Queensland Department of Environment and Heritage
Conservation Program

Proceedings of a workshop on:

Fire management on conservation reserves in tropical Australia

**Malanda,
Queensland,
Australia.
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The opinions expressed in this Proceedings are those of the authors and do necessarily reflect the official policies or views of any of the agencies or organisations represented.

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Introduction:

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The second annual *Fire management on conservation reserves in tropical Australia* Workshop was held at the Malanda Hotel from the 26 to 30th July 1993. This workshop (hereafter referred to as the Malanda Fire Workshop) followed on from the first held at Kununurra in May 1992, under the guidance of Chris Done of the Western Australian Department of Conservation and Land Management.

The workshop aimed at addressing practical management situations encountered by conservation reserve managers rather than the theoretical research issues of fire. The 1993 workshop was designed specifically for conservation reserve managers and was attended by participants from state conservation organisations across tropical Australia. Organisations represented at the workshop were:

Queensland Department of Environment and Heritage
Queensland Department of Primary Industries Forest Service
Queensland Fire Service, Rural Fires Division
Australian Nature Conservation Agency
Western Australian Department of Conservation and Land Management
CSIRO
Conservation Commission of the Northern Territory
Bushfires Council of the Northern Territory
James Cook University
Aboriginal representatives of Kowanyama, Aurukun and Lockhart Councils

In developing the program for the Malanda Fire Workshop, issues raised at the plenary session of the Kununurra Fire Workshop were incorporated as much as possible. Topics were listed under four headings.

1. Standardised fire data collection and monitoring on conservation reserves across tropical Australia.

2. Fire on conservation reserves - Case studies.

3. Education, public participation and fire on conservation reserves

4. Technological issues.

Participants were invited to present papers for each state under these headings. In addition, two keynote speakers, Peter Stanton and Phil Cheney, addressed specific topics relevant to all states. Bruce Gall, Director of the Queensland National Parks and Wildlife Service, opened the workshop and was able to spend time with participants.

These proceedings are the result of the ***Fire on conservation reserves in tropical Australia* Workshop** at Malanda from the 26 to 30 July 1993.

Acknowledgments

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We would specifically like to thank Phil Cheney and Peter Stanton, the two keynote speakers, for making available time to attend the workshop and participating in discussions. Dr Malcolm Gill, CSIRO, Canberra provided for the proceedings, an excellent article on fire monitoring. This contribution is appreciated.

All the assistance, encouragement and enthusiasm of participants was most gratefully appreciated. Hopefully, the proceedings will be to their expectations and of assistance to others interested in fire management in conservation reserves of tropical Australia.

Abbreviations used :

QDEH	Queensland Department of Environment and Heritage
QDPI	Queensland Department of Primary Industries
QFS	Queensland Fire Service
ANCA	Australian Nature Conservation Agency
CALM	(Western Australian) Department of Conservation and Land Management
CCNT	Conservation Commission of the Northern Territory
JCU	James Cook University, Townsville, Queensland
CSIRO	Commonwealth Scientific and Industrial Research Organisation

Keynote addresses

Keynote address

Common perceptions and misconceptions of QDEH fire management programs.

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Fire management, as it now exists in the Queensland Department of Environment and Heritage, has risen, with increasing momentum, from a negligible effort 13 years ago to a stage where we now have significant programs on a range of parks totalling at least 1.5 million hectares.

The main impetus for the fire management program came from the acquisition of large National Parks in the savannah lands of tropical Queensland. In that region, the use of fire as a land management tool was almost universal, and the then Queensland National Parks and Wildlife Service (QNPWS) had no choice but to accept that and to organise its own management accordingly. Born from these exigencies, the program developed and spread, often in the face of apathy or a lack of understanding of its rationale from some within QDEH, and hostility from some individuals and special ineterst gruops outside it. One of the biggest hurdles to overcome in this area, as is the case in so many other areas of endeavour, has been the tendency, in the face of uncomfortable opposition, for conservation reserve managers to take the easy option and do nothing.

The use of fire on National Parks has always been a matter of "damned if you do, and damned if you don't". In the Queensland rural community, there has often, in the past, been hostility towards what they have perceived as a lack of fire management on National Parks. On the other hand, in the more settled places, and in new urban areas, there has been intolerance towards any use of fire.

We might also say that "ignorance is bliss". To many amongst QDEH's middle and upper level management, it often seems that we never had any fire related problems of consequence until we started active fire management. There never was, of course, any lack of problems related to fire management. It was just that sometimes the managers were not very well informed about the field situation. It was assumed that no report of troubles meant no troubles existed.

Born of necessity, and generally missing an active official fostering, fire management on Queensland's National Parks has largely been based on informed guesses and developed and moulded by experience. Whilst it is obvious that if one waited until the parameters of any program were provided by research before taking initial management actions, we would have no pro-active fire management now, it is nevertheless a difficult position to defend. It is a matter of embarrassment that I cannot present some of the distillings of over 30 years of observation, and active involvement in fire management programs, in an attempt to help you respond to the common misconceptions for those programs that will comé your way. These are presented below in somewhat random fashion, and as a series of statements.

"You are burning rainforest"

This is the most common response by the public to some of our National Park fire management programs in the Wet Tropics area and parts of Cape York Peninsula. In the mind of many, any forest in this part of the world is a "rainforest". Our programs, however, are designed to have, and do have, different emphasis.

Much care is taken in all our operations to protect rainforest edges from possible wildfires. It is these, which, burning during severely dry conditions can penetrate the rainforest margin, or well beyond it, and kill it. Fires lit when the ground is moist and wind speed low will not do that.

Apart from critical timing in relation to soil and fuel moisture content we rely on other techniques to protect rainforest margins. At Eubenangee Swamp, where we have a very high value rainforest resource adjacent to grassland, we slash a firebreak parallel to the rainforest margin and about a metre from it. Burning of the grassland then takes place, with initial lighting from the slashed line, usually late in the evening. On the hills behind Cairns, we use a double firebreak system, with early season burning between the breaks to cut off potential downslope ignition points. In this case, the downslope part of the break is the railway line. Elsewhere, for example at Iron Range, we have used a helicopter with an incendiary machine to ignite the edge of tens of kilometres of rainforest margin, thus removing fuel that would otherwise be available to wind driven wildfires which, if occurring late in the dry season, could penetrate that margin.

Our fires are often used to stabilise rainforest margins where rainforest species are actively invading sclerophyll habitats. That is an essential part of a management strategy to maintain biological diversity, but could be the source of much of the perception that we actively set out to destroy rainforest.

"You are playing God"

This is a common complaint of those who believe that the only fires in natural areas should be "natural" ones. The question of *what is natural can?* , of course, lead to endless hours of pointless debate. The fact remains that the "natural" systems we are talking about are largely those that have been shaped by human-ignited fires for tens of thousands of years, and that if we remove those fires, the ecosystem will often change quite dramatically.

If, in the face of rapid and irreversible ecosystem change which is clearly attributable to recent changes in fire management practices, we do not manage to stabilise the situation while we consider our options for maintaining biological (ie. species, strctural and habitat) diversity then those options will soon be lost, In such a case, to do nothing could be just as easily deemed to be playing God. It would appear to be eminently responsible and ethical to manage in such a way as to retain the biological diversity we have inherited.

We have manipulated and destroyed "God's creation" at every step. It would be outrageous smugness to assume that the dismembered remnants are best protected by "acts of God" alone.

"Fire destroys diversity"

I have already inferred that habitat diversity may be lost if rainforest species invade sclerophyll communities. This can happen on some soils in some climates, and is leading to loss of those communities over large areas of eastern Queensland. In that case, the maintenance of fire in the system is a vital factor in maintaining habitat diversity.

Even where the end result is not dominance by rainforest, the absence of fire can lead to gradual loss of biological diversity in many sclerophyll communities. Species rich heathland can, for example, lose all ground cover species and a majority of its canopy species as it converts to a shrubland dominated by Casuarinas. Cypress pine can dominate other areas. In both cases, a severe fire can lead to a dramatic increase in species diversity and a regeneration of apparently "lost" species.

It is acknowledged that fire can also reduce biological diversity. However, in north Queensland, this is more common in unmanaged situations which are subject to frequent severe wildfires. The problem of excessive fire frequency is illustrated by species which are totally dependent on regeneration from seed. These species can be destroyed by a second wildfire before they have had a chance to mature and produce seed. Biological diversity can also be lost when fires destroy isolated patches or strips of rainforest.

"You are losing tree and shrub cover"

This statement often infers that the loss of tree and shrub cover is always a bad thing. It depends, however, on where your observations start. The long exclusion of fire may lead to increasing density of understorey species in most forest and woodland communities. The re-intoduction of fire may have a dramatic effect in the opposite direction which could be seen to be a total disaster if one was not aware of the history of the site.

Fire, in the presence of grazing pressure, may assist in reducing the competitiveness of ground cover species and lead to significant invasions of tree and shrub species, producing the "woody weeds" phenomenon so common on pastoral lands throughout the State. Early patch burns are often the culprit, as they concentrate cattle grazing pressure, but the phenomenon happens just as easily with overgrazing and the absence of fire.

To generalise, however, the loss of tree and shrub cover is not a problem. The overwhelming evidence from the historical record is that the forests and woodlands of Australia are far thicker now, and more "cluttered" with underbrush, than they were at the time of European settlement.

"Fire is destructive"

For those, including some researchers, who are not experienced in the use of fire, it is difficult to imagine anything other than one type of fire - a fire that is hot and destructive, leaving ground cover and shrub layer that is struggling to recover before the next onslaught.

It is demonstrable that fire can be infinitely variable in its effects, and that a skilled fire manager must use different regimes and types of fire for different habitats. In other words, fire programs must have specific objectives. A fire that merely removes the litter in shrubland may be just as destructive to that particular ecosystem as a hot fire is to rainforest, cypress forest, or acacia dominated forest such as lancewood *(Acacia shirleyi*). In the case of shrublands, a hot fire is often necessary to create the conditions under which seeds may germinate. Repetitive very mild fires may prevent full regeneration of the shrubland ecosystem.

In grassy forests, fire may be used to reduce fuel loads with only minor and short term visual or other effects on the system. A forest managed by that type of regime can be contrasted with an unmanaged situation in the same type of forest where the inevitable wildfire can leave visible effects that last for decades.

"You're destroying nesting birds and other animals"

Yes! we are in some cases, but these species evolved with systems that have been fire shaped for a very long time. The fate of individual animals is not important if the species is prospering.

We must manage fire in the landscape in the most appropriate way to preserve the habitat on which species depend, always remembering that a conscious decision to manage the ecosystem to favour one species or a set of species, will inevitable work against the welfare of another set. The species that attract the most public attention are rarely those that play a pivotal role in the ecosystem.

"You're destroying the hollow trees"

A cool fire may give the "coup de grace" to a fire scarred veteran, but our experience clearly shows that burning when the ground and litter are moist is not significantly damaging to hollow trees. A wildfire when the litter is very dry can, however, be catastrophic.

However, it needs to be remembered that a severe fire may provide the scars that lead to the hollow trees of the future.

"You're destroying soil values"

Most Australian literature on this subject does not demonstrate any significant longer term changes in soil nutrient status with different fire regimes. Undoubtedly, however, there are long term changes that are not measurable because they are occurring on a timescale that far exceeds our (European) occupation of this continent.

Much depends on the type of fire regime and how it influences the abundance of nitrogen fixers, as well as what it does to the litter layer.

The picture is generally the same with soil erosion with the added complication of the type of ground cover. Soil on steep slopes, for instance, may be better protected by a dense grass cover than a shrub or litter layer. In that case, a fire regime that maintains a grassy ground cover could be a beneficial and legitimate management aim.

"You are not following traditional Aboriginal practices"

Whilst it is generally desirable to re-establish traditional Aboriginal land management practices this is not always possible because the ecosystem that Aboriginal people were managing has changed dramatically. There is no guarantee that re-establishing a former Aboriginal fire regime will allow that ecosystem to return. Our ecosystems are now subject to pressures, such as domestic and feral animals and weeds, and large scale changes to regional drainage, that were not there in pre-European times.

In addition, National Park management in Queensland does not have the human resources that Aboriginals did to effectively cover the country. (Evidence suggests that the human population density in many rural areas in Queensland is now lower than it was in pre-European times). Hence, we have difficulty in avoiding less desirable but also less labour intensive procedures such as aerial ignition.

"You don't know what Aboriginals did"

After the previous accusation about National Park fire management, this statement can be quite irritating.

We may lack specific local detail of Aboriginal burning regimes in some areas, but there is more than enough knowledge to establish some general principles for northern Australia. "No burning" was never an option where Aboriginal people lived in sclerophyll or grassy vegetation. Burning by Aboriginal people in those plant communities could occur in any month of the year and was done to create mosaic patterns of fuel. Fuel was rarely allowed to accumulate.

"You don't confine yourself to cool burns"

Most of our burns are, by design, cool burns, but the establishment of a mosaic fuel pattern does allow scope for the occasional hot burn, and that is considered desirable. There is evidence from some ecosystems particularly where shrubs are invading grasslands, and in some shrublands, that our burns are either too early in the year, or not hot enough.

In coastal areas, where the loss of sclerophyll communities to rainforest is a matter of concern, it is often extremely difficult to get a fire to carry, let alone burn too hotly. That provides some public relations problems, and the mistaken perception that we are seeking hot burns. This is because when a fire will barely carry in the forest it is often a period of high fire danger outside it, in the developed lands. It is not clear to most people that a fire during a November drought can be a cool fire.

"Fires are now much more frequent than they used to be"

All the evidence, and there is too much to document here, indicates that the converse is true. There are significant parts of eastern Cape York Peninsula and the east coast of Queensland south of Cairns, as well as huge areas of inland Queensland, which have not burnt for decades. What we do know about Aboriginal people makes it quite clear that they would never have allowed such a situation to arise, if for no other reason than that it would have threatened their survival. Would a people who always lived with fire willingly choose to live in a powder keg?

What is likely to be a more realistic statement is that in some areas **severe** fires are now much more common than they ever used to be.

"Fires are destroying the wetlands"

In some cases, this is true. Wetland management, particularly that of the melaleuca forests, is one of the most complex we face.

When the swamps are dry, fires may burn for months, killing even the largest trees as they burn deep into peaty organic layers. Such fires may have been part of the regime that maintained these ecosystems in the past but obviously would have to be very infrequent indeed. Our management techniques are directed at ensuring that fires do not enter the swamps at regular internals while they still carry water, and widescale fuel reduction burning in areas adjacent to the swamps.

Wildfires can destroy the wetlands, and will do so, unless we develop appropriate fire management schedules for them that do include prescribed burning.

"You should forget about burning and rely on firebreaks"

Firebreaks never did, and never will, stop wildfires. They are useful as a strategic part of plans to protect infrastructure and properties adjoining parks, both as lines to back-burn from and as part of wider-scale fuel reduction procedures.

Their construction should be avoided where possible because they can create erosion problems and provide free passage for exotic weeds and soil borne plant diseases. Where mosaic burning practices are intensively developed, fires can be allowed to burn until they come up against fuel reduced areas where they should be more easily controlled it that is desired. In such circumstances, an intensive firebreak system should not be necessary.

Keynote address

Fire behaviour in tropical grasslands

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Introduction

Grasses dominate the fuel type in most vegetation associations in tropical Australia. In many areas, grasses are maintained beneath the open forests and woodlands by regular burning and litter fuels rarely accumulate to significant amounts. Bushfires in these open forests and woodlands have the characteristics of grass fires in the open with some subtle changes caused by interposing a forest canopy between the windfield and the fuel bed. When open forests are protected from fire, litter will accumulate and the density of shrubs will increase. As litter fuels replace the grass, fires will progressively exhibit the characteristics of forest fires. Closed forests may have little flammable fuel beneath them and are fire free except under exceptional circumstances such as following cyclonic damage.

Fire behaviour is the response of the combustion process to both fuel and weather variables. Although pastures might be quite varied in species composition and structure, the physical characteristics of the grass particle are relatively unimportant in determining fire behaviour directly; rather it is how these species react to weather variables which, at times, produces different fire behaviour under certain circumstances.

A sound understanding of the factors which influence grassfire fire behaviour and an appreciation of the spatial and temporal variation of weather will help fire fighters use burning guides and fire prediction systems and make reasonably accurate forecasts of the behaviour and spread of grass fires.

Major grass fuel types

While there are many hundreds of grass species growing in Australia, fire behaviour is determined by the physical structure of the fuel bed and not necessarily the characteristics of individual species. Thus, for predicting fire spread, grasslands can be classified into broad groups with similar structural characteristics. These are: tall tropical grasslands; hummock grasslands; tussock grasslands; improved pastures; and, croplands. The main characteristic which influences the fire spread in these groups is the continuity of the fuel bed. The height of the grass is the main factor influencing flame height.

In this paper I will concentrate on the behaviour of fire in tall tropical grasslands characterised by annual sorghums and other tall grasses, and the tussock grasslands which form a continuous fuel bed.

Annual sorghums and other tall grasses

These grasses occur in high rainfall areas (750 mm) and mostly associated with open forests and woodlands characterised by numerous eucalyptus species of which Darwin stringy (*Eucalyptus tetrodonta*), Darwin woollybutt (*E. miniata*) and northern bloodwoods (eg *E.polycarpa*) are most common.

The most common plants are tall annual sorghums (*Sorghum intrans; S. stipodium*) but tall perennial grasses such as giant spear grass (*Heteropogon triticeus*) and perennial sorghum (*S. plumosum*) dominate some areas. Numerous short grasses, both annual and perennial, occur but are generally sparse where the taller grasses are dense.

The grasses commonly grow as high as 4 m during the wet season. They progressively cure at the onset of the dry season and collapse down with the last storm rains to form a uniform fuel bed around 0.5 - 1.0 m high.

If the areas are not burnt the annual grasses decompose almost completely during the next wet season and only a thin layer of organic material remains on the soil surface at the start of the next dry season. This layer may be supplemented with scattered leaf litter and allows fires to burn earlier in the day season when the annual grasses are only partially cured. Later in the dry season this additional fuel makes no significant difference to fire behaviour.

Tussock grasslands

Tussock grasslands are wide spread and extend from tropical Australia to the Australian Alps. They are perennial grasses which may grow in near pure swards or in association with other annual and perennial grasses. Most of our work was carried out on ungrazed grasslands of Kangaroo grass (*Themeda triandra*). Although these pastures commonly appear to be around 1 m high with inflorescences up to 2 m, the bulk of the fuel in the tussock occurs below a height of 30 cm. These pastures may be treeless or associated with woodlands or open forest.

In the tropics most perennial tussock grasslands develop coarse unpalatable material by the end of the wet season. They are commonly burnt to remove the coarse, dead, unpalatable grass. Where they remain unburnt they can build up substantial fuel loads.

Tussock grasslands of the semi-arid zone (eg Mitchell grass country, *Astrebela spp.*) may be selectively grassed so that by the end of the dry season palatable annuals and ephemerals between the tussocks have been eaten out leaving bare ground. Under these conditions fires are limited by lack of fuel and may spread erratically only under high winds.

Hummock grasslands

The hummock grasslands of the semi-arid areas of Northern Australia are characterised by spinifex grasses (commonly *Triodia pungens or T. basedowii*). These are drought resisting perennials forming large tussocks or hummocks 30-60 cm high and 30 to 100 cm in diameter. The hummocks occupy 30-50 percent of the ground areas, and the interspaces are normally bare. After rain or in good seasons there may be a sparse cover of short grasses and forbs.

Hummock grasses are particularly flammable because the hummock is composed of a dense core of coarse dead material accumulated over a number of years. After rain the hummock may develop a veneer of fresh shoots on its surface giving it a green appearance but it will still burn with surprising ferocity.

A characteristic of fires in hummock grasslands is that, before they can spread, the wind speed must exceed a threshold value necessary to produce a low flame angle and extend the flames across the bare ground to the next hummock. These fires have little lateral or back spread and, under strong winds, develop a wedge shape from the origin spreading out laterally only slowly as the headfire progresses down-wind.

Comparison of grazed and ungrazed pastures

In pastures subjected to grazing there is a progressive change in the nature of the fuel type. Often they are well eaten down before they become fully cured so that they are not only shorter but also more compacted by grazing than are ungrazed pastures of similar species. In many places in Southern Australia, fenced road verges are the only areas where grasses can develop to their natural structure. By the time the grasses are fully cured it is common to have paddocks grazed to less than 10 cm high while the roadside verges have grasses over 1 m high.

Despite the wide variety of species and structural types within grasslands only a few fuel characteristic affect grass fire behaviour. **Fuel height** dramatically influences the height of flames and hence difficulty of suppression, but has only a relatively small influence on fire spread. **Fuel continuity** is the major factor influencing fire spread. Grasslands which are discontinuous either because of the natural distribution of the grasses (eg hummock grasslands) or because of very heavy grazing (particularly in some tussock grasslands) will not carry a fire until the wind speed exceeds a particular value. The **fuel load** will affect the time that it takes the fuel bed to burn out (and may cause severe local heating) but has little effect on other fire characteristics unless it also effects the continuity and the height of the fuel. Other factors such as the fineness of the grass stalks may influence residence time but also has little influence on spread rates.
(*Cheney et al 1993*)

The combustion of grassy fuels

The efficiency of combustion of a grassy fuel bed depends on how it is ignited and the speed that fire spreads through the fuel bed. This primarily depends on whether the fire is burning with, or into, the wind.

A heading fire: is one where the flames are blown towards the fuel. The fuel bed is first ignited at the top and progressively burns down into the lower layers. This pattern of burning can be quite inefficient, particularly under severe burning conditions.

Thick, black smoke associated with heading fires burning under dry, windy conditions indicates that combustion is rapid and incomplete. The fuels are pre-heated and ignited so rapidly that the large volume of flammable gasses given off are not adequately mixed with oxygen to permit complete combustion. Combustion is chaotic and the black smoke indicates that free carbon (soot) and tar particles have escaped from the flame zone before they were completely burnt.

The rapid combustion may produce a black carbonised residue which covers the lower portions of the fuel bed leaving the lower stalks only partially pyrolysed. At times the lower stalks and compact layers at the bottom of the fuel bed, such as a compacted clover, may remain unburned apparently insulated by the deposit of ash.

Backing fires: are fires moving into the wind with flames leaning over the burnt ground. These fires ignite the fuel bed at or near its base and it burns slowly but very efficiently and completely leaving little residue either as partially burned material or carbon. Mostly backing fires leave a fine white ash. The efficient combustion of backing fires produces less smoke than heading fires and in agricultural areas where there are concerns about air pollution backing fires are used to burn crops residues to reduce smoke omissions.

Residence time: is defined as the period that flames remain burning over one spot on the ground. Depending on its thickness an individual particle of grass remains flaming for two seconds or less. The fuel bed takes longer to burn depending on the compaction of the grass and the coarseness of the fuel. Heavy pastures commonly have a residence time of 10 to 12 seconds while fine light pastures have a residence time of 5 seconds or less.

The short residence time of grass fires means that they are extremely responsive to changes in wind speed and direction. A change of wind direction can change a flank fire to a headfire, spreading at its potential speed within 15 seconds. Conversely a lull in the wind can reduce a fast spreading head fire to a backing fire with low flames within 5 to 10 seconds. In tropical areas, strong thermal activity can cause large variations in wind speed and also large variations in fire behaviour. This behaviour has been described as erratic but it is merely a reflection of the variability of the wind.

Flame depth: is the distance of continuous flames behind the fire front. Flame depth is a useful characteristic but can be difficult to observe when flames are tall. It can be calculated by the product of the rate of spread of the fire (R) and the residence time (t_R):

$$FD = R\ t_R$$

Grass fires have a potential mean rates of spread of 18-22 km h^{-1} (5-6 m s^{-1}) . If the fuel bed has a residence time of 10 seconds flame depths for these fast spreading fires will be 50-60 m.

Smoulder time: Heading fires do not burn all the fuel by flaming combustion and depending on the structure and compaction of the lower layers of the fuel bed some fuels will smoulder for a period after the flames have past, often producing a substantial quantity of smoke. The smoulder time for perennial *Themeda* pastures in Northern Australia is around 60 seconds, and a zone of smouldering combustion can be observed in an arc behind the flaming zone. Annual pastures and croplands with little compacted material on the surface have very short smoulder times, whereas very dense tussocks may continue to smoulder in the base for several hours, sometimes creating suppression problems.

Flame height, flame length and flame angle: The height of the flames is the most obvious characteristic of a fire. It is readily observed, often reported or recorded by visual observation, but it is difficult to get consistency or a high degree of precision between individual observers.

This should not be surprising since the diffusion flames of a grass fire are the result of flammable gasses emitted from the fuel bed combining in a turbulent way with oxygen in the surrounding air. Billows of gas may not burn completely as they rise or bubbles of gas burning on the surface become disconnected from the flames below and burn out as they are carried aloft. The convective forces of the buoyant combustion gasses and the wind form a dynamic balance which results in flames of some average length being inclined over the fuel bed. There are wide fluctuations around the mean position depending on fluctuations in the wind velocity, turbulent mixing, and variation in fuel structure and composition.

Despite all this variation, flames do achieve a characteristic average height depending on the characteristics of the fuel bed and the prevailing weather conditions.

The most consistent estimate of flame height (taken vertically from ground level) is to estimate the average height of the tops of the flames as viewed from a distance and integrated for some time and distance around the perimeter. This estimate ignores occasional high flame flushes and gaps in flames created by turbulence. One should not expect a high degree of precision and flame height estimates in steps of 0.25, 0.5. 1, 2, 4 and greater than 4 m should be adequate for most purposes.

Flame length and flame angle are more difficult to define. They are variable over the depth of the flames. The angle of the tallest flames reflects the buoyancy of the strongest burning part of the flames and this is probably the easiest angle to estimate although the angle that the front face of the flames subtend to the fuel bed is probably more important for the physics of heat transfer. However, for practical purposes, an estimate of flame height and the most obvious angle of the flames (without worrying too much about their location), are useful fire descriptors.

Acceleration of fires

All fires accelerate from their ignition point until they reach a quasi-steady rate of spread for the prevailing weather conditions ie the average rate of spread remains the same while the average wind speed remains the same - there may be wide fluctuations in rate of spread associated with fluctuations in wind speed.

A line of fire will reach a quasi-steady rate of spread within 15 seconds but this spread rate (over 100-200 m) will depend on the length of the line ignited.

Similarly a fire starting from a point ignition may accelerate in a series of steps, and reach several quasi-steady spread rates depending on the width of the head fire. (See Figure 1). Each step to a higher rate of spread is associated with a shift in wind direction which increases the width of the fire

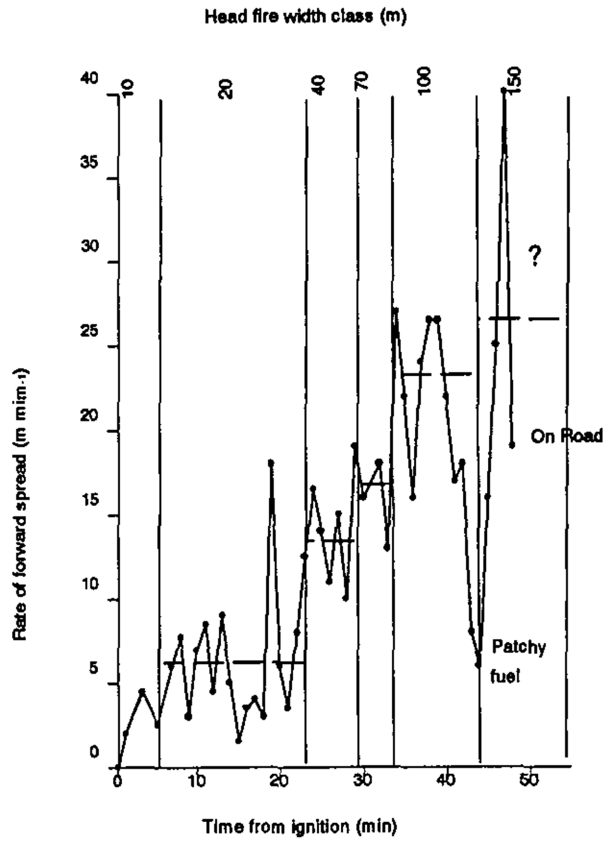

Figure 1 Increase in rate of spread for a fire starting from a point and burning in an open woodland Gunn Point NT. The fire has increased in speed and width in a step wise fashion.

perpendicular to the wind direction. Thus under moderately severe conditions it appears that fires will continue to accelerate until the head fire reaches a width of around 200 m. I am now working to verify this relationship. A paper is currently under peer review.

Fires developing under unstable conditions when there are frequent and substantial shifts in wind direction will accelerate quickly. Fires developing under a stable wind, such as a sea breeze, where there are few shifts in direction may take a considerable time. During experiments we have recorded fires starting from a point which reached their potential rate of spread in 12-14 minutes while others have taken up to an hour.

Factors effecting fire spread

The most significant factors influencing fire spread (once it has reached a quasi-steady rate of spread) are: fuel continuity; grass curing state; dead-fuel moisture content; and wind speed. Factors which have a small or interactive effect are fuel height, fuel fineness and fuel compaction or bulk density. When fuels are discontinuous fire control is relatively straight forward. Winds need to exceed a threshold value before fires will spread. This value depends on the spacing and size of the individual fuel elements. *Burrows* et al (1991) found that spinifex hummock grass lands in the Gibson Desert, with bare interspaces ranging from 47 to 85% of the area, required wind speeds at 2 m of 12-17 km h^{-1} before heading fires would spread. Griffin and Allen (1984) found that wind speeds greater than 3.5 km h^{-1} at 2 m (= 5 km $^{h-1}$ @ 10 m) was required for spread in hummock grasslands in Central Australia.

The following discussion will be restricted to the behaviour of fires in tropical tall grasslands and tussock grasslands which form a continuous fuel bed.

Grass curing state (C)

The curing state of a grassland, expressed as the fraction of dead material in the sward, has an important effect of both the speed a fire spread and its ability to spread across the landscape.

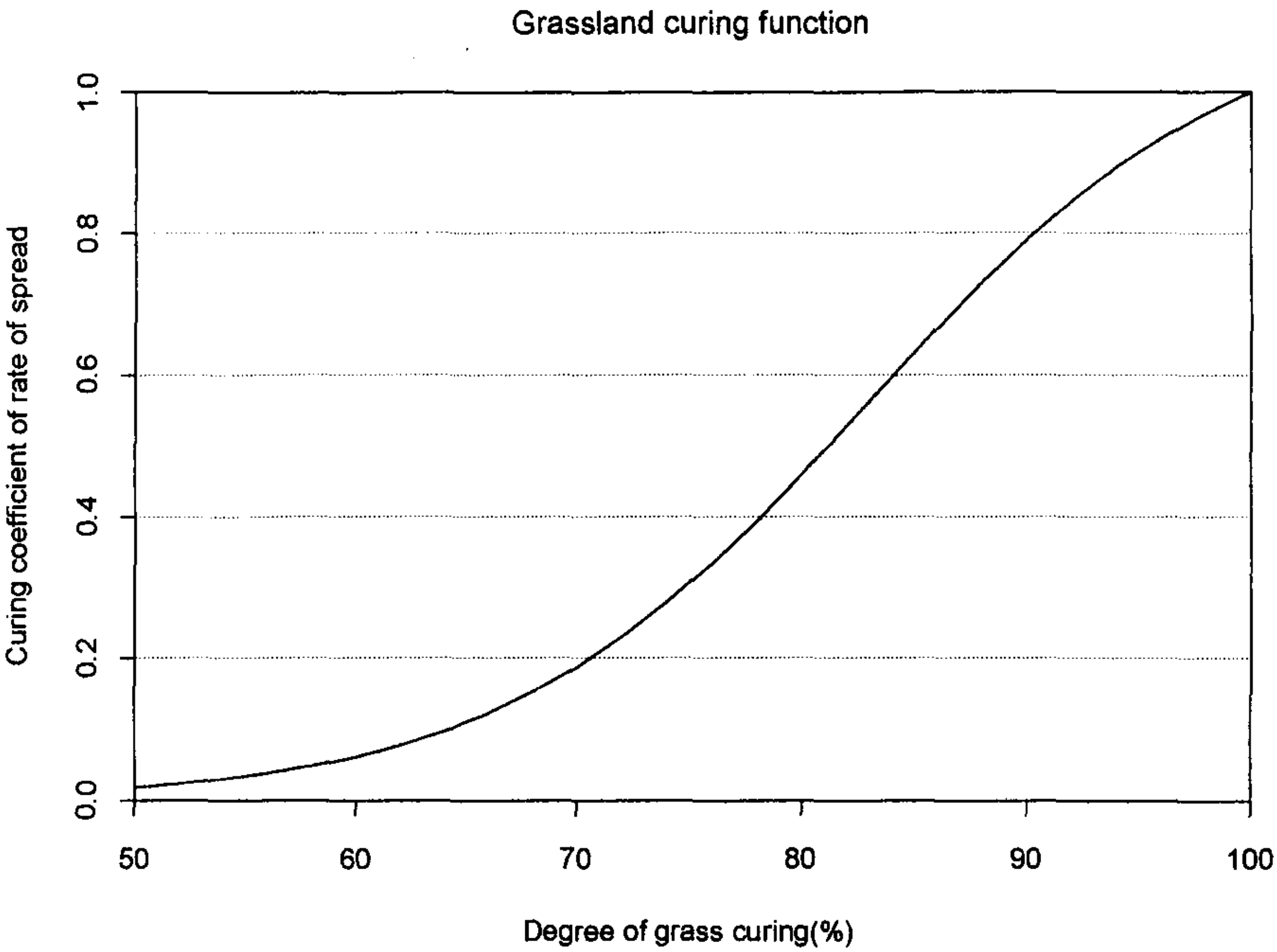

Figure 2 Relationship between rate of spread and grass curing. (Rate of spread is expressed as a relative number - the curing coeficient of rate of spread).

Fires will not spread when grasslands are less than 50% cured. When pastures are uniformly cured the relationship between fire spread and curing is shown in Figure 2. This is a sigmoided function; with the greatest rate of change in the spread coefficient for curing occurring when pastures are 75% cured. When pastures are more than 85% cured they have almost reached their full potential for fires spread and there is little further increase in spread rate when grasses are 100% cured.

However, grass curing state varies only relatively slowly with time. Annual sorghums in Northern Australia commence curing once the grasses have flowered and set seed and the plants lose moisture as shown in Figure 3 over a period of 8-10 weeks. Once stated the curing process of annual pastures is little effected by subsequent rainfalls. If the rainfall is sufficient to germinate seed a green shoot may appear beneath the old sward. This shoot is often not apparent (except where the old pastures had been burnt before the rain) and has no measurable effect on the spread

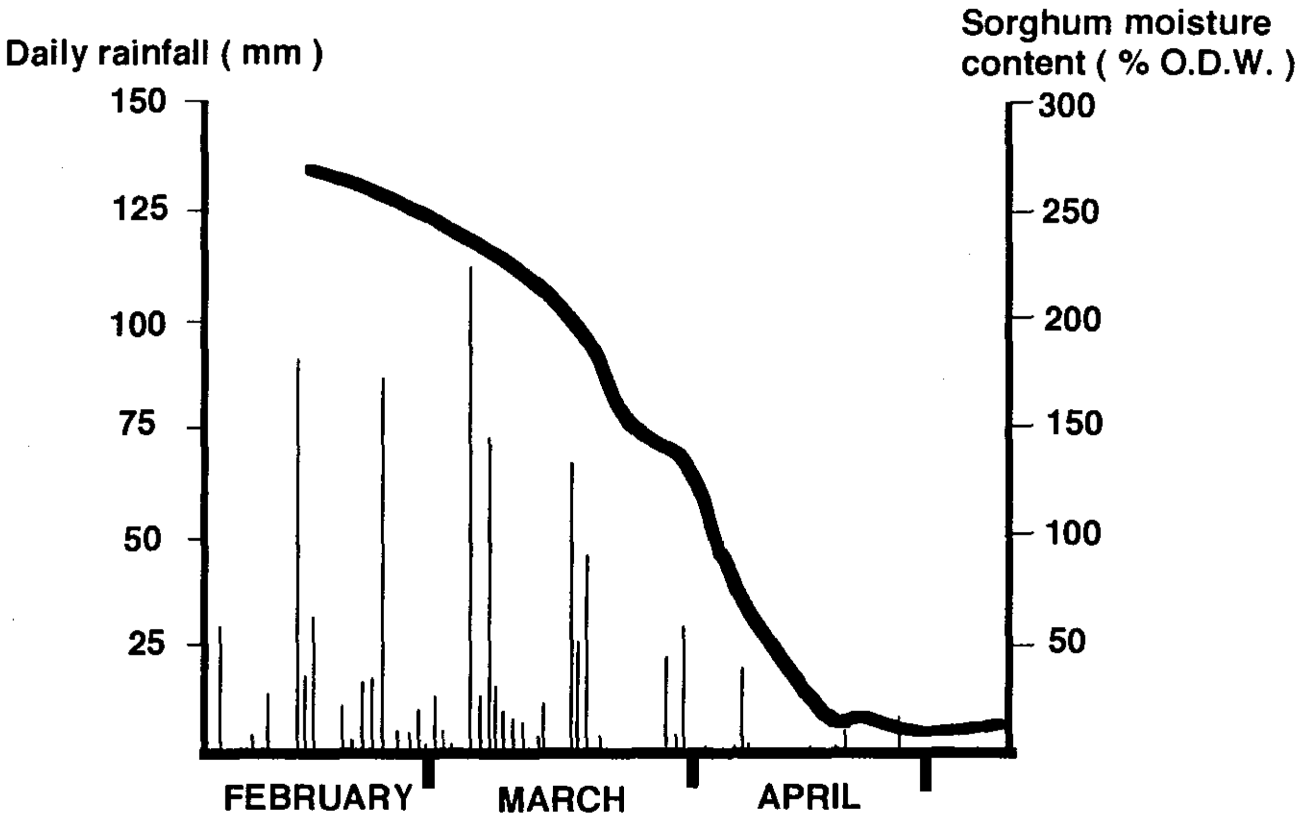

Figure 3 Change in moisture content of *S. intrans* after flowering; Darwin NT.

rate of fires in the fully cured older grasses. Perennial pastures cure more slowly than annual grass and curing is further delayed by rains in the early dry season. Once pastures were more than 85% cured it was difficult to measure the reduction in spread rate from fully cured pastures.

However, it is difficult to accurately predict fire spread across the landscape until all the grasses in the landscape are fully cured. Grasses on ridge lines cure more rapidly than grasses in depressions or creeklines so that early in the dry season fires that spread rapidly through fully cured pastures on ridges may be stopped by green grasses in the depressions which are less than 50% cured.

Satellite imagery used to estimate grass curing in southern Australia actually provides an integrated value of the curing condition of the landscape; a curing value of 80% for a 1 km^2 may represent 90% of the country with 100% curing and 10-15% of country with pastures less than 50% cured. Because quite narrow bands of green grass along water courses can provide an effective barrier to fires, the rate of spread across a landscape assessed as 90% cured may, on average, be somewhat slower than across a continuous pasture which is uniformly 90% cured.

It is difficult to verify any function between curing state and rate of spread because of the large spatial variation of curing state even at an experimental scale. Nevertheless, I feel that the function will adequately describe the effect of curing on fire spread in uniform pastures but users should expect wide variation between observed and expected fire behaviour until pastures are fully cured.

Dead fuel moisture content (M_f)

The moisture content of dead grass under field conditions can range from around 2% to 30-35% before the grass fibres are saturated. Under field conditions fires will not spread under light winds when the dead fuel moisture exceeds 20% . The precise value of the moisture content of extinctions can be difficult to determine experimentally because, often, humidity and M_f are increasing rapidly, there are steep temperature gradients near the ground, and dew may form on the grass at the surface before the ambient air is saturated.

While we have not been able to verify the following in the field we feel that fires may continue to urn up to dead fuel moistures of 25% under windy conditions (> 10 km h^{-1} @ 10 m) when there is better mixing at the grass surface and dew does not form readily. The relationship between rate of spread and dead fuel moisture is shown in Figure 4.

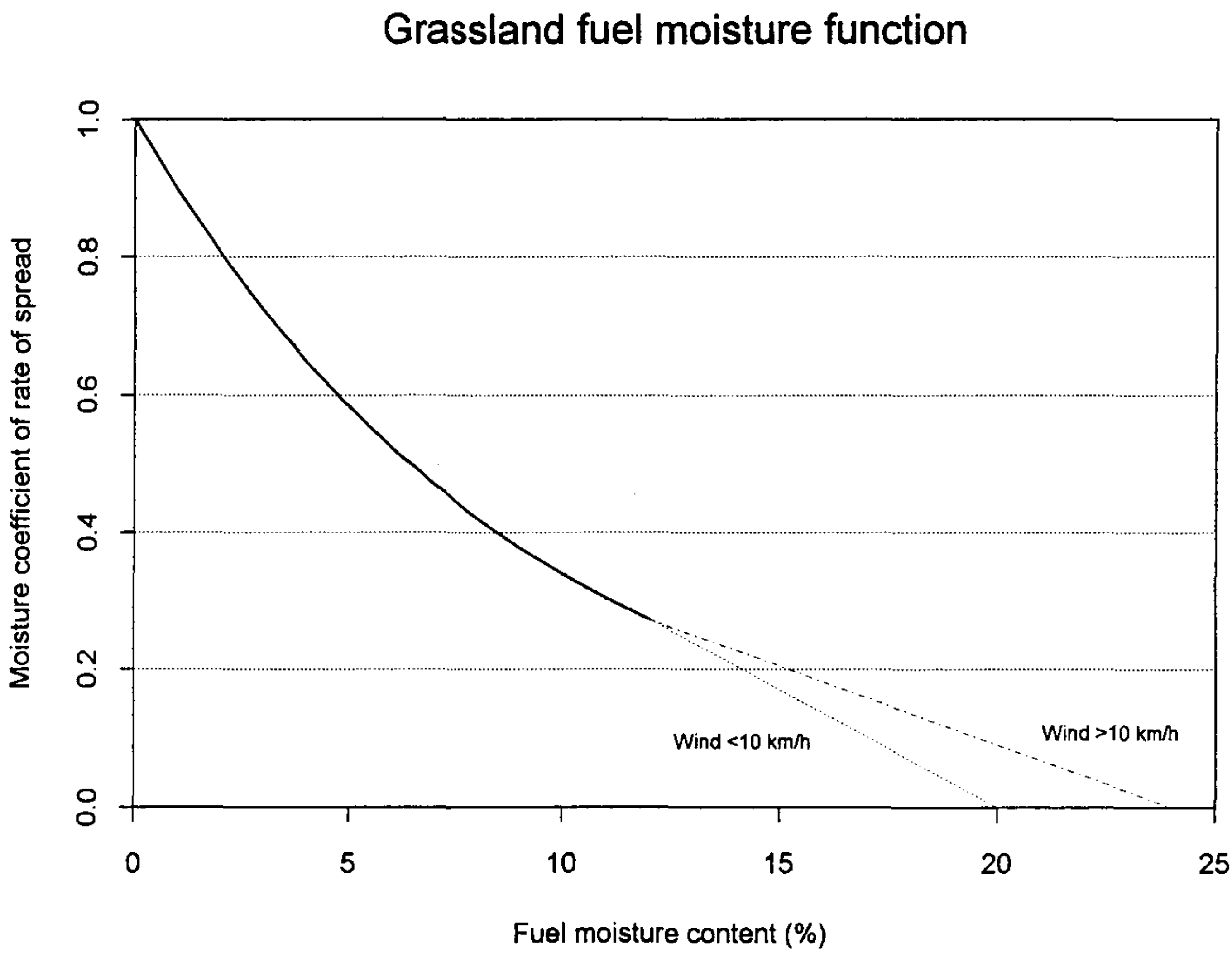

Figure 4 Relationship between rate of spread and dead fuel moisture content at wind speeds above and below 10 km h^{-1}. (Rate of spread is expressed as a relative number - the moisture co-efficient of rate of spread).

