Fire Responses in Four Rare Plant Species at Gibraltar Range National Park, Northern Tablelands, NSW

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Fire responses are reported in four rare species at Gibraltar Range National Park following hazard-reduction burning. *Acacia barringtonensis* Tindale, *Grevillea rhizomatosa* P.M.Olde & N.R.Marriot, *Persoonia rufa* L.A.S.Johnson & P.H.Weston and *Telopea aspera* M.D. Crisp & P. H. Weston were the species investigated. In each species, individuals were tagged prior to a hazard reduction fire and their fates followed for 34 months. In *Acacia barringtonensis*, individuals survived fire and resprouted from buds at the base of stems and from rhizomes but the resprouts were heavily browsed by insects and Swamp Wallabies (*Wallabia bicolor* Desmarest). In *Grevillea rhizomatosa*, individuals survived and resprouted from underground rhizomes and no seedlings were found after fires. After fire in *Persoonia rufa*, all scorched plants died but seedling recruitment occurred from a soil-stored seed. In *Telopea aspera*, most burnt individuals resprouted from basal shoots and survived despite heavy post-fire grazing pressure. Increasing fire frequencies by hazard-reduction burning may threaten the survival of all four species, and it is suggested that other methods of reducing fuel be used to manage fire in this area of Gibraltar Range National Park.

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INTRODUCTION

Hazard-reduction burning for wildfire suppression is thought to have recently increased in fire-prone vegetation around the world (Moritz et al. 2004; DEC 2004). This is particularly so on reserved lands in NSW where the NSW Department of Environment and Conservation annual report (DEC 2004) noted that there were twice the number of hazard-reduction burns in NSW National Parks in 2003-04 than in 2002-03. Hazard-reduction burning may be initiated when fuel begins to accumulate beyond specified thresholds (Gill et al. 1987; Morrison et al. 1996; Morrison and Renwick 2000; Fernandes and Botelho 2003). On the Northern Tablelands and similar areas, fuel may be kept at or below these thresholds by burning as often as every three to five years (Raison et al. 1986; Smith et al. 1992). This is a higher frequency than recommended for perpetuation of many species and vegetation communities in the region (Clarke and Fulloon 1997).

Fire can endanger the viability of species, especially if fire frequency is too high (Benson 1985; Bradstock et al. 1995; Keith 1996; Morrison and Renwick 2000). Keith (1996) identified high fire frequency as a mechanism for plant population decline and extinction through depletion of buds or starch reserves in standing plants and also as a mechanism for depleting soil-stored seed banks before they can be replenished. Hence 'High Frequency Fire' has been listed as a Key Threatening Process in the *Threatened Species Conservation Act* (TSC) 1995.

Some shrubs are killed by fire and, after fire, rely on seedling germination and a sufficient interfire period to survive and reproduce (obligate seeders), whilst others resprout after fire (Benson 1985; Gill & Bradstock 1992; Morrison & Renwick, 2000).

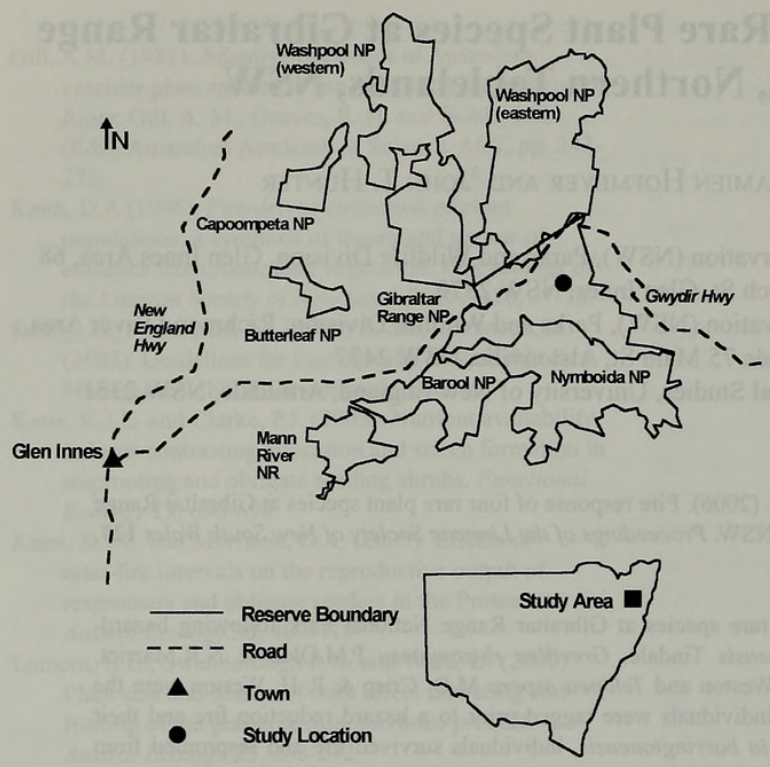

Figure 1. Location of Mulligan's Hut study area within Gibraltar Range National Park.

