Western Desert Traditional and Contemporary Fire Project
A Caring for our Country, 2011-12 Investment project

MERI Report- Monitoring and evaluation of temporal and spatial fire patterns in Martu managed and unmanaged (lightning) landscapes using satellite imagery

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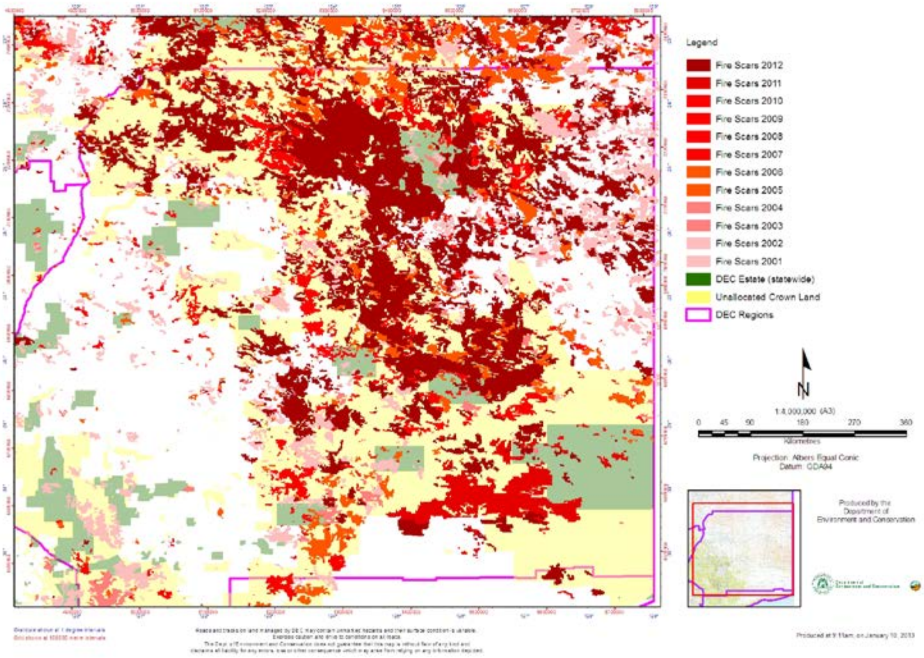
1953 aerial photographs of fine scale fire footprints resulting from traditional Martu patch burning prior to European contact



Contemporary MODIS satellite image showing very large wildfires following cessation of traditional burning over much of the Western Desert

1. Introduction

The Western Desert Traditional and Contemporary Fire Project seeks to increase native habitat in WA's Western Desert by significantly extending appropriate fire regimes across two native title determinations.

Post European contact, there have been many changes to Martu country including:

- Changes in customary lifestyle – general movement of people off country into settlements.
- Altered fire regimes as a result of cessation of traditional burning practices over much of the landscape.
- Invasion by foreign plants and animals, especially buffel grass, cats, foxes, feral camels and other herbivores.

As well as social and cultural issues, this has coincided with alarming declines and extinctions of native animals, especially the medium size mammals and some birds, declines of some important plant species, and general degradation of desert ecosystems.

The continuing decline in the health of the country, including declines in biodiversity, can be halted and turned around by wise management. This will require significant effort and actions to reintroduce good fire management and control introduced predators and herbivores. Not only will good fire management improve the health of country, but it will also provide opportunities for Aboriginal people to get back on country, reduce greenhouse gas emissions and create the potential for an emissions trading scheme. In the longer term, there is the possibility of reintroducing many of the animals that are now extinct in the desert.

One of the key objectives of this project is to mitigate the damaging effects of unmanaged wildfires resulting from the departure from traditional burning practices that shaped these landscapes over thousands of years (Burrows and Christensen 1990; Burrows *et al*. 2006). This will be achieved by progressively reinstating customary mosaic patch-burning by contracting Martu, the traditional owners (TOs) of these lands, to carry out on-ground burning, and in collaboration with the Department of Environment and Conservation (DEC), to carry out targeted patch-burning using aircraft.

Partnerships between Traditional Owners, DEC and the Federal Government through CSIRO and the Caring for our Country (CfoC) program, will have the power to significantly improve the health of country. However, like most conservation and natural resources management projects, it will require a long term commitment of significant resources to halt and reverse threatening processes such as large, intense wildfires. This short term project will not halt or reverse the altered fire regime across the vast expanses of the Western Desert, but will develop the necessary ingredients for long term success, including partnerships, skills, capacity building, systems and procedures. It will also demonstrate that traditional patch-burning strategies can be implemented and will mitigate the impacts of large wildfires.

18 month old spinifex.

Seven year old spinifex

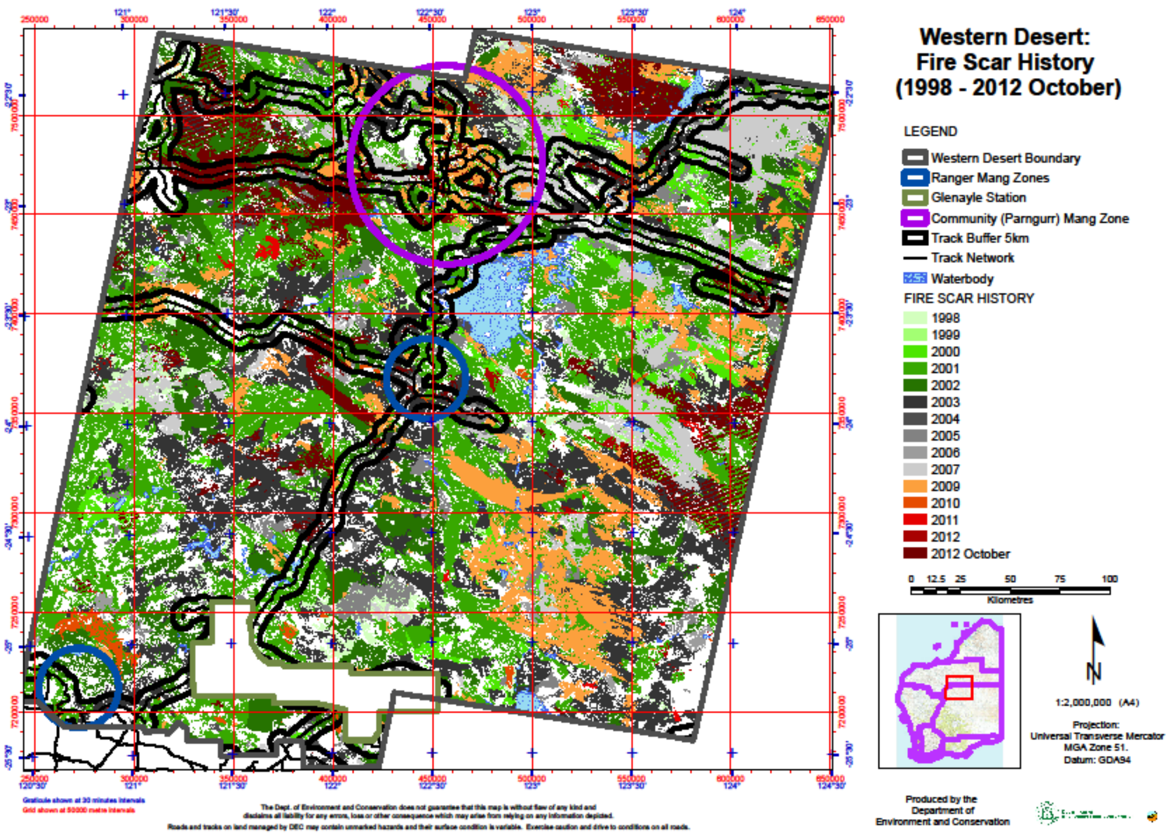


Figure 1: Fifteen year fire history of the project area as at October 2012. The Martu fire managed landscapes are those areas circled and corridors within 5 km of access tracks. Blue circles are the Martu Ranger Fire Management Areas: Jilukaru (North) and Katjarra (South). On the legend, 1998 = fires that occurred from January 1997 to January 1998; 1999 = fires that occurred from January 1998 to January 1999; and so on. 2012 October = fires that occurred from January 2012 to October 2012.

