The fire ecology of *Allocasuarina littoralis* and *Banksia plagiocarpa* in montane heath of the southern Wet Tropics

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Abstract

Montane heath on Hinchinbrook Island and adjacent mainland of the southern Wet Tropics is of conservation significance, due to the restricted distribution of the ecosystem and the co-dominant shrub *Banksia plagiocarpa* (Blue Banksia). Fire is the primary land management action and it has previously been established that *B. plagiocarpa* is killed by fire, while the other dominant shrub *Allocasuarina littoralis* (Montane Oak) can survive fire via coppice shoots. This study provides further specifics about the fire ecology of *A. littoralis* and *B. plagiocarpa*. Observed fires were patchy, and long unburnt heath appeared to be senescing. Around half of *A. littoralis* plants survived fire by coppicing and quickly regrew towards pre-fire stem heights, although age to seed production by seedlings remains unknown. *Banksia plagiocarpa* has fire-promoted seedlings that grow slowly, averaging around 30 cm at three years of age and begin to produce seed in their fifth year. It is proposed that current recommendations of patchy burns every six to ten years be extended to predominantly 10 to 20 year intervals to allow adequate seed production, with occasional more frequent fires and some longer unburnt patches. Patchiness can be achieved by burning with good soil moisture and igniting from ridges downwards. We recommend that montane heath populations of *A. littoralis* receive taxonomic assessment as a potential distinct subspecies because they differ from forest populations in being shrubby and resprouting.

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Introduction

Montane heaths dominated by *Allocasuarina littoralis* (Montane Oak) and *Banksia plagiocarpa* (Blue Banksia) only grow on the granite hills on Hinchinbrook Island and adjacent mainland in the southern Wet Tropics of North Queensland (Fig. 1). This montane heath, classified as Regional Ecosystem 7.12.64, has an Of Concern Queensland Vegetation Management Act (1999) status due to its limited natural extent of < 10,000 ha (REDD).

Fire is a critical aspect of the management of this ecosystem, promoting seedling recruitment of a range of species, but with too frequent fire thought to be detrimental to the population persistence of *B. plagiocarpa* (Williams *et al*. 2005).

Figure 1. View of montane heath on Hinchinbrook Island, dominated by *Allocasuarina littoralis* (olive coloured foliage) and *Banksia plagiocarpa* (bluish green foliage). Photo by Paul Williams.

Banksia plagiocarpa is a fire killed "obligate seeder" shrub with a Vulnerable Queensland Nature Conservation Act (1992) status. The flowers of *B. plagiocarpa* are a nectar source for a range of fauna (Robertson 1999). The montane heath populations of *A. littoralis* differ from their taller forest populations in being able to survive fire by coppicing shoots from buds located below the soil at the base of the stem (Williams *et al*. 2005). This study looked at the growth rates of *B. plagiocarpa* and age at initial flowering to provide a greater understanding of their ecology, especially in relation to fire intervals. It also assessed the proportion of *A. littoralis* that survive fire and the regrowth rates of coppice shoots.

Methods

This paper combines the results of opportunistic surveys undertaken between 2005 and 2016 in montane heath sites with different ages since last fire. These surveys were at Bishop's Peak (18.475° South; 146.122° East) on the mainland, and on Hinchinbrook Island at Mt Straloch (18.452° South; 146.294° East) and Mt Diamantina (18.437° South; 146.306° East; Table 1).

The information collected at both Bishop's Peak and on Hinchinbrook Island involved documenting plant heights, regeneration after fire (i.e. seedling or coppice regrowth), and evidence of flowering and fruiting. However the survey method differed between Bishop's Peak and Hinchinbrook Island. The June 2005 and June 2007 surveys conducted on Bishop's Peak examined heath previously burnt in 2002. These surveys were not restricted to a specific transect, rather details of *A. littoralis* and *B. plagiocarpa* regeneration and growth were recorded for a sample of plants in a general area.