Wind speed (U)

Wind is the most dynamic variable influencing grass fire behaviour. Because wind speed fluctuates widely over short time periods, and varies with height above the ground we have established a convention that for fire spread predictions we use the average wind speed measured at 10 m above the ground. In most cases we recommend that this average be taken over 10 minutes.

The relationship between rate of spread and average wind speed at 10 m for experimental plot fires in the Northern Territory is shown in Figure 5.

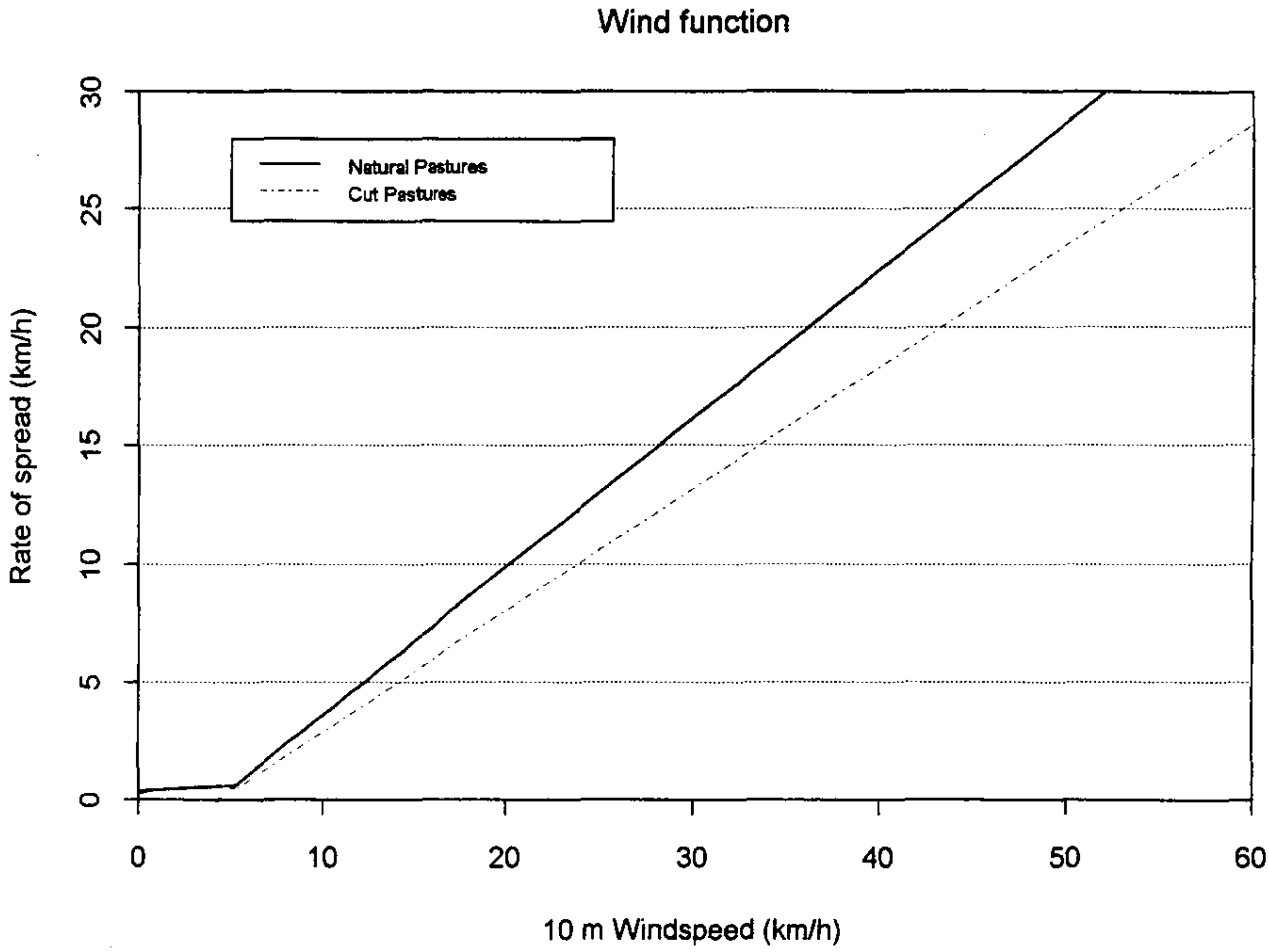

Figure 5 Relationship between rate of forward spread and average wind speed at 10 m for:
(a) Undisturbed grasses;
(b) Closely cropped or grazed pastures.

The development of a predictive relationship between fire spread and wind speed has to consider :

- That the rate of spread at zero wind speed is equivalent to the backing rate of spread in grasslands.
- That there is a change in the mechanism determining fire spread when a fire changes from a backing fire to a heading fire.

Although it is practically impossible to find dead calm conditions during the day, the thermal activity of the fire and from the heated ground behind the front can overcome the influence of light winds and draw the flames over the burnt area - thus creating a backing fire. The wind speed required to overcome this thermal activity and create a heading fire depends upon the available fuel load. Field data suggests that in average fuel loads of 3-4 t ha^{-1}, a wind speed greater than 5 km h^{-1} at 10 m is required to overcome both the thermal activity of the fire and consistently drive the fire forward as heading fire. Our recent research indicates that the commonly published relationships between fire spread and wind speed - where the rate of spread continues to increase with increasing wind speed - are incorrect..

Provided the pastures are continuous, closely grazed or mown pastures will spread about 20% slower than undisturbed grasses. (Cheney et al 1993) We found that tall annual sorghums burnt no faster than shorter Kangaroo grass pastures or natural grasslands of Kerosene grass (*Eriacne burkittii*) flattened by receding floodwaters. Theoretically it may be that rate of spread can be related to fuel bed height. However, considering the difficulties of defining the height of the fuel bed (do you measure to the height of inflorescences, or to some point below which a certain fraction of the fuel occurs?) and lack of significant evidence from field trials we consider it is practical to separate into two classes; undisturbed, ungrazed pastures, and, closely mown or cropped pastures.

In southern Australia most grasslands are grazed and are considerably shorter and more compact than ungrazed pastures and most bushfires occur on grazed lands. We found that the relationship for experimental data from northern Australia was consistent with extrapolations to wildfire data in southern Australia and we concluded that there was no significant difference in grass fires in the two areas which could not be explained by known variables.

Slope

We have no field information to support or refute established relationships between, rate of spread and slope so we have used the relationships of McArthur (1966) Vis:

5° slope, spread increases by 33%;
10° slope, spread doubles;
20° slope, spread quadruples;

Calculations of fire spread up steep slopes indicate that under extreme conditions (eg M_f =2% wind = 50 km h^{-1}) rates of spread up steep 20° slopes may exceed 90 km h^{-1}. These calculations may overestimate fire rate of spread but very high rates of spread must be anticipated on steep slopes. Under these conditions the convection column from the fire may not lift away from the slope and create strong indraft winds enhanced by entrainment at the fire front. Fortunately, these spread rates are short lived and grass fires will be slowed markedly on lee-slopes where eddy-winds may reduce the front to its backing rate of spread. Provided access is not a limiting factor grass fires in divided country can be easier to suppress than fires on level terrain where there is no impediment to fast spreading head fires.

Conclusions

Recent research into grass fire behaviour suggest that there will be very significant changes in the algorithms to predict rates of spread - particularly when fires are large and wind speeds are high.

Fires in tropical Australian grasslands do not appear to behave differently to fires in tall grasses elsewhere in Australia, but will burn 20% faster at all wind speeds above 5 km h^{-1} than fires in short grazed pastures (which have formed the basis of the Mark IV Grassland Fire Danger Meter which is currently used to predict fire spread).

I expect that new equations to predict fire spread in grasslands will improve accuracy of prediction at moderate wind speeds. Accurate prediction of fire spread before grasslands are fully cured will always be difficult due to spatial variation in grass curing.

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Section 1:

Standardised fire data collection and monitoring on conservation reserves of tropical Australia.

Chairperson : Greg Spiers

Fire monitoring research Burra Range/White Mountains National Park

Edward M Jackes OAM
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History:

A fire management project for White Mountains/Burra Range was set up in April - May 1990 by Carolyn Sandercoe (QDEH Conservation Strategy Branch) with the following aims:

> *Aims*
>
> To devise some broad fire management principles for the White Mountains area which seek to maintain the diversity of species and ecosystems over the area which Queensland National Parks and Wildlife Service controls or is likely to control, at the same time ensuring no loss of amenity to neighbours.
>
> To identify and map sensitive areas of vegetation for future more detailed investigation.

In May 1990, eighteen permanent photo point sites were established in the Burra Range area, 274 kilometres south-west of Townsville. Two sites ware additionally selected for monitoring *Xanthorrhoea johnsonii* growth habits.

Botanists and others interested in heath vegetation have long been aware of the Burra Range area. Members of the Townsville Branch of the Society for Growing Australian Plants have been visiting the area for over twenty years.

Staff and students of the Botany Department of James Cook University, Townsville, undertook field trips in the area until 1980 under lecturer Bill Birch. Mr. Birch then retired due to ill-health, and unfortunately died en route to England. Some of the records from May 1972 to April 1975 remain for research plots east of the dam sites, but unfortunately other data had been sent to England and their whereabouts is unknown.

In 1984 the Botany Department of James Cook University published *A Guide to the Plants of the Burra Range* by Dr. Betsy R. Jackes, the second edition being published in 1985.

Subsequent to the late 1970s, major research attention was directed towards rainforest for therein lay the jobs and the funding. In July 1993, third year Botany students made a most successful field trip to the Burra Range and further west. Students visited several sites, particularly Sites 1 and 2 where quadrats were set up nearby, heights of all species and position recorded, and pH and soil samples taken. Species regeneration strategies were noted (e.g. resprouting, epicormic buds etc.) for the area which had been severely burnt in late November 1992 and similar observations were made at Site 8 which had been burnt in November 1990.

Recommendations by Carolyn Sandercoe were for annual photo monitoring of the 18 sites, preferably in July during the major flowering period and annual measurement of selected *Xanthorrhoea* be undertaken over a ten year period. In the case of a burnt site, the recommendation was made for visits every two months particularly in the first two years following fire to observe regenerative strategies. Suggestions were also made that a post-graduate research project could be developed.

At the instigation of my wife, Associate Professor Betsy Jackes of the Botany Department of James Cook University, I agreed in my retirement to regularly monitor the sites, such monitoring has been increased to approximately every six months. It has not been possible to visit burnt sites every two months, in accordance with the initial recommendations.

Photo Point Sites:

The sites were established by the original project team 15 metres perpendicular from the track, sites were usually paired with the track intervening, hopefully as a fire break. An unpainted star steel picket marks the centre of the 10 metre radius site, 5 metres to the south a red and whit banded picket is located.

Two photographs are regularly taken at each site from th unpainted picket, one with the top of the banded picket at the centre top of the camera viewfinder and the second with the base of the banded picket at the centre bottom of the view finder.

Two sites are on the dam track 8.5 km east of the Burra microwave tower, one site is near the quarry 5.8 km east of the microwave tower, two sites are 4 km south of the Flinders Highway on the Terang track, opposite the microwave tower, two sites are on a so-called "TREB track" off the Poison Valley track and the remaining eleven sites are along the Poison Valley track north of the microwave tower as far as 18.3 km from the Flinders Highway.

The red and white banded pickets have suffered fire damage at several sites, at one site an unknown person appears to have 'liberated' one picket, since replaced, and at another site a new track came into use when the original track became rough, unfortunately the deviation was across the edge of the established site!

***Xanthorrhoea* monitoring:**

Carolyn Sandercoe suggests that many *Xanthorrahoea* respond to fire by flowering within a year of fire and the production of the flower spike sends the trunk off in a slightly different direction. Thus observation of trunk zig-zags combined with known growth rates may permit a fire history to be determined.

Two sites off the Poison Valley track were selected by the original project team and ten plants at each site were selected, tie wire placed at the intersection of green leaves and brown dead leaves, and tagged.

Observed vertical growth rates have been small - in recent dry times plants have averaged under 7mm increase per annum. However there has been an increase in diameter and most tie wires have been overgrown with tissue leaving only the stainless steel tag protruding.

Measurements are not able to be taken with the desired accuracy, on tie wire encirclement is loose, one plant has died, and zig-zagging of trunks is not yet easily discernible.

Rather than measuring from a wire band it may be preferable to measure from one point, for instance: a monel metal boat nail driven into the trunk with considerable protrusion remaining. It is intended on the next trip to spray paint a coloured patch on the trunk of the selected plants to more easily identify them as the dead leaf skirts effectively hide the wire bands and tags.

Site Records:

The initial record sheet for each site recorded observed species in groupings of Tall Tree, Tree, Low Tree, Tall Shrub, Low Shrub and Ground Cover, soil type and known fire history.

Subsequent recordings were made on check sheets prepared using Lotus 1-2-3, initially with a separate programme file for each site but then with the use of a master list for all 18 sites.

Data for each site is retained in a separate file.

On each visit the presence or absence of species is noted for each site, new records for the site are especially noted, and comments made on the sheets regarding fire history, recent rain, flowerings and fruitings, the state of the vegetation and the presence of cattle in the area.

The list of species totals 159 at this time with several species listed under new and superseded nomenclature, e.g. several of the Eucalypts are yet to be identified.

Two photographs are taken of each site, double prints are required with the second set of prints sent to the District Office in Charters Towers, both sets of prints are kept in photo albums.

As mentioned, JCUNQ students recently plotted vegetation in areas adjacent to Sites 1 and 2 off the dam road, noted regerative strategies and took soil PH and other measurements at four sites.

I am frequently accompanied by a Ph. D student with research interests in fire management, and several times by QNPWS staff.

We have been delighted to note the recent new recording of *Calytrix microcoma* in Site 16, *Acacia uncifera* in Site 13, and the re-establishment of many species in Sites 1 and 2 following the fierce wild fire of late November 1992. A visit to the northernmost sites a month or so after heavy rain would certainly expand the species list with numerous ephemerals for in the dry seasons only intriguing non-identifiable traces remain.

Financial Considerations:

Costs have been minimal - I am happy to do the recording for interest sakes alone, National Parks have generally met the overnight accommodation costs and the photographic costs, and I've provided the vehicle, running costs, and my time and that of the person accompanying me for free.

Thus for about $200 per annum a valuable amount of data is being accumulated and with the interest shown by the third year Botany students in the course of the recent field trip valuable additional material should result.

The Future:

Three years of written and photographic records are available to the researcher who may wish to initiate a Ph. D or M. Sc. research project.

Many of the third year JCUNQ Botany students were fascinated by the area and the area's potential for research projects for higher degrees. The 1993 field trip was so successful that planning for future field trips is underway. Monitoring of growth in the extra quadrats at Sites 1 and 2 will occur annually by third year students.

I do not pretend to be a botanist, just an interested amateur happy to be of service in his retirement, and hopefully keeping fire sites warm for those who may follow and who are keen to assist in the long term collection of data.

The ten year recording project ends with the May 2000 site visit. Perhaps by that time there will be a luxurious eco-tourist lodge and park interpretive centre in the vast new national park in the White Mountains/Burra Range area!

Fire monitoring and data collection in the Wet Tropics

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Cairns

Abstract

This paper describes the process used to establish fire monitoring programs in the Wet Tropics region of north Queensland. It out examples of programs recently initiated as well as a draft proforma which will attempt to assess fire behaviour.

Background

Fire monitoring in the Wet Tropics is a relatively new Queensland Department of Environment and Heritage initiative. Funding for the program is provided annually by the wet tropics Management Authority.

Introduction

On e of the main management objectives of fire management in nature conservation reserves is to conserve biodiversity (ie. diversity of habitats, vegetation community structural form and species). Fire management is an essential part of this nature conservation strategy. In sclerophyll and grassland systems, the fire management strategy is to emulate the fire regimes to which these ecosystems have adapted over evolutionary time frames.

A fire monitoring program provides a mechanism for systematically recording the effects of prescribed burns. this information is used to review the fire management program to determine if the program goals are being achieved.

The purpose of a program can be twofold :

1. to monitor the response of vegetation to the fire management program with the aim of predicting vegetation response to fire; and

2 to monitor the behaviour of fire with the aim of being able to predict how a fire will behave under certain weather conditions and fuel types.

Developing a monitoring program to assess vegetation response

There are seven steps tin developing a monitoring program :

1 *What are the management goals?*

Identify the goals of the fire management program. Be specific and keep them simple. For example, - "The fire management goal for this habitat is to promote the regeneration of *Eucalyptus grandis* ".

2 *How can we assess if the goals are being achieved?*

Develop a monitoring system that is simple and specific for the goals of the fire management plan.

For example :

Fire management goals	Monitoring methods
To promote *E.grandis* seedlings	Permanent plots/transects
To affect forest structure	Photo points
To affect species composition	Permanent plots
To reduce fuel loads	Sampling points &/or photo points

3 *Select a burn site and a control site*

Site selection can be a time consuming process but it is time well spent. Mapping of the vegetation communities from aerial photography may be a good starting point. We have attempted to select control unburnt sites that are naturally protected from fire but still a part of the same habitat. The control site is crucial in that it provides information on what happens to the vegetation composition and structure in the absence of fire.

4 *Select a monitoring method and sampling strategy*

Methods may include permanent quadrats, transects, or photo points. It will depend on a number of factors - the fire management goals, the vegetation community, labour and access. Designing a sampling strategy that will provide statistically significant information is not supposed to strike terror in the hearts of park managers. Statistics are supposed to reduce the amount of effort required to properly describe a population, or process etc. For example, if I wished to state (as fact) what the dominant grass species are at Eubenangee Swamp, I have two options. I can count every grass in the swamp or I can take several of samples in an unbiased way and determine the average. Replication of samples is essential because of the natural variation that occurs in all communities.

5 *Establish plots and collect baseline information*

This is best before a burning program has been initiated. Information can be collected on a number of features depending on the fire management goal, for example, species diversity and density, soil seedbanks, the density of a single species and plant regenerative responses (e.g. coppicing).

6 *Monitor plots*

Short Term - The plots should be monitored before and after burning, this can be in the form of photographs. This will provide information on how the vegetation in the plot was affected by a particular fire.

Long Term - Monitoring of the vegetation within permanent plots/transects over a long period of time. The vegetation is assessed after every burn or every couple of burns, depending on the resources available. It is essential that the assessment methods be identical o those used when the plot was established.

7 *Assessing the results*

Photographs should be developed and labelled, floristic surveys should be stored on a computer spread sheet and data analysed. National park managers can become involved in analysing monitoring data for their particular management unit. There are a number of statistical packages that are easy to learn and can provide useful insights into the vegetation community trends.

Fire behaviour

Gathering information on fire behaviour in a habitat under recorded weather and fuel conditions provides us with opportunities to be able to predict its behaviour in the future. This becomes particularly important given the turn-over rates of national park field staff.

The proforma attached (Appendix 1) attempts to cover a range of different burning situations (often on different scales). However, what is applicable to some areas won't be to others. The proforma is still in draft stage and any comments from field staff would be appreciated.

Monitoring program established in the Wet Tropics

1 Barron Gorge National Park

A monitoring program was established in the form of three replicate 10 x 10 m plots located in each of two adjacent areas of upland *Melaleuca quinquenervia* forest. The smaller area will remain as the unburnt control and the larger tract will be burnt in the early dry season at 2-3 year intervals. Both areas were measured and stratified into three equal-sized sections with one plot randomly located within each section.

2 Graham Range National Park

A monitoring program has been established in the form of four replicate 10 x 10 m plots, in two adjacent areas of open eucalypt forest, separated by a road. The eastern side of the road will remain as the unburnt control while the western side will be burnt on 2 - 3 year intervals. Both sites were measured and stratified into four equal-sized sections with one plot placed randomly within each section, but always 10 metres from the road edge.

3 Eubenangee Swamp National Park

A monitoring program has been established to :

a) assess the regeneration of the weed, pond apple (*Annona glabra*) with fire management based on four replicate 5 x 5 metre plots in an area that was heavily infested with pond apple.
b) assess the regeneration of a *Melaleuca quinquenervia* swamp severely affected by a wildfire.
c) assess the effects of the current fire management program on the establishment and abundance of endemic grass species.

4 Behana Gorge National Park

A monitoring program has been established to promote in the form of replicate 10 x 10 m plots in two adjacent areas of eucalypt forest, separated by a road. The eastern side of the road will remain as the unburnt control while the western side will be burnt on 3 - 4 year intervals. Both sites were measured and stratified into equal sized sections with one plot placed randomly within each section.

Discussion

Fire, or the lack of it, is probably the most influential ecological process available to conservation managers in Australia. In the conservation reserves of Queensland, the onus is upon the Department of Environment and Heritage to understand the dramatic effects it can have upon landscapes, habitats and species.

A monitoring program designed to detect such effects will hopefully be received enthusiastically by conservation managers, who will be able to understand, refine and even defend their fire programs with ecological information that they themselves have gathered.

The more senior Conservation Program line managers within the QDEH Far Northern Region will play a key role in prioritising this work. Staff involved in fire management, monitoring and research programs should be encouraged to incorporate adequate time in their annual work program to properly record the effects of their fire program on monitoring plots, fill in fire behaviour forms and ensure reports are written satisfactorily. This process will be satisfactorily completed only if the more senior Conservation Program line managers identify these activities as a high priority for their field staff.

Sue Warriner Laurance :
Wet Tropics World Heritage area of Queensland - **Fire monitoring data sheet 1**

SITE:________________________ OBSERVER:____________________
(national park name)

LOCATION:____________________ DATE:________________
(attach map of the burnt area)

Have permit conditions been met, adjoining landholders notified and boundaries secured ___
Attach permit. Fill in or tick the appropriate boxes below.

Weather

Data recorded at park_________ weather bureau__________
Approximate distance from park _________

Last effective rainfall
Days since rain <1____ 1-2____ 3-5____ 5-10____ 10-20____ >20____
Amount __________mm

Temperature start_____°C finish_____°C overnight temp_____°C

Humidity start_____% finish_____% overnight humidity_______%

Wind direction and speed start_____ at ______km/hr finish:_____at _______km/hr

Prevailing winds duirng lead up to fire ____

Comments:____

____

Ignition Description

Burn commenced at _______ am/pm Date_________

Final inspection at __________ am/pm Date _________

Type of burn: Broad area_____ area burnt________ha

Buffer ____ width _______m length________km

System: Aerial________ Ground_________ Other_________

Ignited with: matches_____ torch_____ Incendiary______ Other_________________

Pattern: Grid spacing_______ with wind_________ against the wind________

Comments:____

____

Sue Warriner Laurance :
Wet Tropics World Heritage area of Queensland - **Fire monitoring data sheet 2**

Topography (average or percentage)

0 - 5 degrees _____ 6 - 10 _____ 11 - 15_____ 16 - 20_____ 21- 25_____

26 - 30______ 31 - 35______ >35 ______

Fuel

Understorey description

Height
< 0.5 m_____ 0.5 - 1 m______ 1 - 2 m_____ >2 m______

Ground cover
< 20 %_____ 21-40%_____ 41-60%_____ 61-80%_____ >80%_____

State of Curing (see attached sheet)
<40%_____ 50-60%____ 70-80%_____ 81-90%_____ 91-100%_____

Dominant type of understorey __________________ (grass, shrub or sedge)

Dominant species (if known)

____

Time since last burn (years)
<6 months___ 6-1yr_______ < 2 _____ 2 - 5 ______ 6 - 10 ______ 10 - 20_______

Type of fuel
grass__________ leaf litter_________ branches_____

Percentage of ground covered by fuel
<10___ 10 -25 _____ 26 - 50 _____ 51 - 75 ______ >75_______

Fuel Quantity ______________tonnes/ha variation in fuel ____________________

Fire Danger Index Forest Fire ________ Grassland Fire ________
(McArthur wheel; tick if appropriate)

Vegetation description

Crown cover	Structural type & height (after Specht et al.)	
30 - 70%	Open Forest______ (10 - 30 m)	Low Open Forest______ (5 - 10 m)
10 - 30%	Woodland_____ (10 - 30 m)	Low Woodland______ (5 - 10 m)
< 10%	Tall Shrubland_____ (2 - 8 m)	Low shrubland______ (< 2 m)
Occasional tree/nil	Sedgeland_____	Grassland______

Sue Warriner Laurance :
Wet Tropics World Heritage area of Queensland - **Fire monitoring data sheet 3**

Fire Behaviour (within a vegetation type)

Flame height max__________m min__________m average____________m

Flame length max__________m min__________m average____________m

Distance travelled: 0.5 hr _______m 1hr______m 2hr_______m 3hr________m

Fire stopped because:

Area burnt to firebreaks_____ Deliberately extinguished______

Change of fuel________________ Went out overnight______

Other____

Comments:____

____

Post burn records (to be taken approx two weeks after burn and accompanied by map of area)

Time since fire_________

Describe the burn area continously______ patchy________

Comments____

____

Percentage of exposed ground ___________

Scorch height max_________m min_________m average__________m

Area of forest burnt

Vegetation	AREA (ha)
Tall Forest >30m	____________
Forest/Woodland 6-30m	____________
Tall Shrubland 2-8 m	____________
Heathland	____________
Swamp	____________
Grassland	____________
Other	____________
TOTAL	____________

Beaufort Scale of Wind

Beaufort Number	*Descriptive Term*	*M.P.H.*	*KM.P.H.*	*Specification*
0	Calm	1	2	Calm, smoke rises vertically
1	Light air	1-3	2-7	Direction of wind shown by smoke drifts but not by windvanes.
2	Light breeze	4-7	8-11	Wind felt on face: leaves rustle: ordinary vanes moved by wind.
3	Gentle breeze	8-12	12-19	Leaves and small twigs in constant motion wind extends light flag.
4	Moderate breeze	13-18	20-31	Raises dust and loose paper: small branches are moved.
5	Fresh breeze	19-24	32-41	Small trees in leaf begin to sway: crested wavelets form on inland waters.
6	Strong breeze	25-31	42-53	Large branches in motion: whistling heard in telegraph wires: umbrellas used with difficulty.
7.	Moderate gale	32-38	54-65	Whole trees in motion: Inconvenience felt when walking against wind.
8.	Fresh gale	39-46	66-79	Breaks twigs off trees: generally impedes progress.
9.	Strong gale	47-54	80-93	Slight structural damage occurs (chimney post and slates removed).
10	Whole gale	55-63	94-108	Seldom experienced inland: trees uprooted: considerable structural damage occurs.
11	Storm	64-72	109-124	Very rarely experienced: accompanied by widespread damage.
12	Hurricane	73-Over	125-Over	

State of curing

%Cured	*Colour*	*Physiological Change*
0	Green	From germination to commencement of seed head development.
10	Green	Seed heads formed and flowering
20	Greenish Yellow	Seed heads maturing and opening from the top.
30-40	Yellowish Green	Most seed heads mature and seeds dropping.
50-60	Straw-Odd patch of green or yellow green	Seeds dropped, half to third. Most stems green some paddocks nearly fully cured. Others show green.
70-80	Straw very little green showing	Some greenness in lower third of some stalks.
90	Straw	Odd stalk may show some green. Some gullies may show green.
100	Bleached	All stalks fully cured. Seed head and stalk break easily.

Fires can occur when fuels become 60-70% cured and will burn fiercely at a curing stage of 80-90%.

Fire monitoring and research in Kakadu National Park: An overview

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Introduction:

The third Kakadu National Park Plan of Management (POM; ANPWS 1991) provides guidelines for prioritising fire monitoring and research in the Park. Monitoring is required to assess the effectiveness of the Park's fire management program, and to assess fire impacts. To date, fire monitoring has involved assembling firescar data for Park using mostly LANDSAT MSS imagery.

Fore research, th POM prioritises the development of appropriate methods for protecting fire sensitive environments, and researching the ecological effects of different fire regimes, particularly for relatively fire-sensitive sandstone escarpment and plateau communities.

Fire research in the region predates the establishment of Kakadu NP, with the setting up on the Munmarlary fire plot experiment in 1972 by the CSIRO Division of Forestry and the Conservation Commission of the Northern Territory (CCNT); this study continues to the present. Subsequently, the CSIRO Division of Wildlife Research has established a further experimental program at the Kapalga Research Station, also within Kakadu.

As well as these experimental studies, considerable efforts have been given to the development of an Expert System for fire management, and the associated development of a PC-based GIS, using the ERMS system. Other current research includes studies f the fire ecology of paperbark communities and traditional Aboriginal fire management practice. A broad overview of fire monitoring and research programs undertaken in Kakadu National Park is presented below.

Monitoring

Day-to-day management

Up until recent times reporting of fires through the year was undertaken on Fire Report forms, with a separate form for individual fires. This system has been largely abandoned (except for reporting of unauthorised fires) in favour of field staff undertaking generalised mapping of fires in management districts. Funds have been made available for staff to undertake mapping from helicopters as part of the fire management program. While such data are relatively inaccurate (and cannot be used for deriving reliable fire histories, for example), they do provide staff with important information as to when and where burning has been undertaken; as such generalised mapping is a useful planning tool.

Fire histories 1980-present

Building on previous satellite-based firescar studies undertaken for sections of the park over a variety of years (Day 1975; Press 1988; Graetz 1990; see results in fire management paper), a complete record of the amount of burning undertaken up until the middle of the year, and also by the end of the dry season, will soon be available for the years 1980 to the present. The data comprise digital coverage of early burnt, late burnt, and unburnt country, for each year, based on interpretation of mostly hard-copy, 1;12 5,000 or 1:250,000. LANDSAT MSS false-colour prints (bands 4,5,7). Data for the years 1980-1990 were derived under consultancy from manual interpretation of LANDSAT MSS imagery. Data for the years 1991-1993 have/are being acquired using an interactive computerised process (DuRieu & Russell-Smithj 1993).

Coverages for each year are held on the Park's raster-based GIS, ERMS, using a grid-size of 100 m x 100 m.

Unfortunately, even a preliminary analysis of these data is premature, since it is apparent that data supplied for the years 1980-1990 require substantial verification and editing; in short, the data contain obvious firescar interpretation errors (e.g. errors of omission/commission of as much as 20%). Editing of these data is currently being undertaken. While ground-truth data are not available, for most years the park is fortunate to possess sufficient hardcopy LANDSAT MSS imagery over the dry season to assist re-interpretation. Ideally, the availability of even monthly records is desirable for interpretation, especially in the early dry season when fire scars tend to vanish rapidly due to regrowth, and are typically small in size. A further problem at the end of the dry season is substantial cloud cover on some imagery.

Lessons learned from the 1980-1990 data thus include the requirements to: ground-truth; sample at least a couple of times in the early mid-dry season; maintain close involvement with data collection; and employ reliable consultants. While ground-truth data are not available for 1991, and for 1992 an exercise involving aerial mapping of firescars using GPS proved too inaccurate, effective ground-truthing undertaken in 1993 will provide useful estimates of the accuracy of firescar mapping over 1991-1993 given that the same interpretation methodology has been applied throughout.

Future fire history data acquisition

An important feature of the firescar mapping program is that our current consultant is required to provide us with interpreted firescar data on 1: 100,000 and 1:250,000 maps within 6-8 weeks of the satellite overpass. This feature is obviously very useful for management purposes as it keeps field staff in touch with the data (i.e. we can evaluate our performance as we go along), as well as providing feed-back to the consultant concerning areas of likely misinterpretation.

While this program is proving successful it is also expensive. Costs for acquiring, interpreting, ground-truthing, and installing digital information for 1993 alone, probably amount to $35,000.

More significant for future firescar monitoring in the park, however, is the impending decommissioning of the LANDSAT MSS scanner. Currently, LANDSAT MSS provides us with data at an individual pixel size of 57 m x 82 m resolution. Future options include using more expensive, fine resolution imagery (e.g. LANDSAT TM with a pixel size of 30m x 1.1 km x 1.1 km). This assessment is currently being undertaken. Further, it needs to be borne in mind that no available imagery provides useful information on cloudy days such as commonly occur in the build-up season (Oct-Dec), at a time of year when fires in monsoonal Australia are still prevalent.

The ecological effects of fire

While broad-scale satellite monitoring provides useful data for monitoring the general effectiveness of the park's fire management program (e.g. how much of the park, and of specific habitats, is burnt at different times through the fire season), we have not as yet put in place a program which monitors the ecological consequences of our fire management. However, over the past year or so considerable attention has been given to developing such a program.

A first consideration has been recognition of the need for field staff to have direct control of the program; after all, they are the ones who undertake fire management. The system proposed thus has to be acceptable to field staff, require relatively little time to undertake (given that the fire season corresponds with the major tourism peak), and be useful. As such, we are proposing to develop a system of strategically located photo-points which will require photo-sampling twice (early - mid, and late dry season), or at most three times a year if wet season burning is undertaken. Such data provide for a very reliable fire history record of individual sites and, if selected to sample a representative range of habitat conditions, will provide a powerful learning and analytical tool.

Given that we will soon have five management districts in the park, our intention is to establish about 100 photo-points, with 20 or so per district. Current thinking suggests that the locations of at least half the photo-points need to determined by district staff, and include sites where fire management (including fire exclusion) is actively undertaken (e.g. art sites, facilities, rainforest springs). The other half need to be established systematically so as to capture as broad a range of habitat conditions as possible.

While such a program is intuitively simple, a major stumbling block up until the present has involved the reliable storage/retrieval of large numbers of photos/slides. Technological developments, however, now mean that digital colour cameras are available, and digital photo information can readily be down-loaded for storage on CD-ROMs, and display and analysis on PCs. Such information can be kept in the district office, with occasional archiving onto a central system.

Research

Fire experiments

1. Munmarlary Fire Experiment

A regionally important experimental study of the influence of fire regime on open forest and woodland savanna vegetation was established at Munmarlary, in Stage 2 of Kakadu National Park, in 1972. The experiment was designed to test for floristic and structural changes in vegetation resulting from four separate fire regimes: annual early dry season burning (May-June); biennial early dry season burning; annual late dry season burning (Aug-Oct); and complete protection from fire. The experiment design consists of the four fire treatments applied to separate one hectare plots laid out in three replicate blocks. The experiment continues to be maintained by the CCNT with, in recent years, assistance from Kakadu.

Results from the study to date (Hoare et al. 1980; Bowman et al. 1988) indicate that, with complete protection from fire, dense understoreys develop in both open forest and woodland. However, after 13 years only slight structural differences were observed in burnt treatments, and no marked floristic change was observed under any fire regime. Other published studies based on the Munmarlary experiment plots comprise studies of the responses of birds (Woinarski 1990), ants (Anderson 1991), and epiphytic orchids (Cook 1991).

While the experimental design itself has its weaknesses (cf. Bowman et al. 1988; Woinarski 1990; Lonsdale & Braithewaite 1991), it is evident from results to date that: open forest and woodland plant species are highly resilient (persistent), even in the face of intense, annual burning; and that structural, though not necessarily floristic, development will occur in the absence of fire.

The future of the experiment is now up for assessment. A consultant has been employed to assemble the full data base and, once this is received and the utility of the data assessed, it is probable that a complete resampling will be undertaken early in the 1994 season. Follow-up work will comprise the writing up of experimental results, and the assessment of ongoing requirements.

2. Kapalga fire experiment

A second fire experiment has been established at the CSIRO Division of Wildlife & Ecology's Kapalga Research Station, also within Stage 2 of Kakadu National Park. Commencing in 1990, this is a multi-disciplinary, landscape-scale investigation of the effects of fire on vegetation and fauna, principally in open forest and woodland savanna. The experimental design comprises four fire regimes, each with three replicates, conducted in compartments each approximately 15 km^2 in size and comprising a drainage catchment.

The treatments used in this study comprise: annual early dry season burning; annual progressive burning from early in the dry season, followed by further burning as vegetation cures downslope; annual late burning; and a natural regime where no human-lit fires are applied. To help interpret the effects of these four regimes attention is being given to quantifying fire behaviour (e.g. rates of spread, intensity, flame height). The experiment is planned to run until 1997 (e.g. Andersen & Braithwaite 1992).

3. Fire and floodplain paperbark communities

As an extension to work being undertaken at Kapalga, a research student is currently investigating the response of *Melaleuca spp.* to fire in riverine floodplain and wetland habitats. Such work emanates from observations of heavy mortality in mature paperbark stands, and current lack of understanding of regeneration processes. This study potentially has much relevance for management of floodplain and wetlands; for example, the role of fire in excluding paperbarks from seasonal *Eleocharis* swamps and other wetland habitats important for supporting waterbirds.

Expert System and GIS

Considerable efforts were given in the 1980's to the development of expert systems and other fire simulation models, ostensibly for use in Kakadu National Park (e.g. Walker et al. 1985; Hoare et al. 1986; Moore & Noble 1987). While of conceptual value, these systems have never, and are unlikely ever to be used, in day-to-day fire managements and the reports lie idle on the shelves.

More functional, but still under-utilised, is the park's GIS, ERMS. As well as fire history coverage still being edited, other coverage include elevation (20 m topographic contours), geology, a vegetation habitat map at 1;100,000 scale (Schodde et al. 1987), and various other databases concerning the distribution of weeds, flora, art, and archaeological sites, etc. For other than generalised analyses of fire history data, however, there is a requirement to further develop the habitat map at much larger resolution (e.g. 1: 25,000) given both:

1 evident spatial inaccuracies in the 1:100,000 coverage; and

2 that many sensitive habitats/species distributions are very localised in extent and have been omitted, doubtless as a result of mapping at the relatively small scale used.

The first phase of such a program was commenced this year, with the purchase of rectified base-maps derived from satellite imagery.

Traditional Aboriginal fire management practice

Despite much of the park comprising Aboriginal land, that traditional owners and other Aboriginal people continue to hunt and burn in some areas of the park, and that one of the stated objectives of fire management is to maintain, as far as practicable, traditional Aboriginal burning regimes within the park(ANPWS1991), until recently little documented material has been available on this subject. Studies of traditional resource utilisation and fire management practice in Kakadu's lowlands and wetlands, however, are now nearing completion. These data include extensive video documentary material and interviews, and provide powerful reinforcement for the utility of actively pursuing fire management: if you don't burn early, then you are likely to get burnt out.

Discussion

As outlined above, considerable fire monitoring and research activity has been, and continues to be, undertaken in Kakadu National Park. With respect to monitoring, in the near future we will have available edited, annual fire history data from 1980. As well, we are looking to install a photo-point program which will enable field staff to monitor the long-term effects of their fire management; the challenge is to develop a program which is simple and effective. Maintaining generalised maps of the burning program undertaken by field staff over the year is clearly useful also.

Substantial research effort has been given to fire experimentation, particularly with respect to the responses of open forest and woodland communities in the northern lowlands. Other habitats have received relatively little attention. Such research doe not necessarily require the establishment of expensive experimental programs, however, as GIS technology offers interesting opportunities in this regard. For example, armed with good (accurate) fire history data and a detailed habitat map, one can readily sample for the response over time in particular types of vegetation (and fauna) after a known fire event, without having to impose a long-term experimental regime. Equally important, the use of GIS would enable the researcher to describe the broad range of fire regimes experienced by any one type of vegetation, and sample accordingly. At the present time, the experimental studies so far conducted assume mostly annual or biennial burning.

The Kakadu Plan of Management provides useful guidelines with respect to fire management and identifies a number of practical goals; for example, the need to restrict the widespread occurrence of severe late dry season fires. Refining our goals and identifying means for achieving them requires research. Monitoring our performance is clearly essential if improvements are to be made. I trust that some of our experience in Kakadu, be it positive or negative, may be of use to land managers across northern Australia.

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Fire monitoring and data collection in the Kimberely Region.

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As was mentioned at the first workshop, the establishment of monitoring programs in the Kimberley aimed at assessing issues associated with fire is very much in its formative stages. As the regional ecologist I am currently working on three projects, of which two have been discussed, in part, previously. In order of work priority these are:

1. The Interaction of Fire and Cattle and Their Impact On Rainforest Patches.

This project has been part funded by the ANPWS and has involved CALM's research staff, operations staff from the Kimberley Region, as well as other people considered experts in their field.

For five rainforest patches, three on the Mitchell Plateau and two north of Kununurra, the study is based on seeing what happens to the patches once cattle have been excluded. At present three of the patches are either partly or fully fenced with another one being fenced later this year.

It is intended that for these areas an extensive data base will be built up on their flora and fauna. Associated with this is a baseline monitoring programme which is a series of transects through each of the patches. At 10 meter intervals along the transects data such as presence of rainforest plant percentage canopy cover are recorded. These transects are monitored each year in October when it is thought the patches are the most stressed.

At one patch, Point Spring Nature Reserve, some preventive fire management takes place each year which involves burning buffer areas around the patch.

As was mentioned in an earlier report a late dry season fire in 1992 affected the patches on the Mitchell Plateau. One half of a very small patch was burnt. An inspection in June of this year showed that the edge of the patch has changed and a small outlier of vegetation had been destroyed.

A thought is that there may be a critical size for a rainforest patch where fencing the area off does not stop the deterioration process. The impact of cattle and fires is replaced by the impact of fire burning through high fuel loads. The dilemma is that cattle grazing and trampling may be reducing the intensity of fires coming up to the patches.

It is intended that this yearly monitoring will continue for a further five years with a review of the project at that stage. In that time other 'types' of rainforest may be added to the programme.

An aim of this project is to clearly document what people have seen as occurring to these patches and to raise peoples awareness of this process and ways in which the deterioration process can be at least stopped and perhaps reversed.

2. Fire Impact Monitoring - Purnululu National Park

Two plots adjacent to each other have been selected in the Purnululu National Park. One is a 'no planned burn' area the other a control. The plots have an area of approximately 1 square kilometre and are in an area of eucalypt woodland on red sandy soils at the southern end of the Bungle Bungle massif.

The aims are;

Design a simple monitoring program. Baseline data collection should not require special skills and not need to be undertaken by the same person.

Monitor any changes which are occurring to the vegetation of the park under the current fire regime.

If the design is seen as successful then similar plots could be established for other conservation areas in the Kimberley.

Currently, it is felt that there is a potential for large, damaging fires to occur within the park. Some protective burning is undertaken but the extent and timing of these needs to be more fully explored. Little is known about the impact of the current fire regime upon the environment over time.

