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EPA REVIEW OF FIRE IN THE KIMBERLEY AND INTERIOR REGIONS

The Minister for the Environment has asked the Environmental Protection Authority (EPA) to review environmental aspects of fire in the Kimberley and Interior of the State. The provisional scope of the review is to:

1. Advise on the environmental impacts of the frequency of fire in the Interior and Northern regions of WA, with an emphasis on the Kimberley Region, in particular with respect to:
 - biodiversity conservation and protection; and
 - protection of environmental health (air quality impacts),in the context of the importance of protection of human life, property, assets and infrastructure.
2. Consult with key organisations, government agencies, knowledgeable persons and the community as appropriate.
3. Make recommendations on ways and means to improve the situation.

The review will be conducted under section 16(e) of the *Environmental Protection Act 1986*. It will be chaired by Dr Roy Green, former Deputy Chairman of the Environmental Protection Authority with Dr Andrea Hinwood, current Deputy Chair of the Authority and Ms Joan Payne, Member of the Environmental Protection Authority.

The EPA's task is not about reviewing agencies but it will focus on the environmental consequences of fire.

The EPA has commissioned a brief Issues Paper prepared by Dr Jeremy Russell-Smith, a consultant from the Northern Territory, to stimulate debate and the generation of further ideas, for enhancing ecologically sustainable fire management in the Kimberley and Inland regions of WA. The Issues Paper, including a summary page, is attached. Comment on whether there are other issues that should be considered, and your views on all of these issues, would be welcome and would assist the EPA in progressing this review.

The EPA intends to prepare a review paper dealing with fire issues about March next year and will be seeking the views of interested people and agencies on that paper.

The EPA Review members will be undertaking initial consultation within the Kimberley and Pilbara regions between 7-11 November 2005. This will provide organisations and the community with the opportunity to present their views directly to the Review. There will be further opportunities to provide comment and views to the Review during the first half of 2006.

While details are being finalised, the EPA review members are planning to visit the following places:

Date	Town	Meeting time
Monday 7 November	Newman	Morning
	Roebourne	Afternoon
	Port Hedland	Evening
Tuesday 8 November	Derby	Morning
	Fitzroy Crossing	Afternoon
Wednesday 9 November	Kununurra	Afternoon
Thursday 10 November	Kalumburu	Morning
	Broome	Afternoon

Further details will be provided shortly on times and venues. This information will also be advertised in the local media. This will be an opportunity to present your views and comments directly to the members of the Review.

You are welcome to distribute these documents widely.

If you want more information about the EPA review or the meetings, have comment that you would like to make or to be informed about progress of the review, please contact Colin Murray on (08) 9222 7076 or by emailing colin.murray@environment.wa.gov.au.

Additional copies of the Issues Paper can be downloaded from the EPA's website (www.epa.wa.gov.au) or can be obtained by phoning Marie Ward on (08) 9222 7083 or by emailing marie.ward@environment.wa.gov.au.



Walter Cox
CHAIRMAN

18 October 2005

Fire in the Kimberley and Inland Regions of WA— Issues Paper

October 2005

The Western Australian Minister for the Environment has recently asked the Environmental Protection Authority (EPA) to advise on the environmental impacts of the frequency of fire in the Interior and Northern regions of WA, with an emphasis on the Kimberley Region, in particular with respect to:

- biodiversity conservation and protection; and
- protection of environmental health (especially air quality impacts),

in the context of the importance of protection of human life, property, assets and infrastructure.

The EPA commissioned an Issues Paper to stimulate debate, and the generation of further ideas, for enhancing ecologically sustainable fire management in the Kimberley and Inland regions of WA. The EPA aims to use this Issues Paper to commence its discussion on the nature of problems of fire in the Kimberley and Inland regions of WA, with a focus on environmental and health implications and, where possible, to make recommendations on possible resolution to these problems.

The following issues have been identified as relevant to the EPA review into fire in the north and inland parts of Western Australia;

- ***the frequency and occurrence of fire is related to the amount of rainfall in the previous rainy season(s), the associated build up of fuels and ignition sources***
- ***fire regimes have changed markedly since Aboriginal occupancy, particularly the replacement of fine-grained fire mosaics with large areas of burnt country and other large areas of unburnt country***
- ***the season of burning has changed – for example, most Aboriginal burning in the Kimberley occurred through the dry season, whereas today, most fires occur at the end of the dry season***
- ***in the absence of extensive patchy burning, extensive wildfires may be ignited by lightning (especially in more Inland regions) given vast tracts of available fuels***
- ***despite some information concerning traditional Aboriginal practices being available, much more needs to be learned about relationships between traditional practices and biodiversity management before that knowledge is lost***
- ***late dry season fires in the Kimberley today have major impacts across all landuse and industry sectors***
- ***available studies show that fire-sensitive vegetation (Cypress Pine thickets, rainforest, sandstone country) in the Kimberley is being severely impacted upon by intense late dry season fires***
- ***it is likely that fires in recent times have had a major impact on small to medium sized animals (e.g. bandicoots) and, maybe together with the effects of grazing on grass species and seed availability, also a major impact on many birds***

- ***Late dry season fires can also have significant impacts on soil loss, loss of nitrogen in smoke, and increased greenhouse gas emissions; and impacts on air quality and human health***

What do we need to do to address fire-related issues? There is more information explaining why these issues are important in a short paper that has been prepared by Dr Jeremy Russell-Smith, a consultant to the Tropical Savannas Management Cooperative Research Centre, Darwin and Bushfires Council of the Northern Territory.

Here are some of the questions that the EPA would like comments and suggestions on:

- ❖ ***How can we deliver better fire management?***
 - ***Is it possible to do more preventative burning earlier in the dry season, like old people used to do?***
 - ***Is aerial burning a useful tool?***
 - ***Should we do a lot more ground burning?***
 - ***Should we undertake aerial burning plus a lot of follow-up burning on the ground?***
- ❖ ***Which organisations are best placed to help with fire management?***
 - ***Does your community or pastoral property need more assistance with fire planning?***
 - ***Do you know what the responsibilities are of organisations like FESA, Local Govt, for assisting with fire management?***
 - ***Does your community or pastoral property have a good fire management plan in the event of a wildfire?***
- ❖ ***Do you have enough information to assist you with fire management?***
 - ***Do you know what plants and animals are being affected by fire in your region?***
 - ***Do you need access to fire mapping products produced by the Dept of Land Information to assist you in your fire management planning and implementation?***
 - ***Do you need training in the use of these fire mapping products?***
- ❖ ***How can we better involve the community in fire management?***
 - ***How can you get better cooperation from neighbouring properties?***
 - ***Are you aware of any opportunities for involving indigenous young people in community fire management?***

Your views on these issues, and any other issues that should be considered by the EPA, would be welcome and will assist the EPA in progressing this review.

