Chapter 2

Fire history of the Haasts Bluff study area

Introduction

Large-scale wildfires burn periodically across the spinifex grasslands of arid Australia (Allan and Griffin 1986; Allan and Southgate 2001; Griffin, Price *et al.* 1983). These fires can burn extensive areas of up to 10 000 km^2, and can reach intensities of up to 14 000 kW (Allan and Southgate 2001; Burrows, Ward *et al.* 1991). Fire intervals can also be short, and there are documented cases where large areas of spinifex have re-burned within 2–3 years (Latz, P.K., pers. comm., 2003).

These extensive fires are widely held to be a product of the exodus of nomadic Aboriginal people from tribal lands toward European settlements and missions in the 19^{th} and 20^{th} centuries (Allan and Griffin 1986; Griffin 1992; Griffin and Allan 1985). It is believed that fires of this severity and extent were constrained during 'traditional' times, by the patch-burning practices of desert Aboriginal tribes. These people fired the landscape along travel routes and around points of habitation, thereby reducing the incidence of large fires by 'breaking the country up' and preventing the accumulation of large, contiguous areas of fuel. In contemporary times, however, this system of burning has largely broken down, as Aboriginal people no longer need to actively hunt and burn in order to maintain a supply of food (most foodstuffs are now readily obtainable at settlement stores) (Long 1989).

The large and intense contemporary spinifex fires are believed to have been catastrophic for the native flora and fauna of these ecosystems. These fires have been implicated in the extinctions and population reductions of many small- to medium-sized mammals, such as the western hare-wallaby, *Largochestes hirsutus*, the oqualpi, *L. conspicillatus*, and the bilby, *Macrotis lagotis* (Allan and Southgate 2001; Griffin, Morton *et al.* 1990; Masters, Nano *et al.* 1997). The decline of these mammals under the more severe contemporary regime has been due to 1) the reduced diversity of plant foods offered by this regime, and 2) increased exposure to introduced predators such as foxes and cats following larger fires (Bolton and Latz 1978). There are also concerns that the contemporary fires have had destructive impacts on fire-sensitive communities dominated by species such as mulga (*Acacia aneura*), and native pine (*Callitris glaucophylla*). These fears have arisen from observations that the majority of contemporary fires occur during summer months, and are consequently of very high intensity (Bowman and Latz 1993; Bowman, Latz *et al.* 1994).

Between 2000 and 2003, central Australia experienced the largest fire event in nearly twenty years. During this event, vast areas of both spinifex and non-spinifex landscapes were burned, resulting in widespread concern over the impact that these fires had on natural communities. The aim of this chapter is to construct an accurate fire history of the Haasts Bluff study area, using satellite imagery from 1979–2003. The specific aims are to:

1. Describe the fire history of the Haasts Bluff study area over the past 25 years. This includes determining the total area and frequency of country burned by year, by habitat type, by season, by patch size, and in relation to ignition source (human or lightning).
2. Examine the relationship between antecedent rainfall and fire.
3. Discuss the findings of this chapter in relation to literature concerning changes in central Australian fire regimes since colonisation by Aboriginal and European people.

Methods

Constructing a fire history of the study area

A 23 year fire history for the study area was constructed using Landsat-derived satellite data from 1979–2003 (see Fig. 1.2 for location of study area). For most of the preliminary fire mapping, Landsat Quicklooks were used. These images are copies of Landsat images, re-sampled at a ratio of 1:8 and with a relatively coarse resolution of approximately 240 m. Quicklooks are available free to the general public, and in this study they were used to date and coarsely map the extent of fires.

A spreadsheet previously compiled by Alice Springs Bush Fires Council was used to identify Quicklooks that were likely to contain fresh fire scars. These scenes were downloaded from the ACRES website and rectified in the GIS software package

ARCVIEW ™. Mapping of fire scars from the rectified scenes was carried out using two techniques: image differencing and manual digitising. Where fire scars were large and complex, image differencing was generally used. This function compared the spectral responses of images containing fresh fire scars against older images that had been sampled prior to fire occurrence. Between-image variation in spectral response was then calculated and it was possible to select areas that best described fire boundaries, while excluding areas that represented variation associated with differences in image quality, shadows and/or rectification errors. The fire boundary that was obtained from this technique could then be modified using a variety of cutting and appending tools in ARCVIEW. When fire scars were small and had relatively simple boundaries, manual digitising was generally employed. This process was quicker than image differencing and simply involved visually scanning the scenes and tracing the fire boundaries using an interactive drawing tool.

The boundaries of these coarsely mapped scars were refined using Landsat MSS (multi spectral scanner) and TM (thematic mapper) images. These images possess a much higher degree of spatial mapping accuracy than Quicklooks, with resolutions of 80 m for Landsat MSS and 30 m for TM. The high cost of these images meant that only two MSS scenes (from January 1985 and January 2003) and one TM scene (from June 1999) could be obtained for the study. However, these three images were highly effective, and could be used to accurately map fire scars from up to 3 years previously, provided no overlap of fires occurred within this space of time. The high utility of these images was largely due to the slow recovery of the spinifex vegetation, as regrowth does not conceal fire scars until 2–3 years after a burn.

Once the boundaries of fire scars had been refined, they were saved as shape files and assigned the following attribute fields: month burned, year burned, area burned and source of ignition. Month and year burned fields were generally estimated by referring to the Quicklook scenes. However, when a succession of cloud-covered images occurred it became impossible to identify the timing of the fire with precision. In these situations, internet-based satellite 'hotspot' technology was used instead. Hotspots are capable of identifying points of heat across the landscape and have a spatial accuracy of 1 m. Unfortunately, they were only available from June 2000 until June 2003, and could not be used to locate fires during the 1980s event. Hotspots were also used to estimate the likely source of ignition of fires through calculations of the distance of points of ignition from roads and settlements. When fires were seen to have begun within 2 km from a vehicle track, or within 5 km of a settlement, they were deemed to have been ignited by humans. The respective attribute field of the fire's polygon was then given a value of 1. When the ignition point was outside these limits, they were assumed to have been ignited by lightning, and their attribute fields were assigned a value of 2. When a fire's ignition point could not be identified, its attribute field was assigned a score of 3.