However, fire responses in many species of vascular plants in Gibraltar Range National Park are unknown (Clarke and Fulloon 1997; Williams and Clarke 1997; Hunter 1995; Hunter 1998; Hunter 2003; Clarke and Knox 2002; Knox and Clarke 2004).

Within Gibraltar Range National Park several areas have been subjected to hazard-reduction burning. One of them, Mulligan's Hut, contains populations of four rare shrub species, *Acacia barringtonensis* Tindale, *Grevillea rhizomatosa* P.M.Olde & N.R.Marriot, *Persoonia rufa* L.A.S.Johnson & P.H.Weston and *Telopea aspera* Crisp & P.H.Weston. As fire responses of plants in each of these species were poorly known, fates of plants burned in a hazard-reduction fire in 1999 were recorded together with any recruitment of seedlings of these species after the fire.

METHODS

Study Area

Gibraltar Range National Park is located 90 km west of Grafton and 65 km east of Glen Innes in north-eastern New South Wales (29°329 S 152°189 E) (Fig. 1). The Gibraltar Range straddles the Northern Tablelands and North Coast Botanical Subdivisions. The mean annual rainfall at Mulligan's Hut is 2100 mm. The study area has a mean annual temperature of 13°C on the plateau with a mean annual maximum of 28°C and mean annual minimum of 0°C. The warmest months of the year are November to March. The rock types are primarily granitic and the topography is generally undulating with extensive areas of exposed rock sheeting and boulder fields.

The study area comprised four hectares of open forest immediately north of the Mulligan's Hut camping area in Gibraltar Range National Park where a small hazard-reduction burn was scheduled in 1999. Mulligan's Hut camping area is towards the centre of the Gibraltar Plateau, at an altitude of 900 m. This burn was planned to help protect visitors and facilities in the camping area from wildfire in the park.

The open forest community at this locality is dominated by *Eucalyptus olida* L.A.S.Johnson & K.D.Hill, *Eucalyptus ligustrina* DC. and *Eucalyptus cameronii* Blakely & McKie. The shrub layer is dominated by *Leptospermum trinervium* (Sm.) Joy Thomps., *Dillwynia phylicoides* A.Cunn., *Hakea laevipes* subsp. *graniticola* Haegi, *Petrophile canescens* A.Cunn. ex R.Br. and *Daviesia umbellata* Sm. The ground layer consists of: *Caustis flexuosa* R.Br., *Platysace ericoides* (Sieber ex Spreng.) C.Norman, *Bossiaea neo-anglica* F.Muell., *Goodenia rotundifolia* R.Br. and *Entolasia stricta* (R.Br.) Hughes.

Prior to the hazard-reduction burn in 1999, NSW National Parks & Wildlife Service fire records indicated two large wildfires had burnt the Mulligan's Hut area in 1964 and 1988 with fire-history maps indicating the study site was burnt. Another fire occurred after the project was initiated in 2002 and the subject populations were burnt during back-burning operations.

Target species

Acacia barringtonensis is an erect shrub endemic to high altitude areas of northern New South Wales with a Rare or Threatened Australian Plant (RoTAP) code of 3RCa (Briggs and Leigh 1996). This shrub grows along swamp margins and creek edges in dry sclerophyll forests and woodlands reaching a height of 7 m. Flowering occurs primarily from September to early November (Tindale 1975).

Table 1. Percent survival of tagged plants in four species in relation to amount of leaf scorched during a planned hazard-reduction burn in the Mulligan's Hut area of Gibraltar Range in 1999.

Species	% Leaf Scorch	1 month	3 months	5 months	7 months	34 months	Number of plants
Acacia barringtonensis	0-50	0%	100%	100%	100%	0%	2
	51-75	0%	100%	100%	100%	0%	1
	76-100	0%	50%	57%	54%	7%	28
Grevillea rhizomatosa	0-50	0%	100%	100%	100%	100%	2
	51-75	0%	33%	67%	67%	67%	3
	76-100	0%	20%	39%	57%	52%	49
Persoonia rufa	0-50	0%	50%	50%	0%	0%	2
	56-75	0%	100%	100%	0%	0%	1
	76-100	0%	12%	6%	0%	0%	17
Telopea aspera	100%	12%	94%	94%	94%	94%	17

Grevillea rhizomatosa is known from scattered populations within Gibraltar Range and adjacent areas of Washpool National Park (Sheringham and Hunter 2002) and is listed on Schedule 2 (Vulnerable) on the *TSC* Act. It is a shrub 0.3-1 m tall and is known to sucker from roots and grows in sclerophyll forests on sandy soils near creeks. The species flowers sporadically throughout the year (see also Caddy and Gross this volume).

