CYPLUS

CAPE YORK PENINSULA
LAND USE STRATEGY

LAND USE PROGRAM

FIRE ON CAPE YORK PENINSULA

G.M. Crowley

1995

AUDAX AT FIDELIS

CYPLUS is a joint initiative of the Queensland and Commonwealth Governments

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Due to the timing of publication, reports on other CYPLUS projects may not be fully cited in the BIBLIOGRAPHY section. However, they should be able to be located by author, agency or subject.

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CAPE YORK PENINSULA LAND USE STRATEGY
STAGE I

PREFACE TO PROJECT REPORTS

Cape York Peninsula Land Use Strategy (CYPLUS) is an initiative to provide a basis for public participation in planning for the ecologically sustainable development of Cape York Peninsula. It is jointly funded by the Queensland and Commonwealth Governments and is being carried out in three stages:

Stage I - information gathering;
Stage II - development of principles, policies and processes; and
Stage III - implementation and review.

The project dealt with in this report is a part of Stage I of CYPLUS. The main components of Stage I of CYPLUS consist of two data collection programs, the development of a Geographic Information System (GIS) and the establishment of processes for public participation.

The data collection and collation work was conducted within two broad programs, the Natural Resources Analysis Program (NRAP) and the Land Use Program (LUP). The project reported on here forms part of one of these programs.

The objectives of NRAP were to collect and interpret base data on the natural resources of Cape York Peninsula to provide input to:

evaluation of the potential of those resources for a range of activities related to the use and management of land in line with economic, environmental and social values; and
formulation of the land use policies, principles and processes of CYPLUS.

Projects examining both physical and biological resources were included in NRAP together with Geographic Information System (GIS) projects. NRAP projects are listed in the following Table.

Physical Resource/GIS Projects	Biological Resource Projects
Bedrock geological data - digitising and integration (NR05)	Vegetation mapping (NR01)
Airborne geophysical survey (NR15)	Marine plant (seagrass/mangrove) distribution (NR06)
Coastal environment geoscience survey (NR14)	Insect fauna survey (NR17)
Mineral resource inventory (NR04)	Fish fauna survey (NR10)
Water resource investigation (groundwater) (NR16)	Terrestrial vertebrate fauna survey (NR03)
Regolith terrain mapping (NR12)	Wetland fauna survey (NR09)

Physical Resource/GIS Projects	Biological Resource Projects
Land resource inventory (NR02)	Flora data and modelling (NR18)
Environmental region analysis (NR11)	Fauna distribution modelling (NR19)
CYPLUS data into NRIC database FINDAR (NR20)	Golden-shouldered parrot conservation management (NR21)
Queensland GIS development and maintenance (NR08)*	
GIS creation/maintenance (NR07)*	

* These projects are accumulating and storing all Stage I data that is submitted in GIS compatible formats.

Research priorities for the LUP were set through the public participation process with the objectives of:

collecting information on a wide range of social, cultural, economic and environmental issues relevant to Cape York Peninsula; and

highlighting interactions between people, land (resource use) and nature sectors.

Projects were undertaken within these sector areas and are listed in the following Table.

People Projects	Land Projects	Nature Projects
Population	Current land use	Surface water resources
Transport services and infrastructure	Land tenure	Fire
Values, needs and aspirations	Indigenous management of land and sea	Feral and pest animals
Services and infrastructure	Pastoral industry	Weeds
Economic assessment	Primary industries (non-pastoral, non-forestry)	Land degradation and soil erosion
Secondary and tertiary industries	Forest resources	Conservation and natural heritage assessment
Traditional activities	Commercial and non commercial fisheries	Conservation and National Park management
Current administrative structures	Mineral resource potential and mining industry	
	Tourism industry	

As part of the public participation process, community and other groups associated with CYPLUS were invited to review all draft reports. These reviews were designed to correct any errors of fact (which were then modified in the final report) and to provide an opportunity for people to express their views of the information presented. The comments submitted to the CYPLUS process by various community groups and other interested persons in regards to the Fire project have been incorporated or discussed in the final report. Comments will therefore not be published, however a compendium of referees reports and commentary is available from CYPLUS.

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SUMMARY

This report, commissioned by the Cape York Peninsula Land Use Strategy (CYPLUS), brings together published material on fire that is of relevance to Cape York Peninsula. It includes information on characteristics of fire, sources of fire, the environmental effects of fire, attitudes to fire, how fire is used in the major land-use systems and regulations and responsibilities. It is mostly based on information from the Top End of the Northern Territory, as information from the Peninsula itself is generally lacking.

Fires may be started by lightning or people. Aboriginal people have been lighting fires as part of their management of the land for thousands of years, and fire has been adopted as a land management tool by both pastoralists and National Park managers. Changes in the technology of lighting fires have included the change from flints and fire sticks to matches, drip torches and aerial incendiaries. People lighting fires while traversing the country on foot have been replaced, over the last hundred or so years, by people initially on horseback and then using motor-bikes and cars. Even so some areas may be less frequently visited and thus less frequently burnt. Aerial ignition has been used in recent years, but is presently restricted to the management of National Parks. Unwanted fires may escape across property boundaries or be lit by "vandals". Lightning may start fires in the storm season towards the end of the year.

Most fires on Cape York Peninsula are grass fires. They are first lit as the dry season sets in and the grasses dry out, with the fire season being earlier in the south, centre and west, and later in the north and east where the soils remain moist longer. The first fires are cool and patchy, going out in a few hours. As the dry season progresses fires burn hotter and longer, with late dry season fires sometimes covering thousands of square kilometres. The intensity and extent of these fires depends on the occurrence of follow up rains. Fires on Cape York Peninsula are likely to differ in frequency and intensity from those in the drier Northern Territory.

Fire both removes and releases nutrients for plant growth, with some nutrients being lost to the atmosphere and water-courses. Nutrients released from fires may be important for many tropical ecosystems. There is little evidence that present fire regimes are causing long term soil degradation, and carbon dioxide, the main atmospheric emission, is rapidly resorbed by regrowth after fire. The significance of other emissions is less than clear.

The plants of the region occur in either fire-sensitive habitats, which rarely burn, or in fire-tolerant habitats, which may burn as often as annually. Fire-tolerant woody plants can resprout after being damaged after fire. Herbaceous plants may either die-off over the fire season and remain in the environment only as seed, or become dormant as the soil moisture declines, resprouting, either after fire or when the next substantial rains fall.

Fire regimes have the potential to alter the boundaries between rainforests and eucalypt-dominated communities where these have similar soil moisture requirements. Severe fires open up the rainforests and allow the invasion of grasses and other non-rainforest species. Mild fire regimes permit rainforest species to extend their ranges. The extent of grasslands

is also determined by fire intensity, and the low incidence of hot fires appear to have had a role in their invasion by woody plants. Changes in fire regime over the last century may have caused a thickening-up of the understorey through the woodlands of the Peninsula.

Animals are also affected by fire. Some will be killed and others disadvantaged by a fire-altered habitat, but many species require fires of various periodicities to provide their habitats. The responses of individual species are related to their requirement for food, shelter and breeding habitat, and their ability to disperse and establish territories after the disturbance of fire. A diversity of burning histories appears to be the most effective way to conserve the diversity of animal species found on the Peninsula.

The community views fire in many different ways. How a particular fire or fire regime is viewed depends on an individual's experiences of fire, philosophical position, and land management objectives. Aboriginal people may see fires as a means of cleaning the country, while many non-Aboriginal people see burnt landscapes as unattractive. Fires may be seen as either destructive, killing animals and damaging plants, or rejuvenating, providing stable vegetation communities and animal habitats. Fires may be seen as destroying vegetation or maintaining biodiversity. Fires are seen as an appropriate land management tool by many of the people directly involved in land management, whether as part of indigenous land management, pastoralism or nature conservation, but inappropriate by some members of the public with a concern for conservation and animal welfare, including some land owners on the Peninsula.

There is a dearth of information regarding Aboriginal burning practices on Cape York Peninsula. However information derived from elsewhere in northern Australia suggests that, before being dispossessed of their land, Aboriginal people on Cape York Peninsula would have used fire knowingly for a range of land use purposes. These uses included modifying their living environments to make them more comfortable, hygienic and aesthetic; promoting, attracting or locating foods; recreation; aggression; communication and other social functions. Details of Aboriginal burning regimes may have been lost with isolation from the land, and some uses of fire may no longer be needed. However, there are still important roles for fire in indigenous land management, whether these be for modern or more traditional purposes.

The role of fire in nature conservation is hotly debated because of the potential for fires to kill animals and plants, and the ability of fire regimes to discriminate between different suites of species. On National Parks, fires are mainly used for preservation of biodiversity, protection of fire sensitive environments and prevention of extensive wildfires, as well as for other non-conservation concerns such as protection of visitors and infrastructure. The use of fire has been attacked by some members of the public who would prefer to see an emphasis on fire suppression.

Fire is used by pastoralists to maximize cattle production, and as an aid in controlling and locating stock. Protection and promotion of grass growth is important for ensuring cattle survival through the long dry season, but with developing intensification of the cattle industry, the use of supplementary feeding may replace burning in some instances.

Each land manager uses fire in a slightly way. Indigenous land managers have been recorded using fire through most of the year, with variation between habitats. Managers of cattle stations and National Parks tend to restrict their burning to the period when the grasses first dry off and around storm-time, with a smaller area burnt on cattle station than on National Parks.

Of major concern to most people with an interest in Cape York is the prevalence of widespread late dry season fires. Inter-connected networks of natural and artificial barriers and large areas of fuel reduction burns appear to be the most effective way to restrict the movement of such fires.

Regulations regarding fire are covered by the "Fire Services Act, 1990" and administered by the Queensland Fire Service's Rural Fire Division. The responsibilities of this Division are to issue Permits, which must be obtained for all land management fires, and to provide information, training and support to a network of voluntary Fire Wardens and Rural Fire Brigades on the Peninsula.

ACKNOWLEDGMENTS

This report was commissioned by the Cape York Peninsula Land Use Strategy (CYPLUS). The CYPLUS team (John Lane, Bob Reid, Mark Horstman and Kath Shurcliff) were variously supportive, flexible and tolerant. The CYPLUS working groups have been both challenging and sobering, with their high standards and commitment to obtaining the best future possible for the residents of Cape York Peninsula.

The report would not have been possible without the assistance of the many people who contributed to it in different ways. The dearth of published information concerning Cape York Peninsula was largely offset by the generosity of local residents, managers and researchers. Sue and Tom Shephard introduced me to the complexities of the Cape York Peninsula environment and they, along with many of its other residents, continue to provide perspectives that are in many ways more valuable than a whole swag of erudite publications. John Neldner and John Clarkson (Queensland Department of Environment and Heritage (QDEH)) provided unlimited access to their vegetation information and mapping that forms the basis of the botanical information found in this report. They, along with Garry Cotter (Queensland Department of Lands), provided useful comments on the classification and description of vegetation communities produced in this report. Peter Stanton (QDEH) provided information and perspective arising from three decades of personal and professional involvement with fire management on the Peninsula. Other people who provided primary information, unpublished manuscripts and encouragement included Graham Harrington (CSIRO), Brian Cifuentes and Dave Luxton (Queensland Fire Service), Mike Delaney (QDEH), Michael Douglas (Monash University), Jeremy Russell-Smith (Australian Nature Conservation Agency), Maureen Fuary (James Cook University of North Queensland), Mike Hopkins (CSIRO), David Hurse (Cape York Peninsula Development Association) and Nancy Williams (University of Queensland). A major source of material for this report has been the "Bibliography of Fire Ecology in Australia" (Gill et al. 1991). All publications were provided to me through the sterling efforts of the librarians at QDEH, Joanne Hunt and Maryanne Irvin.

The wide range of specialist areas covered in this report means that critical review by experts in each field was essential. The report was greatly enhanced by vigorous reviewing by Peter Stanton (QDEH), Dick Braithwaite (CSIRO), Lesley Head (University of Wollongong), Graham Harrington (CSIRO), John Woinarski, (Conservation Commission of the Northern Territory), Brian Roberts (University of Southern Queensland), Nicky Horsfall (QDEH), Brian Cifuentes (Queensland Fire Service, Rural Fires Division), Gary Cotter (Queensland Department of Lands), Viv Sinnamon (Kowanyama Land and Natural Resources Management Office), Chris Roberts and John Winter.

My initial involvement with fire on Cape York Peninsula was brought about by working with Stephen Garnett on the ecology of the Golden-shouldered Parrot. In our pursuit of this endangered species and the reasons for its decline, we have been jointly researching the role of fire in the ecology of the Peninsula. Several of the unpublished findings from this work are referred to in this report. Stephen also put in hours of discussion that led to the development of many of the ideas expressed in this report, as well as editing and proofing the drafts and holding the fort during the long hours of typing. This project would never have been completed without his support or the patience of our children, Jeremy and Leah.

1 INTRODUCTION

Lightning has lit fires across Northern Australia for several million years and Aboriginal people have probably used fire as long as they have occupied the continent. So the plants and animals of the Cape York Peninsula have persisted and possibly evolved under a long history of fire. It has been argued that fire has largely shaped some of the Peninsula's vegetation communities and recent vegetation changes have been attributed to changes in patterns of fire over the past century. If this is the case, decisions about burning have the potential to determine the future direction of vegetation change on the Peninsula.

There has been much discussion and debate about how fire should be used in management on Cape York Peninsula, and about whether it should be used at all. Calls have been made for more information and monitoring, and for an integrated fire strategy. As the majority of land managers on the Peninsula - Aboriginal people, pastoralists and the National Parks and Wildlife Service - depend on the natural vegetation communities to meet their management objectives, an understanding of the effects of fires on these systems is essential. Thus fire has been identified as an important land use issue by the Cape York Peninsula Land Use Strategy (CYPLUS).

Any development of a fire strategy on Cape York Peninsula will benefit from the collation and analysis of available information and identification of areas where information is lacking. This report, commissioned by CYPLUS, attempts to provide such an information base. It examines the types of fires which occur on Cape York Peninsula, the environmental effects of fire, attitudes to fire, and how fire is used in the major land uses systems of indigenous land management, cattle grazing and nature conservation.

The knowledge base about fire on Cape York Peninsula comes from three main sources. The first is experience of the residents and managers of the region. Their knowledge is immense but largely undocumented. It ranges from the minutiae of the behaviour of individual plants and animals, usually those of significance to them, to the broader picture of vegetation changes over the course of lifetimes. There is a need for such information to be collected and documented and it is unfortunate that such a task could not be undertaken for this account. Though the anecdotal nature of the material may weaken its value in some peoples' eyes, reference has been made to this source wherever possible. Some of it may be discredited in the long run, but this seems unlikely, as separate sources most often corroborate each other, or are consistent with other materials. Where they are not consistent, it is important to entertain the possibility that the Cape York Peninsula environment is unique, as is detailed further in the following accounts. Analysis of anecdotal knowledge should also provide the necessary focus to ensure future research and management programs are applicable to the Peninsula and its land use requirements.

The second, and most rigorous, source of information comes from research undertaken in the Top End of the Northern Territory over the last 40 years. The earliest work concerned the effects of fire on pasture productivity and cattle liveweight gain, the emphasis having changed over the last decade or so to natural biological systems. In recent years increasing attention has been given to effects of fire on the physical environment. This work has by far the most relevance to Cape York Peninsula. It shows how important it is to distinguish between the tropical systems of mild, repeated burning and those of the mesic southern corners of the continent where the effects of fire are more dramatic and potentially destructive. But these cautions must also be applied to Cape York Peninsula, which although it shares much with the Top End, contains significant areas of habitat not found there. If research is to be undertaken on Cape York Peninsula, priority should be given to areas which match uneasily, if at all, with Top End study sites.

All remaining information on fire has been relegated to the last category, for we have less chance of assessing how relevant it is to Cape York Peninsula. This group includes research from temperate Australia as well as that from other continents with tropical savannas. Undoubtedly, some materials will prove to be applicable, others not. Temperate Australian research has been cited where it provides details that are not documented for tropical systems, or where it corroborates tropical research. Though such findings may, on later examination, prove to be false in the tropics, they provide a different framework in which to assess fire in the environment. Top End research is mostly concerned with patterns that result after fires of set intervals and seasons. These patterns may not be duplicated in the field once experimental controls are removed. There is at present a dearth of process-oriented research which shows how individuals, species and systems respond to fire that may give us more clues as to how species might behave in the absence of scientific rigour. For example, though we know from Top End research how a species' abundance changes given a set fire regime, we rarely know where the animals have gone to, or come from, and why. Some aspects of temperate research can give us clues for what to look for, even if the processes in tropical systems turn out to be entirely different. Temperate research is also of relevance because the longer intervals between fires in those systems are also shared with at least some of the communities on Cape York Peninsula. International references have not been made full use of, as without primary material collected from the Peninsula, it seems too early to provide an international perspective.

Finally, before going on to discuss aspects of fire in detail, it should be stressed how important it is to have primary information and research from Cape York Peninsula itself before properly informed management or policy decisions can be made. There is no aspect of fire that is adequately documented for the area. Bearing this in mind the following accounts must be read only as best bets for the Peninsula.

Table 1.1 Introduction - Key points

- Fire is recognized as a potent force in the environment and as an important management tool, but its use is controversial.
- Policies and land management decisions concerning fire need to be based on appropriate information.
- Research from the Northern Territory provides the most relevant information base for Cape York Peninsula, but caution must be used in applying findings from this research. Research from elsewhere in Australia may be of less relevance, but may need to be used when alternatives sources are lacking.
- There is a need for primary information to be collected and research undertaken on all aspects of fire on Cape York Peninsula itself. Priority should be given to environmental systems not covered by research in the Northern Territory.

2 SOURCES OF FIRE

Northern Australia has experienced natural fire for at least 15 million years (Kemp 1981) and it is likely that savannas carried extensive fires well before the arrival of Aboriginal people (Dunlop and Webb 1991), although it has also been proposed that fires were relatively infrequent and that the region supported greater areas of fire-retarding vegetation (Stocker and Mott 1981). Most fires would have been started by lightning, and although lightning-ignitions still occur in northern Australia, in Kakadu National Park, at least, these are much less significant than human ignitions (Braithwaite and Estbergs 1985).

Most areas on Cape York Peninsula experience around 30 thunder-days per year (Prentice 1978), concentrated between October and March. These storms will have the potential to start fires only in the earlier half of this period when fuel is dry enough to carry a fire (Braithwaite and Estbergs 1985). Because of the high probability of follow-up rains, many lightning-ignited fires burn only small areas, but, when not extinguished by heavy rains, fires at this time of the year can burn very large areas. It may be a regular event for lightning to ignite grass fuel in the lower rainfall areas in the centre of the Peninsula, but unusual in the more mesic environments in the north and east of the Peninsula (Stanton 1992; M. Delaney pers. comm.; S.T. Garnett pers. comm.).

Historically, Aboriginal people through much of Australia started fires by using either sticks or stones as flints to produce sparks that then ignited a dry tinder (Mountford and Berndt 1941; Calley 1957). A slow burning piece of wood could then be used to convey fire across the country (Nicholson 1981). Fires would be lit as people travelled on foot across the country, traversing traditional footpaths in the seasonal search for food (Haynes 1985; Lewis 1985). Early pastoralists lit fires from horses using matches as they mustered. Both Aboriginal people and pastoralists also visited areas specifically for the purpose of lighting fires (Rigsby 1980). Burning nowadays is carried out more often from cars and motor bikes with matches and drip-torches being the principal means of ignition. Methods of burning used in indigenous land management and cattle management are discussed more fully in Chapter 7.

In the early 1980s a program was established by the Queensland Fire Service to use aerial ignition for fuel reduction burning and involving about a dozen private properties and National Parks (Luxton 1990). The aims of this program were to establish a network of strategic breaks in consultation with land-holders and reduce fire hazards in inaccessible areas and other areas as appropriate (Luxton 1990). The program was financed on a subsidy basis, with the Rural Fires Board paying half the cost of the aircraft hire and fuel, although the board covered all the costs in the first year of implementation (Luxton 1990). In 1986, the program covered over 600,000 ha of pastoral land and 400,000 ha of National Park on Cape York Peninsula at a cost of about 33 cents per 100 ha (including unburnt areas; Luxton 1990).