Fire statistics relating to time-since-fire and interval were calculated in the following manner. All fire polygons from 1979 to 2003 were merged in single 'aggregate' themes according to which year the fires had burned. Fires were only recorded in eight years (1981, 1983, 1984, 1985, 1990, 2000, 2001 and 2002), so only eight themes were produced. Each of the eight aggregate themes was then given a new attribute field called 'g-code' and the following numeric values were assigned to that field: for 1981 – 128; 1983 – 64; 1984 – 32; 1985 – 16; 1990 – 8; 2000 – 4; 2001 – 2; 2002 – 1. The themes were then overlaid in Arcinfo ™, thereby producing a single composite theme made up of many smaller polygons. Each of these smaller polygons could then be attributed with a factorial combination of the overlain g-code values and from these combinations it was possible to decode each polygon's fire history, as each combination had a unique value correlating to a particular fire history. For example, a polygon with a factorial combination of 129 represented an area that had been burned in 1981 and 2002 (a g-code of 128 plus a g-code 1 gives a factorial combination of 129). In this way, it was possible to calculate the time-since-fire and fire frequency for the entire study area, as well as to estimate the spatial area associated with each component of fire regime.

Fire statistics relating to area burned by land system for each component of fire regime were calculated by constructing three clip themes based on the extent of the study area's sand plains, dunefields and mountain ranges (boundaries for these areas were based on the Perry *et al.*'s work 'Land Systems for the Alice Springs Area' (1962)). These clip themes were then used to crop the previously constructed fire polygons, allowing calculation of fire statistics for each land system as well as for the total area burned.

Statistical analyses

The relationships between total area burned annually and cumulative antecedent rainfall during the previous one and two years, were analysed using linear regression models in Statview ™. Prior to these analyses, the area burned data were transformed using a base-10 logarithmic transformation.

Results

Fire cycles and rainfall events

The fire history for the study area was characterised by two extensive wildfire events, one during the early 1980s and one during 2000–02 (see Fig. 2.1). An area almost equivalent to that of the entire study area (which was 20 622 km^2) was burned in these two events, with 17 997 km^2 of country being burned during the1980s event and 21 115 km^2 burning during the 2000–02 event. The scale of the 2000–02 fires is well illustrated by Figure 2.2,

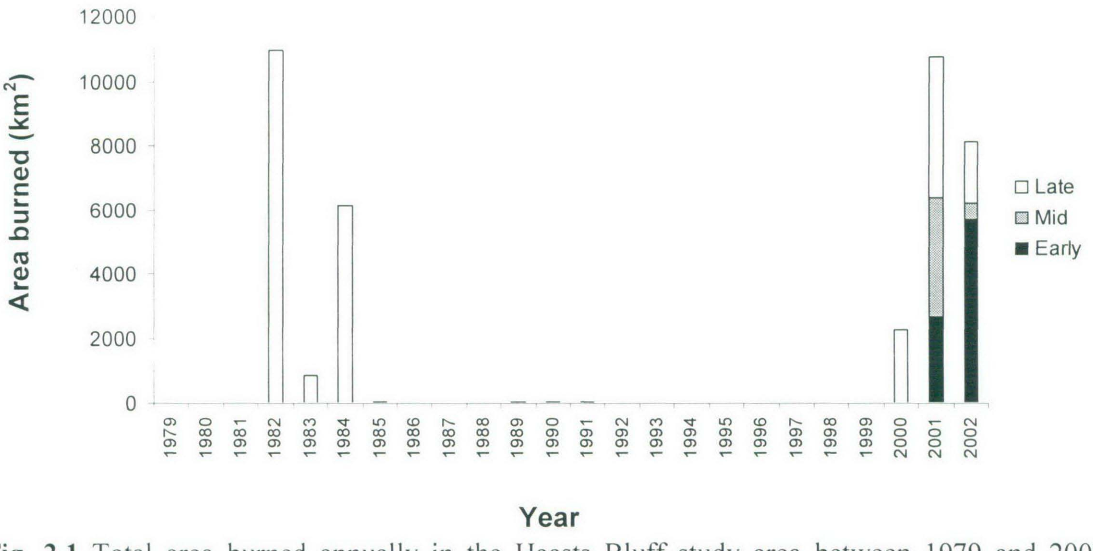

Fig. 2.1 Total area burned annually in the Haasts Bluff study area between 1979 and 2003. Annual totals are stacked by time of year (early: Jan–Apr, mid: May–Aug, late: Sep–Dec).

