritage) assets as you would traditional assets. These include threatened species, habitat assets such as hollows or ground logs or fire sensitive species. This allows you to better prepare yourself and the burn areas.

Some ways to protect fire sensitive threatened species and other assets include:

consider the time of year/season to avoid wetting them before a prescribed burn

clearing around them to bare earth (using a rakehoe). For ground logs and hollows this will also reduce your chance of re-ignition risk

moving the burn area to exclude them.

For threatened species and Endangered Ecological Communities that are fire/smoke dependent, ensure you are burning in a mosaic pattern within the fire regime to support these species' continuation in the landscape.

[115]Fire Management. (2020). [online] Wisconsin Department of Natural Resources. Available at: https://cf-store.widencdn.net/.

Building Your Own Property Fire Management Plan

A Fire Management Plan for a property involves identifying all assets and then defining the management objectives from those. An adaptive approach to fire management is the best way to meet property and home protection objectives, as well as biodiversity objectives. Flexibility within a management plan allows opportunity for different vegetation formations and classes and the different fire regimes they require.

In terms of maintaining appropriate fire regimes for vegetation on your property, it's important to remember that both too-frequent and too-infrequent fires can have negative impacts on native vegetation. A good strategy with fire regimes is to vary the fire frequency over time and space to encourage and allow for the full range of species in an area.

Protecting different types of assets on your property at times will result in conflict. For example, the fire frequency intervals required to protect your property may be shorter than those needed to protect biodiversity. In such situations, advantages and disadvantages must be weighed against each other, and in some cases, tradeoffs will be required.

Prepare a Property Management Plan by following the steps below.

Equipment

You will need:

A3 or A2 satellite image of your property (preferably laminated for ease of planning)
pens or markers, we used these colours to match our legend (shown in Appendix 7): black, blue, purple, green and red
nail polish remover and tissues (to erase mistakes on laminated version)
plastic overlays to do more detailed planning if applicable

Print or view a satellite image of your property.
Add your knowledge to the map. Add in fire history known you to, with the year of the burn, along with vegetation formations. Other points to add include water assets, access points and potential containment lines.
Think about what management objectives you would like for your property. Write them down on your map.
Identify your fire management areas.
Firstly, identify areas that require asset protection such as buildings and infrastructure, cultural or heritage assets, or threatened species/ communities. Mark these as APZs.
Next, mark your other management areas. For example, areas that require a prescribed burn.
Identify the vegetation formations and classes that you have and label them accordingly.
Colour the different vegetation types as per the key found in Table 1: Fire intervals for each vegetation class within the Mid Coast region.
Check fire history for your area and see when and where past fires have occurred. Identify and mark areas of vegetation that haven't met recommended fire intervals in the past.
Develop future burn plans that will maintain areas of appropriate fire regimes, and gradually correct areas where there have been inappropriate fire regimes.
Engage your neighbours to try to coordinate complimentary burn plans as it's likely your vegetation classes span across more than just your property.
Monitor, record and review fires as they occur; planned or unplanned.
Survey how the vegetation responds to the fire events and adjust the fire management plan accordingly.

Pathway for Burning on Private Prop

Planning

Do you have an area in mind that you want to burn?

No → Consider an area around assets in lightly timbered areas or grass paddocks, using existing containment lines like driveways and fire trails.
Refer to Mid Coast 2 Top's online modules for advice on choosing your burn area.

Yes

Do you have an objective for your burn?

No → Refer to Mid Coast 2 Top's online modules to understand the different types of prescribed buns and what you might use them for.

Yes

Asset Protection, Hazard Reduction, Conservation and/or Agricultural

Yes

Aboriginal Land Management → Engage with your local Traditional Owners, found through Local Aboriginal Land Councils or Local Land Services to connect with local First Nations Fire Practitioners.

Approvals

Are you protecting an asset?

