Preliminary Report:-
Fire Responses of Threatened Mammals, and other taxa, in the Mitchell River area, North Kimberley

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Summary

A study was set up in the Mitchell River region to investigate the responses of native mammals to fire regimes. This was initiated to establish factors relating to declines of these animals across northern Australia, and also to aid in planning fire prescriptions.

Sites were chosen inside and outside an established fine-grain fire mosaic surrounding a camp area and walking track. This was to test for a mosaic versus a broad-scale fire effect on mammal populations. Sites were chosen to represent different times since the most recent fire. This would help with designing optimal fire rotations to allow re-establishment of species where they disappear after fires.

A grid of mammal (elliot) traps were set up at sites, and monitored for 4 nights per trapping session was undertaken to establish mammal species and numbers at each site. Other environmental factors, including vertebrate and invertebrate samples, plant species, soil fertility and vegetation structure, were also measured at each site. Eighteen sites were measures in 2007 both on sandstone and laterite substrates, and 8 sites were chosen for longer term studies on sandstone only in 2008 and 2009.

The results show that both mammals and other groups respond to time since the most recent fire. Some species, including northern quolls, several small skink species and large ground dwelling invertebrates, prefered open, more recently burnt areas (<1 year). Others, including rodents and bandicoots, and larger skinks such as Ctenotus inornatus, *were more numerous in older vegetation (>2 years).*

No single fuel age will benefit all species, but the rarity of older fuels means that persistence of vegetation >2 years in patches >10 ha, should be a key component of burn prescriptions.

Fire mosaics (with both recently burnt and long unburnt patches) appear to protect mammals from localized losses. In mosaic areas mammals did not disappear after fires, presumably because they could recolonise straight away from adjoining areas that weren't burnt. In contrast, areas burnt during broadacre fires often had animals (including quolls and common rock rats) disappear for up to 2 years post-fire. This presumably relates to difficulties in recolonising from isolated fire refuges.

The Mitchell region is not uniformly good habitat for mammals. While sandstone areas had good populations of mammals, laterite woodlands did not. This suggests that we should not be complaisant about mammal status in the north Kimberley, and that fire regimes are probably not optimal in many woodland habitats under current regimes.

Mammal numbers appear to be related more to habitat structure (grass biomass, shrub cover) than food resources, though this needs further testing.

Key points of this work are that longer unburnt vegetation (>2 years) components should be retained as a significant part of the landscape (ca. 10-30% land area) to increase persistence of mammals in the landscape. These older vegetation patches should be at least 10 ha in size, and should be distributed throughout the landscape. This will be a major challenge to management agencies given the tendency of high fuel areas to burn preferentially under random ignitions often used in fire prescriptions.

Background

A study was commenced in the north Kimberley, centred on the Mitchell River and Mitchell Plateau regions to examine and understand the responses of native mammals to fire. Once these responses are understood, they can be used to inform fire management of the Kimberley region for conservation purposes. This is a preliminary report provided to update managers on research progress. It will also provide an opportunity for results to be incorporated into fire prescriptions within an adaptive management framework.

Current fire regimes, are identified as a key threatening process affecting biodiversity across northern Australia. Current regimes probably differ both from traditional Aboriginal regimes, and also those occurring naturally due to lightning strike (dominated by smaller scale fires, often in humid, stormy periods) (Russell-Smith *et al.* 2003). Mid to late dry season wildfires now dominate fire regimes in northern and north-western Australia, and seem to be mostly ignited either accidentally or deliberately by people.

These fires, which cover huge areas annually, are thought to threaten a number of important biodiversity components in tropical northern Australia. Particularly affected are the small and medium sized mammals, which have declined markedly in recent decades (Woinarski *et al.* 2001). This group has declined significantly ever since Europeans settled in Australia, and the concern is that this process of decline and extinction is continuing in northern Australia (Johnson 2006; McKenzie *et al.* 2007). The north Kimberley is now the only part of mainland Australia where all historically recorded mammal species are still present. This makes conservation management of this group in the tropics a major priority, both from a national and an international perspective.

One of the key ways in which land management agencies manage northern landscapes is through planned use of fire. Often this prescribed burning is designed to prevent incursion by later, widespread high intensity wildfires. However, without an understanding of animal responses to the different types of fire and fire regime, it is difficult to know how to integrate fire into management, and what we should be aiming for within our burn prescriptions.

Aim

The aim of this study was to identify the responses of threatened mammals to various fire regimes in the north Kimberley region of Western Australia. Studies were established to examine whether Kimberley mammals have similar fire responses to those reported elsewhere in northern Australia (e.g. Kakadu) Andersen *et al.* 2005).

In addition, the findings from this study will be used to guide fire management, within an adaptive management framework. By demonstrating the time taken for mammal populations to recover from fire, burn rotations can be designed to allow these populations to survive. By looking at the type of responses, for instance whether recolonisation or site persistence occurs, we can also decide whether fires need to be applied in patches (mosaics) or uniformly, and what scale these mosaics should be. Further, by continuing to monitor mammal populations within the areas where burning is being applied, we can assess the benefits/drawbacks of fire management actions on target mammal populations and modify as required.

This study will gather data on what mechanisms might be driving fire responses. This is so that fire management can be used to provide the resources/habitat features necessary for survival of these mammal populations. For example do mammals respond to vegetation and habitat structural features (shrub density and cover, grass cover), or to fluctuations in food availability as affected by fire? Or is the response more complex and species specific?

We addressed the question of what might be driving mammal responses underlying fire effects by measuring a range of habitat features at study sites. Habitat features included vegetation structure, plant composition, invertebrate and small vertebrate communities, soil resources and permanent habitat features like rocks. These features were then related to mammal abundance to identify possible drivers of observed patterns.