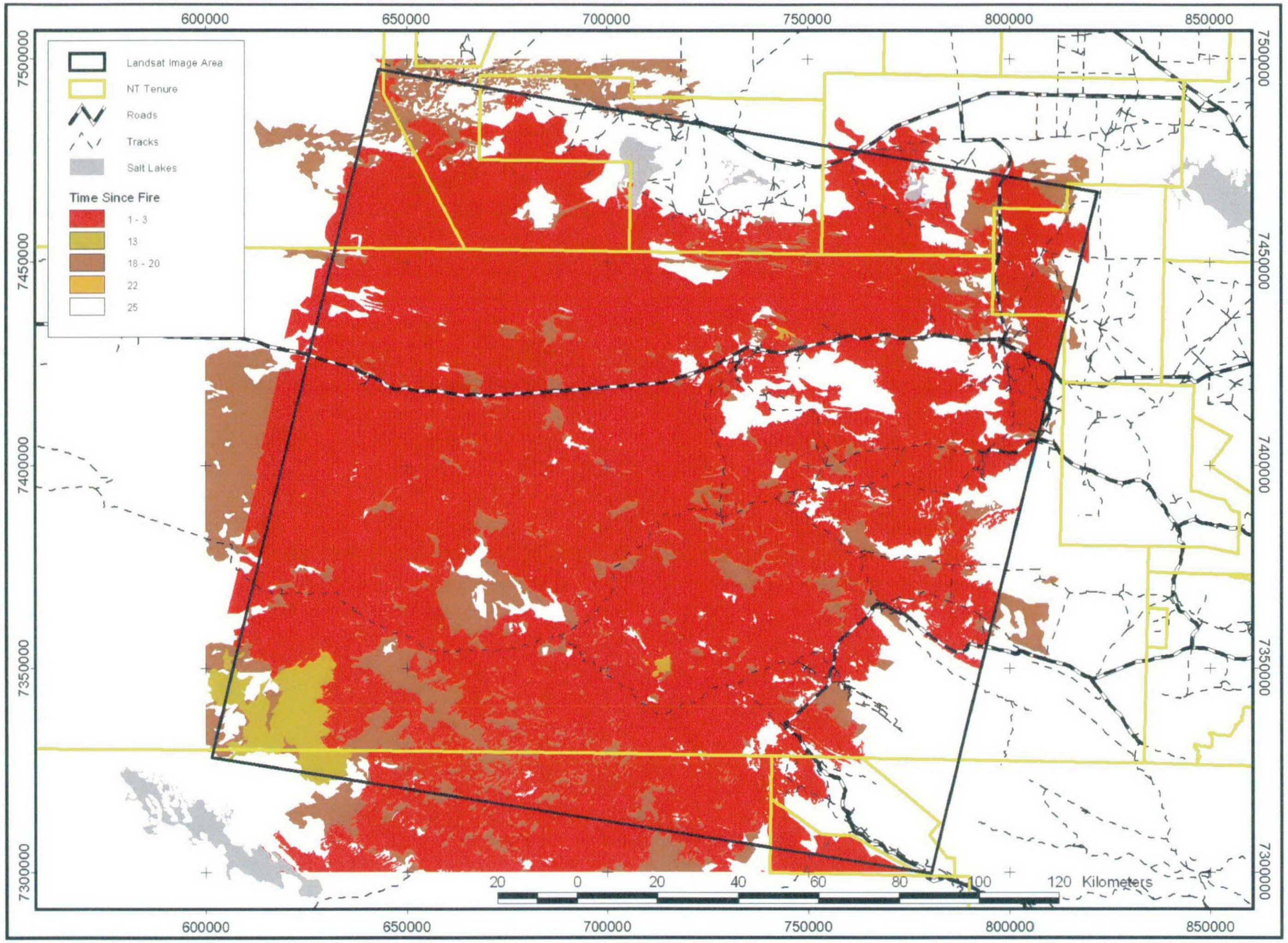

Fig. 2.2 Map of time-since-fire for Haasts Bluff study area (1979–2003). White areas within Landsat image delineate regions that have not been burned since 1979. The fire history outside the image area is not described.

which shows the distribution of areas burned under different times-since-fire. During the 2000–02 fire event, 78.1% of the study area was burned, while only 10.1% remained unburned during the entire study period. There was an almost complete absence of fire during the inter-event period (1985–1999), with only 103 km^2 of land being burned during this time (see Fig. 2.1).

The occurrence of fire events was found to be linked to antecedent rainfall, with above-average rains occurring in the years during and immediately prior to the outbreak of both the 1980s and the 2000–02 fires (see Fig. 2.1 and 2.3). The overall models for the

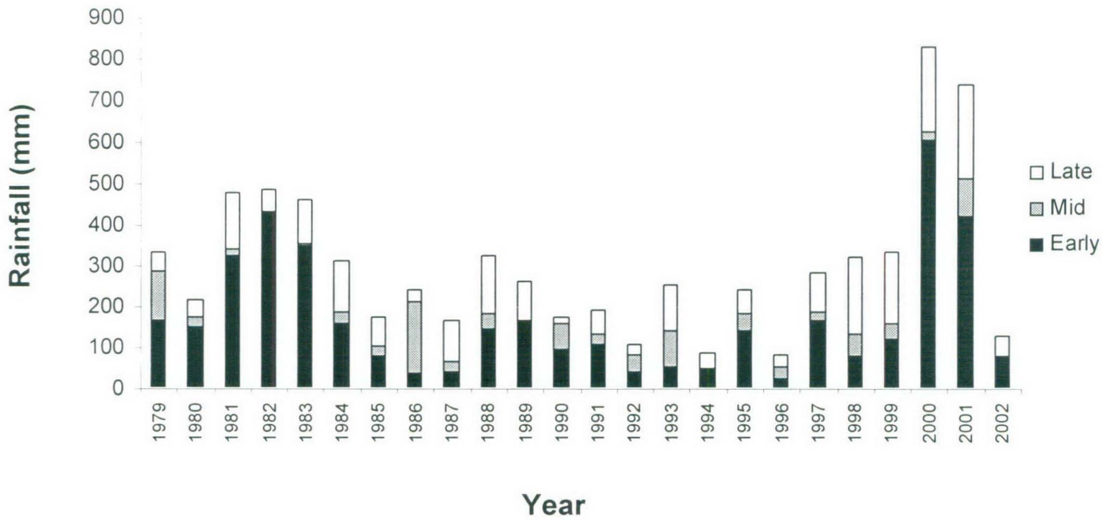

Fig. 2.3 Annual rainfall for the Haasts Bluff study area between 1979 and 2002. Annual totals are stacked by time of year (early: Jan.–Apr., mid: May–Aug., late: Sep.–Dec.). Values were estimated by calculating the annual average of data from Derwent and Glen Helen stations, New Haven Conservation Reserve and the Mereenie gas fields.

regressions of both the previous one and two years cumulative antecedent rain on area burned were significant ($P = 0.014$ and $P < 0.0001$ respectively), indicating a strong relationship between rain and fire. However, the relationship between area burned to rainfall was considerably stronger for the previous two years rain ($r^2 = 0.6$) than for the previous years rainfall only ($r^2 = 0.25$).

