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Response of two locally endemic threatened eucalypt mallees to recent severe bushfire in the Shoalhaven Region, New South Wales

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***Abstract*:** The 2019–20 bushfires in eastern New South Wales were intensive and extensive, with 62% of the native vegetation of the south coast region burnt in a series of large fires. Many of the listed threatened plant species in the region were significantly impacted, including most of the regionally endemic species. This study investigated the responses of two locally endemic mallee species, *Eucalyptus langleyi* and *Eucalyptus sturgissiana* (family Myrtaceae) to the fire in the northern Shoalhaven region.

A six-month study post-fire found that both species recovered well by vegetative means but recruitment from seedling was apparently absent. A loss 1 – 3% of plants due to fire was recorded from monitored populations. The importance of such a loss to the long-term viability of these species is unknown, especially given the likelihood of more frequent and intense fires in the future.

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Introduction

The catastrophic bushfires in the summer of 2019-2020, burning for a total of 74 days, impacted most of naturally vegetated land on the New South Wales south coast. It is estimated that 62 percent of the natural vegetation and 76 percent of the National Park estate on the south coast were impacted by the end of the fire season (NPWS Nowra, pers. comm.). The fire season finished with torrential rain in the second week of February 2020, when many places received 200-300 mm over a period of three days (http://www.bom.gov.au/climate/data/).

The rain ended the severe drought that had reached its most intense in late 2019. Casual observations of the mallees discussed here during the drought found no obvious negative impact from the very dry conditions. No loss of plants caused by drought were observed in either mallee species, despite the severe dry conditions experienced in 2019.

The four study sites experienced a 'high-severity fire', defined as a fire "that result[s] in widespread mortality or foliage loss in the canopy layer of a vegetation community; i.e., fires that cause substantial changes to ecosystem structure and function" (Collins *et al.* 2021). The study sites experienced complete foliage loss and the death of all shrub stems and many trees.

Most populations of threatened plant species in the south coast region were impacted (DPIE 2020). Observations by the author on several threatened species, including these mallees, found that the fire resulted in the complete destruction of all existing above ground plants. Regeneration of these species is highly likely, through roots/rhizomes and seeds, but the extent, timing and method of regeneration are not fully understood nor totally predictable.

The study species *Eucalyptus langleyi* (Nowra Mallee Ash) and *Eucalyptus sturgissiana* (Ettrema Mallee) (family Myrtaceae) are mallee species endemic to the sandstone country to the southwest of Nowra; see Figures 1 and 2. Over 90% of the known populations of these mallees were impacted by the fires (DPIE 2020). The purpose of this study is to undertake a six-month monitoring program of these two threatened mallee species to gain preliminary answers to some of the above unknowns. Both species have been investigated by the author at various times over a period of 35 years.

Among the key questions addressed in this short-term study are: What is the survival rate of the selected species following fire? And, how do the species regenerate after fire and how successful is this after a severe fire?

Figure 1. Mature plants of *Eucalyptus langleyi.*

Figure 2. Mature plants of *Eucalyptus sturgissiana.*

Methods

The study involved investigations at four sites known to contain *Eucalyptus langleyi* or *Eucalyptus sturgissiana*. Duplicate study sites were identified for each mallee species; the four sites had previously been investigated by the author, hence the site numbers used below. Studies were undertaken at each site from two to six months post fire, with five visits to each of the four sites over that period. All sites were burnt on or around 22 December 2019 by a catastrophic bushfire that destroyed all vegetation at the sites. The species, sites, date of fire and 1:25,000 map sheets are set out in Table 1.

Table 1 Summary of the study sites

Species/location (site no.)	GPS point	Date of fire	Altitude	1:25k map
Eucalyptus langleyi				
Braidwood Road (11)	0268523 6120894	22.12.19	275 m	Sassafras
Braidwood Road (7)	0271317 6127003	22.12.19	200 m	Yalwal
Eucalyptus sturgissiana				
Upper Boolijong Creek (B1)	0262324 6114686	22.12.19	390 m	Sassafras
Turpentine Road Track (T2)	0269132 6120346	22.12.19	260 m	Sassafras

While time since the fire is clearly an important consideration in terms of regeneration, time since substantial rainfall is at least of equal importance, particularly following the severe drought of 2019. A significant amount of rainfall fell in the second week of February 2020, breaking the drought in coastal areas. This was six weeks after the fire occurred on the study sites. The rainfall figures for 8-13 February 2020 at the Nowra RAN Air Station, located about 11 km northeast of the study sites, was 367.2 mm; average for February is 145.9 mm (2000 to 2019).