Preliminary Study 2007

This study occurred from May to July 2007. Surveys of mammal populations at both sandstone and laterite/basalt sites were conducted. Sites represented a range of time since most recent fire. This was designed to test if there was any relationship between mammal numbers and time since fire. The aim was to test whether similar fire responses occurred in mammals from the Kimberley to those in the Northern Territory. The study also aimed to determine how long it took mammals to recolonise/recover after fire. This was to provide guidance on fire rotation period. Sites are mapped in Fig. 1 with most recent fire scars.

Sites chosen in the study ranged from one to 24 months since the most recent fire. Time since fire was determined by fire scar mapping from Landsat images (Li Shu, unpublished 2007; Fig. 1). We also used operational knowledge from DEC staff who worked in the area. Eight sites were chosen on sandstone, eight on laterite and two on basalt substrates. In 2007 we used Elliott traps set out in grids of 30 traps (20 m apart) over four nights to get information on mammals species present, and their relative abundance. Only sites accessible by vehicle or short walk (<20 min) were chosen for logistical reasons. From the analysis of Landsat fire scars, all these sites had had a history of low intensity, small scale fires (Li Shu, unpublished).

Detailed Study 2008/09

During 2008, more detailed studies were undertaken at fewer sites, and only on sandstone substrates. This was because there were too few animals at the laterite sites to test any hypotheses, and because a number of important mammal species from a conservation perspective were present only at the sandstone sites (e.g. northern quolls, golden bandicoots).

These studies were designed a) to test whether mammal community dynamics differed between areas with a history of low intensity fires, and those that historically have had high intensity, large scale fires, and b) to provide data on what mechanisms drive the fire responses demonstrated by the mammal populations.

A total of eight sandstone sites were established for this detailed study (Fig. 1). Four sites were chosen from the preliminary 2007 study, for the sake of continuity. These sites represented areas burnt by low intensity fires (see fire scars in Fig. 1). Four additional sites away from fire-protected areas were chosen to represent sites with a history of higher intensity dry season fires (Fig. 1).

In this study, a grid of 25 medium and 24 large Elliott traps set at 20m spacings were used to sample mammal populations over four consecutive nights. Trapping grids covered an area of c. 1.44 ha. Species, sex, body weight, pez length, breeding condition was measured. Mammals were micro-chipped to obtain an accurate measure of abundance. In addition to measurement of vegetation structure, we sampled small vertebrates and large ground dwelling invertebrate communities using funnel traps. By sampling these groups, and through analysis of mammal scats (collected from Elliott traps and analysed for dietary components (% composition), we were able to look at how food resource dynamics might be related to mammal numbers (e.g. northern quolls). We also measured plant community structure, plant floristics, soil nutrients and invertebrate abundance to determine if any of these features related to mammal numbers. Sites were sampled in the wet/dry transition period (Mar/Apr), during the mid dry season (June) and during the late dry/buildup transition (Aug/Sep) in 2008.

Results and management implications

Following is a summary of data from the study in the Mitchell River area. The results are presented in five sections, each representing a different aspect of the study. For each section we have presented a short summary of the implications of the results for fire management. It should be noted that these data represent preliminary results from two years of data collection only. In a highly variable environment like the north Kimberley, it is not possible to yet present conclusive results. However, it is important that managers are kept up to date with progress in this study so that, in an adaptive management framework, changes to fire prescriptions can be made if necessary.

Plate 1. Some of the critical weight range mammals from the Kimberley. Top, Northern Brown Bandicoot (*Isoodon macrourus*); bottom left, Northern Quoll (*Dasyurus hallucatus*) and bottom right, Common Rock Rats (*Zyzomys argurus*).