No → Contact your local Fire Control Centre for information on whether a HRC would be applicable.
If a Hazard Reduction Certificate (HRC) isn't an option, contact your Local Land Services and local Council to determine if:

- the burn can be undertaken as "Environmental Protection works"
- any requirements under the Environmental Planning and Assessment Act 1979 and/or Protection of the Environment Operations (Clean Air) regulations are required.

Documentation prepared by consultants may be required to support your application to burn.

Yes

You may need a Hazard Reduction Certificate. See QR code below for the application instructions and form.

Was your HRC Approved?

No

Yes

Australian Government
NSW Government
Landcare New South Wales
Mid Coast 2 Top Landcare Collective

PEOPLE LED PREVENTION PROJECT

Landcare NSW's People Led Prevention project empowers communities across regional NSW in developing disaster resilience and preparedness skills. Jointly funded by the Australian and NSW Governments.

Authors; Olivia Eglin, Duncan Scott-Lawson and Jessica Leck

erty in NSW

Eco Burn Education

Mid Coast 2 Tops Landcare Connection

Is it the Bush Fire Danger Period (usually 1st October - 31st March*)

Yes → **Do you have a Fire Permit?**

- Yes → **Is it a total fire ban day? Or, are permits suspended?**
- No → Apply for a Fire Permit by going online or contact your local Fire Control Centre. To find both websites, see the QR codes below.

No → **Has the EPA issued a No Burn Notice?** To check, see QR code below, or contact EPA on 131 555, or info@epa.nsw.gov.au.

- Yes → You are banned from lighting during this No Burn period. Contact EPA for more information.
- No → **Is it a total fire ban day? Or, are permits suspended?**
  - Yes → Contact your local RFS Fire Control Centre for more information.
  - No → No

**Check your regions Bush Fire Danger Period by contacting your local Fire Control Centre.*

Preparation

Have you established your planned control lines?

- No → Establish bare/mineral earth control lines using rake hoes, blowers or heavy machinery. Control lines are recommended to be wide enough for vehicle movement*. Use existing trails and roads where possible.
- Yes →

Have you got appropriate water appliances? Your should have a minimum of 4, two for each burn edge.

- No → Contact your local brigade for assistance or contact your local Fire Control Centre and fill in a brigade assist form. Alternatively, ask neighbours to share privately owned equipment.
- Yes →

Have you notified your neighbours and local fire authority?

- No → Call, text, email or letter drop to your neighbour(s) AND submit a notification form using the QR code below.
- Yes →

**The maximum width of a control line must not exceed 4m unless the vegetation is classed as "Heathlands" which may not exceed 6m.*

Congratulations. With the right conditions, you should be ready to burn!

RFS Fire Control Centre	Fire Permit Form	HRC Instructions	HRC Application form	Notify RFS of your burn form	LLS Environmental Protection Works	EPA No Burn Notices

5. Appendices

Appendix 1:Resources

To view any of the resources below, scan the QR next to the resource title:

HotSpots Fire Project: Resources and Materials
Links and documents made for landholders wanting to use fire to manage their properties.

NSW BioNet
A database for biodiversity data managed by the Department of Planning and Environment.

Nature Conservation Council's Fire Ecology Information Sheet
Summary of cool burning, the impacts of climate change on fire regimes and how to conserve biodiversity in relation to management challenges like climate change.