Persoonia rufa is endemic to the Gibraltar Range. It is a spreading shrub with a RoTAP code of 2RC (Briggs and Leigh 1996). The plant commonly grows to 1-2.5 m tall and is found in dry open forests on granitic soils (Sheringham and Hunter 2002; Weston and Johnson 1991). Flowering is primarily between December and February.

Telopea aspera is a multistemmed shrub that grows to 3 m tall and has a RoTAP code of 2RCa (Briggs and Leigh 1996). It is largely restricted to Gibraltar Range and is known from dry sclerophyll forests on granitic soils. Flowering occurs between October and November (Sheringham and Hunter 2002; Crisp and Weston 1993). The flowering response after fire has not been studied in *Telopea aspera.* The closely related *Telopea speciosissima* is a pyrogenic flowerer and recruits two years after fire (Pyke 1987; Bradstock 1995).

Fire response traits

Before the fire individuals of all four species were tagged with stainless steel straps with individual identification codes. Each individual was marked on a map of the study area, to aid relocation after the fire. Plant attributes measured included: basal diameter, height, number of stems, location of regrowth, flowering stage, condition and number of seedlings nearby. All the individuals of *Telopea aspera* within the study area were tagged (17 plants), the populations of the other three species were sub-sampled: *Grevillea rhizomatosa* (160 individuals), *Acacia barringtonensis* (62 individuals) and *Persoonia rufa* (60 individuals).

The intensity of the fire was gauged by using flame height markers, photographs and scorch height post burn. Measurements were taken of all tagged plants before the experimental burn and at one, three, five, seven and 34 months after it.

RESULTS

The *Grevillea rhizomatosa* population was burned by a low-intensity fire (average flame height 0.75 m) that affected 54 tagged plants; 26 were burnt and 28 were scorched by radiant heat. *Grevillea rhizomatosa* responded to fire by increasing the average number of stems per plant from 1.19 prior to burning to 1.78 after being burnt. Although all tagged plants unaffected by fire survived, only 55% of fire-affected individuals were alive at the end of the monitoring period (Table 1). Forty-five (83%) of all surviving fire-affected individuals recovered by

multiple rhizomes at a distance of up to 30 cm (12 cm average) from the parent plant, and the remaining nine plants recovered by coppicing.

A low-intensity fire (average flame height 1.07 m) burned the *Acacia barringtonensis* population where 20 plants were burned and a further 11 scorched. All tagged *Acacia barringtonensis* unaffected by fire survived until the end of the monitoring period. Although 17 fire-affected plants recovered from basal stem buds by the 5-month post fire, only two fire-affected individuals survived until the end of monitoring. Most of these recovering individuals were heavily browsed by both insects and *Wallabia bicolor* (Swamp Wallaby). No seedlings were recorded in the first seven months within the vicinity of affected *A. barringtonensis*. However, at 34 months, 22 putative 'seedlings' between 15–50 cm in height were observed.

Twenty *Persoonia rufa* plants were burned with a low-intensity fire (average flame height 0.75 m). All unburnt tagged *Persoonia rufa* individuals (40) survived until the end of the monitoring period, but no individuals survived that were burnt (Table 1). Three scorched plants continued to survive for 5 months after the fire. Within the study area 30 seedlings were counted five months post-burn. All seedlings were of a uniform height (5 cm) and survived through until the last recording period.

Flame heights exceeding five metres were recorded in the areas where *Telopea aspera* was tagged. This resulted in 100% of the tagged plants being burnt at moderate intensity. Ninety-four percent of tagged *Telopea aspera* plants survived the moderate intensity burn. The sole means of survival was by resprouting from the base/lignotuber. As a consequence of hazard-reduction burning, mean number of stems per *Telopea aspera* plant increased from 4.5 to 9.1. At least two individuals were noted resprouting after the first month, with all remaining surviving plants resprouting by the second month and surviving to the final sample date (Table 1). Heavy browsing of resprouting parts by insects and Swamp Wallabies (*Wallabia bicolor*) was observed on recovering plants after the fire. No plants had flowered within the post-fire monitoring period.