2. MERI (monitoring, evaluation, reporting, improvement)

The total area defined by the Martu and Birriliburu native title determinations is ~20 M ha. Of this, the Caring for our Country (CfoC) project identifies a total of 375,000 ha of native habitat and vegetation that will be managed over the two year life of the project to reduce the threat of large, damaging wildfires. To this end, the stated aim for this project is to work on, or burn 37,500 ha, or 10% of the 'management zone' thereby reducing the size and impact of large damaging wildfires and increasing habitat (seral) diversity. Clearly it will take a concerted effort of patch-burning for the next 10-15 years to significantly reduce the scale and frequency of wildfires over 20 M ha, but this project will be valuable for developing capacity and demonstrating progress towards this ultimate goal.

Part of DEC's role in this project is to:

"*Support the MERI process which incorporates remote sensing of managed and unmanaged areas so as to monitor improvements in habitat".*

Specifically in this regard, to utilise remote sensing as a monitoring tool to evaluate and report on spatial and temporal changes to fire patterns in and outside the Martu managed area. Fire pattern, including the area burnt and the scale of fires, is a surrogate for habitat diversity and ecosystem health. The expectation is that increasing the extent of traditional burning patterns by Martu will decrease the scale and impact of wildfires and increase seral (habitat) diversity.

Specifically, the MERI program was designed to answer the following key questions that link to healthy country, healthy culture, healthy people:

1. Have we achieved our burning target for this project of 37,500 ha in the Martu managed landscapes?
2. What is the temporal and spatial patterning and size class distribution of fires in the Martu managed, and in unmanaged landscapes, where most fires are caused by lightning?
3. What is the current seral (habitat) diversity in Martu managed landscapes and lighting landscapes?
4. What is the current biological diversity and cultural resources value (ecosystem services) in Martu managed landscapes and unmanaged landscapes?

This report deals with the first three questions. Question 4, which links fire-induced habitat diversity with biodiversity, ecosystem health and the value of ecosystem services to Martu (cultural values), is outside the scope of this reporting period and is yet to be completed.

3. Monitoring methodology

In order to adequately evaluate and report on the impact of Martu fire management, it is necessary to examine trends in the variables being monitored prior to 2012 in areas in which pro-active burning by Martu was taking place under the auspices of this project, and areas that were ignited largely by lightning. In these vast and remote landscapes, remote sensing, and in particular, satellite imagery is the only feasible and cost effective tool for mapping fire scars.

A yearly sequence of Landsat satellite imagery with scenes covering a total of 11,665,188 ha, was acquired, interpreted, digitised, mapped and analysed to monitor trends in the temporal and spatial scales of fires over the period 1997-2012, except for 2007, as no imagery was available. A detailed map of the current age of the vegetation, or time since last fire as at April 2013, was compiled.

Contractual obligations required the proactive burning of 37,500 ha, or about 10% of the ~371,411ha 'Martu managed landscapes' (Table 1) over the duration of the project. If Martu fire management is making a difference, then there should be a trend towards;

- More small fires and fewer large fires.
- Greater diversity of vegetation at different times since last fire (seral stage), or greater habitat diversity per unit area.
- Greater biodiversity and ecosystem services to Martu (cultural values).

It is emphasised that it could take up to 15 years of concerted fire management effort across the entire 20 M ha of the Martu and Birriliburu Native Title areas to shift the fire regime from one dominated by very large wildfires to the preferred pre-European contact regime of a mosaic of mostly smaller fires that fragment and mitigate the impacts of large wildfires.

This monitoring protocol operates within the adaptive management framework shown in Figure 2 below. This conceptualises the linkages between 'healthy country' from a cultural and biodiversity perspective, and key factors that determine this, some of which can be managed, such as fire and feral animals, and others which can't be managed, such as rainfall. Essentially, this monitoring protocol is a modified BACI design (Before, After, Control Impact). The variables monitored and the sampling regime are summarised in Table 1.

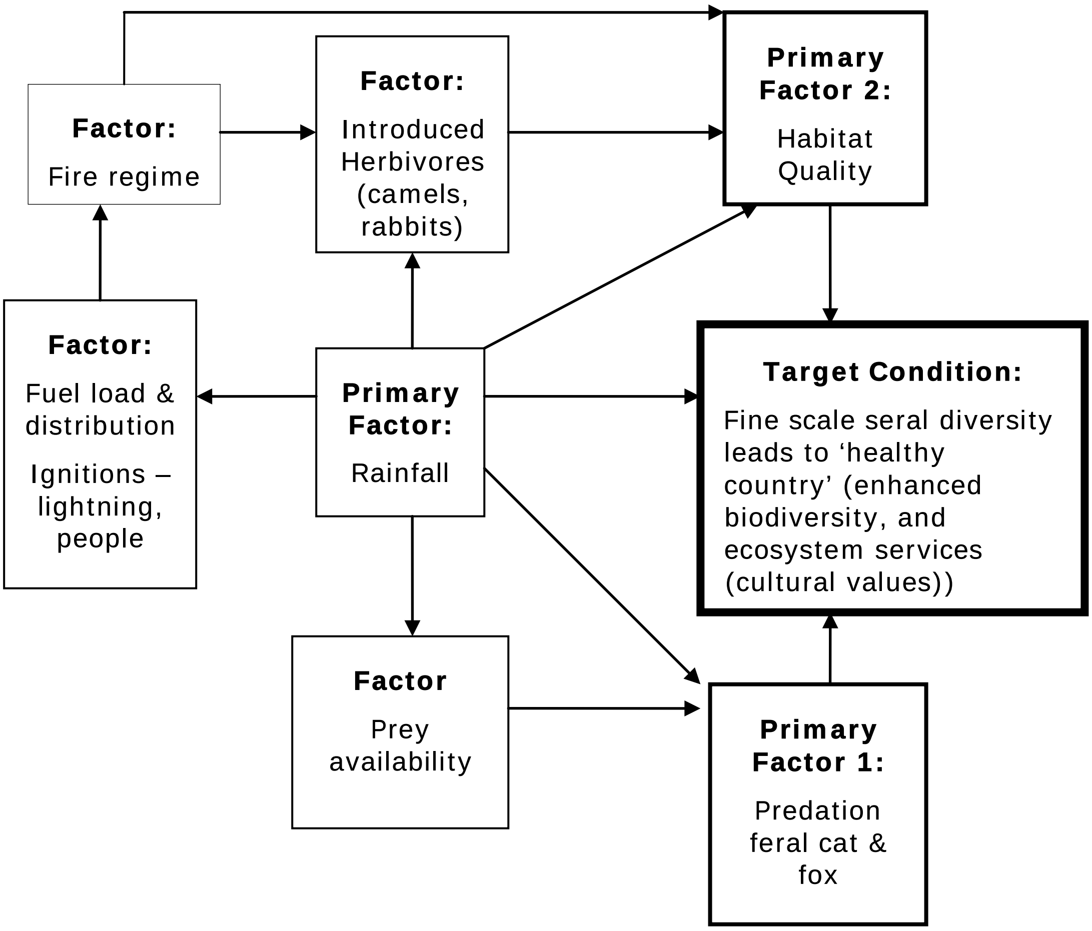


Figure 2: Simplified conceptual model of management system showing interactions between the target condition and factors that influence the target condition. This project focuses on managing fire to achieve the desirable target condition/project goal.