Additional copies of the Issues Paper can be downloaded from the EPA's website (www.epa.wa.gov.au) or can be obtained by phoning Marie Ward on (08) 9222 7083 or by emailing marie.ward@environment.wa.gov.au.

You can also let us know how we can keep you informed during this review. Contact Marie Ward by phone or email or by writing to:

Chairman
Environmental Protection Authority
GPO Box K822
PERTH WA 6842
Attention: Ms Marie Ward

Fire in the Kimberley and Inland Regions of WA— Issues Paper

This paper was largely prepared by Dr Jeremy Russell-Smith, but some additional material was inserted by the EPA Review Committee.

Tropical Savannas Management Cooperative Research Centre, Darwin (Consultant, Project Leader)
Bushfires Council of the Northern Territory (Consultant, Research Coordinator)
Kimberley Regional Fire Management Committee (Member 2000-present)

October 2005

Introduction

The Western Australia Minister for the Environment has recently asked the Environmental Protection Authority (EPA) to advise on the environmental impacts of the frequency of fire in the Interior and Northern regions of WA, with an emphasis on the Kimberley Region, in particular with respect to:

- biodiversity conservation and protection; and
- protection of environmental health (especially air quality impacts),

in the context of the importance of protection of human life, property, assets and infrastructure.

As a means for assisting this process, this document sets out to provide concise background information relevant to that enquiry. While the paper focuses particularly on the fire-prone Kimberley region, many of its observations are pertinent to other inland areas of the State, albeit under annually drier, and thus less fire-prone, conditions.

The paper starts by providing general information on the contemporary patterning of large fires in WA, considering the influence of climate, particularly annual rainfall, on fuel types and their accumulation since-time-last-burnt. As any experienced land (and fire) manager knows, preventative fire management is really about managing fuels, and the growing risk these pose with time. It then looks at the major impacts that contemporary fire regimes (e.g. the combination of fire extent, frequency, seasonality, intensity, patchiness) are having on biodiversity, and associated environmental health values, in the Kimberley. Finally, on the basis of recent experience, the paper identifies some of the issues contributing to these problems and, perhaps more importantly, points to potential solutions. These ideas are not intended as providing the final word, but rather, to stimulate comment and debate, and the generation of further ideas, for enhancing ecologically sustainable fire management in the Kimberley and Inland regions of WA.

The occurrence of large fires in the Kimberley and Inland regions of WA—the influences of rainfall and associated accumulation of grassy fuels

By far the greatest annual extent, and thus frequency, of fire in WA occurs in the annually reliable, higher rainfall regions of the Kimberley, lying generally north of an arc from Broome to Kununurra (**Fig. 1**). Mean annual rainfall in the “Kimberley high rainfall zone” ranges from 700 to greater than 1200 mm, and occurs mostly in the hot summer months Nov-Mar, under the influence of the north-west monsoon (Craig 1997). Rainfall-promoted

growth of grassy fuels (comprising a wide diversity of annual and perennial species) in the north Kimberley is sufficient to support fires at least every one to two years (Walker 1981; Craig 1997). Since 1993, an annual average of over 24% of the Kimberley's 320,000 km² has been burnt, with as much as 34% in some years (**Fig. 2**).

Fire frequency declines substantially south of the Kimberley (**Figs. 1,2**), in parallel with declining rainfall and the associated influence of the summer monsoon. Average rainfall over the greater part of the Pilbara-Goldfields regions is mostly less than 300 mm. Given typical rainfall conditions, fire return periods are predicted to range from up to 5 years in southern parts of the Kimberley, to 20-50 years in arid inland regions (Walker 1980). However, following periods of high rainfall, such as occurred during the mid-1970s and most recently in the late 1990s-early 2000s, very significant areas of inland Australia have been burnt given dramatic growth of Spinifex (*Triodia* spp.) grassy fuels. In such high rainfall periods, extensive fires in inland Australia have been reported as recurring in two years out of three (Allan & Southgate 2002).

Issues—

- ***fire frequency and occurrence is affected by a complex range of interrelated factors, including seasonal rainfall conditions and associated build up of fuels, ignition sources and land use values***
- ***mapping of lightning strikes to the ground needs to be improved***

Characteristics of traditional Aboriginal vs contemporary fire regimes—implications for biodiversity management

Documentation of traditional Aboriginal burning practices, including from the associated historical record, is very poor for the regions in question. Despite this, an understanding of the contrasting burning practices of Aboriginal people prior to European settlement, with contemporary burning patterns, provides important clues as to factors involved with the demise of certain of our fauna, and impacts on fire-sensitive vegetation types.

The record for the north Kimberley demonstrates that burning was undertaken purposefully and methodically throughout the dry season for a variety of purposes, but including for clearing up campsites and country generally to make access easier, for regenerating or protecting bush food plants, providing 'green pick' for game such as kangaroos, and as used directly in hunting such as with 'fire drives' (Crawford 1982; Bowman & Vigilante 2001; Walsh *et al.* 2004). Crawford (1982) indicates that, for the Kalumburu area, by the end of the dry season most clan estates would have been 'thoroughly burnt'. Not so evident in this record is that, as described in a large body of literature for similar conditions in Arnhem Land, including contemporary accounts, burning through the year comprised a very large number of small fires—in effect conserving resources, as well as providing effective protection from extensive fires late in the season. The end result of such annual burning practice was the creation of a substantial mosaic of burnt and unburnt patches, with as much as one half of peoples' home (clan) estates being burnt in any one year (e.g. Jones 1975; Yibarbuk 1998; Yibarbuk *et al.* 2001).

