Summary

Australia has suffered severe declines in its native mammal fauna, with the most drastic declines occurring for native rodents. This is partly due to changing fire regimes, with wildfires becoming more frequent and intense in many regions. In order to halt these declines, it is important to understand how populations respond to, and recover after fire.

My research focuses on the Kimberley region of Western Australia. Funding by the Royal Zoological Society of NSW's Paddy Pallin grant allowed me to carry out a follow-up field season after a fire experiment I performed one year previous. This meant that I was able to trap pale field rats (*Rattus tunneyi*), a vulnerable native Australian rodent, over three trapping sessions: before, immediately after and one year after these prescribed burns.

I found that vegetative cover decreased substantially after fire. This was much more dramatic in the thorough burns than in the patchy burns and certain types of vegetation were more likely to burn than others (in particular, the preferred vegetation of the pale field rat). I also found that as the percentage of the site that burnt increased, the abundance of pale field rats decreased. This was also true for the number of animals recaptured immediately after the fire, with no animals surviving after thorough fires. However, surprisingly, both the vegetation and pale field rat populations completely recovered one year after fire.

This suggests that populations can rapidly recover after fire. However, the mechanism driving the recovery process may differ between thorough and patchy fires. Genetic analyses will help us to determine if post-fire recovery is driven by survival or recolonisation. This information will provide valuable information for fire management strategies in northern Australia, as management can be tailored to promote fire regimes that support recovery for vulnerable native rodents.

Background

Fires are a defining characteristic of the Australian environment. However, research suggests that they are becoming larger, more frequent and more intense in many landscapes[1,2]. Increased fire danger and extended fire seasons are predicted throughout Australia, especially in the savanna regions of northern Australia[2]. It is therefore essential to understand how species respond to fire, as altered fire regimes may increase the risk of extinction for vulnerable species[3].

More mammal species have become extinct in Australia in the last 200 years than anywhere else in the world[4]. In recent decades there has been a rapid decline in many small to medium sized mammal species throughout these northern savanna regions[5]. The cause of these declines is complex and most likely synergistic[6]. However, the increasing intensity and frequency of wildfires has been postulated as a major threat driving mammal declines[7,8].

Native Australian rodents are grossly underrepresented in the literature and rarely receive intensive conservation effort[9,10]. Yet, of the major terrestrial mammal groups in Australia, native rodents represent the greatest number of extinct and threatened species[5,9]. Research suggests that disturbance (for example, fire) can remove cover used by native rodents for shelter, nesting and foraging, increasing the risk of predation[5]. Therefore, there is urgent need for studies increasing our understanding of the processes by which species respond to, and recover from fire, particularly for Australian native rodents.

Robust strategies for managing fire with a strong ecological and empirical grounding are lacking for many ecosystems worldwide[11]. Contemporary fire management supports the idea of mosaic patch burning to create habitat with differing fire histories across the landscape[8,12]. However, this design has received criticism due to its lack of empirical research on the effects of different mosaic patterns on biodiversity[12]. Furthermore, our current understanding of species' responses to fire is largely pattern-based and lacks direct knowledge about the response to, and recovery after, fire[8,13]. Therefore, studies elucidating the mechanisms behind population responses to fire will help us gain a more thorough understanding of the consequences of fire on mammal biodiversity.

Study objectives

My research focuses on the Kimberley region of Western Australia, where changes in the intensity and frequency of fires have already been observed[3,7]. I am assessing the mechanistic response to fire in a native Australian rodent, the pale field rat (*Rattus tunneyi*). Pale field rats have suffered a substantial range reduction across Australia and are considered vulnerable in the Northern Territory[9,14]. This species has also shown strong declines after fire[7]. This research aims to address three major questions, using field research and genetic data. These include:

1) How do fire events affect the vegetation (or cover, that protects pale field rats from predators)?
2) How do fire events affect populations of pale field rats (for example, mortality and dispersal)?
3) Is post-fire recovery driven by *in situ* survival or recolonisation?

Methods

This project took place at the Mornington Wildlife Sanctuary (operated by the Australian Wildlife Conservancy), which is located in the central Kimberley region of Western Australia. In 2015, I carried out the major experimental component of this project and then returned in 2016 to follow up on this field experiment.

During the experimental component of this research (February – July 2015), I set up 10-paired sites, which underwent different burn treatments in a replicated before-after-control-impact (BACI) design. Patchy experimental burns were performed in two sites, to represent early season, low intensity burns (Fig. 1a). Thorough experimental burns were performed in an additional two sites, to represent high intensity fires that typically occur late in the dry season (Fig. 1b). The remaining sites were unburnt controls. Pale field rats were marked with microchips and tissue samples were taken (for genetic analysis) before, six-weeks after and one year after these experimental burns. Detailed vegetation surveys were also conducted across the same time periods.

