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Short-term responses of reptile assemblages to fire in native and weedy tropical savannah

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ABSTRACT

Fire is frequently used as a management tool to reduce the cover of weeds, to reduce the amount of fuel available for future fires, and to create succession mosaics that may enhance biodiversity. We determined the influence of fire on wildlife, by quantifying reptile assemblage composition in response to fire in a weedy environment characterised by very short-term fire return intervals (<2 years). We used reptiles because they are often understudied, and are only moderately vagile compared to other vertebrates, and they respond strongly to changes in vegetation structure. We repeatedly sampled 24 replicate sampling sites after they had been unburned for two years, just prior to burning (pre-burnt), just after burning (post-burnt), and up to 15 months after burning (revegetated) and monitored vegetation structure and reptile richness, abundance and assemblage composition. Our sites were not spatially auto-correlated, and were covered by native kangaroo grass (*Themeda triandra*), black spear grass (*Heteropogon contortus*), or an invasive weed (grader grass, *Themeda quadrivalvis*). Reptile abundance and richness were highest when sites had been unburned for 2 years, and greatly reduced in all areas post burning. The lowest reptile abundances occurred in sites dominated by the weed. Reptile abundance and richness had recovered in all grass types 15 months after burning, but assemblage composition changed. Some species were present only in before our focus fire in native grass, and their populations did not recover even 15 months post-burning. Even in fire-prone, often-burnt habitats such as our study sites, in which faunal richness and abundance were not strongly influenced by fire, reptile assemblage composition was altered. To maintain faunal biodiversity in fire-prone systems, we suggest reducing the frequency of prescribed fires, and (if possible) excluding fire from weedy invasions if it allows native grasses to return.

1. Introduction

Fire is often used as a management tool in natural, recreational, and cultivated areas to remove weeds, reduce the build-up of fuel (Price et al., 2012), and to maintain mosaics of habitat for wildlife (Parr and Andersen, 2006; Pastro et al., 2011). Weed removal is a critical activity, because weeds are among the worst threats to native biodiversity. Exotic grasses, for example, can rapidly change ecosystem functions and services (Elton, 1958; D'Antonio and Vitousek, 1992; Zavaleta et al., 2001). Invasive grasses often grow taller and denser and have higher biomass than native perennial grasses (McIvor and Howden, 2000; Vogler and Owen, 2008; Wilsey et al., 2009; Foxcroft et al., 2010; Lindsay and Cunningham, 2012; Alba et al., 2015). Invasive grasses can alter ecosystems directly by altering the dominant vegetation (D'Antonio and Vitousek, 1992). In

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addition, the interaction between fire and weeds can have negative impacts on fauna. For example, fires fuelled by invasive grasses may burn hotter and more intensely than native grass fires (D'Antonio and Vitousek, 1992; Corbett et al., 2003; Setterfield et al., 2010). Hotter fires can consume more vegetation, which may change faunal resource dynamics, reducing availability of food and shelter, and increasing susceptibility to predators of native fauna (Barnard, 1987; Valentine et al., 2007; Pastro et al., 2011; Penman et al., 2011; McGregor et al., 2014). In addition, hotter fires may increase mortality rates of small vertebrates (Griffiths and Christian, 1996; Barlow and Peres, 2004; Smith et al., 2012; Cross et al., 2015). Repeated fires may reduce species ranges, and fire-sensitive species may become locally extinct (Parr and Andersen, 2006; Driscoll and Henderson, 2008; Penman et al., 2011; Russel-Smith et al., 2012).

Some ecosystems are shaped by natural fires and are highly diverse, suggesting that their fauna are resilient to naturally occurring fires (Woinarski et al., 2004; Andersen et al., 2005; Pianka and Goodyear, 2012). Organisms in these habitats are thought to be adapted to high natural fire frequency (Braithwaite, 1987; Friend, 1993; Trainor and Woinarski, 1994; Corbett et al., 2003; Pastro et al., 2011), and may prefer the habitat structure and composition created by fire (Braithwaite, 1987; Friend, 1993; Trainor and Woinarski, 1994; Singh et al., 2002a; Pianka and Goodyear, 2012). In such environments, the influence of fire, weeds and their interactions on native fauna may be reduced, because the fauna is resilient to fire (Pastro et al., 2014). For example, fire had little effect on the assemblage composition of vertebrates in a tropical savanna in Australia and South Africa (Parr and Andersen, 2006). On the other hand, fire did alter the assemblages of lizards in the Simpson Desert, which is a fire-prone grass habitat (Pastro et al., 2011).