Fortunately, visually identifying and mapping recent fire scars in arid zone spinifex grasslands from aerial photographs or satellite imagery is relatively straightforward compared with some other vegetation types such as tropical savannas or tall forests because the vegetation is low (20–50 cm high) and simple in structure (ground cover only, little or no overstorey); combustion of the vegetation is virtually complete, revealing the surface soil, the signature of which contrasts strongly with the unburnt vegetation; the red sandy soil is the dominant reflector post-fire, and is relatively uniform in colour and texture over large areas; fire shapes in hummock grasslands are quite distinctive and are not readily confused with other features such as changing vegetation types, surface geology, drainages or landforms; the rate of post-fire recovery of the perennial vegetation is relatively slow, with fire scars being visible for at least 5–6 years, and often longer during drought periods and there are few cloudy days.

Table 1: Sampling protocol for the MERI fire scar mapping component of this project.

Management Classification Zone	Total area monitored (ha)	Years of data	Variables (metrics) measured each year			
			No. of fires	**Total areas burnt and % areas burnt**	**Burnt patch size class distributions**	**Fuel ages and diversity of seral stages at 2012**
Combined Martu managed landscapes	371,411	January 1997-April 2013 (except 2007)	✓	✓	✓	✓
Lightning (unmanaged) landscapes	9,012,662	As above	✓	✓	✓	✓
Jilukaru Fire Management Area (~20 km radius)	~125,000	As above	✓	✓	✓	✓
Katjarra Fire Management Area (~20 km radius)	~125,000	As above	✓	✓	✓	✓

3.1 Landsat satellites and sensors

Since 1972, NASA and the US Geological Survey have been launching and managing Landsat satellites, which have provided continuous image coverage of the Earth's surface to date (http://landsat.usgs.gov/about_mission_history.php). Access to this historic archive of images for viewing and analysis, is fundamental to monitoring and reconstructing fire history.

3.2 Imagery and time frame

Of the ~20 M ha of Martu and Birriliburu Native Title Determined area, approximately 11 M ha (55%) was monitored by satellite and mapped for fire scar patterns. The area monitored was covered by the five Landsat scenes 109/076, 109/077, 110/76, 110/077 & 110/078. The time period of interest was from 1997 to 2012. We circumscribed (mapped) the boundaries of fire scars that were clearly visible on an annual time sequence of medium resolution Landsat Thematic Mapper (TM and ETM+), processed to a pixel resolution of 25 m, and enhanced by displaying the spectral bands: 7 (mid-infrared), 4 (near-infrared) and 2 (visible red) in the red, green and blue colours respectively. The annual frequency of acquiring satellite imagery was a trade-off between what we considered as adequate for detecting fire scars on the study area over this time frame and the significant cost of purchasing and processing more frequent images. To minimise the effect of seasonal variation, January images were preferred, however, due to image availability, quality and cloud cover, imagery between December and March was sometimes used.

The imagery used for this study was from Landsat 5 TM and Landsat 7 ETM+. Landsat 7 images were preferred until Landsat 7 ETM+'s sensor malfunction in 2003, which resulted in gaps or data stripping occurring on the images (*Landsat website 2)*. Landsat 5 images were used until it stopped operating in November 2011. The compromised Landsat 7 data were then used for the final year of this project.

3.3 Image pre-processing

The image products were created by the US Geological Survey (USGS), provided in Geographical Tagger Image-File format (GeoTiff) and geo-rectified to Level 1T (terrain corrected). Each band of Landsat data, in the GeoTIFF format, was delivered as a grayscale, uncompressed, 8-bit string of unsigned integers (*U.S. Geological Survey*).

The image processing software '*ER Mapper version 1*'' was used to process and analysis the data. Conversion for each band into a single ERS file (native ER Mapper image), was completed. An acceptable calibration of all images was via the Sun Correction software provided by CSIRO (Furby 2011).

Where Landsat 7 images were needed, further pre-processing was necessary. For some of these images, earlier dated images were used to create fire mosaics, which filled in the gaps in the image.

3.4 Fire history reconstruction process

For each Landsat scene for each year, fire scar boundaries were interpreted using Landsat band combination 742, differenced Normalised Burn Ratio (dNBR) and differenced Near-Infrared (dNIR). The very large area and relatively long time period over which satellite imagery needed to be analysed meant that an automated processing system was warranted for efficiency and to keep costs down. In the majority of the cases fires were determined using the Normalised Burn Ration (NBR), see equation 1. This equation results in a single band with values from -1 to +1, where the fire scars had negative values.

NBR = (band4- band7) / (band4 + band7) *EQ.1*

The fire scar extents for each year's scene were determined, using the differenced NBR or (dNBR), which compares the reflectance of the current year with the reflectance of the previous year, see Equation 2.

dNBR = NBR previous year – NBR current year
EQ.2

Using band combination 742 and dNBR to detect fire scars, it was evident that the dNBR ratio was not always detecting fires that had burnt several months after the date of image acquisition. This was due the apparent post-burn greening-up of the landscape. Consequently, a simple difference between the Near Infrared (NIR) reflectance values of the current and previous year images was used to highlight the difference between the increases in chlorophyll occurring in the new vegetative growth (see equation 3). With reference to the 742 display image, this ratio detected burns that previously had removed chlorophyll from the landscape that was not represented by dNBR.

dNIR = NIR (previous year) – NIR (currant year) *EQ.3*

where, NIR = Near-Infrared band (band 4) on Landsat TM & Landsat ETM+ sensors

Due to the variation between years and scenes, different dNBR and dNIR thresholds were required in order to accurately determine the extent of the burns; these were manually determined on a case-by-case basis.

Each burn scar extent was captured in and exported from ER MAPPER (image processing software) and imported into ESRI ArcGIS (GIS software), where they were converted into polygons, cleaned and attributed with the scar extents provenance (date of burn and ratio used).

All fire scar polygons were overlaid with their respective current and previous year's imagery, using band combination 742(RGB), to verify the degree of accuracy of the fire scar boundaries. Quality Assessment of all fire scars was conducted at 1:25,000. At this stage, any minor inaccuracies of the polygons were manually corrected.

The processing of Landsat data yielded many small polygons, typically 1-2 square 25m pixels (0.0625-0.125 ha) which were classified as noise if they were not in close proximity to an obvious larger burn scar. A minimum fire size threshold was determined to remove this noise. To determine this threshold a comparison was made between the number of polygons removed and the total burnt area lost at each threshold of 0.065 ha, 0.25 ha, 1ha, 2 ha, 6.25 ha,10 ha & 25 ha). At the threshold of <25 ha, 8 of the 15 years experienced a dramatic drop in area. This was deemed as a natural cut-off point for polygon size reduction, so a threshold of <10 ha was applied across the polygons.