The overall pattern of fire occurrence during the study period was similar across all habitat types, indicating that the flammability within these landscapes is similar. Each habitat was subject to extensive wildfires during the early 1980s and between 2000 and 2002 but almost no fire during the intervening period (Fig. 2.4).

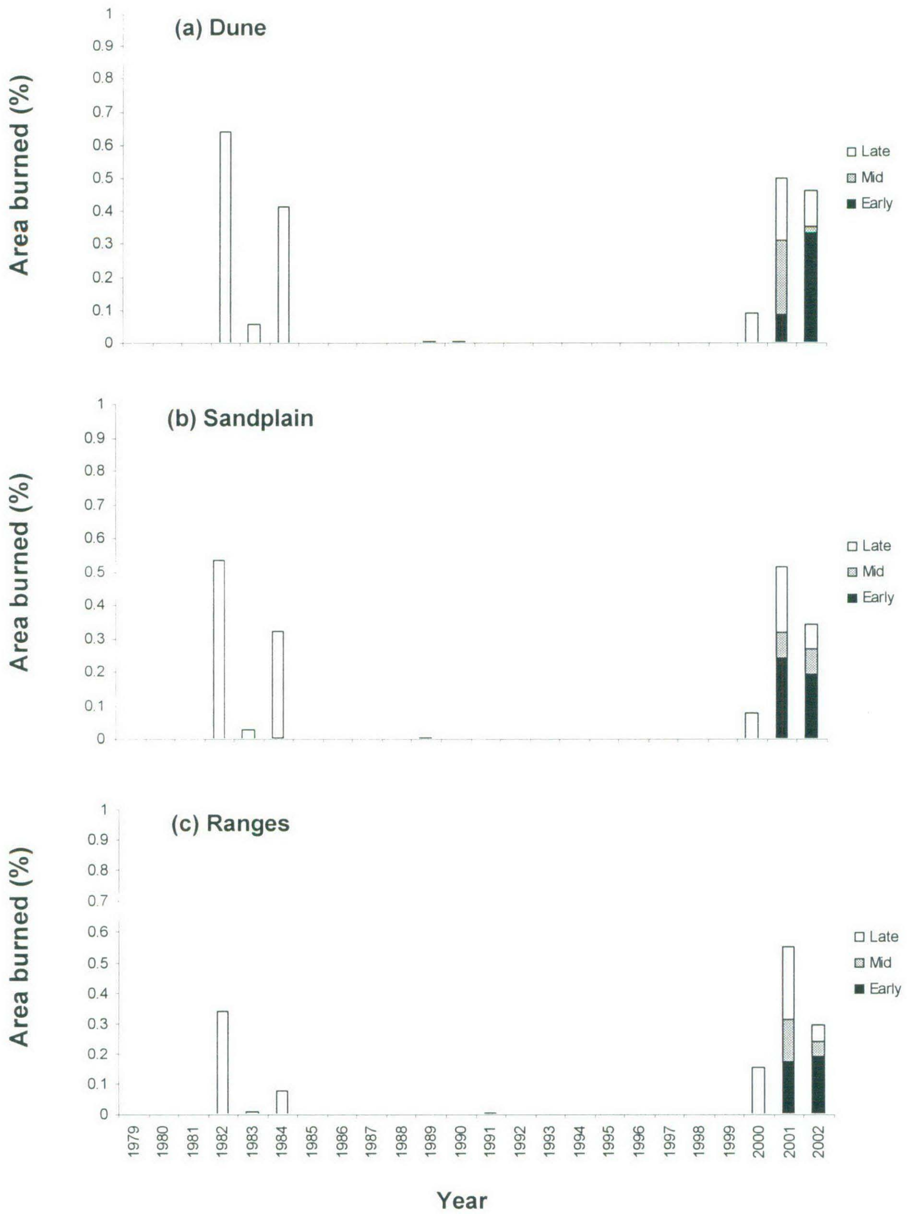

Fig. 2.4 Proportion of area burned within Haasts Bluff study area 1979–2002 according to habitat type.

Fire season

The seasonality of fire differed between the 1980s and the 2000–02 events (Fig. 2.1). For the 1980s event, fires occurred almost entirely in the later months of the year, while for the 2000–02 event the occurrence of fire was more evenly spread throughout the year. The 1980s fire event was also characterised by much larger fires than the 2000–02 event, although the larger error bars for the 1980s years indicates that fire sizes for this period were also much more variable (Fig. 2.5).

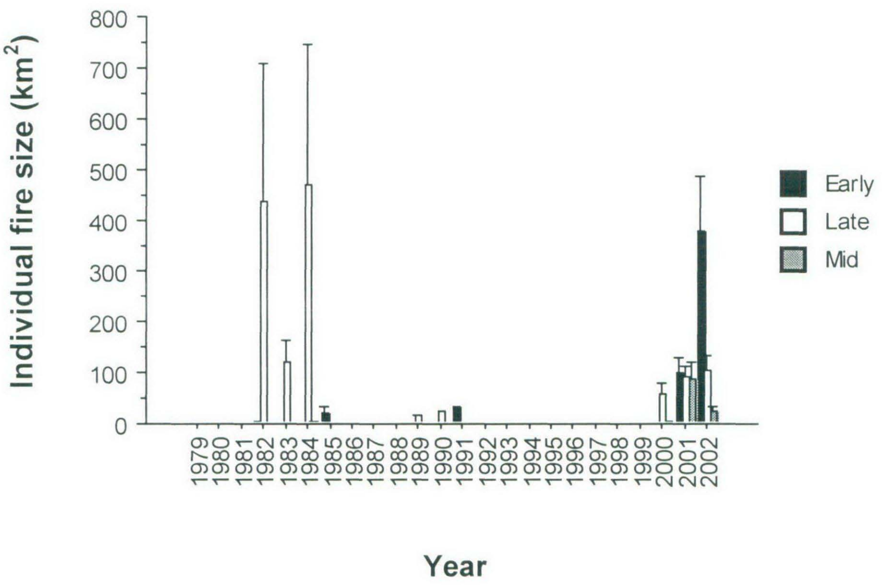

Fig. 2.5 Annual mean area burned by season for Haasts Bluff study area between 1979 and 2002 (early: Jan.–Apr., mid: May–Aug., late: Sep.–Dec.).