Detailed information on landscape-scale traditional Aboriginal burning practices is generally lacking for the southern Kimberley (Craig 1999; Vigilante 2001) and sparse for more inland areas (but see Gould 1971; de Graaf 1976; Kimber 1983; Latz 1995; Burrows

et al. 2005). However, recurring themes for desert areas are: (1) the considerable knowledge and skill possessed by traditional fire practitioners to promote diverse plant resources both for people and prey alike; (2) burning was likely undertaken year-round as opportunity permitted, but not for certain areas for various (including religious) reasons (de Graaf 1976; Burrows *et al.* 2005); (3) the development over time of vast mosaics of unburnt and burnt patches of different ages; and (4) away from communities, roads, and tracks, lightning is the main source of ignition today.

For the Western Desert, the contrast between the fine-grained fire mosaic developed under traditional Aboriginal management, and contemporary burning patterns, has been documented through a comparison of 1950s aerial photos (when Pintupi people were still living a traditional lifestyle in the region) with satellite imagery from the 1970s, after cessation of traditional burning (Burrows & Christensen 1990; Burrows *et al.* 2005). These authors note that, in recent times, the fine-grained mosaic had been obliterated and replaced by a simpler mosaic comprising either vast tracts of long unburnt and senescing vegetation, or vast tracts of vegetation burnt by wildfires. When commenting on the disappearance today of many of the desert small mammals, Pintupi informants made the observation that lack of fine-grained burning, and thus provision of green shoots, was a major factor (Burrows *et al.* 2005).

By contrast, fires in the Kimberley and Inland regions of WA are characterised nowadays typically by extensive wildfires, which will occur whenever sufficient fuels, conducive climatic conditions, and an ignition source, are available. ***The great majority of fires are lit by people***, for a range of purposes including: *prescribed burning*—e.g. as a preventative, strategic fire management tool; for managing pasture condition and woody plant control; as a habitat management tool for biodiversity purposes; and, in increasingly limited situations, as part of Aboriginal cultural responsibilities for managing traditional lands and particular sites; or *uncontrolled burning*, whether by accident, carelessness or design.

Issues—

- ***fire regimes have changed markedly since Aboriginal occupancy, particularly the replacement of fine-grained fire mosaics with more simple mosaics combining extensive wildfires and unburnt patches***
- ***in the absence of extensive patchy burning, extensive wildfires may be ignited by lightning (especially in more Inland regions) given vast tracts of available fuels***
- ***despite some information concerning traditional Aboriginal practices being available, much more needs to be learned about relationships between traditional practices and biodiversity management before that knowledge is lost (Craig 1999; Walsh *et al.* 2004)***

Seasonal pattern of burning in the Kimberley today

The great majority of fire extent in the Kimberley occurs nowadays from July until the rains of the new wet season start (**Fig. 3**). The late dry season period is the hottest and driest time of the year. While pastoralism (both Aboriginal and non-Aboriginal leasehold) is the major designated landuse in the Kimberley (collectively, 49% of land area), there are substantial areas of Unallocated Crown Lands, with lesser amounts of Aboriginal Reserves

and living areas, conservation lands, and defence and agricultural properties (**Fig. 4**). Late dry season fires today affect all these major landuses more-or-less equally (**Fig. 5**).

The increase in tourism and access to remote areas by the general public as well as the public's lack of awareness of the correct use of fire is impacting on biodiversity and pastoral assets and placing significant demands on local resources for fire management.

Given limited early dry season prescribed burning, fires in the latter part of the dry season are likely to burn over very extensive areas (tens of thousands of square kilometres), are more likely to be of high intensity (e.g. scorching the leaves of even canopy trees), and less patchy (i.e. leaving few unburnt areas). These dry season fires impact significantly on pastoral enterprises (e.g. loss of feed; direct impacts on infrastructure), Indigenous cultural values (including impacts on cultural sites and hunting resources), biodiversity values (e.g. impacts on fire-sensitive habitats and species), atmospheric and greenhouse gas emissions, tourism values, and the health and safety of regional communities—including those people who put themselves at considerable risk to fight wildfires.

Issue—

- ***fire regimes in the Kimberley are today dominated by late dry season wildfires, with major impacts across all extensive landuse and industry sectors***

Impacts of contemporary fire regimes on biodiversity and environmental health

Biodiversity—Contemporary fire regimes are inflicting severe impacts not only on fire-sensitive vegetation types in the Kimberley (e.g. rainforest patches, sandstone heaths), but also on savanna woodland habitats in general (**Table 1**). The best documented example is the marked impact of late dry season fires on the relatively fire-sensitive Cypress Pine, *Callitris intratropica*—a species which does not resprout following intense fires, and can only regenerate from seed. A recent extensive survey found 50% of mature *Callitris* individuals were dead and only 6% of stands were in a healthy state with a full range of size classes (Graham 2002). The study showed that there has been a significant reduction in the distribution of *Callitris* as a component of the savanna landscape since the mid-1960s, and predicted that this trend would continue under current regional fire patterns.

In more arid Inland regions, extensive areas of mulga (*Acacia aneura*) shrublands, and other fire sensitive vegetation types, are also reported as being significantly impacted upon by contemporary fire regimes (**Table 1**: van Leeuwin *et al.* 1995; Allan & Southgate 2002; Hodgkinson 2002; Williams 2002; Myers *et al.* 2004). The key issue is the impact of intense fires on the margins of mulga stands, which, following a period of fuels build-up of flammable spinifex (*Triodia* spp.) fuels, promotes a 'fire cycle' of death on mulga stand margins, followed by expansion of spinifex.

Less clear is the extent of the impacts of contemporary fire patterns on associated fauna, given likely interactions also with a variety of other factors (**Table 1**). However, it stands to reason, and as understood by Pintupi fire managers (see above), that obliterating or simplifying the fine-grain fire-induced mosaic through widespread fire (or, conversely, no

fire) will have significant deleterious consequences for the availability of food resources, at least for relatively small, sedentary fauna. Home ranges (i.e. the area of habitat required by individuals to eke out a living) may vary from a few square metres for many invertebrates and skinks (small lizards), through 1-10 ha for many rodents, bandicoots, small bush birds and possums, tens of square kilometres for some macropods (wallabies, kangaroos), and some birds such as finches, parrots and pigeons, to thousands of square kilometres for cockatoos and some raptors (Woinarski *et al.* 2005). Anecdotal declines in emu numbers in the North Kimberley may also represent widespread burning of important fruit and seed resources.