3.5 Fire management zones

The project area was classified and mapped into two 'fire management' zones, or landscapes, based on the prevalence of anthropogenic verses lightning ignition sources (after Bird *et al*. 2012). Fire scars where therefore grouped in the respective management zones (shown in Figure 1). The management zone in which the centroid of a fire scar polygon was located, associated the fire scar to that management zone. The association of each fire scar to these management zones follows that of Bird *et al* (2012): The fire management landscapes were:

- Martu Community Managed Zone (Martu managed landscapes): Equal or less than 50 km radius from the centre of the Martu Community (Parnngurr) and equal or less than 5km buffer from all vehicle routes. The assumption is that in the absence of evidence to the contrary, most fires are lit by Martu in this zone. Two additional management areas were identified being specific areas that the Martu Rangers burnt either from the ground or from aircraft, namely, the Jilukaru Fire Management Zone and the Katjarra Fire Management Zone (Table 1). This included all fires set within a 20 km radius of the centre of the zones and within 5 km either side of access tracks in the zones (see Figure 1).
- Lightning - Unmanaged Zone (lightning landscapes): Greater than 50km radius from the centre of the Martu Community and greater than 5km buffer from all vehicle routes. The assumption is that most, if not all fires in the zone were lit by lightning unless there was evidence to the contrary.

3.6 Fire scar metrics

With each polygon fire scar associated to a management zone based on the location of the centroid of the fire scar polygon, the fire scar metrics below were calculated for each management zone, a summary of which is presented in this report.

- Table listing the polygon area and perimeter of each fire scar
- Descriptive statistics for the scar scars (including mean, median, variance and range of each burnt patch), of each year
- Graphs (per year, per management zone) of the:
    - frequency of polygons
    - total area of polygons
    - proportion of total area of polygons

      Where the following area classes were used:
        - <100 ha
        - 100-500 ha
        - 500 - 1000 ha
        - 1000 - 10,000 ha
        - 10,000 - 100,000 ha
        - > 100,000 ha

A map of the 11.6 M ha in which fire scares were mapped from satellite imagery is shown in Figure 1 above. Also shown marked are the various management zones; the 'Martu managed' landscapes, or areas that Martu have vehicle access to for hunting, ground burning and other activities, and areas that were accessible for ignition by aircraft (see also Table 1). The 'unmanaged landscapes' are those areas beyond Martu influence for the purposes of this study and are generally remote from vehicle access. In these landscapes, most, if not all, fires are lightning-caused. Using annual imagery, the cause of ignition, whether by Martu or by lightning, is not always clear cut. However, knowing where and when Martu visited areas for the purpose of carrying out either aerial burning or ground burning, knowing that most lightning fires occurred under hot, dry summer conditions and were therefore usually very large, and knowing where Martu did not go over the life of the project assisted with determining whether a fire was started by lightning or people. However, it is acknowledged that the allocation of fire cause may have been incorrect in some cases.

4. Results and discussion

A map of the current fire history (as at April 2013) is shown in Figure 1 above. A notable feature is the large area burnt by wildfire over the period October 2012 to April 2013. Most data presented here do not take account of the fires during this period because they occurred outside the time frame of the monitoring period (to September 2012) and of Martu fire management for this project, but fire scar maps are included for interest and to demonstrate the challenges in mitigating large wildfires in these landscapes. In interpreting this map and other data presented here, it should be noted that while the monitoring protocol has delineated a 'Martu management zone', during the relatively short period of this project, Martu did not travel to, or carry out burning in all parts of this zone.

Figure 3 shows the areas burnt for the period December 2011-October 2012, a total of 622,320 ha burnt, with 47,561 burnt in the Martu managed landscapes.

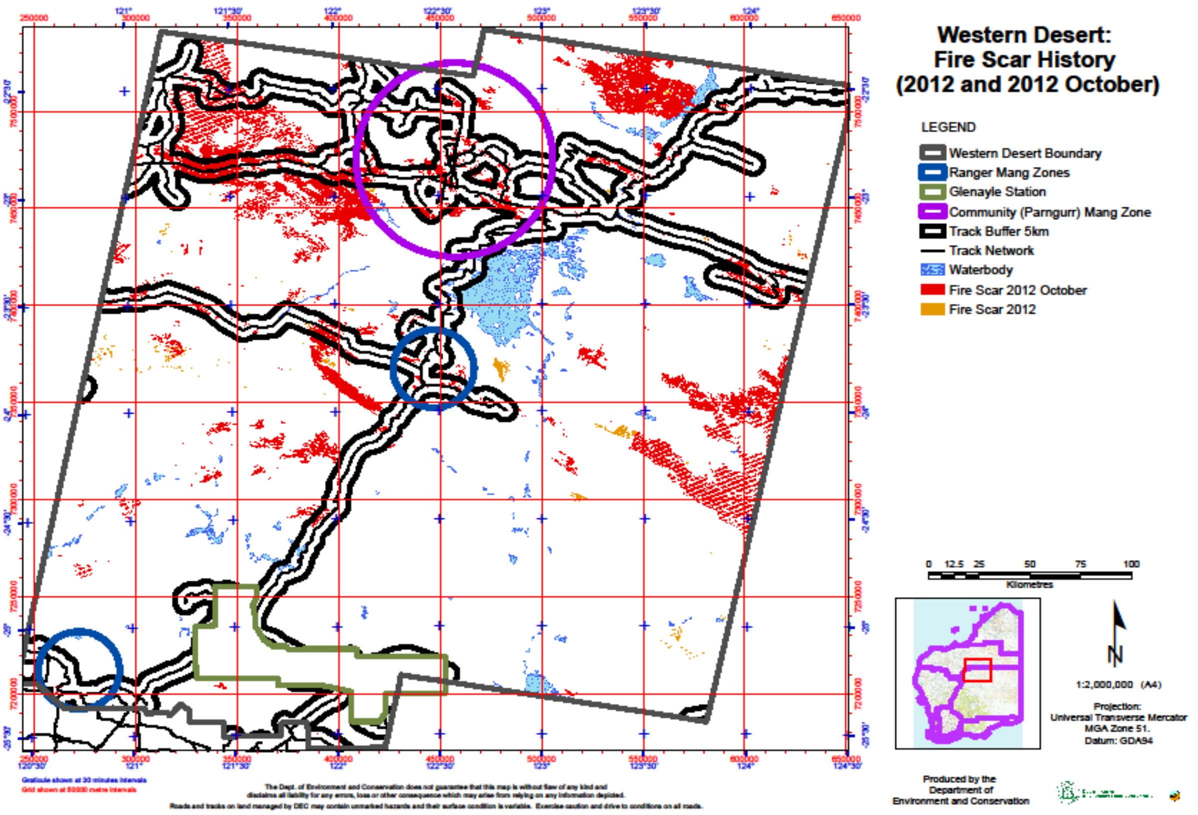


Figure 3: Fires that burnt from January 2011 to January 2012 (Fire Scar 2012)and from January 2012 to October 2012 (Fire Scar 2012 Oct), which covers the main operational period of this project.

Data are analysed and interpreted according to the two broad management zones described above. Further detailed monitoring and analysis was undertaken for the Jilukaru (~125,500 ha) and Katjarra (~125,000 ha) Martu Ranger Fire Management Areas.

Table 2 summarises the mean, median and range in the size of fires for Martu managed landscapes and landscapes dominated by lightning over the period 1997-October 2012 (except 2007), and for 2012 (January 2012 - October 2012)– the operational period of this project. Clearly fires are significantly smaller in the Martu landscapes. In 2012, fires are smaller by an order of magnitude. The range in fire size and the high standard errors around the means indicates high variability in the size of fires in all landscapes.