During the April 2016 survey on Hinchinbrook Island, details were recorded within 10 m X 4 m transects (three in total). The height and observations of recent flowering were recorded for

Table 1. **Survey details.**

Years since last fire	Location, survey year
1.5	An April 2016 survey on Mt Diamantina, Hinchinbrook Island, last burnt September 2014
2.5	An April 2016 survey on Mt Straloch, Hinchinbrook Island, last burnt August 2013
3	A June 2005 survey on Bishop's Peak, Cardwell Range, in heath last burnt in mid 2002
5	A June 2007 survey on Bishop's Peak, Cardwell Range, in heath last burnt in mid 2002
6	A June 2005 survey on Bishop's Peak, Cardwell Range, in heath last burnt in September 1999
21	An April 2016 survey on Mt Straloch, Hinchinbrook Island, assumed to have last burnt in a 1995 fire on Mt Straloch

B. plagiocarpa plants at two recently burnt and one long unburnt site on the south-eastern slopes of Mt Straloch, which appears to have last been last burnt in a 1995 planned burn (Douglas 2004; Table 1). For older *B. plagiocarpa* plants, an estimate was made of the number of years that a *B. plagiocarpa* plant appeared to have been fruiting, based on the number of branching junctions on the bush. This provides an approximation because the flowers are formed at the tip of the branches after which new growth forms multiple branches.

Counts were made of post-fire coppice shoots of *A. littoralis* plants at the two recently burnt sites. The sites surveyed in April 2016 on Hinchinbrook Island were accessed via helicopter. This allowed a broader assessment of the montane heath while travelling between landing sites. In particular, the helicopter flight provided good visual observations of the boundaries of heath burnt in August 2013 and September 2014 and patchiness of burnt (distinguished by recently burnt stems) and unburnt heath within a broadly burnt area.

Results

The areas of montane heath on Hinchinbrook Island that experienced fire in August 2013 and September 2014 contained unburnt patches surrounded by burnt areas. They also had areas with a fine scale patchiness of scattered unburnt *B. plagiocarpa* shrubs interspersed amongst burnt shrubs. In a few locations in long unburnt heath near Mt Bowen, some *B. plagiocarpa* shrubs appeared to be senescing.

Based on the population estimate from the number of dead and coppicing plants, there was a 57% survival rate of *A. littoralis* after the August 2013 fire on Mt Straloch and a 35% survival after the September 2014 fire on Mt Diamantina. A couple of scattered *A. littoralis* seedlings were observed in the recently burnt areas on Hinchinbrook Island, though none within the transects.

The regrowth of coppice shoots of *A. littoralis* was fairly rapid, with about a 40% return to pre-fire heights within 1.5 years (Fig. 2). The 2.5 year old regrowth on Mt Straloch was slightly slower than on Mt Diamantina, reflecting differences in pre-fire shrub heights and probably slight differences in site factors.

Banksia plagiocarpa seedlings grew slowly, averaging only 8 cm tall at 1.5 years since fire and around 30 cm after three years (Fig. 3). At the Mt Straloch site that is estimated to have been unburnt for 21 years, mature *Banksia plagiocarpa* shrubs averaged 1.7 m tall. However, there are some wet gully areas on both Hinchinbrook Island and Bishop's Peak where old *Banksia plagiocarpa* are 3 to 4 m tall. Therefore substrate and moisture influence plant heights.

None of the 1.5- or 2.5-year old seedlings of *Banksia plagiocarpa* surveyed on Hinchinbrook Island in April 2016 had begun flowering. Neither had 3-year old seedlings on Bishop's Peak, surveyed in June 2005. By the fifth year after a 2002 fire on Bishop's Peak, 107 out 329 *B. plagiocarpa* plants assessed (i.e. 32.5%) had begun flowering and producing seed.