While experimental tests of the 'medium-sized mammals and the fire-mosaic hypothesis' have proven equivocal to date mostly as a result of methodological issues (Short & Turner 1994; Allan & Southgate 2002), an instructive example is provided by a preliminary study of the home range requirements of the Partridge Pigeon (a species undergoing significant range decline, including in the Kimberley) in Kakadu National Park (Fraser *et al.* 2003). The study found that Partridge Pigeons, with dry season home ranges of around 8 ha, were observed to occur mostly in areas of high habitat suitability—where between 40-60% of the home range had been patchily burnt. This provided easy on-ground foraging access, but still left abundant annual *Sorghum* seed sources.

Issues—

- ***there is insufficient knowledge of the impacts of fire on biodiversity***
- ***available studies indicate that fire-sensitive vegetation in the Kimberley, and in Inland regions, is being severely impacted upon by intense, relatively frequent fires***
- ***observations of direct fire impacts on Kimberley fauna have not been unequivocally demonstrated, although there is good reason to believe that significant simplification of fire-induced resource mosaics is at least contributory to observed range declines in (a) medium size mammals and (b) granivorous birds in both the arid interior and north Kimberley***
- ***it follows that (a) ecological surveys focusing on the distributions of identified vulnerable taxa need to be undertaken as a matter of priority, especially given the imminent arrival of cane toads (NLWRA 2002; Palmer 2004b), and (b) greater effort is required to understand the fire ecology of tropical savannas and spinifex-dominated habitats in inland regions of WA.***

Water quality and soil loss—By comparison with no burning, or early dry season fires, Townsend & Douglas (2000) report the effects of five years of late dry season fires on a gently sloping northern Australia woodland savanna catchment as: (1) substantially reducing catchment canopy and ground cover; (2) doubling soil erosion; (3) increasing threefold stream sediment concentrations during storm runoff events; and (4) promoting short-lived runoff events early in the wet season that carry sediments and nutrients at concentrations greater than ten times later in the wet season. Similarly, from a recent study of soil loss and movement over one wet season following late dry season fires on hillslopes undertaken in the Top End of the NT, Russell-Smith, Yates & Lynch (unpubl. data) observed: (1) despite significant erosion on both unburnt and burnt treatments; (2) overall there was roughly three times more soil loss, and two times more soil movement, on late dry season burnt plots.

Issue—

- ***very significant soil loss (and thereby loss of nutrient- and organic-rich top soil) is associated with late dry season fires, by comparison with no burning or early dry season fires***
- ***more knowledge of the implications of fire on soil structure and water quality in the Kimberley and inland areas of WA is needed***

Emissions and air quality—Relative to other savanna areas of northern Australia, the Kimberley region of WA is estimated to produce about 28% of total annual emissions from biomass burning, from just 17% of the total savanna area (based on data presented in Russell-Smith *et al.* 2003). Most of the emissions are various oxidised forms of nitrogen or carbon, with carbon dioxide dominating. Water vapour comprises only a small proportion of the smoke, since it is derived mainly from fully cured late dry season fuels. About 10% of the consumed fuel occurs as ash, most of which remains on the ground and is relatively enriched in all major plant nutrients save nitrogen. Of concern is the observation that gaseous losses of nitrogen during savanna fires represent about ten times the amount deposited in rainfall each year; currently it is not known whether this represents a long-term net decline in biomass nitrogen, or whether it is replaced through other biological processes (Cook 1994, 2001a).

Emissions from savanna fires also contribute around 3% of accountable national greenhouse gas emissions, of which burning of grasslands and savannas throughout the WA Rangelands, contributes more than half (NGGIC 1998; Cook 2001b). Accountable emissions are derived from two greenhouse gases, methane and nitrous oxide. Carbon dioxide is not an accountable gas since it is assumed that emissions from burning in one season are taken up in new growth following rain.

The 2004 Western Australian Greenhouse Strategy indicates that 44.8 % of the Western Australian agricultural sources of greenhouse gas emissions are derived from burning of savannas.

Smoke from savanna fires has also been demonstrated to affect human health. A recent study conducted in Darwin, from April to October 2000, revealed a strong relationship between the concentration of respirable particles arising from fires with attendance at hospital (Johnston *et al.* 2002). Asthma presentations increased by a factor of 2.4 on days associated with peak fire activity in September.

Issue—

- ***emissions, particularly from late dry season fires, have very significant implications for loss of nitrogen, national greenhouse gas accounting, and human health***

Fire management in practice

Limited early dry season, preventative fire management is undertaken throughout the fire-prone areas of the Kimberley, as attested to by the seasonal distribution of fires (**Figs. 3,5**). The following section addresses four themes which are identified as major fire

management issues in the Kimberley, and which have a direct bearing on biodiversity conservation and management across all tenures.

(1) Strategic fire management—most fire management in the Kimberley today is undertaken through the Aerial Control Burning (ACB) program, with relatively little on-ground fire management (Palmer 2004a). ACB involves (1) considerable prior planning by the Fire and Emergency Services Authority (FESA), and Department of Conservation & Land Management (CALM), with prospective landholder participants, including other responsible Government agencies, (2) in association with participating landholders, pre-determined aerial ignition lines are flown under the supervision of CALM in the early to mid dry season, primarily to create burnt buffers ('fire-breaks'), but also to create patchy mosaics where required, (3) some follow-up assessment using remote sensing is undertaken to gauge how well the plan was implemented, and (4) occasional follow-up on-ground activities are undertaken by landholders to address gaps in burnt buffers etc.

CALM undertakes the ACB fire management program on lands administered by CALM itself, the Department of Defence, and on Unallocated Crown Lands. FESA undertakes an ACB program in conjunction with local government and pastoralists. Participating private landholders are required to pay for the flying time component over their properties.