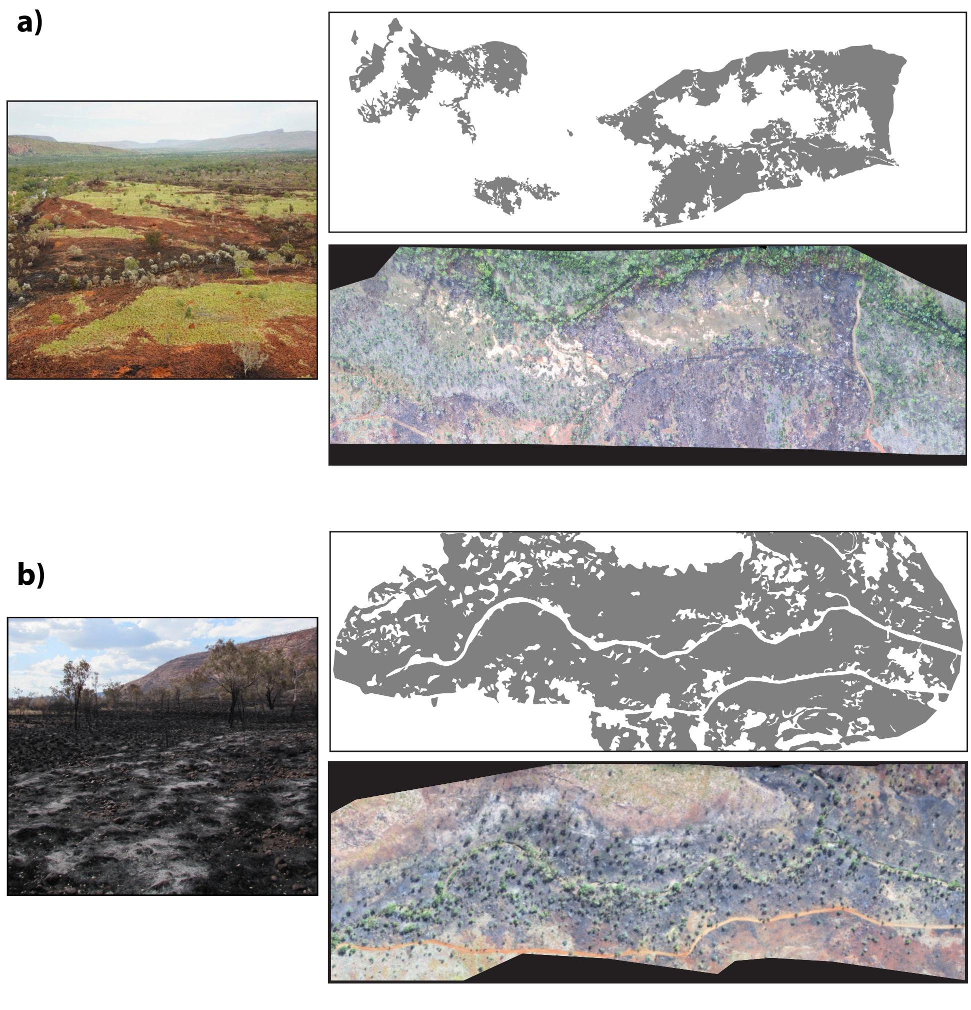
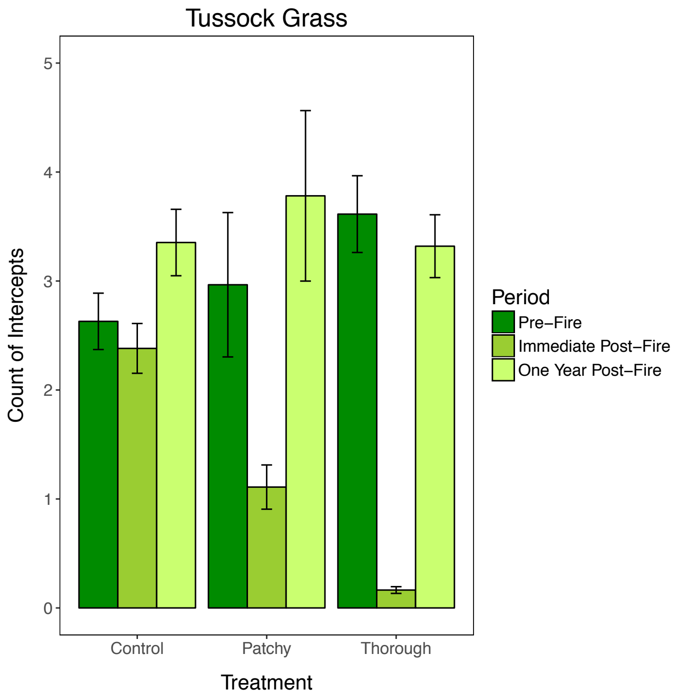