Typically, studies investigating the effects of fire compare areas with different fire histories (e.g., Driscoll and Henderson, 2008; Valentine et al., 2012, Nimmo et al., 2013; Pastro et al., 2014). Such studies examine fire succession, and the long-term effects of fire, but are not designed to quantify short-term effects ($\leq$2 years). It is, however, of interest to examine the same sampling sites before and after fire, to investigate the rate of recovery of flora and fauna. Here we compared replicate sampling sites, dominated by different types of native grass or an invasive weed, over time to determine the short-term effects of fire on fauna. We sampled the same sites when they had not burnt for 2 years, directly after burning, and up to 15 months after burning, when vegetation cover had returned to pre-burnt levels. The environment we studied often burns more than once per year, due to a combination of wildfire and prescribed burns, especially when weed-infested. Determining the short-term effects of fire longitudinally is highly relevant to such environments (Price et al., 2012).

We examined assemblage composition of reptiles, because they are abundant and typically respond strongly to disturbance (Braithwaite, 1987; Pianka and Goodyear, 2012; Smith et al., 2013; Hacking et al., 2014). In addition, reptiles are small-to medium-sized, and only moderately vagile compared to birds and mammals, making them excellent study organisms in which to study small-scale influences of habitat (Pardon et al., 2003; Mills, 2004; Pianka and Goodyear, 2012). Finally, influences of anthropogenic habitat disturbance on reptiles is often neglected compared to other vertebrates.

2. Methods

2.1. Study system

Our study sites were located in savannah and open woodland at Undara Volcanic National Park in north Queensland, Australia (18°19′29.92″S, 144°36′28.31″E). We used a total of 24 sampling sites with eight replicates, each dominated by a particular grass, either native kangaroo grass (*Themeda triandra*), native black spear grass (*Heteropogon contortus*), or non-native, invasive grader grass (*Themeda quadrivalvis*, see Appendix Figure S1 in supporting information). We monitored these sites as they passed through three different states, when they had not been burnt for 2 years (pre-burnt), directly after burning (post-burnt), and up to 15 months after burning (15 months post-burnt) when vegetation cover was similar to pre-burnt levels.

Briefly, the area was a grazing property until it was made a National Park in 1992. At the time of our study, the entire area had not been grazed for 16 years. Black spear grass and native kangaroo grass grow together in the same land type, and we exploited patches (50 $\times$ 50 m) dominated by each grass on small scales at our sampling sites. Grader grass grows in disturbed areas, and was common on the sides of tracks, and in previously cultivated areas at our site, but it also occurred in patches closely associated with, and interspersed with native grasses. We exploited such patches to specifically target differences in the fauna at sites that were influenced in particular by grass species and burning, and not primarily driven by differences in other factors, such as soil type, past history or spatial location. For a more comprehensive description of sampling sites and history see Abom et al. (2015).

Grader grass is native to India, and grows in a sward, emerging as a single stolon, whereas the two native grasses grow in clumps or hummocks (McIvor and Howden, 2000; Keir and Vogler, 2006). Grader grass can grow to 2.5 m, producing high above-ground biomass, whereas these native grasses grow to 1.5 m. A detailed habitat description has been provided elsewhere (Abom et al., 2015), and for a more comprehensive review of grader grass characteristics and biology, see Keir and Vogler (2006).

The rangers at Undara Volcanic National Park implemented prescribed fires in April 2009 and 2010, when environmental conditions were cool enough to allow the fire to self-extinguish in the late afternoons. Sampling sites in the current study had been burnt on rotation every 2 years since 2002, with wildfires also occurring. A wildfire in October 2003 burned the entire park, and one in November 2008 burnt large areas of the park, including some sampling sites (Appendix S1).