Plant conservation and fire

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We have just experienced the most extensive fires ever recorded in eastern Australia. It is timely to consider how fire influences our approaches to plant conservation, and the challenges that a changing climate brings.

How fire affects the persistence of plant species and vegetation communities

Fire plays a role in the development and structure of most Australian vegetation communities. Most vegetation communities are burnt at some time and, within these communities, fire affects the survival of plants and animals. The components of a fire can be thought of as a fire regime – this is fire frequency, severity, season, type (*e.g.,* surface, peat fire), extent and patchiness. These components interact to affect plant species survival at a site. So, in a very real sense, the impact of a fire on a plant at a particular site (including the current fires) depends on both the past fire history at that site and the characteristics of the current fire (severity, season, patchiness). Fires do not destroy bushland, as both plants and animals have strategies to survive fires and recover after the fire has passed. However, depending on the fire regime (*e.g.,* fire severity, frequency, type), some species may decline.

All plant species are not tolerant to all fire regimes, and building an understanding of the degree of each species' tolerance to each component of the fire regime is important for the long-term conservation of native vegetation. This is particularly the case under the expectation of more extreme fire weather and hence, more frequent fire in the near future.

What factors will govern whether or not a plant species can recover after these fires

The 2019-20 fires were unprecedented in extent and severity. While most plant species should readily recover after the fires, some will likely decline. This is due to a range of factors including:

- Increasing fire frequency reducing seed banks and increasing plant mortality.
- Increasing fire severity increasing plant mortality in resprouters and damaging some canopy seed banks.
- Post-fire grazing by horses, deer, rabbits, goats and stock, reducing or eliminating seedlings and resprouting plants.

Banksia serrata **seedling after fire. Photo: Tony Auld**

- Weeds and pathogens acting as additional stressors, affecting growth and survival of seedlings and resprouts.
- Ongoing drought affecting seedling and resprouter survival.

We need to determine where these risks to recovery may occur, prioritise where declines would be particularly deleterious (*i.e.* threatened species, species sensitive to fire or very slow to recover (*e.g.,* rainforest and alpine species), species with low population numbers or very few populations) and carry out monitoring to observe how recovery progresses.

How plants persist after fire

Many plants can survive being burnt in a fire. These plants are called resprouting plants and they are often long lived. Examples of resprouting plants include eucalypts, many of which can resprout from buds protected by bark on the trunk; shrubs that resprout from underground lignotubers; and grasses, sedges and herbs that resprout from underground tubers and bulbs. However, the ability to resprout can vary (even within species), depending on things such as fire severity, plant size and location of dormant buds, drought and disease. To replace those plants that die either in a fire, or between fires, many resprouting plants also produce seedlings after fire and these seedlings need to persist and grow at least after some fires.

Other plants die when they are burnt, and these are called fire-sensitive plants or obligate seeders. In these species, if a plant is completely burnt or is close enough to the heat of the flames to have all its leaves scorched brown, it will die. These plants rely on regeneration from seed and they can be common in species-rich areas such as the heathlands of southwestern WA and Sydney sandstone vegetation. In other places, obligate seeders may be quite rare or absent. For example, grasslands, rainforests and alpine vegetation are dominated by resprouters.

Just because the aboveground plants of obligate seeders are killed by fire, does not mean they do not persist. Obligate seeders have seed banks that can survive fire and, as far as we know, it seems very few plants appear to rely on dispersal back into burnt areas to recover (mistletoes are one rare example, and they may survive in a fire if not scorched). Seed banks may be located on the plant in woody fruits that insulate the seeds from the lethal fire temperatures (*Banksia*, *Hakea, Lambertia*, *Callistemon*, *Melaleuca*, *Allocasuarina*, *Leptospermum*, *Eucalyptus*). Alternatively, seed banks may be held in the soil (*Acacia*, *Persoonia*, native peas (Fabaceae), *Dodonaea*, *Boronia etc.*), and the soil is a great insulator, protecting the seeds from the heat of the fire above.

Recruitment and flowering after fire

The environment immediately after a fire is very favourable for plant recruitment. Nutrients, released by the fire, are available to growing plants, and there is also abundant light and space – as fire has burnt, and in some cases killed, competing vegetation. Consequently, many plants in fire-prone communities recruit new individuals in the first few years after fire.