It is intended that an easily replicable series of baseline data will be acquired for the no planned burn plot and the associated control plot. Attempts will also be made over time to build up a comprehensive picture of the flora and fauna of the two areas. This will be achieved through general flora collection, pit trapping and fauna observation. The input of specialist research staff will be sought wherever possible.

The transects have only recently been put in place. These run approximately north-south and east-west. Measured every 20 metres:

Number of plant species (Grasses and other)
% cover
Rod contacts

Approximately 25 points are assessed on each transect.

These baseline data will build up a picture of the general vegetation structure. Photo points are also included.

3. Monitoring of *Callitris intratopica* Stands

The design of this programme is still very much in its early stages.

It has been noticed by a number of people that there appear to be a large number of dead trees of this species. Some comment has been made that the pure stands of this plant appear to be diminishing and that fire is the main cause of this.

Is this species moving toward a status ob being threatened?

Can it be used as a indicator of change in the vegetation community in which it is found?

Sections of the Gibb River Road have been selected and along these the number of dead and alive cypress pine and their location are recorded. The latter is done using a GPS. Plants are recorded which are within approximately 100 metres of the road and are visible from the road. Again it is hoped that the base line data collection will be a simple process.

Dependant on the outcome of the baseline data collection consideration is being given to monitoring specific groups of the plant.

A literature review is still underway and input on the design of the project from other people is also being sought.

Fire monitoring and data collection at Munmarlary : The last twenty years.

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Conservation Commission of the Northern Territory

The Northern Territory (NT) has a long term fire ecology monitoring site situated in Munmarlary. This monitoring site has been established for over 20 years. The idea was to find out the effects of burning upon the ecosystem and to use the data to underpin management decisions and produce a predictive tool in terms of fire management models. Any model is only as good as the data collected and the extent of the assumptions built into it.

When approaching a monitoring regime it is important to establish the parameters to be collected and to include all variables both controllable and uncontrollable (for example external conditions). To develop a robust management model it is advisable to collect a discrete amount of data and to try not to produce too elaborate a project. In the Northern Territory some of our more diverse ecosystems in terms of structure and species richness are the open forests and woodlands. A minimum data set was established with stringent burning regimes and a long term objective of monitoring for up to 30 years.

The following were addressed when setting up the trials:-

1. **Cultural History**

   It was seen appropriate to choose an area which had had limited post 1788 interference. Aboriginal interaction in the area was taken into account. Also the most pristine areas in terms of native vegetation where chosen, it included the active exclusion of areas of weed infestation. Also an area which could be controlled by the Commission was chosen, this was to ensure maximum protection of the area from fires and other management interference.

2. **Northern Territory Condition**

   The NT is a vast area generally sparsely populated, interspersed with densely populated areas. This amount to huge areas requiring fire management. The climate of the NT is somewhat severe in that for up to seven months of the year there is a dry season where very little rain falls and the opportunity for wild fires is rife. The NT also is an area where there is a diverse range of vegetation types of differing sensitivity to fire which require different management techniques.

3. **Aims of Monitoring**

   They are to establish as far as possible effect upon;

   The vegetation - Its composition and structure in both the short and long term. The following questions are to be answered:
   Are these species adapted to frequent hot fires or do they put up with intermittent cooler fires. What is the natural climax community for the given area. What species cause fire build up?

4. **The Fauna**

   How do they respond to fire regimes, are small islands of unburnt vegetation enough to sustain a given species? Obviously, this is tied to their size, and mobility.

5. **Soil**

   How well does the soil reserve respond to fire? This is afterall the basis upon which vegetation invades an area. Does the regular depletion of the organic layer through burning have direct effect upon the species colonising an area. There is also the physical effect of the fire which causes the crumb structure of the soil to break down yielding it prone to both wind and rain erosion.

6. **Seed Bank**

   How does the fire effect the propagule bank? It encourages some species to germinate but kills others. Again, this effects the overall community composition.

Monitoring

The Mumarlary fire ecology trials are set up as follows:-

1. Two sites selected, each were as representative as possible in terms of vegetation type and soil type, and homogeneous within themselves. One was in the Kay land system (tall open forest) the others in Jay as described by CSIRO. Each plot consisted of three blocks made up of four treatments giving three replications.

Treatments

1. Burn annually early in the dry season to simulate control burning.
2. Burn annually late in the dry season to simulate wild fire.
3. Burn bienially in the dry season to simulate the alternatitive control burning.
4. Unburnt.

Design

Each treatment was of 100 metres square.

Vegetation sampled :

1. ground strata
2. 0-2 metres (shrubs)
3. 2-8 metres - small trees
4. 8 metres + - large trees

1. Ground strata vegetation

   20 randomly located 1 metre square quadrats - +/- measured - stereo - photos were taken of each plot.

   Conventions of recording were established - in the plot if > ½ rooting system at ground surface was in the boundaries of the plot.

2. 0-2 metres

   50 x 2 metres randomly located - identified and counted.

3. 2-8 metres

   50 x 5 metre plot - all non eucalypt species were noted and height classes recorded.

4. 8 metre +

   a) All eucalypts with a 50 x 10 metre plot - 5 metres either side of the random point.

   b) 50 x 2 metre plot

   c) 50 x 5 metre plot

Soil profiles were taken each time and the 0-10 cm and 10-35 cm layers described.

Fire Behaviour Measurements:

Fuel type prior to burning, cloud cover and time and date of commencement of lawn were recorded. The rate of foreword spread is measured, locating the perimeter of the fire at 1 or 2 minute intervals. At this time flame height, flame depth, flame length and angle to the horizontal are recorded. Other general fire behaviour characteristics such as spotting, shape of fire, direction of fire in relation to slope and wind and fuel type and weight in front of the head fire were recorded.

- flame height (vertical height of flame)
- flame length (actual length of the flame)
- flame depth (width of the surface of the fuel in the head fire)

Lighting Techniques

Early burns - lit from spot and were allowed to burn until the plots were burnt out.
Late burns - burnt by a line. Fire burning with the wind.

Fuel Study

Prior to lowering the plots 5 randomly select permanent quadrats are photographed in stereo in order to describe fuel weight, type, structure, packing ratio and base areas. This occurs a couple of days before the burn.

The result of the 20 year regime are presently being compiled and analysed by Jamie Hoare in Canberra and the results should be available early next year (January 1994).

This type of data collection and monitoring is very time consuming and costly. Other methods of monitoring are being developed which will complement these types of long term studies. Such methods are described by Tim McGuffog (in this proceedings) who discusses such technology as the geographic information system and remote sensing techniques as used by the Commission.

Fire monitoring and data collection : Conservation Commission of the Northern Territory.

Tim McGuffog
Senior Fire Control Officer
Bushfires Council of the Northern Territory

Introduction.

Fire research and monitoring have been conducted in the Northern Territory since the mid 1960's when a Fire Research officer was appointed to the Forestry section of the then Commonwealth Department. Various projects were undertaken including the establishment of the Munmalary trials which was initially part of a national experiment and to my knowledge only it and similar trials on Black mountain in Canberra are still conducted today. Other achievements include the establishment of The Bushfires Council and it's Legislation to primarily assist the pastoral industry.

Various other trials such as the Fire behaviour and fire break experiments at Annaburroo in the early 1980's were also undertaken. These trials were part of a joint experiment with CSIRO Fire research to produce a grassland fire danger meter for the Tall Tropical Grasslands of the north.

Current Situation.

The Bushfires Council of the NT has conducted most of the Aerial controlled burning operations over the Top End up until the last 5-6 years. We still conduct operations on behalf of landholders and managers and this includes CCNT parks and reserves. ANPWS also conduct their own operations in Kakadu, however, we still assist in burns on the boundaries with adjoining pastoralists. Monitoring of these operations has taken place to the extent that we have hand drawn maps of operations and records such as burning times, dates, and capsules used for our operations back to their inception.

There has been some recent progress in the digital capture of these operations which is being developed from techniques currently used to map fire history in Central Australia. Some work was conducted in the late 1980's in producing Fire scar maps for the Top end. NOAA satellite images were purchased and rectified and using enhancement techniques developed by CSIRO in Alice Springs and we were able to produce fire scar maps using Microbrian software. Problems including the inability at the time to transfer information onto the Commission's Arcinfo GIS and other problems such as lack of resources and manpower to develop the system lead to it being put on hold until recently.

Future Directions.

We have recently been able to employ a student in Alice Springs to continue with the development of this project. She has been able to produce May and June 1993 Fire scar maps which can now be transferred onto the GIS giving us to opportunity to utilise other information in conjunction, such as pastoral boundaries, vegetation types, land systems, and greenness indexes.

In 1994 we intend to utilise GPS in our aircraft to accurately map aerial burning runs which will later be compared with fire scar mapping. This will afford us the opportunity to better assess the effectiveness of our operations and to develop better planning in the future.

Problems we foresee with this type of imagery include the scale of the NOMA scenes. The one square kilometre pixels are obviously too course for monitoring areas such as the average park or reserve which will eventually require the use of smaller scale imagery such as Landsat. Another problem with the scale is the averaging of pixels in fire scar mapping. An area which is predominantly burnt will show up as being all burnt on the map, and so, is not a true reflection of the actual situation of mosaic or patch burns which we are trying to achieve in our early burning operations. Another problem is the large amount of ground truthing needed to be carried out to verify the scenes. As distinct from the arid zones of Central Australia, areas of the Top End burn annually if not biannually. There is also a rapid recovery after fires, particularly with early burning, green shoot and new leaves will occur in 4-6 weeks. The effects of this spectrally to the NOAA satellite has yet to be determined.

Despite these drawbacks we intend to continue to support this work as it is obviously a much more dependable and potentially powerful management tool which will suit our operations. Further avenues of development include the possible use of greenness indexes to plan the time of commencement of burning operations and possibly in the future to estimate fuel loads across the NT. We are also working with the Bureau of Meteorology in the development of NOAA imagery processing, with the possibility of one day having the software and techniques to enable them to produce regular fire related information for public use.

Fire monitoring in the NT is beginning to take place at a greater pace with the development of computing and satellite imagery techniques. There is still much more work required by all the organisations who use fire as a management tool. Parks and reserves across the Top End need to develop appropriate monitoring of fires so as to capture fire history and enable forward planning. There is also a need for greater cross flow of information between fire managers if we are to avoid reinventing the wheel . Forums such as these will only serve to improve the way in which we collectively monitor fire effects and history across the Top End as well as fostering an exchange of ideas, observations and new or improved techniques.

Monitoring prescribed fires in north Queensland-what are the issues and how might we solve them with a monitoring program?

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Townsville

Before addressing this topic I would like to point out that the *proformas* I have developed and the instructions required to use them (for both field and management staff) are attached as Appendices to this paper. Rather than discuss them at length I would prefer to address the issues with that I believe are important following my experience with monitoring prescribed fires.

Firstly, I think we need to examine the current situation in terms of monitoring prescribed fires in north Queensland, which, as all of our presence here suggests, is far from optimal. Please note that my experience with fires of this nature is limited to HINP with all its associated constraints of access and limited fire control possibilities. As I understand it, this is essentially what takes place if a program is to be initiated in a given park;

(i) a fire management plan for the park is formulated and eventually submitted and finally accepted (with or without modification),
(ii) the optimal conditions are sought in which to conduct burn(s) to achieve the desired management results,
(iii) the fire is ignited, with a fairly straight forward sheet being filled in about the weather, who was there, a few details on the burn itself, and maybe a few photos if fuel pickets have been set up at the site. Staff check the burn constantly to ensure safety of park users etc. until the fire is completely out. This may take up to a week in some instances,
(iv) some time later when time permits a follow up trip is conducted with photos taken for post-fire comparison, and the extent of the burn and the types of vegetation affected recorded,
(v) if we are fortunate someone like Peter Stanton is on hand to recommend times to burn, observe post-fire regeneration etc., and
(vii) in some parks e.g. White Mountains National Park, fire monitoring programs are well established and producing good results as Mick Jackes has shown us earlier this morning.

Although this is a reasonable start given the limited resources available to field staff, I would argue (and I'm sure many of you, particularly having heard about some of the systems now in use in other states would agree) that this is far from good enough, particularly as fire management has become one of the main tools we use to manage our park estate. This is obviously the view of the DEH or it would not be holding a conference of this type, which follows on from the workshops Peter Stanton and Keith McDonald have run over the last few years in Townsville to establish fire management plans for all national parks across the state. Further, as pointed out by earlier speakers (e.g. Jeremy Russell-Smith), the simple burn report currently used by many organisations is of limited use in its current form.

Secondly, I would like to draw attention to the classic discussion of the problem of time, resources and money being insufficient to improve the situation. I realise that in many cases operational staff are very busy and working with limited resources. However, once permanent monitoring sites are established (which is the biggest time period that has to be set aside), then the actual monitoring requires very little time. Some monitoring programs (like versions of the one developed by Malcolm Gill and now used in several states) is designed to take less and less time as the program proceeds. Indeed, if we are to truly achieve professional fire management, then there are several objectives listed by McGrath (1985) that need to be met;

(i) a basic biological survey (flora and fauna) and fact finding mission, determination of fuel loads and management objectives,
(ii) area specific fuel accumulation measures, including patchiness of fuel,
(iii) hazard or risk assessment. This should not be based entirely on fuel loads, and optimally would include likely ignition sources, weather data, shrub fuels (importance of live and dead categories in sampling), likely boundaries-natural or man-made, property locations etc., and
(iv) computer modelling for fire spread and vegetation succession.

The fourth of these objectives is probably the least of our concerns at this stage, particularly since a very large amount of data collected and analysed over specific areas is required for the models to be of any use. However, the first three are very pertinent and I will refer to them as this talk progresses.

One very important point is that both regional and local management staff realise the necessity of this work and allocate adequate time/resources for the field staff to get out and do the monitoring. Further, time must be allocated to examine the results, store the data in whatever format is decided upon, and write reports/notes/leaflets that inform the relevant people about the programs progress. This **must** include the general public as they are the ones we have to convince about the whole nature of the fire management program.

There is also the difficulty of what to include in a monitoring program coming from an ecological viewpoint. I have researched quite a few areas such as seedbank ecology, but to get successful and meaningful results requires a substantial input of time and effort. In fact, the truly successful research programs are very large scale, long-term experiments such as those underway in the N.T. that take into account a wide range of variables including fire season, intensity and frequency. In addition, these experiments are conducted at the landscape scale to allow true experimental replication and ensure meaningful outcomes from the work. But they require huge funding and personnel allocations that we simply do not have. As Peter Stanton has stated on many occasions, we simply cannot wait for research to provide all the answers. Fire related research is at best a complex and long-term process.

So what is feasible to achieve? This introduces the concept of a minimally sized, but useful data set. I have simplified and re-simplified what I have put together in terms of monitoring sheets, but if simplification is taken too far then the information that is derived from them essentially becomes useless. Gill and Nicholls (1989) describe methods of selecting minimal sites and, more importantly, minimal species by eliminating those that are perceived as secure. These species include;

(i) annuals, biennials and some fire ephemerals that will set seed within a year and therefore survive even the highest frequency of fire,
(ii) those with vegetative recovery such as coppice. Not necessarily all species with this mode of regeneration should be disregarded as repeated fires will lead to a decline in their numbers, (I am not sure I agree with this if these species are pre-dominant in the regeneration process i.e. becoming dominant over other species that may have been present),
(iii) ferns. Although little is known about their fire recovery, the presence of spores seems to indicate that they will survive fire (this is supported by what I have seen on the HINP), and
(iv) species that have suffered high levels of mortality following fire should receive a concentrated monitoring effort.

This method, however, assumes that the existing fire frequencies are too high, and therefore tends to concentrate on fire-sensitive species. There is also a need to classify all species according to the mode of regeneration that they exhibit, and Malcolm Gill has now established a national register for such data (Gill and Bradstock, 1992).

Gill and Nicholls (1989) also address the important issue of fire frequency. They suggest that the minimum time between fires be double the juvenile period of the species with the longest juvenile period. This will vary depending on the management objectives, and will be of little use when wild fires interrupt a prescribed burning plan.. I would hasten to add that in the case of, for example, Graham Range National Park then this is unnecessary, but as previously mentioned this paper assumes from the start that fire frequency is too high. This data will also be a long time coming in many cases in the tropics. Another rule of thumb is that when 50% of a species in a population/area have become reproductive then seed production is adequate. I also assume that this notion has not been tested in the tropics. Additionally, it will beyond the predictive ability of any *pro-forma* that is accepted for use to assess this type of information.

The most important variables that I think we should be monitoring include species diversity, fuel loads, and changes in community composition and structure. Anything less than this is unacceptable, whilst any additional information e.g. soil responses which can be gathered over the long term may be very important. Keep in mind that fire, and just as importantly lack of fire, have both been responsible for extinctions of species alike. So we are utilising a powerful tool, that used responsibly can achieve management objectives such as the maintenance of habitat (and therefore species) diversity. There is also a need to consider faunal communities at some stage. Gracefully, I will leave this topic for someone else to address.

I should also say that we need this information regardless of the management aim. You may argue that it is pointless to monitor the effects of fire if you know you need to light three fires in six years to recover open forest from coastal vine forest e.g. Graham Range National Park (a successful operation). However, we must start to accumulate more information than experience, a map and a set of before and after photos, particularly if we are to convince the public that active fire management is the way to go. No doubt many of you deal with concerned people from all backgrounds from lay people through to experienced ecologists (some of whom I might add have quite an incomprehensible, ignorant knowledge about fire management). They will ask what about the effect on the mammals, the insects, the litter fauna? etc. Thus we must have a baseline system established to start recording as a minimum the changes in the vegetation communities in the park estate. This is particularly important given that parks staff are constantly reshuffled around the park estate.

Further, wherever possible we must have control sites that are left unburnt. In some cases this will be quite difficult, and I have had problems with this on HINP where fire control is difficult once ignition has taken place. However, in most of our national parks this will not be the case. These sites are essential so we can actually show people the results of our work. Without them, the results from the plots that have been burnt become much less useful.

So lets now look at what needs to be done at a site to get the information we need. Note that effective management is a process of inventory, survey and finally monitoring (Gill and Nicholls, 1989). The following points take into account these criteria.

1. Detailed species collection of all layers of a vegetation community including epiphytes needs to be conducted. This should culminate in the formation of a simple botanical field herbarium that aids any good local literature available on the plants in a given park e.g. Betsy Jackes' guide to the plants of Magnetic Island and the Burra Range. This must be useful to local staff, and should not become part of the main DEH herbarium but be kept in the local office to which it is the most relevant. I cannot emphasise how important it is that these specimens not be incorporated into the main herbarium. This has happened to an excellent field herbarium for HINP which is now of no use to the staff who need it most. Neither is it important to identify every species, just give them a number or letter, it is the number of species that is important, and we also need everyone to identify species correctly. Plant species can simply be photocopied and the resultant sheets stored in plastic folders in an A4 binder.

2. Establish photo sampling points (see Appendix 3 for instructions). Although a copy of the photos must be kept at the local office, I don't see why we are not using these in public education to help overcome the "all fires destroy the landscape" viewpoint. For example, on HINP, Peter and I know that every species that was present there before the most recent prescribed fire (including species commonly perceived as fire sensitive e.g. sundews) are there now. But who else does? Certainly not the general public. I feel this sort of information must be passed onto the public via education programs. The photos that Mick Jackes has used on his poster of monitoring from the White Mountains National Park shows just how useful they can be. Further, with a bit of extra effort, we could be accumulating very valuable information on growth rates, degree of coppicing following fire etc.

3. Structure sampling quadrat(s) or narrow belt transects (such as those used by Andy Gillison) need to be established in representative areas (see Appendices). In my thesis I am utilising five 10 x 10 m quadrats at each site. However, this number may be unrealistic (particularly for staff with multiple parks and diverse vegetation communities), and I therefore suggest that you start with one in the area to be burnt. Further plots could be added as time permits. Collect heights, dbh data for all trees > 1.5 m. Record all individuals that are < 1.5 m, particularly seedlings of the dominant canopy and mid-storey species. Count dominant understorey species (e.g. grasstrees). Quadrats must be marked sufficiently i.e. at least all corners with a peg, tag and flagging tape. This may seem like overkill but after a fire you need all the help you can get. Particularly in more complex vegetation types, it may be important to incorporate some nearest neighbour techniques similar to those outlined by Steve Goosem of the DEH in his *proforma*. This enables a reasonable assessment to be made on some of the spatial characteristics of the vegetation community in question. However, Kershaw and Looney (1985) strongly recommend that the advantages of counts made from plots far outweigh the modest disadvantage of time requirement for the establishment of the plots themselves. I have also obtained some useful data by placing small scale quadrats (1 x 1 m) in each corner of the plot and the middle as well (n=5). Abundances of all species in these quadrats is monitored. This provides useful information on changes in composition, germinations etc. that larger scale sampling cannot provide.

Sampling frequency must also be addressed. Optimally, about four trips aimed to coincide with the main seasons of the tropics would be conducted. However, this is unrealistic for remote or poorly accessible parks. Solutions to this will need to be discussed, as I think it will be important to establish a monitoring system that is reasonably uniform across the area we are considering wherever possible.

In my experience, vegetation type often dictates the type of sampling that is used to obtain the most meaningful and useful results. The DEH needs to decide if it wants to adopt a uniform sampling strategy for all vegetation types. If this is the case (and I imagine it will be if data is to coded onto G.I.S. systems), then the plotless sampling method utilised by Steve Goosem may be the most appropriate method to adopt. But I would add that this seriously compromises the data that is collected, and unless several central points are established then total habitat diversity will never really be addressed. For example, even in a monotypic community like *Melaleuca viridiflora*, there is usually substantial variation in species composition within the total area of the forest type. Alternatively, if several forest types within a park need to be sampled, then attempting to sample total habitat diversity will be almost impossible. We also need to determine if the DEH perceives any degree of replication in this sampling as important.

To look at the type of data that can come out of the structure sampling quadrats, I've prepared some of the data from a community of *Melaleuca viridiflora* on Hinchinbrook Island (Figure 1). This method gives us easily obtained, precise information on community structure, and allows for direct comparisons once fire has occurred. For example, this data was taken before the prescribed fire on HINP. After the fire, one of the categories (individuals < 1.5 m) doubled in abundance. The outcomes of this and other results needs to be addressed carefully. What is the effect of reducing large numbers of individuals approximately 1.5 - 3 m tall to ground level coppicing? How many times can they sustain this kind of treatment with a ten year fire frequency? These are the sorts of questions we will be able to approach with much improved confidence if we have this kind of information available. This approach also give us the densities of any size class that is measured.

Because these plots also record all the species present in them it is possible to monitor changes in species diversity with changes in various environmental variables (e.g. rainfall) if they are available. Recording of other pertinent information such as times of flowering etc. will also be valuable to the formulation of more responsible fire management practices. The dimensions of these quadrats could be changed so that they represent a belt transect similar to that used by Gillison (1989) in tropical vegetation.

4. There is also scope to target specific species if that is seen as important in the management plan of a given area. Tagging to measure densities, growth rates, mortality etc. are all feasible with little effort in the field. The aluminium tags I've used in the past are useless if fire intensity is even moderate. I therefore suggest stainless steel tags (the DEH has such a tag machine somewhere and these are very good), or if this is a long process of requisition forms, waiting etc. then do what I do and cut up aluminium drink cans and use those.

5. There is also other site information that should be collected e.g. fuel loads. To collect adequate samples in the field takes less than half an hour. Then they need to be separated into live and dead material and oven dried at 80°C for 24 hours if possible. Given that fire affects the litter fauna it would at least be good to know whether we are affecting the composition and loading of this part of the ecosystem. Once again I have prepared some data from a site on HINP (Figure 2). Note that it is important to collect data before the fire to give a reasonable indication of the pre-fire situation. As the figure indicates it may be some time before all aspects of the fuel layer are restored to pre-fire levels.

6. Establishment of a similar plot in a comparable area that is to remain unburnt. This site must be afforded a sound method of protection. It must also be monitored whenever the experimental plot is so that we can get a handle on the natural variation occurring within a given vegetation community. This will then allow for useful comparisons to be made with the experimental plot.

The *proformas* that are eventually used will depend on what is agreed upon here in terms of what exactly will be monitored i.e the number of plots necessary (if plots are decided as suitable), how many vegetation types in an area are to be examined etc.. Further, different vegetation types may need to use different methods. For example, in closed forest (particularly coastal vine forest) it becomes very difficult to assess even a 10 x 10 m plot due to restricted visibility and access through the site. This will need to be taken into account when the sheets are finalised. Similarly, the sheets must be designed so that they are coded in such a way to allow incorporation into G.I.S. systems.

In each office an employee must be appointed to be in charge of all aspects of the monitoring program. This must include the training of new staff. The monitoring program should also monitor the effects of any "naturally occurring" fires, as these may result in the need for changes to the existing fire management plan.

I also think it is important that someone is appointed to develop the monitoring forms (complete with instructions for both management and on the ground staff) to completion following these talks and the forum that is to follow. I am willing to help in this process and will obviously contribute what I have already considered and formulated as part of the initial work I conducted for the DEH on HINP. I am open to suggestions from anyone about the nature of these forms and alternative sampling strategies that could be employed to best monitor the effects of fire on the national park estate in north Queensland. I particularly urge operational staff to become involved in this process, including continual feedback about the success of the adopted program and any perceived improvements to the monitoring process. Finally, the push for additional resources to allow parks staff to adopt any monitoring program must be initiated right from the top of line management hierarchy. These resources then need to be passed on quickly through the bureaucratic system to reach the staff who need them most. Unless this process is successfully achieved, then I do not believe that the DEH can be truly committed to a monitoring program to assess the ecological effects of prescribed fires across the park estate.

Appendix 1. *Proformas* for monitoring some of the ecological effects of prescribed fires.

Proforma 1. Survey of New Sites/Hinchinbrook Island Fire Study Sites

Site No./Location:............. Site photo taken ?:.........
(from marked reference point)
Date:........... Recorder(s):............

Part A - Vegetation composition

Are the strata distinct (D) or continuous (C) ?:...........

Table 1. Vegetation Structure.

Stratum	Dominant species	Height (m)	CSR
T1			
T2			
T3			
M1			
M2			
M3			
L1			
L2			
L3			

Note that;
(i) T=top, M=middle, and L=lower stratum respectively.
(ii) where the strata are continuous, simply record the dominant species present, starting with the tallest.

Vegetation classification formula:..................

Part B- Additional Vegetation Information

Scar heights.......	Percentage of trees scarred.......
0=0-1	0=0-20
1=1-2	1=21-40
2=2-3	2=41-60
3=3-4	3=61-80
4=>4	4=>80

Species regenerating from coppice..

Species regenerating from seed..

Species regenerating from bud..

Species in reproductive phases..

0=buds
1=flowering
2=fruiting (fruit immature)
3=fruiting (fruit mature)

Disturbance evident?...

Part C - Aspects of fuel dynamics

(1) *Photopoint monitoring*

Site:............... Last photo taken:..........
Photo taken this trip ?..................
(if yes, include frame no. indicated on counter on camera):

(2) *Fuel loads*

Samples collected:.........

Table 2. Fuel loads.

Quadrat No.	1	2	3	4	5	6	7	8	9	10
Fuel load- Dry (g)										
Fuel weight (tonne/ha)										

Average fuel weight (tonne/ha) :...........

Pro-Forma **2. Repetitive Survey Information-Fire Management Study Site**

Part A - General

1. Recorder(s):..................
2. Date:.............
3. Photopoints
(frame numbers):...............
4. Plot (B or C):.............

Part B - Permanent plot records

Table 1. Individual quadrats.

Species	Q1	Q2	Q3	Q4	Q5

Table 2. Entire plot.

Species	> 1.5 m height	< 1.5 m height

Are any species **flowering/fruiting**?...

Pro-Forma 3 **- Prescribed Burn Information** *Prescribed burn details*

(i) General information

Reporting officer..................... Site...........................
Time/Date of ignition................. Burn methods....................
Follow up requirements...
Previous fire history of site..

(ii) Area burnt.............................

Table 1. Areas of different vegetation types burnt.

Vegetation type	Area (ha)
Tall forest (>30 m)	
Forest/Woodland (6-30 m)	
Tall shrubland (2-6 m)	
Melaleuca swamp	
Grassland	
Other	
TOTAL	

Mapping Complete?:.............

(iii) Fire conditions.

Last rainfall (mm & date)............. Wind speed/direction...........
Temperature (°C)....................... Humidity (%)...................
Flame height (m)....................... Fuel weight (tonne/ha.)........
Scorch height (m)...................... Rate of spread (m/h)...........

Table 2. Fire severity.

Fire severity.	Estimated % of burn
Light - patchy scorch < 3 m	
Moderate - almost complete understorey burnt	
Hot - all undergrowth burnt, crown scorch	
Severe - extreme crown scorch	

(2) *Regeneration*

Table 3. **Species exhibiting regeneration** (see key provided in instructions)

Species (tag/name or number)	Stratum	Regen. Method	No. Regen. Method	Scorch (%)	Scorch ht (m)	% Cover (vis)
1.						
2.						
3.						

Appendix 2. Instructions for users of each field *proforma*. Note that users should also consult the instructions listed under Appendix 3.

***Pro-forma* 1. Instructions for establishing new sites/monitoring Hinchinbrook Island fire study sites.**

Part A & B

General : The site number (Hinchinbrook Island only) can be obtained from the map provided (see Figure 2.1 of Skull, 1991). If the site is not on the map (or in another national park), then the general location of site should be recorded so that an exact position can be determined from aerial photographs at a later stage.

Vegetation structure (Table 1) : The predominant species in each stratum should be recorded. At least three species from each stratum (there may be less than three strata) is preferable. If the strata are not distinct i.e. they are continuous, then the dominant species present in the vegetation stand should be recorded, starting with the tallest.

Heights can be estimated visually in metres. Gillison (1989) describes a quick method for determining height that allows a check of the visual estimate. Inclinometers, although expensive, can be used to determine tree height more precisely, in conjunction with a tape measure and a simple trigonometric formula (Chapter 3; Skull, 1991). The inclinometer (if used) can then also be used to determine the slope at any given site. Appropriate methods to estimate tree height in different forest types have also been suggested in Chapter 3.

The crown-gap separation ratio (CGSR) of Walker and Hopkins (1990) is a relatively simple technique used to determine plant cover. A ratio of the average width of the crowns in the canopy compared with the average distance between them is recorded. This ratio can later be converted to an estimate of projective foliage cover (PFC) using the field survey handbook (Walker and Hopkins, 1990). Note that the CGSR is only recorded once for each stratum.

This vegetation structure analysis allows a simple classification "formula" to be constructed, either in the field or at a later date when time permits (see Walker and Hopkins, 1990 for more detail). The extra data aid in classification of the forest type and will help to identify successional trends which may be occurring.

Average scar height and percentage of trees scarred should be recorded using the simple system provided. Species that are regenerating by either coppice, seed or bud should be noted. It is recommended that a species list be established as soon as possible for each site. Each species should be given a number which can be incorporated into this pro-forma as a species checklist. This will allow for the rapid recording of potentially many species in this section. A herbarium of the dominant species should also be established. This can use common names if these are more familiar to field staff.

Any evidence of recent disturbance e.g. pigs, goats, noticeable weed invasion etc. should be recorded in the allocated space.

Part C

Permanent photopoints are a convenient tool for monitoring the changes in fuel loads at a given site over a long period of time. The taking of photographs (along with details for the deployment of additional star pickets if new sites are visited, and locating the existing star pickets used for the photographs in the field) is described on sheet 5.

Fuel loads need to be determined prior to the burn as they can vary markedly with season (Walker, 1981). A 50 cm^2 quadrat is used to sample all live and dead (kept separately but paired) fuel up to a height of 1.5 m. This "fuel block" represents the fuel that should burn in a moderately intense fire, and so it is necessary to set the maximum diameter of twigs to be collected prior to sampling. Large, woody stems and branches are unlikely to ignite in a moderate fire. Branches with a diameter greater than 6 cm should be discarded from the sample. This method is the same as that used by Sandercoe (1986) in an investigation of the fuel dynamics of Cooloola National Park.

Samples need to be transferred to a location where they can be oven-dried (for 24 hrs at 80°C) as quickly as possible. They should than be weighed to determine dry weight which can then be converted to tonnes per hectare. These data are then entered in Table 5.

The equipment required to complete all the *pro-formas* in the field is listed with the explanatory notes, as are additional sheets that may/may not be necessary to complete *pro-forma* 1.

Important: It is highly recommended that a permanent plot (see *pro-forma* 2) is set up at any new fire management site prior to future burns.

Pro-forma 2. Instructions for monitoring permanent plot.

1. Plot establishment

Within the vegetation type to be burnt, a representative sample plot needs to be established. A similar plot must be established in an area that will not be burnt to act as a control (this will enable proper comparisons to be made at a later date). It is envisaged that the size of this plot will vary depending on the vegetation type in question, but in most forest types 10 m x 10 m should be sufficient. A suitable tree (i.e. large/permanent) should be selected as the corner of the plot. This tree should be flagged and labelled permanently with an aluminium tag that has the following information recorded on it;

(i) Plot location e.g. Graham Range National Park,
(ii) Date of establishment,
(iii) Plot type (i.e. control or burnt),
(iv) Reference point Q1 (to indicate that this is the corner point of the plot where quadrat 1 will be located).

A permanent peg or stake should also be driven into the ground and flagged. Similar pegs/stakes are then placed at each of the remaining corners, as well as in the centre.

The corner reference point will be the point for quadrat number 1 (a 1 m x 1 m quadrat that lies at the corner of the plot-outer boundaries of the quadrat should correspond to those of the plot). Numbers of the other quadrats should follow the diagram below;

2		3
	5	
1 (marked tree)		4

It is envisaged that in dense vegetation types e.g. coastal vine forest it may be necessary to reduce the size of the plot to 5 m x 5 m. From my experience on Hinchinbrook Island it becomes difficult and time consuming to assess a plot of larger size.

2. Plot monitoring

Using Table 1 of the *pro-forma*, the frequency of each species present in quadrat 1 should be recorded. This then needs to be repeated at each other quadrat point.

To complete the *pro-forma*, the number of tree species needs to be counted over the entire plot. This section is divided to take into account those individuals that are > 1.5 m height, and those that are < 1.5 m height. This section is very important as it allows numbers of the predominant regenerators to be assessed and monitored in the future.

Any species that are flowering or fruiting should be recorded. Fire-sensitive species may benefit from fire management decisions that take this kind of ecological information into account. **Important**: For methods used (and equipment that may be required) refer to *pro-forma* 1 instructions.

Pro-forma 3. Instructions for monitoring on day of burn

Most of the information to be recorded in this *pro-forma* is self-explanatory. This is, however, a crucial section of the *pro-forma*, and should be filled in carefully.

The area burnt in (ii) has to be subdivided into the various vegetation types burnt, along with an estimate of the area affected (Table 1). This should then be placed (as accurately as possible) on a topographic map. The importance of accurate mapping cannot be over-emphasised. Upon return to the site, certain post-fire data should be recorded in the table provided (Table 2). Scorch height can be estimated visually, or measured more accurately as previously described for the height of plant species in general. Percentage scorch is estimated visually. Details of the fire severity should be recorded in Table 2.

Any species exhibiting regeneration from previous fires (e.g. coppicing) should be recorded, as should the method of recovery (Table 3). This will allow species to be placed into guilds/classes. Gill (1981) provides a simple yet effective system of classifying woody plant species in relation to percentage leaf scorch after fire. The following key is taken from Gill (1981). In addition, to standardise descriptions, plants must be recorded as being in one of the following phases:

(1) seedling or juvenile (S);
(2) mature or reproductive (M);
(3) post-reproductive (P).

KEY:
A. Plants just subject to 100% leaf scorch by fire have died (non-sprouters)
- (a) seed storage on plant I
- (b) seed storage in soil II
- (c) no seed storage in burnt area III

B. Plants just subject to 100% leaf scorch by fire have survived (sprouters)
- (a) subterranean regenerative buds
  - (i) root suckers, horizontal rhizomes IV
  - (ii) basal stem sprouts, vertical rhizomes V
- (b) aerial regenerative buds
  - (i) epicormic buds grow out VI
  - (ii) continued outgrowth of active aerial pre-fire buds VII

The resultant classification (i.e. phase+key class) should then be entered in the regeneration method column of Table 3. This table can also be used to record the effect of fire on any unusual dominants such as weeds that were present before the burn was initiated.

Important: It is suggested that if detailed comparisons of pre/post fire situations is required a line transect approach be adopted. This entails the establishment of a transect of suitable length dependent on the vegetation type in question (perhaps 50 m for most vegetation types). Each end of the transect should be permanently marked by pegs and tags. At 50 cm intervals along the transect, the species either touching or closest to the tape should be tagged, identified (at least given a number and specimen taken for future reference) and the height and DBH recorded. If already regenerating from fire than this information is also very important (mode and number of mode of regeneration both important). Note that for small individuals it will be necessary to measure the DBH with callipers. This method allows for detailed data collection regarding growth rates and fire responses of many species simultaneously. Although time consuming initially, the data collected will be invaluable and the method is easily repeatable. If recording sheets are required for this type of exercise I can supply them on request.

Appendix 3.

Instructions for *proformas* relevant to management staff and users.

Pro-formas are used to describe landform, vegetation and soil with a set procedure. This allows practical comparisons to be made either between different sites, or at the same site over time. It is also possible to record a large amount of pertinent field data systematically and concisely. A major aim of this study was to develop field techniques that could be integrated into a *pro-forma*. This would allow some of the ecological effects of fire on the lowland forests of Hinchinbrook Island to be monitored directly.

The implementation of fire management programs is seen as a matter of urgency for a large proportion of the national parks of Queensland (Stanton, 1989). To assess the effectiveness of these programs, it is essential that they are monitored accurately. Monitoring programs are necessary to detect changes that relate to all components of the ecosystem being managed. The information provided by these vegetation *pro formas* should be invaluable to the decision-making process used by management staff. Over time they should also contribute to a greater understanding of the effects of fire on different vegetation communities. This also means that the implementation of management decisions become more accountable and will improve as a consequence.

Much of the vegetation-related information recorded stems from the earlier work of Walker and Hopkins (1984). A similar structural approach has been incorporated into the pro forma presented as a result of this work. Although the value of structural features is well documented (e.g. Webb, 1971), they alone do not provide sufficient information about the ecological effects of fire on a given environment.

If reasonably detailed data can be collected in a standardised manner, it may be possible to incorporate this information into a Geographic Information System (GIS). These systems are designed to display spatial information in a cost-effective manner (Chuvieco and Congalton, 1989). Successful systems have been developed in the Northern Territory (Davis *et al.*, 1986), and based on a prototype developed for Kosciusko National Park, 6 million hectares of fire-prone land in eastern Australia are now managed using these systems (Kessel, 1990). Although limited by modelling constraints and particularly heterogeneous vegetation, these systems can be applied to a wide range of habitats based on the prototype data (Kessel, 1990).

It is unfortunate that neither time nor resources allow for complete ecological studies to be carried out on each vegetation type before any burns are prescribed. Detailed ecological investigations of this nature are, however, not usually feasible before burning as management decisions need to be made immediately, particularly if the maintenance of existing habitat diversity is to be successful (Stanton, 1989). It is, therefore, important that a *pro-forma* records as much information as possible.

The *pro-formas* developed aim to ensure that these decisions take into account a wide range of ecological information. It also highlights the need for a certain amount of data to be collected before the first fires are lit in previously unmanaged areas. This is essential to allow scientifically valid comparisons of the pre- and post-fire environment. To further improve the accuracy of monitoring changes in a given vegetation type following fire, it is strongly recommended that control sites (i.e. within an area that will remain unburnt) are also established. This may not feasable in some cases e.g. where fire control is limited. As burning may soon be prescribed for many of the national parks of Queensland, it is of the utmost importance that the effects of these burns be monitored in detail. These *pro-formas* seek to address part of this problem.

Available time in the field would appear to be the main factor controlling the amount of data collected. If it was feasible to collect adequate data, it may then be possible to incorporate this information into a GIS system. This would be particularly useful, as much of the baseline data required for a GIS (vegetation, soil, and geology maps) is already available for Hinchinbrook Island. GIS's also have a wide range of applications, including impact assessment, and determining responsible recreational use of parks. Furthermore, land management decisions are complex, and require a detailed understanding of how a particular disturbance will affect each component of the ecosystem (Kessel *et al.*, 1984). The information contained in a more comprehensive, ecologically based *pro-forma* may facilitate the decision making process. Although some of the data may not be sufficiently detailed for incorporation into a GIS at this stage, further research could provide the required information. Compiling this type of system requires previous experience with a GIS, substantial funding, and is beyond the scope of this study. These systems are also limited by modelling constraints, and require large amounts of data in areas where the vegetation is particularly heterogeneous (Kessel *et al.*, 1984).

In its current form, the *pro-formas* that have been developed also have limitations. It would be unrealistic to expect a vegetation *pro-forma* to monitor all of the effects of fire on a forest ecosystem. One of the limitations, for example, is that the fate of micro-faunal soil communities is not addressed. In other studies, particular species have been identified as potential indicators of soil recovery following fire (Nuemann and Tolhurst, 1991). This, and other additional information (e.g. fauna data), would result in the development of a more ecologically sound set of *pro-formas.*

There are also other foreseeable developments in the *pro-formas* that could take place to make them more effective and efficient at a particular site once field staff have become acquainted with;
(i) the use of the different *pro-formas*, and
(ii) the response of the vegetation communities within their particular park to fire.

These may include;
(i) giving each plant species a number so that recording becomes less time consuming,
(ii) identifying key species in the successional process following fire and subjecting them to more intensive studies. Important aspects of such a study would include;

- (a) determining growth rates (a relatively simple procedure once individuals are tagged in the field),
- (b) determining germination responses of such species to different fire treatments, and
- (c) monitoring the ability of species coppicing after fire to withstand repeated fires.

In summary, these *pro-formas* have been compiled to assess the effects of prescribed burning on vegetation, and are primarily for use by QNPWS staff. They should enable vegetation and various on site data to be recorded efficiently and effectively. It is essential that the data, once collected, are put to the best use. A monitoring program such as the one supplied allows for regular review of the recorded results from each monitoring site, and it is recommended that time is allocated by management staff for this purpose on an annual basis. This will ensure that any fire management plans already in place are constantly reviewed and re-assessed.

Depending upon the aim of the field trip in question, a different *pro-forma* will need to be completed. A brief set of instructions on how each *pro-forma* is to be completed accompanies each *pro-forma.*

There are three *Pro-formas*;

Pro-forma 1. - Used to establish new sites (and monitor existing Hinchinbrook Island sites) that are specifically for more detailed, long-term study.
Pro-forma 2. - Used to establish new sites, particularly if time/access constraints will limit the amount of data that can be collected. It is anticipated that this *pro-forma* will be the most commonly used by field staff on a regular basis.
Pro-forma 3. - Used to monitor any prescribed fire on the day of the burn

Within some of the instructions (particularly *pro-forma* 1), reference is made to several chapters and appendices in the Masters Qualifying thesis (Skull, 1991) supplied to QNPWS. This thesis can be consulted for further information if required. If this is not possible, then the author can be contacted at the following address;

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The same applies for texts that are referred to in any of the accompanying instructions. The Australian Soil and Land Survey Field Handbook (Walker and Hopkins, 1990), however, is a text that should be readily available to the staff that will use these *pro-formas.* It should also be taken into the field on each sampling trip.