Although judged to be successful at reducing wildfire hazards on the properties concerned, economic stringencies meant the program soon foundered, and aerial ignitions are now limited to National Park areas only (Luxton 1990; D. Luxton pers. comm.). A return to better economic conditions, or an increased interest in fuel reduction burning may see such an approach reinstated on private properties in the future (Luxton 1990). After many modifications to the program, National Parks have combined on-ground ignition with follow-up burns using incendiary devices, initially from fixed-winged aircraft, and more recently from helicopters (Delaney 1993).

There is some concern, as well as empirical evidence, that fires burnt by aerial ignition tend to be of greater intensity, and the vegetation slower to recover (O'Neill et al. 1993). This may simply reflect that aerial ignition tends to be used in more isolated areas, which, either having escaped fires or heavy grazing, may have heavier fuel loads. Alternatively, it may be a product of the imperative to do all burning over the short period for which the aircraft booking has been made, rather than being able to respond to environmental cues as people on the ground may do (Lewis 1985). Satellite imagery indicates aerial burns on National Parks on Cape York Peninsula are generally cooler and individual fires are smaller in area than on neighbouring grazing properties (J.P. Stanton pers. comm.).

Unwanted fires are sometimes reported as being lit by "vandals", escaping from campfires or from the burning of neighbouring properties. Again there is no information on the frequency of such events. When they occur outside the fire plan of the land-holder, their effects can be particularly devastating, especially in the late dry season when such fires can burn large areas. However, there are large areas of Cape York Peninsula, particularly in the northeast, where both lightning- and human-ignited fires are unlikely because of lack of access, and high rainfall and humidities. These areas may now be burnt less frequently than in the past when more densely occupied by Aboriginal people.

Table 2.1 Sources of fire - Key points

- Lightning lit the first fires on Cape York Peninsula and continues to light fires in drier areas during early storms.
- In the past, Aboriginal people with firesticks lit fires while walking across the country.
- People now access areas to be burnt on horseback, in off- or on-road vehicles or in aircraft.
- Ignition techniques include use of matches, drip torches and aerial incendiaries.
- Human-ignited fires include both intentional fires that are part of land management and unwanted wildfires.

3 CHARACTERISTICS OF FIRE

Studies of fire undertaken in the Top End of the Northern Territory (Katherine, e.g. Norman and Wetselaar 1960; Norman 1963a; 1969; and Kakadu National Park; e.g. Hoare et al. 1985; Andersen and Braithwaite 1992) provide useful analogues for fires in the drier areas of Cape York Peninsula where rainfall is mainly driven by monsoonal influences leading to a distinct wet-dry season cycle. However the results of these studies may be less applicable in the east and north of the Peninsula, where average annual rainfall exceeds 1600 mm (Bureau of Meteorology 1981), and in some other areas which, though receiving less rainfall, can have drizzling rain through the dry season (J.P. Stanton pers. comm.). These wetter conditions undoubtedly affect fire behaviour, particularly fire frequency, as well as the vegetation that may be supported in fire's absence (Braithwaite in press a; J.P. Stanton pers. comm.). Though forests of the Wet Tropical World Heritage Area are more suitable analogues for the wetter environments of Cape York Peninsula, these areas have not been the focus of detailed studies of fire behaviour. The following discussion, based largely on the Northern Territory work, is therefore most applicable to the drier habitats of the Peninsula. Even there some differences are likely to occur because of features of the Top End which are not replicated on the Peninsula i.e. the high incidence of lightning (Prentice 1978), the predominance of open forests and of the tall annual grass Sorghum intrans (Andersen and Braithwaite 1992) and the low humidities through much of the region (Bureau of Meteorology 1978). Furthermore, the Peninsula generally has lower evaporation throughout the year and fewer hours of bright sunshine in the dry season than does the Top End (Bureau of Meteorology undated a,b). These features probably combine to dampen fire activity.

Grasses are the main understorey plants in most of the fire-prone habitats in northern Australia, and most fires in the north are grass fires (Gill et al. 1990; Dunlop and Webb 1991; Haynes 1991). Grasses burn readily once they begin to brown off at the start of the dry season, and, because there is some summer rain each year, new fuel is produced annually (Hoare 1985). Because of efficient recycling of biomass by micro-organisms and termites, fuel accumulation reaches a peak after 2-3 years (Walker 1981; Mott and Andrew 1985; Cook et al. unpubl. manuscript). Grass fuels become more flammable as the dry season progresses and moisture levels decline (Hoare 1985; Bowman and Wilson 1988). Fuel loads of woodland and forest areas also increase towards the end of the dry season with leaf-shedding by water-stressed plants (Bowman and Wilson 1988). The only fuel load data for Cape York Peninsula come from grazed grasslands in the Musgrave area, from slopes and drainage depressions bordered by broad leaved ti-tree Melaleuca viridiflora (Crowley and Garnett unpubl. data). These ranged from about 1 t/ha of grass fuels approximately 12 months after a late dry season fire to about 3 t/ha in country that had been unburnt for at least two years. These figures are within the lower range of fuel loads measured at Katherine in Kangaroo grass Themeda triandra grassland (1-1.8 t/ha; Norman 1969; c. 2.5-6 t/ha Mott and Andrew 1985), but lower than for fuel loads recorded at Kapalga in Kakadu National Park (5-11 t/ha Cook et al. unpubl. manuscript).

Fire frequency of the northern tropics has been cited as being between 1 and 2 years (Walker 1981). However, fires appear to be less frequent over much of the Peninsula. Ground based mapping in the Musgrave area showed that, while most of the area was burnt once in a three year period, little country was burnt more than once (S.T. Garnett pers. comm.). Large areas of relatively inaccessible country in the north and east of the Peninsula are apparently burnt only rarely (J.P. Stanton pers. comm.).

Fires in tropical Australia are generally classified according to the time of year in which they are burnt, as season of burn is a good predictor of most aspects of fire characteristics (Hoare 1985). However, deviations frequently occur, so season of burn cannot be used alone to characterize a fire (Andersen and Braithwaite 1992; O'Neill et al. 1993). At all times of the year fire effects are patchily spread through the landscape, as fires respond to changes in wind or fuel conditions (Lonsdale and Braithwaite 1991). Diurnal cycles are also important, especially where these influence wind conditions and humidities. A drop in the wind combined with cool temperatures and dew-fall at night is frequently sufficient to extinguish fires early in the dry season.

Flammability and resultant fire intensity are dependent on climatic conditions but also on moisture content and flammability of the vegetation. The mesic vegetation types of the highest rainfall zones of Cape York Peninsula are unlikely to be burnt at all (J.P. Stanton pers. comm.). Savannas north and east of Coen rarely carry fire before August (J.P. Stanton pers. comm.) and in more southerly tropical forests, over half the fires occur in October and November with severe fires being restricted to unusually dry seasons (Just 1978). In areas of Cape York Peninsula which receive little winter rainfall the abundance of grass fuels mean fires may occur for many months of every dry season. South of Musgrave, fires are regularly recorded from the end of May and a late start to the dry season may allow burning as late as early January (Garnett and Crowley unpubl. data). The first significant storms may not end the fire season, but limit each fire's spread. It is not until the wet season proper that fires become an unlikely event (Hoare 1985).

In general, severity of fires increases from the start of the dry season, with hottest fires occurring from the middle of the year as the air temperature rises, humidity declines and moisture content of grasses is lowest (Hoare 1985; Press 1987; Bowman and Wilson 1988). The persistence of relative humidities in excess of 40% through the year on Cape York Peninsula (Bureau of Meteorology 1978), probably has the effect of restricting both fire intensities and flame heights when compared to other parts of the monsoon tropics (Gill et al. 1990; J.P. Stanton pers. comm.). There are no measures of fire intensity for Cape York Peninsula, but most fires in Kakadu National Park range from 2,000 to 5,000 kW/m, with hottest intensities reaching 18,000 kW/m (R.J. Williams in Braithwaite in press a).

The size of the area burnt by a fire also generally increases as the dry season progresses. Early dry season burns are usually small, sometimes only burning a few hundred square metres. Small creeks, damp drainage depressions and tracks form effective barriers to their spread. Late dry season fires often cross roads and the now-dry creeks, only stopping when they reach major rivers, previously burnt areas or the coast, or when the rains begin to fall. Such fires may burn several hundred thousand hectares (Scattini et al. 1988). Early dry season fires frequently leave unburnt patches because of variation in fuel curing (Lonsdale and Braithwaite 1991). Early wet season fires vary enormously in their impact as the moisture and temperature conditions fluctuate widely (Hoare 1985). Late dry season fires may leave almost no ground-layer vegetation unburnt in their wake.

Differences in fire extent and patchiness mean that fires of different seasons have different potentials to act as fire breaks. Very early dry season fires generally leave much unburnt material which then provides fuel for later fires, and form small isolated burns that may not link up. Combined with leaf-fall from the scorching of the canopy, this means that fires burnt early in the dry season may be inadequate to form fire breaks and hot fires in the late dry season have been seen to burn through such patches (M. Delaney pers. comm.). However, they may form barriers to low intensity mid-dry season burns. These in turn link up with natural barriers forming more effective barriers to late dry season fire (Haynes 1985). Fire patterns which inhibit late dry season fires have been reported where traditional Aboriginal burning patterns are still practiced (Haynes 1985), where aerial ignition programs have been instituted early in the year (Press 1988; D. Luxton pers. comm.) or where a combination of fire sources are present (O'Neill et al. 1993).

Early fires tend to self-extinguish, but late fires are difficult to contain, and there is general concern that increasing areas of northern Australia are being subjected to annual extensive late dry season fires (Day 1985; Braithwaite and Estbergs 1985; Press 1988). Though extensive late dry season fires do occur from time to time on Cape York Peninsula, in few places is this an annual event (J.P. Stanton pers. comm.; S.T. Garnett pers. comm.).

Table 3.1 Characteristics of fire - Key points

- There is a need for information on fire characteristics to be collected from Cape York Peninsula. Adequate information is lacking on fuel loads, fire frequency, intensity and coverage. In the meantime, Northern Territory studies provide the closest analogue.
- High humidities and low fuel loads probably result in most fires being of low intensity.
- Grasses are the principal fuel and grass conditions influence the extent of the fire season and the severity of fires.
- Fire patterns vary along climatic gradients, the fire season being longer and fires more frequent in the south, centre and west than in the north and east.
- Fires generally increase in intensity and extent as the dry season progresses though later fires may be contained by networks of earlier burns.

4 IMPACTS OF FIRE

4.1 Impacts on soils and the atmosphere

The impacts of fire on the physical environments of soil and atmosphere are a matter of shifting balances. Nutrients are converted, released and recycled or lost to the system. These changes affect the ability of the soil to support vegetation, and affect air quality. But the pathways of nutrient flow in Northern Australia, and whether their impacts are detrimental or beneficial, is only just gaining researchers' attention. Again the main studies are from the Northern Territory, and again it can only be assumed that fires on Cape York Peninsula behave in similar ways. Nutrient flows in the more mesic environments of the Peninsula may have more in common with those in fires of southern Australian ecosystems which are also referred to in this report.

Fires in tropical Australia release nutrients only from the above-ground biomass, with more complete combustion of grasses, litter and shrubs than of trees. They are generally too cool to affect nutrients in the soil directly (Cook 1992). Nutrient loss is limited by plants storing nutrients underground as dry season dormancy sets in (Norman 1963b; McIvor 1981). It is equivocal whether regular fires will result in a long term decline in nutrient status of soils of tropical Australia (Holt and Coventry 1991). Losses occur in the form of smoke and subsequent erosion (Kellman et al. 1985, Douglas et al. 1994), but gains are made through release of nutrients to more assimilable forms by combustion of litter and vegetation (Walker et al. 1986; Holt and Coventry 1991) and stimulation of plants which have nitrogen-bearing symbionts (Attiwill 1985). Also many nutrients are returned through rainfall and ash fallout following fires, and increments occur through other sources including biological and non-biological fixation (Cook 1992). Some nutrients lost through fire may be entirely accounted for by such accessions in the course of a year; for others longer periods may be required (Cook 1992, 1994).

Phosphorus, sulphur and calcium appear to be returned to the soil in rainwater in equal amounts as are lost in fires (Cook 1994). Rainwater and other accessions return a smaller proportion of the nitrogen lost in fires (Cook 1994). Nitrogen losses of around 0.45 g/m^2 were estimated for fires in the Katherine district, an amount considered commensurate with annual replacement rates (Norman and Wetselaar 1960). This contrasts with net losses of 1.5 to 2 g/m^2 estimated for annual fires in Kakadu National Park (Cook 1994). Significant net losses have not been recorded in other Australian ecosystems where burning intervals are less frequent (Raison et al. 1985; Walker et al. 1986; Charley and Richards 1990; Lamb et al. 1990a,b).

The burning of vegetation and litter cover exposes the soil to erosion. Early dry season fires expose the soil for much longer than fires later in the year, but the patchy nature of early burns will moderate erosion and may assist in the local recycling of nutrients. Erosion from late dry season fires results in increased sediment flow in streams through the following rainy season (Douglas et al. 1994). The erosion of ash also results in a pulse of nutrient-enriched waters in the first stream flows of the wet (Douglas et al. 1994). As well as causing nutrient losses to the areas burnt, these processes may lead to nutrient enrichment along drainage-lines and depressions (Cook 1992). Communities downstream of fires or receiving ash fallout may be dependent on this source of nutrients (Cook 1994). A recent Northern Territory study found aquatic macrophytes to be prevalent only in catchments where burning had occurred, and diverse communities of aquatic macroinvertebrates that were restricted to streams draining burnt catchments (Douglas et al. 1994).

Fires affect water balance of the ecosystem by increasing the ratio between water run-off and infiltration, partly because of reduced evapotranspiration (Walker et al. 1986). Other changes that can influence plant growth are changes to soil acidity and destruction of plant toxins and micro-organisms, though the latter may be either beneficial or pathological (Walker et al. 1986).

Concerns about the contribution of fires to atmospheric pollution partly arise from the conspicuous effect on visibility (Vines 1977; Cook et al. unpubl. manuscript). The burning of well-cured, dry grasses typical of tropical Australian fires leads to a high proportion of flaming as opposed to smouldering combustion which results most carbon burnt being released as carbon dioxide, though differences in fuel characteristics may mean that carbon monoxide and methane form a greater proportion of emissions in the wetter forests of the Peninsula (Cook et al. unpubl. manuscript).

Carbon dioxide, a "greenhouse gas", is the major emission from tropical Australian fires (Robinson and Robbins 1968; Cheney et al. 1980; Hurst et al. 1994). Though the contribution of vegetation fires to carbon dioxide emissions in Australia is in the same order as that derived from the burning of fossil fuels (Hurst et al. 1994), the long history of vegetation burning pre-dates increases in atmospheric carbon dioxide that have occurred since the industrial revolution (Kemp 1981; Kershaw 1985; Stanton 1991). Also, as losses of carbon to the atmosphere are returned as the vegetation regrows, the net contribution of vegetation fires to the atmosphere is negligible (Cheney et al. 1980; Hurst et al. 1994), especially as transfer of carbon dry matter is greatest in the years directly following fire (Norman 1969). Another significant "greenhouse gas" emitted is methane, with about 10% of Australia's emissions coming from biomass fires (Hurst et al. 1994; Cook et al. unpubl. manuscript). Most nitrogen released to the atmosphere is probably no different to atmospheric nitrogen, a relatively inert gas that composes almost 80% of the atmosphere (Hurst et al. 1994). Other gases emitted, though apparently not in quantities that make a significant impact on air quality, include carbon monoxide, other hydrocarbons, nitrogen oxides, nitrous oxide and nitriles (Hurst et al. 1994; Cook et al. unpubl. manuscript). Some of these gases combine in the atmosphere to produce ozone (Hurst et al. 1994). Fine carbon particles emitted in smoke can help to remove other atmospheric pollutants (Komarek 1973; Komarek et al. 1973).

Loss of nutrients and emission of pollutants will be minimised by the use of patchy, low intensity fires, such as occur in the early dry season and early wet season, and long inter-fire intervals (Cook 1992; Cook et al. unpubl. manuscript). High intensity fires at the end of the dry season may produce greater emissions because of the combustion of trees (Lonsdale and Braithwaite 1991; Cook 1994). However, the burning of moist fuels in early wet season and early dry season fires may increase the amount of smouldering combustion with concomitant increases in carbon monoxide and methane production (Cook et al. unpubl. manuscript). These studies indicate that rather than being a major cause of soil degradation and air pollution, fires play an important role in redistributing nutrients, and imbalances may be offset by adjusting frequency and timing, rather than a complete cessation of deliberate burning (Cook 1994).

4.2 Effects on plants

Woody plants of the Australian tropics show few of the adaptations found in trees and shrubs of more southerly latitudes where intense fires are a feature of the landscape (Gill 1975, 1977, 1981; Dunlop and Webb 1991). Fires may be more frequent in the tropics (Walker 1981), but with a lower fuel load they are not as intense, and frequently do not damage the canopy (Hoare et al. 1980; Stocker and Mott 1981; Lonsdale and Braithwaite 1991; Dunlop and Webb 1991). The foliage of the dominant eucalypts is not highly flammable because of low volatility of their essential oils and they do not often carry fires (Webb 1968; Lacey et al. 1982). Though the dominant eucalypts and ti-trees may require areas of bare ground produced by fire for successful germination (J.P. Stanton pers. comm.), fire-swept surfaces exposed to desiccating summer sunlight provide harsh nurseries for young seedlings (Tothill 1969; Mott 1981; Bowman 1986b) and most fires are inadequate to clear away competition (Dunlop and Webb 1991). The trees and shrubs have not evolved to withhold their seeds in the canopy for extended periods (Dunlop and Webb 1991).

The difficulties faced by seedlings mean that most regeneration tends to be by suckering of old plants from a lignotuber (Lacey et al. 1982). This occurs when plants are damaged by termites, wind or fire, and some of the dominant species, including messmate Eucalyptus tetrodonta and ironwood Erythrophleum chlorostachys, simply shoot from nodes along their root systems (Lacey and Whelan 1976; Lacey et al. 1982; Gill 1981; Press 1987). The many suckering stems produced form a thick understorey within a few years of the last fire, and within four years they reach a size where they are unaffected by most fires and can reach the canopy and reproduce (Lacey and Whelan 1976). This ability to resprout after fire may be a response to poor soil moisture and nutrition (Beadle 1968; Lacey et al. 1982; Dunlop and Webb 1991), and is also possessed by many trees in the drier rainforest communities (Unwin et al. 1985; Bowman and Fensham 1991).

The dominant trees have thick, non-combustible bark, which protects perennating buds in the main stems and branches (Lacey et al. 1982). Thus fires generally kill few trees, although occasional hot spots in the Northern Territory have been recorded as claiming as many as 15% of the trees, including 10% of messmates and 26% of ironwoods (Lonsdale and Braithwaite 1991). Among susceptible species, trees with extensive termite damage appeared more likely to succumb (Langkamp et al. 1981; Lonsdale and Braithwaite 1991).

Fire sensitivity is most likely to be exhibited by plants of more mesic environments, such as core areas of rainforest. However, most plants are unable to tolerate fires at some point in their life-cycles. Chance of survival will depend on the age of the plant and the stage of development of adaptive traits, seedlings being particularly vulnerable (Stocker and Sturtz 1966; Braithwaite and Estbergs 1985), as well as older plants nearing senescence (Lonsdale and Braithwaite 1991). Plants which have just put on new leaf, flower or fruit growth or are still actively growing may also be more vulnerable (Norman 1963a; Lonsdale and Braithwaite 1991; P.A. Werner in Braithwaite 1994). Conversely the tendency towards deciduous habit means that late dry season fires may do less damage to the canopy (Lacey et al. 1982). Height of the foliage above the scorch height is also important, and many of the canopy species are well separated from the flames by high canopies (Lacey et al. 1982). Epiphytic plants are also affected by fires, with a higher number of the orchid Dendrobium affine being found in long unburnt plots than plots which had been subjected to annual or biennial fires (Cook 1991).

Fires may affect the amount of seed available for germination by influencing flowering and seed production, by destroying seeds or by releasing them from dormancy. Initiation of flowering and seed set has been recorded in grass trees Xanthorrhoea spp. (Gill 1981), and many wattles Acacia spp. require high temperatures for their seeds to germinate (Auld and O'Connell 1991).

