NATIONAL BURNING PROJECT

Australasian Fire and Emergency Service
Authorities Council (AFAC)
and Forest Fire Management Group (FFMG)

National Guidelines for Prescribed Burning Operations:
Case Study 7 – Burning for greenhouse gas abatement in Northern Australia

National Burning Project: Sub-Project 4

An Australian Government Initiative

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This document is constructed by GHD from consultation and research between Forest Fire Management Group (FFMG) and AFAC, its member agencies and stakeholders. It is intended to address matters relevant to fire, land management and emergency services across Australia and New Zealand.

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This case study has been prepared by Paul de Mar. It synthesises information from Russell-Smith et al. (2013) with general procedural information about planning and implementing savanna burning.

1 Fire in Australia's tropical savannas

Tropical savannas occupy a high proportion of Australia's tropical north, covering 1.9 million km^2 of land from the Kimberley region in the west, through the Northern Territory to Queensland's Cape country in the east. These savanna regions have annual rainfall of more than 600mm per year, with rainfall restricted principally to the wet season (December to March) producing prolific annual grass growth. A seven to eight month dry season follows during which the landscape progressively dries out, with grasses becoming fully cured and the landscape increasingly primed for fire. This annual monsoonal cycle of wet-season growth, followed by dry-season curing and drying makes tropical savannas the most fire-prone biome on Earth. On average about 20% of Australia's savanna region is burnt each year, mostly in the late dry season when widespread dry fuel conditions promote large, intense fires. Fire occurrence in Australian savannas is unevenly distributed, with near-annual fire frequencies occurring in some lower-productivity savanna areas with unmanaged fire regimes, and much lower fire frequencies (decadal or less) in more fertile and intensively managed beef production areas where active land management seeks mostly to exclude fire (Russell-Smith *et al.* 2013).

These large, high intensity late dry season fire-dominated fire regimes have been shown to have chronically deleterious impacts on savanna biodiversity values (Woinarski *et al.* 2011; Russell-Smith *et al.* 2012). They are also contributing a significant component of Australia's greenhouse gas (GHG) emissions. Savanna fire emissions of long-lived greenhouse gasses (methane and nitrous oxide) account for between 2 to 4% of Australia's annual National Greenhouse Gas Inventory (AGEIS; ANGA 2011a).

Figure 1 Prescribed burning in savanna woodland

These adverse contemporary fire regimes replaced very different traditional Aboriginal methods of fire management. Before European colonisation reached northern Australia, Aboriginal landowners actively managed their land through deliberate application of burning as they moved about their country. They lit many small fires throughout the year, but with a particular focus during a peak traditional burning season in the early – mid dry season when small patch burning activity was intensified. As the dry season advanced, the patterning of these burns created mosaics of burned and unburned land. Back-burning from watercourses and other natural barriers created firebreaks that effectively limited late dry season fire spread and protected vulnerable resources. The effectiveness of this fine-scale fire patterning depended on many groups, being mobile and accessing the extent of their traditional lands, and systematically applying fire. Traditional Aboriginal societal collapse from the late 19th century in many areas brought about the breakdown of this remarkable system of Aboriginal fire management which had up to then been sustained for many thousands of years.

Commercial opportunities to create voluntary GHG emissions offset programs have given rise to the development of savanna burning programs in northern Australia which are restoring more sustainable fire management practices to some savanna landscape areas. These are drawing on traditional knowledge and skills, bringing this together with modern technologies to pursue commercial GHD abatement opportunities, whilst also generating significant social and biodiversity conservation benefits. These programs are commercially viable due to the face that early dry season burns can mitigate the severity and extent of late season burns, thereby reducing GHG emissions and allowing carbon credits. One example, outlined here as a case study of GHG abatement savanna burning programs, is the West Arnhem Land Fire Abatement (WALFA) Program.