Pastoral leasehold participation in the program has been declining significantly in recent years. The reasons for this are various (Palmer 2004a). It is recognised however, that, in the contemporary era, ACB provides the only realistic means for implementing strategic fire management over vast areas and often in very rugged terrain. While costs associated with implementing strategic, preventative fire management are often difficult to assess, it is apparent that many pastoral landholders (as well as responsible agencies) expend considerably more resources responding to wildfires (Elderton 2004; Palmer 2004a).

Issues—

- ***the means for delivering effective preventative fire management in the Kimberley, and other remote locations, needs critical assessment. This applies particularly to delivering an environmentally sound, cost-effective, and inclusive ACB program that is better integrated with on-ground activities.***
- ***there is an associated need to develop regional fire management plans***

(2) Institutional and administrative arrangements—Under the *Bush Fires Act 1954*, Local Government (in the case of the Kimberley, the four Shires) has the responsibility for: (1) along with landowners or leaseholders, addressing fire management outside designated urban areas; and (2) the issuing of permits to burn for designated 'restricted burning times' (s18), which, in the instance of the defined *Kimberley zone*, is 1 April – 14 January. It is apparent that many Kimberley landholders and community members are confused by the respective roles and responsibilities of Local Government and FESA, and, given the extent of late dry season wildfire, presumably are unaware of, or simply ignore, permit requirements (Elderton 2004; Palmer 2004a). The Shires in turn, argue that they have inadequate resources to fulfil their legislated responsibilities (Elderton 2004: 190). FESA provides advice to Local Government and landholders on fire management planning issues, and is responsible for wildfire incident management.

Issues—

- ***the respective roles and responsibilities of the community, Local Government, FESA and other Agencies with legislated responsibilities for aspects of fire management on different tenures, need to be clarified and communicated***
- ***adequate resourcing to meet those legislated responsibilities (including wildfire incident management) needs to be addressed***

(3) Fire information for remote communities—continued support for, and further development of, a number of information products are required to enhance fire management throughout remote areas of WA. There is a need to improve access to, and undertake targeted training in the use of, web-based fire information—particularly the Department of Land Information’s (DLI) FIREWATCH site at www.firewatch.dli.wa.gov.au. This provides timely information (updated every few hours depending on satellite overpasses) on the location of fire ‘hotspots’, and fire mapping information products (such as included in this paper). For Kimberley residents, an allied fire information site is the Tropical Savannas Cooperative Research Centre’s North Australia Fire Information site at www.firenorth.org.au. Information from both sites is valuable for fire management planning, operations, review and can be incorporated into property management planning generally.

To assist the effectiveness of ACB operations, and strategic fire management in general, a number of information products are required or need further development, especially:

- enhanced vegetation mapping—currently the best available vegetation mapping for the Kimberley is at 1:1 000 000 scale (Beard 1979), and this does not identify small but very significant biodiversity assets (e.g. rainforest patches)
- targeted biodiversity surveys, especially for fauna, and associated biodiversity mapping—the Kimberley currently has access to a biodiversity database (KRID—Kimberley Regional Integrated Database, currently held by Kimberley Regional Fire Management Project) which integrates flora and fauna records (from the WA Herbarium and WA Museum, respectively) along with other spatial coverages (e.g. land systems, geology, cadastral and topographic maps, etc.)
- enhanced remotely sensed information concerning the moisture or curing status of fuels, to optimise the timing of ACB runs—a grasslands curing guide booklet is currently available for the Kimberley (Flavelle 2002)
- further development of the ‘weights of evidence’ planning tool which is currently used by CALM in association with ACB participants for guiding flight lines

Finally, there is strong interest from the community to obtain general information about fire management and its effects on biodiversity and pastoral systems (Palmer 2004a). For the savanna community a useful, readable guide already exists (Dyer *et al.* 2002). For the pastoral industry, best practice fire management guidelines have been prepared by Andrew Craig (Department of Agriculture) in consultation with Kimberley pastoralists, which can be found at www.dpi.wa.gov.au/pastoral/policies. These guidelines are due to be updated and posted on the above web site early next year (Andrew Craig, pers. comm.)

Issue—

- ***the provision of and training in the use of, fire management information products and communication tools to meet the needs of the range of stakeholder requirements in the regions (e.g. remote Indigenous communities, pastoral enterprises)***

(4) Engagement of the Indigenous community—Indigenous communities and enterprises are a very significant component of rural populations in remote areas of WA—e.g. they make up around half the Kimberley population, with a median age of 21 years (source: 2001 census data, Bureau of Statistics). A key issue is how to engage the skills and enthusiasm of younger Indigenous people, especially those on remote communities and pastoral stations, in local- and regionally focused fire management. The Kimberley Regional Fire Management Project (KRFMP) has, over the past couple of years, been developing this concept through the formation of community-based ‘Fire Control Teams’, under the supervision of senior community members, with training assistance from FESA, and funding support from a number of institutional partners. FESA has also initiated activities since 2002 to raise awareness of bush fires and the consequences of unmanaged bush fires in Kimberley towns and remote communities. The longer-term objective is to develop employment pathways, especially contract employment, in a variety of natural and cultural resource management activities (Philippiadis & Blackwood 2005).

Issue—

- ***The Indigenous community, younger people especially, need encouragement to become actively involved in fire management, as part developing/including community based fire/land capabilities from which employment pathways can emerge***

Acknowledgements: Thanks to (1) the WA Dept of Land Information for all remote sensing and fire mapping data, (2) Nat Raisbeck-Brown, Kimberley Regional Fire Management Project (KRFMP), for all graphs and maps, (3) Andrew Craig, Jean Fenton, Will Philippiadis, Nat Raisbeck-Brown, Carol Palmer, Norm McKenzie, Peter Saint, and anonymous reviewers for comments on, and / or information concerning, the text, (4) the KRFMP for providing the backbone data to inform this issues paper, at least for the Kimberley. Some limited additional material has been included by the EPA Review Committee. Otherwise, the presentation of assembled ideas is my own.

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Table 1: Summary of major fire impacts on biodiversity, focusing particularly on the Kimberley.