It is recommended that fuel loads should be collected just prior to, and immediately after a prescribed burn. Sampling (e.g. permanent plots of *pro-forma* 2, photopoints, fuel loads, and soil samples) should then take place preferably every 6 months if possible.

It is also recommended that as a minimum, at any new site both the permanent plot detailed in *pro-forma 2* and permanent fuel monitoring points are established. The equipment required to complete **all** the *pro-formas*, along with additional sheets that may be required to complete *pro-forma* 1 are listed overleaf.

Finally, it is very important that the field staff who are to use the *pro-formas* are given sufficient time and training to become familiar with all aspects of their use and the reasons for their implementation.

Equipment required to complete *pro-formas* in the field. The numbers in parentheses indicate which *pro-forma* the equipment is required for.

- 1 m^2 quadrat (collapsible) (1,2)
- Australian Soil and Land Survey Field Handbook (1,2 & 3)
- bags for plant specimens (1,2)
- camera with film (1,2 & 3)
- clipboard and pens (both biro and permanent marker) (1,2 & 3)
- compass (1)
- copies of *pro-forma* (1,2 & 3)
- dbh tape (1)
- flagging tape (1, 2 & 3)
- fuel collection bags (1)
- map of area with sites marked. A large-scaled photocopy of the relevant topographic map should also be taken into the field. This will allow the burn area to be marked accurately for future reference (1,2 & 3)
- measuring tapes (1,2)
- permanent plant tags (1,2 & 3)
- soil sample bags (1,2 & 3)

Additional sheets that may be required to complete *pro-forma* 1.

1-Domin scale of cover abundance
2-Establishing permanent photopoints to monitor fuel loads

Sheet 1. Domin scale of cover abundance.

Cover	Domin Value
Cover about 100%	10
Cover >75%	9
Cover 50-75%	8
Cover 33-50%	7
Cover 25-33%	6
Abundant, cover about 20%	5
Abundant, cover about 5%	4
Scattered, cover small	3
Very scattered, cover small	2
Scarce, cover small	1
Isolated, cover small	X

Sheet 2. Constructing, locating, and photographing permanent photopoints (modified from C. Sandercoe - pers. comm.).

1. General

Two star pickets per site are required. The vegetation at a particular site will govern the size of the pickets used. In this case, 8 ft pickets have been used for the monitoring point (i.e. the picket that is photographed), with 6 ft pickets used at the point of camera placement.

2. Construction

(i) 6 ft star pickets are left unpainted except for a red ring around the top of the post for identification purposes in the field. When placed in the field they should be hammered in vertically so that 120 cm remains above the ground (it helps if this 120 cm mark is placed on the post before transfer to the field).

(ii) 8 ft star pickets should be painted red and white at 20 cm intervals. The top interval is white for photographic purposes. At least 9 intervals (180 cm) should be painted, with the remaining portion of the picket being driven into the ground.

Notes :
(1) A proper driver is essential to position the pickets unless soil structure is very weak.
(2) At least two coats of suitable paint must be applied (e.g. Killrust paint). Only two sides of the pickets need be painted.
(3) Posts may be labelled or flagged if desired.
(4) Depending on the vegetation type, 6 ft pickets may be appropriate in both cases.

3. Location

Star pickets can be located at any site by following this simple procedure in the field:
(1) Locate (0,0) on the permanent transect;
(2) Proceed along the transect until the end is reached (varies from site to site - see Chapter 2);
(3) Turn to the right through 90 degrees;
(4) The first star picket (6 ft - unpainted except for red ring around top of post) is located approximately 5 m away. The second picket (8 ft - painted with red and white stripes at intervals of 20 cm) is a further 5 m beyond the first picket in a similar direction.

4. Photography

To be carried out at least twice a year. Midday will afford the best conditions for photography. Procedure:

(1) Place SLR camera with 35 mm lens and 100 ASA colour print film on top of the unpainted picket;
(2) Aim the camera at the painted picket, using a shutter speed of either 1/60 or 1/125 to maximise depth of field;
(3) First photo : Locate the top of the picket in the middle centre of the view finder.
Second photo : Locate the top of the picket at the top centre of the view finder;
(4) Record site number and date as soon as possible;
(5) Place processed prints in folder, labelling them both beside each photo and on the reverse side of the print.

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Monitoring for fire management in Kakadu National Park, Northern Territory, Australia.

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Introduction

This report is the result of a very brief consultancy. The aim of the consultancy was to provide ideas for monitoring attributes of Kakadu National Park in relation to fire management. The Park is Australia's largest (near 20,000 square kilometres) and is located about 120 km east of Darwin, Northern Territory, in the wet-dry tropics. This report is not intended to be exhaustive nor constitute a literature review of monitoring or of fire matters in the wet-dry tropics. For an overview of the Kakadu landscapes the Draft Plan of Management (Australian National Parks and Wildlife Service 1980) is instructive; Gill et al. (1991) address matters pyric in the wet-dry tropics of Australia; Russell-Smith (1993 a,b) addresses fire management and research issues in the Park.

Fires in Kakadu landscapes were a feature of landscape process between mid March and December under Aboriginal fire regimes (Braithwaite 1991), a period dominated by the dry season. Fires today may also occur outside this period under certain circumstances (e.g. those described by Stocker and Sturtz 1966). Nearly all fires are ignited by people (although lightning fires may be a feature of the period before the wet season in areas not recently burnt). Fires in the earlier part of this period are generally of lower intensity than those which occur later in the dry season. It is recognized that fires in the earlier part of the dry season may be of substantial intensity if there is sufficient fuel, while, later in the season, fires may be of lower intensity if the fuels are light. For simplicity, the earlier, lower intensity fires, will be called "early fires" and the later, potentially more severe fires, "late" fires.

A simple subdivision of this large region would be into three landscape units (Russell-Smith, personal communication): the lowlands, constituting about 57% of the Park, clothed in woodlands and forests of *Eucalyptus*; the floodplains occupying 11% of the Park and covered in graminoid communities with fringing *Melaleuca* communities; and, the escarpment country occurring in 32 % of the area and occupied by communities as diverse as rainforest, eucalypt woodland, heath and spinifex. The escarpment country could be subdivided into hill country (to the south of the Park and mostly supporting eucalypt woodland), and the sandstone country (mostly to the eastern edge of the Park).

Concerns

A number of concerns about fire occurrences and their effects in the Park have been raised by: Russell-Smith (1993 a,b and Russell-Smith and Bowman 1992); other Australian Nature Conservation Agency (ANCA) staff (in personal discussions); and, Aboriginal inhabitants of the area (Lucas 1993). These concerns are that:

- fire sensitive plant communities in the form of *Callitris* communities and monsoon forest are being damaged by fires (Russell-Smith 1993a). [*Callitris* communities and monsoon forests are found in the lowlands and the escarpment country. Late fires, because of their usually high intensity may cause the gradual retreat of such communities - a process contrary to the aims of management.]

- fires may spread to neighbouring properties from the Park. [Late fires are difficult to control. Few barriers to their spread are posed by diurnal weather variation and fuel discontinuity so they are usually extensive. Burning brands can carry fires across fuel breaks. Park boundaries of concern are in lowlands or escarpment country.]

- fires are spreading into the Park from Arnhemland (Russell-Smith 1993 b). [Late fires in Arnhemland - outside the Park on the eastern edge - flow over the escarpment country with the prevailing southeasterly wind and threaten fire sensitive *Callitris/Allosyncarpia* communities there.]

- biotic diversity of the Park is being threatened (Russell-Smith 1993b). [If early fires are minimized, then late fires burn most of the Park. Because of the fire-sensitive communiites - if nothing else - such a fire regime will cause a loss of biotic diversity.]

- encroachment of *Melaleuca* onto flood plains is occurring due to changed fire regimes (Russell-Smith 1993 a). [*Melaleuca* encroachment appears to be occurring in some areas of the floodplain due to the deliberate removal of feral water buffalo in the past few years and the presumed increase in fuel loads. Encroachment may also be encouraged by changed hydrologies associated with the demise of buffaloes.]

- there could be a loss of ground nesting birds associated with changed fire regimes in the lowlands (Lucas interviews 1993). [If prescribed burning takes place too early then ground nesting birds such as the red-eyed pigeons, finches and whistle ducks may be affected. Because fires in the lowlands - where these birds occur - are often annual, the elimination of nesting could be serious in relation to the maintenance of bird populations. A research approach to this problem seems worthwhile.]

- peat fires have occurred in parts of the floodplain which have killed mature *Melaleuca* (Russell-Smith 1993a). [Fires have occurred in peat pockets when water has retreated from floodplains in the late dry season . What changes will occur as a result of this death?]

- times of burning to deliberately eliminate the annual grasses, *Sorghum* spp. needs further defiinition (Park staff, personal communication). [Annual *Sorghum* provides an abundance of early curing fuel in areas other than the floodplains which may be eliminated by wet season fires (Stocker and Sturz 1966), a boon to protection in sensitive areas such as boundaries of the Park, areas around buildings, camping areas and perhaps sensitive plant communities etc. Stocker and Sturtz's work, near Darwin, revealed commencement of *Sorghum* germination, a prerequisite to control, to occur in mid September; fires from this time until mid March (the last fires observed) were successful in its control. The variation in control at Kakadu from season to season may need to be determined. How long the species change lasts is unknown but may be less than a decade. Are species other than Sorghum affected?]

- the best time to prescribe low-intensity fire in the hill country, to avoid burning it all at once, is unknown (Russell-Smith, personal communication). [The variety of hydrological situations affecting grass curing in this area is less than that in the other landscape areas thereby reducing opportunities for burning of the country such that late fires, if they occur, will not have free passage. Timing of burning appears critical.]

- there may be plant species, not known at present, which are affected adversely by current fire regimes. [Non-target species monitoring may be used to address this problem (see below).]

- that the extent of fires in different areas at different times of the year need to be known to see whether or not fire objectives are being met.

To address these concerns, there needs to be management-monitoring, the implementation of research, or both.

Monitoring in general

Monitoring may be desired for performance assessment or for research. It may be undertaken as a guide to planning or to immediate decision making. It may be directed towards a specific target or be general. A key factor in monitoring is that it be as direct as possible. If surrugates have to be used instead of the attribute in question, problems of interpreation and accuracy are bound to arise. The best method is a direct method, but the direct method is not always the most cost effective.

If monitoring is for performance assessment in management: it needs to be effective, routine, simple and cheap; it may be unreplicated in space, depend on current knowledge and deliberately ignore various assumptions behind the process in the interest of being practical . Records need to be kept and reviewed. If monitoring is part of a research program, however: it would not be routine; it would have suitable spatial replication; it would consider all variables that may have an influence on the outcome; it would incorporate detailed record keeping; and, it would need to be done thoroughly and reviewed frequently. Here, we are not concerned with monitoring for research.
Monitoring may be target oriented or have a non-specific orientation. An example of target monitoring is the monitoring of fuel loads as a guide to fire prescription. An example of non-target monitoring is the perusal and archiving of satellite imagery with no particular purpose in mind. Sometimes, the same technique can be used for both target and non-target monitoring e.g. photography may be used to record a recent fire at a site but may later be used to see the heights of shrubs at the time. Possibly target monitoring is best suited to changes that occur in the shorter term; non-target monitoring may be better suited to monitoring slower moving variables, even if not defined at the outset.

Monitoring methods

Satellite imagery for burned areas and non-target purposes

Satellite imagery has been used in the Park for nearly a decade to discern when and where fires have occurred. This monitoring has been useful to assess ingress and egress of fires and estimate areas burned in the different landscapes in different seasons and years. While satellite imagery has been indicative, it has not always been accurate. Problems include cloudiness at the end of the dry season, interpretation of areas that may appear to be burned areas, and cost. Archived images may be used in the future to fill in gaps in imagery already purchased. The use of satellite imagery for the detection of fires and fire footprints in savannah regions has been reviewed by Justice et al. (1993). NOAA AVHRR geostationary 'weather' satellites may be used to assess degree of grass curing (Barber 1990) in 1km pixels, perhaps a useful technique for assessing the most appropriate times of early burning in the hill country; air-borne sensors may achieve the same end (Barber 1990).

Satellite imagery provides a useful non-target record of the Park. Such data can be used to compare scenes in different years for unspecified changes. Given the landscape dynamic at Kakadu, such inter-year comparisons may be too complex to interpret, however.

Aerial survey

New methods of aerial survey include digital multi-wavelength portable systems with sub-3m pixels (programmable airborne spatial/spectral scanner, "*casi*"); this technique presently being tested by CSIRO Office of Space Science Applications in Canberra) seems highly suitable for small areas like those in which *Melaleuca* has been killed by peat fire. It also seems suited to assessment of changes in plant communities in floodplains. Such a technique could be most useful for the monitoring of sensitive communities as even individual trees could be readily identified.

Aerial (helicopter) surveys may be a way to approach the problem of cost-effective assessment of which areas have burned, when and in which landscapes. By using a helicopter, a global positioning system, and suitable record-keeping systems, records of burnt/unburnt locations at say 1000 points per survey could be obtained. Satellite imagery already held could be used to work out appropriate survey transects for most effective operations. Surveys could be conducted at the same times that satellite overpasses occur so cross comparisons could be made if necessary. The aerial technique would be direct, provide immediate data and not be subject to problems of interpretation or cloud cover; it may be substantially cheaper also although costs need to be calculated.

Photopoints

Photopoints may be ground based or even aerial based. Some ground photopoints have already been set up in some areas of Kakadu. They seem to have been set up as a non-target monitoring technique but could be used to address the time-of-burning-*Sorghum* problem in some areas. The author suggests that the following procedure be considered for the design of photopoints: from a permanently marked point north of a fixed photo standard, take a picture of the scene to the direct south, including the 'photostandard' set at say 10m from the camera. The orientation suggested should provide the best illumination of the scene given a random time of picture taking. The photo should include the fuel in the foreground; it could show the greenness of any grass among other things. The 'standard' could be a 2m pole with a rectangular aluminium plate of dimensions 50cm square bolted onto it, for example. The plate could be marked with the site location. The camera could have the facility to record the date of the fire automatically (cameras with this facility are often not expensive). The photography would be carried out at the time, or times, of satellite overpass as determined for general examination of the extent of fires.

Vegetation structure has often been linked with animal abundances. Photopoints for tracking structural change may be identified. Photopoints for curing of graminoid plants, and relative abundances of plant types (grasses, shrubs etc.) may be useful; aerial photopoints for discontinuous fuels in the sandstone country may be useful. Fuel loadings may be checked by measurement if desired.

Aerial photopoints from helicopters or fixed wing aircraft may be useful for use in inaccessible areas and may be useful for problems such as the changes taking place in *Melaleuca* communities.

Species monitoring by presence/absence and by photo

Species such as those that occur in the fire-sensitive communities mentioned above be regarded as 'sensitive species'. There may be many others. Others include epiphytes and mistletoes. Plant species have been identified as 'sensitive' in southern Australia if mature plants die from one crown-scorching fire (Gill and Nicholls 1989); it is worth considering the recording of such fire responses, and others, for all Kakadu plant species and placing the results in the National Register (Gill and Bradstock 1991).

The main idea behind systems of monitoring plant species in a practical way is to identify sensitive and vulnerable species and to target these; if species are known to be highly resilient, they may be dropped from the monitoring system at the outset. For *Callitris* and monsoon forest areas, a species presence and absence for all species in selected quadrats may be the preferred option because the nature of species responses in these sensitive communities is unknown. Techniques for minimizing the number of quadrats to be monitored are available (Gill and Nicholls 1989). Species monitoring may be conducted in quadrats associated with photopoints or at other chosen locations. Durations of monitoring may be linked to times to reproduction of the plants by a rule-of-thumb (Gill and Nicholls 1989).

Experimental management

Simple unreplicated experiments can be a boon to managers as a way to learn more about the area they are managing and as an educational technique for the public. For example, two small adjacent areas can be burned, one in the wet season , one later in mid-dry season. Photopoints can be established. Representative plants can be labelled. A simple plaque can explain why annual *Sorghum* was eliminated from the wet season plot, why shrubs have been unaffected (assuming that they are), while data can be gathered as to the time it takes for *Sorghum* to recolonize the area (through the photos). Such experiments - technically 'trials' rather than experiments - can be temporary, lasting only until they have served their purposes. Such trials may be made in inaccessible areas if such areas were of crucial importance and not to be the focus of visitor attention.

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Forum : Standardised fire monitoring, pre and post burn reports.

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Introduction

One purpose for fire management on National Parks in tropical Australia is to maintain biological diversity. The ecological information upon which management decisions aimed at maintaining biological diversity are based is generally imprecise and covers an uncomfortably short time frame.

This information base must be improved if the biological diversity which currently exists is to be maintained. Knowledge of the ecological role of fire from temperate and mediterranean regions cannot be applied, without significant modification, to tropical Australia.

All agencies responsible for managing nature conservation reserves in topical Australia are undertaking research into fire ecology using their own staff in some circumstances and people from other organisations in others.

A common minimum data set for all fire ecology research in tropical Australia may provide a basis for information sharing, comparison of the effects of fire regimes at different sites and/or over long periods and better integration of the fire research effort across all organisations.

Overview of papers

Seven papers on scientific monitoring methods for measuring the ecological effects of fire were presented. A wide range of management issues, research objectives, attributes, classification systems, measurement frequencies, measurement technologies and data recording systems were explained.

The diversity of approaches to fire monitoring in those presentations reflected factors such as :

- the wide range of ecosystems (from closed complex notophyll vine forest on Queensland's Wet Tropical coast through the eucalypt woodlands to the desert communities of the southern Kimberley);
- differences in both the ecological role and history of fire in each of these;
- the wide range of landuses adjoining nature conservation reserves across tropical Australia; and
- differences the statutory bases, management resources and corporate goals of each of the agencies responsible for managing fire.

Standardised fire monitoring systems

Much of this forum was devoted to discussion of a proposal for standardised pre-burn and post-burn reports, long term monitoring data sheets and a minimum data set.

There are two key questions which need to be asked about this proposal. These are :

- For what would the information from such a standardised system be used?
- What are the essential/core/minimum types of information that need to be collected

to serve that/those purpose/s?

In response to the first question, the workshop participants developed the following list of uses for information derived from the proposed standardised system :

1. To predict vegetation responses to fire and to identify unpredicted responses.

2. To predict fire behaviour.

3. To identify and describe specific fire regimes for each plant community.

4. To record fire history.

5. To record baseline data against which future changes to species and community structure can be compared.

6. To contribute information for community education and interpretation about the use of fire as a management tool for conserving ecological diversity.

7. To add to the information base supporting the ecological, economic, cultural and safety/protection rationales for prescribed burning.

8. To help generate compatible and integrated fire management policies across all land management agencies in tropical Australia.

9. To facilitate fire ecology and management information exchange across tropical Australia by -

    9.1 maximising outputs for available research budgets;

    9.2 avoiding duplication of effort in developing monitoring regimes and data recording systems; and

    9.3 enhancing staff mobility, transfer and exchange.

Uses 1 to 5 inclusive relate to ecological research, which is not surprising since that was the nominated focus of the presentations. However, it is interesting to note that improvements to community education, the economic and cultural rationales for prescribed burning, compatibility and integration of fire management policies and maximising outputs for research expenditure - all of which are non-research issues and therefore unlikely to be considered by such narrow focused and unrealistic people as scientists - are explicitly identified as outcomes of ecological research.

The question of the minimum data set was not completely resolved in the time available during the Workshop. Consequently, a working group was established to develop an agreed minimum data set which could be incorporated into all fire monitoring programs. The membership of this working group is Tim McGuffog, Sue Wigston, Steve Skull, Jeremy Russell-Smith, Gordon Graham and Jim Cruise.

Data considered for inclusion were :

- A structural description (using the classification system in the CSIRO Field Survey Handbook);
- Fixed photo points using consistent camera settings with known marker heights and distances apart;
- Location by GPS and/or 6 or 8 figure grid reference;
- List of plant species present within a defined area;
- Plant species abundance and height per unit area;
- Fire history from the start of the monitoring program if nothing else is available other wise from when the first reliable information can be identified;
- Date of observations; and
- Comments on landuse which may modify the post-fire response.

It was also suggested that the minimum data set might be in two parts - one for research information and the other for day to day management.

There was considerable debate about which staff from each agency would have the responsibility, time and expertise to collect and collate any such long term fire monitoring data. The options included untrained field staff, specialist trained rangers and fully qualified research staff.

Conclusion

The concept of standardised pre-burn and post-burn reports, long term monitoring data sheets and a minimum data set has potential. However, given the constraints of available staff, money, time and expertise and the current unreliability of long term funding, the concept needs further development before any formal proposal can be made.

Section 2 :

Fire on Conservation Reserves : Case studies

Chairperson: Chris Done

Fire management In conservation reserves in the Kimberley

David Grosse
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Introduction

The Kimberley Region of Western Australia covers an area of approximately 421,521 square kilometres. This is twice the size of Victoria and 1/6th of Western Australia's total area.

The Kimberley region has a population of 25000 (ABS 1989) the majority of which live in the six established towns. Visitation of the area is estimated at 40,000 visitors annually. This appears to be increasing steadily as the accessibility of the Kimberley becomes easier.

The Pastoral industry is the main land user with 107 Pastoral leases in 1992. There are also 195 Aboriginal Communities, 7 National Parks, 13 Nature reserves and vast areas of Vacant Crown Land.

Rainfall ranges from 350mm in the south to over 1400mm in the north. Naturally, with this difference in rainfall there is a vast difference in vegetation types and species, from desert communities, grassland plains, Eucalypt woodland & forest to coastal dunes, rainforest pockets and mangroves.

Attempts at fire management are carried out on most C.A.L.M. estate. Areas such as the Prince Regent Nature Reserve are virtually inaccessible so the actual recording of fire behaviour and other relevant information is extremely limited and very difficult to obtain.

Although fires have had an impact on the Kimberley for probably tens of thousands of years, the actual 'on ground' recording system is a very recent occurrence and is still in it's infancy. It also tends to be carried out in areas which are much more accessible and therefore prone to fires, i.e. more visitation - more chance of fire. This is taking place for example in the Hidden Valley and Purnululu National Parks.

From C.A.L.M.'s perspective this increased visitation (and here I am not referring just to tourists) is most relevant for National Parks and Nature Reserves. It is recognised that level of burning undertaken by the Department needs to be reviewed. In particular when protective burning should take place. Mosaic or patch burns based on what is thought to be traditional aboriginal burning practices is aimed at as being the optimum, these effectively control the build up of fuel which in turn reduces the occurrence of large, intense fires which is the current pattern for the Kimberley.

As is well known by burning in this way eventually a multi staged environment will be created thus further producing a range of uneven aged bushland. These burns appear on the surface to have been quite successful in the protection of either life, property or conservation values.

The challenge facing the Department in Kimberley is to work out an effective way of applying very limited resources to achieve this goal. 1993 has been an unusual season with regard to weather conditions. Burning commenced in early April after the then supposed last rains (March). Some areas burnt extremely well e.g. some parts of Hidden Valley National Park we actually got tree scorch whereas 1/2 a kilometre away some areas were too green to ignite. Late rains came in early May which delayed further burning until June.

Nature Reserves And National Parks In the Kimberley

Our National Parks and Nature Reserves in the Kimberley cover a total of approximately 2 million ha. These range from 4ha at Low rocks, an island reserve, to 635,000 ha. at Prince Regent Nature Reserve.

Reserve / Park Name	Area (ha)
Dragon Tree Soak	14182.00
Lacepede Islands	180.25
Point Coloumb	28676.02
Swan Island	29.03
Geikie Gorge	3136.00
Tunnel Creek	91.00
Windjana Gorge	2134.00
Purnululu (Bungle Bungle)	319325.00
Wolfe Creek	1460.00
Ascot	1861.43
Drysdale River	448264.00
Hidden Valley	2069.00
Kununurra Arboretum	
Low Rocks	4.03
Parry Lagoons	36111.00
Pelican Islands	8.09
Point Springs	302.99
Prince Regent	634951.70
Mt. Hart*	370000.00

* Mt. Hart has recently been purchased by C.A.L.M. and is actually a Pastoral Lease held by the Executive Director.

Mid-June produced further rains, up to 30mm in one day and some extremely cold weather (Halls Creek had a maximum of 12 degrees one day). Again, this is a most unusual occurrence.

The end result of this is that the majority of our burning has not been completed and we are into the prohibited burning season now and conditions are rapidly drying. Normally our burning is completed by ate May - early June with adequate results. It is unlikely that the limited burning program that the region has will be completed this year.

One burn that has been carried out recently was at a small rainforest pocket called Point Springs. The method we used to put an adequate break in was one that we pinched from the C.C.N.T. which had been mentioned at the first Fire Workshop and involved the use of a tyre sled. This method was extremely successful on black spear grass.

It involved running up and down the boundary half a dozen times which tended to knock the spear-grass down and sufficiently cure it enough to ignite. It left us with a break of approximately 3 metres wide. The only downfall I can see with the tyre sled is that over larger burns it would take a great deal of time to go around the boundary. Another benefit of the tyre sled is that after an area has been knocked down further curing takes place along the edges

At a later date, perhaps 1-2 weeks, another edge burn can be carried out, thus widening the existing edge or buffer. We have not used the tyre sled on cane grass or spinifex so I cannot comment on whether or not it works.

One method that has been used successfully by us on cane grass os a roller. This flattens the grass and after curing provides an excellent break. Flame height is restricted to a minimum and a clearly defined edge is left. The roller is best used after the last rains and allowed to cure for 1-2 weeks. Again, on large burns this can be a very time consuming task.

Currently the burning done is a sort of "hit and miss" operation. To carry out and be seen to be successful fire managers a dramatic increase in the amount of research and monitoring needs to be done. There is also a need to define a cost effective operations system which involves more field officers in active fire management. Is expected that there will be an increase in burning at the appropriate times. It is felt that more burning is required immediately after the completion of the wet season.

Fire management in mid-east Queensland National Parks

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District Overview

Mackay district responsibilities cover the area stretching from Cape Upstart (north of Bowen) to Cape Palmerston (south of Sarina) and west to include the Nebo and Bowen Shires. This area contains the whole of the Central Coast Biogeographic Region and part of the Northern Brigalow Biogeographic Region.

The main protected area include the following National Parks Eungella, Conway, Dryander, Whitsunday and Cumberland Islands, Cape Upstart, Mt Aberdeen, Cape Hillsborough, Pioneer Peaks, Dippery and Cape Palmerston. Land forms include continental islands, coastal rangers, coastal lowlands, high altitude ranges and tablelands and inland riverine systems.

District climate is strongly seasonal with a district dry season from June to November. Rainfall varies from approximately 600 mm in the north and west to greater than 2,500 mm in the Eungella escarpment.

Vegetation communities represented include upland and lowland rainforest, riverine rainforest, eucalypt woodlands, wet sclerophyll forests, brigalow and softwood scrubs and grasslands on offshore islands.

Management Issues

- A history of non management of fires prior to the last five years with little effort put into prescribed burning programs and main emphasis on wildfire control procedures. This left a legacy of fire damage in some areas and many areas unburnt for long time periods in excess of 10 years.

- A patter of regular fires escaping from cane farming areas leading to rainforest recession on hill slopes. The cane farming community has a perception that grassland area adjoining farms provide a harbourage for rats and needs to be burnt regularly to central populations. This regular burning however, encourages expansion of grassland providing more habitat. Recent research indicates rat populations can be significantly reduced by re-establishing natural vegetation communities and controlling the exotic grasses which are an important seasonal food source.

- Encroaching residential development and numerous small holdings adjoining some parks. The new residents generally have a poor appreciation of fire in the rural context and generally opposed prescribed burning operations. Also they often show little appreciation of the need to maintain adequate fire procedures on their own land.

- Rapid vegetation changes due to fire exclusion in some ares with Rainforest species invading areas of eucalypt woodland. In some cases this process becomes practically irreversible in 15 to 20 years.

- Normally fire conditions are relatively mild, but occasional severe fire conditions occur under prolonged drought conditions leading to uncontrollable fire behaviour capable of burning through vine thickets and doing extensive damage to rainforest areas.

- Remote difficult terrain in some areas leading to access problems for effective fire management. Potential hazards also exist for staff accessing these areas due to the lack of any formal track systems which would allow rapid evacuation if required.

Initiative taken to address issues

- Development of wildfire response procedures, fire management plans and planned program of prescribed burns.

- Strong emphasis on neighbour liaison and consultation to establish credibility and determine community expectations.

- Establish rapport with rural fire brigades and conduct joint burning operations in appropriate areas.

- Emphasis on fire monitoring and mapping to document fire histories.

- Application of JFE jobskills program to initiate a program to revegetate degraded areas on the Eungella Range.

- Establishment of firebreak systems on park boundaries or nearby adjoining land to allow prescribed burning programs to be conducted independently of burning regime on adjoining properties.

- Use of herbicides to created buffer zone between rainforest margins and exotic grasslands. This buffer zone promotes the re-establishment of rainforest vegetation. Rainforest plants are susceptible to damage by fire. Regular fires on rainforest margins will cause the rainforest to recede. This is particularly a problem where exotic grassland adjoins rainforest on steep rocky slopes where conventional fire-breaks are not suitable.

  Herbicides may be used to create buffer zones in these circumstances. Glyphosphate (Round Up) at 10 to 15mL per litre of water will kill grasses but has little effect on rainforest seedlings provided no wetting agent is used.

  The technique used was to spray the emerging grass as soon as practicable after burning. A strap approximately six metres was treated using ten litre compressions sprayers. Large areas may be irrigation sprinklers mounted on the end of a fibreglass rod.

  Results have been very encouraging. Grass growth has been totally removed with little re-establishmnet of grass seedlings due to limited viability of the grass seed. more importantly natural regeneration has occurred rapidly in areas where rainforest beeds were present. Growth rates have at some sites exceeded two metres per year with rapid canopy establishment and elimination of weeds by the exclusion of sunlight.

  These buffer zones also allow easier access to the area for the purpose of lighting fires to burn down slope away from the rainforest margin. The technique is now being used to attempt to revegetate larger areas of fire damaged hillslopes on the Eunguella Range.

In similar conditions to the Cairns hillslopes firebreaks are being constructed where possible to prevent unplanned fires from spreading to the slopes. The intention is to spray strategic areas (gully lines and around remnant patches) to promote natural regeneration and provide green firebreaks to sub divide the grassed area. Tree planting will also be carried out in accessible areas to supplement the natural growth.

The long term intention is to exclude fire from the slopes, but as an interim measure a helicopter will be used to drop incendiaries at the top of slopes to limit the potential damage from wild fires.

- Use of aerial indendiary techniques to access remote and difficult terrain and allow different burning strategy. This program has been undertaken using techniques developed by Australian Nature Conservation Agency staff in Kakadu National Park, in particular the advice provided by Greg Speers has been invaluable.

A Hughes helicopter was fitted with a stainless steel drop tube about 60 mm in diameter. this tube was fitted with a large funnel at the top and mounted in such a way that the incendiary operator could simply drop the indendiary capsules down the tube from this normal seating position.

Injection of the capsules with 1mL of ethylene glycol was achieved by the use of a manually operated "spot gun" linked to a small 1 litre container of glycol strapped to the operators belt. Injection of the capsules was made easier by cutting the injector nozzle back at 45 degrees to provide a sharper point and by depressing the capsule wall with your thumb before injection thereby preventing the nozzle from slipping along the surface of the ball.

This simple technique allowed great flexibility in the rate and placing of incendiaries with a minimum of complicated equipment that always seems to malfunction.

In steep grassland areas the placing of the incendiaries is critical. Alloqnace must be made for wind drift and it appears that the helicopters speed over the ground needs to be kept low. This is best achieved by flying slowly in to the wind, allowing individual ridgelines to be targeted accurately.

The 1993 program targeted about 11,000 hectares, including remote sections of Dicks Tableland and steep coastal rangers and will be expanded in future years.

Fire management In Lumholtz National Park

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Description of Management Area

Lumholtz National Park is located midway between Townsville and Cairns. The park extends from the Hinchinbrook Channel in the east, over the mountains of the Seaview, Cardwell and Kirrama Ranges, and west to the upper reaches of the herbert River. The total area will be 175,000ha upon gazettal of extensions.

Vegetation communities include mangrove forest, swamp melaleuca woodland, eucalypt woodland, wet sclerophyll forest and rainforest. The park is deeply dissected by the Herbert River Gorge and numerous streams and waterfalls.

Annual rainfall totals very from 2100mm on the coast to 800mm in the western section. (See Attachment 1)

Natural Constraints to Fire Management

Topography

The rugged nature of Lumholtz prevents access by vehicle to most parts of the park. Helicopter access for fire ignition and control is possible, however funding levels are not likely to be adequate to place reliance on this form of mechanised management.

The Herbert River Gorge acts as a fire corridor to adjoining properties. It is not possible nor desirable to construct or maintain a mechanical firebreak in the vacinity of the Gorge.

Climate

Rainfall patterns are variable, making long-term predictions of burn times and specific locations to be burnt, meaningless. Different vegetation communities dry out at varying rates. A cool to moderate burn in dry open eucalypt woodland in July/August will generally not carry into adjoining moist eucalypt forest with a more developed understorey (eg. *Casuarina* spp.)

External Factors Affecting Fire Management

Neighbouring Land Use

Grazing

The grazing lands to the west generally use fire as a pasture management tool. Burning regimes vary from one property to the next.

One neighbour does not conduct control burning and treats all fires as "wildfires" to be stopped. They rely on stocking rates to reduce fuel loads. Other neighbouring properties use fire in an attempt to encourage pasture development (native grasses with some introduced species to control shrub and tree regrowth (woody weeds).

Some properties practice winter (June/July) burning. These cooler burns are more easily controlled, however when combined with heavy grazing can result in development of shrub and tree regrowth. *Acacia, Melaleuca* and *Casuarina* species can proliferate under these conditions.

Storm burning (November/December), if conducted when soil moisture content is high (30-50mm of storm rain), may be more suitable in open eucalypt communities where a grass and sparse shrub ground cover is to be maintained.

The introduction of legume species (eg. Stylo) to native pastures is gaining popularity. The legume is seeded over recently burnt ground, generally early in the year whilst soil moisture levels are moderate to high. A program of moderate to heavy grazing in the absence of fire is adopted to allow the legume to take hold (pers. comm. Wairuna Station).

Cattle will continue to be grazed on sections of Lumholtz until at least December 1995. Feral cattle may always be present on the park. Fire management activities will be tailored to facilitate destocking and to protect susceptible areas from post-fire overgrazing.

Forestry

The Queensland Department of Primary Industries, Forest Services Ingham is now concentrating its activities on softwood (*Pinus caribbaea*) plantations to the east of Lumholtz. Fire poses a major threat to these plantations. forest Services actively maintain a system of fire breaks to protect these plantations. Fuel reduction burns are conducted on adjoining lands. Plantation areas are burnt at canopy closure stage (approx. 10 years) in an attempt to modify ground cover composition ie. reduction in flash fuel types such as baldy grass (*Imperata cylindrica*). Normally one, or at the most two, control burns are required to achieve this goal. Park staff work in closely with Forestry to ensure mutual objectives are met.

Sugar Cane

The Herbert Valley cane crowing area is now 95% green harvest. This effectively means the district no longer has cane fires. Some trash burning still occurs however this activity is limited and controllable.

Green harvesting represents a complete reversal in terms of fire management. In past years can fires were one of the main sources of forest fires in the district. All efforts are undertaken to prevent control burns and wildfires from spreading into areas of cane. cane growers are generally supportive of control burn activities and often assist with manpower and machinery.

Rural Sub-divisions

"Hobby farms" and "bush blocks" abut directly onto Lumholtz, often in the absence of effective fire breaks. As a general rule, these landholders view all fire as a destructive phenomenon, and are not supportive of control burning activities. Conflict also arises when control burns clash with pollination time for fruiting trees such as lychees.

Roads and Railway

Lumholtz National Park is dissected by the Bruce Highway, Wallaman Falls Road and Kirrama Range Road. The north coast rail line also runs through eastern Lumholtz. road, and particularly, rail maintenance crews frequently initate fires which result in unscheduled burns. the occasional cigarette and "stray" match also account for wildfires.

Lightning

Lightning strikes along the mountain peaks area a common source of early summer wildfires. Three fires were started in one week from two storms in November 1992. These fires continued to burn for several weeks. One moved down off the mountain and threatened areas of pine plantation near Dalrymple Creek.

Proposed Strategies For Fire Management

- In the short term (1993-1996) priority will be given to completion of vegetation mapping. This information combined with accurate mapping of all fires within the park, will be stored on GIS (ERMS).

- Prescribed burning will be for experimental and protection purposes. On the eastern slopes, a 3 year rotation of cool to moderate burns will continue. Hot wildfires are expected and will be controlled only where property (pine plantations, cane farms, houses, grazing land) is threatened.

- Drier western areas will be burnt at different times of the year. Parch burning to create natural fire breaks will be adopted in an attempt to contain unscheduled (wildfires) within the park. Storm burning will be trailed where and when the opportunity arises. Priority will be given to burns that facilitate destocking.

- Wet Sclerophyll forests that are in the early stage of invasion by rainforest species will receive particular attention. Where adjoining open forests areas have been burnt earlier in the year some late burning may be trailed at these sites. Wet sclerophyll communities that have been subject to regular grazier burns. and the occasional wildfire, appear to be intact ie. an open grassy, sparsely scrubbed ground cover is maintained. Communities that have been invaded by rainforest species are generally isolated from frequent fire due to the presence of roads, or management practices that exclude fire.

  In the absence of sever disturbance (eg. cyclone) it is unlikely that any sclerophyll communities with a well developed understorey of rainforest species, will ever revert to its original structure. These communities may have been restricted by soil type, slope and aspect and it can not be assumed that wet sclerophyll species such as *Eucalyptus grandis* and *Eucalyptus resinifera* will regenerate on the new rainforest margin.

  Loss of these habitat areas has serious implication on the survival of dependent wildlife such as the Yellow-bellied glider.

- Cyclones are regular visitor to tropical Australia. Care will be taken to exclude fore from rainforest communities severely damaged by a cyclone (subject to the above statement).

- Mechanical firebreaks will only be maintained along existing roads and fence lines where appropriate. Boundary firebreak will be sited and maintained in a co-operative manner with neighbouring landholders, the maintenance program will be dependant on adjoining land use.

- Fire monitoring sites will be established at strategic sites (Sue Warriner 1993/94). Mid to long-term fire planning will be based on results of experimental burns and monitoring projects. Specific strategies may be developed for key areas eg. Tropical mountain healthland and Wet Sclerophyll forest sites.

Fire management in Litchfield National Park

John McCartney
Litchfield National Park
Conservation Commission of the Northern Territory

Introduction

Litchfield National park, 120kms south of Darwin, comprises approximately 143,000 hectares of the Tabletop and Tableland Ranges. The Park was previously part of Stapleton, Tipperary and Camp Creek Pastoral leases.

The Tabletop Range dominates the northern section of the Park and is a large woodland plateau surrounded by a highly eroded escarpment and watercourses lined with monsoon forest. River tributaries flow from the plateau over the escarpment to form scenic waterfalls which plunge into clear pools surrounded by perennial spring-fed monsoon forest. Over 200,000 people visit this area each year.

The Southern section is similar, but less developed for tourism and the extent of low open-woodland and floodplains is far greater than in the north.

At present the management of fire at Litchfield is based around the early dry season burning of a percentage of mainly woodland habitat dominated by annual *Sorghum* sp. which in turn affords protection for the more fire-sensitive areas such as escarpments, floodplains and monsoon forest. Early dry season fuel reduction around tourist infrastructure, main roads and Commission assets affords protection as well as being more aesthetically pleasing to visitors than the effects later in the year.

As a new manager for the Park I offer this forum my assessment of current fire management for Litchfield National Park and what I believe we should consider for the future management of fire.

Present management plan and assessment

At present, fire action plans are prepared each year. There are two areas of Litchfield where staff live, Batchelor (the town) and Walkers Creek, a ranger station in the Northwest.

The Walker Creek staff prepare the Northwest and Southwest plan and the Batchelor staff prepare the Northeast and Southeast plan.

The plans are approved by the CDR (Park Manager) and Bushfires Council and form the basis for fire management for the coming dry season.

These fire action plans are developed and written using the following format.

1. To manage fire to ensure:

(a) the safety of visitors,
We have a staff of nine, a large tract of land to manage and large distances between sites used by visitors. In time of fire it is not always possible for us to respond rapidly to contain it. Wildfire emanating from visitor access points is common;

(b) to protect park infrastructure.
Response to contain fire at sites may be slow for the same reasons as above. Financial loss of assets would set the park back; and,

(c) to preserve and protect the natural (wildlife), cultural, historical and educational values of the park. To protect and preserve the natural values of the park is without doubt the most difficult to achieve because this is where one has to determine accurately what those values are, what technique to use to protect them and to monitor accurately any responses.

2. Areas of responsibility

Maps of the Park - these may be a series of overlays or one map, indicating:

(a) roads, 4wd tracks, natural fire breaks such as rivers, service roads, buildings and general infrastructure and walking trails;

(b) topography, indicating slope and elevation and natural fire breaks such as escarpments;

(c) vegetation, indicating major grass, shrub and tree types. This allows us to project areas for fuel reduction burns;

(d) sensitive areas (flora & fauna) which can sometimes be derived from existing plans of management. Little resource data are available for the Park due to lack of research and a lack of a Park Monitoring Programme;

(e) known cultural sites such as Aboriginal art and midden sites have been documented by the Aboriginal Areas Protection Authority. An overall lack of known cultural sites.

(f) historical areas such as remnants of pastoral and mining activities.

(g) water drawing sites available for fighting fires:
water tanks and all take-off points should be located on the resource map;

3. General Strategies

Here is a list of methods which the manager can use to reduce the risk of fire. Most of the methods offer fuel reduction as the main management tool. This could be in the form of controlled burns (including slash/burn, poison/burn), graded breaks or aerial or onground ignition burns, or no burning at all in some areas. The strategy must include a plan to control an area once fire threatens.
At certain times it is possible to carry out low impact fuel reduction burns during the wet season. Annual *Sorghum* spp could be a problem grass because of its ability to spread and perhaps enhance the risk of yearly fires in areas where once fires occurred every 2 or 3 years. Perhaps *Sorghum* also causes changes in the floristic structure of the vegetation it invades because of more high temperature burns. I experimented with *Sorghum* at Keep River National Park, near the West Australian border. Areas with large patches of *Sorghum* that escaped dry and late dry season burning were identified. During the wet when the *Sorghum* seed was shooting the dry fuel was set alight to destroy the new growth. Five years later those same patches remain relatively free of *Sorghum*. Use could be made of this practice in areas such as boundary fencelines (protection of fire entry points and of the fencline), areas immediately surrounding designated sensitive areas to afford greater protection.