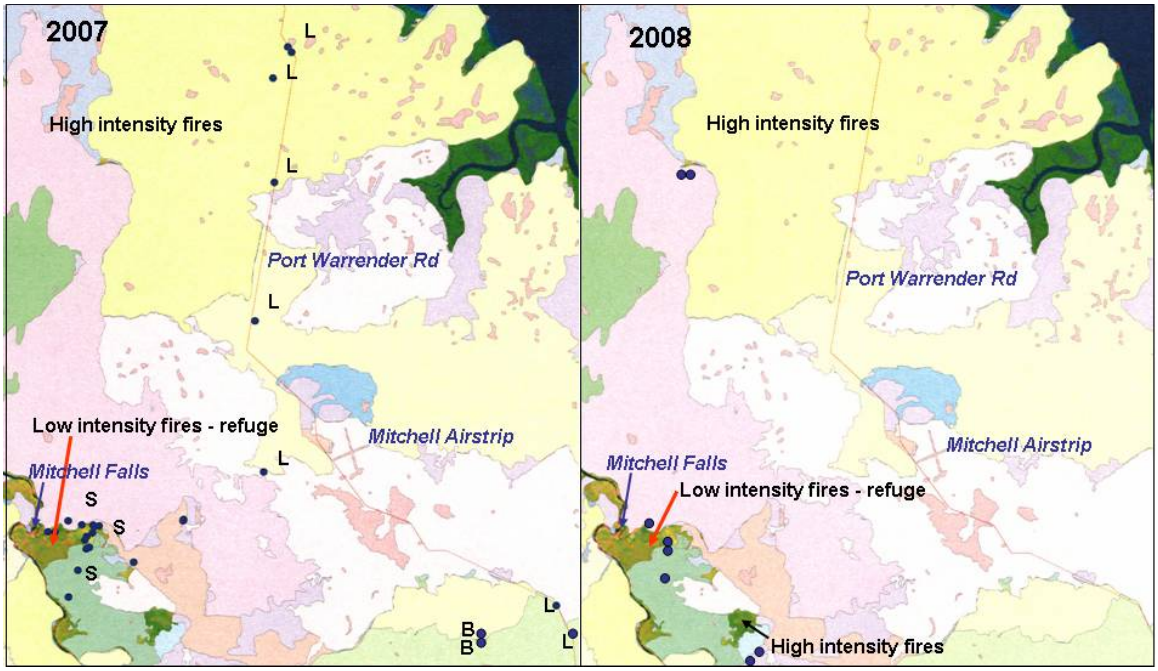


Fig. 1. Map of study area showing trap sites in 2007 and 2008, with fire scars (2000-May 2007). Individual fire scars are represented by different coloured tiles, and are overlaid upon one another. Areas without coloured tiles (Landsat photo of land surface) represent areas where no major fires were detected using remote sensing of Landsat images from 2000-2007. These non-tiled areas are known to have been partially, but not fully burnt, during small scale management and lightning ignited fires. The small, apparently unburnt fragment at the bottom left of the image, however, is believed to have been intensely burnt since 2000 based on its simple understorey structure. Dense laterite woodland canopy overhead may have obscured the fire scar from remote sensing analysis. In 2007, laterite sites are denoted by **L**, sandstone by **S** and basalt by **B**. All sites shown for 2008 were on sandstone.

1. Mammal response to fire

We compared numbers for each mammal species between the recently burnt and long unburnt sites. This data includes repeated measures of all sites across the two years of the study so far. Not all responses were significant in the first year, however, all the major mammal species captured appeared to respond to time since fire when the 2 years of data were combined.

It should be noted that most of these data are taken from sites where small scale (<1 km^2), low intensity fire have predominated, and where there was access nearby (within several hundred metres) to long unburnt vegetation. It should therefore not be seen as necessarily typical of northern savanna landscapes, but rather as an ideal, in terms of animal responses.

The figures below show fire responses of three of the most common mammal species (Fig. 2-4). Sites were on sandstone, with numerous habitat boulders, and have been protected from large scale, intense wildfires since 2000 due to proximity to ranger’s station and camp ground.

The nationally threatened northern quoll had a slight preference for more recently burnt habitats within mosaic habitats (Fig. 2). Their numbers decreased with time since fire.

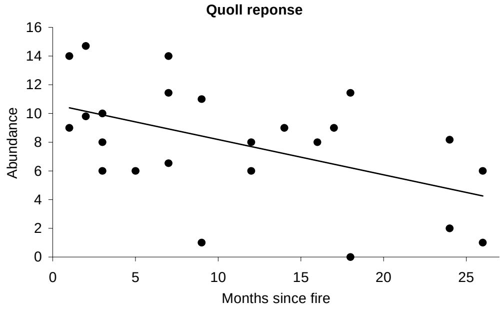


Fig. 2. Quoll abundance (per 200 trap nights) trapped at sites against months since the most recent fire (P=0.022; R^2=0.287).

In contrast, bandicoots and rodents appeared to prefer longer unburnt habitats (Fig. 3, 4). Although numbers varied in the mosaic, few sites had no animals. Co-existence of all species might therefore be facilitated by presence of both recently burnt, and long unburnt habitat, within the area.

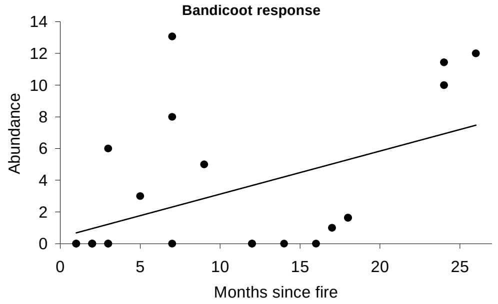


Fig. 3. Bandicoot abundance per 200 trap nights (both *Isoodon macrourus* and *I. auratus*) at sites with differing months since the most recent fire (P=0.015; R^2=0.303).

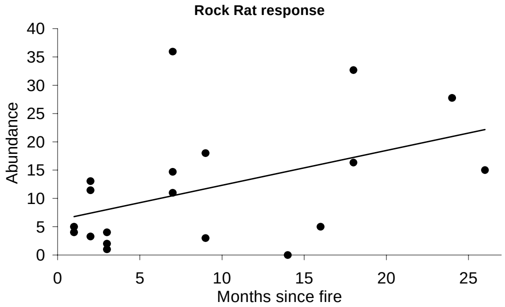


Fig. 4. Common rock rat abundance (animals per 200 trap nights) at sites with months since the most recent fire (P=0.049; R^2=0.209).

Implications

Quolls prefer recently burnt areas (<12 months) while rodent and bandicoot numbers increased with time since fire (>2 years). To accommodate this, prescriptions should include 24 month+ old fuels, as well as recently burnt areas in the mosaic.

It should be noted that this data is taken from favourable habitats where prescribed burn mosaics have been applied since 2000. The study has been protected from large scale dry season fires since 2000, when the Mitchell River National Park was established. Even though fires have been frequent within this area, they have generally been small. Unburnt patches have always been present within the area.

This favourable burn mosaic has been achieved through the initiative of DEC rangers. This should be congratulated and encouraged.

So, although northern quolls appear to prefer recently burnt country for foraging, this must be seen within the context of the overall mosaic. Evidence below (Fig. 5, 7) suggests that quolls do not necessarily maintain viable populations in intensely burnt areas.

2. Effects of fire mosaics versus broad-acre burns

In 2008 we compared mammal populations in areas protected from large fires ("mosaic" areas near Mitchell camp) with areas with a history of intense, broad-acre fires (see Fig. 2). This was to test whether there were any effects on mammals of more severe fire regimes.

There were a number of interesting differences between areas with a history of high intensity versus low intensity fires. Northern quoll populations were more abundant and more stable in areas with a history of lower intensity mosaic burns (Fig. 5). Peak seasonal abundance was during the mid dry season for stable mosaic populations, while peak numbers were later in the dry season for populations in broad-acre burnt areas.