For discussion of fire impacts on: 1) vegetation and fauna of spinifex-dominated communities in inland regions, refer to Allan & Southgate (2002); 2) for mammals generally throughout WA, refer to Burbidge & McKenzie (1989)

Biodiversity attribute	Issues	References
Vegetation and flora		
<ul style="list-style-type: none"> Savanna woodlands and riparian vegetation 	Structural simplification (and associated impacts on habitat resources) due to effects of intense late dry season wildfires, including: loss of shrubby midstoreys; loss of nesting hollows in older trees; loss of flower and fruit resources; replacement of perennial grasses with fire-prone annuals (e.g. <i>Sorghum</i> spp.); loss of fine-grained habitat mosaic	Setterfield 1997; NLWRA 2002; Palmer 2004b; Vigilante & Bowman 2004b; Woinarski <i>et al.</i> 2005.
<ul style="list-style-type: none"> Sandstone vegetation, particularly heaths 	Loss of shrubby species which depend solely on regeneration from seed sources, as opposed to being able to resprout following fire (e.g. eucalypts). Such species, referred to as 'obligate seeders', are particularly vulnerable to frequent, extensive fires given the time required from germination to the development of new seed sources. Typically considered that 4-5 years is required between fires, or that fires are very patchy, for many smaller shrubs. Other longer-lived species such as many wattles (<i>Acacia</i> spp.) may require longer periods.	Russell-Smith <i>et al.</i> 2002; Palmer 2004b; Vigilante & Bowman 2004a
<ul style="list-style-type: none"> Cypress pine (<i>Callitris intratropica</i>) groves 	A long-lived obligate seeder (refer above), this species is in rapid decline throughout the north Kimberley due to extensive, frequent, intense late dry season fires	Graham 2002
<ul style="list-style-type: none"> Rainforest patches 	Severe impact in exposed mainland situations given combination of stock and fire impacts	McKenzie & Belbin 1991
<ul style="list-style-type: none"> Mistletoes 	Significant decline in abundance given late dry season fire impact on host plants—mistletoes provide important nectar and fruit resources for a range of small birds	Start 2001
<ul style="list-style-type: none"> Mulga shrublands and other fire-sensitive vegetation in arid Australia 	Substantial areas of acacia shrublands, particularly those dominated by mulga (<i>Acacia aneura</i>), occur throughout semi-arid and inland areas of WA, in a matrix of mostly Spinifex-dominated hummock grasslands. Mulga is observed (mostly) to be an obligate seeder species, and there is reported (although unquantified) significant decline attributable to contemporary fire regimes in parts of WA (especially the Pilbara and central Australia). Also affected are other fire-sensitive species occurring in Mulga communities, and other vegetation types (e.g. saline vegetation communities associated with palaeodrainage lines, salt lakes and soaks; <i>Callitris</i> and heath communities within the central ranges, and <i>Ficus</i> species on isolated rocky outcrops).	van Leeuwin <i>et al.</i> 1995; Allan & Southgate 2002; Hodgkinson 2002; Williams 2002; Myers <i>et al.</i> 2004
Fauna		
<ul style="list-style-type: none"> Critical Weight Range Mammals (CWRM)—35- 	Very significant range declines reported for a large number of CWRM, including: Northern Quoll (<i>Dasyurus hallucatus</i>), Brush-tailed Phascogale (<i>Phascogale pirata</i>), Golden Bandicoot	Burbidge & McKenzie 1989; Woinarski <i>et al.</i> 2001, 2005;

5500 g	<i>(Isodon auratus)</i> , Golden-backed Tree Rat (<i>Mesembriomys macrurus</i>), Pale Field-rat (<i>Rattus tunneyi</i>). Such declines considered to be at least partly associated with changed fire regimes, including less patchiness, and resultant impact on home range resources—but also a range of other factors possible also, including introduced predators, competitive herbivores (e.g. rabbits) and possibly disease.	NLWRA 2002; Palmer 2004b
<ul style="list-style-type: none"> • Granivorous birds 	Changes in habitat conditions, including woody thickening due to lack of burning, and over- or selective grazing of grass resources, have had profound consequences for 11 species of granivorous birds across northern Australia, including such well known species as the Gouldian Finch, Golden-shouldered Parrot, Partridge Pigeon	Garnett & Crowley 1995; Franklin 1999; Fraser <i>et al.</i> 2003; Woinarski <i>et al.</i> 2005.

Fig. 1: Frequency of burning of large fires (>1 km²) in Western Australia, and Kimberley region, 1993-Aug 2005. Fire mapping derived from NOAA-AVHRR satellite imagery: Source—WA Dept Land Information.