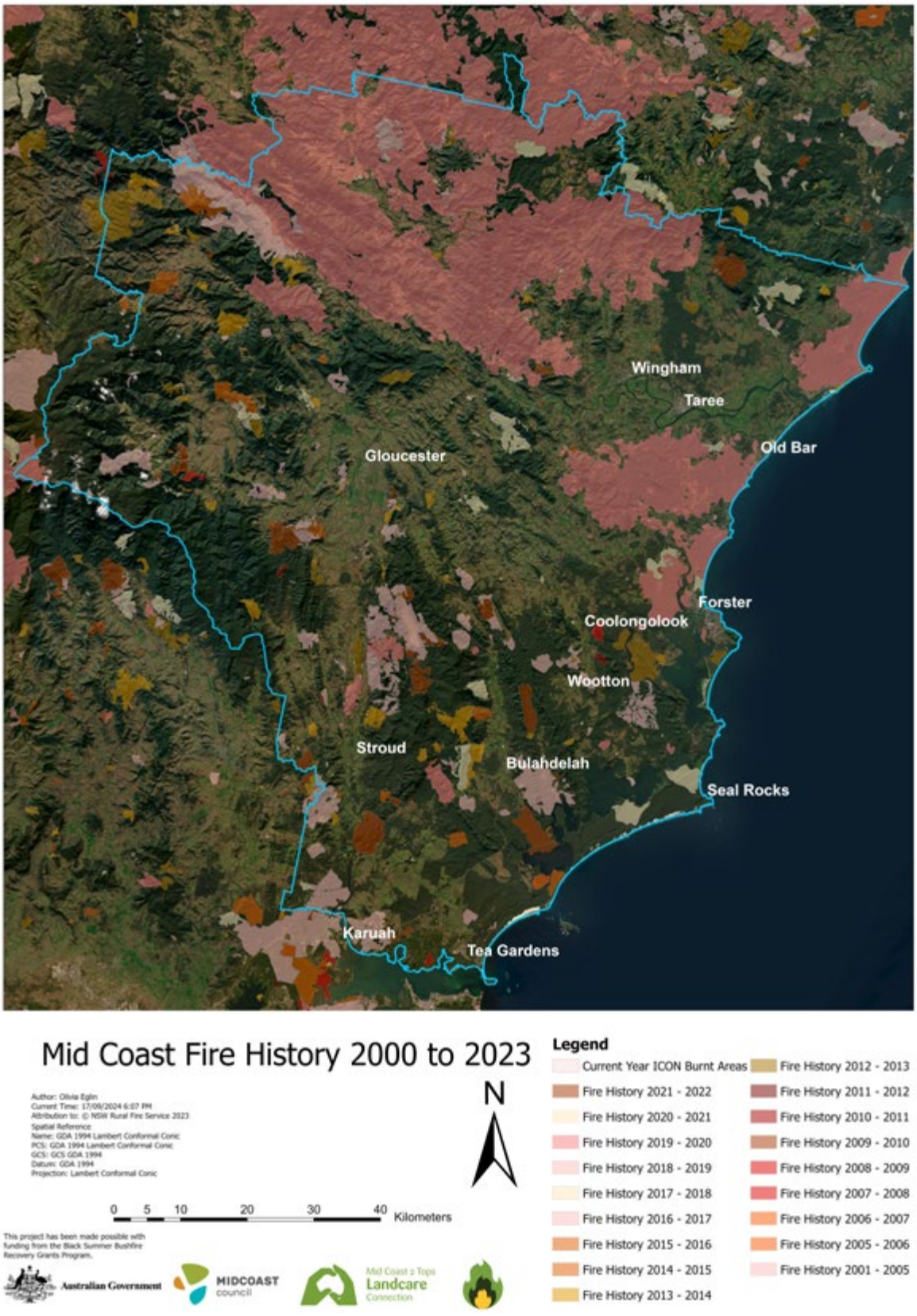
Hunter Climate Change Snapshot
Published by the Office of Environment and Heritage, this report covers the predictions of climate change for the Hunter region.

North Coast Climate Change Snapshot
Published by the Office of Environment and Heritage, this report covers the predictions of climate change for the North Coast region.

For more resources, have a look at the Eco Burn Education page.