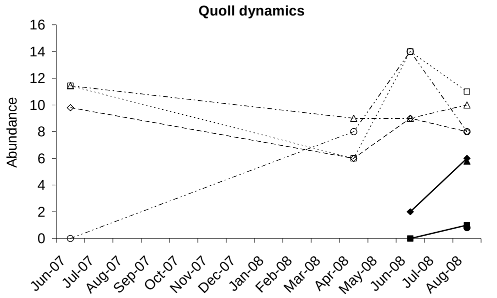


Fig. 5. Northern quoll numbers (per 200 trap nights) at different times at sites of low (clear symbols, dashed lines) and high fire intensity areas (Black symbols, continuous lines).

Common rock rat peak abundance in areas with broad-acre fires also lagged behind mosaic burnt areas (Fig. 5). Rock rat populations fluctuated more wildly that quoll populations, with lowest numbers during the wet season.

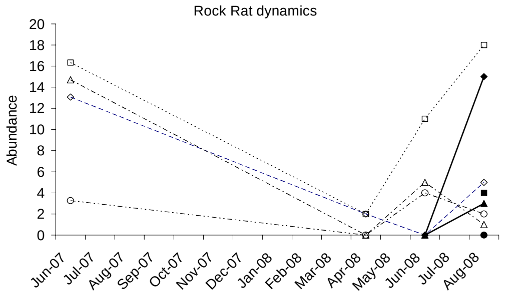


Fig. 5. Common rock rat numbers (per 200 trap nights (tn)) at different time since fire inside low intensity (clear, dashed line) and high intensity areas (black, solid lines).

Northern Quoll and Common Rock Rat populations had considerable delays in population recovery at broad-acre versus mosaic burnt areas (Fig. 6, 7). While there was little reduction in numbers of quolls after fire in mosaic areas, populations had not recovered in some broad-acre burnt sites 2 years after fire (Fig. 6). This suggests that numbers were either reduced dramatically after high intensity fires, or that there was a considerable delay in recolonisation. Delays in recolonisation are likely to be due to difficulties in dispersal from isolated unburnt pockets within extensively burnt landscapes.

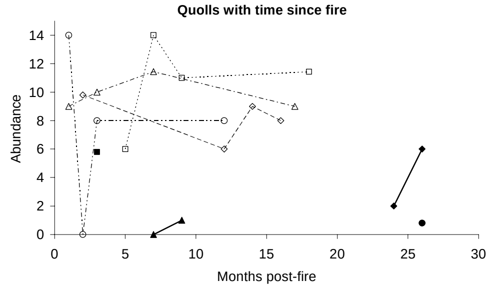


Fig. 6. Northern quoll numbers with time since fire at sites inside and outside burning mosaics.

Although similar numbers of rock rats seem to re-establish in broad-acre and mosaic areas, there was a delay before populations were re-established, with 3 out of 4 sites having no rock rats from between 7 and 26 months post-fire (Fig. 7). This suggests that this species may have to recolonise from scratch after each major fire event. After large fires characteristic of these areas, recolonisation rate will depend directly on proximity to unburnt refuge habitats.

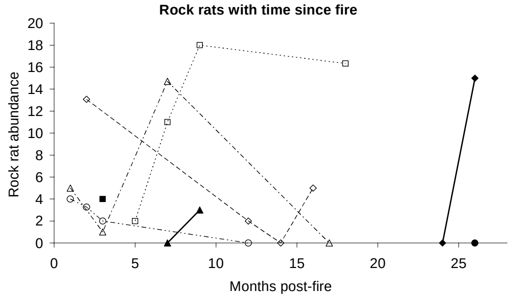


Fig. 7. Rock rat numbers (/200 tn) with time since fire at sites inside and outside burning mosaics.

Implications

Fire mosaics made up of fine grained burns (1 ha-1 km^2) are better for mammal populations than broad-acre fires (>1 km). This is probably because of greater ability of animals to recolonise from nearby unburnt or less severely burnt patches. This will be much slower in than from areas characterized by large landscape scale fires. Populations were more stable in areas protected from large scale fires. Fire management should aim to recreate this mosaic to promote stability of threatened mammal populations.

3. Sandstone versus Laterite/Basalt

No relationship was identified between mammal numbers and fire for laterite and basalt sites. This does not imply, necessarily, that there is no relationship, just that in this study, too few animals were caught to detect any.

As seen in Table 1, a total of only 10 animals, compared to 189 on sandstone, were captured at laterite/basalt sites. Only 3 of the 8 were found on laterite. This is despite very high trapping effort.

Table 1. Mammals captured during 2007 at sandstone and laterite/basalt sites. The number of trap nights are given in parentheses. A total of 8 sites re trapped on sandstone, 8 on laterite and 2 on basalt.

Species	Common name	Sandst. (964)	Lat/Bas. (1336)
Zyzomys argurus	Common Rock Rat	95	0
Z. woodwardi	Kimberley Rock Rat	5	0
Psuedomys nanus	stern Chestnut Mouse	15	8
P. delicatulus	Delicate Mouse	12	0
Melomys burtoni	Grassland Melomys	6	0
Rattus tunneyi	Pale Field Rat	1	0
Leggadina lakedownensis	Tropical Short-Tailed Mouse	0	1
Isoodon macrourus	Northern Brown Bandicoot	17	1
Dasyurus hallucatus	Northern Quoll	38	0
Total		189	10

Reasons for low numbers are unclear. However, based on data from historical records, it appears that laterite environments experience very large fluctuations in mammal numbers compared to sandstone environments. This can be seen from mammal trap success data at a West Australian Museum (WAM) site. Data is shown from 1982, 2003 and 2007 (Fig. 8). It can also be seen by comparing trap success for both sandstone and laterite sites during mammal surveys in 2003 and 2007 (Fig. 8). What seems clear is that dramatic fluctuations on laterite have occurred historically, while sandstone environments apparently have had more stable populations.

