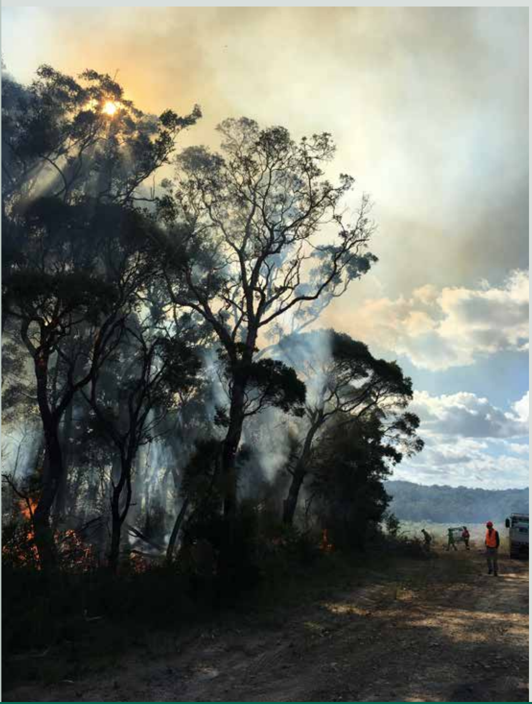
Fire regime shift and the challenges facing threatened plant species in temperate Australia

In brief

Australian plant species have adapted to particular fire regimes to maintain healthy populations. Climate change and the increasing management of natural areas with fire, especially near the growing urban interface, is shifting many fire regime elements, such as fire season, intensity and frequency.

We undertook research to determine how fire regimes are changing, particularly after the wildfires of 2019-20. We also investigated how plant species cope with shifts in the fire regime, especially in response to season, and how this interacts with fire frequency.



The fires in the 2019-20 bushfire season burnt vegetation considered fire-sensitive, such as rainforests, and areas that had only recently been burnt. This means that the fire frequency has been pushed below the persistence thresholds for some plant species. Wildfires are starting much earlier and continuing later compared to the historical hot season annual fire window, shifting the fire seasonality. Along with implemented fires occurring outside of the historical hot season, these shifts can impact the life-cycle of some plant species. We found that plants that sprout and flower post-fire, and species with seasonally germinating seed banks, both could suffer negative impacts if burnt at the wrong time of year.

We recommend that when managing with fire, making sure that areas are not burnt consistently in the same season every time will help to avoid negative impacts on susceptible plant species. Similarly, areas burnt by extremely severe fires could take longer to recover – meaning that when managing fires in such areas, leaving a longer time interval in between burns could assist plant recovery.

LEFT: Fire implemented for a season of burn experiment in the Noosa Shire, southeast Queensland. Image Mark Ooi.

Background

Conserving threatened plant species in fire-prone habitats requires an understanding of the plants' fire adaptation strategies. This includes identifying any specific requirements that a species may have regarding fire season, fire intensity, or fire frequency in order for new plants to establish after fire and ensure the continuation of that population. Without the required fire regime conditions, seeds of some species will either not be produced in sufficient numbers or not germinate, reducing the ability of a species to persist. Knowledge is lacking on the specific fire needs and tolerances of many threatened plant species.

Australian native plants use two main strategies for persisting in fire prone regions. These are post-fire obligate seeding and post-fire resprouting and flowering. Post-fire obligate seeders are killed during fire and rely on seed banks in the canopy or soil for recovery and population persistence. Whereas, those that flower post-fire rely on newly produced seed to propagate.

Research on the maintenance of species in temperate fire-prone regions has concentrated on fire-frequency or time since fire, and largely ignored other factors. Fire frequency is important because if fires occur too often, some species do not have time to recover during

Background (continued)

the inter-fire period and local decline or extinction can occur. However, other components of fire regimes and their spatial pattern, may play equally important roles in driving the population dynamics of species. Fire season is potentially critical to plant population processes such as flowering, germination and seedling establishment. Unless these responses are understood and quantified, managers will struggle to predict the sensitivity of plant species to shifts in fire regimes, including the fire regimes they implement.