Appendix 2: Fire History of the Mid Coast

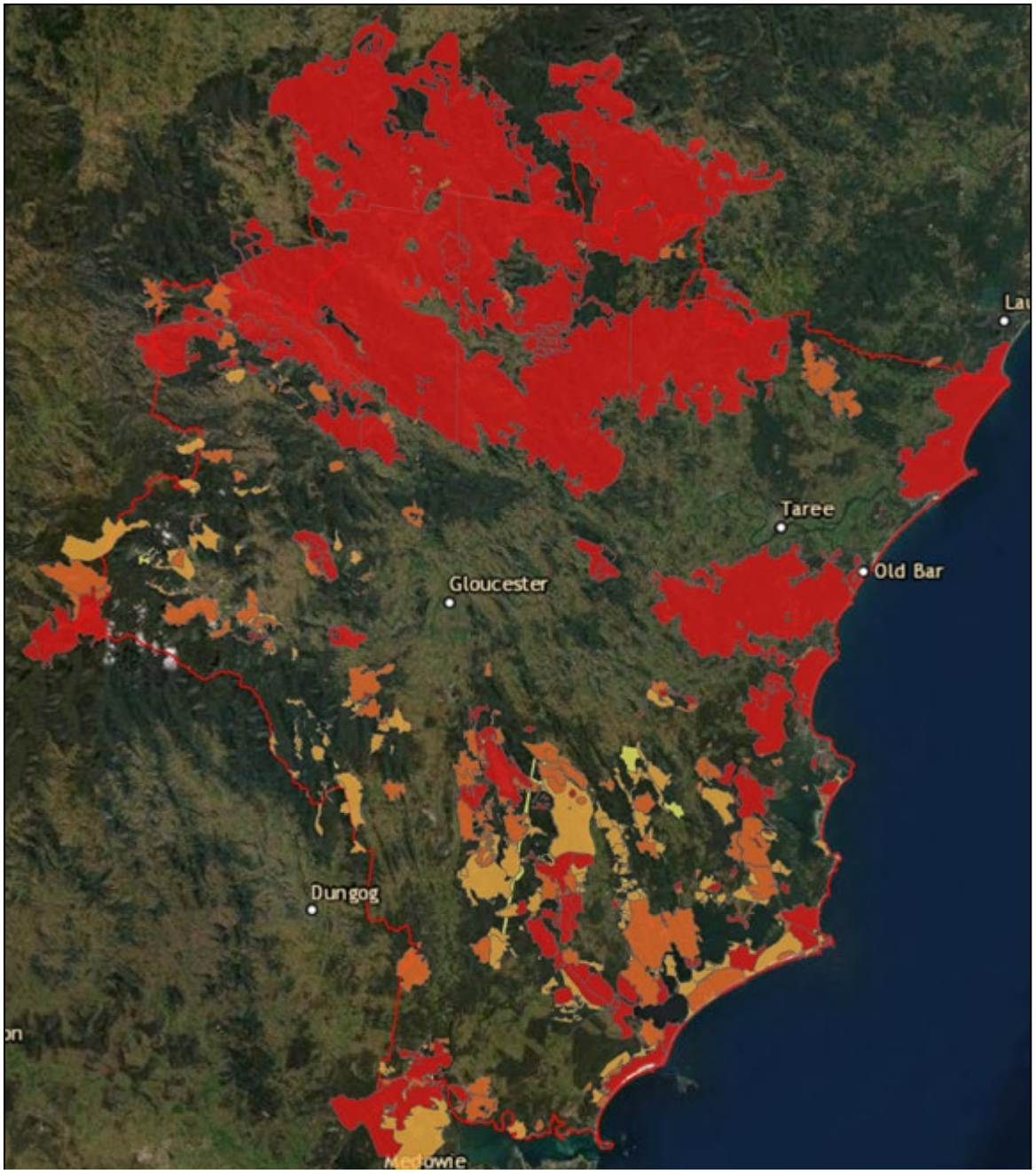
Figure 1 – Mid Coast Fire History in more detail since 2000



Note that colours of fire year are not indicative of fire severity and/or intensity. The colours differentiate between the decade the fire burnt and the extent of the fire.