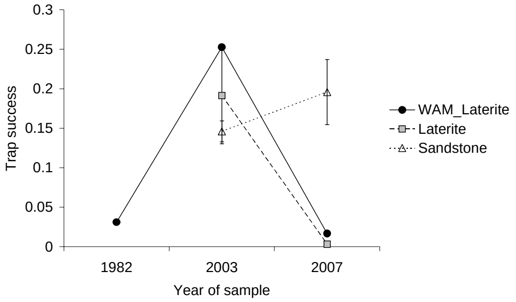


Fig. 8. Historical trap success (proportion of traps with animals) rates at sandstone and laterite sites, and at one WAM (Western Australian Museum site) on laterite substrate.

The small number of mammals captured at laterite/basalt sites preclude statistical analysis. However, the scarce evidence we do have suggests a fire effect on mammals. Three paired burnt/unburnt sites enable a comparison of mammal numbers from similar sites except for their burn status (Fig. 9). At all 3 paired sites there were fewer mammals in the recently burnt area.

While this data is not conclusive, it is at least suggestive that fire has a negative short term effect on mammal numbers in laterite/basalt environments. The fire response of mammals here is therefore similar to that found in nearby sandstone environments.

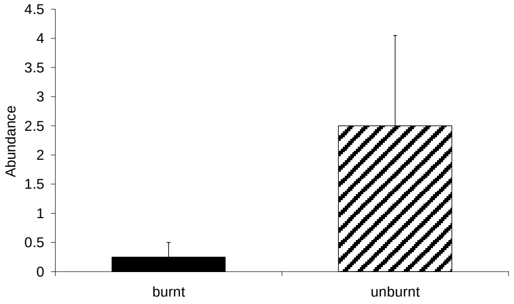


Fig. 9. Trap success (percentage animals/trap) at paired burnt and longer unburnt sites ($P>0.05$).

Implications

In terms of available evidence it appears that recent fire (<12 months) negatively affects rodents/bandicoot abundance in laterite, basalt and sandstone environments. The extent of annual burning should therefore be limited to the extent that there are refuge areas of older fuel present throughout the landscape. The provision of frequent, unburnt patches of at least several hectares should be a target of fire management in laterite, as in other environments.

Mammals generally in savanna woodlands, with no permanent shelter features (large rocks), are likely to respond similarly to those in laterite environments. Populations are likely to experience boom-bust cycles. In these open habitats with no permanent habitat structures, provision of ground cover vegetation through fire management is particularly important. This is because vegetation cover represents the only available cover. Burning should seek to retain lots of unburnt patches within the landscape.

4. Fire responses of other animals

The Mitchell study provides data not only on threatened mammal species, but also on a range of other animals. These results highlight that, although relatively resilient to fire regimes compared to mammals, these other groups should also be considered when undertaking burn prescription planning.

Fire responses among other plant and animal groups appear to be more diverse than for mammals. Virtually no relationship between fire regime and plant species composition was detected in this short term study. As seen below, fire did affect vegetation physical structure.

Reptiles

Reptile communities showed a distinct change from burnt to longer unburnt patches, with different sized animals dominating the different habitats. In patches of vegetation which had been consumed by fire, most reptiles caught were small (<99 mm) (Fig.). Conversely, in patches of unburnt vegetation (>12 month) reptiles were often larger (>200 mm). Patchy burnt areas (those with some ground cover by vegetation) had equal proportions of the different size classes.

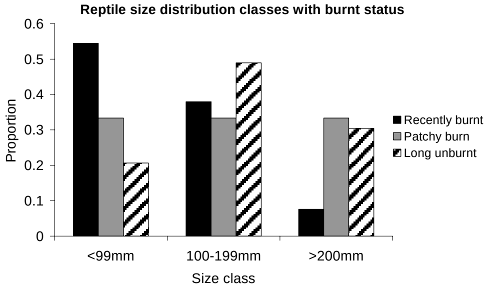


Fig. 10. Proportion of reptile community <99 mm long, between 100 and 199 mm long, and >200 mm long captured in burnt, partially burn and unburnt vegetation patches.

Following on from this, there was a change in reptile communities with time since fire. For instance, smaller skinks (species <99 mm) were more common at sites with more recent fires (Fig. 11). These skinks, including *Carlia* spp., *Notoscincus ornatus, Proablepherus tenuis* and *Morethia ruficauda*, seem to prefer recently burnt country. In fact these species were sometimes more abundant in recently burnt habitats, than skinks in long unburnt habitats. Being small, perhaps these species could shelter from predators more readily in burnt habitats compared with larger species.

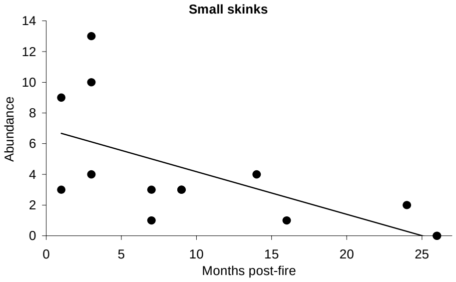


Fig. 11. Skink numbers (<100 mm) with months since most recent fire (P=0.012; R^2=0.418).

In contrast, larger skink lizards (>100 mm long) including *Ctenotus inornatus* and *Glaphomorphus isolepis*, appeared to prefer longer unburnt habitats (>12 mon) (Fig. 11). They appear to prefer habitats with good herbaceous ground cover, and this may be related to the need for greater cover from predators.

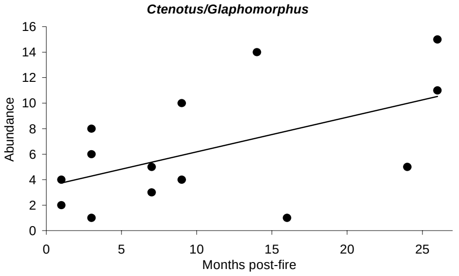


Fig. 12. *Ctenotus* spp. and *Glaphomorphus* spp. numbers with months since most recent fire (P=0.042; R^2=0.292).