2 West Arnhem Land Fire Abatement (WALFA) Program

The WALFA Program has been in commercial operation since 2005. The program is conducted entirely on Aboriginal-owned land in West Arnhem Land covering approximately 28,000 km^2. The area can be characterised as a vast, remote, rugged, biodiversity-rich, fire-prone and largely unpopulated landscape where, between 1990 – 2004, an average of over 40% of the region was burned each year, predominantly by late dry season (LDS) wildfires.

Through the commencement and maintenance of a strategically planned early dry season (EDS) burning program, the extent of late dry season fire has been substantially reduced and a finer-scale mosaic of burnt and unburnt areas has been restored with significant benefits for biodiversity. Since 2005, the WALFA program has successfully created GHG emission offsets of more than 100, 000 tonnes of CO_2e[1] per year. The revenue stream created through GHG offset creation has also given rise to sustained social benefits including traditional owner ranger employment opportunities. Traditional owners are able to return to infrequently-accessed parts of their traditional lands, to plan and undertake burning programs to reverse the land degradation and biodiversity decline trends previously occurring, and restore more sustainable fire management. This has also allowed traditional owners to fulfil cultural obligations to care for country, which in turn contributes to improved well-being.

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[1] *Gasses such as methane and nitrous oxide are converted into equivalent carbon dioxide (CO_2e) (the concentration of CO2 that would create the same greenhouse impact as the gas in question) for carbon accounting purposes.*

It is noteworthy that the program was the world's first savanna burning GHG offsets program (which has blazed the trail for others since) and was enabled by more than a decade of scientific research to develop a nationally accredited emissions accounting methodology specifically for savanna burning.

3 Program and Operational Planning

Unlike fire planning processes in much longer fire interval systems in southern Australia, in the WALFA savanna burning approach, seasonal program and operational burn planning are brought together into a single iterative planning process. This is due to the very clear imperatives to position early dry season burns within the landscape in locations that maximise their intersection with possible late dry season fire paths thereby minimising the spread potential of late dry season fires. Getting this early dry season burn planning right is crucial to program success due to the obvious commercial program success depends on late dry season fire reduction to achieve GHG emissions reduction. In theory, in an optimised program, just the right amount of early dry season burning positioned in optimal locations in the landscape (adjusted each year to account for seasonal conditions and the distribution of fuel loads remaining from the previous year) is implemented to reduce the extent of late dry season fire to within target levels. Too much early dry season burning may lead to sub-optimal program implementation costs; too little or in the wrong places may lead to failure to achieve the desired reduction in late dry season fire.

In contrast to burn program design drivers in southern Australia, which are often focussed on reducing fuel hazards adjacent to specific fire-vulnerable assets, in the WALFA program the focus is on the whole landscape, to identify how to minimise the extent and impact of late dry season fires at the landscape scale.

Accordingly, to maximise program success potential, burn planning by the traditional landowners are best informed by:

- The best available knowledge of where recent fires have occurred across the planning area and in the areas immediately outside the planning area boundary;
- Sound historical and traditional knowledge of typical fire spread and behaviour patterns in the landscape, to inform consideration of how future planned and unplanned fires (both early dry season and late dry season) can be expected to spread;
- Knowledge of current seasonal conditions and anticipated landscape drying pattern detail;
- Experience in how to apply a substantial program of early dry season burns, in a tightly constrained timeframe, with limited resources and optimising use of natural features to contain fire spread; and
- Understanding of cultural traditions governing how fire should be applied across lands involving a number of custodians and other cultural considerations.

Planning is typically done is by convening meetings of traditional owner groups who have customary authority to make decisions about burning on traditional lands and who possess detailed knowledge of local landscapes, seasonal growth and drying patterns, how local flora and fauna respond to these, and traditional fire management knowledge. Planning meetings involving a large number (sometime as many as 100 people) of traditional owner managers representing different land owning groups are held typically in March prior to the start of the dry season. At these planning meetings the traditional owner groups make use of key strategic information obtained through contemporary technologies, such as satellite-derived fire scar mapping[2] and recent weather data and trends and seasonal climate outlook information, for informing their decisions about burn program design.