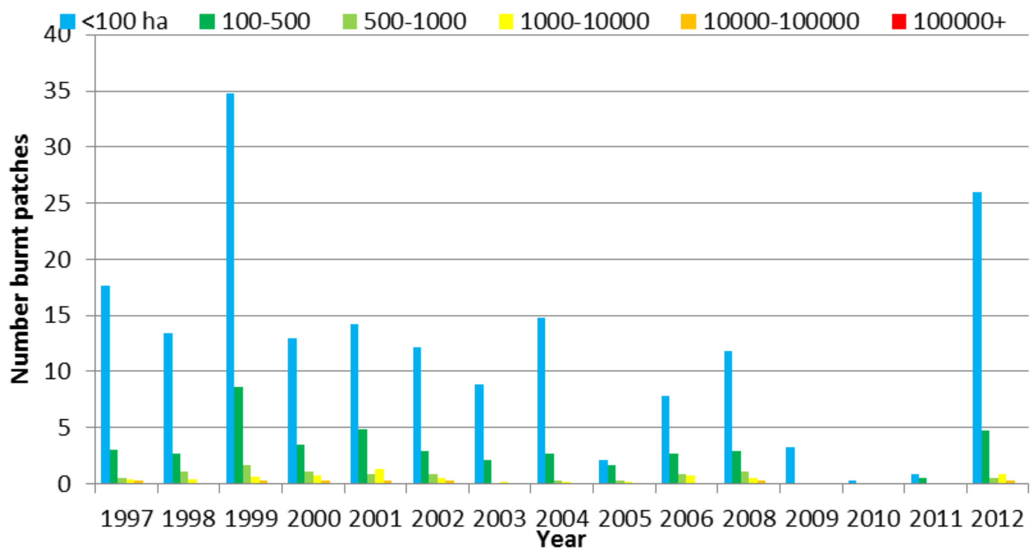
Table 2: Fire size statistics for Martu managed and unmanaged (lightning dominated) landscapes

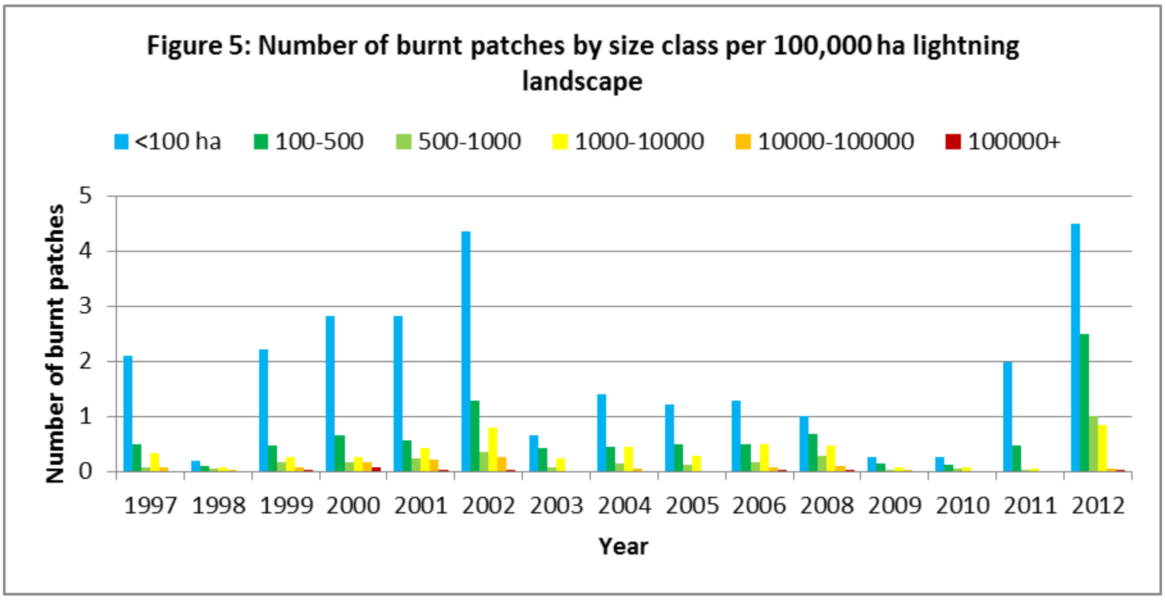
Fire size (ha)	**1997- October 2012**		**2012 only**	
	Martu	Lightning	Martu	Lightning
Mean (s.e)	365 (186)	1,882 (651)	410 (146)	5,262 (186)
Median	48	809	32	92
Range	10-11,957	10-346,302	10-13,746	10-105,300

Figures 4 and 5 show the trends in the number of fires by size class, and per 100,000 ha of each of the broad management zones for 1997 to October 2012 (except 2007). These figures clearly show that the number of fires in the smaller fire size classes is significantly higher, by an order of magnitude, in the Martu managed landscapes. The increase in the number of small fires in Martu managed landscapes in 2012 is evident.

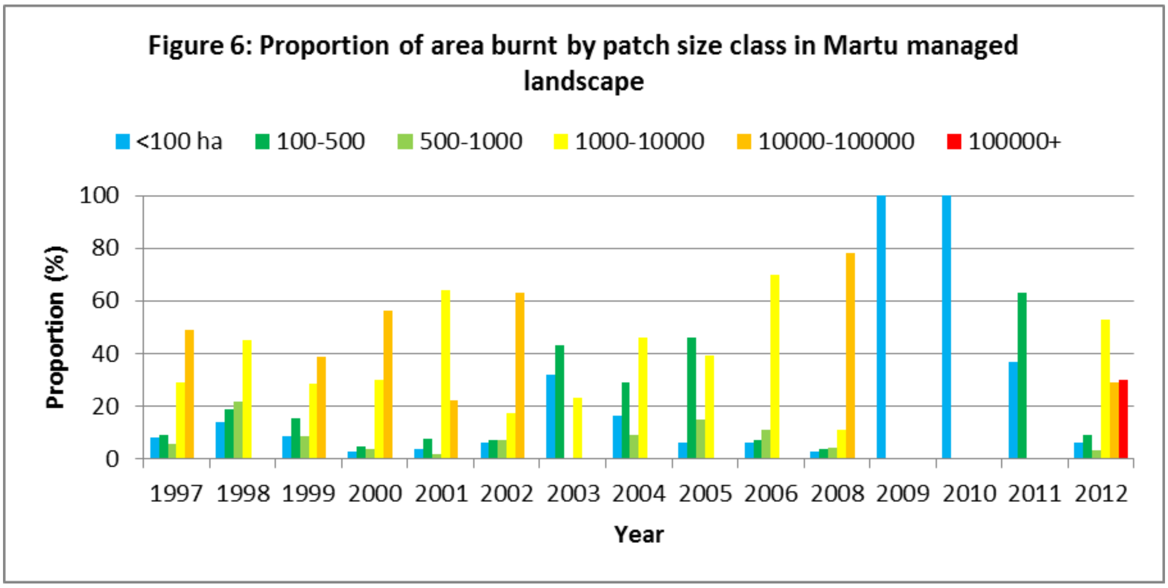
Because of the area affected by large (wild) fires, the number of large fires is low in both landscapes, but is significantly lower in the Martu landscape. For example, in 2012, there were no fires larger than 10,000 ha in the Martu landscape, but in the unmanaged landscape, there were 6 such fires, or 0.066 fires per 100,000 ha. Aside from year 2000, the highest number of small burnt patches in the Martu landscapes was in 2012, associated with this project.