The flammability of fuels during the warmer months of the year was highlighted by the increased mean fire size during the late season for each year during the 1980s event (see Fig. 2.5). For the 2000–02 event, fire size was more evenly distributed across the seasons. There was one exception to this trend, with the fires of 2002 being far greater in size during the early compared to mid and later months.

Fire interval

Large proportions of the study area had been burned by a short fire interval during the study period. This was evidenced by the large areas that had received fire frequencies

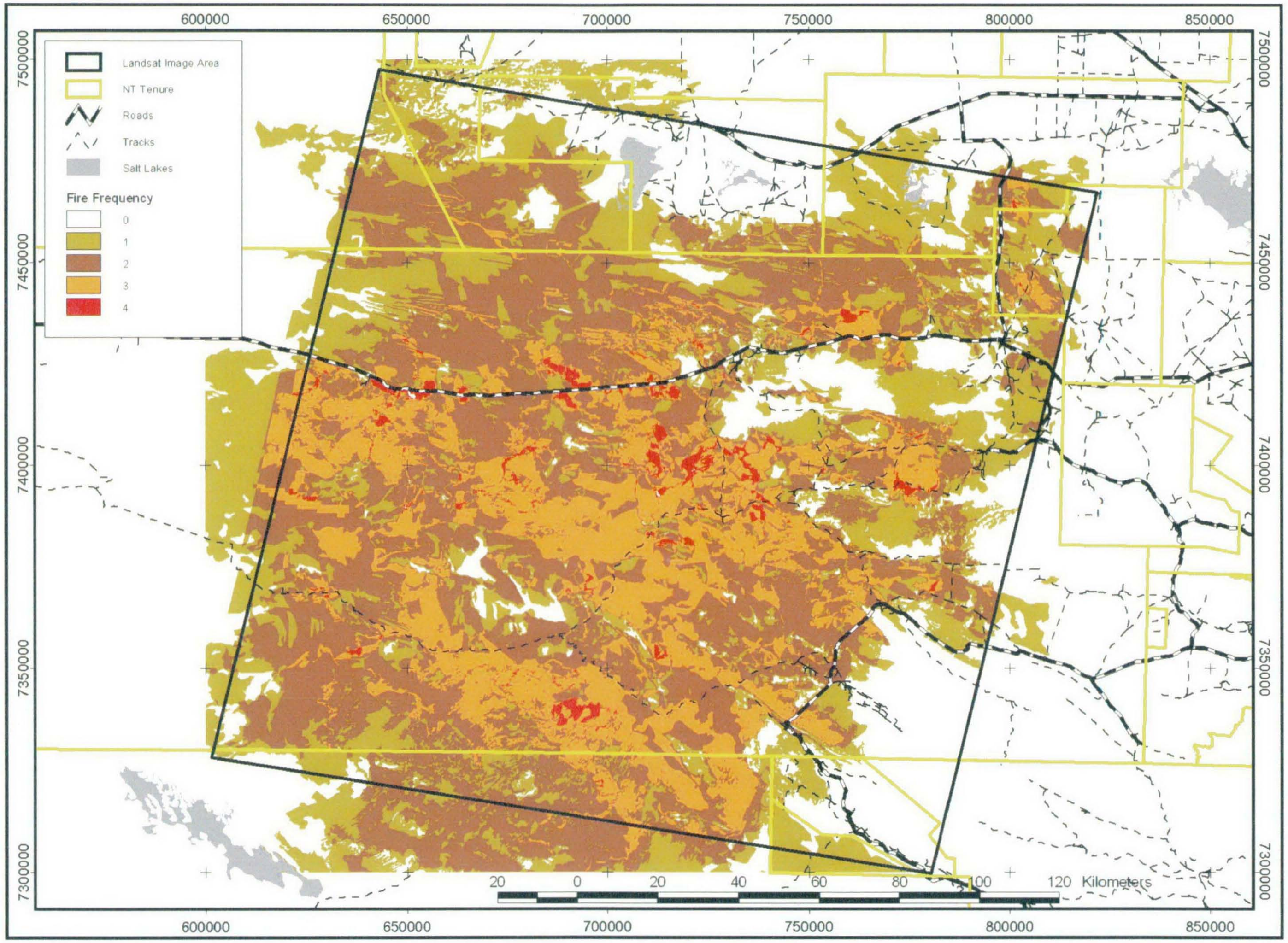

Fig. 2.6 Map of fire frequency for Haasts Bluff study area 1979–2003. White area within Landsat image area indicates no fires since 1979, while the fire history of regions outside of image area are uncertain.

of three or four (see Fig. 2.6). Areas burned with a frequency of 4 were burned twice during the 1980s and twice during the 2000–02 event (hence receiving an interval of <3 yrs twice during the study period), while areas burned with a frequency of 3 were burned once in either the 1980s or 2000–02 event and twice in the other event (hence receiving an interval of < 3yrs only once). Figure 2.7 shows the proportions of each habitat type burned with a short fire interval during the study period (35% of the dunes, 16% of the ranges and 25% of the sandplain).