Appendix 3: Fire History of the Mid Coast

Figure 2 – 1980 to 2020 Fire History



Mid Coast Fire History 1990's to 2020's

N

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
Author: Olivia Eglin
Date: 12/07/2022
Time: 3:35:00 PM

0 5 10 20 30 40
Kilometers

Legend

FireYear

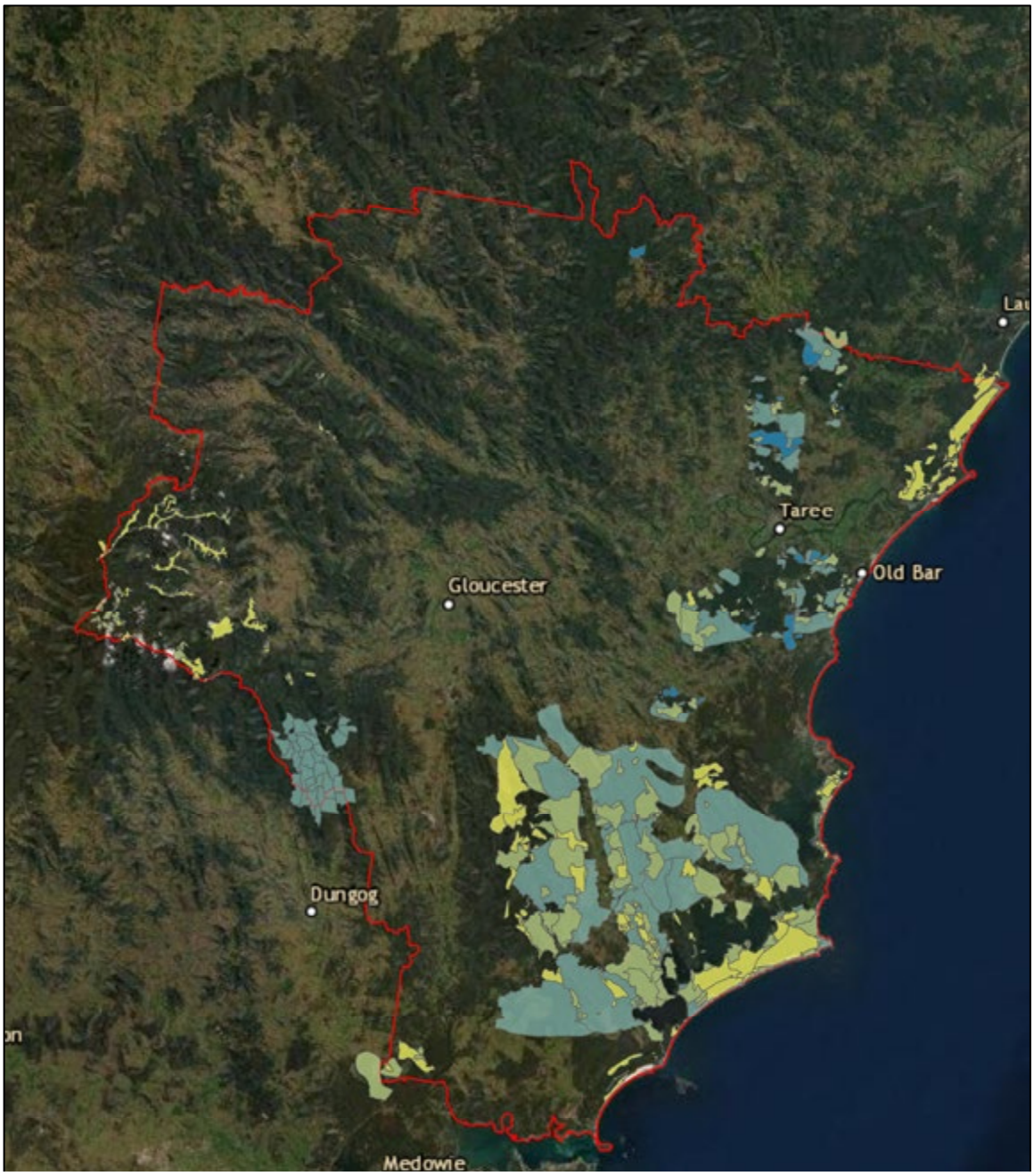
1980 - 1990
1990 - 2000
2000 - 2010
2010 - 2020
LGA boundary
World Imagery