Figure 4: Number of burnt patches by size class per 100,000 ha of Martu landscape





Figures 6 and 7 show the proportion of the area burnt by burnt patch size class. These graphs further demonstrate that there are fewer large fires and more smaller fires in Martu managed landscapes. For example, in 2009, 100% of the area burnt in the Martu landscapes was burnt by fires <100 ha. The yellow and red bars in the figures indicate area burnt by very large fires and it is clear that there is much more red and yellow, or larger fires, in the unmanaged landscapes.



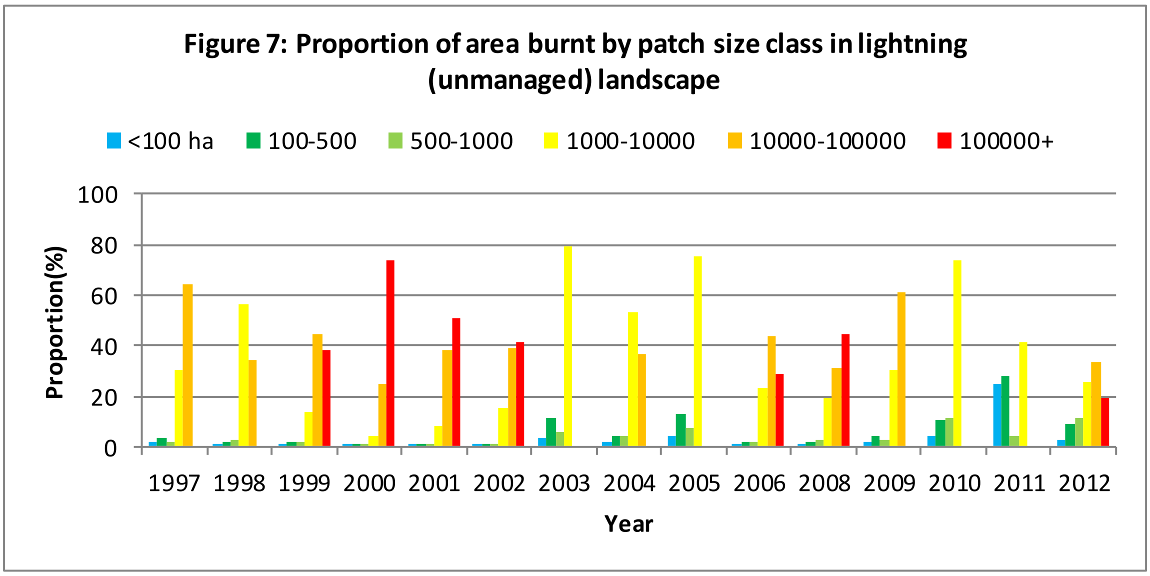
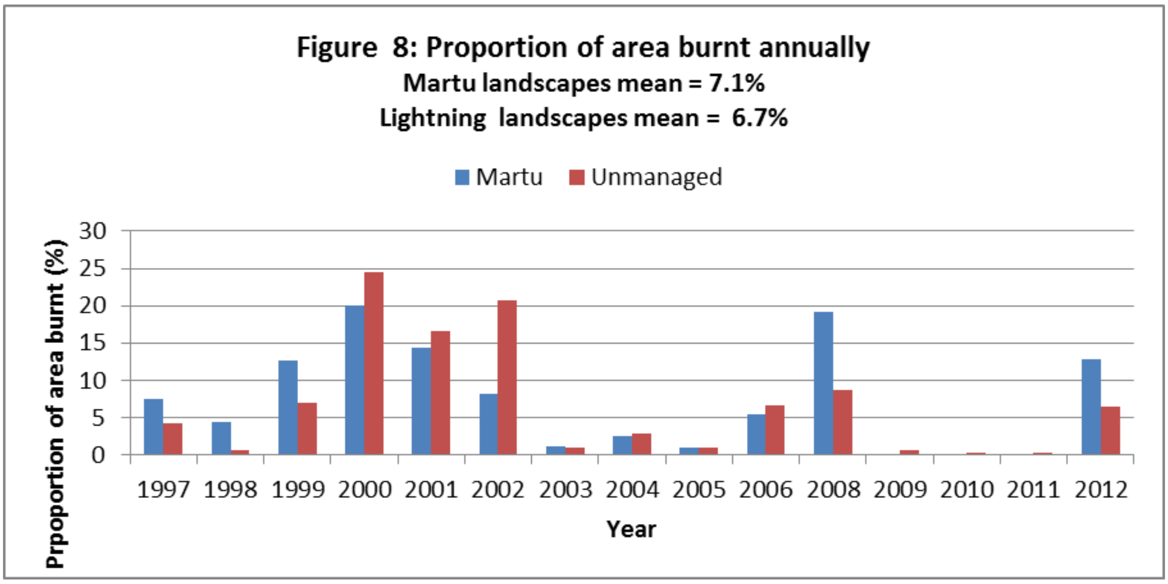


Figure 8 shows the trend in the proportion of each management zone burnt annually from 1997-2012. A noticeable feature is the high year-to-year variability, ranging from <1% to almost 25% of the area burnt in a year. Over this 15 year period, the mean annual proportion of area burnt in each management landscape is similar, at around 7%. However, from Figures 4 and 5, it can be seen that in the Martu managed landscapes, a higher proportion of the burnt area is made up of smaller fires, whereas in the unmanaged landscapes, there is a higher proportion burnt by larger fires. In 2012, the proportion of area burnt in the Martu landscapes (12.9%) is almost double that of the unmanaged landscapes (7.4%).

Figure 8 also shows that in 2012, a total of 47,561 ha, (~12.8%), was burnt in Martu managed landscapes, exceeding the 37,500 ha CfoC contract obligation . It also shows that there was a higher proportion of very large fires in the unmanaged landscape compared with the Martu managed landscapes. For example, in the unmanaged landscape in 2012, almost 20% of the area was burnt by fires >100,000 ha but there were no fires of this size in the Martu managed landscapes. Nevertheless, relatively large wildfires (10,000-100,000 ha) also occurred in Martu managed landscape.

Figure 9 demonstrates the beneficial effects of Martu management with the proportion of area burnt by smaller fires being considerably greater than in the unmanaged landscapes.