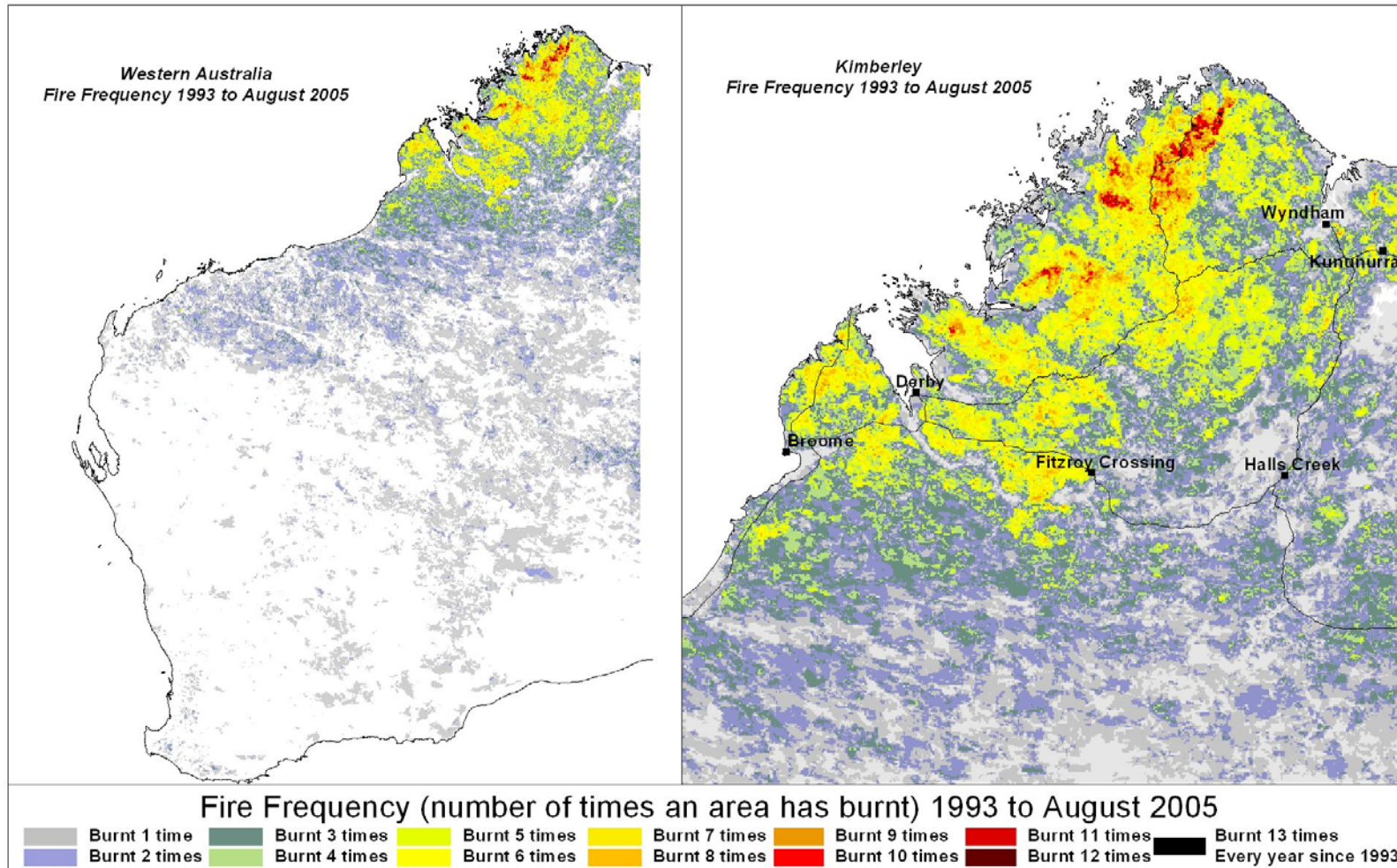


Fig. 2: The proportion of inland regions burnt by large fires (>1 km²) in WA, 1993-2004

