A report to the Townsville-Thuringowa Landcare Association

FIRE MANAGEMENT AND THE VEGETATION COMMUNITIES OF THE TOWNSVILLE AND THURINGOWA SHIRES: SOME ECOLOGICAL CONSIDERATIONS

FINAL REPORT

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1. INTRODUCTION

1.1 General introduction

Fire has always been a part of the Australian landscape. Its role in land management, and our attitudes towards it, however, are rapidly changing.

Lightning-ignited fires began to shape our flora and fauna communities long before human occupation in Australia (Singh *et al*. 1981). The arrival of Aboriginal people up to 60 000 years ago marked the beginning of an intensive fire management regime which encouraged the widespread expansion of dry sclerophyll forests, and the contraction of wet non-sclerophyll forest (Nicholson 1981). These burning practices were permanently interrupted following European settlement, with large tracts of land subsequently remaining unburnt (Florence 1994). This has resulted in massive and continuing ecosystem changes country-wide (Lewis 1989, Stanton 1992, Innis 1994).

Fire management can be a controversial issue, based on questions of what should be burnt, how often, when and why? People's attitudes towards, and knowledge of fire use varies considerably, relating to individuals perception of what constitutes a natural landscape, and their relationship with the land (Crowley 1994). The three major roles of prescribed burning include the conservation of biodiversity, pasture management, and property protection/hazard reduction (Leigh and Noble 1981).

Fire management in conservation reserves aims, where possible, to restore, regenerate and maintain habitat diversity. In some areas this may equate to a re-establishment of the presumed pattern of traditional Aboriginal burning (Press 1987, Bond and Van-Wilgen 1996). Fire may be used to manipulate conditions for a particular species, and to maximise biodiversity by maintaining a mosaic of differently aged vegetation communities (Wouters 1994). Most prescribed burns in flammable vegetation communities involve low intensity fires which reduce fuel loads and hence the risk and spread of high intensity crown fires (Claus 1990). Crown fires are, however, a relatively uncommon occurrence in this region (Harrington *et al.* 1996). Current burning regimes represent the "best guess" management practices, for at this stage we are only beginning to learn how fire should be managed in different vegetation communities.

It should be noted that the re-establishment of tradional fire regimes may, in some instances, be either inappropriate or unachievable. This may be the case where habitat changes such as exotic species invasion (e.g. Guinea grass replacing native grasses) and habitat conversion (e.g. the conversion of open woodland to forest) are widespread or even irreversible.

Prepared for the Townsville and Thuringowa Landcare Association (TTLA), this report reviews fire management in the Townsville and Thuringowa Shires. It aims to identify and recommend appropriate burning regimes for the range of vegetation communities within the study area, and focuses on fire use for biodiversity conservation. The review contains information on the ecological effects of fire, the responses of major vegetation communities to fire, proposed burn regimes for individual vegetation communities, and a brief review of the procedures involved in the establishment of fire monitoring plots.

Due to the general lack of relevant scientific data relating to fire management within this region, the proposed fire regimes were primarily derived from literature reviews and discussions with people either responsible for, or concerned with, fire management in the region. Local fire monitoring plots established by the Queensland National Parks and Wildlife Service (QNPWS), the Townsville Department of Defence and various research organisations will produce data crucial for determining suitable fire management practices in the future. This report endeavours to provide an updated and unified approach to prescribed burning practices in the Townsville and Thuringowa Shires, to help ensure that the complex variety of vegetation communities are conserved.

1.2 Causes and history of fire in north Queensland

Fires may be ignited by lightning or people (Auld 1994). Lightning, which typically occurs during early wet season storms, was the primary source of ignition across northern Australia prior to human settlement (Crowley 1994). Lightning storms have the potential to ignite fires early in the wet season (October-March) when fuels are still dry enough to be flammable (Braithwaite and Estbergs 1985). However, fires were likely to be relatively infrequent before the arrival of Aboriginal people due to the predominance of fire-retardant vegetation, and the likelihood that follow-up rains would extinguish lightning-ignited fires (Stocker and Mott 1981, Kemp 1981).

Most fires in north Queensland are ignited by humans (Stocker 1980). Aboriginal people have utilised fire extensively over the last 60 000 years, using either sticks or stones as flints to produce sparks which ignited a dry tinder (Crowley 1994). Burning encouraged new grass growth which attracted animals for hunting, increased the access to other food sources, created paths for travelling, and played other important roles in Aboriginal culture (Nicholson 1981, Hallam 1985). Extensive areas of north Australia were burnt seasonally by the Aboriginal people, promoting the expansion of dry sclerophyll forests and grasslands, and producing a relatively stable mosaic of habitats (Press 1987).

Following European arrival, the settlers reduced the area available for Aboriginal burning and implemented their own land management techniques (Lewis 1989). These techniques were inherited from other cultures which viewed fire as a destructive force which should be suppressed and restricted (Stanton 1992, Innis 1994). Consequently fires were less frequent, but inevitably more intense, resulting in rapid changes to plant and animal communities (Bowman 1995).

Current prescribed burns conducted in conservation reserves attempt to re-establish traditional Aboriginal regimes in fire-dependent vegetation communities using site-specific “Fire Action Plans” (Stocker 1980). Matches, drip torches and other incendiary devices are used to ignite fires early in the dry season under favourable conditions (Press 1987). Within the Townsville and Thuringowa Shires, the complex diversity of land tenure, landuse and management principles makes fire management for ecosystem and landscape conservation a challenging task.