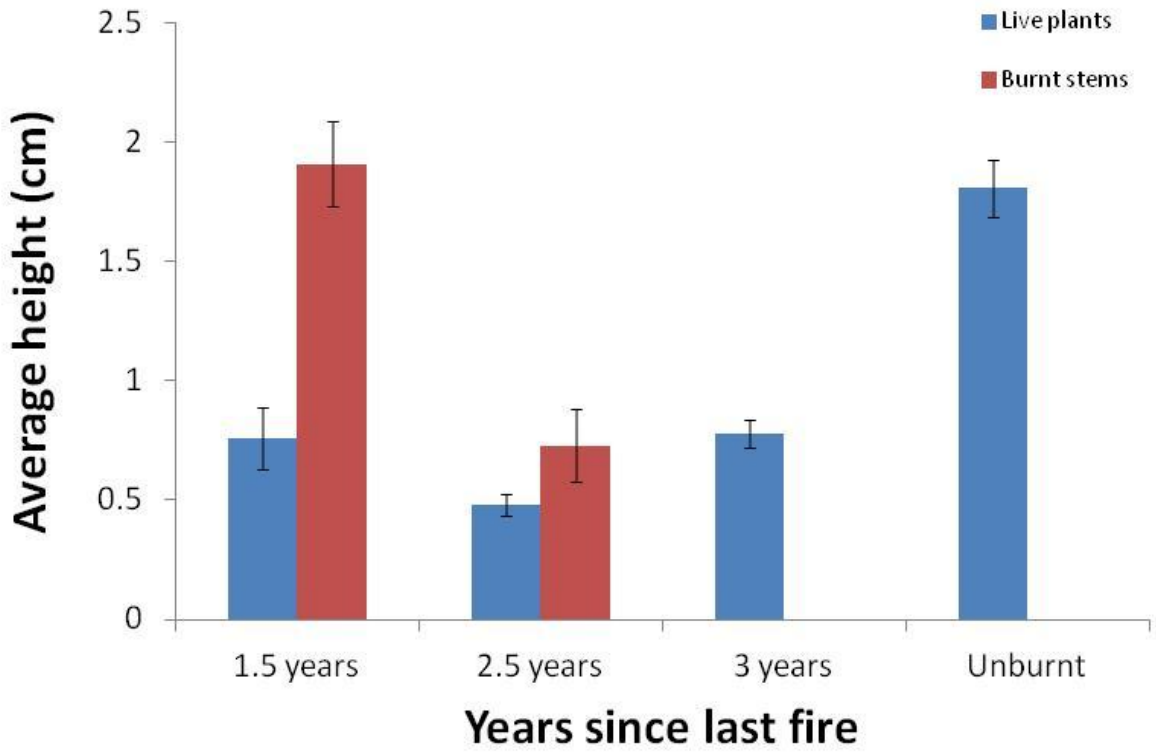

Figure 2. **The growth rate of *Allocasuarina littoralis* coppice shoots with years since fire.** Dead stems are those to which the coppice shoots were attached, indicating the pre-fire heights. The data for 3 years since last fire are from Bishop's Peak; remaining data are from Hinchinbrook Island. Error bars are one standard error from the mean.