Many of the operational details of how particular burns in a program will be implemented are considered at this planning stage. This includes such things as deciding the sequence of burns because designing a program that has minimal reliance on containment resources frequently involves using burns completed early in the sequence to provide containment for burns lit later in the sequence. It also involves early burning of parts of the landscape that dry out early in the drying cycle, using moister parts of the landscape to contain fire spread.

Figure 2 Spot ignition in savanna

A required outcome of this early planning meeting is that all major planned aerial incendiary and ground ignition activities are documented on available maps for incorporation into a GIS for distribution to all participating project ranger groups and managers. These pre-season mapping products are used both to inform planned fire management activities over the ensuing fire season, but also to help assess the effectiveness of that planning in subsequent formal evaluation. At the end of each fire season pertinent program data are assembled (e.g. monthly mapping of fires from the NAFI website; assessment reports from participating organisations which include operational details, employment data, identification of weaknesses and successes, etc.), for inclusion as part of formal annual program reporting.

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[2] *See the North Australia Fire Information website: http://www.firenorth.org.au/nafi3/*

By necessity, seasonal burn program designs are less prescriptive and inherently more flexible than burn programs in southern Australia. Because burn timing and use of natural features are commonly used to restrict fire spread, planning involves making assumptions about spread direction and extent for individual burn stages within a sequence. It is to be expected that actual burn extent or coverage for any particular burn stage may not turn out as assumed. Therefore flexibility is required to review assumptions through the program delivery process by periodically reviewing satellite imagery-derived burn scar maps, or aerial assessment of burn coverage after burns have been completed and to readjust assumptions for burns later in the planned sequence. Hence program planning and operational planning are necessarily an integrated and iterative process, generally being a much more flexible and intuitive process than applied in southern Australia. It is expected that changes to a burn program or specific operational burn will be required as program delivery progresses, due to the potential for occurrence of unplanned fires, or that planned burns have coverage different to that originally planned. Wind direction and speed are the main variable affecting the degree to which fires spread as planned – for most of the dry season and certainly through the early dry season period, wind direction is very predictably from the SE. Winds typically become more variable closer to the start of the oncoming wet season.

Burn program delivery incorporates the use of ground and aerial ignition techniques.

The WALFA prescribed burning program is typically completed before the onset of very hot weather (typically from early August on). That does not necessarily mean that all burning needs to cease because, if adequate breaks of sufficient quality are put in, burning for such things as hunting purposes can then be undertaken safely even in very hot months.

4 Operational burn site analysis

In identifying areas to be burnt during a burning operation there is a range of factors to be considered, with some of the more critical factors being:

- What is the status and distribution of fuel loads left over from last year's fire program?
- How will the planned burn area link up with other recently burnt areas in the landscape to form effective buffers against late dry season fire spread?
- What geographic area is the burn to be contained to, and what physical constraints are there to achieving successful containment?
- What, if any, preparatory ground works may be required to facilitate successful containment or to protect specific assets (within or near the planned burn area) from fire impact?
- Under what fuel and weather conditions will the burn need to be conducted to keep the burn within the planned area?
- What ignition methods, lighting patterns and burn-out period will be required to achieve this? and
- What resources will be required to carry out the burn, including consideration of which traditional owners with traditional rights to burn particular land areas will need to be involved?

The outcomes and decisions from these analyses essentially form the basis of the burn plan.

5 Scheduling and implementing the burn

Due in particular to the reliance on natural landscape features such as moist and still-green areas, and waterways to contain one or more sections of a burn, it is necessary to monitor landscape drying indicators and patterns to schedule burning for when conditions become suitable.

Direct observation of landscape condition indicators such as the physical condition of vegetation, ground moisture and landscape drying progress are made. Decisions to schedule and commence a burn are based on when areas targeted for burning are in a condition to sustain fire spread within the burn area, the landscape features to be relied on for containment are still in a condition to contain fire spread, and when weather patterns indicate conditions will be suitable. Such decisions are typically made on the basis of localised traditional knowledge and understanding of seasonal drying and weather patterns.