1.3 The fire regime

Fire regimes are determined by how often fire occurs (frequency), when it occurs (season) and how intensely it burns (intensity). Fires also vary in their type: ground fires burn underground in organic layers in the soil; surface fires burn just above the ground surface; and crown fires burn in the canopies of trees (Bond and Van-Wilgen 1996). Another source of variability lies in whether fires burn with the wind or upslope (headfires), or against the wind or downslope (backfires) (Crowley 1994). An understanding of the effects of fire frequency, intensity and season of burn on soils and biota is essential for developing management strategies appropriate for different vegetation types.

1.3.1 Fire frequency

Fire frequency depends upon fuel characteristics and climatic conditions influencing the ignition and maintenance of a fire (Walker 1981). Fuel characteristics are determined by the vegetation type and seasonal conditions controlling plant growth and senescence (Stocker 1980). This includes fuel quantity, composition size fraction and moisture content (Cheney 1994). Fire frequency is often inversely related to site fertility, since low plant nutrient contents slow decomposition and therefore increase fuel accumulation (Christensen 1993).

1.3.2 Fire intensity

Fire intensity usually increases as the dry season progresses due to the rising fuel loads, drier fuels, stronger winds and lower humidity (Williams *et al.* 1995). Fire intensity is generally measured by scorch heights, patchiness, the area burnt and temperatures reached (Press 1987). The frequency and intensity of fires in flammable vegetation communities is typically inversely related. High fire frequency tends to reduce the fuel load, leading to lower fire intensity and vice versa (Stocker 1980).

1.3.3 Season of burn

In north Queensland the possibility and lately intensity of fire increases as the dry season progresses (Stocker and Mott 1981). This results from fuel production and accumulation during the wet season followed by a long dry season which slowly cures fuels and an increased likelihood of electrical storms prior to the subsequent wet season (Williams *et al.* 1995). Most fuel reduction burns in the region are performed early in the dry season (April-June) or at the beginning of the wet season (December) to avoid high intensity fires. Fires conducted during these times tend to be more patchy, smaller in area, and have lower scorch heights (Press 1987).

1.4 The ecological impacts of fire

1.4.1 Soil fertility

Fire directly influences soil fertility by providing inputs of heat and ash, and indirectly through subsequent changes in plant communities and soil fauna (Raison 1980). The availability of exchangeable calcium, organic carbon, extractable phosphorus, nitrogen and other nutrients increases temporarily following fire (Tomkins *et al*. 1991). This results from nutrient addition at the surface from ash deposition, increased nutrient availability from organic matter combustion and increased mineralization resulting from soil pH changes and a reduction in carbon:nitrogen ratios (Waring and Schlesinger 1985).

Although nutrient availability is relatively higher in the “ashbed”, nutrient losses are often large during and following fire, possibly causing long-term nutrient depletions (Grove *et al.* 1986). Nutrient losses during fire result from volatilisation and the removal of nutrients in smoke particles, air currents and updrafts (Raison 1980, Nambiar 1985). Furthermore, post-fire increases in denitrification and leaching (of available cations and phosphorus resulting from increased soil exposure) act to reduce soil nutrient concentrations (Flinn 1985).

The long-term effects of burning regimes on soil fertility and nutrient cycling are difficult to predict, and depend upon interactions between the soil, climate and vegetation (Raison 1979). Soil nutrient losses may potentially exceed the benefits of increased nutrient availability in ecosystems with closed nutrient cycles such as rainforests (Waring and Schlesinger 1985). These types of ecosystems require long-term stability of efficient nutrient accumulation, retention and recycling (Ashton 1976).

1.4.2 Fauna

The responses of individual faunal species to fire varies widely and depends on their ability to survive or escape the blaze, the success of post-fire predator evasion and competition for food, shelter and breeding habitats (Crowley 1994, Wilson 1996). These factors are largely influenced by the fire frequency, intensity and timing, and whether mosaic refugia exist (Catling and Newsome 1981). The impacts of fire on birds and mammals have been more extensively documented than for reptiles, while there is a paucity of data available for amphibians (Wilson 1996).

1.4.3 Flora

The tolerance of different plant species to fire varies greatly, reflecting the evolutionary response of plants to fire regimes (Nambiar 1985). Plant growth, survival and reproduction are directly affected by fire (Bond and Wilgen 1996). Fire tolerance results from fire resistance and an ability to recover following fire (Gill 1975). Plant resistance to burning is determined by the fire regime, plant developmental stage, and the presence or absence of adaptive traits (Braithwaite and Estbergs 1985). Fire, and the lack of it, have both been responsible for species extinction in Australia (Gill, 1996).

Plants may adapt to fire by developing dormant buds, and protective bark and fruit (Gill 1975). Trees in fire-prone areas tend to have thick non-combustible bark which protects perennating buds in the main stems and branches (Lacey *et al.* 1982). Plants with long, bare trunks and canopies held high above the ground can escape defoliation by fire (Bond and Van-Wilgen 1996). Some plants, including gumtrees (*Eucalyptus* spp.), she-oaks (*Casuarina* spp.), bottle-brushes (*Callistemon* spp.), ti-trees (*Leptospermum* spp.) and paperbarks (*Melaleuca* spp.) store seeds in woody, fire-resistant fruit on the parent plant for release following fire (Auld 1994). Alternatively, many wattles (*Acacia* spp.) and grevilleas (*Grevillea* spp.) store seeds in the soil seedbank which are stimulated to germinate by the heat produced during a fire (Auld 1994).