Intense fires are more likely to favour those of the ground layer, and mild fires are more likely to favour canopy species (Braithwaite 1994). While even mild fires can be devastating for herbaceous plants, in monsoon-tropical environments their growth periods are usually outside the fire season. As fire, by and large, occurs within the period of seasonal drought, dormancy or decay through the dry season protects herbaceous plants from damage (Press 1987). There are many annual plants, including the annual grasses that dominate much of the northern landscape (Andrew and Mott 1983). These set seed and die as moisture disappears from the soil, and, though fires may deplete their seed stores, enough remains for the next year's crop (Watkinson et al. 1989). Annual grasses can be eliminated from an area if burnt before they have set seed (Stocker and Sturtz 1966). Perennial grasses have buried growth buds, though the depth of these, which varies between species, determines how hot a fire can be tolerated (Stocker and Mott 1981; Frost 1985). Fires that damage perennial plants which are still actively growing may create opportunities for annual plants to colonize (Frost 1985). Seeding strategies of perennial grasses varies, with shy, early seeders surviving the dry-season only as established plants (Crowley and Garnett unpubl. data), and late seeders producing a soil store of seed that is ready to germinate at the break of the summer rains (Tothill 1969; Mott 1978).

The conditions following fire have a significant influence on the recovery of plants in most communities. It has been reported that grazing of "green pick" in the early dry season may weaken perennial grasses (Scattini et al. 1988; Stanton 1992). Short intervals between fires may also reduce survival if plants have not had the opportunity to regain their former status (Noble 1982). The length of time until rains is also important. Woody perennial components burnt early in the year may have regained much of their canopy before the wet season sets in (O'Neill et al. 1993), herbaceous perennials may resprout for a time and then die back, while annual species will simply persist as seeds until it rains. Later burns, particularly those after the first storms, mean ground cover species, notably grasses, can quickly re-establish and impede shrub recovery (Stanton 1992).

Different fire regimes will thus benefit or disadvantage different plant species. This may ultimately lead to changes in vegetation communities as will be discussed in the next section.

4.3 Major vegetation types and their responses to fire

Fire is considered a secondary modifier of the distribution of vegetation communities rather than a primary determinant (Frost et al. 1986; Braithwaite in press b), with the distribution of most savannas in northern Australia being primarily determined by moisture and nutrient availability (Braithwaite in press b), which in turn control vegetation flammability and fire frequency (Bowman and Minchin 1987; Bowman and Panton 1993a; Bowman et al. 1988). In the wet-dry tropics most savannas will remain as savannas regardless of fire regime (Braithwaite in press b, pers. comm.). Where rainfall is less seasonal, savannas are more likely to be invaded by rainforest species when fire is excluded (Braithwaite in press b, pers comm.).

Soils of low fertility certainly limit the species which can grow in Peninsula environments (Pedley and Isbell 1971). However, the extent to which fire has controlled vegetation communities on Cape York Peninsula appears to be greater than for the Top End of the Northern Territory, and vegetation changes that have occurred this century (as discussed below) suggest fire regimes are of considerable significance in determining the areal extent of at least some vegetation communities (J.P. Stanton pers. comm.). This is not surprising given the greater moisture status of large areas of the Peninsula (Chapter 3). Nevertheless, almost all the material cited in this report implicating fire as a controlling factor for the vegetation on Cape York Peninsula is of an anecdotal nature and there is a need for more thorough documentation of these processes.

Most research examining vegetation change in northern Australia has been concerned with the dynamics of rainforest/savanna boundaries. Much less attention has been given to the dynamics of grassland/woodland boundaries. However, studies of structural changes which occur within savanna communities in response to varying fire regimes are of relevance here. Absence of fire, or a predominance of low intensity fires, has the potential to shift dominance to the canopy, and high intensity or frequent fires, to the ground layer (Hoare et al. 1980; Braithwaite and Estbergs 1985; Press 1987; Bowman et al. 1988; Braithwaite 1994). Long unburnt vegetation develops a continuum of growth between the understorey and the canopy (Braithwaite and Estbergs 1985; Gill et al. 1990) and, as suckering after fires may increase the number of plant shoots, failure to use follow-up burns may lead to an even thicker mid-canopy layer (Crowley and Garnett, unpubl. data). Annual burning may prevent suckering plants and seedlings from reaching a height that protects them from fire damage (Press 1987). Again ample anecdotal evidence exists from Cape York Peninsula of an escalated shift towards canopy species in savanna communities and widespread invasion of grasslands by woody species in the last century (Stanton 1992), but more rigorous documentation of these processes is lacking.

The 30 broad vegetation groups recognized for Cape York Peninsula (Neldner and Clarkson 1994) have been consolidated here into 8 categories in relation to their differing responses to fire. The main communities in which fire plays a role can also be classified as savannas, habitat in which grass cover predominates over tree cover (Lacey et al. 1982). Savanna communities on Cape York Peninsula include most eucalypt-dominated communities, the drier ti-tree woodlands and the grasslands. Much of the writings about fire referring to Australian savannas will apply to these communities. However, variation both between and within different savanna communities exist. Therefore, wherever possible, the type of savanna to which the conclusions apply have been identified. Fire is believed to play an important role in the persistence of at least two of the savanna communities on Cape York Peninsula, the grasslands and the eucalypt open forests and woodlands of the high rainfall zone, which have persisted under long histories of Aboriginal burning, but whose distributions are currently contracting (Stanton 1992). The progressive removal of Aboriginal people from involvement in the management of land on Cape York Peninsula correlates with declines in the areas of grasslands and wetter eucalypt communities, both reductions and expansions of rainforest patches, and a change in the structure of vegetation of most other communities (Stanton 1992). These changes have been more profound in areas where cattle grazing, with its attendant fire management practices, has not been viable (Stanton 1992). The gazettal of National Parks in the 1970s and 1980s may also have resulted in an acceleration of vegetation change because of initial, deliberate avoidance of hot fires (Stanton 1992).

Not all vegetation change can be attributed to changes in fire regime, but fire may have combined with other factors. The introduction of large herbivores (cattle, horses and pigs) has undoubtedly affected the ground layer vegetation and soils, enabling the establishment of opportunistic native plants and weedy exotics (Stocker and Mott 1981), and sown pasture species have also become established in native pastures to various extents (Stanton 1992). Particularly wet years in the 1950s and 1970s are believed to have led to unusual episodes of plant growth, and changing vegetation structure may be most marked where this was not followed up by vigilant burning programs. This is a process that has been documented for much of the rangelands of eastern Australia (Hodgkinson and Harrington 1985). Trees arising from these periods are now too well established to be eliminated by fire, but fire may be used in controlling further such recruitment events.

Table 4.1 Vegetation communities of Cape York Peninsula

Vegetation type	**Broad vegetation groups** (Neldner and Clarkson 1994)	**Area** (sq. km)	**Area** (%)
Rainforests	1,2,3,4,5,6	7481	5.6
Eucalypt communities			
High rainfall open forests and woodlands	13,14,15	2505	1.9
Other woodlands	7,8,9,10,11,12,16,17	82912	62.1
Ti-tree communities			
Paperbark swamps	19	1827	1.4
Broad-leaved ti-tree communities	18,20	17186	12.9
Grasslands	21,22,23	8111	6.1
Heathlands	24	4461	3.3
Other	25,26,27,28,29,30	9056	6.8
Total		133,539	100

4.3.1 Rainforest associations

Major stands of rainforests and related scrubs are found in the higher rainfall areas (average annual rainfall > c. 1,600 mm) in the far south-east of the region, as well as in an interrupted band from the south of MacIlwraith Range through to the northern limit of Cape York Peninsula (Stanton 1976). Gallery rainforests occur as a thin band along most rivers and major streams of the Peninsula, while patches of mainly deciduous scrub are found on inland slopes and alluvia (Neldner and Clarkson 1994). Rainforests of the Peninsula have been classified and described in some detail by Pedley and Isbell (1971), Lavarack and Stanton (1977), Hynes and Tracey (1980), Specht (1986) and Neldner and Clarkson (1994). Rainforests of the higher rainfall areas include a range of evergreen and semi-deciduous vine forests and thickets (Neldner and Clarkson 1994). Most types are highly diverse with no conspicuous dominant species but may include emergent sclerophyllous or softwood trees. Gallery forests include paperbark-dominated riparian forests (Melaleuca spp.; Neldner and Clarkson 1994).

Rainforests are generally restricted to areas with high soil moisture, and though they may be further limited by fire (Bowman 1986a), fire rarely penetrates the more mesic rainforest communities to any extent (Specht et al. 1977). Many of the core species are highly fire sensitive, while those on the boundary with eucalypt communities and deciduous scrubs can resprout after fire (Unwin et al. 1985; Bowman and Fensham 1991). Fires penetrating the edge of rainforests, particularly after cyclone damage, may open up habitats for weeds and annual grasses, which will then provide fuel for future fires (Stocker and Unwin 1986; Press 1987; Unwin et al. 1988). However, if not retarded by blady grass Imperata cylindrica invasion, rainforest canopy recovery may occur after individual fires (Stocker and Unwin 1986).

In the Northern Territory, Aboriginal people have been recorded as both protecting rainforest communities from fire using early burns, and using fire to remove unwanted litter, promote yams and eliminate snakes (Russell-Smith and Dunlop 1987; Lewis 1989). Aboriginal fires may have had a role in the contraction of rainforest communities in the Northern Territory (Stocker 1981), but appear to have had a more protective role in the recent past (Dunlop and Webb 1991). An increase in the prevalence and extent of hot, late dry season fires appears to be responsible for attrition of rainforest patches in the western two thirds of the Peninsula (Stanton 1992). But in higher rainfall areas of the north and east of the Peninsula rainforest expansion has occurred on a large scale (Stanton 1992). The widespread phenomenon of the invasion of wetter eucalypt communities by rainforest plants, is dealt with in the following section. Mild fires are used by the National Parks and Wildlife Service to ensure the protection of vulnerable stands of rainforests, and hotter fires are used to stabilize rainforest margins where rainforest species are invading eucalypt forests (Stanton 1994).

4.3.2 Wet eucalypt open forests and woodlands

Wet eucalypt open forests and woodlands are found in wetter areas, including areas where rainforests have been opened up by cyclones or fire has prevented rainforest from developing (Stanton 1976). Open forests of the coastal plains are dominated by Melville Island bloodwood Eucalyptus nesophila, Clarkson's bloodwood Eucalyptus clarksoniana, carbeen Eucalyptus tessellaris, and Eucalyptus novoguinensis. Small areas of open forest in the far southeast of the region are dominated by large-fruited red mahogany Eucalyptus pellita, broad-leaved white mahogany Eucalyptus umbra, pink bloodwood Eucalyptus intermedia and narrow-leaved ironbark Eucalyptus crebra (Neldner and Clarkson 1994). There is often an understorey of blady grass and seedlings of rainforest trees. Many of the major components of this community are rarely found in any other vegetation communities on the Peninsula.

As some of these communities occupy areas which could revert to rainforest in the absence of fire as has been documented for the more southerly tropics (Harrington and Sanderson 1993), deliberate burning seems required for their survival. Emergent eucalypts are found in many rainforest communities on Cape York Peninsula and throughout north Queensland (Tracey and Webb 1975; Neldner and Clarkson 1994) indicating the wet eucalypt communities to have contracted significantly, particularly since Aboriginal people have been prevented from burning the land (Stanton 1976). Although the area affected on Cape York Peninsula has not been measured, over half the wet eucalypt forest types on the western boundary of the rainforests of the Wet Tropics World Heritage Area have been invaded by a dense rainforest understorey since the 1940s (Harrington and Sanderson 1993). Rainforest expansion in north Queensland has been occurring since rainfall increased in the region about 8,000 years ago (Hopkins and Graham 1994), but the disappearance of several patches of wet sclerophyll forest in the last 20 to 30 years under stable climatic conditions and in the absence of vigilant burning (Stanton 1992) is too rapid to have been the result of climatic adjustment alone (J.P. Stanton pers. comm.). Aboriginal occupation of the area pre-dates the period of recent climatic amelioration, and Aboriginal burning practices undoubtedly influenced the rate of rainforest expansion (Stocker and Unwin 1986). Methods required to maintain these communities are still being developed. In some places, despite annual or biennial burning after the first storms, rainforest species are beginning to dominate (G.N. Harrington pers. comm.). However, along the eastern margin of the major rainforest stands, fuel loads after two years are sufficient to produce fires in August to October that are hot enough to keep rainforest species from overtaking these wet sclerophyllous stands (J.P. Stanton pers. comm.).

4.3.3 Drier eucalypt woodlands

By far the most extensive vegetation communities on Cape York Peninsula are the drier eucalypt woodlands (including tall woodlands and open woodlands), which are also widespread across northern Australia (Pedley and Isbell 1971; Anning 1980). Several eucalypts are found in the woodlands of the Peninsula, but messmate Eucalyptus tetrodonta is by far the most dominant. Other important species include gum-topped bloodwood Eucalyptus hylandii, Clarkson's bloodwood Eucalyptus clarksoniana, Eucalyptus chlorophylla, ironbark Eucalyptus cullenii and Molloy red box Eucalyptus leptophleba (Neldner and Clarkson 1994). Ironwood Erythrophleum chlorostachys is an important non-eucalypt species. Most woodlands have a dearth of understorey shrubs and the ground layer is dominated by grasses which are described in more detail in the pasture section.

The vegetation structure of these woodlands has been attributed to regular burning that prevents smaller plants from reaching the canopy (Sandercoe 1988; Gill et al. 1990). In the absence of fire, suckering and seedling eucalypts form a shrub layer that is continuous with the canopy (Gill et al. 1990), but the understorey does not appear to increase in species diversity (Bowman et al. 1988).

Annual fires have been reported for eucalypt woodland communities in the Northern Territory, but detailed satellite mapping in the east Kimberley indicated the frequency was closer to triennial (O'Neill et al. 1993). Some woodlands of Cape York Peninsula undoubtedly are subjected to high frequencies of fire, particularly in the drier areas and areas accessible to the Cape York Peninsula Development Road. However, wetter areas away from main roads appear to be burnt far less frequently, and in these latter communities invasion by rainforest species may occur in the absence of fire (J.P. Stanton pers. comm.).

Late dry season fires appear to be most effective at reducing the number of sapling stems (Bowman et al. 1988) and have the capacity to kill a large proportion of canopy trees (Lonsdale and Braithwaite 1991). However, patchiness in the death of trees results from changing intensity of fire with changes in fuel and wind conditions, and is generally minimal (< 1% per year). Fires have not been recorded as eliminating species from an area, but there is concern that they may do so in the long term (Lonsdale and Braithwaite 1991).

4.3.4 Paperbark swamps

Paperbark swamps are found in areas that are inundated for long periods each year. They are dominated by a number of ti-tree species, notably Melaleuca quinqenervia, Melaleuca leucadendra and Melaleuca saligna, along with other plants tolerant of inundation, including Lophostemon suaveolens, golden guinea tree Dillenia alata and Xanthostemon crenulatus (Neldner and Clarkson 1994).

Fire may penetrate these habitats in drier years, but significant incursions on Cape York Peninsula have not been reported. However, fires late in the year have been recorded as causing the contraction of some stands in Kakadu National Park (Lucas and Lucas 1993; J. Russell-Smith pers. comm.). In the Northern Territory, burning of paperbark swamps by Aboriginal people has been recorded as having a variety of purposes, including to protect the habitat from late fires, to expose burrows of food animals and for the promotion of "green pick" to attract grazing animals (Haynes 1985; Lewis 1989; Lucas and Lucas 1993).

Most plants of the wetter ti-tree associations have a low tolerance of fire. For example, coastal ti-tree Melaleuca quinquenervia has a poor suckering ability, and fires may see its replacement by broad-leaved ti-tree Melaleuca viridiflora (Tweddell 1982). However, low intensity fires appear to do little damage (Lewis 1989; Lucas and Lucas 1993).

4.3.5 Broad-leaved ti-tree communities

Communities dominated by broad-leaved ti-tree Melaleuca viridiflora are widespread across Cape York Peninsula on poorly drained soils of heavy texture (Pedley and Isbell 1971; Stanton 1976). On better drained margins a variety of species are found notably quinine Petalostigma spp. and silky grevillea Grevillea pteridifolia. Other important local dominants include Melaleuca stenostachya, Melaleuca citrolens, Melaleuca foliolosa, Asteromyrtus symphocarpa and Xanthorrhoea johnsonii (Neldner and Clarkson 1994). The understorey is composed of numerous grass and herbaceous species, most of which are annual or dormant through the dry season.

Drier ti-tree associations are inundated for at least some time in the wet season, but are fire-prone through most of the dry season. The expansion of these associations over the last 50 or more years at the expense of grassland has been described (Stanton 1992) and is evident from descriptions of more open country found in diaries and records of early European explorers and settlers (J.P. Stanton pers. comm.), as well as from examination of aerial photographs (Stanton 1992; V.J. Neldner pers. comm.; J.P. Stanton pers. comm.). It has also been observed by numerous local residents. Having established extensive populations after the wet years of the 1950s and 1970s, the broad-leaved ti-tree is proving difficult to reduce to its former range (Stanton 1992). It is highly fire-resistant, with almost total recovery after both early and late dry season fires, and control measures are currently being investigated (Crowley and Garnett unpubl. data).

4.3.6 Grasslands

Grasslands are found in areas of the Peninsula subject to seasonal inundation, such as floodplains, alluvial plains, tidal flats and drainage depressions (Pedley and Isbell 1971; Stanton 1992; Clarkson and Neldner 1994). Extensive grasslands occur around Princess Charlotte Bay, south of Aurukun, on the Lockhart and Nesbit flood-plains and north of Silver Plains (Pedley and Isbell 1971; Stanton 1992), but smaller patches are found throughout the Peninsula.

Marine floodplains and alluvial plains are dominated by panic grass <u>Panicum</u> spp., sedges <u>Fimbristylis</u> spp., native rice <u>Oryza australiensis</u> and salt water couch <u>Sporobolus virginicus</u> and may have scattered clumps of screw pine <u>Pandanus</u> spp. and <u>Corypha elata</u> (Stanton 1976). Dominant grasses in inland depressions include wanderrie grass <u>Eriachne</u> spp., wire grass <u>Aristida</u> spp., love grass <u>Eragrostis</u> spp. and sedges <u>Fimbristylis</u> spp. Blady grass <u>Imperata cylindrica</u> glades occur near Lockhart River, where rainforest species appear to have been kept at bay by fire (Pedley and Isbell 1971). As the grasslands intergrade with neighbouring communities (such as the ti-tree woodlands), there is some justification in considering them as phases of neighbouring vegetation types (Pedley and Isbell 1971).

Although grassland areas are usually annually inundated, they cure quickly when exposed and are among the first areas burnt in the dry season. Such fires may extinguish in the green grass at the margins of adjoining woodlands (Trezise 1991). If burnt late in the dry season, they produce hot, fast- moving fires. It may then take up to three years to produce enough fuel to carry another fire (O'Neill <u>et al.</u> 1993), although fires can sometimes burn after a single growing season (S.T. Garnett pers. comm.).

Grasslands have been described as the most threatened habitats on Cape York Peninsula (Stanton 1992). Their attrition has been caused in part by an invasion of woody plants, such as ti-trees, coolibah and rainforest, and has been attributed to cessation of traditional Aboriginal burning practices, notably a decline in late dry season fires, in combination with disturbance caused by introduced animals (Stanton 1992).

4.3.7 Heathlands

Heathlands are restricted to northern and eastern Cape York Peninsula (Pedley and Isbell 1971; Stanton 1976; Lavarack and Stanton 1977; Specht 1986; Neldner and Clarkson 1994). They are unusual in Australia in the predominance of broad-leaved species. A simple heath of <u>Asteromyrtus lysicephala</u>, <u>Banksia dentata</u>, <u>Baeckea frutescens</u> and pitcher plants <u>Nepenthes mirabilis</u> occurs on waterlogged soils. A more diverse heath, in which <u>Grevillea</u>

pteridifolia, Grevillea glauca, Choriceras tricorne, Jacksonia thesioides, Hibbertia banksii, Leptospermum fabricia and Asteromyrtus brassii are important, grows on deep, well-drained soils. Low closed heath dominated by Acacia crassicarpa, Syzygium banksii, Neofabricia myrtifolia and Leucopogon yorkensis occurs on coastal dunes. Heaths may grade into other communities on the Peninsula, in which the major plant species are also found as understorey components (J.R. Clarkson pers. comm.).