Implementation of the burn will follow a lighting sequence and pattern agreed upon among the participating traditional owners. Lighting techniques may include ground ignition using matches and drip torches, and aerial ignition from helicopters using aerial incendiary machines, or a combination of the two methods. Once lit, fire spread progress is monitored from the ground or air, whilst active burning can also be tracked via MODIS satellite imagery via the NAFI website.

As there is very limited capacity for response to, or management of escaped fires, there is a high degree of reliance on natural features and prudent burn timing and lighting patterns to achieve safe burn containment. Public safety issues are principally associated with public roads and settlements. Local communities are well-accustomed to fires burning in the landscape. Throughout the dry season smoke and fires are a common sight in northern landscapes. Local communities are generally adept at anticipating fire behaviour and making decisions to avoid harmful impact. Measures such as fire or smoke hazard warning signage for public safety on roads are mostly restricted to major public roads used by non-local motorists, tourists and other visitors potentially not familiar with vegetation fires.

In recent years there has been an increasing emphasis on suppressing potentially extensive fires, especially in the late dry season. Suppression activities in these remote locations are very expensive and logistically challenging. Assessment of suppression potential relies heavily on remotely sensed fire mapping products available on NAFI (location of surrounding burnt areas; likely distribution of fuel loads based on fire mapping for previous years), and BoM weather (especially wind) forecasts. Where it has been deemed strategically important, and suppression activities likely achievable, ground crews are typically dropped in by helicopter. Firebreaks are established by rakehoes and mechanical leaf blowers and ignition from these is undertaken. Some water bombing using small helicopters has also been attempted, but essentially suppression has relied on on-ground activities.

6 Outcomes assessment and continuous improvement

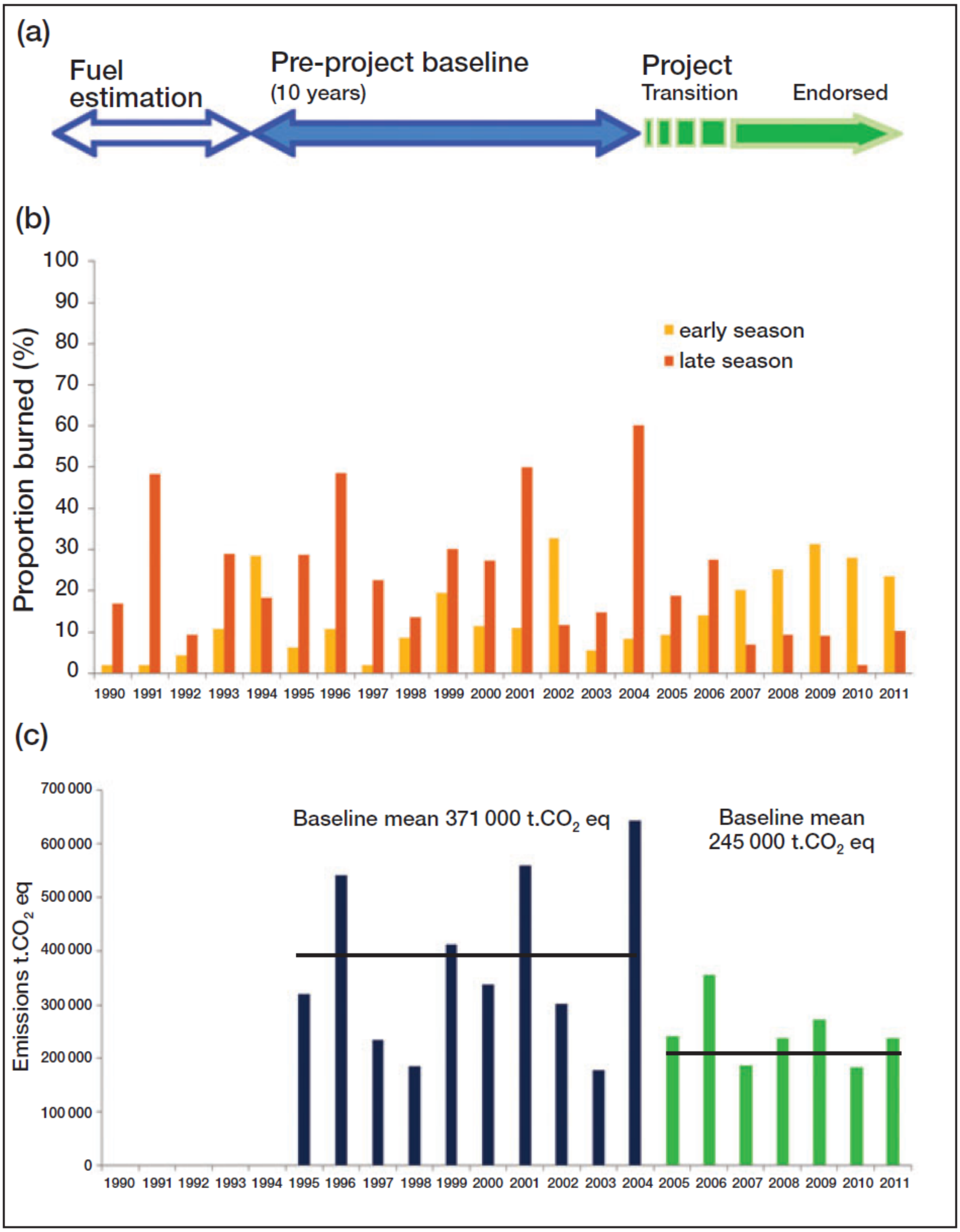
A unique aspect of the GHG abatement-driven savanna burning program is the very strong focus on program performance assessment which is driven by the commercial GHG abatement imperatives. Each year, the extent of early dry season and late dry season burnt areas is quantified using a prescribed fire scar mapping methodology, and strict accounting protocols prescribing all methodological and computational procedures are followed to calculate annual GHG emissions from the program area. These are then compared against the calculated and approved 10-year, pre-project baseline emissions to quantify the reduction in GHG emissions. Thus every year there is effectively a quantitative performance assessment of the GHG emissions reductions outcomes achieved from the program.