DISCUSSION

Species responses

Whilst many individual plants died as a result of the hazard-reduction fire, all species persisted in the study area by different fire response syndromes. The immediate post-fire response of surviving *Acacia barringtonensis* was basal resprouting. These resprouting stems were heavily grazed, which may be a cause of the decline of this species towards the end of the monitoring period. Only at the last survey, at 34 months, were putative seedlings noted in the vicinity of dead individuals. Subsequently, these 'seedlings' were revisited three years after the last monitoring (May 2005) and were found to be shoots from roots that extended back to 'dead' individuals that were tagged. Thus it would seem that, though delayed by nearly three years, this species' response to the hazard-reduction burn was resprouting. The delay may have been in part due to increased grazing pressure that immediately followed this fire. Increased grazing pressure is not a necessary consequence of fire. Indeed, following an extensive wild fire, it may be less than before the fire. However, small burnt areas within large unburnt surrounding areas, such as may arise from some hazard-reduction fires, may be particularly attractive to browsing and grazing animals and experience much more pressure from them than surrounding unburnt areas.

No seedlings of *Grevillea rhizomatosa* were found during the monitoring period and populations appear to be maintained by resprouting from underground rhizomes. Keith (1996) noted that resprouters might be killed if stored starch reserves are exhausted by repeated fires. Though numbers were too low for statistical comparisons, more of the smaller plants in terms of stem diameter and height survived, potentially indicating an age effect ability to recover post-fire (see paper by Knox and Clarke this volume). The smaller *Grevillea rhizomatosa* plants in this study may have depleted smaller quantities of starch reserves. Following the second burn three years later about 65% of the original survivors of the hazard-reduction burn did not recover from the second fire.

Standing populations of *Persoonia rufa* individuals were the most susceptible to extirpation by the end of the monitoring period from low-intensity burns. Although some temporary recovery occurred (due to coppicing after minor scorching), the species persisted in the fire-affected area mainly by germination from a soil-stored seed bank; hence this species should be classed as an obligate seeder.

Telopea aspera was the most resilient in terms of recovery of those individuals present before hazard-reduction burning. Almost all of the tagged plants survived to the end of the monitoring period, despite the imposition of increased (and heavy) herbivory on newly forming foliage. This species responded to fire by resprouting from basal/lignotuberous buds, with

fire increasing the number of stems per plant post-burn. Of the four species monitored, *Telopea aspera* was the first to show signs of recovery after fire but no seedling recruitment was observed.

Implications

Landscape burning at short intervals can have major effects on plant populations (Bradstock 1995; Bell 2001) and may drive the decline of plant populations (Keith, 1996). Consequently, frequent fire can have a significant effect on the composition of flora and fauna (Clark 1988; Andrew et al. 2000; York 2000; Moritz et al. 2004). The current study has identified varied fire responses of plants in four rare species within Gibraltar Range National Park. Although populations of all species persisted after a hazard-reduction burn, most were reduced in numbers and at least two were affected by an increase in post-fire herbivory. This herbivory may have delayed the regeneration of *Acacia barringtonensis*, and may have detrimental long-term effects on *Telopea aspera* in terms of depleting starch reserves. As no plant in any of the four species flowered 34 months after the fire, fire intervals of greater than three years will be needed to maintain their populations.

Hazard-reduction burns may have minimal effects on the number of wildfire events particularly in fire-prone vegetation (Turner et al. 2003; Moritz et al. 2004) and this is likely to be the case here at the Mulligan's Hut site (e.g. the 2002 fire that effected the Mulligan's Hut area). Though hazard-reduction burns are planned, wildfire events are not, thus by increasing the amount of fire in the landscape without being able to predict wildfires there is an increased risk of population decline and extinction. Whilst hazard-reduction burning can reduce the intensity of a wildfire for several years (Raison et al. 1986) it may not prevent the area from re-burning during a wildfire, especially in severe fire weather (Turner et al. 2003; Moritz et al. 2004). Additionally, hazard reduced ground is often chosen as an area from which back burns are planned during wildfires control operations because of lower fuel levels. If hazard-reduction burning is undertaken at the maximum frequency without considering unplanned fires then critical thresholds of fire frequency for long-term survival of populations can be exceeded as has occurred at Mulligan's Hut. To ensure the persistence of our focal species a fire interval that allows seedlings to mature and a seed bank to accumulate is required. Whilst these demographic factors are yet to be quantified it is suggested that the minimum interval between fires to ensure the persistence of the focal species will be more than ten years.

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