Fires promote seed germination in many species. Factors promoting seed germination (provided soil moisture and ambient temperatures are favourable) include: soil heating during and after fires (*e.g.,* physically dormant legumes and wattles); smoke (physiologically dormant species); and the interaction of these. Some resprouters have no seed banks at the time of a fire and need to flower soon after fire to recruit new plants. This can lead to spectacular floral displays in the first few flowering seasons after fire (*e.g.,* in *Xanthorrhoea*, *Telopea*, *Conospermum*, *Doryanthes*). In addition, there are other species thought of as 'fire ephemerals' because they appear (germinate, or resprout from below ground storage organs) after fire in relatively large numbers. These plants then flower and set seed, before largely disappearing from the aboveground vegetation.
They await the next fire as seeds, bulbs, tubers etc in the soil. Some may be present aboveground for a very short time (<2 years) while for others it may take 10-20 years for all above ground plants to senesce.

Plant resilience to climate change and fire

The general consensus in climate change modelling suggests that Australia will experience an increase in the number of days with extreme/catastrophic fire weather, increased temperatures and ongoing episodes of drought. This is likely to lead to slower recovery of species after each fire. In temperate forests, increased frequency and severity of wildfires may occur, while in more arid and semi-arid areas there may be fewer fires as there is less fuel. Two characteristics of plants play key roles in their persistence: that is, storage of resources to allow resprouting and the maintenance of seed banks to buffer losses from the adult population. Both will be impacted by climate change.

Seed banks buffer plants against changes, but plants that rely on seed banks are vulnerable to 'interval squeeze' (Enright *et al.* 2015) where they do not have enough time to recover (grow to flower and produce seeds) between fires, and seed production may be reduced. Reductions in plant growth as a result of drought will both delay and reduce seed production after fire. Hence, it will increase the risk of a species being unable to recover from a short-interval fire (before the seed bank is replenished). This reduction in seed bank affects a plants' capacity to recover not only if it is killed by fire, but also from other disturbances such as drought, grazing or pathogens.

Pimelea **seedlings after fire. Photo: Tony Auld**

Patchy fire in heath. Photo: Tony Auld

Resprouting *Leptospermum*. Photo: Tony Auld

Temperature, on the other hand, affects how long seeds can remain viable in the soil: increased soil temperatures lead to increasing seed mortality or decay (Ooi *et al.* 2009). Temperature also affects dormancy loss and determines when the favourable window for germination occurs, particularly in species with physiological dormancy (Merritt *et al.* 2007). Species with a narrow range of temperature across which they will germinate are likely to be more greatly affected by a warming climate than species with a wide germination temperature range (Walck *et al.* 2011). Climate warming will change the seasonal opportunities for germination. For species with a requirement for cold temperatures prior to germination (cold stratification), areas of suitable climatic habitat are likely to decline, leading to shifts or contraction of distribution ranges. Species with a limited range are likely to be most affected (*e.g.,* mountain tops, edges of continents). Changes to rainfall will also affect available soil moisture and germination.

For resprouters, regrowth after fire is dependent on stored reserves and these reserves need to be replenished between fires. Short interval fires can lead to reduced resprouting capacity and increased rates of tree mortality (Fairman *et al.* 2019). Moreover, resprouters are unlikely to be able to rely on recruitment from seed to replace adults that die in such situations, as juvenile plants need sufficient time to become fire resistant. If drought is more common, a plant that resprouts after fire may also be more susceptible to the impacts of drought stress (embolisms in vascular tissue leading to death of new shoots).

Investing in *ex situ* seed banking and cultivated seed production (where feasible) for for high priority species (*e.g.,* threatened species that are amenable to long-term storage) is essential as a backup for their long-term conservation.

Finally, we need to plan for how to protect important plant species and communities in the wild under increasing conditions of more frequent and severe fires. The success of actions to minimise the severity of the fires that burnt the Wollemi Pine illustrates what can be done or at least attempted. This type of planning may be needed to protect ancient rainforest remnants, long-lived conifers and other plants and vegetation that is of significance but cannot tolerate the fire regimes of tomorrow.

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Woody fruits of *Banksia serrata* open after fire and release their seeds. Photo: Tony Auld