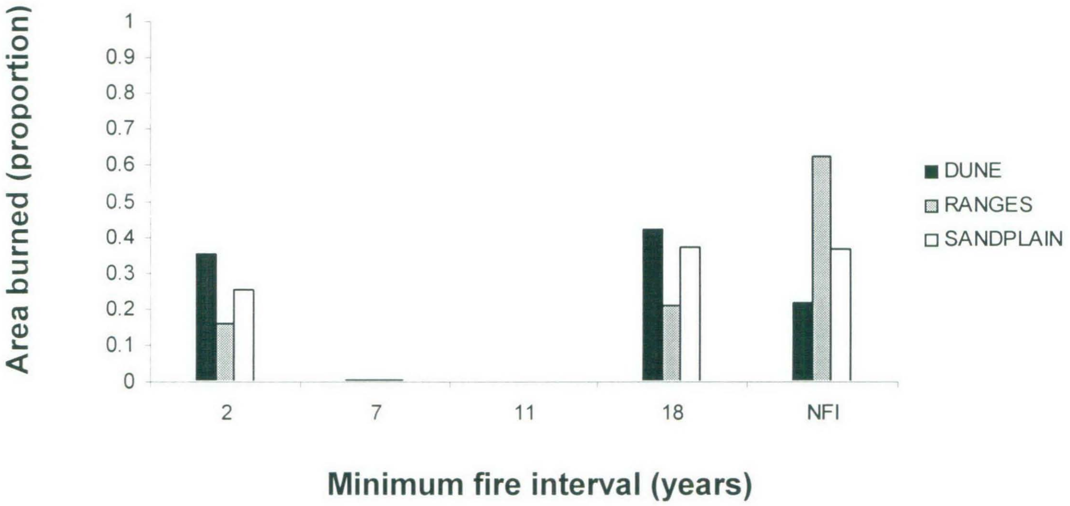

Fig. 2.7 Area burned according to minimum fire interval (years) in the Haasts Bluff study area between 1979 and 2003. NFI indicates that no fire interval could be determined (as only one or no fire was recorded for these areas during the study).

Considerable proportions of each habitat type were also burned at longer fire intervals of approximately 18 years, with 42% of the dunes, 21% of the ranges and 37% of the sandplain habitats being burned at this interval. Substantial areas of each habitat burned only once during the study period. Consequently, the intervals at which these regions had previously been burned could not be determined (22% of the dunes, 63% of the ranges and 37% of the sandplain were attributed to this category).

Source of ignition

The proportion of the study area burned by lightning compared to human-ignited fires was similar across all seasons (Fig. 2.8). Neither human nor lightning-ignited fires burned large areas during the winter months. The number of fires presumed started by humans was greater than those started by lightning for all seasons, and appeared to increase in a linear fashion from early through to later months (Fig. 2.9).

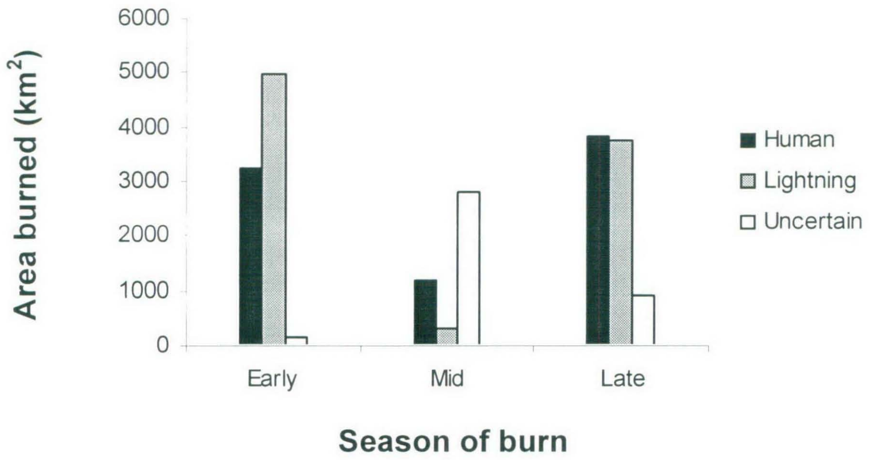

Fig. 2.8 Comparison between the area burned by fires ignited by humans, lightning or uncertain for the three seasons: early, mid and late (early: Jan.–Apr., mid: May–Aug., late: Sep.–Dec.).

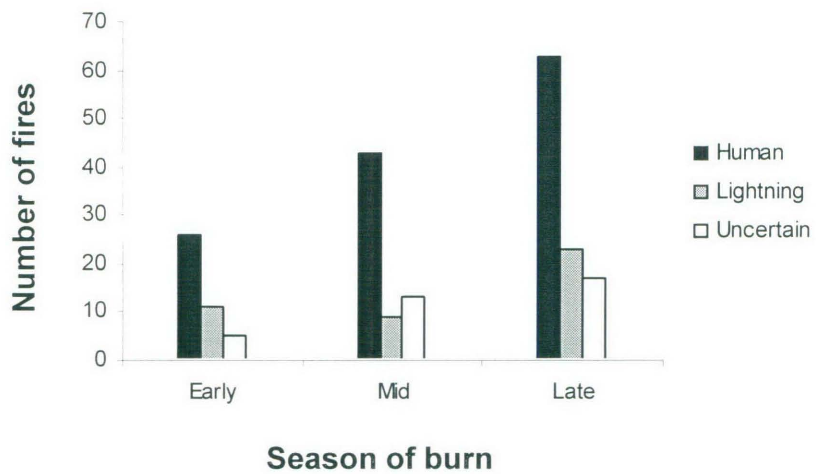

Fig. 2.9 Comparison between the count of fires ignited by humans, lightning or uncertain for the three seasons: early, mid and late (early: Jan.–Apr., mid: May–Aug., late: Sep.–Dec.).