Fire-tolerant plants may also regenerate from lignotubers or epicormic shoots. Lignotubers are large woody below-ground nutrient storage organs which contain buds able to resprout after fire (Attiwill 1994). Similarly, epicormic shoots are branches derived from buds along the stem allow plants to continue photosynthesis and growth when fire has burnt the tree canopy (Crowley 1994). These features are common in species occurring within fire-prone woodlands, shrublands and savannas, perhaps most notably in eucalpyt species (Gill 1975).

Species possessing fire survival and regeneration adaptations can persist successfully within fire-prone communities. For species lacking adaptive traits, fire-induced mortality acts as a key factor in regulating population growth and community composition (Bond and Van-Wilgen 1996).

1.4.4 Vegetation communities

Fire influences the distribution, floristics and structure of plant communities (Raison 1980). While soil moisture and nutrient availability are the primary determinants of vegetation distribution in northern Australia, fire regimes act as a secondary determinant (Walker and Singh 1981). The sensitivity of plant species to fire determines the post-fire recovery, and hence distribution of, vegetation types (Ridpath 1985). Fire therefore poses a significant disturbance to community interactions, community functioning and can also initiate plant succession at burnt sites (Putman 1994).

The widespread distribution of eucalypt forests and other sclerophyllous vegetation types across northern Australia largely results from regular burning by Aboriginal people (Florence 1994). Rainforest communities are highly sensitive to fire, and may be invaded by wet sclerophyll forests following a high intensity fire (Bowman and Dunlop 1986). Conversely, and far more widely documented for the wet tropics region is the loss of wet sclerophyll forest following the invasion of rainforest species (Harrington *et al.* 1996).

Within most vegetation communities, a low fire frequency/intensity tends to shift dominance to the canopy (Braithwaite 1994). The influence of fires on vegetation communities, and the implication on fire management regimes in the Townsville/Thuringowa Shires are further discussed in Section 4.1 of this report.

2. STUDY AREA

The study area includes the Townsville and Thuringowa Shires. Flora surveys have been conducted in the region by Perry (1953), Isbell and Murtha (1972), the Townsville Harbour Board (1974), Cumming (in prep.) and Lukacs and Skull (1996). These surveys have revealed that the region consists of a variety of floristically and structurally diverse plant communities which reflect the local range of climatic, topographic and edaphic environments (Isbell and Murtha 1972).

A high diversity of vegetation communities occur in the study area, with woodlands, open woodlands and low open woodlands representing the most widespread (Lukacs and Skull 1996). Lower and more open communities generally occur with decreasing rainfall (Lukacs and Skull 1996). Although the study area contains urban developments, intensive industries, semi-rural subdivisions, cattle properties, national parks and army land (Lukacs and Skull 1996), this report mostly relates to the latter four.

3. METHODOLOGY

3.1 Vegetation communities of the Townsville and Thuringowa Shires

The distribution of the vegetation communities in the study area is currently being determined from assessments of aerial photographs. The identified patterns are subsequently being verified by field flora surveys in the Townsville Shire by Lukacs and Skull (1996) as part of an ongoing study, and in the Thuringowa Shire by the Thuringowa City Council (R. Cumming, in prep.). In the case of the Townsville Shire the finalised vegetation maps are currently in the process of being digitised into an ArcCad GIS system. These results will be presented as part of a separate investigaton for the Townsville City Council.

The vegetation classification scheme used in this report follows a modified version of recent flora surveys performed from Crystal Creek to Clements State Forest (J. Kemp, pers. comm.). The major vegetation communities defined here include: estuarine (mangroves, treeless areas associated with mangroves); dune (strand vegetation, beach scrub, dune ridge forest); paperbark swamps; seasonal wetlands (grassland, pasture, sedgeland); rainforest (vine forest, vine thicket); wet sclerophyll forest; dry sclerophyll forest; riparian communities; and weed dominated communities.
These categories are based on groups of vegetation communities which are broadly similar in their response to fire and contain similar structure and distribution patterns. Assessments of potential fire management strategies have entailed examination of the conservation status of various vegetation communities in some cases.

3.2 Assessment of the conservation status of the vegetation communities

The conservation status of vegetation communities in the Townsville and Thuringowa Shires were evaluated from the following two documents:

Conservation Status of Queensland's Bioregional Ecosystems: Draft Summary (QDEH 1995)

This report includes an assessment of the conservation status of vegetation communities in the 19 biogeographic regions of Queensland. The biogeographic regions are determined by geology, landform, climate and vegetation, and are further sub-divided into provinces. The conservation status of individual vegetation communities on specific geologies within each province are then sub-divided into four classes according to their present distribution/extent compared with that of pre-European settlement. These classes include:

- **Endangered**: <5% pre-European extent remains in an intact condition across regions. Given recent trends in landuse, the regional ecosystem is at risk of disappearing from the landscape within 10-20 years;

- **Vulnerable**: 5-10% pre-European extent remains in an intact condition in the region. Given recent trends in landuse, the regional ecosystem is at risk of disappearing from the landscape over a longer period than 20 years through continued depletion;

- **Of Concern**: 10-30% pre-European extent remains in an intact condition in the region or is a spatially restricted regional ecosystem presently subjected to the threat of depletion. For the former, given recent trends in landuse, the regional ecosystem could be substantially reduced in the area in the medium and long-term; and

- **No Concern**: >30% pre-European extent remains in an intact condition in the region and/or the regional ecosystem is well represented in protected areas. For the former, it is unlikely that the regional ecosystem will be substantially reduced in the area in the medium to longer term (QDEH 1995).