Researcher Ruby Paroissien inspecting seed production on a Gymea lily. Fire season affected both seed production and seed chemistry. Image Mark Ooi.

Research aims

We had two main aims. Firstly, we wanted to understand how the 2019-20 bushfires impacted vegetation at the landscape scale, in particular if some vegetation types were pushed below the minimum fire interval recommended under the Guidelines for Ecologically Sustainable Management which have informed fire management activities in NSW for the past 16 years (Kenny 2004).

Secondly, we aimed to determine if fires occurring earlier or later in the fire season impacted how plant species recovered and how this related to fire frequency recommendations. By addressing these knowledge gaps, we hoped to identify management options to deal with changes to fire regimes.

What we did

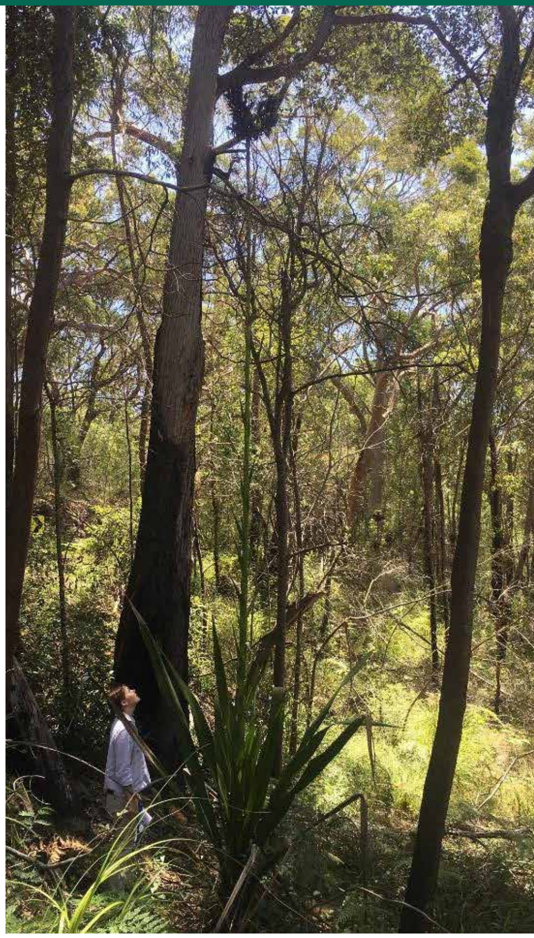
We examined the Endangered shrub *Asterolasia buxifolia*, and the Protected Species Gymea Lily (*Doryanthes excelsa*). We also studied other unlisted plants species that all behave in a similar way to *A. buxifolia*, and several shrub species that resprout after fire. All species occur in fire-prone temperate dry sclerophyll forests in the greater Sydney region and are fire-adapted, but their response to fires occurring in different seasons was unknown.

To test the impacts of fire seasonality on resprouting and flowering, we used a space-for time approach, quantifying the proportion of plants flowering after fires in different seasons. Additionally for the Gymea Lily, we conducted a series of analyses on the germination and chemistry of seeds produced after plants had been burnt in different seasons.

To test the impacts of fire seasonality on the way plant species with soil-stored seeds germinate and therefore recover post-fire, we conducted a desktop survey. We assigned the seed dormancy class for 3990 plant species. We wanted to see whether species with a particular type of seed dormancy were evenly distributed across the Australian continent, as well as determine if dormancy type was associated with the likelihood of being threatened.

We also conducted a landscape-scale assessment of the impacts of the 2019-20 bushfire season on different vegetation types in NSW. We undertook a comprehensive analysis combining remote sensing, fire history records and plant trait-derived fire interval thresholds.