Discussion

The Haasts Bluff region's contemporary fire regime

Fire cycles

Fire cycles in the Haasts Bluff fire history database were characterised by periodic, widespread wild fires, driven by fuel accumulations that occurred following extreme rain events. This pattern of fire occurrence is consistent with the results from other arid Australian databases, including the Great Victoria Desert database (Haydon, Friar *et al.* 2000), the Tanami Desert database (Allan 1993) and the Uluṟu-Kata Tjuṯa National Park database (Allan 1993). This finding also supports the fire study of central Australian rangelands by Griffin *et al.* (1983), which used anecdotal bushfire reporting to demonstrate a strong link between antecedent rainfall and wildfire occurrence during the period 1970–80.

The pre-condition of above average rainfall for fire occurrence is also characteristic of semi-arid ecosystems overseas, such as the dry savannas of central Africa (Frost 1985), the *Austrocedrus* woodlands of north Patagonia (Kitzberger, Swetnam *et al.* 2001) and the grasslands and sage shrub lands of California (Minnich 1983). The fuel dynamics of these systems are analogous to those of spinifex grasslands, in that large fires are normally constrained by insufficient fuel, but are facilitated when extreme rain events promote plant growth and allow fuel continuity to occur. These relationships between large wildfires and extreme rainfall events are in contrast to the fire dynamics of more biomass-rich ecosystems, such as those of Australia's coastal regions. In these areas, fuel moisture is the main limiting factor for fire spread, and widespread fire normally only occurs when climatic conditions produce prolonged droughts and extensive fuel drying (McArthur 1972).

It is unclear exactly how extreme rainfall events cause a shift in spinifex fuel structure from one where fires are inhibited, to one where large scale fires are able to travel. The most popular explanation is that rain promotes the growth of inter-hummock forbs and grasses, and when cured, these plants provide the fuel necessary for fire to carry from one hummock to the next (McArthur 1972). This explanation seems unlikely in the Haasts Bluff area, as inspection of spinifex vegetation in this region reveals that unless the landscape is burned, very little germination of inter-hummock species occurs (this issue is examined further in Chapter 4). It seems more likely that the primary reason that fires are able to travel following extreme rain events is that spinifex hummocks grow and expand following rain, thereby increasing fuel continuity (Allan, G., pers. comm., NT Bushfires Council, 2003). This may not be the case in more northern spinifex systems, however, where substantial rains can promote inter-hummock growth, even in the absence of fire.

Previous studies have attempted to predict quantities of cumulative rainfall that would allow spinifex communities to burn. For example, Griffin *et al.* (1990) suggested that approximately 6300 mm of cumulative rain would produce sufficient fuel for central Australian spinifex communities to burn again under extreme summer conditions. In the Pilbara, only 5000 mm in *Triodia wiseana*-dominated communities, and 9000 mm in *T. basedowii*-dominated communities, were required before sufficient biomass had accumulated to carry fire (Casson 1994). The fire patterns observed in the Haasts Bluff study run counter to the idea that flammability is driven by a 'threshold' cumulative antecedent rainfall figure. This is well illustrated by central Australian rain records from 1873 (see Appendix 2.1), which indicate that cumulative antecedent rain, as well as the time intervals between fire events, can vary considerably between fire events. The results from the Haasts Bluff study instead suggest that it is the occurrence of extreme 'pulses' of rain that drive spinifex systems toward a flammable state. It appears from this study that this pulse needs to be in the vicinity of 800–1200 mm over a period of two years for fires to occur.

Fire season

The extent of fire across the study area was far higher during warmer months, and this was reflected not only by the increase in total area burned during these months, but also by an increase in mean fire size. Factors that may account for this increase in the size and extent of fires during warmer months include the higher incidence of lightning strikes that occur in summer and the presence of climatic conditions that are more conducive to summer fire spread, such as higher ambient temperatures, lower humidity and stronger wind conditions (Burrows, Ward *et al.* 1991; Cheney and Sullivan 1997; Griffin and Allan 1984). Increased fire occurrence during warmer months is common to spinifex-dominated landscapes not only in central Australian areas (Burrows, Ward *et al.* 1991;

Griffin, Price *et al.* 1983), but also in the Pilbara and Kimberly regions of north Western Australia, and in the Top End of the Northern Territory (Craig 1999; Russel-Smith, Ryan *et al.* 1997). Burning during the warmer months, after the first storm rains, is also a preferred pastoral management practice in the spinifex-woodlands of central western Queensland (Turner 1979).

It is difficult to speculate about the effects of summer-dominated fire regimes in the Haasts Bluff region, owing to a paucity of research having been conducted in this area. However, it would be interesting to know whether seasonal variation in fire timing causes a similar vegetation response in the Haasts Bluff systems to that caused in spinifex grasslands in the Pilbara and Kimberly regions of Western Australia. In these more humid regions, winter fires are known to promote forb growth, and to influence the mode of regeneration of *Triodia* species, with cooler winter burns promoting resprouting, and intense summer fires killing plants and promoting regeneration from seed (Craig 1992; Suijdendorp 1967). Seasonality of fire in the Pilbara and in coastal Western Australia is also known to influence the establishment of woody shrubs, with lower intensity winter fires promoting increased post-fire survival of plants (Stretch 1996; Suijdendorp 1981).

Fire interval

This study confirms the often quoted observations of Peter Latz (NT Herbarium), that follow-up fires can occur at intervals of as short as 2–3 years after initial spinifex fires. These follow-up fires are apparently fuelled by short-lived grasses and forbs that germinate and grow when rainfall in the order of 500–1000 mm occurs following initial fires. Short interval follow-up fires are undoubtedly of a lower intensity than the initial fires, owing to a lack of *Triodia* hummocks in the fuel array of the follow-up fires (*Triodia* hummocks, which burn far more intensely than non-spinifex fuels, require at least 5–7 years growth before becoming a substantial component in spinifex grasslands).