4. Stakeholders

The list of people who need to be consulted about the plan will include:

(a) all immediate neighbours such as landowners who have a common boundary with the park. Neighbours at Litchfield utilize the land in several different ways which include:
Pastoralists- cattle
Horticulture- mangoes
Tourism- Caravan parks,food,horse riding etc
Town Council- Batchelor
Government body- school;

(b) Bushfires Council who run the annual aerial ignition program, issue permits, designate fire ban periods and can assist with control and equipment. The aerial ignition programme of the NT bushfires has changed recently and now Bushfire Council charges participants in the programme for the service. In some areas this has resulted in a noticeable decrease in the use of the service by large landowners. This in turn puts the fire risk later in the year greater and the chances of fires from these properties entering the park much greater. For the Park, aerial ignition burning is essential in order to reduce fuel loading over large inaccessible areas. We have to ensure funds are available in our budget to cover the cost of this service. Other priorities can sometimes put pressure on these monies;

(c) Aboriginal groups traditionally associated with the Park, have the right to hunt and gather food within the Park. Generally in Litchfield there are only a few who do and this is confined mainly to plant material. They may wish certain areas to be burnt to promote the production of, and provide easy access to, food.

(d) Concessions include people who operate businesses within certain areas of the Park. Normally park staff assist in protecting these areas from late dry season fires;

(e) Local volunteer brigades.

Legislative requirements are an important part of the plan. The Bushfires Act requires landowners to reduce fuel from their boundaries and so, as a landowner, we have a responsibility to prevent fire from entering or leaving the Park. We have legislation in our own Act, the Territory Parks and Wildlife Conservation Act, Section 12, covering Plans of Management for each park. Plans of Management require that a fire management plan be prepared for each Park.

6. Resources

A list of all fire suppression resources available to allow staff to carry out the plan:
(a) manpower such as the Parks staff and others you may call upon to assist;
(b) tools and resources such as, fire fighting equipment, slip-on units, backpacks, grassrollers, rakes, protective equipment, vehicles, tractors and 4wd motor bikes

7. Fire History

This was included in the action plan as a heading but there was no more than that except for "data to be installed". Fire history is important information and can be used when formulating the years following action plan. For example, known problem areas such as regular fire entry points, prevailing winds and areas that get burnt yearly.

8. Safety

This includes:
(a) ranger training. Staff need to be trained in fire control and management techniques to ensure the best decisions are made when formulating the plan and when in the field fighting fires;
(b) Visitor safety. Manage visitors through direct contact, adverts placed in newspapers and internal signs.

9. The (action)Plan

Documentation and timetable of how the year's fire reduction for the protection of people assets and wildlife from the effects of fire is to be achieved. The problems associated with the action plans are:
(a) how do we carry out a programme with limited human resources, and;
(b) does the plan cater for this year's fuel loading?

10. Monitoring

At present no monitoring plan has been written for Litchfield National Park. Commission policy states that a monitoring programme must be written for each Park. Monitoring fire and its effects over time will prove to be of benefit in fire management. Monitoring fire will allow us to compile fire history, floristic information on the effects of fire and will allow us to make more subjective judgements in future fire plans.

Litchfield National Park have the base for management plans but there are huge information gaps. They will be identified in the Fire Management Plan and prioritised in the Fire Action Plans.

Many interstate visitors and the general public ask me why we burn. Simply, we burn because if we don't someone does it for us and if they don't manage to burn it all then lightening strikes later in the year will cause a very destructive fire. Reasons why people light fires have been speculative, for example, illegal hunting made easier by burning, revenge against the service and tradition. Despite early dry season burns in April-May there have been up to five different fires burning on the Park at one time.

Fire management in Kakadu National Park : an overview

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Introduction

As outlined in the Plan of Management (POM; ANPWS 1991) the main objectives of fire management in Kakadu National Park are as follows:

* maintain, as far as practicable, traditional Aboriginal (*bining*) burning regimes within the Park;
* maintain biodiversity;
* protect life and property within and adjacent to the Park, and minimise the spread of fire both from entering or leaving the Park;
* provide for the identification and protection of sensitive environments and species, and promote research into these aspects;
* maintain community education and interpretation programs covering the role of fire in Kakadu; and
* monitor the effectiveness of Park fire management programs.

As well as these objectives the POM recognises that, through its direct influence on habitat, fire management plays a critical role in conservation of native flora and fauna generally.

In this paper I will focus largely on the practice of fire management in Kakadu NP; matters to do with monitoring and research are covered in a companion paper (*this volume*). Given the evident importance placed on Aboriginal burning in the POM, it is useful to start with some general comments about traditional burning regimes, and why such practice generally satisfies the requirements of conservative fire management practice.

Traditional burning: then and now

At the time Ludwig Leichhardt and his band of adventurers traversed the lowlands of the South and East Alligator Rivers it is estimated that there were between 2,000-3,000 people utilising the resources of these systems (Keen 1980). The pattern of human occupancy was markedly influenced by seasonal conditions. Thus, during the wet season many clans returned to their estates through the Arnhem land escarpment and plateau; some remained at large camps scattered along floodplain margins. Essentially, however, the wet season was a time of maximum dispersal of people across the landscape (eg. Schrire 1982; Jones 1985).

Beginning with short, dry spells in the wet season, burning was undertaken progressively through the year as clans travelled through their estates (eg. Jones 1969, 1975, 1980; Haynes 1985, 1991). Fires lit early in the dry season were patchy and small in extent, increasing in size and intensity as grasses cured with the progression of the seasons. Even as late as July fires typically are self-extinguishing at night, given relatively cool nights, high soil moisture levels, dew, and patchiness of cured grasses. By July most vegetation associated with drainage lines and low-lying areas associated with riverine floodplains is unlikely to heve been burnt.

Also, in some areas at least, by this time protective burning had been undertaken on the margins of fire-sensitive, resource-rich habitats such as rainforest patches, paperbark forests, and spiritually significant sites (eg. Jones 1980, Lucas 1993).

From about July/August onwards, however, fires may burn all night,including through areas partially burnt earlier in the season. At this time of year (*gurrung* in the Maiali seasonal calendar), burning needed to be undertaken with considerable circumspection (Lucas 1993); for example, by making sure that fires were directed onto previously burnt areas. Uncontrolled fires at this time of year can burn for weeks, consuming the resources required for feeding prey species and people alike. With the arrival of the first storms in October-December, in *gunumeleng*, burning could be resumed in ernest. At this time burning was concentrated especially on the floodplains and fringing woodlands, where people were now gathered availing themselves of abundant food resources such as waterbirds and waterlilies (*Nymphaea* spp.), lotus (*Nelumbo nucifera*), and water chestnuts (*Eleocharis* spp.) (eg. Lucas et al. 1993). *Gunumeleng* is also the period of naturally occurring, lightning-lit fires.

A major consequence of such widespread use of fire over the landscape is that it would have provided for a significant level of control over late dry season (*gurrung*) fires; thus, the potential for widespread human-lit, intense ("destructive") fires would necessarily have been markedly diminished (eg. Haynes 1991). Such a controlled fire regime is likely to have been in operation in the western Arnhem land region for at least the last two to three thousand years, associated with massive human population increase attributable to the formation of the resource-rich freshwater wetlands (Jones 1985).

In turn, the collapse of the regional Aboriginal population by the turn of the last century (Keen 1980) may be anticipated to have had repercussions with respect to fire ecology. Certainly, oral evidence indicates that, over the past three decades at least, late dry season fires have become prevalent in the Arnhem Land escarpment as a result of lack of fire management (Lucas et al. 1993). These observations mirror findings of regional collapse of fire-sensitive *Callitris* populations (Bowman 1993), and severe fire impact on regional rainforest communities (Russell-Smith 1984; Russell-Smith et al. 1993).

A second major consequence of this imposed, traditional fire regime is that it creates a mosaic of early burnt, late burnt, and unburnt patches. Such a mosaic enhances habitat diversity which, as many faunal studies undertaken in the region argue, is essential for maintaining suites of animal species with different requirements (eg. Braithwaite 1985, Woinarski 1990, Andersen 1991).

In sum, therefore, traditional Aboriginal fire management practice is clearly pertinent to contemporary fire management of Kakadu National Park both because such burning has helped fashion regional landscapes over recent millennia, as well as provide a practical model for managing fire in a highly fire-prone environment. The challenge for Park managers is not to emulate past practices (because human occupation patterns have changed so dramatically in recent times), but to learn to adapt new burning techniques and technologies for achieving a 'balanced' fire management program such that a full complement of habitats and species can be conserved.

Contemporary fire management

While Aboriginal residents of the Park continue to burn country, mostly in limited areas associated with hunting activities, the great majority of burning is undertaken as part of the Park's management program. Fire management on Park boundaries is undertaken in cooperation with the CCNT's Bushfires Council.

A practical implication of adopting the traditional fire management model is that, in order to reduce the frequency, extent and intensity of wildfires in the Park, considerable effort must be given to breaking up grassy fuels in the early-mid dry season. As such, staff undertake a concentrated program of burning as soon as grasses cure sufficiently to carry fire; in most years this means burning begins in May and is largely completed, at least for the escarpment and lowland woodland savannas, by mid-July. Floodplain burning, on the other hand, is maintained throughout the year given that such habitats may remain moist well into *gurrung.*

A second practice, undertaken only in limited situations to date, has been to employ early wet season burns to reduce the density and cover of tall annual grasses, especially *Sorghum intrans.* This species, which typically grows to over 3 metres through the wet season, provides one of the main woodland fuels. Early wet season burns can virtually eliminate annual *Sorghum* by removing the crop of new shoots; such burns, however, presumably also remove other annual species. Wet season burning is currently undertaken only along roadsides and around campgrounds etc. It has major potential, however, in other situations; for example, in areas adjoining the Park boundary.

Apart from fire management targeted at specific sites (eg. camp-grounds, boundaries), for further discussion the greater part of the Park is usefully considered as comprising three major landscapes types, each with its own requirements and problems: the escarpment and plateau, the lowland woodland and open forest savannas, and the floodplains.

Table 1: Proportion (%) of major landform features burnt in Kakadu National park , 1992-93

	Apr/May	**Jun/Jul**	**Sep/Oct**	**Total**
1992*				
floodplains	0.4	36.1	6.8	**42.9**
lowlands	1.3	47.0	4.3	**51.3**
escarpment	0.0	14.1	3.5	**17.6**
whole Park				**45.2**
1993**				
floodplains		38.3		
lowlands		42.8		
escarpment		9.2		

* data from DuRieu (1993), interpretation of LANDSAT MSS
** data from ground-truthing of 503 random points

Escarpment and plateau

Growing mostly on sandstone-derived substrates, the vegetation of the escarpment and plateau comprises extensive areas of relatively fire-sensitive rainforest, heath and cypress pine communities, as well as eucalypt woodland. Vegetation studies (eg. Russell-Smith 1984; Russell-Smith et al. 1993; Bowman 1993) and Park experience demonstrate unequivocally that plant communities (i.e. habitats) on the sandstone have received massive fire impact in recent times; such observations are borne out by satellite monitoring studies (eg. Day 1985)

The major problem for fire management in the escarpment is that the Park adjoins a largely uninhabited tract of country (Arnhem Land) that receives little fire management; as such, in the mid- to late dry season, uncontrolled fires driven by predominantly south-easterly winds may burn into Park, unchecked and on 100 km+ fronts, from as far away as 200 km or more. For recent times satellite imagery available in the Park records such fires as occurring in 1972, 1982, 1984 and 1987.

Until as recently as 1991 Park staff were able to do little to address this problem; the use of helicopters has changed all that. Now, burning is undertaken from as early as possible, targeting the open sand plains which support predominantly eucalypt woodland; vegetation on the sandstone itself is left unburnt. By burning as little as 17% of the escarpment in 1992 (with 14% burnt by the end of July), two large late dry season fires were effectively kept outide the Park. This year 10% was burnt by the end of July (Table 1).

Lowlands

Vegetation on the lowland plains comprises mostly eucalypt woodland or open forest savanna, often with a tall grassy understory of annual *Sorghum* grasses. While helicopters now give easy access to the lowlands, much fire management is ground-based, particularly along roads and around settlememnts and other facilities. Protective burning is undertaken around springs and along watercourses. Most burning, however, is typically broad scale, in an attempt to break up the country as early as possible.

Following the experience of the 1980s where burning in the lowlands was often dominated by, or comprised extensive areas of late season, *gurrung* fires, recent practice has involved working much harder on controlling the fire regime. In 1992, for example, some 47% of the lowlands were burnt between June-July, with only 4.5% being burnt late in the season (DuRieu 1993). This year 43% of the lowlands was burnt early (Table 1). While the amount of burning undertaken in the lowlands probably needs to be reduced in coming years, and more strategic burning put in place, it is hoped that the days of widespread late dry season fires are gone.

Floodplains

Comprising mostly open herbaceous communities and fringing paperbark (*Melaleuca*) forests, floodplains currently present the major challenge for fire management in Kakadu. The problem is essentially one of fuel load. Up until the turn of the century it is probably realistic to consider that Aboriginal people progressively burnt much of the floodplains, especially through the late dry season when hunting and foraging effort was concentrated on floodplain resources. From the turn of the century on, it is probably realistic to consider also that fuel loads were largely kept down by the huge herds of water buffalo which came to roam (and totally modify) these plains. With the demise of large numbers of buffalo through the 1980's as part of the national BTEC program, grassy and cyperaceous fuels are now building up.

Current practice is to burn the floodplain margins as early as possible, so as to reduce the possibility of fires later in the season exiting from floodplains or, conversely, from surrounding woodlands. Such burning is readily achieved by staff driving around floodplain margins (using 4WD quads) or by using helicopter ignition. The problem then becomes one of returning and returning, burning a little bit more each time.

In areas which dry out late, the problem is one of critical timing given that hot, but slow moving fires can burn on the humic soil surface while the grass cover is still green and moist. Paperbarks and other woody species with superficial root systems are particularly susceptible to being killed by such fires. Further, in the absence of rain or substantial previously burnt firebreaks, such fires are virtually impossible to stop. In 1992 and again this year, about a third of the floodplains in the Park were burnt early (Table 1). Such burning in 1992 did not stop a particularly severe, late season fire from burning an entire floodplain system from its inland extremity to the coast, over a distance of approx. 50 km.

Discussion

Given that a stated aim of the current fire management program is to employ early dry season burns for reducing the impact of more intense fires later in the season (ANPWS 1991), it is useful to assess how well that aim has been, and is being, achieved. While satellite monitoring firescar data for the whole Park over the years 1980 to the present are still being assembled (*see* Russell-Smith 1993), some data are available from studies undertaken by ANCA staff and its consultants. Each of these studies has examined the relationship of early to late dry season burning in different portions of Kakadu NP using LANDSAT imagery.

Past studies, summarised in Table 2, show that the incidence of late dry season fires through the 1980s has been widespread; in two studies (Day 1985; Graetz 1990) late dry season fires are shown to have been markedly more prevalent than early dry season burns in repective years over all years examined. In the third study (Press 1988) this pattern is demonstrated for three of the six years examined, in both Kakadu NP Stages 1 and 2.

On the positive side, Press (1988) was able to demonstrate the effectiveness of early dry season burning in reducing the incidence of intense late season fires. As well, the study by Day (1985) was very useful as it demonstrated that some past late dry season fires have emanated from outside the Park, particularly from the south-east.

Limited data for 1992 and 1993 (Table 1) indicate that the pattern of burning has shifted markedly towards the early to mid-dry season, as part of a concerted program. The data for 1992 are particularly instructive as they indicate that the great majority of burning is occurring in the cool months, June-July.

As apparent also in these 1992 data, a challenge ahead for fire management in Kakadu will be to reduce the extent of burning required to effectively achieve control of the fire regime, particularly in the lowlands. Another challenge, previously outlined, includes developing an effective strategy for floodplain burning. But perhaps first and foremost, greater attention must be given by land managers across northern Australia to communicating the need for effective fire management to a largely uninformed and sceptical public.

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Preservation of diversity in semi-arid Lawn Hill National Park

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Introduction

Three hundred and ninety thousand hectares of Queenslands north west highlands are now under the management of the Department of Environment and Heritage; comprising Lawn Hill National Park and Resource Reserves as shown in Figure 1. Sections of two of the perennial Gulf streams which drain the Barkly Tableland, the Gregory River at 200 million litres per day and Lawn Hill Creek at 100 million litres per day, are represented within the park.

Stretching 130 kilometres in length and sharing a common border with the Northern Territory, this estate contains a diverse representation of floral habitats, unique to Queensland as parts of the Top End and habitats spill over the border into the North West Highlands of Queensland.

Fire management implications for new additions (Highland Plains and Riversleigh Pastoral Holdings) to the Departmental estate are not dealt within this paper.

The Gorge Section of the park is of immense biological importance with riparian forests, dry vine thickets over-lying both fire-protected areas of limestone and sandstone, and the presence of rare or endangered flora and fauna. The major vegetation community outside the permanent spring fed waterways is spinifex over-lying limestone.

Experience with the prescribed use of fire in riverine, dry vine thicket and adjacent spinifex communities has been gained around Lawn Hill Creek over the past five years. the objective and methods for management of fire in the Gorge section of Lawn Hill National Park will be reviewed here.

Objectives

A. Protection of Life:

- Visitation exceeds 12000 persons annually.
- 80% of visitation occurs in the dry season months (April - November).
- There is an increasing staff and accident risk potential.

B. Protection of Property:

- Departmental and neighbouring infrastructure.
- Neighbouring stock and grazing land.
- Park visitor camping equipment and vehicles.

C. Reduce Fuel Loads:

- Along riverine areas to encourage a diversity of plant species and variable age structure within vegetation communities.
- In spinifex that abuts riverine areas to create fire breaks and encourage proliferation of soil nourishing pioneer species.
- Around dry vine thicket margins to protect fire sensitive species eg. *Ficus, Nauclea, Celits, Brachychiton, Melia* and *Mallotus* spp.

D. Optimise biological diversity by actively using fire as an ecological tool to:

- Encourage expansions of the restricted riverine and dry vine thicket habitats over the less diverse but expansive spinifex habitat.
- Control introduced plants and thus confine the distribution of their seed stocks.

'Fire Fighting' will cease to occur through management of mosaic patterns of differently aged vegetation with utilisation of natural fire freaks, e.g. creek, escarpment or bare colluvial areas. Man-made fire breaks will be kept to an absolute minimum, being mindful of the sensitivity of the land to erosion and the expense of maintaining permanent fire breaks on this rugged landscape.

Methods

1. Figure 2 details the nine vegetation communities of the park and their sensitivity to fire. Fire exclusion zones are applicable in some types;

   a) For specific species preservation; and
   b) As benchmarks to assess changes in burnt communities.

2. Figure 3 shows natural fire breaks where there are low levels of combustible fuel.

3. A fire management plan has been developed which describes;

   a) Each vegetation type with indicative plant species.
   b) Specific fire management objectives.
   c) Prescribed burning methodology.
   d) Notes on weed species, cautions to be exercised, and notes on special faunal species habitat protection.

4. A Fire Record Data Sheet (Attachment 1) has been formulated for monitoring with simplicity in mind, to address both pre-fire safety checks and post-fire effects on vegetation communities; and to enrich the fire history and long term understanding of practices. Satellite imagery was trialled but was found to be unreliable as unburnt exposed rock areas showed up similar by on the imagery to recently burnt areas. Photo-monitoring in 'typical' communities have been set up to record visual changes and species composition.

5. An annual fire action plan is submitted for District Manager approval. Figure 3 identifies areas of vegetation communities that require attention to meet the requirements of vegetation mosaics, bearing in mind local staff resources and seasonal growth patterns. From experience, it is best to request an ambitious number of locations for prescribed burns, so that optimum conditions are best utilised without the need for further approvals. Any standover is rescheduled for the following year.

Conclusion

Since the above methods are being used and understood by present staff, management of the extended area of Park estate including Riversleigh and Highland Plains sections, will require similar strategies. It is likely that Aboriginal assistance will be available to assist in re-establishing fire management regimes for the greater National Park estate.

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From cattle station to National Park - A twenty five year personal history of fire use on Lakefield National Park

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To understand the current fire regime on Lakefield National Park it is necessary to briefly review the history of Lakefield over the past one hundred years, or what we know of it.

Lakefield and Laura were selected around 1878 as grazing properties for cattle, presumably to supply beef to the lucrative market of miners attending the Palmer River gold rush at the time. Laura Station, being situated on the main access road to the Palmer, made it a very profitable operation.

The specific area of the leases at that time is vague. However, over the years other leases were acquired and added to form one of the largest cattle properties on Cape York Peninsula. Lakefield and Laura were at times held co-jointly at other times separately. The area of the National Park at the moment is 537 000 hectares.

During the first 70-80 years, it was relatively lightly stocked as different owners tried different pastoral practices and programs centred on the system known as *open range* grazing. This system did not lend itself to the controlled breeding that was introduced in later years. In 1966, it was purchased by Tipperary Land Corporation as one whole unit. It was from this point on that large scale development began with fencing, stock yards, dams, outstations and various other infrastructure being constructed. This led to the controlled breeding whereby cattle numbers increased dramatically.

When purchased by the then Queensland National Parks and Wildlife Service in 1978, there was approximately 20,000 head of cattle grazing Lakefield. Destocking commenced in 1980 and over the next eleven years over 33,000 head of cattle were recorded being shifted from Lakefield.

Because the park is adjacent to many cattle properties and total boundary fencing was out of the question, almost 300 kilometres of fencing was constructed to create a stock free zone of approximately 280 000 hectares within the park. It is difficult to estimate what number of cattle may still be in the stock free zone. However, a rough estimate would be between 500/1000 head. Throughout the whole period of grazing, Lakefield was subjected to some form of management.

The burning program in those days was not as widespread or nearly a intensive as we have today. In the grazing industry, fire was used as a management tool for three principal reasons :

1. To control cattle tick infestation by burning infected areas to kill seedticks that used tall grass to access their hosts.

2. To promote fresh pasture regrowth for stock.

3. To facilitate mustering of stock.

To achieve these results burning off would commence as soon as grass would burn after the wet season, consequently the areas burnt were usually limited, resulting in a much smaller mosaic pattern than we have in the current program. Because cattle grazed the area continuously throughout the wet season, accumulated pasture growth was nothing like what we have today which resulted in fires of much lower intensity. All burning would cease by the end of June and resume on a limited scale during the storm season wherever "rank" grass remained.

Briefly, the grazing fire regime could be summarised as;

1a. Early burns of less intensity.

2a. A more mosaic pattern of fires

3a. A much smaller area burnt overall. Approximately 15% as compared to 40% today.

For better or for worse, the results of this fire regime are what we have inherited. With the removal of over 30 000 head of cattle we are left with a situation where vegetation and grass has increased 50-60%. Unrestricted growth of grass has reached a height and density never before imagined over such a large area.

This is the major problem we have to contend with - how to implement a fire management program best suited to the environment, protection of infrastructure, safety of visitors and neighbouring properties while carrying a large fuel load over a large area?

Only limited grazing continues on Lakefield by way of stock grazing permits and the area now designated for prescribed burning each year has increased to approximately 50%. Prescribed burning on this scale is a huge task that requires considerable planning and precise timing to achieve the best results. Obviously, seasonal conditions determine the planning which subsequently governs the timing. Other factors for consideration are wildfires in the no burn areas during storm time, neighbouring property situations plus all the other standard requirements. It is therefore essential that any fire plan of this magnitude must remain flexible to cover all or any contingencies. Intensive prescribed burning on Lakefield commenced in 1983 but because of the destocking program being carried out at the time, we were restricted in methods and application.

When destocking terminated in 1986, it was then possible to implement a full scale program to a specific plan. The basis of this plan was to develop a mosaic pattern to break up the whole area in such a way as to meet the essential requirements for wildlife, infrastructure and public protection and, most importantly, fuel reduction to ensure protection against devastating wildfires in the dry season.

In the initial stages different strategies were tried using different methods and some were successful and some were not. It was only by trial and error that we have progressed to the most practical and successful regime being applied today. It is very likely that, in time, we will need to revise the current regime in light of further knowledge of the environment.

The current strategy is based on using natural barriers where ever possible. The main access road through the park from south to north forms the primary fire break with most burn areas radiating from it. Because all the fence lines are slashed and burnt prior to the fire program some of these lines are incorporated as fire breaks. This helps significantly in achieving the break up required.

As was mentioned earlier, timing is most important because water courses designated as fire breaks must still be green enough to successfully contain the fire. During the past six years, the wet seasons were not sufficient enough to cause a flow in these natural barriers. Consequently, the grass they carried matured in line with the surrounding vegetation and were thus useless as firebreaks.

This is when flexibility in the plan is required. Lakefield is situated on what is known as the Laura Basin on Caper York Peninsula. It stretches from Princess Charlotte Bay almost to the township of Laura encompassing the lower reaches of the Normanby, Morehead, North Kennedy and Hann Rivers (plus many other tributaries which join the rivers) which all flow into Princess Charlotte Bay. There are many different land units in the park and a wide diversity of vegetation types. Put simply and briefly, it could be described as low coastal grass plains adjoining Princess Charlotte Bay, to box/coolabah flood plains between the river systems rising to open grassy woodlands of melaleuca and eucalypt.

On the higher country in the south, grevillea, acacia and bloodwood dominate on the lighter sandy soils with sparser grass coverage. With the many and varied land and vegetation types over such a large area, the curing of grass also varies from one area to another. To compensate for this it is sometimes necessary to implement ad-hoc burns prior to or after the main fire program. Because of the limited time frame and restricted resources, the same fire strategy is applied to all types of land units on Lakefield. However, certain areas designated by the Principal Conservation Officer (P.J.Stanton) are treated separately at different times of the year for various reasons (eg. to control weed species such as rubber vine).

In recent years, we have introduced early burns as stage one of the burning program by using a small helicopter to reach inaccessible areas. This allows the fire management officer to select suitable areas that will ignite at that time and thus further fragment the prescribed burn area. This has the distinct advantages of :

1b. Providing a safe haven for wildlife during the major burns

2b. Establishing to some extent a barrier where no natural barrier exists

3b. Ensuring much cooler, slower burns.

Stage two of the burning program consists of on ground burning which is the major part of the program and requires a full complement of staff plus all the necessary plant and equipment. Most of the staff have to be moved in from other management units. Consequently, a period of three to four weeks notice is required, which means the commencement date is determined at least five weeks ahead. For obvious reasons, once the starting date is confirmed it has to be adhered to. It also means the major part of the fire program is governed by weather conditions prevailing in five weeks time. In my experience ideal conditions have seldom prevailed over the eight to nine day ground burning program.

On any given day, the winds may increase to 25 to 30 knots, which, in a heavy fuel area, will create a very hot fire. Consequently, severe scorching of the canopy results. On the other hand, if the fuel is less than 80%, cured a 10 - 12 knot wind is usually required to carry the fire. So generally speaking, prevailing weather conditions determine the result of the day.

Stage three of the burning program, is carried out by aerial burning to fill in the areas not satisfactorily covered by the ground burns and to reach iareas inaccessible from the ground. This is a very important part of the program because, without establishing satisfactory breaks in these areas, wildfires will penetrate to the no burn areas and the whole plan literally goes up in smoke. The aerial burning flights also allow time to carry out monitoring of overall result of the program. The aerial burning is usually delayed as long as possible to allow any late curing areas time to dry out. With completed ground burns from stage 2,the late curing areas tend to be well separeted by burned breaks.

This article is confined to fire management on Lakefield National Park. It is intended as a practical view of fire management relating to a specific area. Other areas may warrant an entirely different burning regime. I am not qualified to comment on the scientific value or otherwise of this fire regime. That can only be determined by monitoring the effects of our imposed fire regime that for all intents and purposes has proven to be a successful tool in light of what we know today.

Fire management - in the wake of two centuries of mismanagement - in conservation reserves of tropical Australia

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Abstract

Just as contemporary technologies are changing the face of the earth at an unparalleled rate, the demise of Aboriginal land management "technology" in the last two centuries - the traditional use of fire as an ecological tool - has caused massive and continuing changes in ecosystems across northern Australia.

Ignorance and an inherited abhorrence of fire - what better recipe for inaction - have masked an insidious and incremental loss of habitats, the loss of biological and genetic diversity, over two centuries. Fire has an inevitability about it. Through an "enlightened" decade of debate which now seems fickle, academic and downright naive - what is natural ("let nature take it's course"), what time in the evolution of our ecosystems do we wish to emulate, were Aboriginal burning practises self-serving with little regard for their environment - the build up in fuel loads has fed wildfires which have capitalised on our apathy, and made our decisions for us. The net result has been a change in entire ecosystems, some irreversibly so.

Introduction

The crux of the matter for humanity is one of keeping our options open; "the preservation of genetic diversity is both a matter of insurance and investment necessary to sustain and improve agricultural, forestry and fisheries production...as a buffer against harmful environmental change, and as the raw material for much scientific and industrial innovation - and a matter of moral principal" (IUCN 1980: Sect. 2).

Paralleling the demise of Aboriginal burning practises, the introduction of hard-hooved domestic stock to the Australian landscape was accompanied by widespread erosion and the loss of soils. Soils which might be classified as renewable in evolutionary time scales "are virtually non-renewable because of the very low rate of formation and the very old landscapes on which they occur" (De Lacy 1993: p17). Even under ideal conditions "nature takes from 100 to 400 years or more to generate 10 millimetres of top soil" (IUCN 1980: Sect. 2).

Coupled with the loss of soils, and the cessation of the managed use of fire as an ecological tool, an invasion of natural ecosystems by hordes of noxious plants and animals, has left contemporary land managers with a complex scene indeed. A scene where the trend in diversity of life forms is inevitably downwards, and to a large extent, irreversible. A number of case studies from the tropics are cited below in examining these deleterious changes to ecosystems.

Maintenance of Biological Diversity

Haynes (1985: p207) observations of the traditional burning practises of the Gunei people of north-central Arnhem Land clearly demonstrated their strong conservation ethics towards "fire-sensitive" plant species which occur in habitats notable for their biological diversity:

> "very positive efforts are made, even according to ritual observance, to keep fire out of these areas" (closed forest, monsoon forest and thicket).

There is strong evidence for the loss of biological diversity with the demise of Aboriginal land management practises. Haynes (1985: p213) research on the Gunei revealed their knowledge of a range of wildlife that were disappearing (Spectacled Hair Wallaby *Lagorchestes conspicillatus*, Northern Bridle Nail-tailed Wallaby *Onychogalea unguifera*, Hooded Parrot *Psephotus chrysopterygius*) in "dirty country" (ie. neglected pre-existing fire management regimes). In addition, Bolton and Latz (1978 cited in Bridgewater 1992: p304) demonstrated the "near extinction of the rufous hair-wallaby Lagorchestes hirsutus in the spinifex areas of central Australia consequent to the removal of traditional Aboriginal fire management methods".

The concurrent introduction of grazing animals and consequent effects on plant species composition in the native grasslands also needs to be considered in relation to the demise of Aboriginal burning regimes. However, whilst spinifex pastures "provide valuable drought relief for graziers...such pastures are not suitable for fattening or breeding cattle" (Innis 1990: p15). Consequently, so far as grazing is concerned, spinifex pastures are amongst the least affected native pastures in tropical northern Australia. The correlations between loss of faunal species and altered fire management regimes, rather than with the effects of grazing, therefore holds true.

In the semi-arid highlands of north-western Queensland, Innis (1990:p5) demonstrated how spinifex, encouraged by fire, has invaded fire-sensitive vegetation types and thus reduced biological diversity; a phenomenum resulting from two centuries of unmanaged, broad-acre, high-intensity fires:

"Spinifex is ideally suited to an arid environment. It thrives on impoverished soils with low rainfall and proliferates after high intensity fires which render the soil bare to erosion and unsuitable for other plants...Amidst this vast expanse of spinifex, the park managers dilemma is how to protect (and expand) the vulnerable fire-sensitive plant communities which cling to fissures in rocky outcrops, and grow around springs and along waterways. These are the oases of the arid inland...Examples of these communities are found in spring-fed gorges, along creeks and perrennial rivers, and, at the drier end of the scale, in the lancewood *(Acacia shirleyii)* and dry vine thickets which typically persist only where natural firebreaks occur."

Stanton (1988: p4) encapsulates the broadscale changes in ecosystems which have accompanied the demise of Aboriginal burning practises, as evidenced by air photo records:

"The greatest changes are occurring in the wet tropics and parts of the south-east of the state (Qld)... aerial photo evidence reveals that in some areas the progression from open grassy sclerophyll forest to sclerophyll vine forest has occurred in as short a space as 30 years. The wet sclerophyll forests are under threat."

Whilst there can be little doubt that the sclerophyll vine forests and rainforests harbour a greater diversity of plant and animal life than the adjacent wet sclerophyll forests and grasslands (Frith 1982: p12 - 14), Stanton (pers. com.) argues that the irreversible loss of entire habitats (such as wet sclerophyll forest) and associated rare or endangred fauna (eg Yellow-bellied Glider *Petaurus australis*), is of greater concern. During an interview on ABC radio, Stanton (1990) defined the crux of the matter:

> "...already two-thirds of those pockets (wet sclerophyll forest) are now in a condition where they cannot be burnt...we must preserve our options...we're not going to make value judgements on rainforest versus eucalypt forest...where you see obvious change in an irreversible direction in an ecosystem...take whatever steps are necessary to hold that change, to preserve that diversity".

This is of course a very different scenario to the disastrous repetitive wildfires originating from sugar cane fields, which have raced up hillsides from Tully to Cairns, laying the rainforest bare. Thankfully, cane is now harvested green, and the slow regeneration of the rainforest back to it's former range is increasingly evident. Stanton (1988: p4) notes that on Long Island in the Whitsundays "a 1938 photo of a grassy *Eucalyptus alba* woodland is in a location that today cannot be photographed; it is a young closed forest made impenetrable by lantana." Many would argue the value judgement that rainforest is an improvement over open grassland, but addition of the knowledge that grasslands on islands provide representation of native pastures where most of those on the mainland have been invaded by a range of introduced legumes and grasses, might tip the balance in favour of maintaining grassland communities on such islands (Thompson and Nolan 1993).

Use of fire as an ecological tool was by no means a skill restricted to the "first Australians". Lewis (1986: p45 - 46) demonstrated strong cross-cultural similarities in the use of fire between Aboriginal Australians and North American Indians with "Australian and North American hunter-gatherer's uses of fire were strategies for resource production no less manipulative that those found with farming", and noted the rarity of investigations into the "ways in which human foragers have helped shape selected habitats or, in some instances, influenced near total environments through prescribed uses of fire".

The issue of fire management in conservation reserves

A "deeply ingrained abhorrence of fire" (Stanton 1988: p4) and the "still widely accepted Euro-American folk view which sees fire merely as a destructive environmental force" (Lewis 1986: p46), have been fed by such catastrophes as the 1939 "Black Friday" and 1983 "Ash Wednesday" wildfires in South Australia and Victoria, setting the scene for contentious fire management programs by Conservation Agencies across Australia.

Especially in the last decade, a number of authors have been busily setting the record straight. As recently as 1982, Horton hypothesised that Aboriginal burning practises merely "replicated the natural patterns of burning", but this has been effectively rejected (Lewis 1986, 1989, 1992, Hallam 1985 cited in Lewis 1989: p946) to show "they altered natural processes in ways that allowed...environmental conditions favourable to their adaptions as hunters and gatherers" (Lewis 1986: p51). Lewis (1986: p21-22), for instance, encapsulates perhaps 40,000 years of Aboriginal burning regimes across Australia with:

> "selectively setting fires across a variety of habitats, while excluding fires from others, setting them at different times of the year, burning areas under varying degrees of frequency and intensity, with the result that they influence the productivity and diversity of plants and animals...On returning to an area after an extended absence and, with the build-up of fuels, Aboriginals will set fires, some of which may result in conflagrations causing, in our view, great devastation...this is done not to destroy vegetation in an area but, rather to "make it right"...The problem is not high intensity fires; the problem is that there have not been enough low intensity fires in previous years...or insufficient early season fires".

Stanton (1988: p4) potently meshes Aboriginal land management practises with contemporary management of protected areas with:

> "What we inherited 200 years ago was a land whose ecosystems were intensively and systematically managed; whose habitats in all their forms were the relatively stable end product of land use practises shaped by ritual and tradition. And we have changed all that in our time. It is inescapable that our changes have been universally disastrous in terms of loss of species. Aboriginal man's main tool in the management of the landscape was fire. We, as a society, have largely ignored the striking significance of that fact, and have allowed our protective attitudes towards our native ecosystems (where we occasionally have them) to be coloured by inherited attitude from other climates and other cultures...as land use managers, we should not be so blind."

Table 1 summarises a range of fire management regimes utilised in various vegetation types across tropical northern Australia. The protection of fire-sensitive species is a major objective except in particular circumstances where threatened habitat types (eg. wet sclerophyll forest) are being lost because of the advancement of fire-sensitive habitats (eg. rainforest) in the absence of a fire management regime.

The role of management planning in fire management strategies

De Lacy (1993: p152) defines planning as "a process which begins with objectives; defines strategies, policies and detailed plans to achieve them; establishes an organisation to implement decisions and includes a review of performance and feedback to introduce a new planning cycle." From the Queensland perspective, the Department of Environment and Heritage has a range of planning processes in train to tackle the onerous task of fire management in protected reserves.

In a perfect world, the QDEH, corporate plan would be reflected in regional strategic plans and individual park management plans down to a range of action plans addressing specific park management issues such as prescribed burning. The evolution of new legislation (*Nature Conservation Act* 1992; subordinate legislation, the *Nature Conservation Regulations*, have not as yet been proclaimed) and the time-consuming nature of the public participation process has meant that there are currently very few approved management plans for protected reserves in Queensland.

Fire management plans and fire action plans addressing prescribed burning programs are never-the-less in place for all other than recently acquired reserves. Such plans are concise documents - detailing objectives, strategies and methodology for the protection of life and property and the retention of biological diversity, and monitoring programs to assess change - requiring annual updating to reflect current resource knowledge and Departmental policy, as well as seasonal effects on fuel loads.

Another planning strategy employed is the production of educational material, targeting fire managers across conservation agencies with the findings of recent research via newsletters or publications (eg Fire Information Research Exchange, contributions to Australian Ranger Bulletin, published proceedings of fire management workshops), and information brochures on fire management for the general public. An effective strategy employed for contentious fire management programs near or adjacent to highly populated urban areas has been the use of press releases prior to lighting fires; explaining our purpose before-hand such that news-worthy "wildfire" issues are relegated to history rather than becoming contentious, when fires are actually lit.

The Queensland Department of Environment and Heritage is like any other organisation with respect to the frequency of staff movements. Our planning framework provides a range of training programs to curtail the loss of local knowledge and experience, which so often accompanies staff transfers and threatens "re-invention of the wheel". Induction manuals for new or relieving staff detail administrative and operational (including fire programs) procedures, the annual revision of fire management and fire action plans updates current knowledge, and the regular provision of fire workshops either internally, in co-ordination with the Queensland Department of Primary Industries (Forest Service) or incorporating University course training modules, have all proven effective approaches to training.

Finally, the success or failure of implementation of fire management programs on conservation reserves invariably hinges on the co-operation of neighbours - adjoining land owners often having different land uses and objectives of land management! Departmental community nature conservation policy ("Good Neighbour Policy") highlights the essential role of regular liaison with neighbours, working from a foundation of shared concerns such as fence maintenance, control of noxious plants and animals, and the provision of firebreaks to control wildfires.

Table 1 **Prescribed burning regimes utilised in various vegetation types across tropical northern Australia (adapted from Stanton 1988[1], Innis and O'Keefe 1992[2], Humphries and Stanton 1992[3], Thompson and Nolan 1993[4], and Russell-Smith 1993[5]).**

Vegetation Type and Indicator Plant Species	Fire Management Objective	Prescribed Burning Regime	Traditional versus Contemporary Fire management
Dry vine thickets[2]. *Brachychiton spp. Ficus spp. Diospyros spp. Celtis spp. Tinospora smilacina*	Exclude fire so as to encourage regeneration of this vegetation to it's former extent (where well developed soils remain)	Burn fire breaks in adjacent spinifex - frequency will depend on seasons/re-generation of spinifex. Burn spinifex according to underlying soil type and predicted encroachment of dry vine thickets.	Vegetation types formerly more widespread. Lack of proactive fire management and resultant high intensity fires have eliminated except where there are natural firebreaks.
Riverine mid-dense forest dominated by palms[2]. *Livistona rigida*	Promote species diversity with regular low intensity fires (summer burning during period of highest rain- fall) to reduce fuel loads from palms.	Biennial/annual burning to reduce accumulation of volatile palm leaf-blades in the whole of this type. Attempt to alternate 100m strips of burnt/unburnt vegetation from year to year.	Post-Aboriginal fire regimes - absence of the controlled use of fire - has created a monoculture of palms. See below for optimum development of this vegetation type.
Riparian forest with few or no palms (*Livistona rigida*)[2] *Ficus racemosa. Nauclea orientalis.*	Exclude fire or ensure low intensity fires where exclusion is not possible, so as to maintain high plant diversity.	Burn fire breaks in adjacent spinifex - frequency will depend on seasons/re-generation of spinifex.	Extremely fire-sensitive community. Limited remaining occurrences of this vegetation type due to natural fire breaks, rather than proactive fire management.
Mitchell grass plains[2]. *Astrebla, Chrysopogon and Iseilema spp.*	Re-establish fire regimes to control woody weed invasion and establish experimental fire plots.	Experimental burning under differing regimes in conjunction with monitoring to assess the effects on species composition and abundance in the grasslands. Trial only in areas where cattle are excluded.	Fire is effective in controlling native (*Lysiphyllum, Atalaya, Acacia victoriae*) and exotic (*Acacia nilotica, Prosopsis, Cryptostegia*) woody weed invasions. Pastoralists fire management regimes have excluded fire.
Wet sclerophyl forest[1] *Eucalyptus grandis E.resinifera*	Halt the loss of wet sclerophyll forest (by advancing rainforest margins) using fire.	Maintain grassy open forest - rainforest margin by the proactive use of fire. Light sclerophyll margins every 3-5 years.	Succession by rain forest over the former complex mosaic of rainforest - wet sclerophyll forest - grassy open forest now irreversible in much of the wet tropics.