Figure 1. Vegetation immediately after fires, fire mapping of burn scars and aerial views of fires for an example of a:
a) Patchy fire and
b) Thorough fire

Summary of Key Results

1) Vegetation

Using a Generalised Linear Mixed Model (GLMM), we found that fire reduced the amount of cover provided by the vegetation. There was also an interaction between the type of vegetation and the effect of fire. The majority of pale field rats were captured in tussock grass vegetation. This preferred habitat was also the vegetation that was most effected by fire. This figure represents our model predictions. The y axis represents the level of cover and the x axis shows the three sessions for each treatment. In the control sites, there was no difference in the level of cover between the trapping sessions (with a slight increase in cover one year later). However, in the patchy sites, cover decreased immediately after fire. This decrease was much more dramatic in the thorough fires. However, in both fire treatments, the vegetation completely recovered one year after the fires.

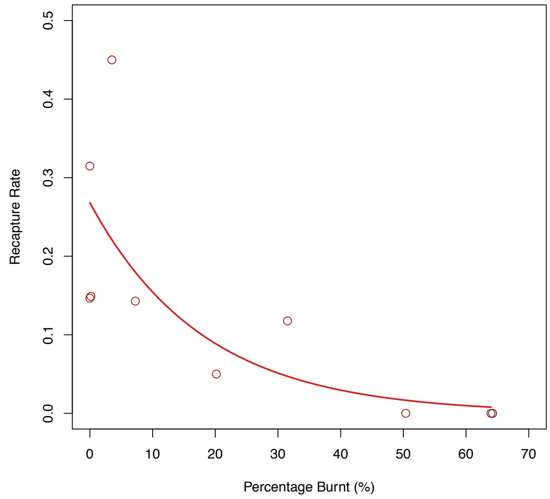


2) Pale field rat abundance

Fire had a major impact on pale field rat abundance in the short-term. Below, the x axis shows the percentage of the site that was burnt and the y axis shows pale field rat abundance. Raw data (points) and the model predictions from a GLMM (lines) are shown across the three trapping sessions. Before fire, there was no relationship between the % burnt and abundance (following expectations, as there should not be any relationship before the fire experiment was performed). Immediately after fire, the abundance of pale field rats declined as the percentage of the site that was burnt increased. However, much like the vegetation, one year after fire the abundance of pale field rats had completely recovered (so that, again, there was no relationship between abundance and % burnt).

3) Pale field rat recaptures

Finally, we looked at the recapture rate from before to immediately after fire (using a GLMM). The recapture rate between the first and the second trapping session also decreased dramatically as the percentage of the site that was burnt increased. Only 18 animals were recaptured one year after fire. All of these recaptures were found in control and patchy sites. The one animal that we recaptured in a thorough burn was actually a long distance disperser from an unburnt site.



Conclusion and Future Goals

While we didn't find any long-term differences in abundance after patchy *versus* thorough fires, these results give us a hint as to what might be the driving population recovery process. More animals survived in patchy fires, where there was more vegetative cover and protection from predators. Some animals were recaptured one year later in these patchy sites, suggesting that recovery may have stemmed from *in situ* survival. By contrast, there were almost no survivors and no recaptures after thorough burns, most likely due to amplified predation (particularly by feral cats[15]). This suggests that recovery in these sites is driven by recolonisation. I am currently analysing the genetic data collected during this experiment, which was genotyped using Diversity Array Technology methods (DArTseq™)[16]. This genetic data will be used to determine whether unmarked individuals caught after the experimental burns originated from the pre-fire population, and are therefore *in situ* survivors. Alternately, these individuals may be immigrants that rapidly recolonised the burnt area from unburnt habitat. Characterising these short-term, post-fire demographic processes is critical for understanding the starting point for population recovery[13]. Furthermore, I will determine whether recruits to the study sites during longer-term fire recovery are sourced from locally-born individuals or immigrants. This will help to resolve the mechanisms underlying population recovery.

Characterising these post-fire recovery mechanisms is important for both understanding basic populating dynamics of the pale field rat, as well as for developing conservation management strategies for this declining native rodent. Without intensive, purposeful and effective fire management, this species, along with many other small mammals declining across northern Australia, will potentially be added to our long list of extinct mammals. Without knowledge about the mechanisms underlying fire recovery, fire management is currently lacking vital information. By understanding how populations respond to, and recover after fire, fire management can be tailored to promote fire regimes which most support recovery for vulnerable native rodents. Rodents also characterise the extinction process for small, ground-dwelling mammals in Australia, so their requirements for conservation can be applied to these other vulnerable species too. Thanks to the support of the Royal Zoological Society of NSW, this research will lead to tangible outcomes for the judicious use of fire management to facilitate fauna recovery by the Australian Wildlife Conservancy, and will ultimately provide valuable information for fire management strategies across the savannas of northern Australia.

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