Townsville City Council Regional Growth Options Study: Conservation Priorities (Lukacs and Skull 1996)

This report is based on rapid (and ongoing) assessment of the conservation status of vegetation communities in the Townsville Shire. This study aims to provide the council with information regarding the condition and conservation status of all remnant terrestrial and wetland plant communities within its jurisdiction. This information is then intended to be integrated into planning and managerment decisions. The conservation status of each vegetation community was primarily evaluated using the *Conservation Status of Queenslands Bioregional Ecosystems: Draft Summary* (QDEH 1995), *Delineation of Key Coastal Areas for Northern Region* (QDEH 1994) and the *RAKES Report* (Stanton and Morgan 1977).

4. RESULTS

4.1 Response of the major vegetation communities to fire

The fire management aims and prescribed burning practices for major vegetation communities in the Townsville and Thuringowa Shires are summarised in Table 4.1. This table follows the format of "Fire Action Plans" used by national parks, although the use of fire for weed management is considered separately in Section 4.1.9. The following discussion provides brief descriptions of the different vegetation communities, and relates this information to their fire response and management.

It is important to note that wherever possible, fire management for any vegetation community should avoid being overly prescriptive. Although the maintenance of habitat diversity may be the overall management aim, consideration must be given to maintaining within habitat diversity i.e. maintaining a plant community so that a range of successional stages are represented across the landscape. Furthermore, it should be appreciated that communities at different successional stages may require diferent fire management approaches.

It should also be noted that under drought conditions a lack of sufficient fuel will, in some cases, prevent prescribed fire being utilised as a management option (e.g. for Rubber vine control in woodland and riparian areas). If fire will carry, it should be used with caution as any existing soil erosion problems could be exacerbated, particularly without active follow-up management (rehabilitation) of a given area.

4.1.1 Estuarine

Mangroves

Mangrove communities are usually closed forests which occur in coastal intertidal zones subjected to periodic inundation, waterlogging and high salinity (Love 1981). They exist on the seaward coastal margins, along saline river mouths and in deep swales behind dunes. Mangrove forests exhibit successional zonations approximately parallel to the shore which correspond to increasing land elevation from the shoreline and related environmental gradients (Semeniuk 1983). Throughout the Townsville and Thuringowa Shires mangrove communities are typically dominated by *Bruguiera* spp., *Rhizophora* spp., *Ceriops tagal* (Yellow mangrove), *Avicennia marina* (Grey mangrove) or *Aegicerus corniculatum*.

Although fire rarely enters mangrove communities, high intensity wildfires fuelled by strong sea breezes in the treeless areas associated with mangroves may scorch mangrove margins (Stocker and Mott 1981). To maintain the high conservation value of this fire-sensitive vegetation community, fuel reduction burns could be conducted in adjacent treeless areas, as outlined in the following section.

Treeless areas associated with mangroves

This vegetation type occurs on poorly drained, highly saline, silty coastal basins which are occasionally inundated with saltwater (J. Kemp, pers. comm.). Chenopod shrublands dominated by *Halosarcia indica*, and *Sporobolus virginicus* (Saltwater couch) grasslands are most commonly associated with mangroves in the study area. In extremely saline areas there may be large patches of bare saltpans, whereas areas of low salinity are frequently dominated by sedges (Saenger *et al*. 1977, Leigh 1981).

The risk of reasonably intense fire is relatively high in this vegetation type due to the predominance of low, often highly flammable vegetation, combined with the occurrence of strong sea breezes (Leigh 1981). High intensity fires may damage nearby mangrove or dune vegetation communities, reducing the integrity of coastal systems (Brock 1993). The effects of fire on *Halosarcia indica* and *Sporobolus virginicus* communities, however, is currently undocumented. Alternative low-medium intensity fires conducted every 2-5 years appear to be effective in reducing wildfire risk and in maintaining a mosaic of differently aged communities (QNPWS 1995a). Research into the response of this vegetation community to fire is essential, since this vegetation type is probably threatened by local urban and industrial development (C. Johnson, pers. comm.).

4.1.2 Dune systems

Strand vegetation

Strand vegetation communities occur on foredune beach sands, and are locally dominated by *Spinifex sericeus* (Beach spinifex), *Ipomoea pes-caprae* (Goat's-foot morning glory) and *Carnavalia rosea* (Beach bean) (J. Kemp, pers. comm.). The top of the primary dune is characterised by *Casuarina equisitifolia* (Beach she-oak) open woodland, which may contain *Hibiscus tiliaceus* (Beach hibiscus), *Thespesia populnea* and *Pleiogynmum timorense* (Burdekin plum), and a variety of herbaceous species. Strand vegetation grades into beach vine thicket further inland (Carolin and Clarke 1991).