There was even a shift in the sizes of skinks from the same species between burnt and unburnt areas. For *Ctenotus inornatus* we found that smaller individuals were generally found in recently burnt areas (Fig. 13). In contrast, larger individuals were found where there was greater vegetation cover, either where vegetation was only partially burnt, or where vegetation had been unburnt for >12 months.

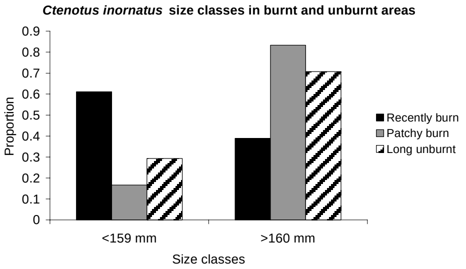


Fig. 13. Size class frequency of *Ctenotus inornatus* in recently burnt areas, areas with partial vegetation consumption by fire, and in long unburnt vegetation (>12 months).

Another group of reptiles represented in recently burnt environments were active dragon species, including *Diporiphora bennettii* (Fig. 14). This species was also found in some areas which had not had fire for 2 years, so it is not clear based on this data what the overall preference is. Future studies will gather more data on this.

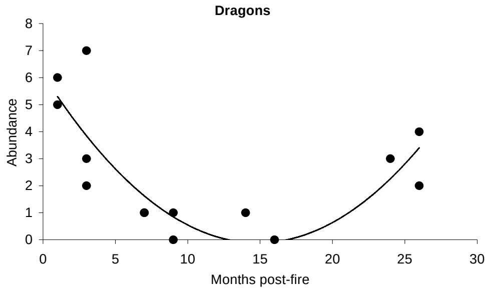


Fig. 14. Dragon numbers with months since most recent fire (P=0.002; R^2=0.681).

Invertebrates

Invertebrate communities also have complicated relationships with fire. Large ground dwelling invertebrates (beetles, crickets, centipedes, spiders, cockroaches, scorpions) were more common at recently burnt sites (Fig. 15). In contrast, invertebrates of the herbaceous layer in sandstone habitats increased with time since fire (Fig. 16). Interestingly, the opposite trend was identified for invertebrates of the herbaceous layer in laterite habitats (Fig. 17). Ant species and functional groups also showed a range of both positive, negative and neutral responses to time since fire.

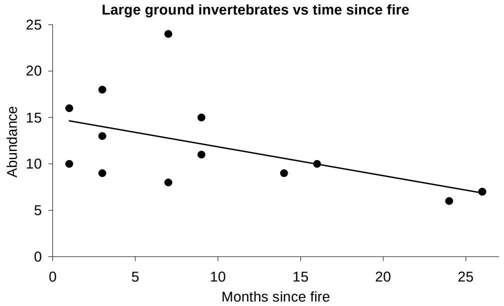


Fig. 15. Number of large ground dwelling invertebrates with time since fire (*P*=0.037; R^2=0.314). Invertebrates include ground spiders, cockroaches, crickets, beetles, centipedes and scorpions.

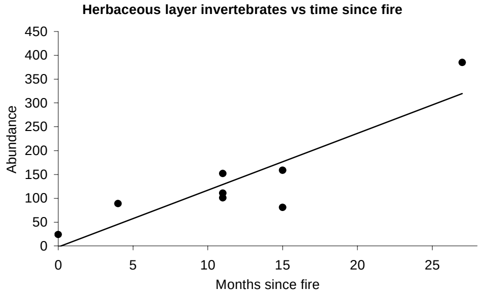


Fig. 16. Numbers of invertebrates in the grass layer at sandstone sites with differing time since fire (*P*=0.004; R^2=0.783). Species include grasshoppers, spiders, caterpillars/butterflies, wasps, flies, etc.

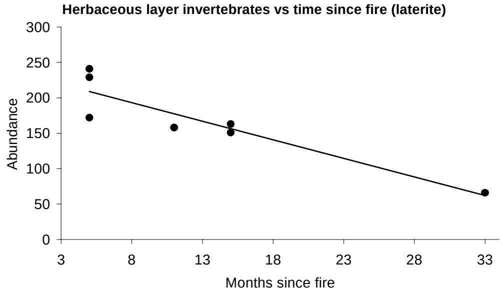


Fig. 17. Numbers of invertebrates in the grass layer at laterite sites with differing time since fire (*P*=0.004; R^2=0.836). Species include grasshoppers, spiders, caterpillars/butterflies, wasps, flies, etc.

Implications

What this data shows is that different groups of species need/prefer both recently burnt and longer unburnt habitats. Conservation management should therefore aim to provide both recently burnt and longer unburnt habitats, not all of one or the other. Too much of one seral stage, without refuges of preferred habitat, is likely to result in population instability for species adapted to particular post-fire stages, and boom-bust cycles are likely to result. This can increase the chance of localized declines or extinctions of some species. Fire management should therefore seek to reduce this chance by providing a range of post-fire fuel ages.

It is clear that some biodiversity groups are more abundant in habitats >=2 years after fire. Given the rarity of this fuel age in the Kimberley, this should be a particular focus of fire management.

5. What's behind mammal responses? Habitat structure or food?

The strongest relationship between mammals and environmental features is with vegetation structure. Northern quoll density was statistically related to grass fuel loads, with increased grass with time since fire resulting in fewer quolls (Fig. 18). As a predator, less grass may make it easier for quolls to hunt for prey items.

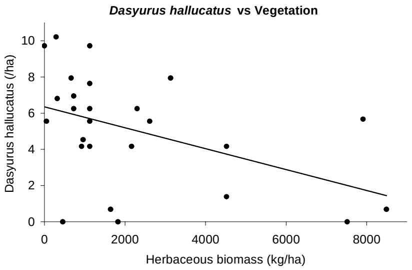


Fig. 18. Number of Nth Quolls with grass biomass (*P*=0.019; R^2=0.208).