As the level of commercial return is linked to the level of GHG emissions reductions, there are strong commercial incentives to review and evaluate burn program design and implementation so that improvements can be made to increase future GHG emissions reductions below baseline levels.

In the WALFA program the application of a strategically planned early dry season burning regime has significantly changed the fire regime. As a result of the program, an average of 20.9% of the WALFA project area was burned in the early-season period, and 10.9% by late-season fires – whereas, in the 10 year pre-project baseline period, an average of 7.6% was burned early and 32% late. Thus in the case of the tropical savanna landscapes in the WALFA program area, annually treating around 20% of the landscape with planned, low intensity early dry season burning has served to reduce the area of higher-impact late dry season by two thirds. While not reported on as part of the accounting methodologies, it is apparent from fire scar interpretation that the average size of late dry season fires has also been substantially reduced. Hence more burning leads to less fire overall, and a substantial reduction in the worst-impact fires – large, intense late dry season fires.

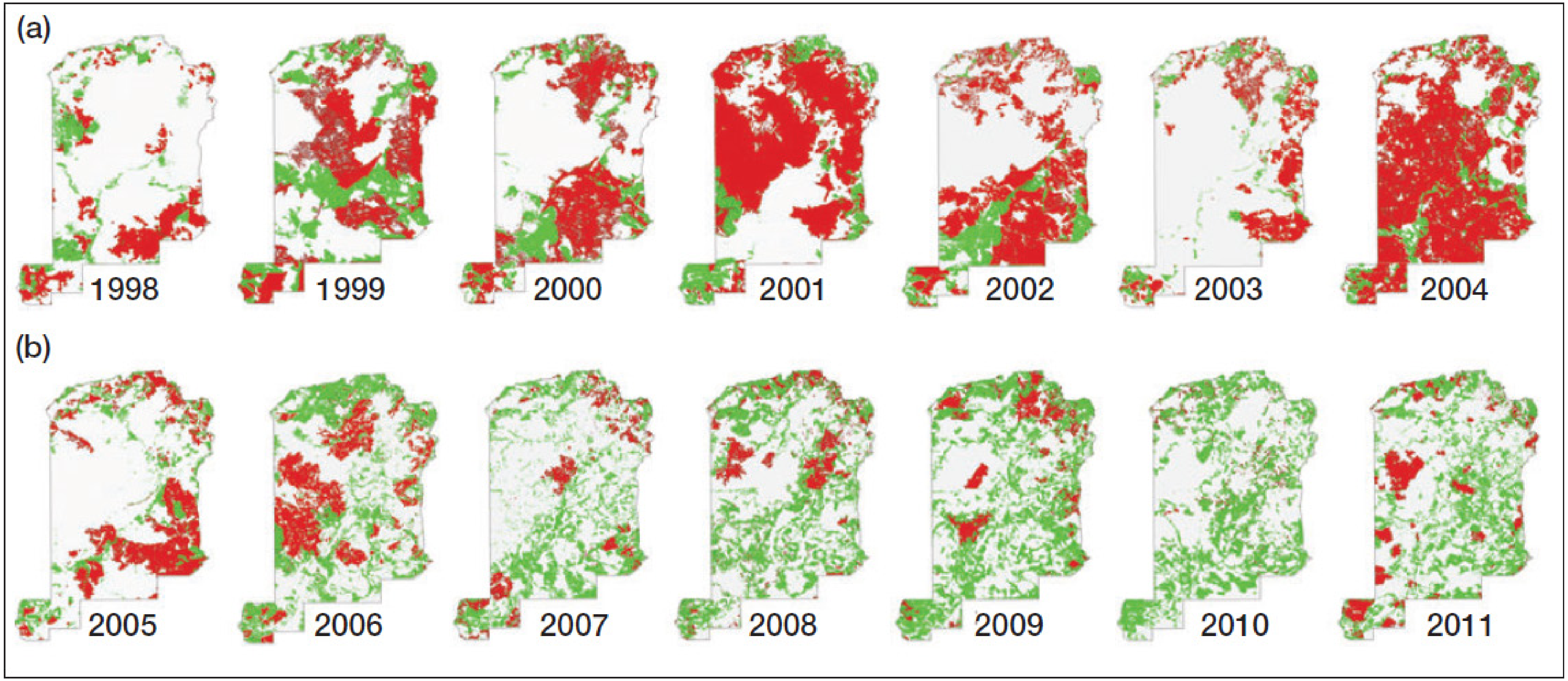
Figure 3 and Figure 4 (reproduced from the Frontiers in Ecology article by Russell-Smith *et al.* (2013) with kind permission of the authors) showed program results and trends in graphical form (Figure 3) and as map depictions (in Figure 4). The substantial reductions in late dry season fires, particularly from 2007 onwards are clearly evident. Figure 4 also reveals substantially reduced late dry season fire size from 2007 relative to the late dry season fires which occurred in the pre-project baseline period (1995 – 2004).

Figure 3 Application of Australia's savanna burning emissions accounting methodology to the West Arnhem Land Fire Abatement Project (WALFA) area



(a) Conceptual emissions accounting framework as outlined in the text;
(b) Seasonality of burning in the WALFA area, 1990–2011, derived principally from Landsat imagery; and
(c) Resultant calculated savanna burning emissions in pre-project baseline period (1995–2004) and project period (2005–2011), where black lines represent mean emissions for respective periods.

Figure 4 Contrast in the spatial patterning of early season (green) and late season (red) fire extent in the WALFA region for:



(a) Final 7 years of the pre-project baseline (1998 – 2004), characterized by little early season fire management and resultant extensive late season wildfires; and

(b) First 7 years of the project (2005 – 2011), characterized by development of an extensive mosaic of small, patchy, management-imposed early season fires, especially after the transitional period of 2005 – 2006.

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The report was prepared by Paul de Mar (GHD) and edited by Wayne Kington. Valuable contributions, including photographs, were received from others and their contributions are also recognised.

8 References and further reading

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