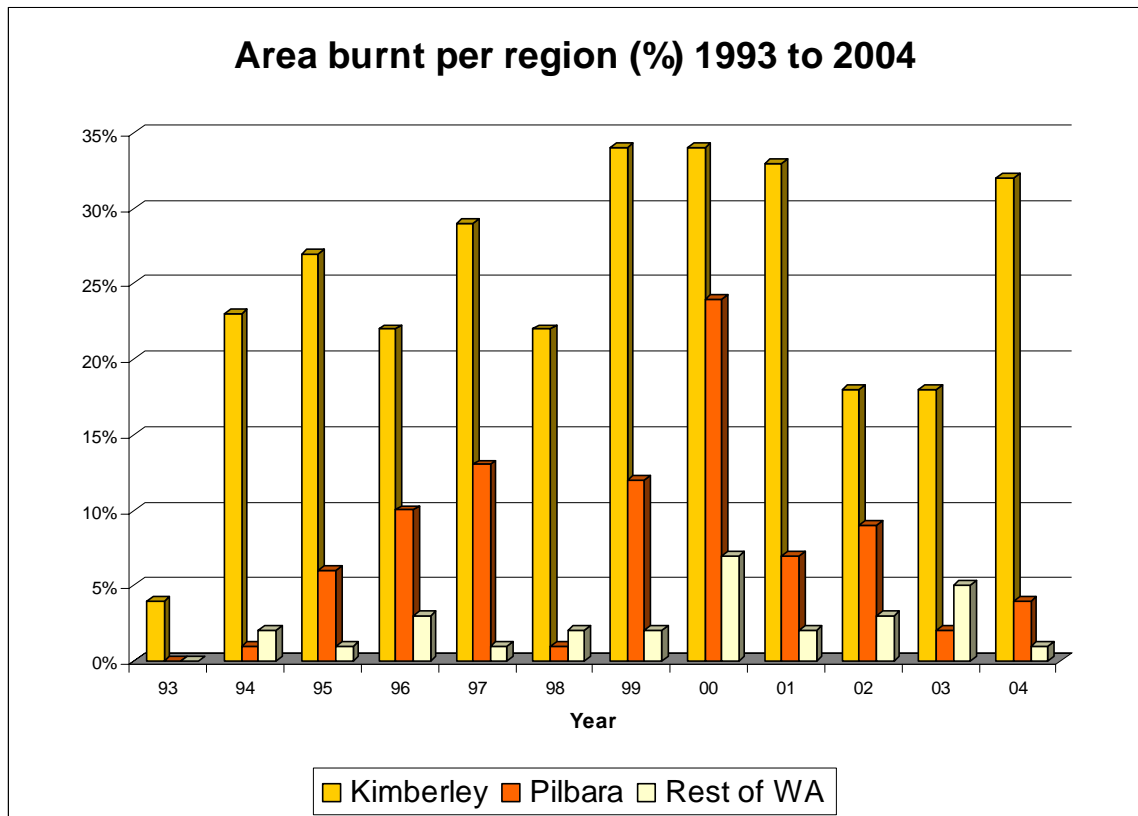


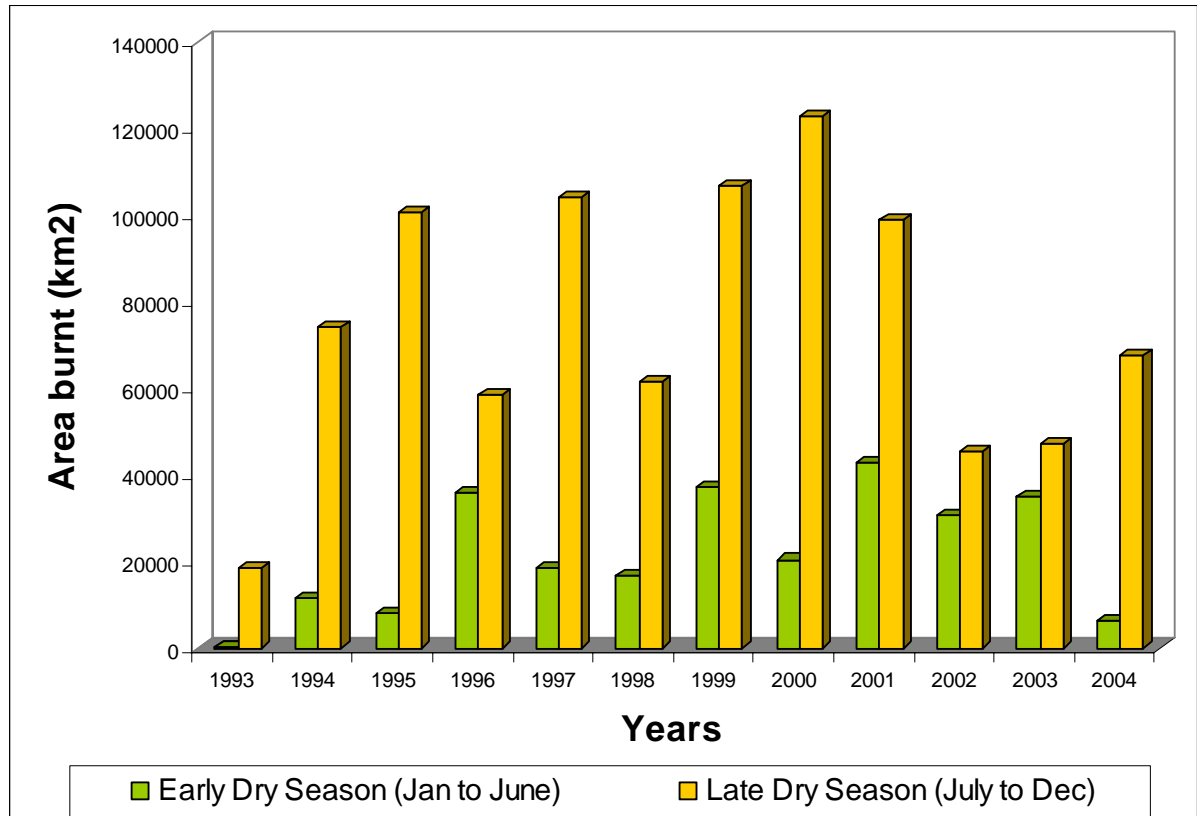
Fig. 3: Area of Kimberley burnt in early and late dry seasons, 1993-2004

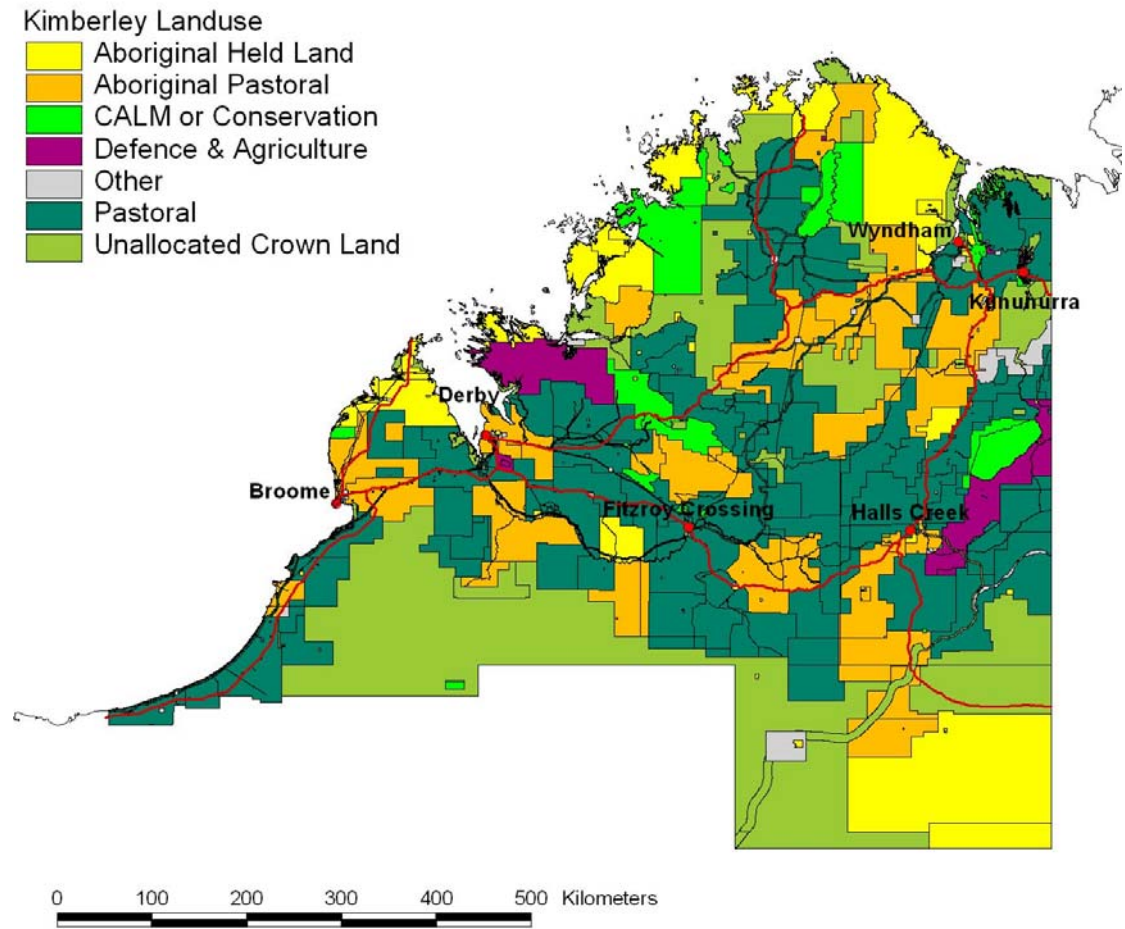
Fig. 4: Landuse in the Kimberley

Fig. 5: Mean proportion of major landuse types burnt in the Kimberley, 1993-2004, by season, where: AHL = Aboriginal Held Land; AP = Aboriginal Pastoral; CALM = CALM and conservation estate; D & A = Defence and Agriculture; PL = Pastoral Leasehold; UCL = Unallocated Crown Land