Information recorded during the site visits included:

– The condition of the existing plants, based on the abundance of resprouting and general observations;

– The state of regeneration of the population; photographs and stem heights were recorded.;

– Counts of the number of individual plants present; a random transect counted a minimum of 100 plants per species. Sucker nodes were not counted individually.

– The presence/absence of seedlings; a search was made of all sites for small plants, which were easily found due to the very open ground cover following the fires.

Specimens of each species were gathered under the licence of the Janet Cosh Herbarium at The University of Wollongong, where the specimens will eventually be lodged. Photographs were taken of selected stands at established photo-monitoring points.

Results – *Eucalyptus langleyi*

Eucalyptus langleyi is endemic to the sandstone country to the west of Nowra (Mills & Jakeman 2010), extending from North Nowra southwest to an altitude of 275 m in the vicinity of Turpentine Road. The species, listed as vulnerable under the NSW *Biodiversity Conservation Act 2016* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999,* has been well-studied over many years (Kevin Mills & Associates 2002, 2017; Mills 1985, 2010). All known 48 sites are numbered in KMA (2017) and these site numbers are used here when referring to the current study populations. The total population determined by counts at each of the known sites in 2017 was a minimum of 12,155 plants.

Visits to Sites 7 and 11 surveyed by KMA (2017) two months after the December 2019 fire found that the majority of the mallees were re-sprouting from their lignotubers. All existing stems were killed in the fire. There was prolific growth of shoots from lignotuber one month after the high rainfall event of early February 2020. Figures 3 and 4 show regrowth from lignotubers at Site 11, two and 6.25 months post-fire. The longest sucker stems were 85 cm long 4.4 months post-fire and 140 cm after 6.25 months.

Figure 3. *Eucalyptus langleyi* at Site 11, two months post-fire. Fire - 22 Dec. 2019, photograph - 20 Feb. 2020. Fire damage often results in the lignotuber separating into several shooting nodes, often producing a circular pattern of lignotuber shoots.

Very few *Eucalyptus langleyi* were killed by the fire. A count of 204 plants at Site 7 found two obviously dead plants (representing a one percent loss) and four largely dead plants with only a few shoots. Partial destruction of lignotubers during successive fires results in a fragmented pattern of shooting stems; as shown in the photograph at Figure 3. While no large-scale excavations were made, it is most likely that the bulk of the lignotuber survives underground, linking the above-ground shooting nodes.

A small plant about 15 cm tall with a single stem at Site 7 had an extensive root system. The only other small plant seen over 35 years of observation was during a 2001 survey, when a similar-sized plant was found to have a small lignotuber. Such a strategy, that is producing an ‘over size’ root early in a plant’s life, may be an adaptation to fire, ensuring the survival of such a small and vulnerable plant. Seedlings have never been seen by the author; it is apparent that regeneration by seed is occasional at best.

Figure 4. *Eucalyptus langleyi* at Site 11, same stand as Figure 3, 6.25 months post-fire; photograph 15 June 2020.

What is the survival rate of the species following fire?

A count found that the mortality rate at Site 7 was about 1%; i.e., two dead plants out of 204 inspected. The post-fire survival rate for the species is therefore high.

How does the species regenerate after fire and how successful is this after a severe fire?

Eucalyptus langleyi produces epicormic shoots prolifically from the lignotuber. As time goes by these stems are naturally thinned out, resulting in some 40 or more shoots per plant being reduced to 10-20 long-lived stems; see Figure 1. Seedlings have not been seen; KMA (2002) found one small plant in a wide survey of sites and none were seen in an extensive survey in 2017 (KMA 2017). In the current study, one small plant was found. The species successfully survives fire, losing few plants even in the most severe of fires. What the long-term prognosis is for such a species is unknown; is it in long term decline or is the infrequent seedling enough to keep up with the occasional loss of plants?