Fires occur in these communities despite the fact that some are found on extremely wet soils. Cool fires lead to very little regeneration; hotter fires release seed dormancy in a range of species that disappear from the vegetation as time since last fire increases (Stanton 1992). In patches that have been unburnt for 50 years or more black she-oak is most abundant (Stanton 1992). Such communities thus appear to be adapted to hot, relatively infrequent fires (Dunlop and Webb 1991), and a fire strategy whereby small areas are burnt at intervals of 5 to 10 years has been proposed (Stanton 1992).

4.3.8 Pastures

Consideration of pasture as an entity is warranted because it forms a relatively uniform layer beneath a varying canopy of the different vegetation communities (Gunn and Story 1970; Pedley and Isbell 1971), and because the fire management regimes used by pastoralists are directed more at pasture productivity than canopy composition. Native pastures on Cape York Peninsula are principally used for free-ranging or extensive cattle production (Anning 1980; Scattini et al. 1988). Stocking rates are limited by low quality, dry season feed (Mott and Tothill 1984; Scattini et al. 1988), and attempts have been made to increase them by the use of supplements and introduction of Brahman bloodlines (Anning 1980). Economic considerations, rather than pasture condition, are the main basis of cattle management decisions (Scattini et al. 1988).

Pastures of Cape York Peninsula have been mapped by Galloway et al. (1970) and Weston and Harbison (1980). They have been described by Gunn and Story (1970), Scattini et al. (1988) and Weston (1988) and are currently under re-examination (G. Cotter pers. comm., J.R. Clarkson pers. comm.). The more recent maps show a dominance of fire grass Schizachyrium spp., wanderrie grass Eriachne spp., wire grass Aristida spp., giant spear grass Heteropogon triticeus, blue grasses Bothriochloa spp. and Dicanthium spp., silky browntop grass Eulalia fulva and cockatoo grass Alloteropsis semialata through most of the Peninsula. Native sorghum Sorghum plumosum and black spear grass Heteropogon contortus are regionally abundant. Blady grass Imperata cylindrica pastures occur in the higher rainfall areas (Weston 1988). Although native pastures contain several species, usually only a few are suitable forage (Scattini et al. 1988). Native sorghum pastures are considered to be the best on the Peninsula (Scattini et al. 1988), while fire-grass pastures that dominate most of the area provide poor quality forage. Blady grass pastures have been described as poor grazing country (Weston 1988).

Growth of pastures begins with the onset of the wet season as annual grasses germinate and perennial grasses reshoot. The season of growth for most grass species is about 3 months during the wet season, after which the grasses either die-off or become dormant until the next year (Scattini et al. 1988). Growth and nutritional value of the herbage reach an early peak then decline rapidly as the dry season sets in (Mott and Tothill 1984).

A second growth peak occurs when perennial grasses are released from dormancy by early dry season burning. Dry season burning leads to an increase in the nutritive value of forage by removing dead grass, both in the short term (Falvey 1977) and carrying on into the following early wet season (Winter 1987).

Timing of burning may be important to determine the relative composition of perennial grasses. Elsewhere in Queensland, burning early in the dry season every one to three years or in the early wet season every 2 years has been found to favour kangaroo grass Themeda triandra and burning in the late dry season to favour black spear grass and native legumes (Pressland et al. 1981; Tothill 1983; Walker et al. 1983). In the Katherine region, late dry season fires led to an increase in annual grasses and forbs (Norman 1963a). Fires during the wet season have been found to reduce kangaroo grass and native sorghum but not ribbon grass Chrysopogon fallax (Smith 1960). Pasture productivity of some perennial grasses, such as native sorghum, may be maximized by burning at approximately five year intervals (Smith 1960; Norman 1969). The promotion of annual grasses, which appear to have lower nutrient levels than perennial grasses (Cook and Andrew 1991), may be an adverse effect of some burning regimes.

There is concern that burning at a time when perennial grasses are actively growing, changes in cattle breeds and the use of supplements will enable greater grazing pressure in the early wet season and a decline in perennial grasses (Mott and Tothill 1984; Scattini et al. 1988). However over most of the region stocking densities have remained conservative with little evidence of pasture degradation (G. Cotter pers. comm.). Weed infestations may be a problem locally, with Hyptis suaveolens, Sida acuta and Urena lobata colonizing sites disturbed by over-grazing (Scattini et al. 1988), notably in horse paddocks, and annual grasses are now more abundant where erosion has occurred (Scattini et al. 1988).

4.3.9 Other vegetation types

A range of other vegetation types with restricted distributions are found on Cape York Peninsula (Neldner and Clarkson 1994). Mangroves, sedgelands, lancewood Acacia shirleyi open forests, aquatic vegetation, saltpans, sandblows and rock pavements are almost never affected directly by fires, but may receive sediment and nutrient inputs as a result of them. The vegetation of beach ridges, coastal strandlines, coral atolls and cays, and a miscellanea of myrtaceous-dominated communities, on the other hand, are subjected to fire at various intervals. Characteristics of fire and the responses of the plants to fire in these communities will show many similarities to those found in heathlands and woodlands described above.

4.4 Animals and fire

Areas of rarely-burnt vegetation, such as rainforest, maintain suites of species that are ill-adapted to fires, but the responses of animals to fire in other habitats are complex, with individual species having different responses to different fire regimes, and responses being moderated by climatic conditions (Braithwaite 1994). It has been argued that post-fire successions of species typical of other areas in Australia are not found in the open forests and woodlands of northern Australia because of the short periods between fires (Braithwaite 1987). Hence, most studies in Northern Australia have concentrated on the response of communities to fire frequency and timing (Braithwaite 1987; Woinarski 1990; Trainor and Woinarski 1994).

An animal's response to fire is influenced by its ability to survive the blaze and then subsequently to survive predators and competitors and to find food, shelter and breeding habitat (Andersen 1991; Friend 1993). These features are poorly known for the many species found on Cape York Peninsula. Studies from similar habitats in the Top End (e.g. Braithwaite 1987; 1994; Woinarski 1990; Andersen 1991; Trainor and Woinarski 1994) have concentrated on the change in species abundance in response to fire regimes rather than on the mechanics of responses. However, the available studies can be augmented by behavioural work from more southerly latitudes to develop a picture of the way animals might respond to fire in the tropics.

Animals may persist through a fire by hiding in protected environments such as tree hollows or soil fissures (Braithwaite 1987; Kerle 1985), or by fleeing to other areas. Studies from temperate Australia show that animals fleeing fires may be more vulnerable to predation, especially if they are unable to re-establish quickly in suitable habitat (Friend 1993). After a fire, survivors may remain or return, or seek a new home range in unburnt country. This will depend on habitat suitability as determined by needs for food, shelter and breeding, and their interactions with other animals (Andersen 1991; Friend 1993). New animals may colonize the burnt country, with some species being most common in recently burnt habitat and others in long unburnt areas (Crawford 1979; Braithwaite 1987; Woinarski 1990; Trainor and Woinarski 1994). Assemblages of animals will thus vary with the fire history of a site, there being most differences between recently or annually burnt and long unburnt sites, while biennially burnt sites may be intermediate between the two (Andersen 1991).

Animals that rely on habitats that are infrequently burnt or unburnt at specific times of the year may have specific dietary or habitat requirements that are destroyed by fire (Kerle 1985; Andersen 1991; Sands 1993). These species may persist only in unburnt areas or where fires are patchy. Animals that are most frequent on recently burnt ground may appear less specific in their requirements, often having the mobility to move through a series of burnt habitats in which to feed (Braithwaite and Estbergs 1987; Garnett and Crowley unpubl. data). However, such species may be disadvantaged by both complete exclusion of fire and too extensive fires which prevent fires being burnt at critical periods (Garnett and Crowley unpubl. data). Fire-adapted generalists include omnivores, carnivores and scavengers which benefit from an abundance of fleeing, injured or dead animals (Braithwaite and Estbergs 1985). Ground foraging birds often move on to burnt areas in which fallen seeds, though reduced in number, are more visible and accessible (Crawford 1979; Braithwaite and Estbergs 1987; Press 1987; Garnett and Crowley unpubl. data). The food of herbivores can be almost eliminated by fires but regrowth of grasses following a fire may be more nutritious

(Press 1987), with the result that herbivores may require or be advantaged by a progression of burnt sites (Bolton and Latz 1978; Christensen 1980; Andersen 1991). Although less frequently burnt, canopies may take longer to recover, with the development of flowers and fruits being affected by fire (R.J. Williams in Braithwaite in press a), and this may explain the patchy distribution of mammals that feed principally in the canopy (Kerle 1985).

It has been argued that the biodiversity of the savannas of northern Australia, and of other Australian ecosystems, will be maintained by using a diversity of fire regimes to maximize habitat heterogeneity (Burbidge 1985; Braithwaite 1991, in press a,b). This is supported by many of the studies cited in this report that show most of the more vulnerable species will be protected by a burning regime which ensures small areas being burnt throughout much of the year in order to create a fine mosaic of vegetation patterns. This should ensure that fire-sensitive animals can readily move out of burnt areas and animals adapted to recently burnt areas can move on (Fox 1982; Kerle and Burgman 1985; Friend 1993). Aboriginal burning is believed to have produced such a mosaic (Bolton and Latz 1978; Haynes 1985; Braithwaite in press a), but the more extensive fires that are a feature of much of Northern Australia today may mean larger areas from which species can be eliminated, and fewer refuge areas from which animals can recolonize (Trainor and Woinarski 1994; Garnett and Crowley 1994a; D. Sands pers. comm.). Burning a succession of small areas through the year should help to maintain the habitats of several suites of species on Cape York that could otherwise be at risk, namely species that require a particular post-fire vegetation stage, and those that require long unburnt vegetation.

4.4.1 Invertebrates

Like most animals, insects and other invertebrates may be killed in the passing of a fire or affected afterwards by changes to habitat, food supply and interactions with other species (Andersen and Yen 1985; Andersen 1988, 1991). As fire barely raises soil temperatures below the first few centimetres (Beadle 1940; Scotter 1970), invertebrates that forage on the ground or reside in the soil are relatively unaffected by the passing of a fire (Frost 1985). Others, such as spiders, cockroaches, centipedes and millipedes may escape by finding shelter within the area being burnt. Conversely, populations of surface and vegetation dwellers, such as bugs and grasshoppers have high death and departure rates (Greenslade and Mott 1983), and are the focus of increased attention by predators attracted by the smoke (Braithwaite and Estbergs 1987). Fires in the early dry season, when many invertebrates are at a larval stage (D. Sands pers. comm.), may be more destructive than those later in the year, when much of the vegetation has died or dried-out and many invertebrates are dormant (Majer 1985).

After fire has removed the surface vegetation, many insects will no longer be able to find shelter from predators or the moist microhabitats they may require. Herbivore numbers are at least initially reduced because of a lack of food and increased predator activity (Greenslade and Mott 1983). However, rapid regrowth of foliage after fires appears to result in an increase in herbivore abundance (Andersen and Braithwaite 1992). Grass-harvesting termites decline in numbers as fire removes their food (Holt and Coventry 1991), but this may also occur when grasses are shaded out by increasing canopy cover in fire's absence (S.T. Garnett pers. comm.).

The only detailed study of invertebrate-response to fire in the Australian tropics concerns ground foraging ants (Andersen 1991). Large differences were found between the ant communities of unburnt and annually burnt areas, with biennial burns resulting in an intermediate fauna. Annual fires promoted hot climate specialists and colonizers of open ground, such as meat ants Iridomyrmex. Species that forage in the soil or litter and species which compete poorly with meat ants were most abundant in unburnt areas.

In the Northern Territory, extensive early dry season fires are apparently endangering some species of butterfly (Sands 1993). Butterflies at this time are mostly still at the larval stage and are therefore unable to escape fires. This problem is most conspicuous where the burning affects critical insect habitats, such as rainforest margins and along creek-lines, which have a high diversity of host plants (D. Sands pers. comm.). Extensive annual burning is also reducing the abundance of some food plants which require two or more years to flower. When the population of the host plant declines below a critical level, insects which are entirely dependent on them may decline by an even greater extent (D. Sands pers. comm.). Another problem is the elimination by fires of large areas of suckers with lateral growth, which provide food and habitat for many insect species. These problems should be alleviated by patch burning which ensures some strips of country remain unburnt each year (D. Sands pers. comm.).

4.4.2 Frogs

As most species of frogs found on Cape York Peninsula are restricted to non-flammable habitats, fire is unlikely to be an important factor for them. Burning appears to be beneficial to frog populations of the savannas with numbers increasing in regularly burnt areas and decreasing in long unburnt areas at Kapalga in the Northern Territory (L.K. Corbett in Braithwaite in press b). Species diversity, stable in unburnt areas, increased under regular burning (L.K. Corbett in Braithwaite in press b).

4.4.3 Reptiles

Reptiles may escape from the heat of a blaze under rocks, in termite mounds or in the holes of spiders, goannas or rodents (Braithwaite 1987; Woinarski and Gambold 1992), though they may find fewer refuges in extensive, late fires than in earlier fires (Trainor and Woinarski 1994). Larger animals may also be less able to find shelter during a fire (Friend 1993). Death by starvation or increased exposure to predators may also be a problem for prey species, but of benefit to predators (Braithwaite and Estbergs 1987).

Fires have also been found to affect reptiles with regard to their needs for shelter, breeding habitat and food (Braithwaite 1987; Friend 1993). Studies from temperate Australia show that reptiles that establish soon after fire tend to live in burrows and feed in the open (Friend 1993), followed later by those that need to forage from the shelter of vegetation and use elevated perches to capture food on bare ground. Later colonizers tend to live in leaf-litter, sheltering in flammable and elevated or soil habitats. In northern Australia habitat requirements may be more influenced by soil type and vegetation community than by fire, with species moving along moisture gradients through the year and taking refuge in creek-lines during fire (Trainor and Woinarski 1994). Studies in the savannas of Kakadu National Park found that repeated early or late burning regimes did not eliminate any lizard species, and that some species were found only in vegetation that had been burnt (Trainor and Woinarski 1994). However, abundance of some species was reduced by burning, and reptiles which prefer a moist litter layer were most affected by late dry season burns (Trainor and Woinarski 1994). Other studies in the area have shown that dry season breeders are most successful at finding food where fires are absent or patchy, whereas wet season breeders may be more resilient to fire regime (Braithwaite 1987). Some species, however, show no clear relationship to fire and may be found in areas with a variety of fire histories. The wide range of responses of tropical lizards to fire indicates that no single fire regime will suit all species. Rather maximum animal diversity should be achieved by a range of different burning patterns.

4.4.4 Mammals

Many mammals appear to have specific fire requirements, whether these be exclusion of fire or regular burning. Immediate responses to the passing of fire are largely determined by the vegetation layer in which animals shelter and the animal's mobility. Kill rates of small mammals which rarely travel far may be high where fires are uniform and leave few unburnt patches. Tree-dwelling mammals will be most severely affected when canopies are scorched. Studies from temperate Australia show burrowing mammals are the least vulnerable (Friend 1993). Moist gullies have the potential to protect many animals from fire. These will be more effective sanctuaries from early rather than late dry season fires.

Elsewhere is Australia, small macropods have been shown to need a progression of vegetative regrowth following fires (Christensen 1980; Bolton and Latz 1978), and some species have been recorded as gathering on burnt ground to dig out the bases of grasses and roots of wild yams immediately after fires (Lewis 1989). Several species of native mice <u>Pseudomys</u> spp. have been recorded as invading and remaining common for short periods after fires (Bamford 1985; Kerle and Burgman 1985; Friend 1993), and northern quolls <u>Dasyurus halluctus</u> have been recorded as being most abundant soon after fires (Kerle and Burgman 1985). On the other hand, native rats and small marsupials, such as bandicoots, generally establish only after vegetation recovery has progressed (Kerle and Burgman 1985). Long periods between fires, which allow the development of shrub and litter layers, are important for persistence of the northern brushtail possum <u>Trichosurus arnhemensis</u> and may be necessary to allow trees to grow to a size where hollows suitable for nesting can form (Kerle 1985). Canopy protection may be a requirement of other arboreal species, notably those which feed on flowers and fruits, including other possums, gliders and bats (Kerle 1985). Dingoes, able to take a variety of prey, have been reported as being relatively unaffected by fires (Recher 1981).

A study of mammal-response to a number of fire regimes in Kakadu National Park found that areas unburnt for three to four years supported the greatest number of mammals but some mammal species were most abundant in each of the fire treatments (Braithwaite in press a,b). The preference of individual species for a particular fire regimes varied between years, probably in response to variation in rainfall and flower and fruit availability (Braithwaite in press a,b). Mammal diversity was related to habitat diversity at both canopy and ground level (Braithwaite 1994), thus maintenance of habitat diversity with diverse fire regimes appears necessary for maintaining mammal biodiversity (Braithwaite in press 1994).

4.4.5 Birds

While the mobility of most birds means that few adults will be killed by a fire, nests of some species will certainly be destroyed, and birds leaving a burnt area may be exposed to predation and have difficulty establishing territories elsewhere. Birds that are advantaged by fires in the short term or by a high fire frequency tend to be seed-eaters, carnivores or omnivores that feed on the ground, especially those that are highly nomadic and can move to areas of new resources (Braithwaite and Estbergs 1987; Woinarski 1990). These species usually experience an increase in food availability, visibility or accessibility immediately after a fire (Crawford 1979). Movement of such birds to newly burnt areas is more apparent in the early dry season than in the late dry season when more extensive burnt areas are available (Woinarski 1990). Though fires towards the end of the year have been touted as causing the most damage to seed-banks because of high fire temperature and the already diminished seed-bank size (Woinarski and Tidemann 1991), seed destruction may be more than offset by the removal of obscuring vegetation cover (Garnett and Crowley, unpubl. data).

As the area burnt increases, birds which prefer unburnt habitat are likely to concentrate on the remaining unburnt country (Woinarski 1990). Fruit-eaters may become more abundant in long unburnt areas (Braithwaite in press b), but will be relatively unaffected in the short term by fires in which the canopy is not damaged (Woinarski 1990). Exclusion of burning in eucalypt woodlands and open forest may lead to a limited increase in the diversity of bird species, particularly of species that feed or nest in the shrub layer and those which obtain insects from leaves and bark (Woinarski et al. 1988; Woinarski 1990; Braithwaite in press b).

Patterns of burn are important for the survival of some bird species on the Peninsula. For example, widespread late dry season fires are a likely cause of the contraction of the Brown Treecreeper Climacteris picumnus, which appears to have a limited ability to recolonize after fire (Garnett and Crowley 1994a). Burning after the first storms of the wet season to expose bare ground and scorch germinating seed is considered important to the survival of the Golden-shouldered Parrot Psephotus chrysopterygius which suffers from an inability to find food at that time (Garnett and Crowley unpubl. data). Of particular concern is the effect of fires on tree hollows used for nesting. The wet eucalypt open forests and woodlands that require hot fires for their maintenance provide nesting habitats for hollow nesting birds including threatened species such as the Red-cheeked Parrot Geoffroyus geophroyi aruensis, the Eclectus Parrot Eclectus roratus macgillivrayi, the Palm Cockatoo Probosciger aterrimus aterrimus, the Masked Owl Tyto novaehollandiae kimberli and the Rufous Owl Ninox rufa meesi (Garnett 1992). On the one hand fires may be required to allow the formation of hollows (Braithwaite et al. 1985; Perry et al. 1985; Inions et al. 1989; Garnett and Loyn in press) on the other, fires have been recorded destroying nests and young as well as nesting trees (Young 1991). Where the area burnt is large and the intervals between fires is great this may lead to a decline in abundance of hollow-bearing trees (Lindenmayer et al. 1990). Proposals to minimize damage to tree hollows and their occupants are to burn such areas only when fuel moisture is high (Stanton 1991) and to burn away litter from known or significant nesting trees early in the dry season (Roberts 1994). These recommendations would also apply to the vulnerable Red Goshawk Erythrotriorchis radiatus whose nesting trees on the edge of riparian rainforests are sometimes destroyed by late dry season fires. The ecotone between the rainforest and the wet eucalypt forest is important habitat for the endangered Cassowary Casuarius casuarius and may provide much of its food (Garnett 1992).