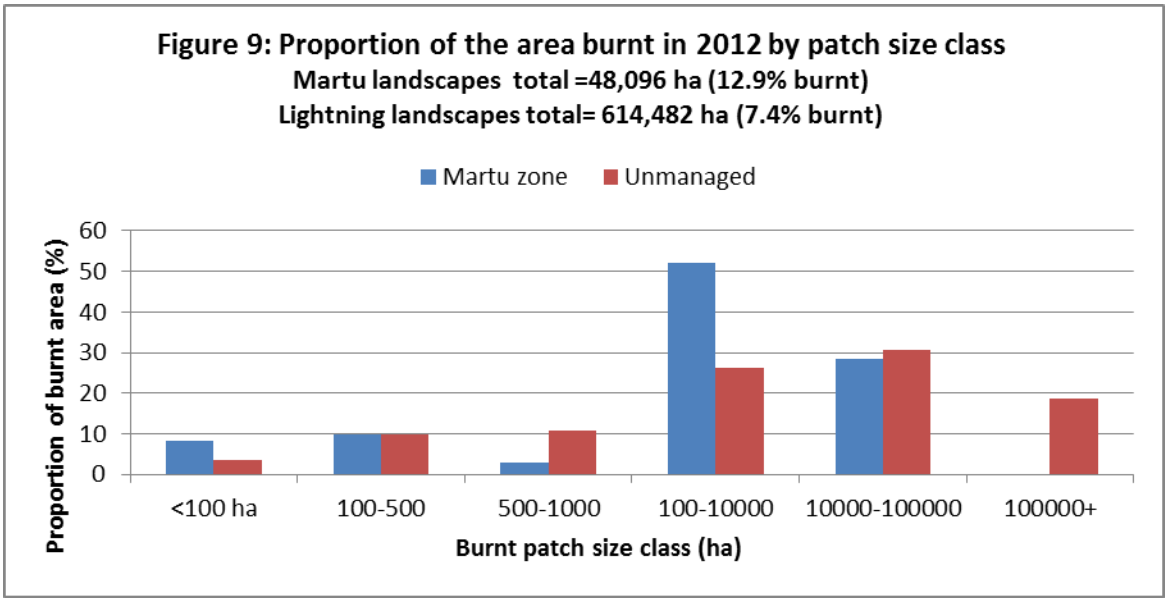
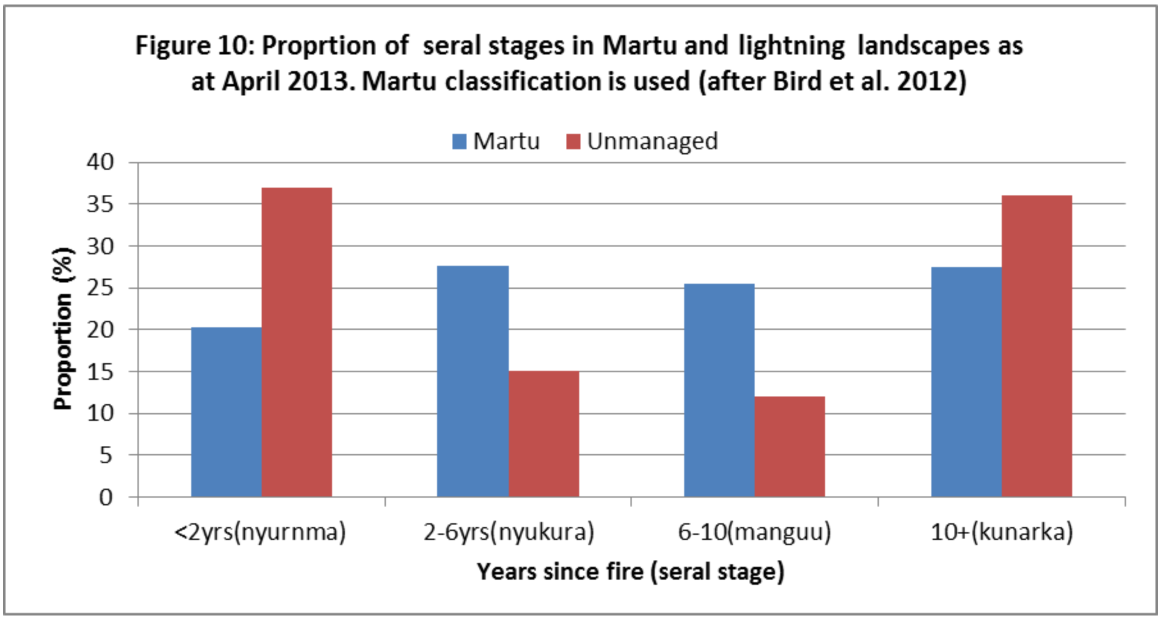


Figure 10 shows the age class distribution, or seral stages of vegetation in Martu managed and unmanaged landscapes. The 'seral stages', or age of the vegetation since last fire, uses the Martu classification as reported by Bird *et al*. 2012. In the Martu managed landscapes, there is a trend towards are more uniform distribution of 'seral' stages, with each of the four stages occupying about a quarter of the area. The lightning-dominated (unmanaged) landscapes are dominated by either recently burnt spinifex (nyurnma or waruwaru) and longer unburnt spinifex (kunarka). This indicates an unstable fire situation, with large tracts of the landscape flipping from longer unburnt to recently burnt following inevitable large wildfire events. This 'instability', or flipping of seral stages is modified in the Martu landscapes as a result of Martu burning. Increasing the extent of burning by Martu will increase the proportion of area in the younger seral stages, decrease the area in the older seral stages and further increase the resilience of the landscape to large, intense wildfires.



Figures 11 to 14 provide fire scar metrics for the Jilukaru and Katjarra Martu Ranger Fire Management Areas. The increase in the number of smaller fires in 2012 as a result of Martu patch-burning is evident. However, the northern area (Jilukaru) was impacted significantly by large wildfires over the period October 2012 – April 2013, with ~30% of the management area burnt. Martu burning had a slight impact on fragmenting the wildfires in this area because only ~4.5% of this area was burnt in 2012 before the wildfire event, so the effect of the burning was minimal. The southern Fire Management Area (Katjarra) was not impacted by the 2012/13 wildfires because, by chance, none started in the area. However, because only about 2% of the area was burnt in 2012, and a high proportion of the area contains relatively long unburnt vegetation (most last burnt by wildfires in 2000 and 2001) there is a high probability that large, uninterrupted wildfires will occur in this area unless more patch-burning is done in the coming years. This underlines the importance of a concerted and on-going burning effort if large and damaging wildfires are to be mitigated. At least 10% of the defined management area needs to be patch-burnt annually to significantly mitigate the adverse impacts of large wildfires.

Figure 11: Number of burnt patches by size class for the Jilukaru Fire Management Area (125,600 ha) in the Martu managed landscapes.

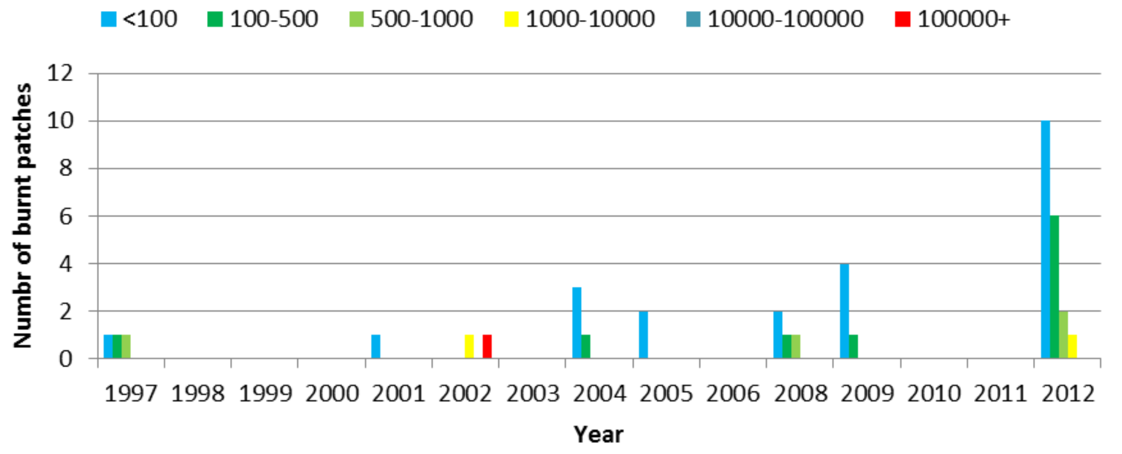


Figure 12: Number of burnt patches by size class for Katjarra Fire Management Area (125,600 ha) within the Martu managed landscapes