Results – *Eucalyptus sturgissiana*

Eucalyptus sturgissiana is endemic to the high-altitude areas to the southwest of Nowra (Mills & Jakeman 2010). This mallee occurs on the Nowra Sandstone and occupies a similar habitat to *Eucalyptus langleyi* above about 260 m altitude. The species is listed as vulnerable under the NSW *Biodiversity Conservation Act 2016*. The mallee is relatively well known; all 101 known stands, other than those on Ettrema Plateau, are numbered and these numbers are used here (KMA 2015). The minimum number of plants in the 101 stands was 1,044 plants, with an estimated 1,185 plants in 21 patches on the Ettrema Plateau recorded during a 2015 aerial survey (OEH, pers, comm., January 2020).

Visits to Site T2 and Site B1 in 2020 previously surveyed by KMA (2015) found that the majority of the mallees were re-sprouting from their lignotubers. The photographs at Figures 5 and 6 show regrowth from lignotubers at Site B1 2.5 and 6.25 months post-fire. The longest sucker stems were 100 cm long after 4.4 months and 116 cm after 6.25 months post-fire.

Figure 5. *Eucalyptus sturgissiana* at Site B1, 2.5 months post-fire. Fire - 22 Dec. 2019; photograph 02 March 2020.

Figure 6. *Eucalyptus sturgissiana* at Site B1, same stand as Figure 5, 6.25 months post-fire; photograph 15 June 2020.

A count at the larger stand at Site B7 and surrounds, west of Site B1, found that out of 113 plants identified on 14 May 2020 (nearly five months post-fire), 103 were alive, six partially dead and four dead. Some of these dead plants were probably part of a live individual nearby rather than genetically distinct individuals, as the lignotuber of this mallee separates due to bushfire and disjointed plants are typical. Survival rate for the species is therefore high.

What is the survival rate of the species following fire?

Counts of apparently dead plants, no sucker growth and severely burnt, found that the mortality rate at one site was 3.5%; i.e., four dead plants out of 113 inspected. This is substantially more than was found with *Eucalyptus langleyi.* This figure is quite high and if typical, may pose a serious long-term problem for this species, which appears to produce few seedlings. This would be exacerbated with a predicted increase in fire frequency and severity.

How does the species regenerate after fire and how successful is this after a severe fire?

Epicormic shoots produced by the lignotuber of *Eucalyptus sturgissiana* are prolific post-fire. As time goes by these are naturally thinned out, resulting in some 70 or more shoots being reduced to 5-10 long-lived stems per plant; see Figure 2. Seedlings have seldom been seen (KMA 2015) and none were found within six months after the 2019-2020 fire.

Conclusion

The populations of *Eucalyptus langleyi* and *Eucalyptus sturgissiana* will largely recover to close to pre-fire numbers, although there was some loss of individuals, from 1% to 3.5%, respectively. Successive fires can severely damage the lignotubers, reducing their size and separating the above-ground part of the lignotuber into several shooting nodes. Observation suggests that the central section of the lignotuber dies and disappears, at least partly through fire, with the shooting stems forming on the outer edge of the

lignotuber. Over time the stems form the fragmented pattern obvious is older plants.

The ability to regrow from the lignotuber is an evolutionary strategy that allows the species to survive in a high fire prone environment and in the case of the 2019-2020 fires, a very severe fire. There was very little recruitment observed in either species, an observation consistently made over many years, so that the species' survival depends almost entirely on the ability to resprout from the lignotuber.

The capacity of these species to survive in an increasing fire intense environment brought about by climate change is unknown, but loss of individuals of both mallees may be significant for the long-term survival of the species as seedlings are apparently very scarce and mature plants are lost in fires, albeit in apparently small numbers.

Given that these mallees largely occur within a land tenure that is dedicated to their conservation and that pre-fire plants are generally regenerating successfully after the fires, the main threat to the survival of these species is the fire regime that is experienced into the future. The threat from fires to range-restricted species such as these mallees is of particular concern (see also Zimmer *et al.* 2020). A higher frequency of severe fires, as predicted for the future (e.g., Climate Council 2019), is likely to result in the loss of individuals at a higher rate, but the quantum and importance of this loss is unknown and not easy to predict.

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