Maintenance of the habitat of this species by fire has been suggested as a prerequisite in its conservation (Stanton 1992).

The limited studies available indicate that birds of fire-prone environments in northern Australia have a range of responses to fire, and that fire management that selects a single burning regime will disadvantage many species. Hence a wide variety of burning histories, such as that produced by burning small areas throughout the dry season, is likely to maximize bird diversity.

4.4.6 Introduced animals

Introduced animals that range across much of Cape York Peninsula include both those that are managed for economic purposes (i.e. cattle and horses) and those that are self-propagating pests (i.e. feral pigs and cats). The number of species in both groups is far more limited than in other areas because of severe seasonal climatic fluctuations and the abundance of dingoes and spear-grass (Tothill et al. 1985; Weston 1988). In relation to fire responses, only cattle have been studied, although impacts of fire, whether positive or negative, appear confounded by the problems of inadequate nutrition through the long dry season.

The most serious impact of fire on cattle is the loss of dry season forage to extensive wildfires late in the year (Anderson et al. 1988; Tothill 1983). This may lead to death of animals through starvation or disease resulting from loss of condition. Fires lit earlier in the dry season, when there is still moisture in the soil, produce "green pick" that is more nutritious than dry dead forage (Falvey 1977). But whether this results in better animal performance is disputable (Clem et al. 1983; Tothill 1983; Anderson et al. 1988; McLennan et al. 1986). Equal animal weights may be achieved by feeding lick to supplement the bulk of old grass (Tothill 1971; McLennan and Clem 1983). Winter (1987), on the other hand, advocates combining lick supplements with spell burning. Fire has been reported as reducing the abundance of cattle tick (Davis 1959) although this may only be effective under certain circumstances (Tothill 1971; Anderson et al. 1988). Andrew (1986) proposed making use of the attraction of cattle to newly burnt grass as a way of keeping them away from unburnt over-grazed areas and preventing the development of soil degradation. Other details of management practices relating to cattle production are dealt with in Chapter 6.

Table 4.2 Impacts of fire - Key points

Physical impacts

- Fires play an important role in the redistribution of nutrients.
- There is little evidence that present fire regimes cause long term nutrient losses to the ecosystem.
- Carbon dioxide generated in fires is largely negated by reabsorption through regrowth after fires.
- Fires contribute other pollutants to the atmosphere, but the extent of their impact is unclear.
- Adverse impacts of fires on the soil and atmosphere may be moderated by adjustments to fire regimes.

/cont.

Table 4.2 (cont.) Impacts of fire - Key points

Plants and vegetation communities

- Many plants of Cape York Peninsula can survive or re-establish after fire.
- Extent of recovery will depend on intensity of burn and conditions following fire.
- Vegetation communities on Cape York Peninsula have evolved with a regular fire regime.
- Interruption to Aboriginal burning patterns have coincided with significant changes in the distribution of vegetation communities, notably expansion of rainforests at the expense of eucalypt open forests and woodlands, expansion of ti-tree woodlands at the expense of grasslands, and the contraction of isolated rainforest patches.
- Regular burning appears necessary to prevent the above changes, but in many cases their reversal seems unlikely.
- Changes in burning regime also appear to have caused an increase in density of the understorey of the open forests and woodlands.
- Fire is important for maintaining all but the wettest vegetation communities on Cape York Peninsula, although optimum regimes have yet to be determined.

Animals

- Fires may destroy individuals, but in many cases are required to maintain animal habitats.
- Fire affects an animal's the ability to find food, shelter and breeding habitat, and to survive predation and competition.
- Response to fire varies between species and a diversity of fire regimes, from fire exclusion through to regular and irregular burning patterns, are likely to be required to maintain animal diversity.

5 ATTITUDES TO BURNING

In many of the writings about fire on the Australian continent, the divisive nature of the topic is discussed. There is recognition that whatever stance is taken, there is a good chance that it will be unpopular with a large sector of the population and that opponents will be vociferous in their dissent. This occurs at both the professional level and within the wider community: scientists argue amongst themselves about interpretation of experimental fires (Lonsdale and Braithwaite 1991; Bowman 1992; Lonsdale and Braithwaite 1992), and there is disgruntlement in the public sphere about how fire is managed by the authorities (e.g. Fulloon 1991; Heinsohn 1991; Young 1991). Differences of opinion exist at every level and are influenced by a number of factors ranging from philosophical positions, personal experience, assimilation of information and aims (Glascock 1972; Hall 1972; Table 5.1). Among those that have responsibility for managing the land there is also a great variety of opinions, and in some cases this may lead to real conflict (Price 1989). Ultimately, fire management will be affected, not only by the attitudes of land managers, but by those of the general public whose actions will influence legislators and policy makers (Hall 1972).

A survey of literature relating to fire on Cape York Peninsula (Table 5.1) shows that there are many different ways fire is viewed. The aim of this survey was restricted to the identification of attitudes which might be relevant to the formation of management and policy decisions made on Cape York Peninsula. While some attitudes may be offensive to some people, their presentation is made with the aim of enabling such issues to be addressed and not with the intention of exacerbating conflict. The classification of statements as attitudes is neither to give them validity, nor to deride them.
Most attitudes can be supported by facts, but it is the selection and interpretation of facts that leads to their classification as attitudes. While every attempt has been made to identify the range of attitudes held regarding all aspects of fire in the region, it was not the aim of this exercise to list every time an attitude was encountered. Attitudes that the author has only heard expressed have not been recorded, but this information may have been used when judging whether attitudes reported from areas outside Cape York Peninsula have relevance in the region. It should be noted that the attitudes listed may not be those of the authors of references cited, but merely have been recorded by them.

Attitudes on Cape York Peninsula vary from the belief that no fires should be deliberately lit and all fires should be suppressed (Fulloon 1991) to the attitude that regular burning is part of the responsibility of land managers to maintain landscape and lifestyle and to protect biodiversity (Parry and Clark 1991; Stanton 1991). Between this there are various opinions about how much burning is acceptable or desirable, from minimal amounts (Heinsohn 1991; Young 1991) to a level that is compatible with the needs of grazing animals (McKeague and Wincen 1991). There are also considerable differences in opinions about the acceptability of fires at different times of year, the extent of fires, how fire has been used, the effects of fire and the desirability of regulation.

Table 5.1 Attitudes expressed or reported in publications dealing with fire on Cape York Peninsula.

Material derived from outside Cape York Peninsula has been presented in brackets. See text for further explanation.

Image of fire	
Fires are destructive	Fulloon 1991; Heinsohn 1991; Young 1991; Stanton 1994
Fires rejuvenate	Harrington 1991
Fires are part of Aboriginal lifestyle	Parry and Clark 1991
(Burnt landscapes are clean)	(Haynes 1991)
(Burnt landscapes are dead and unattractive)	(Haynes 1991)
Role of fire in natural communities	
Natural communities on Cape York Peninsula have evolved with, and partly as a result of, fire	Harrington 1991; Stanton 1991
Fire has a major influence on stability of vegetation communities	McKeague and Wincen 1991
Fire has maintained the structure of the grassy woodlands	Trezise 1991
Use of fire by graziers has maintained integrity of Cape York Peninsula	McKeague and Wincen 1991
Changes in fire regime since the arrival of Europeans have led to changes in vegetation and fauna populations	Parry and Clark 1991; Stanton 1991
Extensive fires have the potential to destroy much wildlife	Young 1991
Effects of fire vary with the season and frequency of burn	Harrington 1991
(Fire is a negative ecological factor that has necessitated the evolution of protective adaptive responses by flora and fauna)	(Tingay 1985)
Biodiversity	
Fires lead to a loss of biodiversity	Heinsohn 1991
Fires lead to a shift in species abundance	Harrington 1991
Fires maintain biodiversity (in at least some cases)	Heinsohn 1991
An imposed absence of fire has lead to a loss of biodiversity in some habitats	Stanton 1991
Weeds	
Burning results in invasion by weeds	Fulloon 1991; Heinsohn 1991
Burning is an appropriate tool for weed control	Stanton 1992

/cont.

Table 5.1 (cont.) Attitudes expressed or reported in publications dealing with fire on Cape York Peninsula

Soil	
Protection from fire will lead to improved soil fertility	Fulloon 1991; Heinsohn 1991
Low soil fertility is likely to prevent changes in vegetation in response to an altered fire regime in many habitats	Harrington 1991
Soil erosion/stream siltation is an undesirable result of fire	Fulloon 1991; Heinsohn 1991
Pollution	
Fires on Cape York Peninsula are unlikely to have contributed to the "Greenhouse" gas problem	Stanton 1991
Increased "greenhouse" gases are an undesirable result of burning	Heinsohn 1991
Role of fire in management	
Fires are essential to clean up the country	Parry and Clark 1991
Burning is an important land management tool	Harrington 1991; McKeague and Wincen 1991; Parry and Clark 1991; Stanton 1991
Deliberate burning has no place in land management	Fulloon 1991
Lack of burning is as much human interference as is deliberate burning	Harrington 1991; Stanton 1991
Burning is/should be carefully executed to achieve specific goals	Horsfall 1991; McKeague and Wincen 1991; Parry and Clark 1991
All human-ignited fires are undesirable	Fulloon 1991; Heinsohn 1991
If deliberate burning isn't used by land managers, fires from other sources will be more destructive	Stanton 1990; Trezise 1991
Active or more active burning is required to maintain at least some natural communities on Cape York Peninsula	McKeague and Wincen 1991; Stanton 1991
The area of Cape York Peninsula burnt each year is too large	Fulloon 1991; Heinsohn 1991
Vandalism	
Fires lit by "vandals" or "tourists" are of great concern	Fulloon 1991; Heinsohn 1991; Parry and Clark 1991

/cont.

Table 5.1 (cont.) Attitudes expressed or reported in publications dealing with fire on Cape York Peninsula

Information base	
Traditional knowledge about burning patterns is still held by at least some members of the Aboriginal community	Horsfall 1991; Parry and Clark 1991; (O'Neill et al. 1993)
Aboriginal people have lost knowledge of some aspects of traditional burning practices, and may no longer have the need of them	Roberts 1994
(Certain aspects of Aboriginal burning are more likely to be lost or discarded than others)	(Head in prep.)
Information on fire in the Northern Territory is useful on Cape York Peninsula	Horsfall 1991
Information collection and research	
Collection of information on traditional Aboriginal burning patterns is valuable	Roberts 1994
Research is required to develop fire management programs	Harrington 1991; Heinsohn 1991 Trezise 1991
Effects of land management should be monitored	Harrington 1991
Fire programs should be based on scientific information	Heinsohn 1991
It is acceptable to experiment with fire management patterns on Cape York Peninsula to gain information	Harrington 1991
Skill assessment	
Traditional use of fire by Aboriginal people was controlled, well-directed and responsive to changing environmental conditions	Horsfall 1991; Rigsby 1980
Traditional use of fire by Aboriginal people had no intended aims	Rigsby 1980
(At least some Aboriginal people have a good understanding of the reasons for burning and the effects of burning)	(Lewis 1985)
Aborigine and Islander communities have their fair share of pyromaniacs	McKeague and Beckett 1990
Skill is required to use fire to achieve desired ends	McKeague and Wincen 1991
Recently arrived land managers are less skilled at fire management	Trezise 1991
Fire management on Cape York Peninsula is done in the absence of adequate knowledge	Young 1991
Fire wardens have the necessary experience to issue Permits	Burke 1990b
Fire wardens are not always sufficiently experienced to issue Permits	Trezise 1991

/cont.

Table 5.1 (cont.) Attitudes expressed or reported in publications dealing with fire on Cape York Peninsula

Education	
Education of land managers about desirable burning practices is required	Trezise 1991
Education programs are needed to facilitate successful conservation of land resources by Aboriginal land users	Parry and Clark 1991
Public education is required about the harmful effects of wildfires and wildfire prevention	Heinsohn 1991
Responsibilities and regulations	
Fire on Cape York Peninsula should be used under supervision	Young 1991
Traditional owners should have the responsibility for burning on their own land and be involved in management on lands outside their management	Parry and Clark 1991
Regulations need to be tighter	Trezise 1991
Rural Fires Board needs additional facilities and expertise	Trezise 1991
Government involvement in burning programs on private property is needed	Trezise 1991
Permits to burn at any time of the year should be replaced by a restriction on the period of burning	Stocker 1981
Changes in burning	
Grazier's fire practices are a continuation of Aboriginal burning practices	Trezise 1991
Control burning practices have declined in living memory	Trezise 1991
Late season wildfires have become more prevalent in living memory	Trezise 1991
Co-operation	
A regional, cross-sectional approach is required to formulate a fire strategy	Parry and Clark 1991; Trezise 1991
A wider understanding of fire would help to alleviate community disharmony about fire	McKeague and Wincen 1991
Diverse opinions about fire are held by many members of the community	McKeague and Wincen 1991
Co-ordination of fire management could be best met by the formation of a Cape York Peninsula Fire Service	Wattle Hills Rural Fire Brigade 1994

/cont.

Table 5.1 (cont.) Attitudes expressed or reported in publications dealing with fire on Cape York Peninsula

Optimum strategy	
A complete return to Aboriginal burning patterns may not be possible or appropriate	Harrington 1991; Stanton 1992; Roberts 1994
In the absence of information, burning should not be used	Heinsohn 1991
In the absence of information, a range of burning patterns should be tried	Harrington 1991; Stanton 1992
There should be less or no active burning on Cape York Peninsula	Fulloon 1991; Heinsohn 1991
Specifics of burning	
Month of burn should be varied to allow different species to recover	Young 1991
Late dry season fires (e.g. October fires) are undesirable or unacceptable	Fulloon 1991; Trezise 1991; Young 1991
Late dry season fires are probably required to maintain certain areas	Stanton 1992
Control burning needs to be carried out over several months	Trezise 1991
Burning should be at 2 yearly intervals, if at all	Young 1991
Fuel reduction	
Fuel reduction burning is the only way to avoid catastrophic wildfires	Stanton 1991
Fuel reduction burning can prevent late season wildfires	Trezise 1991
Fuel reduction is unacceptable in many or most cases	Fulloon 1991; Heinsohn 1991
Fire-fighting	
Fire-fighting has a limited role in fire management	Stanton 1991; Trezise 1991
Fire fighting is an important component of a fire management plan	Wattle Hills Rural Fire Brigade 1994
National Parks	
Fire exclusion should be the major or only strategy used on National Parks	Fulloon 1991; Heinsohn 1991
The area of National Parks burnt each year is appropriate	Stanton 1991
Limited fire breaks should be burnt on National Parks, but fuel-reduction burning is not acceptable	Heinsohn 1991
Only small areas should be burnt on National Parks to maintain biodiversity	Heinsohn 1991

/cont.

Table 5.1 (cont.) Attitudes expressed or reported in publications dealing with fire on Cape York Peninsula

Special requirements	
Habitats of rare birds on Cape York Peninsula should never be burnt	Young 1991
Early burns protect some areas that should not be burnt, such as swamps	Trezise 1991
Result of removal of fire	
Removal of fire would lead to a less fire-prone and more productive environment	Fulloon 1991; Lowry 1992
Removal of fire would lead to a highly fire-prone environment	Stanton 1991

Differences in attitude occur at three levels. The first is the lifestyle level. People may be comfortable with fire where it is an integral part of their lifestyle, such as in many Aboriginal communities, or they may feel uncomfortable in fire-blackened environments (Haynes 1991; Head in prep.). The second level is the attitude to the mechanics of fire. People may object to its destructive potential and feel that it is inappropriate for people to use such a weapon against the environment (Fulloon 1991), while others see fire as having regenerative capacities (Harrington 1991). The third level concerns the land use objectives for which fire is to be used. For example, there is disagreement whether National Parks should be used to maintain habitats or protect life (Section 7.2), and whether or not grazing is a valid land use for Cape York Peninsula (Meaney 1991). There may also be internal inconsistency in the attitudes held by an individual, such that a person may believe that biodiversity should be maintained, but not feel comfortable with the use of fire to do this.

Attempts to align any opinion with particular community sectors from such a survey would be inaccurate and incomplete (Hall 1972). However, publications quoted in the survey highlight the fact that attitudes to fire vary both between and within identifiable sections of the community. For example, opponents to fire often cite conservation as the reason (Heinsohn 1991), but many people concerned with conservation are either supportive of the use of fire (Harrington 1991; Stanton 1991) or feel they do not have enough information to take fixed positions (J. Downey pers. comm.). Similarly while there is wide acceptance of the use of fire in the pastoral industry (Wincen and McKeague 1991), there are pastoralists who feel this acceptance is misplaced (D. Hurse pers. comm.).

Differences in attitudes to fire arise from differences in experience, responsibility, objectives, education and available information (Glascock 1972; Hall 1972; Mount 1989). The influence of direct experience is eloquently described by Trezise (1991) who, several years after settling on Cape York Peninsula with an abhorrence of fire, came to see it as an important tool in land management. Other new settlers have experienced similar shifts in attitudes, even if they do not embrace fire as whole-heartedly (Trezise 1991; Stanton 1992). Discomfort with fire may be more pronounced in people from outside tropical Australia, especially if they come from areas where there have been devastating wildfires (Lewis 1989; Press 1989; Ritchie and Collins 1994).

Trezise's shift in attitude partly arose from observing how fire behaves and affects the environment, but also from the responsibility of having to make viable land use decisions. These considerations have also affected the attitudes of other land managers, particularly on National Parks (Stanton 1991, 1994). Those who do not have the responsibility of land management may be more concerned about immediate loss of trees and wildlife caused by fire than its long term land management capabilities (Shea 1989; Fulloon 1991; Heinsohn 1991; Meaney 1991; Stanton 1991; Young 1991). Inclusion of the public in the development of fire management policies may lead to greater public acceptance of the use of fire for specific objectives (Llewellyn 1989; Shea 1989). Both pastoralists and National Park managers on Cape York Peninsula are primarily concerned with maintaining biological systems in which fire is a part (Chapter 6). However, faced with different objectives, such as the promotion of rainforests, fire may not be seen as appropriate (Fulloon 1991).

Both formal and informal education has had a large part in affecting people's opinions. People may be influenced by media reports of fire which frequently highlight destruction of life and property. The teaching and communication of vegetation science derived from European and American experience may also bring with it the belief that "climax" vegetation can only develop properly in the absence of disturbances such as fire (Mount 1989), although the large body of research into Australian ecosystems is countering that view (Gill et al. 1991).

Finally, where there is least information on fire and its effects there is greatest latitude for different attitudes. This report has highlighted the lack of documentation of all aspects of fire on Cape York Peninsula, and there is concern that management decisions are made in the absence of adequate information (Heinsohn 1991). There is also the problem of the form the information takes. Information of an informal, anecdotal or cultural origin may not be given the credence of that from the scientific literature, particularly when it is held by people of different cultures and experience (Lewis 1989). In the Northern Territory, the accumulation of scientific research examining the effects of fire has helped to validate the Aboriginal approach to fire management (Lewis 1989) and a wider acceptance of the role of burning in land management (Price 1989).

Previous surveys of attitudes to fire have concentrated on the attitudes of "fire-bugs" who have been apprehended for illegally lighting fires (Glascock 1972). The motivations of such people has been shown to vary from negligence to perpetration of wilful damage. In both cases the low probability of being caught and prosecuted is a significant factor in their decision to burn (Glascock 1972).

Conflict over the role of fire in land management on Cape York Peninsula will affect the level of agreement that could be reached in formulating policies for the region. It is therefore important to determine where conflicts can be addressed by compromise or consensus positions. Differences in opinion regarding adequacy of training and information could probably be obviated by higher levels of training and research, and conflicts between fire use on neighbouring properties could be alleviated by adequate firebreaks.

The degree of consensus in fire management will be affected by issues other than attitudes to fire itself. For example, Aboriginal people residing on pastoral leases in the Northern Territory are constrained to burning at times acceptable to the pastoralists, at least in part because of the uncertainty of the legality of their tenure (Head et al. 1992; O'Neill et al.