Bandicoot and rodent numbers (Fig. 19), on the other hand, were positively related to vegetation cover. Herbaceous biomass correlated both with habitat shelter from predators, and with perennial grass seed production. Rodents and bandicoots may benefit either from increased cover by grasses, or from resources in the grass layer.

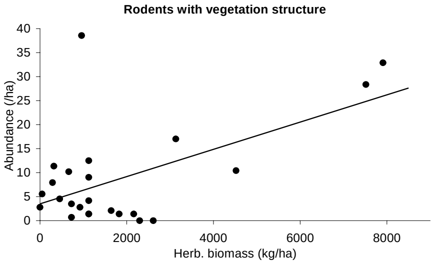


Fig. 19. Number of rodents with grass biomass (*P*=0.004; R^2=0.313).

The relationship between mammal numbers and food resources is less clear. There is certainly a seasonal decline in rock rat populations during the wet season that may be caused by a food shortage (Fig. 5). Rock rat diet is thought to be grass seeds, predominantly of *Sorghum* (or *Sarga*) spp. The annual decline in rock rat numbers coincides with the loss of *Sorghum* seeds due to germination during the wet season. Dietary analysis of rock rat scats needs to be undertaken to determine if *Sorghum* seeds are the major food resource for this species before we can be sure of the link between food shortage and annual population declines in the wet.

Based on scat analyses and ground vertebrate/invertebrate community dynamics, quolls seem not to be limited by a particular food resource. Quolls have a diverse diet including invertebrates, small vertebrates and also various plant materials (Fig. 20). Quolls do not appear to have a strong preference for any particular prey item. Because of this diverse diet, and the ability to switch prey items, it is unlikely that shortage of any one species/group will affect them. Therefore, while some prey groups decline with time since fire (large ground dwelling invertebrates, Fig. 15), others increase (larger skinks and rodents, Fig. 12, 4). It is certainly not the case, as for some other species, that quolls track a particular prey item.

Interestingly, there is a weak trend in quoll resource use with time since fire (Fig. 20). Total invertebrate and small vertebrate diet content declined slightly with time since fire, while at the same time the mammal component increased. This is consistent with higher rodent and bandicoot density with greater time since fire. Leaves made up a higher component of quoll diet in the first month following a fire, perhaps due to higher palatability, though this was a minor overall component of the diet.

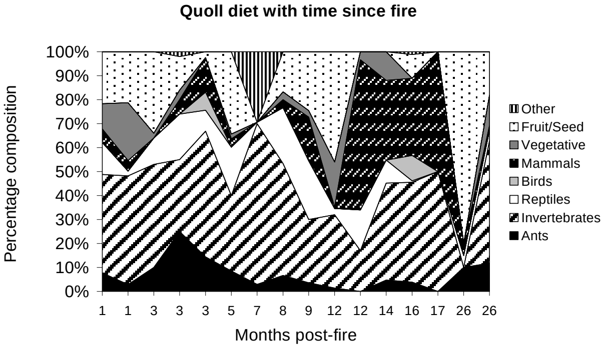


Fig. 20. Quoll diet composition with time since fire. This data is based on analysis of scat contents. Cats were collected from animals trapped at the various sites during this study.

Implications

Habitat structural change caused by fire appears to be the main factor relating to mammal abundance. This data suggests that its not food, but predator interactions, that limit populations. Recently burnt habitat apparently makes for better hunting by quolls, even though food availability is not greater here. Feral cats, dingoes and raptors, are also likely to prefer burnt areas for hunting, perhaps leading to reductions in rodent and bandicoot populations in these open areas. Long term and repeated removal of significant vegetation cover through extensive, early and frequent fires, should be avoided within prescribed burning operations.

Plate 2.Difference in vegetation ground cover from 2 months post-fire (top) to 11 months post-fire.

Conclusions

There appears to be a distinct successional shift in mammal, small vertebrate and invertebrate communities from immediately after a fire, through to about 2 or 3 years post-fire. In fine grain mosaics, quolls, large ground dwelling invertebrates and small skink species (species <100mm) are more common in recently burnt areas. In contrast, rodents, bandicoots, larger skink species (e.g. *Ctenotus inornatus*) and grass layer invertebrates are more common in more densely vegetated areas that have not so recently been burnt. In broad-scale mosaics (intense, large burns) occurrence of all CWR mammal species is less predictable and populations less dense, though other groups (e.g. reptiles and invertebrates) were unaffected by mosaic size.

We have no data on community change beyond 3 years post-fire, but communities are likely to change beyond this period too.

The implications of these results are clear. There are distinct fauna communities associated with different fuel ages. We should therefore aim at multiple fuel age structures under fire prescriptions. Older fuel age areas (>2 years post-fire) should always be present within the landscape. This fuel structure is particularly important for threatened CWR mammal species. This is also the rarest habitat type across northern Australia under current fire regimes. Without provision of this (longer unburnt) habitat type within savanna landscapes, CWR mammal species may decline to extinction as they have done in many other parts of Australia (Johnson 2006). Prescribed burning operations should therefore aim to retain small patches (<1 km^2 or <1 km across) of longer unburnt vegetation (>24 months). A useful goal to aim for would be 10% of the country should be made up of fuels >2 years old.

>2 year post-fire vegetation is currently the rarest and most difficult outcome to achieve in the highly flammable tropical savanna landscapes. But perhaps this habitat is the most important for conservation, particularly of threatened groups like the small and medium sized mammals.

Preliminary results from the Mitchell Plateau study are not only important for mammals, but also for other fauna communities, including small reptiles. Although our study only sampled the more common species, data are probably indicative of overall patterns among fauna communities. It is therefore highly likely that some of the less commonly trapped species, including larger predators, as well as some of the rarer small species, most probably also respond to fire regimes. In light of this, prescribed burning operations should always aim at diverse fuel age structure at the local scale (within several km), wherever conservation of biodiversity is an aim of land management.