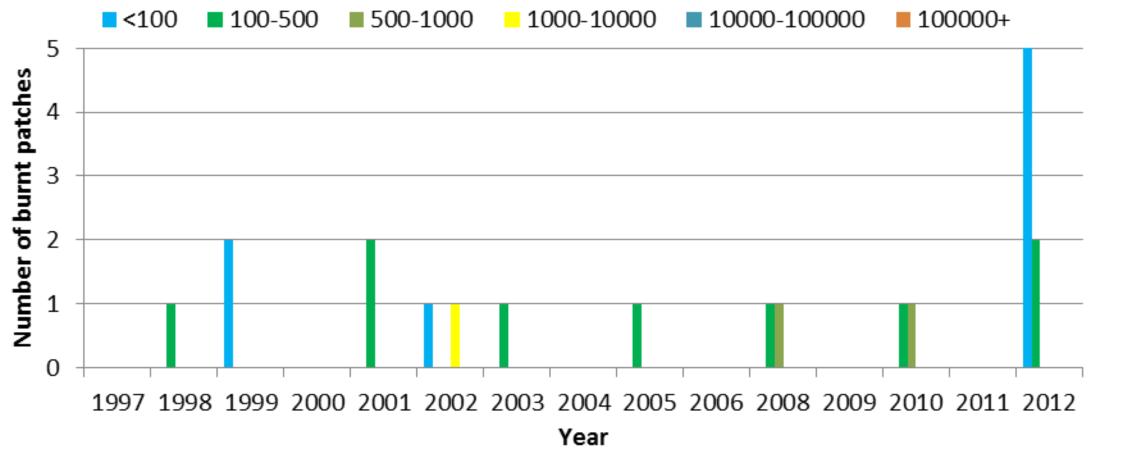


Figure 13: Proportion of the area burnt in 2012 by burnt patch size class. Jilukaru Fire Management Area = 5,414 ha burnt Katjarra Fire Management Area = 1,026 ha burnt.

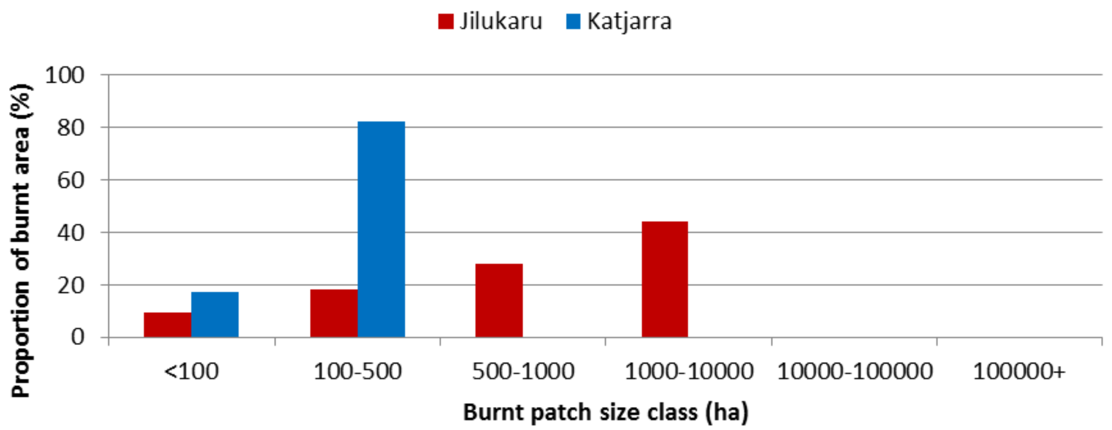
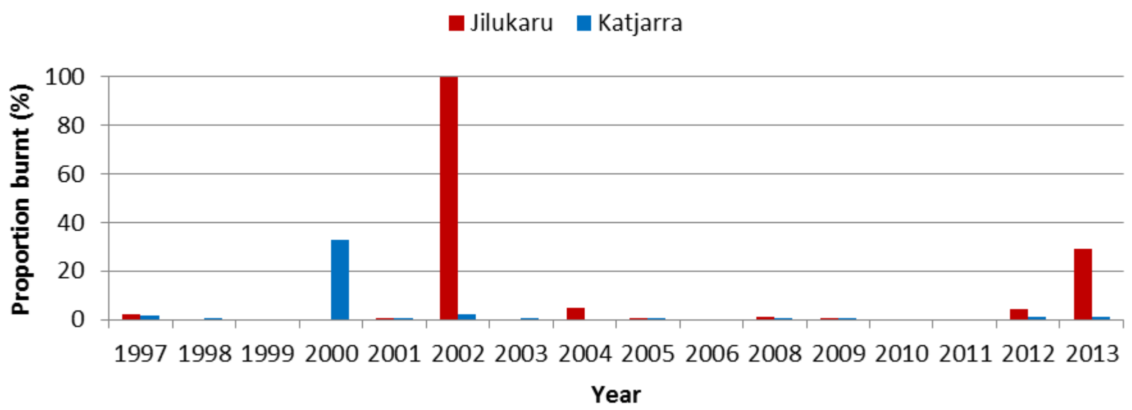


Figure 14: Proportion of Jilukaru and Katjarra Fire Management Areas burnt per annum (2013 is from October 2012 to April2013)



5. Conclusions

The purpose of this monitoring protocol was to answer the following questions:

1. *Have we achieved our burning target for this project of 37,500 ha in the Martu managed landscapes?*

The answer is yes, at least 47,561 ha was burnt in the Martu managed landscapes up to October 2012.

The area burnt is likely to be higher than this, because some of the Martu fires crossed over the ‘management area’ boundaries and burned into the ‘unmanaged’ areas and there are many small fires that have not been mapped at this scale of mapping (see methods section). This highlights a difficulty in attempting to ascribe fire management activities to defined boundaries, when in the absence of barriers to fire spread; fires can cross these boundaries from any direction. Obtaining Landsat satellite imagery at more frequent intervals would help to account for fires that cross management boundaries, but this is considerably more time consuming thus more expensive. A more effective approach in determining when fires occurred and approximately where fires originated, would be to supplement Landsat imagery with regular MODIS images. However, these have a much lower resolution and a considerable loss of detail would occur.

2. *What is the temporal and spatial patterning and size class distribution of fires in the Martu managed and unmanaged landscapes where most fires are caused by lightning?*

In Martu managed landscapes, there is a discernable trend towards smaller fires and fewer larger fires compared with the lightning-dominated landscapes. The strength of this trend, or the extent to which Martu fire management mitigates the scale and impact of wildfires will be directly proportional to the extent and scale of Martu burning. Within a defined landscape, or ‘management area’ it will be necessary to patch-burn at least 10% of the area per annum, on-going, to mitigate large wildfires. Across the 20 M ha of the Martu and Birriliburu Native Title Determinations, it is an unrealistic expectation that this can be achieved given current and foreseeable capacity. However, defining priority areas for fire management, as Martu have done with the Jilukaru and Katjarra Fire Management Areas, as well as zones around Martu communities, and with continued support and capacity building, good fire management can be put in place to protect cultural, infrastructure, biodiversity and environmental values from damage and destruction by wildfires.

3. *What is the current seral (habitat) diversity in Martu managed landscapes and lighting landscapes?*

A clear trend is emerging. Martu fire management results in a more equal distribution of seral (habitat) stages compared with unmanaged areas where fire regimes are driven by lightning. Not only does this provide greater habitat diversity and opportunities, but it also increases the resilience of these landscapes to large, damaging, wildfires. As mentioned above, more and sustained patch-burning is needed in priority areas to increase habitat diversity and to increase the resilience of these landscapes to wildfires. Essentially, if people burn more, wildfires burn less.

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