1993). Consensus over fire policy formulation will also be influenced by attitudes regarding the legitimacy of different land uses. It seems unlikely that people with the opinion that the pastoral industry has no place on Cape York Peninsula (c.f. Meaney 1991) will be in a position to negotiate a co-operative fire management policy with representatives of the pastoral industry. The co-operative approach to land management exhibited in CYPLUS working group meetings may, however, provide a successful venue for achieving a co-ordinated fire management policy.

Table 5.2	**Attitudes to burning - Key points**
•	A broad spectrum of opinions regarding fire are held in the community.
•	Fire is viewed as anything from anathema to essential to land management.
•	Attitudes to fire vary at the level of personal comfort, mechanics of fire and land use objectives.
•	A person's attitude to fire will be influenced by personal experience, responsibilities, objectives, education and available information.
•	A wide range of opinions about fire may lead to conflict but the potential for conflict could be reduced by more information on fire behaviour and the effects of fire on Cape York Peninsula.
•	Co-operation in fire management will be governed by other issues of land use conflict.

6 THE USE OF FIRE IN LAND MANAGEMENT

6.1 Introduction

Land tenure on Cape York Peninsula is held by three principle groups: Aboriginal communities, cattle producers and the National Parks and Wildlife Service. The management objectives and methods of each of these groups differ, yet each uses fire for particular reasons. Aboriginal people use their land for a variety of purposes which have changed through time, along with the use of fire. Cattle producers objectives may have remained the same through their century of occupancy, but the techniques employed have varied. Similarly management of fire on National Parks has evolved considerably since the initial purchases of land in the 1970s. Thus the description of the use of fire in these land use systems below is one of changing patterns.

Though there is more information available on fire used in land management on Cape York Peninsula than for most other aspects of fire, there is still a need for more primary information to be collected in many areas, particularly for indigenous usage of fire. In its absence, material from elsewhere in Australia, principally Northern Australia, has been used to construct scenarios for the Peninsula. In both cattle production and National Park management decisions to burn are made more on personal experience than on documented research findings. In much of the research that has been undertaken examining burning for cattle production, stocking rates used have been far greater than used in extensive cattle management on the Peninsula. Hence there is the need for research on fire effects on the Peninsula that is targeted at the levels of production currently supported, as well as for the conservation of biological systems which need to be protected. The simplest and most practical method of doing this is to monitor of the effects of management systems already in place.

Other land uses may gain increasing significance on the Peninsula, among them tourism. The interactions of tourists with fire are problematic. As the chapter on attitudes indicates a wide variety of responses to fire is held in the community and this will be reflected in the tourists visiting the area. Tourists may be attracted to the spectacle of a blaze (Ritchie and Collins 1994), but find burnt country uninteresting or threatening (Lewis 1989). Such attitudes may conceivably affect visitation rates, and there is certainly scope for interpretation of fire which will enhance tourists' appreciation of the ecosystems of Cape York Peninsula. However, tourists do not manage lands, though they may be held responsible for unwanted fires. At present management of fire for the tourist industry on the Peninsula is restricted to the small amount of burning on National Parks that is required to ensure tourists' safety.

6.2 Indigenous use of fire

There is a paucity of documentation regarding indigenous fire management on Cape York Peninsula, with the only published material relating to the Wik Munkan people (Thomson 1939), although a study of the use of fire by Wujal Wujal people has recently been undertaken (N. Williams pers. comm.). A smattering of largely anecdotal material is found in the writings of early European explorers and anthropologists on the Peninsula whose main interests lay elsewhere. Such information is combined with information from outside the Peninsula to provide a model of Aboriginal burning patterns, and whose application can be tested against future work undertaken within Aboriginal and Islander communities, such as that currently underway in the Injinoo community (Roberts 1994).

Even less is known about the burning practices of Torres Strait Islanders. Although the use of fire is restricted to garden preparation on some islands (M. Fuary pers. comm.), Islanders on Badu Island burn flammable vegetation on an annual basis (Draffan et al. 1983; Garnett and Jackes 1983) and use fire in the hunting of pigs (S.T. Garnett pers. comm.). Differences to mainland Australia are likely because of both cultural differences and an ecological setting in which many species, notably wallabies and kangaroos are absent.

There are many reasons for assuming that Aboriginal burning practices on Cape York had, and still have, much in common with those from elsewhere in northern Australia. They can be categorized as follows:

(1) Climatic conditions are broadly similar across the northern tropics (Dick 1975), although the Peninsula includes environments at the wetter end of the spectrum (Chapter 3).
(2) There are broad similarities in vegetation communities, although the vegetation of the wetter areas of the Peninsula is more diverse and mesic (Pedley and Isbell 1971; Anning 1980; Bowman 1988).
(3) The perceptions of environments and use of resources by Aboriginal people are consistent across northern Australia (Jones 1980; Stevenson 1985).
(4) Perceptions of season largely follow patterns of rainfall on Cape York Peninsula and in the Northern Territory (Chase and Sutton 1981; Jones 1980; Haynes 1985, 1991; Lewis 1985, 1989), although the emphasis given to temperatures at inland Kakadu (Haynes 1985) has not been recorded on the Peninsula (Thomson 1939; Chase and Sutton 1981).
(5) Other aspects of Aboriginal culture, including technologies for making fire (Nicholson 1981), and at least some reasons for burning (Table 6.1), show consistency across northern Australia.
(6) Displacement from traditional lands, restrictions to movement and actions, involvement in the cattle industry and westernization of lifestyles and diet have occurred to a similar extent across much of northern Australia.

The main differences noted above arise from the existence on Cape York Peninsula of wetter environments than are found in northwestern Australia. Such areas contain resource-rich rainforest associations that are readily used by the local people. However, it is the presence of these communities, rather than cultural differences, that explains Aboriginal use of them (Jones 1980).

The following discussion deals with what is known of Aboriginal fire cultures in northern Australia whether or not it has been influenced by western ways. While it is valuable to establish how Aboriginal people used and viewed fire at the time of first contact with Europeans, a simple dichotomy between "traditional" and "non-traditional" fire practices does not exist. Instead there has been a continuum of evolving patterns (Anderson 1980; Chase 1980; Head in prep.).

Aboriginal burning in northeastern Australia goes back at least 40,000 years (Singh et al. 1981; Kershaw 1985), and possibly beyond 100,000 years (Kershaw et al. 1993). It seems likely that a highly seasonal climate coupled with a eucalypt-dominated landscape prevailed across most of northern Australia throughout this period (Hopkins et al. 1990; Luly 1994), and that Aboriginal people evolved burning regimes in response to environmental conditions as they changed through time (Head in prep.). The advent of Aboriginal burning is believed to have had significant impact on the Australian environment, not only in altering the vegetation, but in increasing erosion rates which would have led to declines in soil fertility (Hughes and Sullivan 1981, 1986; Kershaw 1989; Flannery 1994). In the recent past, however, Aboriginal fire appears to have had a protective and sustaining role for many habitat types (Dunlop and Webb 1991; Bowman and Panton 1993b).

Aboriginal burning has been documented as being attuned to climatic conditions which are identified from environmental cues (Thomson 1939; Jones 1980; Lewis 1985). The number of seasons and their identification varies between areas, and as each season requires a different approach to burning, this means a number of dialects of fire practices exist (Haynes 1991). Nevertheless, similar modes of propagation and outcomes of fire are reported from across the northern part of the continent.

The fire management of different habitat types by Aborigines is largely concerned with the optimization of resources (Jones 1980; Haynes 1985; Stevenson 1985; Lewis 1989; Head et al. 1992; Table 6.1), and appears to have resulted in maximizing habitat diversity (Bolton and Latz 1978; Latz and Griffin 1978; Hallam 1975; Braithwaite 1994). This does not mean that Aboriginal people intentionally undertake long term manipulation of the environment for conservation or any other purpose (Dwyer 1994; Barnes and Shelton 1994), only that burning practices used are likely to preserve or increase resources that are important to them. This may be ensured by conventions which dictate that certain habitats may only be burnt in certain ways. For example, traditions of the Gunei people prohibit the burning of open forests that provide fruit and flowers for people, possums and bats until the arrival of cool weather that prevents canopy scorch and excessive spread of fires (Haynes 1985). Also, fires are not permitted in some areas before the harvest of yams (Thomson 1949). There are stories in Aboriginal cultures that explain burning practices and dictate the ways in which certain places and habitats are burnt. These include beliefs that people will be punished for burning places that should not be burnt (Jones 1980) and rituals that dictate how an area must be burnt and cleansed (Haynes 1991).

Fires are lit to gain access to foods such as yams, goannas or buried tortoises (Russell-Smith and Dunlop 1987; Lewis 1989; Lucas and Lucas 1993.), or to flush out and trap animals such as kangaroos or lizards (Gould 1970; Hallam 1975, 1985; Jones 1980; Lewis 1985, 1989). Fire is also used to attract food animals, with swamps being burnt to attract kangaroos and wallabies, possibly several times through the year as each part dries out. Burning of swamps to enhance nesting habitat of Magpie Geese has also been reported (Lewis 1989).

Table 6.1 **Uses of fire in Aboriginal cultures**
* Documentation for Cape York Peninsula

Use	References
Resource management	
Cleaning-up the country (e.g. clearing away old grass, suckers etc)	de Graaf 1975; Jones 1980; Haynes 1985, 1991; Lewis 1985, 1991; Lucas and Lucas 1993; Head in prep.
Opening the landscape to assist travelling and improve visibility	Stocker 1966; Hallam 1985; Parry and Clark 1991; Head in prep.
Gaining access to food and other resources	Hallam 1985; Lucas and Lucas 1993; Head in prep.
Increasing abundance of plant foods	Lewis 1985
Producing "green pick" to attract animals	Stocker 1966; Jones 1969; Hallam 1985; Lewis 1989; Haynes 1991; *Roberts 1994
Trapping and killing food animals	*Thomson 1939; Stocker 1966; Gould 1970; Hallam 1975, 1985; Jones 1980; Lewis 1985, 1989; *Roberts 1994
Promoting new growth, particularly of yams	Jones 1980; *Parry and Clark 1991;* Roberts 1994; Head in prep.
Protecting fire sensitive habitats and fruit trees	Haynes 1985; Lewis 1985; *Roberts 1994
Felling trees for canoes and sugar bag	*Roberts 1994
Altering or maintaining animal habitat	Lewis 1985
Protecting food resources in the canopy	Lewis 1989; Lucas and Lucas 1993
Preventing later fires escaping	Lewis 1989; Lucas and Lucas 1993
Reducing fuel	Hallam 1985; Lewis 1985; Lucas and Lucas 1993
Clearing around campsites and settlements	Jones 1969, 1980; Lewis 1985, 1989; Lucas and Lucas 1993; Head in prep.
Managing cattle	Lewis 1989
Other cultural reasons	
Signalling	Jones 1969
Enjoyment	Jones 1969; Lewis 1985
Aggression/defence/retaliation	Carron 1849; Beaglehole 1968; Haynes 1978; Hallam 1975, Nicholson 1981
Cleaning an area after a death	Head 1993
Collecting ash to chew with tobacco	Head _et al._ 1992

Decisions to burn are also made in response to the accumulation of fuel and undergrowth, a practice that is called "cleaning up the country" (de Graaf 1975; Jones 1980). This has been interpreted as a strong desire to imprint a human signature on the landscape arising from a view intrinsic to Aboriginal cultures that burnt ground is clean (Haynes 1991; Head 1994). "Cleaning up the country" is seen as a responsibility but is also an enculturated response to an environment which appears cluttered, untidy and claustrophobic (Jones 1980; Haynes 1985, 1991; Lewis 1985, 1991; Head in prep.). It is also likely to have arisen from a realization that unburnt country does not support important resources (de Graaf 1975) and from a desire to remove the difficulties of walking naked through vegetation in which there may be blady grass, snakes, wasps, or possible aggressors (V. Sinnamon pers. comm.). Fires are lit to clear around campsites and settlements to provide more secure living conditions by removing cover for snakes and habitat for mosquitoes (Jones 1980; Lewis 1989; Head in prep.). Fires are used to clear pathways to enable people to travel more easily through the country by foot or by car (Hallam 1985; Head in prep.). Other reasons for burning include both spiritual and social reasons, such as acts of defence or aggression, celebration or mourning (Table 6.1).

Different habitat types are burnt in different ways. Some habitats are rarely burnt (e.g. rainforests and paperbark swamps), some are burnt regularly (e.g. eucalypt open forests and woodland), and others may be burnt repeatedly in the one year (floodplains and seasonal swamps). Areas around habitats that need protection are burnt early when the chances of fires penetrating them are low (Haynes 1985) or may be burnt with very mild burns, when litter accumulation gets to undesirable levels, again at a time when risks of damage are negligible (Russell-Smith and Dunlop 1987; Lewis 1989).

Aboriginal burning in northern Australia has been reported as being carried out through most of the year whenever ignition is possible. This period extends between about March and early January, but will vary between places and years according to the moisture of the ground cover (Jones 1975; MacDonald 1988, Braithwaite 1991; Sinnamon pers. comm.). Fire frequency in the Top End of the Northern Territory appears to increase until the end of July, with a second peak being recorded around storm time of October to December when at least some fires will be ignited by lightning (Haynes 1985; Lewis 1989; Braithwaite 1991). Fires may still be used in the late dry season for specific purposes, such as to attract or trap and kill animal foods, especially along drainage lines where there is enough moisture to produce "green pick" (Lewis 1989; Braithwaite 1991). Wet season burns, though considered uncommon, are also undertaken for specific purposes, such as clearing camp sites (Lewis 1989).

There is ample evidence to indicate an extended period of active burning on Cape York Peninsula. Early European explorers recorded Aboriginal people lighting fires from May to November (Heeres 1899; Carron 1849; Hann 1873; Jack 1922). Thomson (1939) recorded Wik Monkan people starting to burn in the early dry season and systematically burning grassed areas between late July and early October. During the storm time (October to December) fires were lit to ambush wallabies and kangaroos. Only in the wet season proper, in which the fuels are too moist to burn, were fires not lit. A "burngrass" season is recognised by contemporary Injinoo people, but details of burning patterns have been lost (Roberts 1994).

On Cape York Peninsula small residential groups have been recorded as banding together to burn specific tracts of land (Rigsby 1980). Burning may be undertaken differently by men and women using fire in relation to their daily activities (Hallam 1975). Aboriginal fires in the Top End are reported as being of limited extent, of having a low scorch height, of being burnt through much of the year and as resulting in a mosaic of different-aged burns in which about half the area remains unburnt in any year (Haynes 1985; Lewis 1985, 1989). Deviations from these patterns are explained by a failure to observe proper burning practices, rather than as being a component of them (Haynes 1985; Lewis 1989).

Intentional burning practices undertaken by Aborigines have been reported as leaving at least half of the country unburnt (Haynes 1985; Lewis 1985, 1989; O'Neill et al. 1993). However, the amount burnt varies between habitats (J. Russell-Smith pers. comm.). Parts of the Peninsula appear to have been burnt more extensively as early European explorers sometimes travelled for days over burnt ground late in the year (Jack 1922).

Control of fires is exercised by timing and placement of burns, lighting fires under predictable wind conditions, post-fire regeneration (to control for fuel conditions) and, in specific circumstances, by fire-fighting (Stocker 1966; Lewis 1989). In the early dry season burns are limited to small areas as fuels may be moist and partially cured and therefore of low flammability. Burn areas are also restricted by lighting them well into the day, leaving only a few hours in which the fire can burn before the dew falls and the wind drops. Later fires are limited in area by a combination of natural barriers and barriers created by earlier burns (Haynes 1985; Lewis 1989). In some cases control may be a by-product of Aboriginal burning patterns, but in others it is intentional (Lewis 1989; Lucas and Lucas 1993). For example, the edges of the swamps may be burnt as soon as the grasses cure to prevent later, dry season fires on the swamp escaping to unburnt areas outside the swamp (Lewis 1989). It is nevertheless likely that some fires escape beyond target areas, particularly when unusual climatic conditions prevail.

Interruption to Aboriginal burning patterns on Cape York Peninsula, and elsewhere in northern Australia, commenced in the late 19th century as the Aboriginal population living in traditional settings declined because of death, disease and displacement, and the management of the land was assumed by white pastoralists (Stanton 1976; Press 1987; Rigsby 1992). Movement of Aboriginal people off their land did not occur in one period alone but was episodic, with forced removals having commenced in the early years of the century and continuing until quite recently (Rigsby 1992). This started with atrocities against Aboriginal people during the Palmer river gold rush in 1872 and the establishment of missions in the 1890s and 1900s (Stanton 1976). Across northern Australia many Aboriginal people worked on cattle stations as stock hands or domestic workers, which ensured some continuity of contact with their traditional lands (Coombs et al. 1990/1; O'Neill et al. 1993), and Aboriginal use of fire was to a degree viewed as compatible with that of pastoralists (Head 1994). Aboriginal people were also actively discouraged from using fire by the Native Mounted Police (Rigsby 1981). Aboriginal involvement on cattle stations declined during the 1960s and 1970s with structural changes in the cattle industry and introduction of award wages for Aboriginal workers (O'Neill et al. 1993). These patterns of decline are now being reversed. The 1990s have seen the purchase of a number of properties by and on behalf of Aboriginal communities, returning to them the role of land managers on Cape York Peninsula. The involvement of Aboriginal people in the management of National Parks, many of which are in the process of being claimed as Aboriginal land, may also provide management responsibilities to Aboriginal people. Thus Aboriginal involvement in land management on Cape York Peninsula possibly reached a trough in the 1970s and 1980s, from which it is now recovering.

Over the past century, declining involvement with the land have led to changes in Aboriginal people's use of fire. A return to the land has not automatically bought with it a return to old burning regimes. Studies in the Northern Territory have shown that particular burning practices are more likely to have been discarded while others tend to be maintained or re-introduced when the right to burn is regained (Head in prep.). Management and collection of plant food resources is presently less important because of an increasing reliance on shop-bought foods (Haynes 1991; Head in prep.), while burning skills associated with cattle management have acquired significance (Lewis 1989). Of the many reasons for burning "cleaning up the country" is the most resilient (Haynes 1985, 1991; Head 1994), and "clean up" burns of "dirty" country are likely to be undertaken regardless of other ecological factors (Haynes 1985; Lewis 1989; Head 1994). With a currently less mobile population and a lower population density, less accessible areas that would have been burnt under traditional management may not be either visited or burnt regularly (Haynes 1991). Burning seems to be undertaken most actively around settlements and outstations (Press 1988; O'Neill et al. 1993). This means that under contemporary Aboriginal management large areas may be exposed to late dry season fires (Press 1988; Bowman et al. 1990; Haynes 1991; Head 1994).

Where Aboriginal people share occupancy of land with pastoralists in the east Kimberley they show restraint about burning late in the year to avoid conflict with pastoralists (O'Neill et al. 1993; Head in prep.). It appears such restraint partly arises from a fear of being thought of as "pyromaniacs", although their uncertain tenure on the land must also be a factor (Head in prep.). In other respects, Aboriginal burning in the east Kimberley is indistinguishable from that of pastoralists, and fires still appear to be predominantly of low intensity (O'Neill et al. 1993; Head 1994).

The above descriptions indicate that there is a high degree of intention in the burning practised by indigenous Australians, both in the control of fire behaviour and its environmental consequences, and that these features are carried into contemporary management. It seems clear that Aboriginal people have a strong awareness of the reasons for burning, whether they be of an ecological or cultural nature (Lewis 1985). They may not always be in a position to undertake burning according to accepted practices, and many members of the communities may now have limited knowledge of appropriate fire management practices. It has been pointed out that Aboriginal people may not actively ascribe management aims to their actions (Stevenson 1985) and their management has been described as "de facto" (Jones 1980). However, this cannot negate the wealth of information reviewed here that shows Aboriginal people often use fire with intent, under control and reap the rewards. Loss of information, or of the need to practice some aspects of more "traditional" burning practices, may have occurred to varying degrees in many communities. The degree of skill and care described for some groups may therefore not be maintained across all communities. Fire management and education form an important part of management strategies currently being developed on Aboriginal lands (Roberts 1994; Kowanyama Aboriginal Land and Natural Resources Management Office 1994) and in some communities there are moves afoot to form co-ordinated emergency services groups, whose functions will include fire management (B. Cifuentes pers. comm.). Opportunities to recover information on the old ways are fast disappearing (Rigsby and Williams 1991; Roberts 1994). Knowledge of fire in Aboriginal communities tends to be held by older members of the community (Lewis 1989) and it is not uncommon for reports of Aboriginal culture to acknowledge informants who have recently died as having provided the bulk of the information (e.g. Head 1994). This provides great urgency if material comparable to that collected elsewhere in Australia is to be assembled for the communities on Cape York Peninsula. Aboriginal people may be unwilling to provide accurate information on fire practices, especially where they consider it may be used against their interests (Haynes 1991), but this problem would be overcome where information is collected within and for the use of Aboriginal communities (e.g. Roberts 1994).