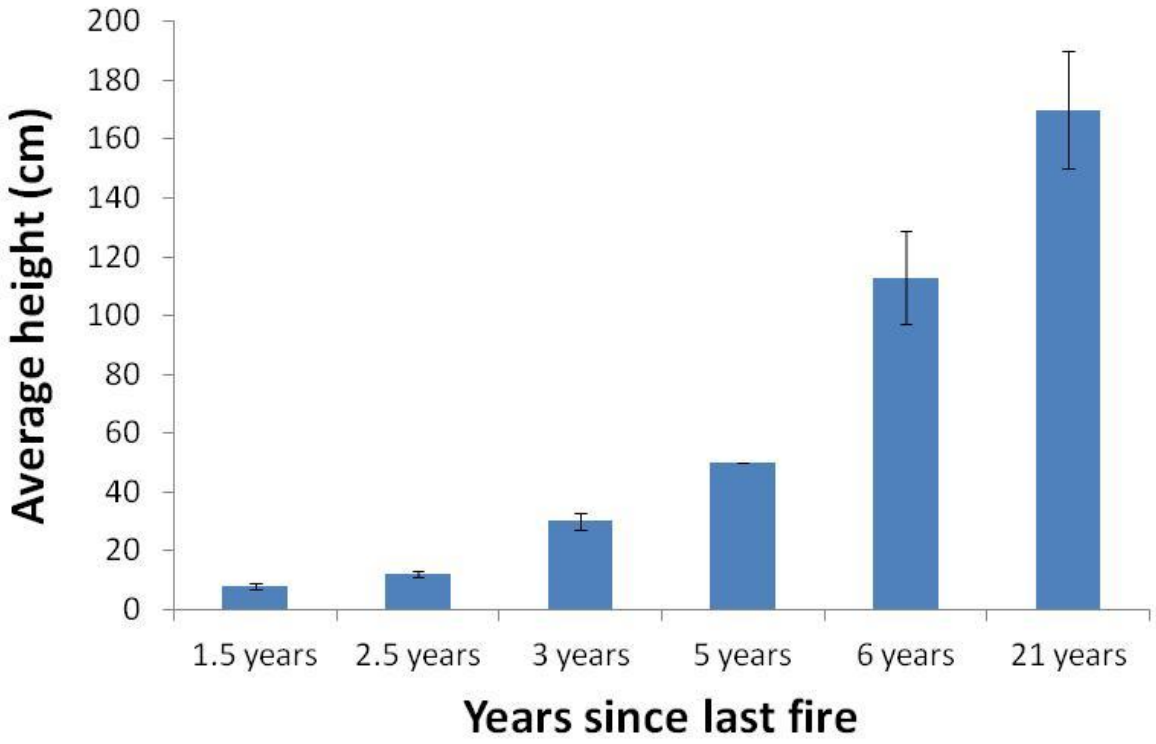

Figure 3. **The average height of *Banksia plagiocarpa* plants with years since last fire.** Error bars are one standard error from the mean.

Counts of fruiting junctions on unburnt and recently fire-killed mature *B. plagiocarpa* plants, evaluated on Hinchinbrook Island in April 2016, indicated an average of 5.5 fruiting junctions on plants assumed to have germinated after the 1995 fire. Two plants on Mt Diamantina had 11 fruiting junctions suggesting long unburnt plants.

Discussion

The post-fire regeneration of *A. littoralis* shrubs combines scattered seedlings and frequent coppice regrowth, although age to seed production by seedlings requires assessment. The survival rate, via coppice shoots, was around a third to half the pre-fire population. This ability to survive fire is consistent across Bishop's Peak and Hinchinbrook Island, and following a range of fires. Combined with its smaller shrubby size, the capacity to coppice after fire distinguishes the *A. littoralis* population in the montane heath from the consistently fire-killed *A. littoralis* trees of the surrounding eucalypt forests (Williams *et al.* 2012). Therefore, we suggest, these montane heath *A. littoralis* shrubs should be appraised for possible subspecific distinctness from forest populations of the species.

As *B. plagiocarpa* is killed by fires that fully scorch its crown, with regeneration via seedlings, the survey of different recent fires provides a useful assessment of different aged *B. plagiocarpa* plants. The seedling data indicates *B. plagiocarpa* is a slow growing shrub with a relatively long juvenile period (about five years or more) before initial seed set. In comparison, many other obligate seeder shrubs in north Queensland and the Arnhem Plateau in the Northern Territory begin flowering by their third or fourth year (Russell-Smith *et al*. 1998; Williams *et al*. 2006).

