

How plants cope with fire

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Australian Network for Plant Conservation Inc

Introduction

Fire in the Australian Environment

Fire plays a role in the development and structure of most Australian vegetation communities (Gill et al. 1981; Whelan 1995; Bradstock et al. 2002, 2012; Miller and Murphy 2017; Keith and Auld 2017). Most plant communities are burnt at some time and, within these communities, fire affects plant and animal survival. Fires do not destroy bushland, as both plants and animals have strategies to survive fires and recover after the fire has passed (see How plants recover from fire below). The environment immediately after a fire is favourable for plant recruitment. Nutrients released by the fire are available to growing plants, and there is also abundant light and space. Consequently, many plants in fire-prone communities recruit new individuals in the first few years after fire.

Animals, in contrast, may survive fire by sheltering from the flames, for example in the soil, under rocks, bark or in areas that do not get burnt (unburnt refuges). The survivors can then begin to recolonise the burnt areas as the vegetation regrows. The more extensive fires are and the more severe, reduces the survival capacity of animals. Other animals, such as birds, must wait until the vegetation has recovered before the habitat will be suitable. Ongoing survival of animals after the fire will depend on available shelter and food and a lack of feral predators.

The current 2019/20 fires are unprecedented in extent and severity. In addition, some of the areas burnt may have also been recently burnt in other wildfires or hazard reduction burning. When the same location is affected by multiple fires, or fire is combined with ongoing drought, human disturbance, or adverse impacts of weeds or feral grazers such as rabbits, goats, deer, horses, stock or camels, this may compromise the recovery of some plant species or vegetation communities.

Hence, we need to assess where these possible risks to recovery are, along with carefully monitoring what recovery actually occurs. No plantings or seeding into burnt and naturally regenerating areas should occur in the period immediately after the fire (at least one year) as we need to assess natural plant recovery after the fires (many plant species have mechanisms to cope with fire (see **How plants recover from fire** below). It is also to leave dead trees as these provide habitat for a range of animals.

Care in the bush after fire:

A word of warning! Stay out of recently burnt areas until it is safe. You can ask the local National Parks & Wildlife Service office when it is safe to return. Many trees many continue to smoulder after fire, and trees and branches may continue to fall in strong winds several weeks after the fire has passed. Keep to formed tracks and do not walk in areas where plants are regrowing and seedlings emerging as this can damage their recovery. All the features described here can be easily seen from walking tracks. The environment after a fire is a fascinating but fragile one, enjoy it and learn from it, but respect it as well.

As for seed collection in the post-fire environment, we need to be very cautious.

- Soil and canopy seed banks are the key to the resilience of native vegetation.
- There should be no collections of seeds in burnt areas in the period immediately after the fire, except for critical threatened species seed banking. Within the first one to ten years post-fire is the period when many plants replenish their seed banks and build resilience to future fires. For this reason, taking seeds at this stage can have serious impacts, and we need to be sure seed banks have replenished first. Different taxa will do this at different rates. We also need to minimise disturbance to recovering plants in burnt habitats.
- We also need to ensure we do not take too much seed from unburnt areas as these seeds provide food for animals and also help maintain seed banks that allow the plants in those currently unburnt areas to survive the next fire.



Grasstrees (Xanthorrhoea species) rapidly regrowing after a fire.



How plants recover from fire

Plants that can survive a fire

Many plants that are burnt can survive a fire. These plants are called **resprouting plants**. Now this does not mean all such plants survive all fires, but rather that at least some plants will survive. As some individuals may be killed by fire, the number of individuals that survive will depend on a range of factors such as the size of the plant and the heat of the fire (fire severity). Many resprouting plants also produce seedlings after fire (see below).

There are three strategies for surviving a fire in resprouting plants:

RESPROUTING STRATEGY ONE

Trees and some shrubs have dormant buds beneath their bark and these buds survive the heat of a fire.

Many trees and some shrubs have trunks that survive a fire. Trees such as gums or eucalypts (Eucalyptus, Corymbia) and apples (Angophora) have dormant buds in their trunks and these buds are protected by the bark from the heat of the fire as the fire passes. For smooth-bark gum trees, the bark that protects the tree from the heat of the fire is often shed soon after fire, to spectacular effect. In the weeks after the fire, the dormant buds, known as epicormic buds, produce new shoots and leaves and give the trees that strange green trunk appearance. It may take some 18 months to 3 years after the fire for new tree canopies to be formed. As well, some shrubs have stems that may survive a fire and new shoots will emerge from the blackened trunks after fire. Some common examples are the dwarf apple (Angophora hispida), some Banksias (Banksia serrata) and geebungs (Persoonia levis).

Not only do gum trees respond in this way, many of the plants in the wet eucalypt forests and rainforests also have trunks that survive a fire. Good examples are the coachwoods (*Ceratopetalum apetalum*) and turpentines (*Syncarpia glommulifera*).

When fires burn with a high fire severity, even the trunks of trees can be damaged or killed and only the lower trunk may survive. This effect may be common when moist forests or rainforests burn.