BELOW: *Researcher Ruby Paroissien investigating impacts of season of burn on post-fire flowering of Gymea lily. The flower spike of this species can reach more than five metres high. Image Mark Ooi.*



Key findings

Multiple megafires burnt across over 5.5 million hectares in temperate south-eastern Australia during the 2019-20 bushfire season. This pushed a third of the native vegetation burnt (~ 1.8 million hectares) below their recommended minimum threshold. The fires in the 2019-20 bushfire season burnt through some vegetation that had only recently previously burnt, and infiltrated large proportions of fire-sensitive vegetation, such as rainforests, that usually act as fire refugia. This means that the fire frequency had been pushed below the persistence thresholds for some plant species.

We found that the wildfire season is generally starting much earlier in the annual fire (primarily summer) period, and continuing later, meaning fires have changed seasonality. Along with fires that are implemented for management, which occur outside of the historical hot season, these shifts can impact the life-cycle of some plant species. Continuing adverse fire regimes pushed by subsequent megafires in the future means that some vegetation community types are at risk of irreversible changes in vegetation community composition or even collapse.

With regards to fires occurring more often outside of the historical summer fire season, some aspects of species' responses were affected whilst others were not. Impacts of fire seasonality on species' ability to resprout were minimal, however, the flowering response of post-fire flowerers were much lower after spring burns. This means, that for species that depend on fire to stimulate a flowering event, less than half of the plants flowered after spring compared to summer or autumn burns.

Spring burns resulted in the lowest proportion of plants flowering for both the Gymea lily (*Doryanthes excelsa*) and the spiky shrub mountain devil (*Lambertia formosa*). Burns outside of summer delayed the flowering of the Gymea lily. For species that only flower, and therefore produce seeds after fire, this really reduces the chances of them successfully producing new seedlings that can recruit into the adult population. Importantly, we found that the impacts of season of burn were not merely a product of differences in fire severity.

When investigating the distribution of seed dormancy types for shrub species across the Australian continent, we found a much higher proportion of species with physiological seed dormancy (such as seeds that need heat or smoke to germinate) were threatened, but only in south-eastern Australia. We concluded that this was a result of the seasonal emergence requirements of physiological seed dormancy species in this region, and that out-of-season fires could have negative impacts on recruitment for species with seasonally germinating seed banks. This is supported by several other studies of physiological seed dormancy species in south-eastern Australia, including *Leucopogon exolasius, Asterolasia buxifolia* and a number of *Boronia* species.

Waratahs resprouting post fire in a dry sclerophyll forest, Patonga, NSW. Image: Doug Beckers Flickr, CC BY-SA 2.0

Further Information

Mark Ooi - mark.ooi@unsw.edu.au | Tom Le Breton - t.lebreton@unsw.edu.au

Implications

Our findings show that both fire season and fire intensity can affect the magnitude and timing of seedling emergence in wild populations of species with physiological seed dormancy. The burning of species with physiological seed dormancy or that flower post-fire outside of their historic season of fire (usually the hot summer months) can reduce their capacity to regenerate.

For threatened plant species management, it is crucial to understand the mechanisms influencing the distribution of plant species. For those species sensitive to seasonality of fires, the main impact found so far seems to be a reduction in the capacity or speed of recovery. One of the potential approaches to minimising seasonality effects if implementing ecological burns, would be to extend the minimum fire interval depending on which season the previous burn occurred in.

We recommend that when managing with fire, making sure that areas are not burnt consistently in the same season each time. This will help to avoid negative impacts on susceptible plant species. Similarly, areas burnt by extremely severe fires could take longer to recover.

Continuing adverse fire regimes pushed by subsequent megafires in the future, means that some vegetation community types are at risk of state-shift or even collapse, and therefore innovative approaches to fire management are required. Fire season very rarely receives the spotlight when looking at impacts of fire regimes, perhaps due to the complex interaction of processes that occurs when fire season is altered, particularly with severity and moisture. Our results highlight the importance that both fire and the season in which it occurs play in the reproductive success of some plants. We call for an expansion of the current fire management framework beyond fire frequency to address the additional impacts of fire intensity and fire season on native flora. This is especially pertinent given the projected widening of fire season and increasing intensity of wildfires as a result of climate change.

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