Most plants along the strandline are able to recover from low intensity fire, and exhibit a moderate fire-tolerance (Love 1981). This vegetation community will be conserved by conducting low intensity burns every 3-5 years from the leeward side of foredunes back to firebreaks (QNPWS 1995a). This reduces the fuel load and the risk of high intensity fires which damage both strand vegetation communities and adjacent beach vine thickets.

Beach vine thicket

Beach vine thickets/scrub, occur as small patches amongst dune ridge forests on deep sands containing some humus (Carolin and Clarke 1991). They contain a dense overstorey of *Pleiogynum timorense* (Burdekin plum), *Terminalia* spp., *Mimusops elengi* (Red condoo), *Canarium australianum* (White beech), *Cupaniopsis anarcardioides* (Tuckeroo) and *Acacia crassicarpa* (Beach wattle) with a well developed midstorey and a sparse understorey. Beach vine thickets are often located in sheltered dunes or near inland mangrove lines which act as natural firebreaks (Carolin and Clarke 1991).

This vegetation community is fire-sensitive and requires protection from wildfire (Innis 1994). Fire exclusion can allow regeneration of this vegetation to its former extent, and may be achieved by conducting prescribed burns in adjacent strand vegetation and dune ridge forest.

Dune ridge forest

Dune ridge forests are widespread along coastal dune ridges and are usually dominated by an overstorey of *Eucalyptus tessellaris* (Moreton-Bay ash), *Melaleuca dealbata* and *Acacia crassicarpa* (J. Kemp, pers. comm.). This woodland community contains a well developed mid storey of *Alphitonia excelsa* (Soapwood), *Planchonia careya* (Cocky apple) and *Exocarpus latifolius* (Native cherry) and a sparse grassy understorey.

Many dune ridge forests in the study area are of local conservation concern, since degradation has resulted from inappropriate fire regimes and weed infestation (Lukacs and Skull 1996). This vegetation community depends upon fire for ecosystem conservation, but is sensitive to highly intense fires which result in the dominance of *Acacia crassicarpa* (P. Williams, pers. comm.). Fire regimes involving low intensity fuel reduction burns every 2-4 years should conserve this vegetation community by maintaining a mosaic of differently aged vegetation (QNPWS 1995a). Pro-active fuel reduction burns are particularly important when this community contains the rare *Livistonia drudei* (Cabbage palm).

4.1.3 Paperbark woodlands

Communities of *Melaleuca viridiflora* (Broad-leaved paperbark) and *Melaleuca nervosa* are present on swampy alluvial plains on duplex soils in the Townsville and Thuringowa Shires (Isbell and Murtha 1972). These vegetation communities form open woodlands (sometimes with *Eucalyptus* spp. overstoreys) with well developed grassy understoreys and are usually partially inundated during some of the wet season (Gillison and Walker 1981). On sites with adequate drainage, *Petalostigma pubescens* (Quinine tree) and *Grevillea pteridifolia* (Silky grevillea) are more common (Crowley 1994).

Melaleuca woodlands are generally fire-tolerant, being prone to dry season fires (Crowley 1994). Most fires in this vegetation type are of low to moderate intensity, since low fuel loads result from the typically low soil nutrient availability (Gillison and Walker 1981, Skull in prep.). The reductions in fire frequency in broad-leaved paperbark communities following European settlement have resulted in their expansion into adjacent grasslands throughout Cape York Peninsula (Stanton 1992). Paperbark woodlands are, however, vulnerable in the Townsville Shire (Lukacs and Skull 1996), and are listed as of concern regionally (QDEH 1995). This is the consequence of extensive clearing, wildfires from accidental ignitions and annual back-burns on private land (Skull 1995).

Current fire management of *Melaleuca* spp. woodlands (*M. viridiflora* and *M. nervosa*) in conservation reserves involves maintaining a mosaic of differently aged vegetation by conducting fuel reduction burns every 3-5 years (QNPWS 1995b). Additionally, current research (Skull in prep.) indicates that a fire frequency as low as 1-10 years is also appropriate for the preservation of community structure (i.e. making sure there is adequate representation of the canopy species in all layers of the community). The higher fire frequencies have been proposed for adequate orchid conservation (Lavarack 1994). A range of fire frequencies is therefore recommended wherever possible.

4.1.4 Seasonal wetlands

Natural grasslands

Natural grasslands are defined here as savanna which has not been grazed by domestic stock (Lloyd and Burrows 1988). They are distinguished by the virtual absence of trees, consisting primarily of grass species (Weston 1988). Grasslands in the region occur on seasonally inundated alluvial plains and may be dominated one of *Themeda triandra* (Kangaroo grass), *Heteropogon contortus* (Black spear grass), *Aristida* spp., *Cynodon dactylon* (Couch grass), *Imperata cylindrica* (Blady grass), *Sporobolus jacquemontii* or *Ischaemum* spp.