Fire will continue to play a role in meeting the needs and aspirations of Aboriginal people. However, even if a return to the old ways of burning is found to be desirable for ecological purposes, it is unlikely to be met by a return to old lifestyles (Stanton 1992). Nevertheless, Aboriginal people still see themselves as of, and responsible for, their traditional lands, even where they have had infrequent access to them (Chase 1980). This perception of responsibility extends to fire management, and co-management of such lands has been mooted (Parry and Clark 1991). To a limited degree, Aboriginal people practise fire management on non-Aboriginal lands on which they live in the Northern Territory (Press 1987; O'Neill et al. 1993), although their legal rights to do so are far from clear. There are presently no provisions for such joint management on Cape York Peninsula.

6.3 Nature conservation

Nature conservation is the principal concern of National Parks on Cape York Peninsula but is also an important land use on areas outside gazetted parks, including on private land. There is perhaps more dissension about the best approach to fire management for nature conservation purposes than for any other land use. Indeed the definition of nature conservation is a matter of dispute. For some the protection of life is paramount and damage to individual animals and plants is abhorred (Fulloon 1991; Heinsohn 1991; Young 1991). This leads to a dislike of fire and its destructive potential. Another argument against using fire as a management tool is that human intervention into ecosystem functioning is undesirable (Fulloon 1989). Thus all but lightning- ignited fires are viewed as unnatural. These attitudes lead to an emphasis on fire prevention and fire-fighting, with a varying acceptance of fuel reduction burning as a necessary evil. One proposed means for implementing such a program on Cape York Peninsula is the formation of local fire brigades whose roles would include education, research, fire break formation and enforcement of regulations (Wattle Hills Rural Fire Brigade 1994). Formation of fire breaks would include widening of roads, slashing roadsides and planting of fire-resistant species, and using some, cool prescribed burns.

The other approach to nature conservation is the maintenance of biodiversity, at both the species level and the ecosystem level. This is an over-riding principle of National Park management in Queensland (Claus 1990). Management of National Parks on Cape York Peninsula seeks to maintain habitat diversity, and, where possible, to reinstate former habitats where recent diminution is evident (Stanton 1992). Duff and Braithwaite (1990) describe three alternative fire management regimes which have been proposed for maintenance of natural tropical ecosystems: (1) reinstatement of Aboriginal burning regimes, (2) widespread, low intensity, early dry season burning, and (3) burning through the year with a diversity of intensities and frequencies. Each system should help minimize the spread of fires in the late dry season. However the choice of system has important implications for nature conservation.

Aboriginal burning patterns allowed the persistence of the major environmental features found on Cape York Peninsula at the start of the century, and may have had a role in their creation (Chapter 4). A return to such regimes should therefore result in their conservation. However recreation of such regimes in the absence of adequate documentation is unlikely to be possible (Andersen and Braithwaite 1992) and environmental change that has occurred in the last century may not be reversible using Aboriginal burning patterns alone (Chapter 4; Stanton 1992).

Restricting burning to the early dry season can be simply executed. But assumptions that this leads to non-destructive fires are over-simplistic (Braithwaite 1994). Early fires may damage plants that are still actively growing (Scattini et al. 1988; P.A. Werner in Braithwaite 1994), and destroy insect larvae (D. Sands pers. comm.), as well as seeds that have not yet fallen (Crowley and Garnett unpubl. data). Because they tend to be patchy, early dry season fires allow maximum recruitment of seedlings and saplings to the canopy (Braithwaite 1994). Elsewhere in this report thickening up of the understorey is identified as an adverse feature of recent fire management regimes on Cape York Peninsula. Burning in the early dry season is unlikely to address this problem adequately.

Progressive burning through the year allows early burns to be put in place to break up the fuel load and hotter, late fires to be used for habitat modification purposes, such as thinning out invading rainforest understoreys and reclaiming grasslands from invading ti-trees (J.P. Stanton pers. comm.). A progression of burns along swamps and floodplains as these dry out through the year provides feed for herbivores. However, this system carries with it the risk that later fires will escape to non-target areas, particularly to neighbouring properties where fuel reduction burning may be minimal.

Although burning on National Parks on Cape York Peninsula is not entirely progressive, it includes components of early burning for fuel reduction and fire-break creation, late dry season burns for habitat modification, and some early wet season burns for weed control (Shaw 1994; Brake 1994b; Stanton 1992; Table 6.2). This pattern of burning represents a shift away from earlier policies, initially of fire-exclusion, and then of restricting fires to periods when cool burns would be assured (Stanton 1991; 1992). The inclusion of early burns arose from the realization of the increased likelihood of wildfires in their absence, and the more recent inclusion of burns in the late dry and early wet seasons is an attempt to assure retention and reclamation of grassland and eucalypt forests and for control of introduced weeds (Stanton 1992). The current approach is based on a belief that a return to a fire regime similar to that used by Aboriginal people may be required to maintain habitats (Stanton 1992).

The need for these changes in strategies highlights the lack of biological information that has been available to produce adequate fire management strategies on National Parks in the area (Press 1989; Claus 1990; Stanton 1990). Indeed the selection of areas for burning early in the dry season is generally based on satellite photographic assessment of fuel load (Saxon and Rees 1990) rather than on biological indicators. This situation is beginning to be addressed actively with the commencement of programs designed to examine the effects of fires on plant and animals both on and off conservation reserves, and passively with the assimilation of relevant research from similar areas such as the Top End of the Northern Territory.

Thus while the overall fire management strategy used at present is aimed at biological management, the main operational reasons for using fire on National Parks on Cape York Peninsula include fuel reduction, infrastructure protection, habitat manipulation, feral animal control, weed control and boundary definition (Table 6.2). Further environmental considerations of the burning programs include the necessity for watershed protection and erosion prevention (Claus 1990; Stanton 1992).

For each conservation reserve on Cape York Peninsula a fire management plan is formulated, implemented and assessed annually (Skull 1994; P. Harris pers. comm.). The plans detail the rationale for burning, the designated areas of burn and a timetable for implementation. Traditional owners and neighbours are informed of dates of proposed burning activity and their involvement invited where appropriate (Shaw 1994). Where grazing licences exist on National Parks, licensees are included in discussions of burning programs, and sometimes in their implementation (Saxon and Rees 1990). The role traditional owners will play when many of the parks become Aboriginal land is unclear, although those employed as Community rangers are already involved at an operational level. In Kakadu National Park the traditional owners undertake fire management in the small areas intensively used by them for living, hunting and gathering (Press 1987). They are also consulted with regards to the fire management of other sections of the Park (J. Russell-Smith pers. comm.).

Table 6.2 Summary of reasons for burning in National Park management on Cape York Peninsula

Conservation related reasons	
Preservation of biodiversity	Claus 1990
Preservation of endangered species and communities	Claus 1990; Stanton 1992, 1994; Shaw 1994
Weed control	Saxon and Rees 1990
Habitat maintenance	Saxon and Rees 1990; Shaw 1994
Protecting fire sensitive habitats	Shaw 1994
Reducing likelihood of late dry season fires	Saxon and Rees 1990; Shaw 1994
Preservation of physical landscape	Claus 1990
Protection of hollow trees used for nesting	Brake 1994b
Other management related reasons	
Infrastructure and property protection	Claus 1990; Saxon and Rees 1990; Brake 1994b; Shaw 1994
Human safety	Claus 1990; Saxon and Rees 1990; Shaw 1994
Stock management using production of "green pick"	Saxon and Rees 1990; Shaw 1994
Preventing fires entering or leaving park areas and maintaining good relations with neighbours	Claus 1990; Shaw 1994
Fuel reduction	Shaw 1994

Infrastructure protection is usually amongst the first burning undertaken in the dry season, and involves tractor slashing of grass before it sets seed and following with cool burns two to three weeks later (Saxon and Rees 1990; Shaw 1994). These generally cover small areas, but may extend hundreds of kilometres along fence lines. The woodlands and grasslands are burnt in a broad mosaic pattern, with the aim of burning a third to a half of the habitat each year (Saxon and Rees 1990). The areas burnt each year and the timing of burns is determined by previous fire history in terms of fuel load, the state of grass curing and drying and the distribution of natural and artificial fire breaks. Early dry season burning of these areas is undertaken when grasses are 60-70% cured, with afternoon burns, and when the wind is at 10 knots or less (Saxon and Rees 1990). Burning of these habitats for fuel reduction, infrastructure protection, feral animal control and boundary definition is generally undertaken on Rokeby and Archer Bend National Parks around May to July (Shaw 1994; Table 6.2). Such burning is not possible until later in the year on Iron Range National Park, and depending on conditions, has been undertaken between August and October (Brake 1994b). Burning used to reduce rainforest and ti-tree invasions ascertained from areal photographic and other evidence has been undertaken around the time of the first storms in October or November in Lakefield, Rokeby and Iron Range National Parks (Brake 1994b; Shaw 1994; J.P. Stanton pers. comm.; Table 6.2). Rubber vine Cryptostegia grandiflora is controlled by burning when fuel loads are in a condition to produce hot fires (Stanton 1992). Grader grass Themeda quadrivalvis is reduced either by fire prevention for several years or by fires which destroy seedlings in the early wet season (Bishop 1981; Stanton 1992). Wildfires may be left to burn where adequate breaks are in place, or back-burning may be used to restrict their spread (Brake 1994a; Shaw 1994).

The main method of burning is the use of drip torches from four wheel drive vehicles, followed up by aerial ignition from a helicopter (Luxton 1990; Saxon and Rees 1990; Teece 1993). Safety of staff and visitors is ensured by following strict safety precautions (Saxon and Rees 1990).

Success is largely measured by the completeness of burn, and a visual assessment of resultant vegetation structure (Shaw 1994; Brake 1994a). Thus only broad patterns of vegetation are monitored, and details of the response of individual species have not been monitored. These short-comings are acknowledged (Batt 1994; Warriner Laurance 1994), and result from the rapid increase in National Park Estate over the last two decades in advance of provision of staff, resources, funding and training (Saxon and Rees 1990). A recent workshop identified the need for more detailed monitoring of fires on National Parks to assist in the prediction of fire behaviour and to determine response of species and habitats to different fire regimes and thereby enable the designation of appropriate fire regimes (Batt 1994; Skull 1994; Warriner Laurance 1994).

Studies are also being undertaken outside National Parks by the Department of Environment and Heritage to assess the effect of fire regimes on species of conservation significance (Garnett and Crowley 1994b). These studies are highlighting the importance of using fire to control ti-tree invasions of grassland and of early wet season burning to assist the survival of the endangered Golden-shouldered Parrot Psephotus chrysopterygius. Such burning regimes have been in place for many decades on some properties on Cape York Peninsula as part of routine cattle management practices, resulting in those properties having high conservation value. Managers of some other properties have also expressed interest in altering their burning patterns to assist in the recovery of Golden-shouldered Parrots, even where this may mean making adjustments to previous development plans. It is envisaged that these burning practices will also benefit other species of conservation significance.

6.4 Cattle grazing

Cattle have been grazed on Cape York Peninsula since 1865 (Stanton 1976), but many pastoral leases were not taken up until around the turn of the century (Pike 1983). Cattle numbers are estimated to be about 100,000 head with an annual turnoff of 16,000 head, although the industry plans to expand those numbers ten-fold with the selected use of clearing, supplementation and sown pastures (Wincen 1993). Each property also runs a plant of horses and may have sundry other domestic animals. Cattle grazing on Cape York Peninsula is principally based on native pastures supplemented with licks and limited areas of sown pastures (Anning 1980). Cattle husbandry frequently involves mustering of free-ranging cattle over unfenced properties, though many properties now depend more on fenced paddocks (Anning 1980). Stocking rates are low because of poor herbage quality, being quoted as between 20-50 ha per beast (Anning 1980; Mott and Tothill 1984; McKeague and Wincen 1991). Turn-off times of 5 to 8 years have been reported for the region (Anning 1980; Mott and Tothill 1984), but are now considered to be shorter (G. Cotter pers. comm.). Cattle are sold as stores through most years, or as fat cattle in the better seasons (Mott and Tothill 1984).

The use of fire in the cattle industry across northern Australia has been well documented (Davis 1959; Smith 1960; Tothill 1971; Mott 1981; Pressland et al. 1981; Pressland 1982; Anderson et al. 1988; McKeague and Wincen 1991; Table 6.3). Though many publications deal with Cape York Peninsula to varying extents and the broad principles of burning are known, there is yet to be a thorough documentation of the extent to which fire is used and the variations between properties.

Fire was undoubtedly used by pastoralists on Cape York Peninsula from the early years of cattle grazing. Early European explorers recognized the palatability of the recently burnt grasses (Hann 1873) and had the opportunity to observe use of fire by the traditional inhabitants (Lewis 1985). Burning on pastoral properties in northern Australia was often done by Aboriginal stockmen, and it is likely that traditional knowledge influenced burning patterns (Lewis 1985; Arlidge 1993). However, fires were clearly burnt for cattle management, with the burning by Aboriginal people for other purposes sometimes actively discouraged (Rigsby 1981). The principal reasons for burning on Cape York Peninsula cattle properties have been described as maintenance of feed through the dry season (Davis 1959) and assisting cattle control and cattle hunting (McKeague and Wincen 1991).

The importance of fire for different roles varies from area to area and year to year, depending on environmental conditions. For example, increasing visibility for mustering is more important in the tall native sorghum pastures in the north of the region (McKeague and Wincen 1991) than in the shorter fire-grass pastures further south. Variation in soil moisture status across the region also influences the extent to which fires are burnt for "green pick". Attitudes of land-holders are also important, with pastoralists having little experience in tropical Australia often being reluctant to use fire at all (Trezise 1991). Thus the change in ownership of at least a dozen of the larger pastoral holdings in the last three to four years will have implications for the extent to which fire has and will be used.

Table 6.3 Summary of reasons for burning in cattle management

Removing rank grass and increasing crude protein concentration of forage	Davis 1959; Smith 1960; Landsdowne 1971; Tothill 1971; Mott 1981; Pressland et al. 1981; Pressland 1982; Anderson et al. 1988; McKeague and Wincen 1991
Promoting fresh grass growth and extending period of green grass availability	Davis 1959; Tothill 1971; Pressland et al. 1981; Pressland 1982; Anderson et al. 1988; McKeague and Wincen 1991
Controlling cattle movements, especially to assist in mustering	Davis 1959; Tothill 1971; Pressland et al. 1981; Pressland 1982; Anderson et al. 1988; McKeague and Wincen 1991
Improving visibility for mustering	Pressland 1982; Anderson et al. 1988; McKeague and Wincen 1993
Reducing fire hazards and forming breaks against late dry season fires	Tothill 1971; Pressland et al. 1981; Pressland 1982; Anderson et al. 1988; McKeague and Wincen 1991
Controlling cattle tick infestations	Smith 1960; Tothill 1971; Pressland et al. 1981; Pressland 1982; Anderson et al. 1988; McKeague and Wincen 1991; Teece 1993
Controlling weeds and woody regrowth	Tothill 1971; Pressland et al. 1981 Pressland 1982; Anderson et al. 1988; McKeague and Wincen 1991
Preparing seed-beds for exotic pastures	Stocker and Sturtz 1966; Mott 1981; Pressland et al. 1981; Pressland 1982; Anderson et al. 1988
Spelling over-grazed country	Andrew 1986
Controlling pasture composition	Anderson et al. 1988
Rejuvenating legume based pastures	Pressland et al. 1981
Stimulating seed production	Pressland et al. 1981

Decisions about burning are usually based on fuel and soil moisture levels, curing of grasses, climatic conditions, position of fire-breaks and the likelihood of fires spreading beyond control (Davis 1959). In contrast to other areas in northern Queensland, where most, if not all, fires are lit after the first storms of the wet season (Arlidge 1993), the early dry season is the time of most management fires on the Peninsula, as it is in the Top End of the Northern Territory (Lewis 1985; Press 1988). Timing depends on the duration of the previous wet season, with the first burns being earliest in the drier areas, usually starting in late May to early June between Laura and Musgrave and in August around Coen (Garnett and Crowley unpubl. data). Habitats that dry fastest are burnt earliest (Lewis 1985; Trezise 1991). Burning may be most frequent on soils with a high water holding capacity, such as drainage depressions, as these produce the best "green pick" (McKeague and Wincen 1991). Dry season burning on cattle stations in the Northern Territory has been described as extending over 4-6 weeks (Lewis 1985). Dry season burning in the Musgrave area may be restricted to as little as two weeks, although when this period falls varies from year to year (Crowley and Garnett unpubl. data). Estimates that over half the area managed for pastoralism in the Top End is burnt annually (Lewis 1985; Press 1988), appear unlikely to apply to much of the Peninsula (J.P. Stanton pers. comm.; S.T. Garnett pers. comm.).

Early fires are partly for "green pick" and partly for formation of fire breaks. Burning for mustering and other purposes may be undertaken at this time in order to take advantage of the "green pick" produced before soils completely dry (McKeague and Wincen 1991). Using fire to attract cattle to areas of healthy pastures and away from over-grazed areas by has been recommended (Andrew 1986), but the extent to which this has been adopted on Cape York Peninsula is unclear. Many land-holders stop burning once fires begin to burn through the night and make their control more difficult (Davis 1959; Anning 1980). Pastoralists may also choose to burn less extensively following a poor wet season.

Fires are also lit on some properties at the break of the wet season, generally after the first heavy rainfall, but before all the grasses shoot (Davis 1959; Teece 1993). Called storm-burning or clean-up burning, it is particularly used to remove areas of rank grass (Teece 1993) and to keep the country clear of shrubby growth (McKeague and Wincen 1991; Stanton 1992). Further benefits of burning at this time include the conservation of some of the litter layer which may be too moist to burn, helping to prevent soil erosion, and the stimulation of rapid grass shooting by the sun warming the blackened soil (Anderson et al. 1988). However, where rain is spasmodic, grasses in these areas may also die-off quickly. The use of storm-burning may be prevented by several factors (Garnett and Crowley unpubl. data). Areas left to be storm-burnt may be lost to earlier wildfires; heavy continuous rains may prevent the fuel drying out sufficiently to hold fire; and there is a reluctance to burn when rain is patchy and fires may be difficult to contain. Burning is generally avoided in the mid- to late dry season because of fears of losing large areas of cattle forage. If there is enough moisture to allow the sprouting of grasses at all (Anderson et al. 1988), cattle grazing the shorter feed produced may lose rather than gain weight (Anning 1980). Wildfires, which mainly occur at this time, are thus an economic liability. However, wildfire prevention may rate behind other factors in deciding the timing and extent of burning. While fires late in the season are likely to remove most forage, the closer the wet season approaches, the greater chance the cattle have of surviving until new growth appears. Also, as wildfires may not burn out large areas of a property every year, the risk of losing forage by burning extensive breaks early in the dry season may seem more threatening than losing forage later in the year.

There is not universal agreement about the merits of using fire, or of its effects. While some advocate the use of fire to control cattle tick, others dispute its efficacy (Davis 1959; Tothill 1971; Anderson et al. 1988; Teece 1991; Arlidge 1993). Burning is not always considered a positive component of pasture management. Fire may destroy sown or naturalized pasture plants (Anning 1980) although these are largely being usurped by fire-tolerant species (McKeague and Wincen 1991). Shifts in species composition may be a problem in some areas, such as where too frequent fires appear to be causing the replacement of Flinders grass Iseilema spp. by the less desirable spear grass Heteropogon contortus (Norman 1960), or where suckers and the introduced grader grass Themeda quadrivalvis increase after fire at the expense of both native perennials and sown pastures on the basalt soils of Lakeland Downs (D. Hurse pers. comm.).