The impact that short interval follow-up fires have had on the ecology of the Haasts Bluff region is unknown. Based on the findings of humid Australian and overseas studies, it could be predicted that population sizes of obligate seeding plant species with long primary juvenile periods may be reduced by such events (Cary and Morrison 1995; Nieuwenhuis 1987; Vlok and Yeaton 2000; Zedler, Gautier *et al.* 1983). In addition, populations of resprouting plants may have been affected, especially among species that are slow to recover carbohydrate reserves following initial *Triodia*-fuelled fires (Bowen and Pate 1993; Bowen and Pate 2004).

Contemporary vs. pre-European fire regimes in the Haasts Bluff region

Fire cycles

Reconciling the congruence between contemporary and pre-European fire regimes in central Australia is problematic, owing to a lack of quantitative documentation of pre-European fires. Many authors believe that the coming of Europeans led to an abrupt increase in mean fire size, due to the cessation of traditional patch-burning practices after nomadic Aboriginal peoples took up sedentary lives in European missions and ration depots (Burrows and Christensen 1990; Griffin and Allan 1985; Griffin, Morton *et al.* 1990; Long 1989; Morton 1990).

The results of the Haasts Bluff study largely contradict these widely held perceptions, indicating that Aboriginal burning practices are still widespread, with human ignitions now about three times higher than lightning ignitions, and the total area burned by human ignited fires roughly equal to that burned by lightning ignited fires. This result, together with the finding concerning the pre-condition of above average rainfall for fire occurrence, calls into question whether fire dynamics across spinifex landscapes have changed as drastically since the arrival of Europeans as has previously been suggested (Bolton and Latz 1978; Griffin, Morton *et al.* 1990).

During pre-European times, it is likely that low fuel continuity during drier periods would have limited large-scale fires, with Aboriginal burning being small in scale and confined to routes of travel and around points of habitation. It is also likely that the contemporary rain-fire cycle observed in this study was prevalent during Aboriginal times. It is suggested that following times of exceptional rainfall, the mosaic burning of the Aboriginal people would still have been inadequate to prevent massive build-ups of fuels and the subsequent occurrence of large fires (Latz, P.K., pers. comm., 2006; Kimber, R.G., pers. comm. 2005). A review of the fire management strategy of Uluru National Park supports this view, by highlighting the limited capacity of patchwork management burns to constrain the outbreak of large wildfires following above-average rains between 1999 and 2001 (Allan, Phillips *et al.* 2003). Examples of regions where pre-European wildfires are known to have occurred following high rainfall periods include the Peterman Ranges and the Western Desert (Gill 2000; Kimber 1983).

It is difficult to demonstrate empirical shifts in fire regimes, although Burrows and Christensen (1990) attempted to do so in their comparative study of the 'traditional' burning regimes of the Pintubi people in a desert area of Western Australia. In their study, the authors contrasted aerial photography from 1953 – that clearly indicated a patchwork mosaic of burns produced by Aborigines living a nomadic existence – with photos from the 1970s and 1980s, when the area had been de-populated. A clear shift toward larger-scale wildfires was evident. Unfortunately, this study was constrained by lack of replication, with only a single 1953 photographic series being used to illustrate a traditional fire regime. This series had been produced at a time when prior rainfall would have been unlikely to promote sufficient fuel accumulation to allow the spread of large-scale fires (see Appendix 2.1). Furthermore, the 1986 imagery used in the comparison was sampled at a time when large-scale wildfires had recently occurred in the Western Desert (in response to three years of above average rains – see figs 2.1 and 2.3). The conclusions of the authors' that the landscape prior to European arrival was characterised by a small-grained mosaic of burned patches are therefore valid, but it remains uncertain whether the patch burns of the Aborigines would have acted to limit the occurrence of larger fires during times of peak fuel abundance after large rain events.

Fire season

It appears that the seasonality of large-scale fires in the Haasts Bluff region has changed little since the arrival of Europeans. In a recent review of historical evidence concerning pre-European fire regimes in central Australia, Gill (2000) noted that early explorers made greater numbers of references to fires during the spring period than during other times of the year. These observations are also supported by Kimber (1983), who in a synthesis of historical and contemporary fire reports from central Australia, indicated that prior to the arrival of Europeans, fires were largest during summer months (owing to monsoonal lightning influences and increased flammability of fuels), although small-scale fires still commonly occurred during cooler months due to firing by Aboriginal peoples. My own interaction with senior Aboriginal people from Haasts Bluff community supports the view that prior to the arrival of Europeans, Aboriginal peoples burned on a year-round basis. On a camping trip to Muranji rockhole in the Clelland Hills on 30th July 2004, Narputta Nangala, who was born near Muranji, and Alice Nampitjimpa, who was born near Kiwirrkurra community in Western Australia, described accounts of their use of fire during their youth. Both women spoke of daily hunting forays in which family members *always* carried a smouldering fire stick, regardless of season, and lit up the land as they searched for game and edible plants.

It is suggested that the seasonality of fire under the contemporary regime is similar to that which would have existed prior to the arrival of Aborigines in Australia. This is because during pre-human times, summer seasons would still have been characterised by increased flammability of fuels, owing to higher temperatures and lower humidity. Additionally, lightning would have been the sole ignition source, and presumably was most common during summer (Griffin 1984).

Fire interval

If extensive fires occasionally occurred prior to European arrival, then it is possible that traditional burning regimes involved higher fire frequencies than at present. During pre-European times, the desert would have been subject not only to periodic landscape fires, but also to ongoing mosaic burning by Aboriginal peoples. It should be pointed out, however, that the traditional burning regime of Aboriginal peoples would not have been ubiquitous across the landscape. Rather, as Griffin and Allan (1985) noted, it would have been concentrated around focal areas of heavier utilisation, such as waterholes and along routes of travel. It is these areas that would have received higher fire frequencies under the traditional regime, than under the present one. For the large areas of waterless land that Aboriginal peoples never visited, it is suggested that fire regimes would have been similar to those of today i.e. intermittent fires at long intervals, occurring after above-average rains.