Although grasslands are seasonally inundated, they cure quickly in the dry season, becoming highly flammable (Williams *et al.* 1995). Fire affects the floristics of grasslands significantly, since many grassland species exhibit varying post-fire germination success (Stocker and Mott 1981, Tothill *et al.* 1982). Large areas of *Themeda triandra* have been replaced by *Heteropogon contortus* grasslands following frequent fires throughout northern Australia (Grice and McIntyre 1995). This occurs as the germination of *H. contortus* seeds are favoured by high soil surface temperatures following fire (Stocker and Mott 1981).
Fire regimes in grasslands currently involve low-medium intensity burns every 3-5 years (QNPWS 1995b). Grasslands in the Townsville and Thuringowa Shires were probably burnt annually by the Aboriginal people (R. Butler, pers. comm.). Rapid fuel accumulation in grasslands allows annual fire, and there is evidence to suggest that annual low intensity burns were conducted by Aboriginal people in this vegetation community throughout Australia (Lonsdale and Braithwaite 1991, Kirkpatrick *et al.* 1995). Indeed weed and woodland invasions into grasslands within the study area suggest that vulnerable grassland communities are not being burnt frequently enough (Tothill *et al.* 1982, Lukacs and Skull 1996). It is therefore recommended that grasslands are burnt at 1-2 year intervals.

Pasture

Pastures include native and exotic grasslands which are grazed by domestic stock (Lloyd and Burrows 1988). Pasture communities in the Townsville and Thuringowa Shires are most commonly dominated by *Heteropogon contortus* (Black spear grass), *Dicanthium sericeum* (Queensland blue grass), *Aristida* spp., *Bothriochloa* spp., *Sorghum* spp., *Imperata cylindrica* (Blady grass), *Themeda triandra* (Kangaroo grass) *Heteropogon triticeus* (Giant spear grass), and introduced herbaceous legumes such as *Stylosanthes* *humilis* (Townsville stylo). Pasture has been considered separately from natural grasslands as fire is primarily used to remove rank unpalatable growth, stimulate new growth/"green picks", extend the grazing season by burning after the last summer rains, remove woody growth and facilitate the establishment of exotic pasture species which increase pasture productivity (Tothill 1971, Anderson *et al.* 1988).

Many north Queensland pastures are over-grazed (Anning 1988). This has resulted from drought, changes to cattle breeds able to tolerate lower quality feed, the provision of food supplements during the dry season, and over-stocking of cattle (A. Grice, pers. comm.). Over-grazing directly reduces the fuel load available for fire, and results in shorter more compacted grasses which don't carry fire well (Cheney 1994). Consequently, few pastures have been been burnt within the Townsville and Thuringowa Shires over the last decade.

The workshop "Fire for the Management of Northern Australian Pastoral Lands" held in Townsville this year revealed that some monsoon tallgrass and tropical tallgrass pastures are burnt every 3-4 years, sub-tropical tallgrass every 2-5 years and *Aristida-Bothriochloa* communities every 5-10 years on certain north Queensland cattle properties (A. Grice, pers. comm.). However, grazing practices need to be altered to facilitate fire regimes which mutually enhance pasture productivity and conservation values. Low intensity fires conducted in mosaic patterns every 2-4 years may be appropriate for pastures which are not heavily grazed, although site conditions must be evaluated prior to burning.

Sedgelands

Sedgelands occur in seasonally to permanently inundated areas in depressions or along slow flowing drainage lines over river alluvial plains (Briggs 1981). Within the study area they are dominated by *Eleocharis dulcis* (Bulkuru), *Lepidosperma laterale* and *Chorizandra* spp., with *Brachiaria mutica* (Para grass) in disturbed areas. Sedgelands are a rare community in the Townsville and Thuringowa Shires, and it is recommended that they are protected from fire (QNPWS 1995b). This is achieved by burning areas of para grass and adjacent communities every 2 years whilst sedges are in a protected state i.e. standing water is present or after the upper parts die off leaving dormant underground tubers (QNPWS 1995b).

4.1.5 Rainforest communities

Vine Forest

Tropical humid rainforests or vine forests consist of floristically and structurally complex, predominantly broad-leaved, non-sclerophyllous forest (Walker and Singh 1981). High species diversity and distinctive life forms, including epiphytes, lianes, tree ferns, palms and special root and stem structures are characteristic features of tropical rainforests (Webb and Tracey 1981). In north Queensland rainforests form a discontinuous belt adjacent to the coast of north-eastern Australia (Stocker and Highland 1981). Throughout the Townsville and Thuringowa Shires closed canopy rainforests occur in limited areas, with further information regarding their distribution soon to be available (R. Cumming, in prep.).

Fires rarely enter rainforests due to the high humidity, low wind speed and high fuel moisture associated with these habitats that generally suppress fire (Stocker and Mott 1981). Fire may invade rainforests after major canopy disturbances such as drought and cyclones which create gaps for the growth of grasses and other flammable vegetation (Unwin *et al.* 1985). Most core rainforest species are highly fire sensitive and are commonly destroyed by high intensity fire (Stocker and Mott 1981). Some species occurring on the ecotone boundary with eucalypt species are fire tolerant, and produce epicormic shoots following fire (Ridley and Gardner 1961).

The exclusion of fire is essential to conserve this vegetation community (Webb and Tracey 1981) and involves maintaining firebreaks at the margins of its former extent (QNPWS 1995b). The management of vine forest ecotones is controversial, since many wet sclerophyll forests are being reinvaded by rainforest due to inappropriate burning practices (Stanton 1995). The management of ecotones between these vegetation communities is discussed further in Section 4.1.6.