The estimate of the number of flowering years based on branching junctions on plants on Mt Straloch and Mt Diamantina averaged 5.5 years. Adding the required five years before any *B. plagiocarpa* plants begin seeding provides an average age of at least 11 years old for the shrubs surveyed on Mt Straloch and Mt Diamantina. Queensland Parks and Wildlife Service records (Douglas 2004) indicate Mt Straloch and Mt Diamantina were unburnt since 1994 and 1995 (i.e. 19 years prior to the recent burns). This suggests that the fruit junction counts, combined with minimum seedling flowering age, either underestimate the number of fruiting events of the bushes, or the seedlings took more than five years to begin producing seed, or *B. plagiocarpa* plants don't fruit every year, but on average every two to three years. Further assessment of the frequency of *B. plagiocarpa* flowering events is required.

Data indicating *B. plagiocarpa* plants begin fruiting in their fifth year and possibly fruiting biennially thereafter, suggests adjusting the current fire guideline recommendations in the Hinchinbrook Island Fire Strategy (Douglas 2004) and for this regional ecosystem (*https://environment.ehp.qld.gov.au/regional-ecosystems/details/?re=7.12.64* – sighted 23 April 2017). That is, to expand the fire intervals from the current recommendation of 6 to 10 years out to predominantly 10 to 20 years while ensuring fires are patchy, with occasional more frequent fires and some longer unburnt patches. This will allow adequate time for seed production of *B. plagiocarpa*.

The presence of montane heath covering a broad range of times since last fire, and the patchiness observed in the recently burnt heath, is a good indication that a variable fire regime is already in place. This has previously been identified as an indication that a burn will provide ecological benefits and is a high priority given the significance of the ecosystem (NPRSR 2013).

Burning at the most frequent end of this range – i.e. at a ten year interval, will likely be quite patchy due to low fuel build up, assuming fires under mild weather conditions and good soil moisture. This will help mitigate the short interval by ensuring patches of unburnt heath persist. However, it would likely be best that no ridge or hilltop be burnt with a eight year interval twice in a row - i.e. a second burn should occur after at least ten years after the first because the shorter interval is scarcely longer than the maturation time of *B. plagiocarpa*. It is also important that a few areas have fire intervals beyond ten years, to allow some *B. plagiocarpa* plants to continue producing seed amongst a landscape containing some recently burnt, regenerating heath.

Past surveys on Bishop's Peak (Williams *et al*. 2005) indicate the value of recently burnt heath, which contains greater species diversity than longer unburnt heath. Long unburnt heath is also important to allow the build up of seed supply and heath structure. The best way to achieve a mixture

these heath ages is to target separate ridgelines during different fires, and to ensure burns are as patchy as possible by implementing burning under moist soil conditions soon after the wet season. The resulting patchy fires should ensure some surviving mature *B. plagiocarpa* plants amongst post-fire seedlings.

The eucalypt woodland below the montane heath benefits from more frequent fire than the heath, and past late dry season wildfires in eucalypt woodlands have carried uphill, burning extensive areas of heath on Bishop's Peak. Regular, early dry season burning in eucalypt woodland below the montane heath is necessary to reduce the risk of wildfires carrying too extensively upslope into heath. These fires are likely to carry into the lower edge of montane heath, but as long as they are patchy, occur during moist conditions, and use spot ignition downslope of the heath, the impact will be reduced.

A further issue requiring consideration is the impact of cyclonic events, and the need to review fire management on exposed montane heath slopes in relation to such events to ensure time for recovery. In February 2011, Tropical Cyclone Yasi caused the complete defoliation of around 95% of mature *B. plagiocarpa*, and caused mortality amongst seeding and mature trees along exposed ridges and summits on Bishop's Peak by both severe trunk damage (splitting) and full leaf canopy stripping (M. Parsons, personal observation April 2011). This severe canopy damage included tree mortality within a regenerating area of *B. plagiocarpa* burnt in June 2010 under mild conditions. Seedlings of *B. plagiocarpa* below 50 cm in both recently burnt and long unburnt habitat were observed to survive and persist through this Category 5 cyclone. This indicates that the tolerance of young plants to very strong winds can provide resilience to the ecosystem.

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