Table 1 (cont.) **Prescribed burning regimes utilised in various vegetation types across tropical northern Australia (adapted from Stanton 1988[1], Innis and O'Keefe 1992[2], Humphries and Stanton 1992[3], Thompson and Nolan 1993[4], and Russell-Smith 1993[5]).**

Vegetation Type and Indicator Plant Species	Fire Management Objective	Prescribed Burning Regime	Traditional versus Contemporary Fire Management
Rainforest [1,4] Indicative plant spp. highly variable in complex system	Re-establish denuded areas of rainforest in areas where wildfires have eaten deeply into their margins.	Exclude fire by protecting with firebreaks at margins of former occurrence. Chemical control of fire-promoting grasses or replanting with pioneer species will assist rehabilitation.	Degradation is a contemporary phenomena associated with previous annual burning-off of sugar cane (now harvested green) and fires escaping upslope.
Paperbark Woodland[3] *Melaleuca spp.*	Re-establish fire management regime to reduce fuel loads. Control serious infestation of the exotic *Annona glabra*.	Ignite early in the dry season when surface water will prevent burning deep into the peat layer, which would otherwise seriously degrade the habitat.	High fuel loads in peat layer with post-Aboriginal fire regimes have resulted in extensive damaging fires. Added bonus for contemporary fire regimes is control of *Annona glabra.*
Monsoon Forest[5] *Syzygium spp.* *Carpentaria acuminata*	Exclude fire so as to encourage regeneration of this vegetation to it's former extent (where well developed soils remain).	Protect margins with early dry season burning. Wet season burning to remove fuel loads from *Sorghum* grasses where they occur.	Vegetation types formerly more widespread. Lack of proactive fire management and resultant high intensity fires has degraded or eliminated type except where there are natural firebreaks.
Cypress Pine Forests[5] *Callitris intratropica*	Preservation of remaining cypress pine forests.	Annual, low intensity, early dry season burns around forest margins. Exclude fire from entering where possible.	Cypress is threatened over much of its former distribution, as a result of frequent late dry season fires.
Sandstone Heath[5] *Triodia spp.* *Plectrachne spp.*	Promote structural and floristic diversity by breaking up type into mosaics of differently aged vegetation.	Low frequency mosaic burning including early and late dry season burns.	Post-Aboriginal fire regimes typically amount to frequent, intense and widespread, late dry season fires.

Conclusion

Innis (1993) points to the need for integration of "traditional land owners and present-day land managers" in "co-operative land management drawing on the traditional ecological knowledge of Aboriginal people". But as Johannes (1989 cited in Birckhead 1992: p298) points out, it cannot be assumed that fire management skills and knowledge still remain in the wider Aboriginal community; "It must be recognised as well, that owing to the radically changed circumstances of Aboriginal people since white invasion and colonisation over the past 200 years, much of this knowledge and practice has already been lost 'as its possessors die' or the young become alienated from their traditions." Compounding these difficulties, the use of fire by contemporary land managers needs also to be mindful of a range of noxious plants and animals, "poised" to occupy niches created by "disturbance".

And for all the current "enlightment" of nature conservation agencies in the traditional and contemporary use of fire as an ecological tool, it is abundantly clear that the best we may be able to achieve, is to emulate traditional Aboriginal fire management practices on "islands" (protected reserves alienated by surrounding land uses), amidst a "sea" of land tenures typically managed under differing (or no) fire regimes, and before a legion of noxious plants poised for the inevitable mistakes which will enable their succession. And for all that there are still those who would "let nature take it course."

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Section 3 :

Education, public perception, and fire on Conservation reserves :

Chairperson : Gordon Graham

Fire on lands adjacent to conservation reserves - the north Queensland situation.

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Abstract

Legislation aimed at governing rural fire management has existed in Queensland since 1928.

During most of that time the legislation was specific to rural fire management, known as the Rural Fires Act, and administered by a government instrumentality known as the Rural Fires Board.

The Fire Service Act of 1990 replaced the Rural Fires Act and brought about the erection of a single fire service in Queensland.

The Rural Fires Board was replaced by an advisory council consisting of a presiding officer and six members representing organisations whose interests are affected by rural fires.

Rural fire management is currently administered by the Queensland Fire Service through its Rural Fire Division.

This paper presents an overview of the structure, philosophy and methods employed by the Rural Division of the Queensland Fire Service.

The Rural Fire Division currently has responsibility for 1566 Rural Fire Brigades, 2,234 Fire Wardens, 48,000 volunteers and 81% of the land area of Queensland.

A model is presented which illustrates the characteristics and constraints of current fire management systems in both a rural and urban context, their relationship to conservation reserves and to each other. This model also identifies the interfaces between the various management systems and the likely impact of fire at and beyond the interfaces.

Major issues impacting on fire management are identified, and objectives and strategies for addressing these issues outlined.

The Present Situation

Legislation

Fire Service Act 1990

Provides for the constitution, functions and powers of The Commissioner of Fire Service and the Queensland Fire Service and for the prevention of and response to fires and certain other incidents endangering, persons, property or the environment and related purposes.

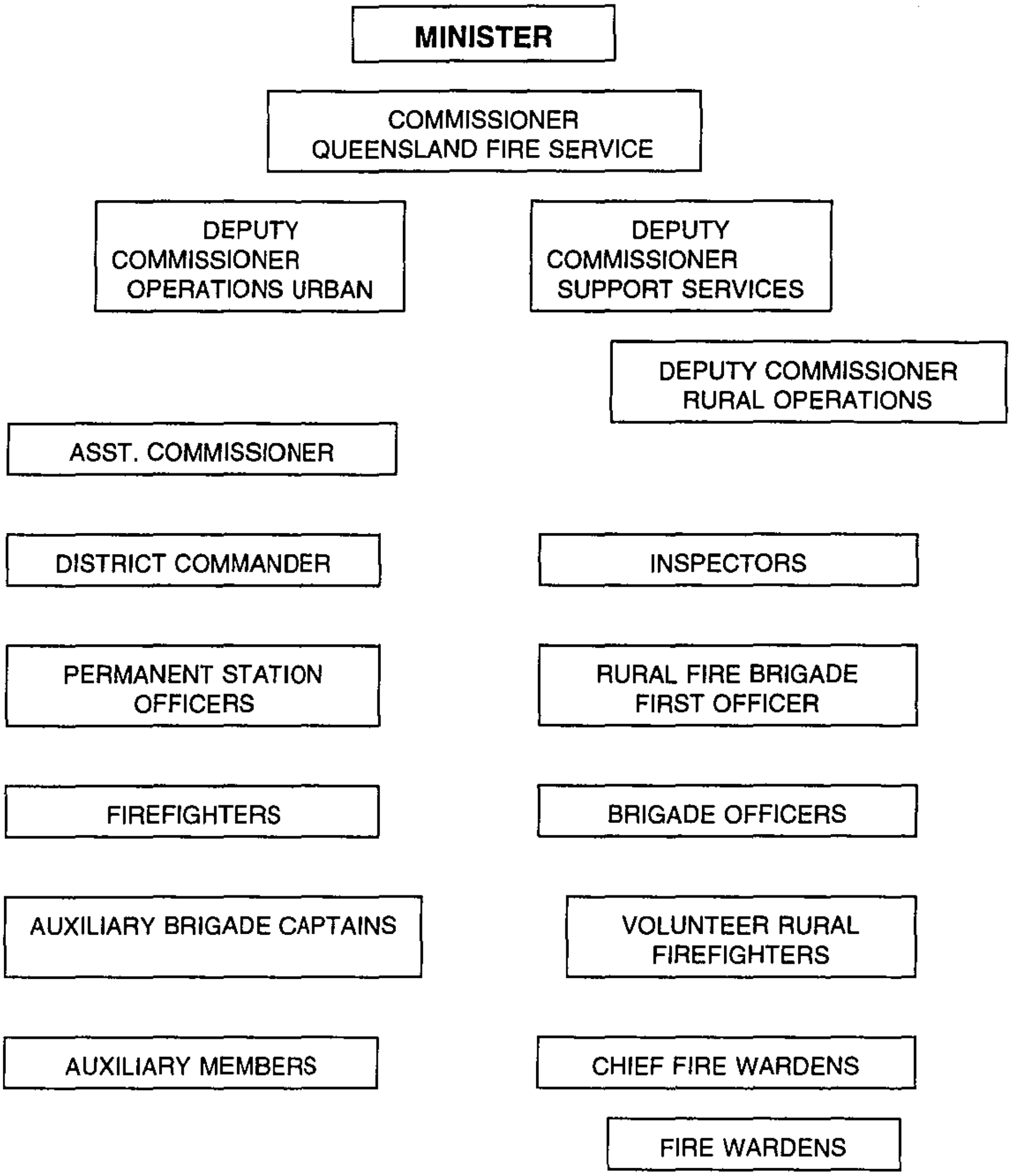
Other current legislation which impacts on use and control of fire on lands adjacent to conservation reserves is:-

National Parks & Wildlife Act 1975 - 1989

Forestry Act 1959 - 1991

There are also well established common law principles and precedents which apply to the use and control of fire.

STRUCTURE OF QLD FIRE SERVICE



RURAL FIRE DIVISION STRUCTURE

MINISTER

COMMISSIONER
QUEENSLAND FIRE SERVICE

RURAL FIRE COUNCIL

DEPUTY COMMISSIONER
RURAL OPERATIONS

SENIOR INSPECTORS

TRAINING & PLANNING OFFICER

CARTOGRAPHIC OFFICER

DISTRICT INSPECTORS

TRAINING STAFF

DRAWING OFFICE ASSISTANTS

Basic Philosophy of Operation

The aim is to make every rural fire some individual's responsibility.

Fire control is a property owner's responsibility supported in an organised manner by the community through the Rural Fire Brigade. Centralisation of fire suppression resources in rural areas is not encouraged, except as supplementary resources to property equipment.

Centralisation of fire suppression resources in urbanised areas is encouraged.

The subsidised equipment scheme is aimed at encouraging the widespread availability of fire suppression resources within a community.

The Permit to Burn system is aimed at encouraging hazard reduction burning through the provision of legal protection for responsible users of fire and punitive action for irresponsible users.

Fire Wardens and Permits To Burn

The Fire Warden network and permit to burn system is the basis of rural fire management in Queensland, and is aimed at promoting hazard reduction through the controlled use of fire to reduce major fuel build-ups, thus mitigating against the occurrence of uncontrollable wildfire events. The permit to burn system also allows land management burning to be carried out in a properly regulated fashion, and provides protection to the community and permitted alike.

This system has been a fundamental feature of rural fire management in Queensland for over 40 years.

Fire Wardens operate under a delegation of authority from the Commissioner of Fire Service, are appointed for a specific area - Fire Warden's District - by either the Commissioner or by Order-in-Council, and hold office until cancellation of the appointment or gazettal of a replacement. There are significant numbers of Police and Forest Officers who hold the position of Fire Warden.

Powers and Authorities of a Fire Warden are briefly :

(1) Receive applications for and issue, withhold or condition Permits.

(2) Decide on applications for prohibition.

(3) Receive reports on unauthorised fires.

(4) Order extinguishment or control of fires.

(5) Enter on land and demand name and address.

(6) Lay complaints.

The Commissioner of Fire Service may also authorise the lighting of fires by way of a notification published in the Government Gazette.

Permits to burn are required all year round and for all fires over two metres in any dimension lit in the open air.

In addition to its regulatory effect, strict compliance with the permit provisions of the Fire Service Act relieves a permitted of Civil liability for damage which may be caused by a fire lit under the authority of a permit; this relief from liability is provided for in the Fire Service Act.

The procedure which must be followed when seeking a permit,
i.e. neighbouring landholders must be consulted and given the opportunity to object, allows the interests of all parties to be taken in to account by the Fire Warden when issuing a permit, and enables any permit issued to be conditioned accordingly so as to give the maximum amount of protection to all parties.

Breaches of the Permit to Light Fire provisions are investigated by Divisional Inspectors and, if necessary, evidence is handed to Police for further action leading to prosecution.

Maximum penalties for breaches of the Fire Service Act are:

(i) In the case of a natural person 50 penalty units - currently $3,000 - and/or six (6) months imprisonment;

(ii) In the case of a body corporate 200 penalty units - currently $12,000

Rural Fire Brigades

Rural Fire Brigades are the basic operational units of the Rural Fire Division and are totally manned by Volunteers.

The Concept

People within a community joining together for mutual protection for themselves, their property and their environment against fire and other related incidents.

The Methods

The concept is administered for the Government by the Rural Fire Division by providing assistance through:

(1) The Administration of a volunteer Fire Warden Network.

(2) The administration of a volunteer Rural Fire Brigade Network.

(3) The provision of Inspectorial and Training staff.

(4) Provision of Insurance cover and Workers' Compensation.

(5) A public education and training program.

(6) The provision of specialised equipment under subsidy.

Incentives

(1) *Subsidised Equipment*

This equipment ranges from fire tenders to hand operated equipment and is subsidised by the Commissioner to registered Rural Fire Brigades on a dollar for dollar basis.

(2) *Workers Compensation*

This is in keeping with a normal Worker's Compensation policy to members who have no personal cover. If they are privately associated with a Worker's Compensation policy, then that policy is extended to cover fire work.

(3) *Compulsory Third Party Insurance*

This applies to unregistered vehicles, provided they are clearly identified as a Rural Fire Brigade Unit. Unregistered vehicles so identified are deemed to be registered and covered by Third Party Insurance while engaged in bona fide brigade activities.

(4) *Comprehensive Insurance*

All vehicles held by Rural Fire Brigades as public vehicles are comprehensively insured by the Commissioner, subject to advice from the Brigade regarding the necessary details. A fleet policy is held by the Commissioner for such vehicles and each is specifically identified by engine number etc in the policy.

(5) *Compensation for Damage to Private Equipment*

This policy covers privately owned equipment provided it is not otherwise insured, and used at actual Rural Fire Brigade activities either for hazard reduction or actual fire suppression operations. The policy currently has an overall upper figure of $150,000 an anyone piece of equipment and certain farms must be completed by the First Officer of the brigade to activate the claim.

(6) *Protection from Liability*

Officers and persons acting at their direction, and in good faith, are protected from civil liability by the Fire Service Act.

Rural Fire Brigades are recognisable and legally constituted fire control authorities, whose officers have been delegated the necessary powers by the Commissioner of Fire Service, and are governed by a code of practice issued by the Commissioner.

Issues

Public perceptions.

The need for an integrated management approach.

The need to have adequate suppression capabilities available.

Duty of care.

Provision of resources.

Smoke management.

Objectives

To develop public understanding of the role of fire in the environment to the extent necessary to allow its continued effective use as a management tool.

To resolve conflicts resulting from differing management approaches and develop an integrated management approach.

To develop suppression capability in line with hazard risk levels along with a co-ordinated approach which effectively utilises all available resources.

To minimise incidence of opportunistic actions under common law and fully discharge duty of care obligation.

To establish resourcing levels commensurate with management responsibility.

To keep smoke effects from land management and hazard reduction burning at a level which is environmentally and socially acceptable/responsible.

Strategies

Public Education

Develop public education packages which:

(1) Explain the role of fire in the natural environment.

(2) Promote the benefits of low intensity prescribed burning as a mitigation measure.

(3) Highlight costs, effects and consequences of management strategies which do not include the appropriate levels of hazard reduction and/or prescribed burning - especially totally suppression oriented strategies.

(4) Explain the roles of the various agencies and individuals in an integrated fire management system.

(5) Promote hazard reduction and prevention of unwanted fire.

Management

Foster consultation and co-operative interaction between all the stakeholders both public and private through:

(1) Formation of consultative groups and joint development of policies.

(2) Identification of common goals and objectives.

(3) Workshops and seminars.

(4) Sharing of information and technology.

(5) Development of integrated management plans with inputs from all stakeholders.

Suppression

(1) Carry out hazard analysis and risk categorisation surveys.

(2) Determine and state suppression requirements.

(3) Carry out inventory of existing suppression resources and capabilities.

(4) Inform all stakeholders and responsible agencies of outcome.

(5) Involve all stakeholders in a consultative process aimed at developing strategies to overcome deficiencies which may have been identified.

(6) If necessary promote formation of action-oriented groups involving all stakeholders to formulate a plan to co-ordinate and promote maximum utilisation of available resources.

(7) Develop standard operating procedures, detection, reporting and communication systems.

Duty of Care

(1) Identify areas of high hazard.

(2) Encourage appropriate hazard reduction measures.

(3) Where prescribed burning is involved maximise protection through the permit to burn system.

(4) Develop a consultative approach to dealing with areas of contention and involve all stakeholders where possible.

(5) Support and strengthen the Fire Warden and permit to burn system through public education, training and seminars.

(6) Ensure the continued integrity and effectiveness of the permit to burn as a protection against civil liability by monitoring procedures and correcting where necessary to ensure that proper regard is had to protection of both permitted and neighbours.

Provision of Resources

(1) Administer subsidised equipment scheme on a needs oriented basis - determined by hazard analysis and risk categorisation.

(2) Improve collection of data and statistics necessary to support initiatives aimed at improving resource availability.

(3) Determine and define areas and levels of responsibility so as to limit avoidance of discharge of responsibility for provision of resources by individuals and agencies.

(4) Improve information sharing and co-operation so as to maximise utilisation of available resources.

Smoke Management

(1) Ensure appropriate weightage is given to smoke management through the permit to burn system especially in sensitive areas.

(2) Support development of the initiatives advocated by the Australian Association of Rural Fire Authorities with regard to smoke management and prescribed burning as contained in its policy developed at the conference
in May 1992.

FIRE THREAT **CONSERVATION RESERVES** **FIRE THREAT**

INTERFACE

URBAN	***RURAL/RURAL RESIDENTIAL***
Protection - Firebreaks - Who does - Who pays - Environmental effects (Soil Erosion etc)	***Protection*** - Firebreaks - Who does - Who pays - Environmental effects (Soil Erosion etc)
Prevention/Mitigation - Fire Service Act - Fire Wardens - Permit to burn - Hazard reduction - Local Authority by laws - Public Education	***Prevention/Mitigation*** - Fire Service Act - Fire Wardens - Permit to burn - Hazard reduction - Local Authority by laws - Public Education
Suppression - Emphasis on structures & the man made environment - Professional Fire-Fighters (Paid) - Well equipped for structural fires - Funded by levies - Direct attack - Reliance on water & extinguishants - Rapid response - Other agencies may be involved	***Suppression*** - Emphasis on bush & grass fires as well as structures & the man made environment - Rural Fire Brigades (Volunteers) - Limited resources - Direct or indirect attack - Less reliance on water - Backburning - Reliance on privately owned equipment in many areas - Response variable due to volunteer manning & possible dispersion of resources - Greatly aided by hazard reduction - Other agencies may be involved

CONSERVATION OFFICERS & FOREST OFFICERS 3.0 K NATIONAL PARKS & FORESTRY ACTS

NEIGHBOURS 1.6 K SUBJECT TO DIRECTION OF PRESCRIBED PERSON

Losses - Potential for substantial damage to the man made environment (structures) &/or loss of life	***Losses*** - Potential for damage &/or loss of life across all environments - Damage may be restricted by hazard reduction
Threat - Maximum threat at interface - Threat diminishes with distance from interface - Greatest need for management at interface	***Threat*** - May originate at distance from interface - Need for management beyond the interface
Values - Urban values - Lower level of understanding of need for fire/land management - May be resistance to hazard reduction especially burning of any kind	***Values*** - Range of values - Higher level of understanding & acceptance of need for fire/land management - May however be conflicting land management values/objectives
Smoke - Likely to be high level of concern with smoke	***Smoke*** - Lower level of concern with smoke but still an issue in many areas
Social/Political - More likely to be highly organised pressure/lobby groups which are issue based	***Social/Political*** - Less likely to be highly organised pressure/lobby groups

FIRE THREAT

Fire on state forests adjacent to conservation reserves in northern Queensland

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Policy

Queensland DPI Forest Service fire policy is currently being revised. However, in broad terms the aims of the policy are to protect human life, property, forests and environmental values on DPI Forest Service lands from damage and destruction by wild fire. This will be achieved by:

- providing staff with appropriate training and equipment to carry out all necessary fire protection tasks;
- carrying out research into fire behaviour and ecology and;
- monitoring fire protection policy and upgrading this when necessary.

From an operational view point, prescribed burning is the Forest Service's most widely used practice to achieve the aims of its fire policy. With the exception of rainforests, prescribed burning is used in natural and plantation forests for the following reasons.

(1) Fuel level reduction so that any subsequent unscheduled wildfires will be easier to control.

(2) To establish buffer strips and firebreaks.

(3) To control weed species such as lantana and wattle.

(4) To improve grazing values for lessees (and at the same time control their fire lighting). Grazing also assist in reducing fuel loads.

(5) To encourage regeneration.

(6) To improve access.

In recent past fuel level reduction was the prime motivation in burning wet and dry sclerophyll forest types on a 3 year cycle. However, although fuel levels are still important in determining burning regimes, for environmental reasons such as allowing better development of natural regeneration, the length of the burning cycle is being increased. A minimum of 5 years will be used in wet sclerophyll forest types and 7 to 10 years in dry sclerophyll forest types. This is a general guideline which may be altered due to local circumstances. For example where residential areas border on State Forest more frequent burning maybe necessary to reduce the danger to property. Areas subject to high public visitation may also be burnt more frequently.

The Forest Service has traditionally aimed at engendering a high degree of fire consciousness into our neighbours and lessees. Experience has shown that neighbours with safe burning habits and a sense of responsibility with fire will save Forest Officers considerable worry and expense.

Forest Estate

The distribution of State Forests and Timber Reserves in North Queensland coincides with the more heavily timbered areas. Although these areas are largely covered by rainforest, there are also significant areas of eucalypt dominated sclerophyll forests. The sclerophyll forests together with the pine plantations centred in the lower Herbert Valley, Cardwell and Kuranda are the main focus of the Forest Service's fire control activities.

A brief overview of fire related activities on Forest Service land which is adjacent to conservation reserves in north Queensland is provided below.

Eungella/Cathu Area

Some fuel reduction and top disposal burning is carried out. Maintenance of roads and firelines is carried out regularly to facilitate both controlled burns and wildfires.

Herbert Valley

Protection of pine plantations is the major focus of the fire program in this area. This is largely achieved through the establishment and maintenance of a system of fire breaks around the plantation areas. These are used to contain fires which start in the plantation and to keep external fires out. The majority of these breaks are outside of the World Heritage Areas.

Burning off the external plantation breaks has the potential to effect forests in the World Heritage Area. This was of particular concern in the Wallerman Escarpment area of the Tinkle Creek catchment where fires were burning up the escarpment and into the rainforest.
To prevent this while still maintaining a regular burning program around the plantations, a parallel break system is proposed to contain the controlled burns. A similar parallel break system is used to maintain a buffer between Broadwater State Forest and surrounding cane farms.

Cardwell

No controlled burning is carried out in the World Heritage Area. Again the major focus is on protection of the plantation estate.

Other organisations such as the National Parks and Wildlife Service and the Transport Department are notified when and where controlled burns will be carried out. Forest Service equipment and staff are also made available for use by other organisations.

Ravenshoe/Koombaloomba Area

Last year extensive areas of pasture in open eucalypt forests were destroyed by fire on Crown Holdings west of the Tully Falls/Koombaloomba Road. These fires originated within the World Heritage Area. With increased public visitation to this area, the risk of similar fires starting in forests with a heavy fuel build up will increase if no action is taken. This financial year the Forest Service will grade a number of existing tracks and fire breaks in this area. When conditions are judged to be suitable, a number of controlled burns will be carried out to reduce fuel loads. Such fires would also reduce the invasion of rainforest elements into the wet sclerophyll forest types.

Conclusion

Fire policy can be set to ensure the safety of human life, property, forests and environmental values, but a range of factors must be taken into account if the goals set are to be achieved. For example, to achieve good regeneration after forest harvesting controlled burns may have to be delayed. Similarly fuel in plantations must be allowed to build up until canopy closure has been achieved before fuel reduction burning can be undertaken. Such delays mean that the risk of fire is increased in the short term to achieve a particular management objective. These risks must be compensated for by taking such precautions as increasing surveillance during periods of high fire danger and maintaining a good fire break system.

Public intervention can also undo the best laid plans for fuel and fire management. This risk is highest in areas that receive high visitation or are adjacent to urban areas. The Mt Baldy State Forest fires in November, 1992 are a recent example of such intervention.

It is important that all natural resource managers have a good understanding of factors which can effect fire policy as well as fire behaviour. Managers are then in a better position to interpret fire policies and to provide input into policy changes when they are required. This in turn will make fire policy more relevant to local needs and conditions and will contribute to achieving policy aims more effectively and efficiently.

Public perceptions of fire in the World Heritage Area and adjacent hillslopes of Cairns and solutions to fire problems

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QNPWS
QDEH
Cairns.

Steve Collins
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Barron Management Unit
QNPWS
QDEH
Cairns.

Summary:

Public perception of fires depends on how the public is classified and how fires are classified. Generally fires on the hillslopes of Cairns have resulted in the destruction of rainforest and invasion of these sites by exotic plant species - predominantly grasses. Public perception has followed national trends.

Since the early 1970s there has been a growing community concern about destruction of the forests of the Cairns hillslopes. However until urbanisation of the Cairns environs and the recent change to green harvesting of sugar cane there was little improvement in the fire problem.

Now the upper slopes, at least, are classified as the Wet Tropics World Heritage Area. There has been a massive worldwide campaign to convince the broad community that rainforests are important so any agent of destruction, such as fire, is seen as bad. However much of the World Heritage Area is open eucalypt forest which needs fire for its survival. Local community reaction to fire management programs can be moulded provided that plans have local input to ensure that community requirements are met along with broader aims.

Cairns has witnessed the introduction of a number of fire management innovations because of past wildfire damage and the expanding urban area. The National Parks and Wildlife Service has consistently been the leader:- area based multi-tenure fire plans, firebreaks incorporating buffers of rainforest vegetation, revegetation programs, helicopter support and TAFE based fire training.

Contents

1. Overview of the Cairns Area

1.1 Location and Topography

Cairns City (latitude 16° 55' South, longitude 145° 47' East) is located on a coastal plain a few metres above sea level on the far north coast of Queensland, Australia. The land surface rises abruptly by about 500 metres to the surrounding hills which dominate the landscape. Some outliers such as Mt Whitfield jut out of the plain. To the east is the Yarrabah area and the coastal Murray Prior Range. Westwards the escarpment leads to the Atherton Tablelands. Granitic mountains with elevations of up to 1000 metres dominate parts of the edge of the tableland making the tablelands seem higher from the seaward approach. Figure 1 shows the topographic divisions of the Cairns area.

1.2 Climate

The climate of Cairns is that of a tropical trade-wind coast (Gentilli 1972). Temperature varies little throughout the year although it is lowest in June, July and August. Rainfall distribution follows the typical wet and dry season pattern shown in Figure 2. The amount of rain received during the dry season is significant. Curing of grass, the main fuel, follows both species and rainfall trends. Safe conditions for burning during the early dry season vary markedly over short distances.

Another typical feature of the climate of Cairns is its variability from year to year. The inability to predict when the dry season will start or if the wet season will end is a major frustration for the planning of fire management regimes.

Most of the year during daylight hours a steady south-easterly wind blows. At night a westerly breeze drains off the tablelands. Wind characteristics have distinct local patterns. This effects fire behaviour and is closely watched by cane farmers if they are involved in cane burning. (Pezzutti pers com)

Rainfall along the coast and hillslopes shows a marked gradient due to the height of the flanking ranges and the orientation of the coast to the prevailing wind. (Tracey 1982). Mt Bellenden Ker, the second highest mountain, has an elevation of some 1500 metres and receives about 8000 mm per year while Babinda, on the adjacent costal plain, receives half of this at about 4000 mm per year. Cairns is 55 km north-north-west and averages about 2100 mm. Wangetti 40 km north west of Cairns only averages 80% of Cairns. The coastline at Wangetti is parallel to the prevailing wind. Rainfall increases further north.

1.3 Land Ownership

Upper slopes and ridge tops are generally owned by the Government of Queensland and, mostly, are now part of the **Wet Tropics of Queensland World Heritage Area (WHA).** The WHA is not a tenure in itself but is an umbrella status over many land ownership types. Most of the WHA is either State Forest or National Park. (Anon 1992). The lower slopes are usually privately owned as at Redlynch. The main hillslopes area between these extremes are a mixture of State, Municipal and privately owned lands. The proportion varying from place to place. The Wangetti area north of Cairns is exceptional in that the State owns virtually all the land and, superficially,it would appear that it should control its own fire regime.

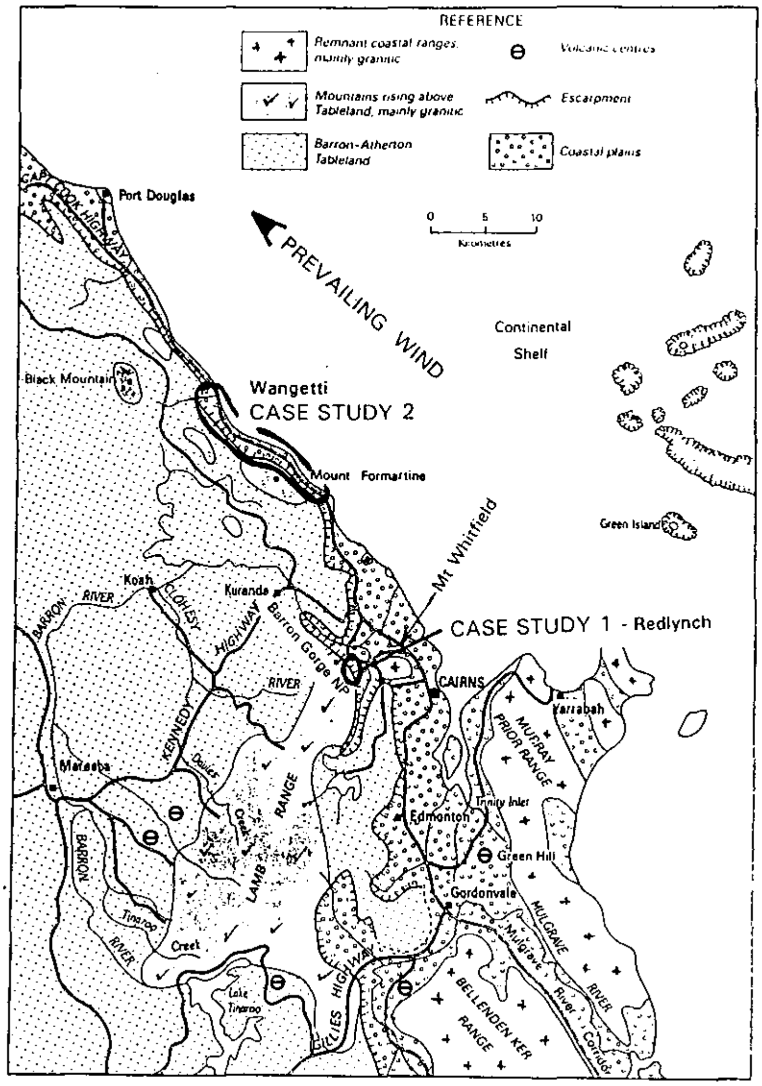


Figure 1: Topographic divisions of the CairnsaArea
(Based on map from Wilmott and Stephenson, 1989)

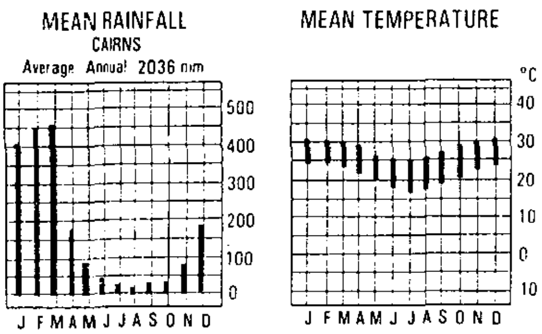


Figure 2: Average rainfall and temperature patterns for Cairns (Source: Cairns 1:25,000 topographic map(1988), Dept of Geographic Information, Brisbane)

1.4 Vegetation, Land Use and Fire History

The coastal **plain** has mainly been **cleared** and replaced by fields of sugar cane. One pocket of "natural" coastal vegetation remains at Wangetti 40 km north of Cairns. Remnants of the rarest lowland rainforest in the WHA are found there but wildfires and weeds have badly fragmented these isolates.
Suburban expansion is now replacing many of the cane fields near Cairns. This expansion has also spread onto the lower parts of the surrounding hillslopes and has dramatically reduced the incidence of wildfires on the slopes above.

Most of the **hillslopes** are covered with **rainforest or sclerophyll forest**. The latter type usually has low native grasses with or without shrubs. The boundaries between the two main types have oscillated in prehistoric times with changes in climate and in fire regime. Reduced burning of the sclerophyll forest in many areas has resulted in a rapid invasion by rainforest species. However the glaring feature of the Cairns landscape is the **hillslope grassland.**

These tongues are fire induced and have been heavily invaded by a number of exotic plant species especially guinea grass and molasses grass. Fires used to be an annual event (Hoare 1989). They usually originated from the cane farms. In the Redlynch area and Barron Gorge National Park burning off from the Cairns-Kuranda railway line was the main cause while at Wangetti it was roadside incendiarism. Juvenile delinquents are a major cause of fires now.

The high intensity fires have progressively killed back the natural tree cover - particularly the rainforest on the hillslopes. Fire intensity is greatly increased by the slope and by the greater height, biomass and flammability of the exotic grasses. Molasses grass was deliberately introduced to assist in land clearing because of its high flammability (Harris pers com). **This is the fire problem around Cairns.** It is a feature of abused tropical hillslopes. However the solutions to this problem are further advanced at Cairns than elsewhere.

2.0 Public perceptions of fires near Cairns

2.1 The Cairns public of today

Cairns is a major growth centre. Its population is swelling with the influx of people from southern Australia. These immigrants have memories of Ash Wednesday fire disasters and the annual destruction of life and property associated with wildfires in the southern summer. Consequently there is a significant portion of the population that views any fire in the environment as a potential problem. The original rural Queenslander probably had a different attitude - fire is often a way of life to him/her.

Cane farmers traditionally used fire prior to the annual harvest. Cane farmers and their families accepted the rain of aerial debris following each fire. Urbanised Cairns people now barely tolerate the nuisance of carbonised floaters soiling swimming pools, yards and drying clothes. As a contrast cane fires are a tourist attraction.

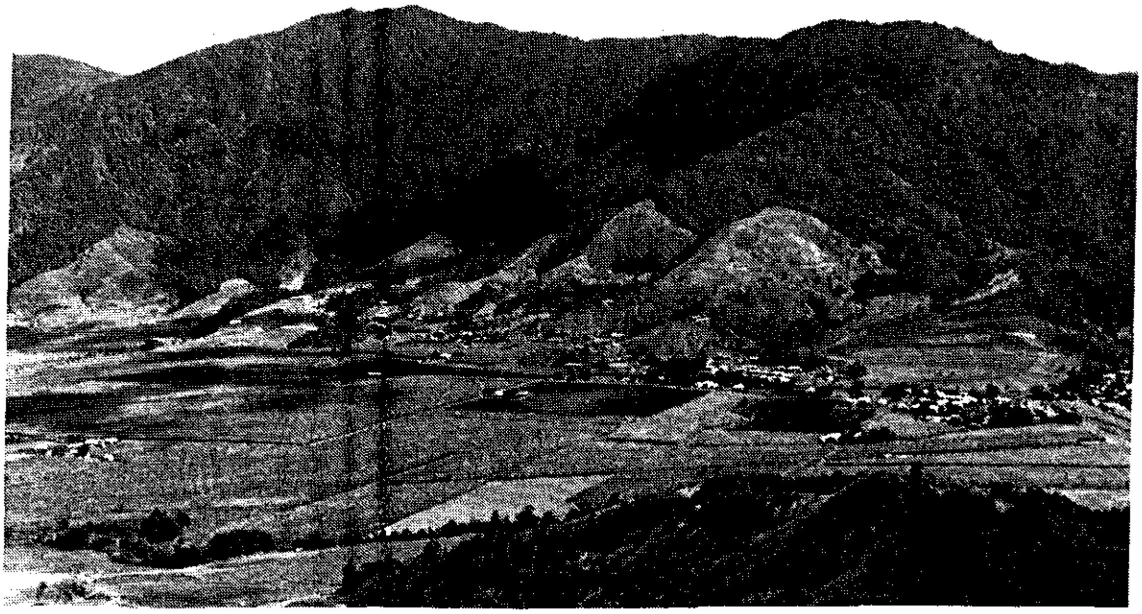


Figure 3: Typical Landscape at Redlynch, Cairns (1980's) - forested hillslopes fire induced (exotic) grasslands on the lower slopes; cane fields on the plain.

Figure 4: Fire degraded rainforest on a hillslope near Cairns: dense sward of two (2) metre tall exotic grass.

2.2 People living on fire prone hillsopes

No houses have been completely burnt due to wildfires near Cairns. However, many hillside suburban houses have only been saved because of the efforts of the fire brigade. There are a number of prime fire danger areas on the hillslopes. However, the impression is that few people correlate the tall grass by the back door with the possibility of destruction of their house by wildfire. One house across the road from a regular wildfire area on Mt Whitfield has a wooden car deck and wooden shingles on the roof. There is a strict building code because of the potential for cyclones but no building design guidelines for minimising potential bushfire damage.

In March 1993, after a number of severe fires on Mt Whitfield less than six months previously, about 30 people attended a Rate Payers Association meeting to discuss solutions to the fire problem. (This was about three times the normal attendance and was only achieved after letterboxing the entire area!) Comments at the meeting were a mixture of :

"you have to burn the hills early" - a resident of 20 years
"what can we do to help" - secretary of the Rate Payers Association
" why wasn't something done years ago" - a new resident from Sydney

Virtually no response has came from my resulting fire prevention proposal.

A spectacular hillslope fire late in 1992 did not attract any media attention (McKenzie pers com). Fires as an issue have lost media attention over the past few years.

2.3 Public apathy towards government sponsored issues

Fire plans prepared by Steve Collins my co-presenter have met with little response. Without the personal dedication and enthusiasm of a limited number of people in public positions nothing would be happening about the fire problem on Cairns hillslopes - or many other issues.

Cairns City Council had a poor 10% response rate to letters sent to households during recent public consultation about traffic management works in an area where residents had been vocal about lack of consultation (Cairns Post p15 8/7/93). The Wet Tropics Management Agency as part of its public consultation prior to formal development of The WHA Management Plan drew less than ten (10) people to the two public meetings it held in Cairns last year. (Anon 1993). Response to the proposed fire policy for the WHA was with reservation although farmer groups supported fire suppression or regular burning depending on whether they were on the coastal side of the range or inland respectively. Concern about fires rated the similar to that for feral pigs! Given that only 437 people attended the 34 public meetings and workshops and only 374 written or short comment submissions were received there is a massive untapped public opinion for the whole WHA.

2.4 Raising awareness 1970 -1990

The late 60's and early 70's was the period when Australia awoke to the conservation movement. Woodchipping was a major focal point. There was a serious proposal to woodchip the hills of Cairns which brought a reaction from several notable people. At the same time the Wildlife Preservation Society of Queensland (WPSQ) began to question the ethos of hillslope burning which was slowly destroying the hillslope forests. Older residents accepted the burning but new residents could see the damage being done to the hills. The editor of the Cairns Post newspaper also became a sympathiser.

However, the sugar industry was the prime power block and any criticism of burning the hills was taken as an imposition on a landholders rights. (Most hillslopes were owned by cane farmers). Slowly the industry began to portray itself as responsible fire managers as public awareness was raised.

Members of the WPSQ formed the VHF - Volunteer Hillslope Fire Fighters - to attempt to control hillslope fires when local farmer-based fire brigades would not. Eventually a broad based group called the Cairns-Mulgrave Hillslopes Protection Committee was formed in 1978.

(This section is based on the recollections of Peter Harris who was an active member of the Hillslope Volunteers and a QDEH/QNPWS employee)

2.5 Cairns-Mulgrave Hillslopes Protection Committee

The Committee sponsored education, management planning, fire prevention activities and active wildfire control. It diversified to other hillslope issues.

Staff of QNPWS were always key members. Over the past ten (10) years most of the fire management initiatives attributed to the Hillslopes Committee have come from them. Parts of the Barron Gorge National Park were badly fire degraded and getting worse. The Redlynch case study (Appendix 4) is an example of the progress being made to bring a severe hillslope fire problem under control.

2.6 Tourists

Tourism is the now the prime industry for Cairns. Tourist perception is a significant factor in decision making. The new international airport became operational in the mid 1980's. QANTAS is now hubbing its Japan - Queensland operation from there. These have given a massive boost to tourism. Cairns is the fourth most popular destination for international tourists and the tenth most popular for Australians (Cairns Post 19/7/93).

"The hillslopes form the immediate backdrop ...(and)... a tourism research study conducted throughout the Cairns/Mulgrave area in 1986 highlighted the importance of this .... The survey, amongst others, listed a choice of four major attractions:-

Reef **Climate** **Landscape** **Lifestyle**

Of these ... the overpowering beauty of the surrounding mountains was by far the highest and most consistently ranked.." (Clark, Griffiths and Lindsay 1991)

Consequently, removal of the grass dominated fire scars and their causes is a major issue for Cairns.

2.7 Outlying areas

The Captain Cook Highway carries hundreds of tourists daily north from Cairns during the main tourist season. Beside this highway hazard reduction burning in native forest was carried out during June and July 1993. This occurred in the Wangetti area at the start of the tourist season.

At least one bus load of tourists, at considerable hazard to other road users, stopped to take photographs of the flames. Over 2 to 3 weeks several people only asked the reason for the burning at the local tourist attraction and on having this explained were satisfied. There were no known indignant letters to the editor of the Cairns Post newspaper despite the moderate scorch along 3.5 kilometres of roadside. The bad visual impact diminished after a month.

Prior to the event articles about the reasons for the burning were placed in the two relevant newspapers. Liaison was undertaken with all landholders, involved government departments and with the local community. The local fire brigade initiated the consultation phase while staff from National Parks, Forestry and the Wet Tropics Management Agency undertook the planning and fire operations.

The small local population was pleased with the hazard reduction effort. One resident said "I've lived here all my life and nothing has ever been done like this before" (despite the repetitive wildfires). After we had cleared around scattered trees and then burnt a dense pocket of exotic grass the First Officer (Captain) of the local fire brigade said "and the leaves are still on the trees".

2.8 Analysis of reactions

There has been a polarisation in the community. The previous National Party Government of Queensland ran a concerted effort to thwart the declaration of the WHA. The WHA was only proclaimed in 1988. Preservation of rainforest replaced the anti-woodchipping campaign of twenty years earlier. Some people moved to take up land in the north because of the rainforest (Cairns Post p7 30/10/90) while older landholders had cleared it for farming or used it for timber production. Gradually the preservation views have been accepted. Hence fire if it destroys older growth rainforest is seen as bad.

A recent study has documented that over half the area of wet sclerophyll forest types on the western side of the WHA have become (irreversibly) dominated by a dense rainforest understorey over the past 50 years (Harrington and Sanderson 1993). The public is generally unaware of the invasiveness of rainforest and of the counter attack that is being mounted by managers of National Parks to prevent rainforest from spreading too far into sclerophyllous forest. Prescribed burning is the tool used by national park managers to prevent raniforest expansion.

Fire is a dilemma for some people.

Fire can be: **Wildfire** **Hazard reduction** **Ecological**

Wildfire is not accepted by most people. Hazard reduction burning to protect life, property, reforestation efforts and rainforest is accepted - just. Ecological burning is in the balance.

The following comments apply equally to the wet/dry tropics as to the desert of central Australia for which they were written:

> "Ecosystem managers need to apply fire for particular purposes, while demonstrating responsibility and the necessity of burning to the community. Public relations is therefore considered a high priority for all fire managers.
> The long term success of a fire management strategy rests on proper public education and sympathy, especially at the local level, as much as on the techniques or strategies used." (Preece et al 1989)

3. Some solutions for Cairns

3.1 Fire Planning

3.1.1 Specific Areas

The Hillslopes Committee promoted the development of multi-tenure fire plans. Steve Collins from National Parks (which is now included in the Department of Environment and Heritage) began fire plans in 1989. These plans covered wildfire response (reactive) as well as management of land to prevent and control fire damage (pro-active). They gave a focus for his work which had involved changing National Park fire management from 1986. However although individuals or agencies could adopt their assigned roles there was no official mechanism for the plans as a whole to be approved or to be enforced - other than by existing laws. Conservation agreements with individual landholders was a partial solution for the Redlynch area.