Vine Thickets

Vine thickets are floristically diverse, fire-sensitive low closed forests which occur on rocky substrates along gullies and in hilly terrains which have increased water availability and fire protection (Webb 1978, Fensham 1995). The structural and taxonomic affinities of vine thickets with rainforests have been used to infer an evolutionary relationship (Richardson 1996), though vine thickets occur in lower rainfall isohyets and contain more deciduous and/or semi-deciduous species (Webb 1968). Remnant vine thicket patches occur along riparian zones, and in sheltered sites within dry eucalypt forests on colluvial slopes throughout the study area. They are locally dominated by combinations of *Canarium australianum*, *Mallotus phillippensis* (Red kamala), *Austromyrtus bidwilli* (Cold tree), *Pleiogynum timorense* (Burdekin plum) and *Drypetes lasiogyna* (Lukacs and Skull 1996).

Fire is usually suppressed in vine thickets due to the absence of ground fuel, a relatively moist microclimate, and protective topographical and substrate features, although high intensity fires can invade the margins (Bowman and Dunlop 1986, Fensham 1995). This possibility can be minimised by conducting fuel reduction burns in surrounding dry eucalypt forests every 3-5 years (QNPWS 1995b). Vine thickets are regionally endangered habitat types (QDEH 1995), and their continued existence relies upon fire exclusion (Kahn and Lawrie 1987).

4.1.6 Wet sclerophyll forests

Wet sclerophyll forests occur in restricted areas near vine forest on elevated slopes in the northern section of the study area. They are tall open forests which may be dominated by *Eucalyptus grandis* (Rose gum), *Eucalyptus resinifera* (Red stringybark), *Allocasuarina torulosa* (Forest oak), *Eucalyptus intermedia* (Pink bloodwood) and *Eucalyptus tereticornis* (Forest red gum). The understorey usually consists of ferns, shrubs and grasses (Ashton 1981a).

Wet sclerophyll forests are derived from vine forest subject to high intensity fires lit by Aboriginal people in the past (Ashton 1981b). Throughout much of north Queensland remaining sections of wet sclerophyll forests are being reinvaded by rainforest species due to reduced fire frequencies (Unwin *et al.* 1985, G. Harrington pers. comm.). Current fire management of this ecotone aims to re-establish wet sclerophyll forests to their former extent (P. Williams, pers. comm.).

Allocasuarina torulosa forests are highly fire sensitive and fire should be excluded to preserve this habitat since dense stands will resist rainforest invasion (Harrington *et al*. 1996). The likelihood of fire decreases three years after burning in eucalypt dominated wet sclerophyll forests due to grass suppression, and is virtually eliminated after 30 years (Harrington *et al*. 1996). The expansion of eucalypt dominated wet sclerophyll forests may be encouraged by conducting low intensity fuel reduction burns at 3 year intervals (Harrington *et al*. 1996). This should remove a relatively high proportion of rainforest saplings, although dense mid-storeys of *Lantana camara* (Lantana) may suppress burns (Ashton 1981b). Rose gum are sensitive to frequent burns, and there have been suggestions that infrequent high intensity fires would be more effective in conserving wet sclerophyll forests (P.

Williams, pers. comm.). The establishment of fire monitoring plots which examine both fire regimes should help resolve this issue.

4.1.7 Dry sclerophyll woodlands

Dry sclerophyll woodlands are widespread throughout the study area, occupying low rainfall areas on the plains and ranges. These open woodlands and woodlands may be dominated by *Eucalyptus clarksoniana* (Grey bloodwood), *E. crebra* (Narrow-leaved ironbark), *E. tessellaris* (Moreton-Bay ash), *E. platyphylla* (Poplar gum), *E. acmenoides* (Stringybark), *E. dallachyana* (Ghost gum), *Lophostemon suaveolens* (Swamp mahogany) and *Grevillea striata* (Beefwood) (Isbell and Murtha 1972). Dry sclerophyll woodlands have well developed grassy understoreys, and a relatively sparse mid-storey (Stocker and Mott 1981).

Frequent burning of dry sclerophyll woodlands by the Aboriginal people resulted in the prevalence of fire-dependent species and canopy dominance (Noble and Slayter 1981, Florence 1994). Some woodlands of *Eucalyptus platyphylla* (Poplar gum) in the study area have been overburnt from frequent, accidental wildfires (P. Williams, pers. comm.). In general though, fire frequency has decreased dramatically in dry sclerophyll woodlands since European settlement in the region, resulting in dense mid- and understoreys (G. Morgan, pers. comm.). In particular, long-unburnt *Eucalyptus clarksoniana/E. tessellaris/E. platyphylla* woodlands have developed dense understoreys of *Acacia simsii*, *Dodonaea* spp. (Dodonaea) and *Lantana camara* (Lantana) (P. Williams, pers. comm.).

Fuel reduction burns conducted in 3-5 year intervals in a mosaic fashion appears to be effective in maintaining the integrity of dry sclerophyll woodlands (Press 1987). The season of burn and climatic conditions should be varied to create different fire intensities and maintain habitat diversity. Dry sclerophyll woodlands associated with vine thickets should be burnt every 2-3 years to avoid scorching of vine thicket margins (QNPWS 1995b). The sensitivity of the different dry sclerophyll species to fire, however, is virtually unexplored, implying that current fire regimes are based on fire-induced changes in structure. Possible variations should be investigated as, for example, *Eucalyptus exserta* (Queensland peppermint) which occurs in fire-retardant granite outcrops may exhibit higher fire sensitivity compared to other eucalypts (P. Williams, pers. comm).