Further work

We need to further test fire related patterns of fauna response. So far trends are fairly weak, due to high variability in the data across seasons and between sites. Further work will allow the trends to be more rigorously tested. Studies will continue into 2009, with 2 further field trips, one in Feb/March (wet season) and one in June/July (mid dry), in order to provide this corroborative data.

We will also continue to collect data on both habitat structural and dietary change at each site with time since fire. In this way we hope to improve our data on driving processes underlying fire effects.

In the future, we hope that these sites may be annually assessed for CWR mammal community trends. This is particularly important with continued threats to CWR mammals in northern Australia from fire, cattle, the invasion of cane toads, and of course feral cats. As one of the few areas where species like northern quolls are still common, these areas and populations in the Mitchell River area provide crucial ongoing indicators of the impacts of threatening processes in the far north.

References

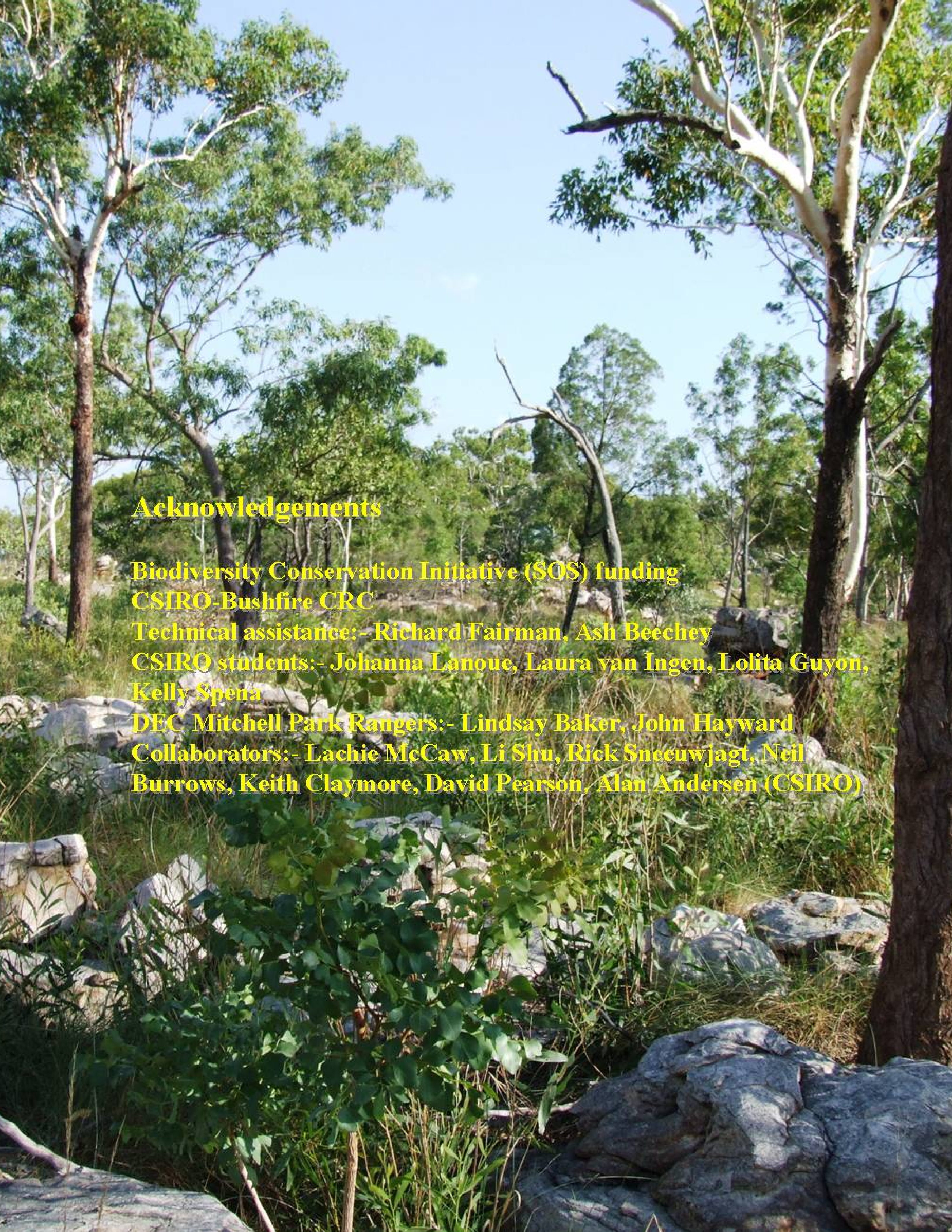
Andersen AN, Cook GD, Corbett LK, Douglas MM, Eager RW, Russell-Smith J, Setterfield SA, Williams RJ, Woinarski JCZ (2005) Fire frequency and biodiversity conservation in Australian tropical savannas: implications from the Kapalga fire experiment. Austral Ecology 30, 155-167

Johnson C (2006) 'Australia's Mammal Extinctions: A 50 000 Year History.' (Cambridge University Press: Melbourne)

McKenzie NL, Burbidge AA, Baynes A, Brereton RN, Dickman CR, Gordon G, Gibson LA, Menkhorst PW, Robinson AC, Williams MR, Woinarski JCZ (2007) Analysis of factors implicated in the recent decline of Australia's mammal fauna. Journal of Biogeography 34, 597-611.

Russell-Smith J, Yates C, Edwards A, Allan GE, Cook GD, Cooke P, Craig R, Heath B, Smith R (2003) Contemporary fire regimes of northern Australia, 1997-2001: change since Aboriginal occupancy, challenges for sustainable management. International Journal of Wildland Fire 12, 283-297.

Woinarski JCZ, Milne DF, Wangandeen G (2001) Changes in mammal populations in relatively intact landscapes of Kakadu National Park, Northern Territory, Australia. Austral Ecology 26, 360-370.



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