My temporary solution for the Wangetti Fire Plan of 1993 was to request each recipient of the plan to sign a statement accepting the short term responsibilities as laid out in the plan. Generally I have found that working with single landholders in strategic areas has been a satisfactory way of achieving good results for the first year of a plan. The use of statutory powers by local government for ensuring the removal of fire hazards has been successful in lowering the incidence of escape fires.

3.1.2 Strategic

In 1989, under the auspices of the Hillslopes Committee, DASETT - the Commonwealth Department of The Arts, Sport, the Environment, Tourism and Territories - through its Wet Tropics office in Cairns - the precursor of the Wet Tropics Management Agency - funded a study of the fire problem around Cairns. Mr. J. Hoare, fire expert from CSIRO Division of Forestry and Forest Products, completed his report in November 1989. Unfortunately, the legislative changes he proposed were never implemented. This would have created a special fire zone around the hillslopes and an administrative system for wildfire mitigation similar to that which operates in NSW. Appendix 2.

He also recommended fire management aims for various parts of the Cairns area based on earlier work by Steve Collins. However, without the necessary legislation, conformity with the plans is only voluntary. The challenge now is to ensure that the existing fire management statutes are used to maximum effectiveness.

3.2 Improved wildfire suppression and prevention

3.2.1 Better Co-ordination

Although still needing some fine tuning, the fire fighting agencies around Cairns are now operating cooperatively. Fire risk minimisation is still a problem.

The Urban Brigade of the Queensland Fire Service provides the main focus for fire calls and initial response. Unfortunately, it lacks four wheel drive capability and is often hampered by low staffing (8 people to a shift) and lack of water pressure around some high elevation subdivisions. The Airport Rescue and Fire Fighting Service assists with some hillslope fires close to the airport. Its four wheel drive appliances and vehicle mounted monitors are useful near the base of slope. However, the Brigades are rarely involved in vegetation only fires on hillslopes.

QNPWS Rangers provide leadership and some resources for ground and aerial fire fighting away from roads and houses.

Queensland Railways now assists with fire control along the Cairns-Kuranda railway line although its personnel are mostly concerned with infrastructure protection. Fire prevention activities along the line, which traverses the Barron Gorge National Park, are planned in conjunction with QNPWS. Hazard reduction along railsides is achieved via slashing on flatter areas and herbicide on steeper areas. Revegetation programs are also under way to compartmentalise the grass fire problem. Appendix 4.

Both the Mulgrave Shire Council and the Cairns City Council have periodically contributed towards a fire fund for helicopter hire, equipment purchase and revegetation activities. They also provide staff to assist National Parks with fire control on hillslopes. Being landholders they are also being encouraged to be active in fire prevention on their own lands.

The Rural Fires Division of Queensland Fire Service provides advice. It is progressively having less influence in the Cairns area as the volunteer rural (cane farmer) brigades are displaced by the levied services of the professional Division when the cane farms are subdivided. Several smaller non-farmer brigades exist towards Yarrabah in the east and Wangetti in the North. Co-operation with these is sought whenever fire operations are planned for these outliers.

3.2.2 New Techniques

Steve Collins (over the past eight years) and I (over the past eight months), have introduced a number of new techniques to hillslope fire suppression and prevention.

Water bombing to assist ground fire fighters is now a recognised technique for suppression of wildfires on hillslopes. The Government of Queensland via the Bureau of Emergency Services, Aviation Division, operates a Squirrel helicopter which is available for fire control operations. A 500 litre Bambi Bucket is used in conjunction with a 11,000 litre Bouywall mobile pool. Foam injection is being considered.

Helicopters are used to ferry fire fighters to inaccessible areas and for fire lighting. Webb Helicopters of Emerald, central Queensland, has developed a light weight helicopter-borne aerial fire lighter. Following trails at Mareeba in May 1993 the machine was used operationally as part of the Wangetti Fire Plan in June. This device gives a safe and efficient method for lighting fires.

The traditional 4WD mounted mop-up unit owned by National Parks has been converted to use bush fire fighting foam. Queensland DPI Forest Service developed a system based on the Dosatron induction device. This will allow more efficient mop-up of logs and trees as well as for laying foam firebreaks. However, its use is limited to areas accessible to four wheel drive vehicles.

A vest style knapsack spray has been successfully trialled and will be used when purchased in quantities. For fire prone areas that are badly degraded sprinkler-based fire breaks are being considered as part of an overall revegetation and fire protection scheme.

3.2.3 Training

An accredited system of bush fire fighter training was introduced in 1993. Cairns College of TAFE developed the course in conjunction with myself.
The modular course was adapted from that of Bush Fire Fighter Level 1 as developed by the Department of Bush Fire Services, NSW. Several new modules were added such as Helicopter Use and Safety, Fitness and Health and Fire Prevention. Joint authority operations were also covered. All of these are important to minimising the Cairns fire problem.

Some 37 personnel from six (6) agencies are expected to graduate from the five day course. Most participated in the Wangetti hazard reduction program as the practical part of the course. Lectureship for the ten (10) modules was undertaken by specialists and experienced staff from seven (7) different organisations. Details are contained in Appendix 3.

Several Government agencies cater for the fire training of their staff. This is usually achieved at central training schools - particularly using the QDPI Forest Service's resources at Gympie. However, no satisfactory method previously existed for the accredited training of staff from municipalities. Local variations to courses are now possible with decentralised training.

3.3 Redlynch Firebreak Case Study - Revegetation

See Appendix 4

3.4 Wangetti Coastline Case Study - Prescribed Burning

See Appendix 5

3.5 Administration and the Law

Queensland has a system of Fire Wardens for the control of permits to light fires. Fire Wardens can be members of QDEH/QNPWS or QDPI Forest Service. Since, in most cases, unwanted fires will be coming from outside of the World Heritage Area it is preferable that the boundaries of all Fire Warden districts be adjusted so that the managers of the World Heritage Area have full control over fire practices on and adjacent to the area. This system was used in Victoria where rural fires were a threat to the State owned forests.

Intrusions across administrative or property boundaries inevitably lead to friction. Brigade boundaries may include vacant crown land but should exclude other lands of the State such as State Forests and National Parks. Exceptions may exist where agreements have been reached about infrastructure protection or staff are too remote to adequately service the area. Co-operative conservation areas on private lands may also need to be excluded from Fire Brigade boundaries if there is likely to be any conflict between conservation fire management and fire brigade attitude.

The Queensland Fire Service Act requires amendment so that co-operative fire management districts can be established under a local committee. This system is included in the equivalent Act for NSW. This would provide a mechanism for the approval and policing of fire plans and hazard reduction efforts on a systematic basis across all land tenures.

At present there is no mechanism for systematic hazard reduction. It is an ad hoc affair with reluctance by both municipalities and Queensland Fire Service (QFS) to initiate a program. QFS could take a lead under its Act however generally hazard reduction matters are left to local Government. Municipalities are quite varied in the use of their powers but usually limit them to abandoned land in and adjoining residential areas.

Given the significance of the World Heritage Area fire planning both on the WHA and surrounding it needs to be done in a professional manner and to be supported by appropriate legislation. Committees without proper constitution or legal power can only be advisory. Lack of authority has hampered the Cairns-Mulgrave Hillslopes Committee since its inception. Now is the time to modernise with the Wet Tropics World Heritage area becoming a model for co-operative fire management planning.

4. Conclusions

Major changes to land use and community attitude have occurred since the late 1960's when a conservation conscience began in Cairns. At that time the incipient destruction of the hillslope forests was accepted as inevitable. The Cairns-Mulgrave Hillslopes Protection Committee was formed in the mid 1970s to formalise the efforts of earlier groups and provide better co-ordination.

However fires on the hillslopes continue to be destructive to the environment in some areas. The Hoare Report (1989) and the Fire Management area plans and the techniques introduced by Steve Collins (NPS) have assisted in achieving improved wildfire control, improved co-ordination of fire control and improved fire prevention on hillslopes in recent years.

Most wildfire control efforts on hillslopes are interagency fires due to the various land ownerships and legislative responsibilities. Co-ordination can be improved further. However without the legislative changes this will always be prone to the host of difficulties that beset committees. The solution lies in revision of the Queensland Fire Service Act to make it similar to the Bush Fires Act of NSW.

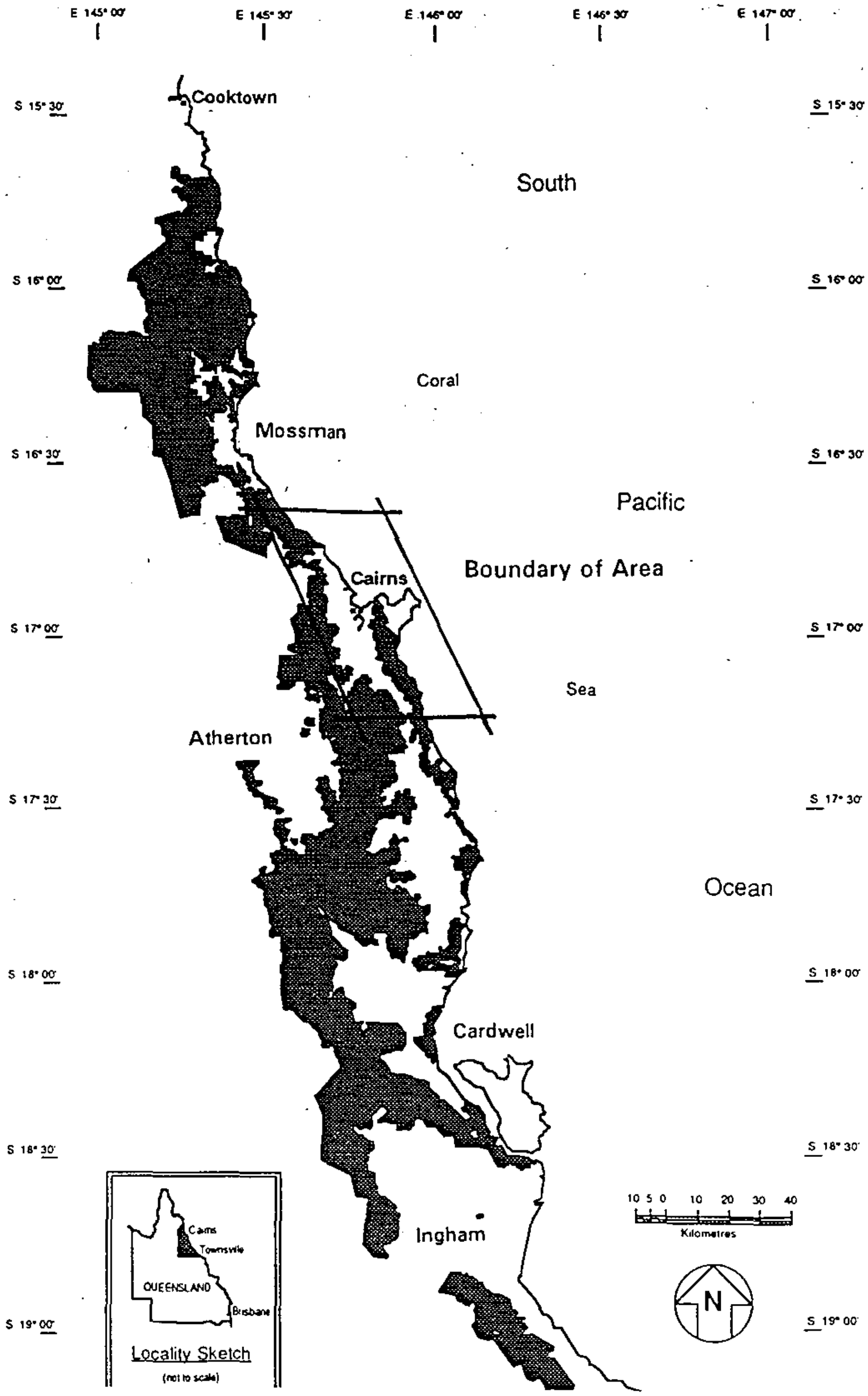
A significant improvement to the degradation of tropical hillslopes can be made by hazard reduction and fire prevention planning being treated seriously by municipalities and by Queensland Fire Service. Most of the problems begin on the flats NOT the hills. Some large landowners are now taking responsibility for hazard reduction but without support by the proper authorities this initial enthusiasm is liable to be lost.

Apathy may be the main community attitude towards fire in the Cairns area now as it was 20 years ago. However, the general perception now is that wildfires are bad. Incendiarism is a major cause of unwanted fires. This is a community problem. There is a significant role that public pressure can play and the perception of fires as bad can assist. However this needs to be tempered by an allowance for professionals to use fire wisely for farming, landscape protection and for nature conservation.

APPENDIX 1 Map : Wet Tropics World Heritage Area of Queensland - with Cairns area highlighted

APPENDIX 1

Wet Tropics of Queensland World Heritage Area



APPENDIX 2 **Recommendations of the Hoare Report (1989)** (Source: The Cairns Post 13/12/89)

Source: The Cairns Post 13/12/89 APPENDIX 2

Fire plan to protect hillslopes

by CATHERINE LINDSAY

'Report certainly on the right track'

NEW fire management strategies for protection of hillslopes in Mulgrave shire may be in place by February next year.

Cairns-Mulgrave Hillslopes Fire Protection committee chairman Mr Bob Griffiths said strategies recommended in a CSIRO hillslopes fire management report — released two weeks ago — were being considered by committee members.

Mr Griffiths said members and other relevant authorities would make submissions based on report recommendations for consideration at the next hillslopes committee meeting in February.

The report was commissioned by the Department of Arts, Sport, Environment, Tourism and Territories (DASETT) with hillslopes committee support following concern a lack of fire management policy was leading to destruction of rainforests in the region.

The report was based on a 10-day study carried out by CSIRO fire ecologist Mr James Hoare on hillslopes management from Buchans Point south to the Gillies Highway.

Principle recommendations include:

- Mulgrave shire and Cairns city councils with the Wet Tropics Management Authority draft complementary legislation to declare hillslopes and ranges comprising Mulgrave shire and World Heritage boundary a "special fire management zone". The shire council would be responsible for fire management and co-ordination of fire suppression in the zone.

- Mulgrave Shire Council draft legislation to appoint an appropriately skilled fire control officer who has legal authority to organise and co-ordinate fire management and control activities including fire break construction, fuel reduction and fire suppression.

- The hillslopes committee form a district bush fire protection committee to advise and assist council and the fire control officer.

Committee representatives may be drawn from the shire and city councils, Queensland National Parks and Wildlife Service, Queensland Forestry Department, Rural Fires Board, Cairns Fire Brigade and bush fire brigades, Wet Tropics Management Authority and the Cairns District Canegrowers Executive.

CONTINUED PAGE 2

Fire plan 'on the right track'

FROM PAGE 1

Involvement from Main Roads Department, Queensland Electricity Board and Queensland Railways may be included on a part-time basis.

● The bush fire protection committee identify annual funding requirements for fire management and control plus training, publicity and education programs. Funding arrangements should be established with local, state and federal governments and local businesses.

Mr Griffiths said strategies contained in the report would give the hillslopes committee "teeth" through legislative power to halt degradation of hillslopes by fire and promote rainforest regrowth.

"This is a very comprehensive document which deals with all the problems involved in hillslopes protection. I think the report is certainly on the right track," he said.

CSIRO report outlines hillside protection plan

STRATEGIES for protection of Marlin Coast hillslopes will include construction of fire breaks, buffer strips and fire access trails, according to a recently released CSIRO hillslopes fire management report.

In the report the region from Buchans Point south to Gillies Highway has been divided into eight divisions. Marlin Coast comprises part of two divisions — the MacAlister range and Lamb range.

The report recommended several initial measures to be taken in developing fire management plans in Marlin Coast divisions, including:

● The Main Roads Department slash buffer strips at least 5 m wide alongside Captain Cook Highway between Trinity Beach and Palm Cove.

● Mulgrave Shire Council and other relevant management agencies construct a fire trail around the base of hillslopes which are adjacent to areas of high fuel hazard and ignition risk.

● Council construct fire access trails along major accessible ridges from the top of the range to the highway — such as behind Buchans Point, Clifton Road and Panguna St.

Reduction of buildup of hazardous fuel along sections of Kennedy Highway.

Construction of fire breaks between rural-residential developments and the base of hillslopes along Redlynch and Freshwater valleys to protect property and revegetating areas from unplanned fires.

Establish buffer strips either side of Redlynch Intake Rd to reduce risk of roadside ignitions.

Extension of Cairns-Kuranda railway line treeplanting program into Freshwater valley.

● Queensland Environment and Conservation Department (QDEC) and Cairns fire service place priority on fire suppression along the railway line, particularly in revegetating areas and steep highly degarded areas above Redlynch and Freshwater.

● Land management agencies rehabilitate degraded hillslope areas using native vegetation not exotic pines and cease prescribed burning to reduce fuel in eucalypt woodland.

● Council and Cairns fire service erect educational and fire danger signs along Captain Cook and Kennedy highways, the railway line and Redlynch Intake Rd to inform the public of the current fire danger and of fire management strategies being carried out.

APPENDIX 3 **Hillslopes Fire Suppression Training, Cairns 1993**

MODULES for the TAFE COURSE:

TROPICAL HILLSLOPES WILDFIRE CONTROL - CAIRNS, 1993

MODULE		LEADERSHIP		VIDEO	PRACTICAL
ID	TITLE	AGENCY	STAFF	SUPPORT	
1	Safety & Survival	TAFE	1	NSW BFS - Safety Vic CFA - Safety & Survival	Demo Personal Protect Equipment
2	Fire Behaviour (a) Fire Extinguishers (b) Hillslopes	 Airport FS DEH	 6+ 1	 Telecom - Fire Extinguishers NSW BFS - Fire Behaviour Vic CFA - Weather	 Use 3 types extinguishers
3	Hand Tools	DPI	2	NSW BFS - Hand Tools	Field - rake hoe, beater, knapsack, slasher, brushcutter
4	Fire Suppression (a) General grass (b) Hillslope	 QFS Urban DEH	 11+ 2	 NSW BFS - Suppression TAFE rough cut video SEI - Bambi Bucket	
5	Fire with water (a) Urban (b) Forest	 QFS Urban DPI/DEH	 11+ 3		 Hydrant, hoses and pumper Mop-up units +/_ foam
6	Fire Prevention Hazard Reduction	DEH	1	Vic CFA - Topography NSW BFS - Hazard Reductn DEH - Hazard Reduction	Planning exercise Participate in hazard reduction burning
7	Communications	TAFE DEH	1 1		Hand held radios Pagers, mobile phone
8	First Aid	Q Ambulance			Dummies
9	Helicopter	BES	6	DEH - Aerial Fire Lighter DEH - Bambi Bucket Slides	Use helicopter for ferry & water bombing
10	Fitness & Health	TAFE	1		Gym & hillslopes trail

NOTES:

BES = Bureau of Emergency Services DEH = National Parks Service DPI = Forest Service
QFS = Queensland Fire Service Airport FS = Airport Rescue and Fire Service
NSW BFS = Dept of Bush Fire Services, NSW Vic CFA = Country Fire Authority, Vic

Staff involvement in lecture/demonstration for 3 concurrent classes for June/July 1993

APPENDIX 4

Redlynch Case Study:
Revegetation and Fire Management
of Fire-degraded Tropical Hillslopes

1.0 Introduction

The Redlynch Fire Management Area (Diagram 1) is situated on the lower eastern fall of the Lamb Range to the immediate west of the suburb of Redlynch, Cairns, Far North Queensland. It is an area where wildfires from cane farms and the railway corridor have chronically deforested extensive areas of hillslopes. In response to this situation, the Queensland National Parks and Wildlife Service has developed a fire management program on two rural freehold properties which border on the Barron Gorge National Park and which are traversed by the Cairns-Kuranda railway line. Over the past eight years the footslopes and flats below the railway line have been converted from cane fields to a rural-residential land use.

Rainforest or vineforest types 2a, 6, 12a, 13a and 13d (and hybrids thereof), Eucalypt Woodland (16b) and swarms of exotic grasses (particularly of Guinea Grass, *Panicum maximum*, Molasses Grass, *Melinus minutiflorus*) and other weedy species (eg, Japanese Sunflower, *Tithonia diversifolia*) of the fire-degraded hillslope communities (type 23b of the Webb-Tracey vegetation classification system ref Tracey -1982) constitute the existing vegetation cover of the area. Fire management efforts, in the initial phase, have been directed towards the re-establishment of rainforest or the dominant naturally occurring vegetation formation.

2.0 The Fire Problem

Over a period of more than 100 years the hillslopes of the study area have been regularly ravaged by intense wildfires. Ignition of fires generally occurred within the cane fields on the flats or, more regularly, from the railway line corridor on the foothill flanks. Fires from these sources resulted in large tongues of fire-induced grassland extending up hillslopes replacing rainforest and other more open forest types beyond the boundaries of the freehold parcels and penetrating the National Park. With each successive fire, the rainforest ecotone receded upslope creating a greater area of degraded forest containing more volatile fuel (grass) and promoting subsequent fires of higher intensities. This process accelerated the destruction of the rainforests and, over a longer period, damage even to the fire adapted eucalypt woodlands.

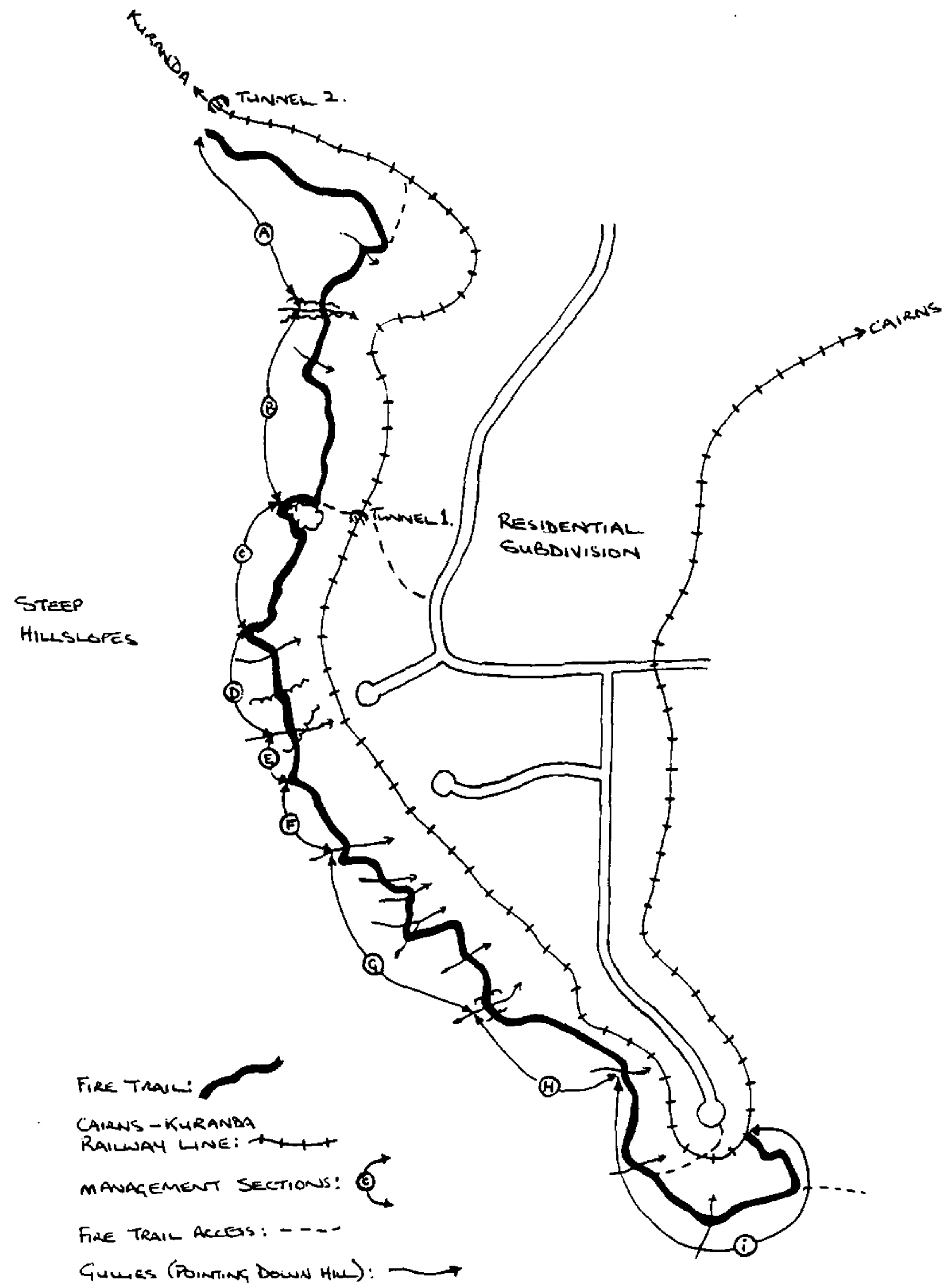


DIAGRAM 1: Map of Area Shown on Photo 1.

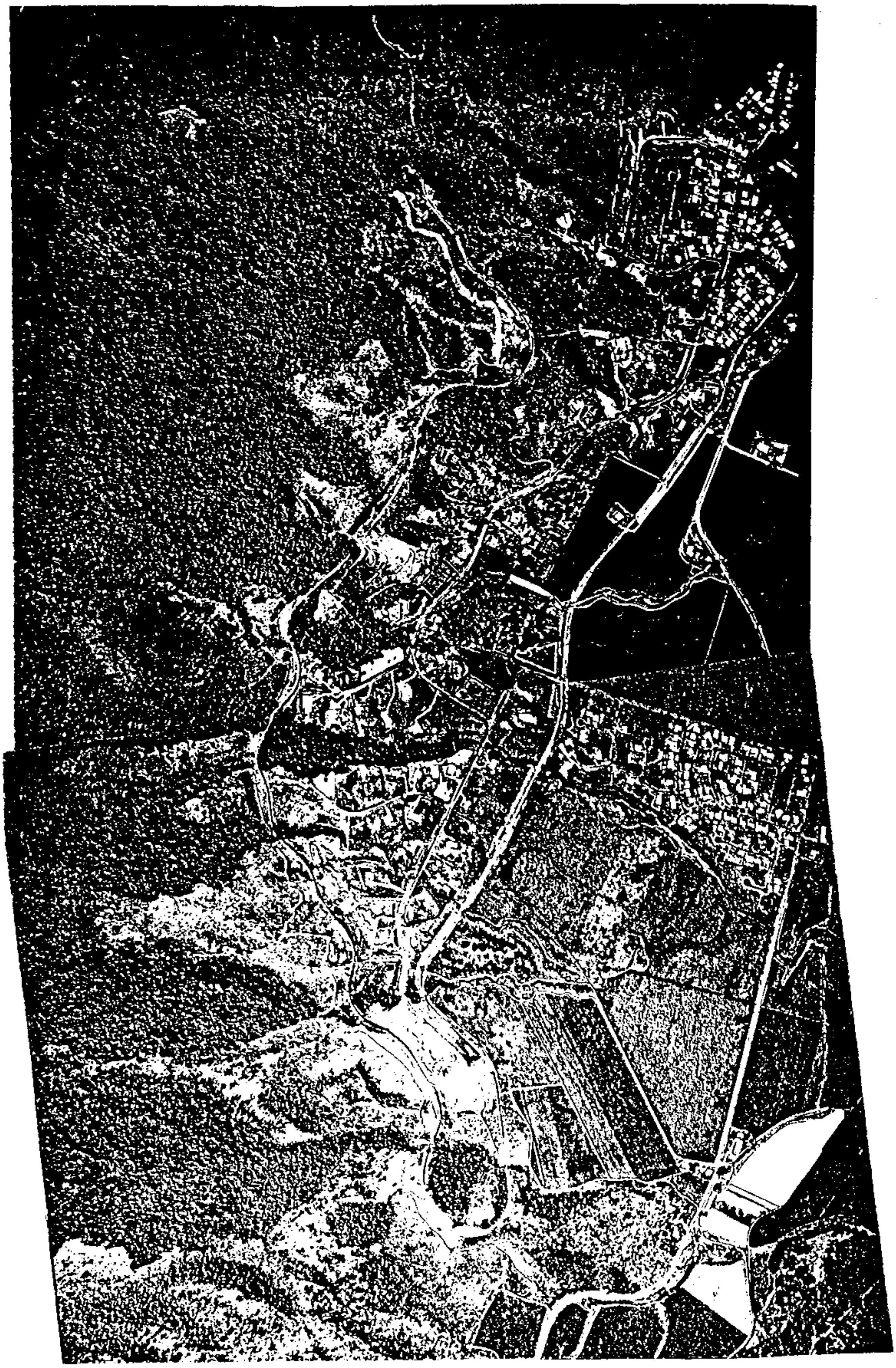


PHOTO 1: Aerial Photo Showing Redlynch Case Study Area
Scale Approx 1:10,000. Date 1991.

3.0 Causes

3.1 Historical

Following initial clearing during the construction of the railway line for most of the first 100 years, the area was subjected to environmental abuse associated with the Queensland Railways Department's "Line Maintenance Program" which sought to exclude fire from wooden sleepers within a cleared strip by actively "burning-off" the area around the line. Wildfires were caused by direct incendiarism from travellers on the trains as well as by escapes from burning old sleeper dumps. Burning became a well entrenched "vicious circle" within the officialdom of the Railways Department. The increase in the area of fire-degraded grassland created a greater fire risk to line infrastructure. Slope instability increased. Landslips and rock falls periodically blocked and damaged the line. This, in turn, prompted the greater use of 'protective' "burn-offs" which further intensified the problem. So too did the practices of cane farmers who regularly burnt-off foothill vegetation in vain efforts to protect crops from fires from adjacent lands or to reduce the perceived "vermin threat" when burning the cane prior to harvesting.

3.1 Recent

Recent trends such as changes in Railways management and the development of "green" cane harvesting techniques have reduced threats and thus diminished the problem of frequent hillslope fires. However, now, the major causes of fires appear to be from passengers on the tourist train, "rubbish fire" escapes from adjoining residential "acreage" properties, locomotive or rolling stock causes, or of more concern, deliberate incendiarism.

4.0 Causes

4.1 New regimes

Around 1980-81, concern regarding the degradation of the National Park from regular and frequently intense hillslopes fires resulted in Queensland National Parks and Wildlife Service (QNPWS) bringing considerable pressure to bear on the primary causes - ie, those emanating from the Queensland Railways Department and from cane farmers - to cease their damaging fire management practices. General community concern also amplified this pressure. However, it was not until September 1987 that the Queensland Railways Department officially agreed to apply for Permits to Burn from the Rural Fires Board.

4.2 The National Parks Program

In 1983, the Queensland National Parks and Wildlife Service recognised the importance of coordinating action to solve the fire problem and established a fire management program for the area. The Service (now within a Division of the Queensland Department of Environment and Heritage), with permission from two neighbouring landholders, commenced annual hazard reduction burning of the grassy encroachments and the adjoining freehold. This entailed backburning from the rainforest margins downslope to the railway line. Railways staff set fire to the grass on the rail reserve once the fire had approached to within 20-100 metres. This process served to protect the rainforest edges but could not assist with re-treeing of the regularly burnt grassy hillslopes.

An initiative in 1985-86 saw the Service establishing written "conservation agreements" with the private landholders for the implementation of intensive fire management efforts on their land to further reduce fire risk and to promote the recovery of the hillslopes. Service staff decided to develop a firebreak system. This involved the creation of fire trail upslope of, and parallel to, the railway corridor; the area between these being the much reduced annual burning zone. Above the fire trail a revegetation program was started to compliment the burnt strip and assist with the broader re-treeing task.

The hillslopes were subdivided into various management sections using naturally occurring firebreaks and barriers such as rainforest patches, moist gullies and other wetlines, prominent ridgelines etc. It was intended that should a wildfire start in any individual section it would be relatively easy to contain within that section. Thus fires would be prevented from spreading throughout the entire management area which had been the problem until then. With the exclusion of fire it was envisaged that natural regeneration would heal some of the prominent fire scars on the western mountainous backdrop to the city.

4.3 Firebreaks/Fire Trails

The burnt buffer strip firebreak was initially formed from a manually constructed mineral earth fire trail (*ca.* 3-5 metres in width) positioned along the catchdrains at a distance of between 20-200 metres upslope of and parallel to the railway line. The grassy strip between the fire trail and the railway line is burnt annually to provide a wide fuel-free strip. The manually cut fire line proved to be far too labour intensive to maintain with existing staff resources and prescribed burning too difficult to control in some conditions. Subsequently, in 1987, a bulldozer was employed to construct, in its place, a joint fire trail and four-wheel drive access track (Photo 2). This allowed the use of "slip-on" fire fighting units on four-wheel drive vehicles for the rapid control of small wildfires and for assistance with the annual burn off.

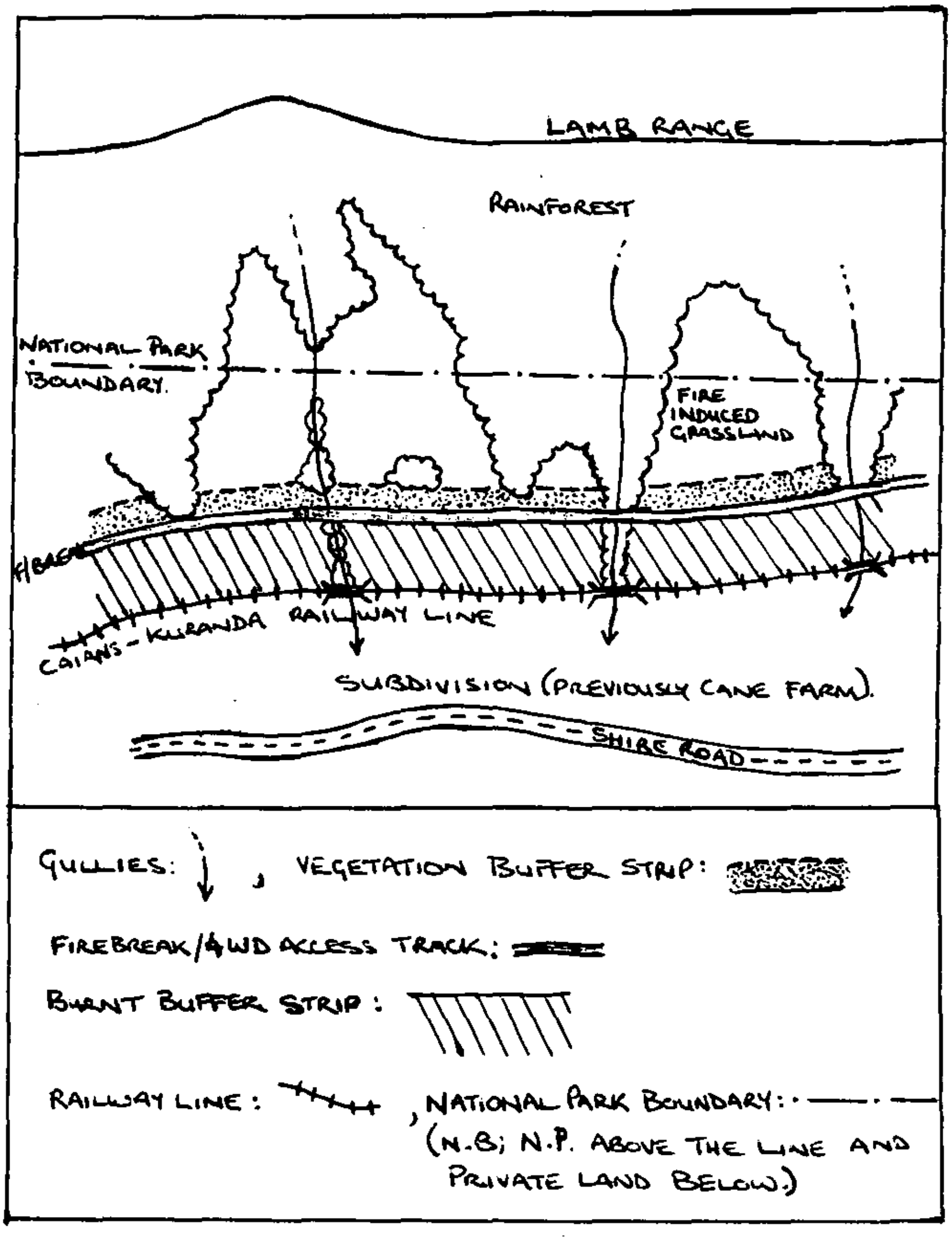


DIAGRAM 2: Schematic View of the Hillslopes at Redlynch, Cairns showing the fire break concept including:

railway line annually burnt buffer strip 4WD access trail
vegetation buffer strip above the trail
linkages to old growth rainforest compartmentalising the grassland fire problem

Approx. edge of Tree Buffer ↗ | Fire Trail ↑ | Railway ↑

PHOTO 2: **Newly Constructed Fire Trail On Steep Hillslope** Above The Railway line. The vegetation buffer strip has not been planted. Date 1987

PHOTO 3: Community Volunteers Planting a Section of the Vegetation Buffer Strip via the Annual "Tree Train".

This trail/track extended for a distance of 4.3 kilometres at a construction cost of $19 000. The annual cost of its maintenance is conservatively estimated at $500 (which excludes costs associated with revegetation activities). Funding for this management effort came primarily from the Queensland National Parks and Wildlife Service budget, although other significant contributions (via the Cairns and Mulgrave Hillslopes Protection Committee) came from the Cairns City Council, the Mulgrave Shire Council and the Queensland Railways Department.

The multiagency Cairns-Mulgrave Hillslopes Protection Committee became a recognised body in 1975. It grew out of a volunteer group called the Cairns Hillslopes Fire Protection League - promoted by the Wildlife Preservation Society of Queensland - which was established in the late 1960s to focus attention on, and to ameliorate by active suppression, the problems associated with regular fires on the hillslopes of the Cairns area.

5.0 Revegetation

5.1 The Concept

The vegetation buffer incorporates the planting of local ecotypes of native trees to form a strip with a minimum width of 10 metres upslope of the firebreak. This strip is densely planted to rapidly establish a canopy which serves to shade out the dense exotic grasses which constitute the large volatile fuel loads which promote such fires. This revegetated strip not only serves to restrict the spreads of fires but also furnishes a seed source for adjacent areas, attracts bird and other animal vectors which add to the local seedbank, and acts to control slope erosion.

A mixture of fast-growing pioneer successional species such as Bleeding Heart (*Omalanthus novo-guineensis*), *Macaranga* spp. and wattles (*Acacia* spp.) etc. were employed, together with a mix of later successional phase rainforest species. The former were used to promote the early suppression of grass and other weed growth while the latter form the building blocks of a more permanent forest canopy. At sites along the route which formerly supported a non-mesic forest cover, non-rainforest species such as eucalypts, Turpentine (*Syncarpia glomulifera*), etc. were used to reconstruct the appropriate suite of ecosystems. Regular maintenance was required for the first three to four years. however, The oldest plantings have become substantially "fire-safe" in the approximately six years since their establishment.

5.2 Tree Planting

Queensland National Parks and Wildlife Service staff undertook the planting of over 4 000 trees over the first four years of the program. A "Greening Australia" group assisted by planting one of the first patches. The Cairns and Mulgrave Hillslopes Protection Committee provided a focus for the growing community awareness of the problem, for supply of funds and for hands-on support. Through the activities of this committee a series of annual community volunteer planting days has been organised. The first of these was held in 1987. Volunteers were transported to the sites via rail on the "Tree Train" courtesy of the Queensland Railways Department (the former environmental "bandit") and attendances have ranged from 100 to more than 180. (Photo 3)These events have proved to be popular and successful with a total of 11 500 trees planted. In this way the local community has been given a sense of real ownership of the project and a hand-on understanding of management problems associated with indiscriminate fires. Unfortunately the remaining sites needing rehabilitation are too steep and inaccessible. The 1993 community plantout was moved to a more accessible fire degraded area on hillslope lands controlled by Cairns City Council.

5.3 The role of the Wet Tropics revegetation scheme

Although funding assistance continued, the Service found it difficult to maintain the level of management required for this effort. To this end a significant breakthrough was achieved through efforts of the Cairns and Mulgrave Hillslopes Protection Committee lobby. In January 1991, the Cairns Rainforest Unit (the then local arm of the Commonwealth Department of Arts, Sport, the

Environment, Tourism and Territories) succeeded in obtaining funding for the establishment of the Mulgrave Shire Unit of the Wet Tropics Revegetation Scheme. This unit consisted of timber workers who had been displaced from their former employ due to the Wet Tropics of northern Queensland being added to the World Heritage List.

This unit, with some advice and overseeing from Service staff, and supported by a plant nursery at Stratford carried on with revegetation efforts and took over the maintenance of the Redlynch program. Fortunately the program has continued far past its initial goal of a 6-12 month period. Some 18-20 000 trees have been planted out to complete the vegetation buffer and to extend some existing rainforest pockets along protected gullies etc. This has further served to enhance the compartmentalisation of the management area and the associated diminution of fire risk.

6.0 Results

The regular maintenance of the firebreak/fire trail and the associated vegetation buffer strip has resulted in a marked improvement in the situation. The effectiveness of the fire management program has been greatly enhanced with the significant reduction of rehabilitation time and the expansion of fire-suppressing stands of vegetation.

6.1 Wildfires

Since the establishment of the Redlynch Fire Management Program, the last major outbreaks to occur within one of the fire exclusion sections were:

(i) in 1982 when a cane trash fire on Soderberg's farm in the Freshwater Valley escaped up the hillsides and burnt into a limited section at the southern margin of the area;

(ii) in 1984 when persons ignited a fire which burnt out two ridgelines in a nearby area.

(iii) in 1989 a fire reburnt the areas previously burnt in 1982 and 1984; this fire came from the freehold land below the railway line.

Apart from these incidents and some minor incursions associated with back-burning from the bare firebreak, fire exclusion has been successful over the management area and the area has been essentially fire free for seven years.

6.2 Fire exclusion and fuel accumulation

Fire exclusion allows tree seedlings to establish naturally however it also lets the grassy fuel accumulate This is also a contentious issue especially for landholders of properties adjacent to parks and reserves.

The 1989, wildfire presented a valuable opportunity to assess the extent and intensity of damage due to fuel build-up in the absence of fire. From current experience in this environment it appears that fuel accumulation increases to reach a maximum during the first two to three years of fire exclusion and thereafter natural biodegradation maintains or reduces such fuel loads. A research project co-ordinated by the Queensland National Parks and Wildlife Service has, during 1993, been investigating the accumulation of fuel over time. Interim results show that in the first year fuels accumulate to about 8 -12 tonnes per hectare (on the slope). The maximum of up to 20 tonnes per hectare is reached within a few years.