Tree trunks may only survive where the heat of the fire was low (on the side of the tree away from the approaching flames). The lillypilly (*Acmena smithii*) is a good example of this. Another typical effect of fire on resprouting trees is the hollowing of trunks on one side of the stem. Fires at a particular site will tend to burn in a certain direction and usually the upslope side of a tree receives more heating and longer exposure to flames. Over time and many fires, the trunks may be hollowed out, e.g. in scribbly gums (*Eucalyptus haemastoma*).



Epicormic regrowth in eucalypts and small trees.

RESPROUTING STRATEGY TWO

Many shrubs, grasses, sedges, lilies, terrestrial orchids and ferns regrow after fire from dormant buds in underground organs. These are protected from the heat of fires by the soil.

The above ground parts of herbs, sedges, grasses, some shrubs and many ferns are killed by fire and these plants recover after fire by regrowing from living stems or dormant buds in underground organs. Such organs may be rootstocks (often referred to as lignotubers when there is a single swelling at the base of the plant), bulbs or apical buds buried in the soil. These survive the fire by being protected from the heat of the fire by the soil. These plants reshoot very soon after the fire and are usually the first plants to turn recently burnt areas green. Some examples are christmas bells (Blandfordia spp.), a range of sedges and grasses and many shrubs such as dwarf apple (Angophora hispida), waratah (Telopea speciosissima), mountain devil (Lambertia formosa), banksias (Banksia oblongifolia, Banksia robur) and hakea (Hakea spp.). Trees may have to regrow from below ground when



the trunk is killed or damaged by fire. This is frequently the case with gum trees that have a multi-stemmed or mallee habit. Rock orchids (*Dendrobium speciosum*) occur on sandstone outcrops and the plants survive fires by having their roots protected by growing canes.



A waratah, Telopea speciosissima, recovering after fire from an underground lignotuber

RESPROUTING STRATEGY THREE

Some plants regrow from buds protected from the heat of fires by leaves or old leaf bases.

These plants have a growing bud (apical bud) which is protected from the heat of the fire by leaves and old leaf bases and can actively regrow after a fire. Such plants include grasstrees (*Xanthorrhoea*), *Kingia* spp., *Macrozamia* spp., Gymea lilies (*Doryanthes excelsa*), tree ferns and cabbage tree palms (*Livistona australis*). Rather than having dormant buds in their trunks, these plants have their growing tip protected at the base of the leaves at the top of the plant. This growing tip is not damaged by fire and the plant can produce new leaves after a fire. Typically, these new leaves have dead or scorched ends.



Tree fern resprouting from apical bud

New seedlings after fire

Many plant species that resprout after fire also try to recruit new individuals into their populations after fire. The recruitment of seedlings is necessary to replace individuals that die in fires or at other times. This allows the species to persist at the site in the long term. Plants recruit new individuals by having seeds stored in woody fruits in the canopy or in the soil (a soil seed bank) prior to the fire. Alternately, they may flower soon after fire (see below).

Fire causes the opening of woody fruits in resprouting plants such as banksias (*Banksia*) and titrees (*Leptospermum*) and seeds are released onto the soil surface after the fire has passed. These seeds can then germinate when adequate rain falls and may also be a food source for a variety of animals after a fire. Fires can also influence the germination of seeds from the soil seed bank (see below).



Banksia serrata seedling



Flowering after fire

For some resprouting species, there are no seeds available when a fire passes. These plants try to flower as soon as possible after fire so that their seeds are released into the favourable post-fire conditions. In these species, seeds released after flowering have no dormancy and will germinate when sufficient rain occurs. Essentially, this group of plants can be thought of as being stimulated to flower after fire. They come from several plant families and are responsible for some of the most spectacular floral displays seen after a fire. Many flower in spring (depending on geographic region) making the first and second springs after a fire the best time to visit to see flowering displays. Some species may flower within weeks of the passage of a fire e.g. Brunoniella australis and Lobelia dentata, while for others it may take anywhere from 6 months to 2 years to flower. The most spectacular examples include christmas bells (Blandfordia), dwarf apple (Angophora hispida), waratahs (Telopea speciosissima), Gymea lilies (Doryanthes excelsa), grasstrees (Xanthorrhoea) and a range of orchids such as rock orchids, and tuberous orchids (e.g. the fire orchid, *Pyrorchis nigricans*). Other resprouting plants that do have a seed bank may also flower soon after fire.

Plants that are killed by fire

These plants will die even if they are not directly burnt, if all the leaves on the plant are scorched by the heat of the flames. These plants are called **firesensitive plants or obligate seeders** and they can be common in some vegetation types (e.g. roughly 40% of the plants in the Sydney Region are killed by fire). Such plants are usually shrubs, climbers and ground covers. After the fire, these fire-sensitive species must produce seedlings to persist. Each species needs to have a store of seeds (called a seed bank) before it gets burnt. These seeds can be stored in one of three ways:

SEED BANK STRATEGY ONE: Canopy seed banks

Some plants store seeds in woody fruits on the branches. When these plants are burnt, the heat from the fire causes the woody fruits to open and release the seeds held inside. Seeds are held in woody fruits on the branches or canopy of the parent plant. There are around 200 plant species with canopy seedbanks in the Sydney Region (some 10% of the fire-prone flora). These plants occur in four Families (Proteaceae, Casuarinaceae, Myrtaceae and Cupressaceae). The most common and well known plants are the eucalypts (*Eucalyptus*) and banksias (*Banksia*). Many of the eucalypts can survive a fire (i.e., they are resprouters), although some Ash species and some species from south Western Australia are killed if they receive 100% leaf scorch. Many others are shrubs that are killed by fire (fire-sensitive). While not all banksias are killed by fire, they all have woody fruits on the branches of the plant. Other common plants that are killed by fire and have woody fruits are some hakeas (Hakea), some conesticks (Petrophile), drumsticks (Isopogon), some she-oaks (Allocasuarina), some ti-trees (Leptospermum), bottlebrushes (Callistemon), paperbarks (Melaleuca) and native pines (Callitris). After a fire, it is possible to walk through the bush and see a range of woody fruits opening. Some are spectacular, with the black burnt outside contrasting with vivid creams and browns inside the fruits, especially in banksias and hakeas.



Woody fruits of old man banksia, Banksia serrata, open after fire and release their seeds.

SEED BANK STRATEGY TWO: Soil seed banks

Most plants store seeds in the soil. These seeds wait till a fire has passed before they germinate.

Many of the plants in the areas burnt by the current wildfires have some form of soil seed bank, except for many rainforest species. For example, 89% of the fire-prone Sydney flora is predicted to have a soil



seed bank. Most of these plants have what are called persistent seedbanks, i.e., at least some seeds that are released by plants are dormant and when they reach the soil they persist for several years. These plants represent both plants that can survive a fire (**resprouters**) and those killed by fire (**firesensitive**).



Acacia suaveolens seedlings emerging after fire.

Seed germination after fire

For plant species with canopy or soil seed banks, there is often germination of seedlings after a fire. Regardless of whether they can resprout or not, plants with soil seed banks are perhaps the quickest plants to place seedlings into the post-fire environment and hence, exploit favourable conditions for growth, providing there is sufficient rain after the fires have passed. For fire-sensitive species, such germination is needed for the species to continue to exist at a site after a fire. Consequently, once there is sufficient rain after fire, masses of seedlings can be seen germinating if you look carefully around on the ground.

Seedlings can be distinguished by the presence of seed-leaves or cotyledons. These are the photosynthetic storage organs in the seed and appear before the true leaves grow. In most dicotyledons (trees, shrubs, climbers), there are two cotyledons and they usually look very different from the leaves above them on the stem. However, in geebungs (*Persoonia*) there are several cotyledons, that radiate around the stem like the points of a star. In monocotyledons (grasses, sedges, lilies) there is only one cotyledon and it is often difficult to see as it falls very quickly or remains largely buried in the soil. Finding seedlings of this group is often very difficult. Seedling germination after fire is most spectacular in the wattles (*Acacia*), which can be distinguished by their characteristic pinnate juvenile leaves. Other species such as native peas (Fabaceae), flannel flowers (*Actinotus helianthi*), grevilleas (*Grevillea*) and she-oaks (*Allocasuarina*) also have lots of seedlings after a fire.



Post-fire flowering of Flannel flowers

A number of species are regarded as fire ephemerals in that they are only common (or present aboveground) in the first few years after fire. Examples include flannel flowers (*Actinotus*) in both eastern and western Australia, some grasses (e.g. *Austrostipa*), grevilleas, wattles, *Lasiopetalum* spp., *Alyogyne* spp. and Lobeliaceae.

Why seeds in the soil germinate after fire

- There can be a range of reasons why seed germination is promoted by fire
- Heat from the fire breaks the dormancy of seeds in the soil. This occurs in many species, especially wattles and peas (Fabaceae).
- Chemicals in smoke or from the leachates from charred wood break the dormancy of seeds in the soil. This is common for many species in Australia and other parts of the world.
- There is sufficient soil moisture to promote germination.
- Ambient temperatures are favourable for germination.
- There will also be strong interactions between the above factors.

For other plant species, seed germination is not cued to the passage of a fire. However, seedling establishment may still be concentrated in the first few years after fire when establishment conditions are favourable. For these species, seed in a soil seed bank will periodically transition from a dormant to a non-dormant state with germination occurring when the soil is sufficiently moist and temperatures



optimal. There is no concentration of seedling emergence after a fire, seedlings emerge from the soil seedbank regularly, in a slow trickle, although successful seedling establishment may only be possible after a fire. Alternatively, seedling establishment may only occur at times other than just after the passage of a fire, although this is not readily known in Australian ecosystems.

SEEDBANK STRATEGY THREE: Dispersal into burnt areas as there is no local seed bank

A few plants rely on seeds being dispersed in from unburnt areas to regrow after a fire.

For a few species there may be no local seed storage in a plant community. When that community is burnt, such species rely on seeds being dispersed into the burnt area from neighbouring unburnt areas or patches. We don't know if there are many species that have this requirement, apart from mistletoes (e.g. *Amyema*).

Further Reading

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