The increase in woody regrowth over the last century has negative implications for the cattle industry, as well as for the biological integrity of the Peninsula (Chapter 4). There is therefore a need to identify the contribution of cattle grazing with its attendant fire regimes to vegetation changes that have occurred, and methods of reversing, or retarding such change in the future.

6.5 Integration

There are many similarities in the way fire is used in land management across Cape York Peninsula, but there is also important variation. Aboriginal burning in the past was probably more diverse than any burning undertaken today, with fires being lit across the landscape through much of the year. While future Aboriginal land management may resemble these patterns, there are several reasons for different burning patterns to be adopted. The nature of current burning patterns by Aboriginal people on Cape York Peninsula is too poorly documented to allow its comparison with other systems.

Even deliberate attempts to recreate past Aboriginal burning practices may be impractical (Andersen and Braithwaite 1992). Their methods of burning relied on the mobility of a population which travelled through country now considered so remote that it is burnt from helicopters. Budgetary constraints mean that aerial burning is more likely to be undertaken over short periods, rather than throughout the dry season. The present management of National Parks attempts to mimic past Aboriginal burning practices, with large areas being burnt over two to three months in the dry season as the vegetation dries out, and other areas being burnt late in the year when fire temperatures are likely to be hotter, but the chance of fires travelling very far is low. Whether there are important ecological implications for not burning in the middle of the dry season is yet to be determined.

About a third to a half of the area of most National Parks is burnt each year, but a concern for maintenance of feed means that less burning appears to be undertaken on most grazing properties. If there is indeed less extensive early dry season burning than in the Top End of the Northern Territory, this may be because the wetter conditions reduce the risk of wildfires on Cape York Peninsula (Chapter 3). But late dry season wildfires do occur, if not annually. Because early dry season fires often fail to join up to form effective breaks, when wildfires do occur they travel vast distances. These propositions are supported by anecdotal information, but need rigorous testing by the provision of detailed data for Cape York Peninsula on timing, frequency, and extent of fires, as well as surveys of the approaches of individual land managers.

Conflicts may arise when adjoining properties have different approaches to fire management. This is not necessarily only the case when neighbours have different land uses. Different management approaches on pastoral leases mean that there may be as much difference between properties used for cattle grazing, as between cattle stations and National Parks.

The main source of conflict is when a fire crosses the boundary between properties. Fires burning late in the year have the greatest potential to spread across boundaries and burn large areas. Fires at this time of the year may originally have been lit for land management purposes, such as when one property has received early rain, or they may have been lit by other sources, such as escaped camp fires or lightning. Where adequate breaks have been burnt early in the year, the spread of these fires should be limited (Press 1987). If breaks follow boundary lines, the spread of fires from one property to the next can be minimized, but not completely stopped.

By and large this report highlights the potential for integration of fire management regimes with different objectives. Land used for low impact, extensive cattle management has high value for nature conservation, and with some adjustments fire-management for cattle may help to preserve habitats for endangered species (Garnett and Crowley unpubl. data). Moreover, habitat degradation in the form of increases in woody plants is undesirable for both conservation and grazing purposes. Adjustments to burning regimes to reduce woody growth will thus benefit both the conservation and pastoral potential of the Peninsula. Initial work is showing that well-targeted, hot fires towards the end of the dry season are most effective at reducing broad-leaved ti-tree infestations (Garnett and Crowley unpubl. data). The reduction in fuel accumulation by grazing stock (Stocker and Mott 1981), means that fires lit on grazing properties are likely to be limited to the cooler end of the temperature spectrum. Since destocking to allow fuel accumulation may be impossible on most properties on the Peninsula because of limited fencing, fire could be used to attract cattle away from areas to be burnt by hot, late fires. These fires would need to be well confined within adequate breaks to prevent their escape across the Peninsula. The extent to which such practices can be successfully implemented is yet to be tested.

Table 6.4 The use of fire in land management - Key points

Indigenous land management

- Though details may have been lost in many areas, Aboriginal use of fire on Cape York Peninsula, as elsewhere in northern Australia, is likely to have been highly skilled and targeted for specific purposes, with cognisance of its environmental effects.
- Aboriginal burning has been characterized as being undertaken through much of the year, using knowledge of vegetation flammability, position of fire-breaks and fire behaviour to enable control.
- Reasons for Aboriginal burning can be summarized as providing comfort and safety, optimization of and access to resources, recreation, communication and aggression, and more latterly, managing cattle.
- Reasons for burning practices have changed with different circumstances and requirements of Aboriginal communities. Restrictions on movement, access and land tenure over the last century having led to a reduction of active fire management and the current role of fires in Aboriginal communities is under examination.
- Present features of Aboriginal burning regimes on Cape York Peninsula are yet to be documented.

/cont.

Table 6.4 (cont.) The use of fire in land management - Key points

Nature conservation

- The major use of fire in nature conservation on Cape York Peninsula is for the maintenance and protection of a diversity of habitats on National Parks.
- Other uses of fire on National Parks include watershed protection, erosion prevention and weed control as well as protection of people and infrastructure.
- Timing and frequency of fires is determined by local conditions including regrowth and fire hazard.
- Burning is undertaken to set plans using ground and aerial ignitions. Areas to be burnt are designated by assessment of fuel loads and, in some cases, desired structural changes to vegetation. Success of burn is monitored to determine extent of burn. The response of individual species are not monitored.
- A section of the community, including some land-holders, endorse fire exclusion for conservation because of concerns about destruction of animals, nests and habitat, and a belief that human interference in the environment is undesirable.

Pastoral industry

- Fire is used by pastoralists to maximize cattle production·, particularly to maintain feed through the dry season.
- Fires are principally lit in the early dry season and, to a lesser extent, around the break of the wet season.
- Fires are lit when fuel moisture levels and climatic conditions are likely to extinguish them overnight.
- Deliberate burning is restricted by concern about loss of forage and an inability to control fires.
- Burning is not universally accepted as an appropriate management tool, and its use varies depending on environmental conditions and attitudes of land managers.

Integration

- Present fire regimes are unlikely to entirely re-create past Aboriginal burning patterns, and too little information exists on present Aboriginal burning regimes to allow comparison with other systems.
- Features of fire management that are shared between National Parks and many pastoral properties include an emphasis on early burns, with some burning towards the end of the dry season or at the break of the first storms. However, burning appears to be less extensive on most pastoral properties, leading to a greater risk of wildfire propagation and spread.
- Differences in approaches to fire management may lead to extensive late dry season wildfires spreading between properties. This can most effectively be reduced by adequate early dry season burning. However, the incentive to burn adequate breaks will depend on the rating of wildfire risk against other management considerations.
- Fire management on individual properties may be compatible with more than one land management objective. For example, fire regimes appropriate for managing cattle, especially those that emphasize pasture maintenance can also be of benefit to conservation.

7 REGULATIONS AND RESPONSIBILITIES

Regulations and responsibilities regarding fire are covered by the "Fire Service Act, 1990" (Burke 1990b). The following is a brief description of the Act and its operation as found in several publications by the Queensland Fire Service and its officers (Burke 1990a,b,c; Phillips 1990; Queensland Fire Service 1993). It is not in any way to be construed as legal advice, which should be sought from the Queensland Fire Service or other appropriate legal advisers. The aim of the Act is to minimize damage by fire to persons, property and the environment. The Act does not seek to prevent or prohibit the use of fire, but rather promotes the use of fuel reduction burning as a means of preventing wildfires. The Act is administered by the Queensland Fire Service, whose Rural Fire Division is responsible for non-urban areas and in 1994 had a budget of around $3,600,000 per year. The Rural Fire Division operates as a network of volunteers consisting of about 68 Rural Fire Brigades. These brigades have more than 51,000 voluntary members, who, together with 300 Fire Wardens, are administered by about 20 employed staff. The activities of the Rural Fire Division in the area are overseen by the District Inspector for Cape York Peninsula.

Rural Fire Brigades generally consist of property-holders who have a common interest in the protection of their properties against wildfires. Brigades undertake various roles including fire protection, public education, fire-fighting and fund-raising to purchase equipment, and may also partake in fuel-reduction burning at the request of a land-holder. The purchase of equipment for fire control measures is subsidized on a dollar for dollar basis by the Queensland Fire Service. Workers Compensation, Public Liability Insurance, and Insurance of privately owned vehicles used in the Brigade's activities are also covered by the Queensland Fire Service. Appliances and other equipment used solely for Brigade activities are exempt from Department of Transport Registration. The Queensland Fire Service also provides advice, information (including fire danger meters and instructions on their use), training and administrative support.

Land-holders (occupiers) have primary responsibility for fire on their land, and management fires cannot be lit without a Permit to Light Fire. Exceptions exist for small areas of burning (< 2 m diameter), fires for destroying a carcass of a beast, or fires to clear up sawmill waste. Land-holders must take all reasonable steps to extinguish unauthorized fires they find burning on their properties and report them to the Fire Warden or other authority.

To obtain a Permit to Light Fire the applicant must notify land-holders of neighbouring properties not separated by a fire-break (road or watercourse 10 m wide and free of fuel) to obtain their consent. They must then apply, either orally or in writing, to the local Fire Warden for a Permit. Information which must be provided for the issuing of a Permit includes name, address, area to be burnt (including portion number and Parish), the names of neighbours and whether their consent has been given, the reason for burn (e.g. fuel reduction) and precautions that have been taken to contain and control fires. Where the consent of a neighbour has not been given, and the Fire Warden judges the application should be granted, the applicant is merely required to give the dissenting neighbour at least 2 hrs notice before lighting the fire. The Permit holder is responsible to ensure the safety of motorists by burning in a way that minimizes smoke hazards, erecting warning signs, and, where appropriate, either patrolling affected sections of roads themselves or enlisting the help of the Police to do so.

Fire Wardens are expected to have a good knowledge of local conditions on which to base decisions about whether an application to burn should be granted. Fire danger meters and reference to the District Inspector may aid in assessing the risk of fire spread before a Permit is given. No Permit can be granted where wind speeds exceed 24 kph. In issuing Permits Fire Wardens may stipulate the time fires are to be lit (this may extend from a specific hour of a specific day to a month-long period) and nominate the wind conditions which will achieve the best and safest burn. They may also stipulate the number of people required to attend a fire, the type of equipment to be on hand, if any, and whether a Rural Fire Brigade is required to attend.

Permits provide legal protection to the land-holder. Should the fire result in unforseen damage while the requirements of the Permit are followed the holder of a permit cannot be found to be reckless or malicious. Correctly recorded Permits also indemnify the Fire Warden.

Chief Fire Wardens may only issue Permits where a local Fire Warden is unavailable, and no Fire Warden may issue a permit outside their gazetted district. However, Chief Fire Wardens can instruct a Fire Warden to cancel a Permit where this is warranted by atmospheric conditions. Notice of cancellation must be delivered to the Permit-holder in writing. When fire dangers are extreme, the Commissioner may proclaim a State of Fire Emergency which nullifies all current Permits to Light Fires, and new Permits must be issued when the State of Fire Emergency is lifted before any fire can be lit. Even under State of Fire Emergencies, a decision to back-burn may legally be made by the Rural Fire Brigade's First Officer when a wildfire is threatening.

The Commissioner may direct a land-holder to take measures to reduce fire hazards. A Fire Warden may order the extinguishment of any fire that is considered dangerous, or undertake such action and recover the cost from the land-holder or the person responsible for the fire. Failure to comply with such an order renders the offender liable for prosecution. Breaches of the permit system are investigated by the Inspector and if necessary handed to the police for further legal action and prosecution. Arson is a criminal offence, and penalties include fines and imprisonment with hard labour for up to 5 years.

The Queensland Fire Service Act applies statewide and applies to government bodies and departments as well as private individuals and organizations. The only recognized exception is on land under the control of the Queensland Department of Environment and Heritage or the Queensland Department of Primary Industries' Forest Service where fires have been lit by authorized agents of the relevant department. Fire is not specifically mentioned in the "Nature Conservation Act 1992" which governs management on National Parks in Queensland. However, fire is considered a valid tool to meet the management requirements of National Parks (P. Harris pers. comm.). Where a fire on a National Park has not been authorized by the National Parks and Wildlife Service, claims may be made for restitution of damage from the person who lit the fire.

There is some doubt as to whether all legislation prohibiting or regulating fires holds on Native Title lands, as Native Title legislation protects traditional Aboriginal activities (Hughes in press). It is therefore possible that Permits are not required for burning for the purpose of hunting, gathering, or cultural or spiritual activities of the traditional owners, and that such burning is not prohibited by State of Fire Emergencies (Hughes in press). On the other hand, regulations which do not impinge on Aboriginal law and custom would be operative, including requirements to prevent fires spreading to neighbouring properties and to inform land holders and authorities when fires cannot be contained (Hughes in press). The ambiguity of the situation reinforces the need to foster co-operation between neighbouring property-holders (Chapter 6).

Isolation makes the policing of the Fire Services Act on Cape York Peninsula difficult. A very low proportion of illegal ignitions are reported or end in prosecutions. However, the requirement to contain fires is more readily policed. Several infringements have resulted in a warning notice being served on the property owner concerned, and some infringements on Cape York Peninsula have led to prosecutions (B. Cifuentes pers. comm.).

As the Permit system allows for fires at any time of the year, it has been called into question by Stocker (1981) who claims that, because of the inconvenience, land-holders often don't bother to apply for Permits. Stocker proposed a system whereby burning off was allowed only in the early dry season, similar to the restrictions in place in the Northern Territory (O'Neill et al. 1993). Another critic has suggested the tightening of the Permit system is needed (Trezise 1991). However, it has been argued that the present Permit system is the only way that use of fires can be adequately controlled and monitored (Burke 1990a,b). Permits are also a useful tool to determine whether reported fires have been intentionally lit or are wildfires that require control measures to be used against them (Burke 1990b).

Augmentation of the Rural Division of the Queensland Service has been called for in the form of increased funding, staffing and facilities (Trezise 1991), and a proposal has been put forward for the formation of a Cape York Peninsula Fire Service which would facilitate many of the roles which are the responsibility of the Rural Division (Wattle Hills Bush Fire Brigade 1994).

It has been proposed that Aboriginal people should be involved in burning on their traditional lands even where these lands are no longer under their control (Parry and Clark 1991). Where Aboriginal hunting on pastoral leases is permitted in the Northern Territory, the legality of Aboriginal people lighting fires is far from clear (Head et al. 1992, Hughes in press). Fire management on National Parks now involves Aboriginal rangers at an operational level (Shaw 1994), but it is not yet clear the extent to which traditional owners will be involved at the policy level. Although Aboriginal people live, hunt and burn in only a small section of Kakadu National Park, Aboriginal elders are consulted about fire management and no restrictions are placed on burning on the Park by Aboriginal people (J. Russell-Smith pers. comm.).

Table 7.1 Regulations and responsibilities - Key points

- Fire regulations are governed by the Queensland Fire Services Act 1990 which promotes prescribed burning and other measures necessary to minimize the damage caused by fire.
- Land-holders have primary responsibility for fire on their properties.
- Permits to Light Fire are required for all land management fires, with the following exceptions. Fires lit for management on National Parks and Forestry reserves are exempt from the provisions of the Queensland Fires Services Act 1990 and some regulations of the Queensland Fire Services Act may not apply to Aboriginal burning on Native Title lands.

8 CONCLUSIONS

The characteristics and effects of fire on Cape York Peninsula are poorly documented, and there is a great need for the collection of first-hand material directly from the area. Though many factors controlling fire will closely resemble those documented elsewhere in Northern Australia, there are likely to be important differences arising from the wetter conditions. Moreover, nowhere else in monsoonal Australia has disappearance of grassland been flagged as a major conservation concern, although it is certainly occurring in specific areas (J. Woinarski pers. comm.). Other differences may be more subtle. Both Aboriginal and pastoral burning regimes developed in response to the environmental conditions found on the Peninsula are likely to have at least some attributes not found outside the area. These would in turn have influenced the flora and fauna. In the absence of data from the Peninsula itself this report should thus be viewed as proving a framework for the analysis of fire, rather than a comprehensive documentation of fire and its effects on the Peninsula.

Overall, fire appears to be needed for the long term maintenance of ecological systems on Cape York Peninsula. Although fire may be a significant vehicle for direct losses of nutrients from the soil, contribute to air pollution, and expose the soil to erosion, it is also an important source of nutrient release for new growth. The best approach to these problems appears to be adjustment of fire regimes rather than complete fire exclusion. Fires damage or kill plants, but also remove dead material and promote regeneration in many species. Fires kill some animals and dispossess others that require unburnt habitats, but advantage animals that need fire-altered landscapes in order to survive. Some habitats will be maintained by the same fire regimes that degrade others.

Even where desired regimes are identified, the problem remains as to whether adequate control can be exercised for them to be made into reality. The complexities of fire behaviour and fire effects and the ranges of ignition-sources described in this report indicate that the best-intentioned planning can go awry.

Most opinions regarding the desirability of fire and the extent to which it should be used are value judgements, and there can be compelling arguments to support many standpoints. Where clear objectives exist, however, such as to maintain ecosystems or pasture forage, decisions about the role of fire will need to be based on achieving these objectives, rather than on feelings about the immediate effects of fire itself.

Of the positions for which no supporting evidence could be found there are two particularly worthy of repudiation: the first is that Aboriginal burning was random and could not be considered in any way as land management. There is ample evidence to show that burning has been an integral part of Aboriginal lifestyles, contributing to the well-being of its users. The second is that fire protection can be effective in the region without use of extensive fuel reduction burning. Many people have come to Cape York Peninsula with this intuitive belief, and most have been convinced otherwise after a few years of residence. The lack of conclusive empirical evidence from the Peninsula, even though it can be derived from elsewhere, may have contributed factor to the propagation of both these myths.

A unifying theme through this report has been the undesirability of extensive late dry season fires, because of their effects on vegetation, wildlife, the pastoral industry and aesthetics. This does not mean that there is agreement on the best way of reducing their occurrence. The success of fuel reduction burning in the early dry season has been demonstrated in the Northern Territory. This approach is to varying degrees, compatible with both pastoral production and nature conservation. However, the use of fire on Cape York Peninsula for any purpose, including fuel reduction, is still contentious.

Where property boundaries constrain both fires and land use systems, different approaches to fire management need not create conflict. However, problems arise in a multiple-use system, or where adequate fire-breaks do not exist along boundaries as can be the case through much of the Peninsula. The land use system on the Peninsula may become increasingly multiple-use oriented, especially on Aboriginal lands which combine hunting and gathering with either National Park management or pastoralism. Fire management strategies will help determine the success of these enterprises.

Changes in burning patterns resulting from changes in management over the past century have accompanied, and probably precipitated, changes in the structure and extent of major vegetation communities, and the decline of some native animals. While these changes have been pronounced in places, and re-establishment of former vegetation communities is unlikely in the short term, the level of extinction on Cape York Peninsula has been low (Garnett 1992; Bowman and Woinarski 1994), and habitat alteration far less advanced than in more heavily populated areas (Stanton 1992). Management of fire in the future therefore provides an opportunity to ensure the Peninsula retains its high conservation value.

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APPENDIX

Terms of Reference for the Fire on Cape York Peninsula project:

1. Conduct library search and consult to assemble written or mapped information relevant to CYP on:
   - roles of fire in natural systems;
   - roles of fire in pasture systems;
   - consequences of burning or not burning in natural systems under different conditions (time of y ear, fuel load, etc);
   - consequences of burning or not burning in pasture systems under different conditions;
   - present frequency of deliberate burning (grazed areas, National Parks, Aboriginal Lands, other areas) and impacts;
   - present frequency of wild fires and impacts;
   - major events (including ERIN data) impacts.

2. Base on vegetation maps provided through CYPLUS, indentify, describe and plot maps of general habitat types that are meaningful to residents and relate to the impacts of fire (six to ten if possible, <u>examples</u> might be grasslands, open forests of bloodwood and stringybark, …).

3. Review information from Tasks 1 and 2 and any other easily obtainable information to develop and document a number of propositions about reasons for burning, the use of fire and its impacts on the various habitat types.

4. Take propositions from Task 3, feedback from community consultation to be conducted through the CYPLUS Taskforce and results from experimental burns to be undertaken by staff from QDEH, develop "best bet" recommendations for the use and management of fire in the habitat types and recommendations for future research. Include statement of current government policy initiatives.