Because of the steep gradients of slopes and the natural propensity for established grass sward to break down in the absence of mechanical disturbance, biodegradation is accelerated during the annual wet season resulting in the flushing of excess ground fuel materials. It seems likely that if wildfires are restricted to at least a five year cycle, then natural regeneration has, depending on the local situation and current conditions, sufficient time for establishment to a stage where it can sustain some fire damage and still survive. The 1989 fire event appears to support this.

While the meteorologic conditions associated with that outbreak were quite extreme, not all regenerating trees and shrubs were destroyed. There has been a rapid post-fire recovery, presumably associated with the release of plant nutrients during the fire.

6.3 Increased Public Involvement and Awareness

The Redlynch case constitutes a practical example of effective hillslope fire management. Moreover, it is an example of what can be achieved if conservation management involves the wider community. Public concern and active participation enabled Queensland National Parks and Wildlife Service to convince the members of the Cairns Mulgrave Hillslopes Protection Committee of the virtue of a coordinated effort to solve this land degradation problem. On the 13th of July, 1990, the Cairns and Mulgrave Hillslopes Protection Committee adopted the Draft Barron Gorge National Park Subdistrict Fire Management Plan as a model for the development of fire management plans for the remainder of the hillslopes surrounding Cairns City.

The "Tree Train" concept has been continued into 1993 as the "Green Bus" initiative. A bus has been used to convey community volunteers to other fire-degraded sites on the hillslopes behind Cairns (such as along the Lake Morris Road) to participate in plant-outs and to continue an important component of this ongoing program. Public involvement remains a significant facet which contributes to the success of the program. Members of the local community now feel a distinct ownership in what has been achieved to date.

7.0 Conclusion

he Redlynch fire management case has proved a successful model for the reduction of ecological and visual impacts of fire. It has seen the reduction of fire risk and the rehabilitation of fire degraded ecosystems as well as the development of greater inter-organisational cooperation and a significant increase in public awareness of, and participation in, conservation management.

The firebreak and revegetation effort at Redlynch is mainly on freehold land outside of the National Park. The less steep foothills of the southern part are likely to become residential subdivision. However because the local municipality has been actively involved in the fire prevention scheme appropriate arrangements should be made at the time of subdivision. The now well established fire trail should continue as an attractive walking track and revegetated areas should be retained as public "green space".

The hillslopes behind Redlynch are now well on the way to recovery. The wildfire risk to both adjacent residential properties and to the integrity of natural systems within the National Park have been markedly reduced.

Steve Collins
July 1993

APPENDIX 5

Wangetti Coastline Case Study: Prescribed burning of native forest

1. The Fire Problem

The Wangetti area is classified as Wet Tropics World Heritage Area (WHA). However it had limited protected area management prior to this and has had a history of severe almost annual wildfires. These have usually been deliberately lit by roadside incendiarists. The Cook Highway is the primary through road. It follows close to the beach. Consequently fires start at sea level and burn uphill with high intensity in the initial rush. Little had been done to combat the fire problem other than fire suppression near the township and the Highway by the small volunteer Hartleys Creek Rural Fire Brigade.

2. Topography and Vegetation

The study area is about 50 square kilometres in area. There is a basin at Wangetti covering about 10% of the area. Remnants of the rarest rainforest type in the WHA are found along Tin Creek which is in the centre of the basin. The majority of the area is a steep escarpment descending some 700 metres from the top of the Macalister Range to the sea in a horizontal distance of approximately 1500 metres.

Virtually all the area is covered with native forest. It is predominantly dry open eucalypt forest in the south. The low grassy (kangaroo grass) understorey is intact near Wangetti but closer to Cairns this forest type has been invaded by guinea grass and molasses grass. Consequently high intensity burning is occurring with subsequent damage/death to trees. As yet there are only small treeless patches.

Rainforest predominates in the north, beyond the top of the range and also along many gullies. Vine thickets occur on steep rocky areas north of Wangetti. The gullies are numerous, often rocky and usually have little rainforest along their lower reaches.

3. Fire Plan for 1993

Ignition of fires from the roadside was the main problem. The authority in charge of the highway had carried out herbicide spraying to the guide posts. However in many areas this was insufficient in width to deter incendiarists. Assets to protect included several buildings, a Telecom exchange, the magnificent hillslopes vista and the rare rainforest along Tin Creek.

The strategy chosen was to adopt a holding campaign until better management planning was carried out in the area. This included hazard reduction burning in specific locations based on analysis of the natural breaks and known sources of ignition:

(a) Small block burning immediately north of the school where fires had previously started
(b) Roadside buffer burning for 2.5km at a with of 30 m to 50 m along the edge of Tin Creek basin linking the township with the cleared rifle range.
(c) Two 150 hectare strips of hillside to be burnt via helicopter ignition mid way along the range
(d) a third block of hillside to be burnt via helicopter to protect the small resort of Ellis Beach

4. Results

Most of (a), (b) and (c) were carried out on June 23, 1993. This was treated as the first training exercise for the dry season. It involved personnel from Forestry, National Parks, Daikyo (a development company in Cairns), and the local rural fire brigade. A private hire helicopter with aerial fire lighter was used to ignite the hillslope blocks.

The day was overcast and calm. sufficient light rain (3mm) had fallen on the 19th and 20th of June to prevent the first attempt at burning beside the Wangetti Education Centre. Mild windy weather followed. On the 23rd June the drought index was 404, dry bulb temperature ranged from 26^0 at 1400 hrs (start) to 23^0 at 1800 hrs (finish lighting). Relative humidity rose from 51% to 68% over the same period. Neither factor appeared to alter the fire behaviour on the flats where the kangaroo grass produced flames of about 1 m and a scorch of about 5 metres. All fires on the flats were extinguished before the crews departed.

The helicopter ignition was done with several runs near the top of the range. Excellent control against over run was maintained. Fires developed rapidly and raced upslope between the lines. Plans to bring the fire line progressively down the hill were abandoned. At 1900 hrs the downslope land breeze started. Apparently no dew formed that night and by 0600 hrs the next day (24/6/93) the first fire edge reached the base of the slope. The fire edge progressively reached the highway during the following 20 hours. It then rained!

Subsequent delays due to wet weather and lack of preparedness at the resort prevented the helicopter being used for 2 weeks and then the area failed to ignite - different grass species, a wetter area being closer to Cairns, 1 year old fuel instead of 4 year old fuel and the gelled fuel had lost viscosity due to storage. BUT the same day kangaroo grass burnt well on the flats!. It rained that night. Ground ignition on the flats the following afternoon produced an excellent hazard reduction burn with variable scorch to 3 metres.

5. Conclusions

Time since rain - measured in hours - appeared to be the key to responsible burning in dry eucalypt forest with a grassy, native species understorey. The aerial fire lighter is an excellent tool but it has its limitations. The type, age and curing of grass fuel needs to be well researched. These factors can vary markedly over short distances. This is particularly hard to determine for the upper slopes of inaccessible hillslopes. It may be dry enough for a head fire to run uphill from the coast but a backfire may fail when lit from the top of the range. Grid lighting may be possible but beware of massive head fires.

Details of the Helicopter Fire Lighter System

Operator: Webb Helicopters, PO Box 722, Emerald, Qld 4720

Helicopter: Bell 47 or Kowaski 3 seater. Air to ground speed approximately 40 knots, flying height 40 metres + above ground level

Other necessities: Pilot/bombardier, navigator/fire boss, aerial fire lighting device, supply of super petrol - at least 20 litres, methanol and "Surefire" powder [ratio 20 litres: 500g : 300g]. These ingredients are mixed preflight.

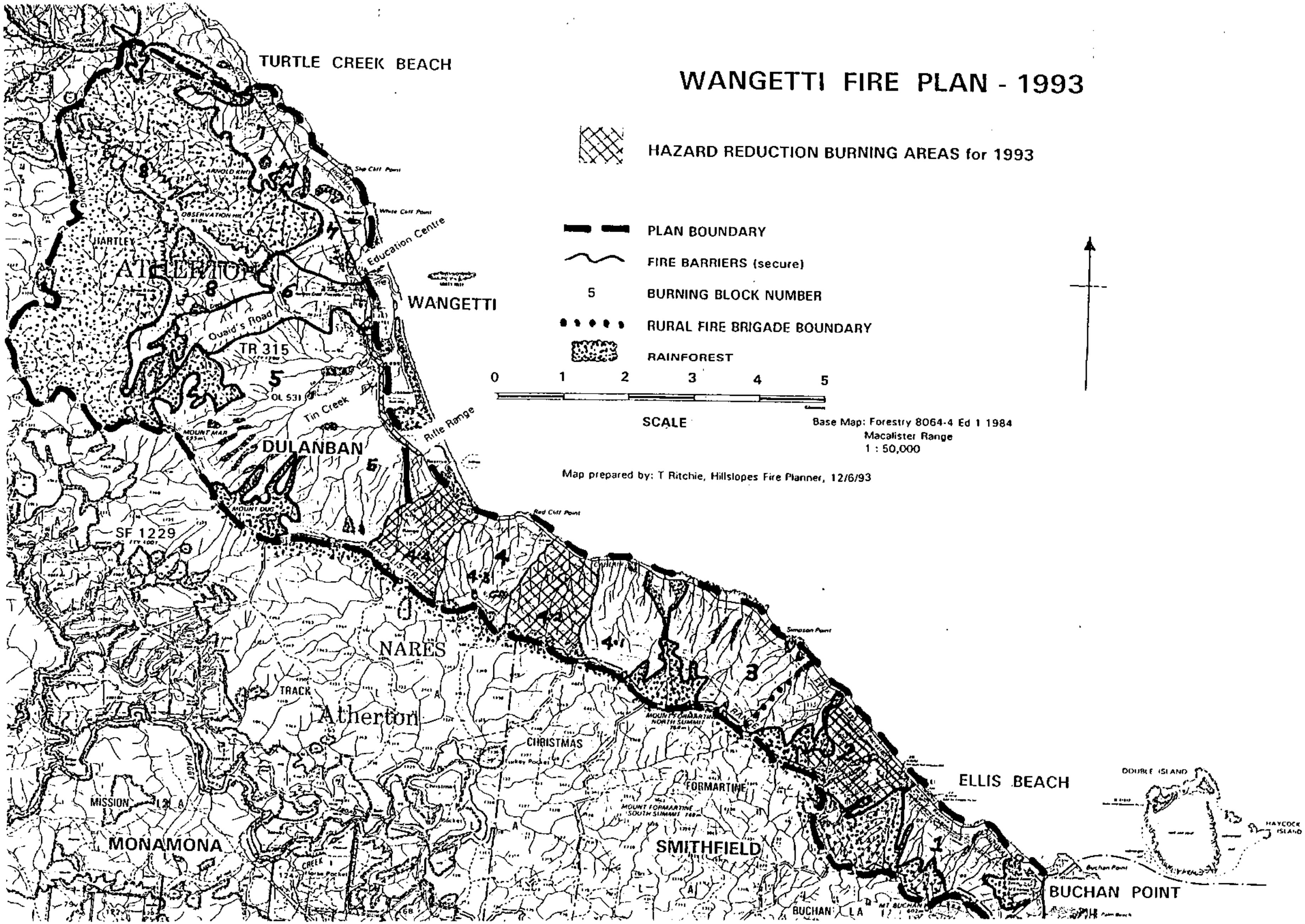
Fire lighter: consists of a fuel tank - 60 litre capacity - attached to a frame that also supports an electric pump, twin gas bottles, twin ignition coils and with a burner (nozzle on a tube) projecting from the rear. The spark from the coils keeps the gas alight which in turn ignites the difficult to light gelled petrol.

Attachment: The fire lighter device is held approximately 3.5 metres below the helicopter via a cable from the cargo hook. This hook can be released both electrically and manually by the pilot should an emergency occur. Two electrical leads are plugged to the helicopter - one works the pump and the other the ignition coils. The pilot controls these by switches either on the instrument panel or on the joy stick.

Results: Approximately 8 kilometres of fire line was lit on continuous stream. This used 15 litres of gelled fuel. Spot application is possible. This would have used far less fuel. The rate of flow can also be adjusted prior to take off but not in the air.

Conclusion: An excellent tool for the fire manager. The gelled fuel is quite safe. Lighting is usually done into the wind; this coupled with positive switch off of the electrics means a very accurate start and finish to a run. Navigator error will be the main cause of over runs and fires lit in the wrong position.

Trevor Ritchie


WANGETTI FIRE PLAN - 1993
HAZARD REDUCTION BURNING AREAS for 1993
PLAN BOUNDARY
FIRE BARRIERS (secure)
5 BURNING BLOCK NUMBER
RURAL FIRE BRIGADE BOUNDARY
RAINFOREST
0 1 2 3 4 5
SCALE
Base Map: Forestry 8064-4 Ed 1 1984
Macalister Range
1 : 50,000
Map prepared by: T Ritchie, Hillslopes Fire Planner, 12/6/93
TURTLE CREEK BEACH
WANGETTI
Education Centre
ATHERTON
HARTLEY
Quaid's Road
TR 315
OL 531
Tin Creek
Rifle Range
DULANBAN
SF 1229
NARES
TRACK
Atherton
CHRISTMAS
FORMARTINE
SMITHFIELD
MISSION
MONAMONA
ELLIS BEACH
DOUBLE ISLAND
HAYCOCK ISLAND
BUCHAN POINT
BUCHAN
MACALISTER
Red Cliff Point
Simpson Point
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Forum : Case studies of public education regarding fire management in conservation reserves

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Abstract

Land managers are beginning to use fire for conservation purposes but their efforts are often thwarted by lack of public understanding and support. This has the potential to seriously hamper conservation efforts and the need for public education is well recognised. Various ideas were discussed during the forum, but little work has been done in this regard by most agencies. Public education was identified as an area requiring urgent attention if fire management plans are to be successfully implemented. A co-ordinated effort, if possible, could benefit all as there was considerable over-lap of issues and concerns between agencies.

Summary of Papers

The three papers relating to public education and fire management took different approaches to the topic, exemplifying the breadth of the issue. Dave Luxton and Brian Cifuentes outlined the legislation and organisational framework of the Queensland Fire Service and explained that the Q.F.S. relied heavily on public involvement through volunteer fire brigades. Public perception of fire was identified as a service-wide issue and a specific objective to develop public understanding has been adopted. Although strategies have been recommended, there has been no implementation to date. Geoff Kent concentrated on Forest Service policy and emphasised the need for protection of life and property and for co-operative burning with neighbours. Trevor Ritchie and Steve Collins presented a specific case study where there had been extensive, successful public involvement.

Public education had clearly been considered by the three agencies represented, but other than the case study, practical application was limited. The issue was explored further through an open forum where participants identified who they should be targetting and exchanged ideas on possible techniques.

Educating the public regarding fire management

Which public?

'The public' is a diverse collection of people, all with different atttitudes and behaviours. Attitudes are based on past experiences, social norms, up-bringing, education and peers, and underlie how people will behave or react in different situations. Understanding these different attitudes is the first step in being able to influence or change them. If the 'target audience' is defined and analysed, messages and communication techniques can be made specific, thus enabling maximum effectiveness.

The forum discussion was aimed at reducing participants concept of the 'general public' into component groups of particular relevance to fire management. The list proved endless but included:

. 'conservationists'/'greenies'
. adjoining landholders
. tourists
. campers
. Local Authorities
. graziers
. Government Departments

Efforts to date

The discussion then focussed on past experiences regarding public education. Participants were asked to give examples of techniques they had used and comment on whether they had been effective. Examples given were printed publications (brochures, press releases, magazine or newsletter articles), volunteer tree planting groups, and a public forum aimed at addressing community concerns.

Examples were limited, highlighting public education as an area requiring further attention.

What needs to be done?

The remaining time was spent discussing the issue in general terms. Suggestions were made for future actions, but it was difficult to reach concensus. The group felt that there were two possibilites worth pursuing: 1) the production of a booklet aimed at tourists and explaining environmental aspects of fire management in northern Australia; and 2) an attempt should be made to develop a co-ordinated approach to public education, although it was recognised that this would be difficult given the range of agencies involved.

Conclusion

It was widely recognised that public education is critical in order to gain support for prescribed burning programs. However attempts to date have been *ad hoc* and sporadic. The area needs to be explored further and a strategy prepared that is acceptable to all agencies. Common elements may be identified which would allow for a co-ordinated approach and better resource/idea sharing.

Section 4 :

Technological Issues

Chairperson : Tim McGuffog

Fire ignition techniques In Kakadu National Park

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Kakadu National Park
Northern Territory

Introduction

Necessity is the mother of invention. Well if that is the case, innovation must be the father of invention. Put them both together, mix in some initiative, a little money, and the product may be somewhere in the realm of the requirement. The 'when and where' of fire management ignition is far more important than the 'how'; suffice to say that the 'how must produce the results expected, providing the 'when and where' is properly calculated.

Matches may have been born of Necessity and Innovation but more likely due to a lack of willingness, time and motivation in rubbing two sticks together. There would have been the knockers too, I'm sure. They are considered to be one of the most basic implements we use and it is safe to say we take them for granted, until we haven't got any. Nevertheless, we still use matches and other methods to light fires in Kakadu. Keep it simple and you have a better chance of success. Matches are still used in vast quantities for ignition from vehicles. The R22 helicopter is used for aerial ignition. Drip torches are used extensively.

The easy way out is often the preferred option but not necessarily the most effective or efficient. Innovative ideas, even mentioned in passing, can turn out to be most effective in fire management. There are a lot of very experienced personnel in the agencies across Australia, some with extremely brilliant ideas just busting to be listened to. If you're a manager, take the time to listen. If you're not sure about the idea then try it out.

History

Kakadu has used several methods of ignition and some have been discarded because of the difficulty of operation, cost, lack of enthusiasm, motivation and other reasons. Lack of enthusiasm is normally a direct result of the other two. You will not get personnel to operate equipment, efficiently or effectively if they don't like how it works, what it achieves or if it costs them in blood sweat and tears or a combination of all these.

The methods of fire ignition in Kakadu have ranged from throwing matches out of the windows of a vehicle to auto incendiary machines. The Vic Dept of Conservation and Environment were kind enough to loan us their auto incendiary machines for the cost of maintenance.

These machines were fitted to fixed wing GA aircraft (CAA, VH registered). Their effectiveness was questionable, though a good many fires were ignited for a good many years, the machines continually jammed and misfired and the cost was astronomical for aircraft hire. This may not necessarily be the circumstances in other areas or agencies.

The efficiency levels were well down due to manoeuvrability, availability and nausea problems. An operator sniffing glycol and keeping their fingers away from the injector head down and bum up made for a myriad of sins performed in the rear of the aircraft. The aircraft were also used for commercial tourist operations which meant a considerable effort in coordination to procure an aircraft for our needs, when we needed it. Having the aircraft when we want it is 80 % of the battle. Burning runs are not much good if what you want to burn is wet from heavy dew. But if that was when the aircraft was available, we had to make the best of it.

The current systems employed in Kakadu are a combination of trialled exercises that have fitted the

budget projections. This does not necessarily work, but unfortunately it is what most of us have to contend with. It is much more advantageous to make the budget fit the operation.
The option for R22 use was a coincidence. A company looking for work, due to falling mustering jobs, wrote to us inquiring options in our proposed, updated burning program. The two were married pretty quickly and a trial was initiated.

The Current Situation

The R22 has a drop tube mounted on the passenger side and is located between the legs. Also in front of the operator is a bucket which holds two trays of capsule type incendiaries and a reservoir of ethylene glycol. The glycol is delivered via a drench gun and is injected directly into the vial. The vial, held in the gloved left or right hand is then dropped down the tube hopefully having the desired effect.

It takes approx 3 seconds to drop each vial. Accuracy levels are excellent and the ability to put the fire exactly where you want it is a distinct bonus. It allows us the preciseness we require for proper management. That's not to say we're always right, we're only human after all.

No GA fixed wing aircraft are used for incendiary bombing. The R22 helicopters are used exclusively for bombing and mapping. There are still other more cost efficient ways being evaluated. Some options may be considered radical. For example, I have been granted funding and permission to evaluate a Skyfox (ultra-light) aircraft, in Kakadu, for a period of approximately 100 hours. The use of such craft has to potential to save us $40,000 per year.

The Future

Ultralight aircraft are being evaluated for the possibilities in reducing costs even further. For example, the R22s cost approx $200.00 per hour. A pilot operating the helicopter may not be conversant with the ethics of fire management or have the environmental awareness which we expect from full time Rangers and staff. Kakadu is fortunate to be involved with a company whose pilots have these qualities.

However, it would be even more advantageous to have our own staff operating the aircraft. This is another matter of funding, time allocation, personnel etc. etc. An equally reliable ultralight can cost in the area of $30,000 to $50,000 to purchase and $20.00 to $30.00 per hour running costs. It would be a requirement to operate these with our own pilots due to the constraints on commercial operations of ultralight aircraft.

Other operational costs and constraints are somewhat less than GA requirements giving the Service a greater flexibility. It is a hard thing to sell to the bureaucracy and maybe seen as another 'Spiers' crank idea; but a saving of $40,000 per year can be achieved. If the $40,000 was not there in the first place it may be seen as a better idea.

These ideas are not new and are being evaluated by other agencies around Australia and the world. Kangaroo censusing is being carried out in Queensland with a Drifter Ultralight, Fishery inspections with ultralights are being trialled in Tasmania. The World Wildlife Fund are using ultralights for wildlife censusing in Africa. United States Government agencies use them extensively. I believe the NSW Police are about to introduce them, the Indonesian Government has just placed an order for 1000 Skyfox aircraft for various tasks and the list goes on.

It is important that environmental agencies continually strive for more efficient operations. We are the first to get the chop when things get tough at the bank. To be able to continue with high efficiency levels, in the face of adversity, can only advantage the environment and those who have to work in it, with it and for it.

Fire ignition techniques in the Top End

Tim McGuffog
Senior Fire Control Officer
Bushfires Council of the Northern Territory

Introduction:

Fire is an integral part of land management in the top end of the Northern Territory. The Bushfires Council of the Northern Territory has utilised and developed a number of ignition techniques since the early 1970,s to expand and implement an annual controlled burning program on behalf of land managers.

This program was originally developed to assist pastoralists in fire management and to prevent the recurrence of the large unchecked wildfires which occurred in the late 60's and early 70's. With continually changing land use and tenure, we have had to adapt our operations to suit the activities and management requirements of our clients. The hardened economic climate has also required that we ensure the cheapest, yet effective and safe program that we can offer, while retaining a high degree of control over burning operations.

Background:

Althought the Bushfire Council is an autonomous body, it is administered by the Conservation Commission of the Northern Territory (CCNT). This has fostered a closer working relationship with national park management personnel in recent years and synchronisation with other unit's of the CCNT such as Park Planning and Soil and Land Conservation. We are also developing a continuing and, I believe, mutually beneficial co-ordinating role between national park managers such as the Australian National Parks and Wildlife Service (which was recently renamed the Australian Nature Conservation Agency - ANCA) which manages Kakadu and Uluru National Parks and adjoining pastoralists.

As with other Australian states, fire ignition techniques in the Top End were initially developed and utilised by the Foresters for protection of forestry resources. This was eventually extended to include the wide scale aerial protective burning operations on pastoral properties across the Top End. Prescribed burning operations on national parks and other nature conservation reserves is not altogether new, because these reserves were, in most cases, part of pastoral leases which participated in past burning programs.

However, there is a difference in the scale and intensity of the operations which reflects the management aspirations of the two groups. The pastoralist utilised aerial control burns, principally on the less productive country, in an effort to save or protect his pastures to carry his stock through the Dry season. He may also have used the aerial ignition service to clear the land for mustering or the encourage green shoot for his stock.

The scale and intensity of burning also increased as you moved from the more productive perennial grasses south of Katherine into the tall rank annual grasslands to the north. Here, there is generally a more complete burn as a result of the prescribed aerial and ground burning combined with other activities such as bull catching, pig hunting, aboriginal burning, and wildfires.

Prescribed burning operations in national parks and other reserves, is generally conducted in a way so as to protect national park assets, ensure the safety of visitors, and to protect environmental assets such as monsoon forests, paperbark swamps, and wetlands from late season fires.

The methods of ignition have changed little in this time. The application or delivery of fire to the target is where most change has occurred.

Early techniques ranged from the use of D.A.I.D's propelled from a modified .22 calibre rifle until their use was outlawed, to the various forms of capsules using potassium permanganate and ethylene glycol, still used today. We have modified various forms of semi-automatic incendiary machines, ranging from the prototype of the Western Australian machine, to a rotary cartridge system, to the currently used Western Australian machine.

The use of these machines was and still is the most cost effective means of conducting our program over the vast areas of parks and pastoral properties in the Victoria River Downs, Gulf and Arafura regions, given the extensive distances and length of the incendiary drop lines involved. In the late 1980's, our programs involved up to 17000 kms of drop lines across the Top End.

In the closer settled Vernon Region (Darwin Rural areas), we utilised a helicopter to deliver hand injected incendiaries and this is still practiced today. The use of this technique has been extended to those areas where there is limited ferry time or where we need precession accuracy.

Current Situation

We are still utilising these techniques of aerial ignition. However, we are continually assessing aerial ignition methods for improvement, safety, and economic efficiency. Economic requirements have necessitated implementation of a user pays system of aerial ignition and consequently, a greater requirement to provide a service at minimum cost and maximum efficiency. We are soon to purchase a new light-weight incendiary machine being developed in Western Australia which will enable us to utilise a smaller and less expensive fixed wing aircraft. Wherever possible, we will also utilise smaller rotary aircraft.

A not so new but still extensively used method of incendiary application, is the capsule launcher which I believe was developed in the Northern Territory. This equipment is used extensively for roadside burning and to widen roadside burns to establish an effective break. We have about thirty of these units which we use ourselves and also make available to other land managers who wish to use them. The unit is a vehicle mounted device which propels an hand primed incendiary by means of compressed air. The distance can be regulated by adjusting the air pressure and the trajectory, but is generally about 100 metres.

A recent acquisition, is the new *Heli-fire Heli Torch* which we intend to use for specific controlled burning applications. It can be used under any helicopter, down to the small and cost effective *Robinson* , which has a hook. We are currently developing a portable control panel which will alleviate the need for machines to install this expensive unit as well as increase the availability of suitable helicopters. The *Heli Torch* unit consists of a 60 litre fuel tank and an ignition device which is controlled by the pilot. The fuel tank is filled with a congealed petrol mix and this is delivered past an ignition device. The result is a globule of flame which can be regulated for size and intensity.

This has been trialled very effectively in the arid zones of the Northern Territory. Bushfires Council staff have effectively ignited areas of spinifex in continuous lines. In the past, this was both time and staff resource consuming because each clump generally had to be individually lit to establish an effective fire front. In the Top End, we have plans to use this new equipment in the coming months in a number of areas, to ignite as hot a fire as is possible, to control woody weeds. These include large areas of mimosa in the north and another weed, commonly called belly ache bush, in the Katherine area. Future utilisation may also include other forms of woody weed control, wet season burning, and in select situations were we need and can safely establish a fast and extensive back burn operation.

Future directions.

As was previously mentioned, there is an increasing pressure to provide a service at the lowest possible cost, not only to the pastoralist, but to the government and other agencies. Options to reduce costs that have been considered by our unit include user pays, use of smaller aircraft, and providing the means for users to carry out operations themselves, rather than us providing the operators. Another option that needs further consideration is less expensive substitutes for the current vials and balls of potassium permanganate and ethylene glycol. At between 20 and 25 cents per unit, these add significantly to the cost in any aerial ignition operation.

We have found that there is considerably less early season burning taking place than was the case not so many years ago. This is a reflection on the user pays system for aerial burning operations recently introduced by the Bushfires Council and is also a direct result of the Brucellosis Tuberculosis Eradication Campaign (BTEC) which has taken place in the NT over the past 5 years. This program has effectively eradicated stock from most of the previous free range areas across the Top End.

As a result, pastoralists have been forced to control stock behind fences and utilise considerably smaller areas. Large areas of these leases are now not used because of the costs involved, and subsequently, have higher fuel loads and little or no management. The consequence of these two events is the greater number and extent of wildfires or late season burning and this is reflected most prominently in the costs of control, loss or damage to developed assets and to a lesser known extent to the environment.

The other major influence affecting the extent of current operations is an increasing public questioning of fire management in the Top End. There is an ever increasing influx of tourists and local residents migrating from southern states. They bring with them a southern ideology in regard to fire management and they find it hard to comprehend the volatility of Top End fuels, the fire dependency and resistance of much of the vegetation, and most importantly, the vastness and lack of development and controls in place to put out perceivably large wildfires.

There are ill-informed members of the public who believe that the continuous burning of the bush is leading to irreversible damage to a fragile environment. Others are particularly concerned with the smoke which is a common feature of Top End skies in the dry season. These people include asthmatics, tourists and pilots to name a few and this problem is of increasing concern, particularly in Darwin, as it is located in the north west where the predominant dry season winds are south easterly.

Although some of these points are off the subject of ignition techniques, they are problems that we as managers who use fire as a tool, are under increasing pressure to overcome or explain, even as we are looking at ways to improve our operations. Problems of public perception has been apparent in the Northern Territory for some time and various attempts by Government authorities such as the Bushfires Council, CSIRO, ANCA, and the CCNT have been made to address the situation. There is still a need, however, for a concerted effort to continue research into fire effects and monitoring. We need to explain and manage operations so as to minimise adverse conclusions by the public while maximising benefit. Only through a concerted and collaborative approach by all of the users of fire in tropical Australia can we ensure it's continued and legitimate use.

Fire monitoring in the Northern Territory is beginning to take place at a greater pace with the development of computing and satellite imagery techniques. There is still much more work required by all the organisations which use fire as a management tool. National parks and reserves across the Top End need to develop appropriate monitoring of fires so as to capture fire history data and enable planning. There is also a need for greater cross flow of information between fire managers so as to avoid reinventing the wheel.

The evolution of aerial ignition techniques on northern Cape York conservation reserves
(A field perspective)

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Queensland Department of Environment and Heritage
Coen
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Introduction

The major Conservation Reserves on Northern Cape York are Rokeby, Archer Bend, Jardine and Iron Range National Parks and Heathlands and Iron Range Departmental and Official Purposes Reserves.The diversity of these Reserves is enormous.

All these Reserves fit very well into the description of Cape York given by J.P.Stanton in the first two paragraphs of his introduction in "National Parks for Cape York Peninsula". The declaration of these parks throughout the 1970s and 80s brought with it the need to establish fire management programs under the less than favourable circumstances of extreme isolation and poor resources.

Since then, the Department has become the major leader in the preparation and implementation of structured fire management programs on Cape York. This has involved a constant review of programs and the use of modern fire ignition technology.

It is not intended to dwell on the technical details of various programs and ignition systems but provide an overview of the techniques used and how they evolved (warts and all) in the Cape York situation.

Fire Ignition Techniques - Some Basic Realities

The principles of fire ignition remain the same irrespective of what technology and techniques are used. For instance, the humble firestick has the same capacity to effect the outcomes on a particular distribution of flora or fauna as the modern technology of the helicopter and incendiary devices. It is all a matter of timing.

One lighted matchstick on the east side of Cape York Peninsula during October/November has the capacity to burn out more area than an intensive aerial ignition program in June/July. This fact has largely been overlooked by those sections of the community that contend that the aerial incendiary program is inappropriate.

One of the major dilemma's facing modern managers who run fire management projects, after the desired outcomes have been identified, is in the cost effectiveness of the particular type of ignition technique to be used. It does not necessarily follow that one particular technique or the most complex technique is the best in all areas. In fact, bearing in mind the ever increasingly important cost factors, the converse may be true.

This is certainly the case in northern Cape York operations where we use a mix of ignition techniques.The type of technique used on northern Cape York Reserves is largely determined by the scope of the operation and in many areas by the **safe burning - time frame** . The technique used has also been determined through observing the old maxim "learn by your mistakes". This learning process is only achieved by firstly accepting that we **do** make mistakes and secondly by being prepared to admit to those mistakes.

All of these Reserves had previously had some fire regime imposed on them either through

Aboriginal traditional practices or through standard grazing management practices. In the early 1980s, it became obvious that there was no way that we could adequately cover the large and often inaccessible areas of these conservation reserves. At that time, all of the ignition was carried out through the use of conventional hand held or vehicle mounted fire lighters. Even if we had quadrupled the staff to carry out burning operations on vehicle, foot or horseback, we still would not have been able to carry out the required burning.

The beginning of the aerial incendiary program

In 1985, a whole new era began with the first use of an aerial incendiary machine on the Cape York Peninsula conservation reserves at Lakefield and Rokeby/Archer Bend National Parks. It should be noted that this did not replace ground operations which are still carried out.

To the best of my recollection the aircraft used was a chartered Islander and the incendiary machine, a Mark II, was supplied by the Rural Fires Board. Those were very heady days. We, at last, had this wonderful piece of technology that could give us the ability to cover all those large and inaccessible areas with a minimum of fuss.

Little were we aware at the time when the aircraft first arrived that this would indeed be a learning experience. We learnt that fumes, from burning capsules caught up in the incendiary machine, made one feel quite ill. We learnt the importance of having a navigator, who knew where he was, on board and that air to ground communications were a must.

A certain Management Officer and myself were forced to asked for burnt hamburgers with plenty of egg on them at a Road House/Cafe after the aircraft became geographically embarrassed. We also had the delicate duty of explaining to a Contract Musterer (the Park was being destocked at the time) that we had no idea how his cattle would survive on the charcoal remnant of his once large hay stack that had the misfortune to be in the wrong place at the wrong time. With modest but firm alacrity I must add that I was not in the aircraft navigating at the time, where I should have been, due to a bout of plastic induced sickness on the first day of operations.

By the time the aircraft was happily winging its triumphant way back to Cairns, both the Management Officer and myself, securely on the ground thank goodness, were seriously thinking of putting in an official requisition for a couple of violins and wondering what sort of monster we had unleashed on Cape York. Despite these now humorous setbacks, the program was a success and set the framework for use in future years.

Operations 1985 to 1987

After 1985, the aerial incendiary program was quickly accepted as a very efficient ignition technique. Operational procedures and contingency plans were developed to ensure that a repetition of first years mishaps could not occur. However, the following limitations did begin to become apparent;

..... * ... the aircraft type was not suitable for use in tight situations or precision ignition;

* ... condition of fuel loads in the more remote locations could not be .... assessed prior to operations;

* ... operations could not be carried out in one round on the larger parks as ..... different areas dried out at different times;

* ... schedules had to be set well in advance to ensure availability of .... aircraft and the incendiary machine. The combination of the these limitations meant that we operated, unwillingly of course, on the assumption that nature would conform to operational planning when in fact the reverse should have been applied.

Operations 1988 to 1993

In 1988, we used a helicopter for the first time in our aerial program. The Helicopter, a Squirrel, was provided free of charge by the State Emergency Service. The incendiary machine was still a Mark II hired from another Queensland Government Department for one hundred dollars per day when it was being used.

The helicopter certainly solved some of the problems experienced with the fixed wing aircraft. However, the lack of availability on short notice still continued to create problems.

It was during this time that we also started having serious reliability problems with the incendiary machine. Several events can be recalled where we would have gladly kicked that infernal machine out of the helicopter.

At Heathlands, on one occasion we ended up cranking out approximately 2000 capsules by hand just to complete the program. Another time at Rokeby, we were forced to abort the program entirely as the machine had a complete breakdown.

During this time, liaison with various other organisations was being carried out with the view to producing a ultra reliable incendiary machine. However, an additional larger problem was looming on the horizon by 1992.

The State Emergency Service advised us that they could only spend one night out at a time in the field and that user pays charges would be levied by 1993. It was expected that the charges would be approximately $650 per hour. After having evolved from a box of matches to a helicopter, it certainly seemed that our aerial program for 1993 was doomed by the excessive costs of technology.

In the latter part of 1992, it was noted that the Northern Territory Bush Fires Council were using a simple incendiary device from a Robinson helicopter and details of the system were obtained from them. The system seemed too simple and fool proof to be true but it was vowed that we would be using it on Cape York during 1993.

In March 1993, I had the opportunity to meet Greg Spiers of the Australian National parks and Wildlife Service at Kakadu and he kindly provided the necessary information and aluminium pipe. For that I am forever indebted. It was then only a small step seeking permission from Top End Helicopters -Darwin NT. (who own the Approval for the design and had to obtain the Approval from DOT for a substantial fee) to use the device on Cape York Peninsula.

The device simply consists of an aluminium drop tube mounted to the helicopter into which the capsules are dropped after having been injected by a hand held injection gun. In terms of aerial ignition, it represents the essence of simplicity. For our particular purposes on Cape York Peninsula, and compared with other systems currently available, it is extremely cheap to operate.

The costs of manufacture of the device would not exceed $200. It can be used on Robinson Helicopters which are currently running at approximately $230 to $240 per hour on wet hire. Total running costs would not exceed $280 per hour in the Cape York situation.

Conclusion

To date, the 1993 fire program on Cape York has gone off without a hitch.

Staff comments indicate that they can put the capsules out at a rate that is almost comparable with the automatic incendiary machines. We now have all the versatility we require as light helicopters are readily available on short notice. We do not have troubles with malfunctioning incendiary machines that can only be repaired by a qualified electrician up to 800km back in Cairns. We do not need ground crews. Each park can afford to have an incendiary device.

The next major step required for remote aerial incendiary operational costs to be reduced would be for some innovative thinking and acceptance, by the powers that be, for the use of light aircraft that are available on the market.

The quality and designer skills that go into the manufacture of some of these fully certified aircraft is comparable to that which goes into the design of a Jumbo 747.

In conclusion, I would like to say - "Sure, lets use technology but for our own sake let us not overlook the obvious and simple techniques". They do have itheir place. Too often are we convinced that bigger and more complex is best when the reverse is often true.

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Assistance and advice from W.K. Goodwin, Senior Fire Control Officer, Bush Fires Council of the Northern Territory; G.Spiers, Fire Management Officer, Kakadu National Park, Australian National Parks and Wildlife Service ; and S.Taylor, Director/Chief Pilot, Top End Helicopters is greatly appreciated.

Forum : Technological issues of fire on the conservation reserves of northern Australia

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Speakers from Queensland, Northern Territory and Western Australia took us through the evolution of ideas and techniques used in prescribed burning across the region. It was apparent that there had been parallel evolution and good cross fertilisation of ideas in some respects and the workshop allowed for an increase in the latter to happen more easily.

Dave Grosse from the Kimberley told us that his department (CALM) had not yet been able to try out helicopter ignition techniques in the tropics but that there was still a reliance on the Britten Norman Islander and incendiary machine to create strategic burnt buffers. He was very keen to try some helicopter ignition using the much cheater to run R22 system as developed by the Kakadu managers.

Tim McGuffog of the Bush Fires Council of the NT took us through the history of prescribed burning in the "Top End" and described the mix of fixed wing and rotary wing techniques used as well as some of the ground methods. He acknowledged the contribution made from the early forest protection and management work (ie incendiary machine and staff input) in the south of WA and that this liaison was still active with a new incendiary machine under development.

Tim also pointed out some of the problems facing his organisation which I believe are faced by all of us. Some of these included the smoke problem, the difficulty of convincing some people and groups that fire is and should be an accepted part of the equation in the region, the reduced use of burning early in the season compared to a few years ago and this he attributed this to the application of a user pays system which many pastoralists are currently finding beyond their means.

Greg Speirs from Kakadu National Park (ANCA) described development of the simple incendiary tube and system for use on the R22 chopper and outlined his vision to use ultra light aircraft in the future. Kakadu has been at the forefront of innovation in fire management.

Ron Teece's paper on the development of Lakefield from a pastoral property to a national park compared and contrasted the burn regimes and management aims under the two different land uses. This paper was presented by Mick Delaney who then took a deep breath and described the evolution of aerial ignition techniques on Cape York.

Mick's message was that the high technology methods may be all very well but the cost may be prohibitive. Keep it simple!!

The forum on technological issues gave participants the opportunity to discuss such issues as the use of satellite information in planning and monitoring burns, the use of GPS, Helitorches for smaller choppers , Ramset LP gas propelled incendiary launcher and video monitoring of plots.

A means of keeping up with new technology is required and it was suggested that information be distributed via the '***FIRE***' newsletter. Any delegate who has information on new technology in this area is asked to prepare it for inclusion.

Plenary Session

Dave Batt
Training Manager : Conservation
QDEH
Brisbane

The Malanda Workshop provided an opportunity for fire management and research staff from the Western Australian Department of Conservation and Land Management, the Conservation Commission of the Northern Territory, the Australian Nature Conservation Agency, the Queensland Fire Service : Rural Fire Division, the Queensland Department of Environment and Heritage (incorporating the Queensland National Parks and Wildlife Service) and the CSIRO Division of Forestry and representatives from several Aboriginal Communities in tropical Queensland to meet and discuss fire management issues.

The major issued identified at this Workshop can be summarised as follows :

> The precision of, and political and community support for, fire management on the conservation reserves in tropical Australia are presently constrained by (among other factors) imprecise, or in some cases, non-existent data bases.
>
> However, the pressures for wildfire hazard minimisation, conservation of biological diversity and for maintenance of cultural fire management practices by Aboriginal communities demand that decisions must be made and that fire management actions must be taken now on the basis of the information which is currently available.

A future situation in which there is greater precision in the control and predictability of fire behaviour - and consequently, the ability to minimise wildfire and to use fire for the conservation of biological diversity will be based on the research and monitoring programs instigated in the present.

The major outcomes of this workshop are :

- a proposal for the development of a common fire monitoring system/procedure to be used by all agencies responsible for managing fires on conservation reserves in tropical Australia and for the routine sharing of the information derived from fire monitoring;
- a proposal for the development of a range of interpretive/educational materials to improve community understanding of the role of fire in the tropical landscape;
- increased capacity for cooperative prescribed burning and general fire management between fire management agencies in tropical Australia; and
- an exchange of information about the technology which is available, or being developed, for lighting and fighting fires and for researching and monitoring the effects of fires.

A vote of thanks to Australian Nature Conservation Agency, for the grant which provided the bulk of the money for us to run the Workshop, was made by all participants.

The next *Fire management on conservation reserves in tropical Australia* Workshop will be held in the Northern Territory in 1994 and will be organised by the good folks from the Conservation Commission of the Northern Territory.

The recommended topics for the 1994 workshop in the Northern Territory are :

1 Training:

- Competency based training;
- National accreditation system;
- **Maintaining control of standards and content**

2 Aboriginal traditional burning/fire regimes:

- ecological and cultural objectives of burning - conflicting or compatible?
- consultation processes;
- incorporating traditional/cultural burning into fire management plans and current conservation reserve management practice;

3 Comparison of statutory bases for fire management.

4 Smoke management.

5 Legal/litigation issues.

6 Fire ecology:

- identifying/defining precise fire regimes for particular species and communities;
- identification of current gaps in our knowledge base (eg. fire requirements of Mitchell Grass communities);
- establishment of common research priorities.

7 Education and public participation:

- message consistency;
- target groups x objectives x media x message content;
- funding sources for the proposed book on tropical savanna fire management.

8 Cooperative prescribed burning and wildfire suppression.

9 Report on monitoring program development.