Attribution to: State Government of NSW and Department of Planning and Environment 2010, NPWS Fire History - Wildfires and Prescribed Burns, licenced under Creative Commons CC-BY, 18/02/2022, https://datasets.seed.nsw.gov.au/dataset/fire-history-wildfires-and-prescribed-burns-1e8b6.

Note that colours of fire year are not indicative of fire severity and/or intensity. The colours differentiate between the decade the fire burnt and the extent of the fire.

Appendix 4: Fire History of the Mid Coast

Figure 3 – 1950 to 1990 Fire History



Mid Coast Fire History 1950's to 1980's

N

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
Author: Olivia Eglin
Date: 12/07/2022
Time: 3:14:36 PM

0 5 10 20 30 40 Kilometers

Legend

FireYear

1950 - 1960
1960 - 1970
1970 - 1980
1980 - 1990
LGA boundary
World Imagery

Attribution to: State Government of NSW and Department of Planning and Environment 2010, NPWS Fire History - Wildfires and Prescribed Burns, licenced under Creative Commons CC-BY, 18/02/2022, https://datasets.seed.nsw.gov.au/dataset/fire-history-wildfires-and-prescribed-burns-1e8b6.

Note that colours of fire year are not indicative of fire severity and/or intensity. The colours differentiate between the decade the fire burnt and the extent of the fire.

Appendix 5: WHS and Safety Considerations for Fire Management

The WHS and Safety Considerations document covers:

- Operational considerations when planning for fire on your property
- Safe use and maintenance of fuel management equipment like powered hand tools, pumps etc.
- Safety relating to manual handling, PPE etc.
- Other WHS considerations.

To download or view the document, scan the QR code.

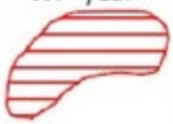
Appendix 6: Bushfire Protection Measures and Information

The Bushfire Protection Measures and Information document has been put together by a local Bush fire consulting company. The document outlines:

- Bush fire Attack Level (BAL)
- Recommendations for building design and Asset Protection Zones
- Landscaping and gardening relating to bush fire risk
- Access and water requirements
- Hazardous materials.

To download or view the document, scan the QR code.

Appendix 7: Property Fire Management Plan Legend

Feature		Symbol	Notes
Built Assets and Infrastructure			
Structural assets			House, sheds, yards, stockyards, other buildings
Powerlines			
Fence lines			Internal and external fence lines
Unlocked gates			
Locked gates			
Tracks and trails			Driveway(s), fire trails, access tracks
Water Features and Infrastructure			
Pumps		P	Static pumps, location of mobile pump
Waterways			Rivers, creeks, drainage lines
Water tanks			Indicate if this is marked as a Static Water Supply (SWS)
Farm dams			Indicate overflow with arrows
Fire-fighting water point	Vehicle		Indicate if accessible for fire tankers
	Helicopter		Indicate if accessible for helicopters
Native Vegetation			
Areas of uncleared Native Vegetation			Label Vegetation Class and boundary of native vegetation e.g. STR = Subtropical Rainforest, CVGW= Coastal Valley Grassy Woodlands
Fire History			
Planned fire		PF 'year' 	Prescribed hazard reduction/ ecological/ cultural burn Record year next to fire type e.g. PF 2023 Mark extent by outlining the boundary of what is to be burnt
Unplanned fire		WF 'year' 	
Management Areas			
Management area		Area 'no.' 	Mark areas on your property using a PURPLE line

Key/legend guide to make you Property Fire Management Plan.

Eco Burn

Education