4.1.8 Riparian communities

Riparian communities in the Townsville and Thuringowa Shires include open forests of *Casuarina cunninghamii* (River she-oak), *Melaleuca leucadendra* (Weeping ti-tree), *Melaleuca dealbata*, *Eucalyptus tereticornis* (Blue gum), and various other rainforest derived species (Isbell and Murtha 1972). They occur along creek banks/beds and drainage lines in the region, often on soils with relatively high nutrient and water availability (Isbell and Murtha 1972).

Most riparian species, particularly those derived from the rainforest, are fire-sensitive, although the eucalypts can tolerate fire (Stocker and Mott 1981). To protect riparian communities low intensity fuel reduction burns should be conducted in adjacent vegetation communities where appropriate (QNPWS 1995b). The exclusion of fire in riparian communities is vital to maintain the roles these communities play in catchment management.

4.1.9 Weed dominated communities

A weed is defined as any plant growing where it is not wanted (Townsville City Council 1996). Although native plants can thus be weeds, this discussion concentrates on exotic weed invasions. Major exotic weed infestations of *Ziziphus mauritiana* (Chinee apple), *Cryptostegia grandiflora* (Rubber vine), *Leucaena leucocephala* (Leucena), *Lantana camara* (Lantana), *Passiflora foetida* (Stinking-passion flower), *Panicum maximum* (Guinea grass) and *Brachiaria mutica* (Para-grass) occur in the Townsville and Thuringowa Shires (Lukacs and Skull 1996). Infestations are most severe in riparian and dry sclerophyll woodlands where they significantly reduce biodiversity and pasture productivity (James 1996).

Where fire is used to control woody weeds in dry sclerophyll woodlands, there is usually a slight increase in the intensity or frequency of fire compared to that used in natural communities. Fire is used to control *Brachiaria mutica* (Para grass) in sedgelands, and high intensity fires can reduce the biomass of *Lantana camara* (Lantana) within dry and wet sclerophyll forests. Controlled burns performed within the Town Common have demonstrated that fire is ineffective in the control of *Ziziphus mauritiana* (Chinee apple) and *Passiflora foetida* (Stinking passion flower) (P. Williams, pers. comm.).

Fire successfully controls rubber vine infestations if there is sufficient fuel to produce a high intensity burn (Vitelli 1995). Fuel accumulation may be low in infested areas due to the competitive exclusion of understorey grasses by rubber-vine (Anderson *et al.* 1988, Fuller 1996). Insufficient fuel loads are of particular concern in overgrazed pastures (A. Grice, pers. comm.). Increases in fire frequency/intensity in dry sclerophyll woodlands for weed control may be detrimental to the ecosystem in the short-term, but this is generally viewed as a favourable trade-off to weed control and eradication (P. Williams, pers. comm.).

It is also pertinent to note that recently fired environments can provide high quality habitat for exotic species. Careful follow-up examination of burnt areas should ensure that management aims have not been compromised by exotic invasion and corrective treatment applied as necessary.

Table 4.1: Fire management objectives and prescribed burning regimes for vegetation communities of the Townsville and Thuringowa Shires.

Major vegetation unit	Vegetation community	Fire Management Objectives	Prescribed burning methods/protective measures
Estuarine	Mangroves	Exclude fire, protect at the margins	Burn associated treeless areas at high tide
	Treeless areas associated with mangroves	Conduct low-medium intensity fuel reduction burns	Burn every 2-5 years at high tide
Dunes	Strand vegetation	Conduct low intensity fuel reduction burns	Burn every 3-5 years from the leeward side of dune back to firebreaks
	Beach vine thicket	Exclude fire, protect at the margins	Conduct fuel reduction burns in adjacent strand vegetation and dune ridge forest
	Dune ridge forest	Conduct low intensity fuel reduction burns to maintain a mosaic of differently aged vegetation communities	Burn every 2-4 years early in the dry season
Paperbark woodlands		Conduct low intensity fuel reduction burns to maintain a mosaic of differently aged vegetation communities	Alternate 1-3, 1-5 and 1-7 year fire intervals.
Seasonal wetlands	Natural grasslands	Conduct low intensity fuel reduction burns to maintain a mosaic of differently aged vegetation communities	Burn every 1-2 years
	Pasture	Conduct low intensity fuel reduction burns	Generally burn every 2-4 years, depending on grazing pressure and dominant pasture spp.
	Sedgelands	Protect from fire by conducting fuel reduction burns in adjacent communities where appropriate	Burn the borders of adjacent vegetation communities every two years where appropriate

Table 4.1 Cont.

Major vegetation unit	Vegetation community	Fire Management Objectives	Prescribed burning methods/protective measures
Rainforest communities	Vine forest	Exclude fire, protect at margins where not invading wet sclerophyll forests	Conduct fuel reduction burns in adjacent wet sclerophyll forests
	Vine thicket	Exclude fire, protect at margins	Conduct fuel reduction burns in surrounding dry sclerophyll forest
Wet sclerophyll forest		Conduct low intensity fuel reduction burns to maintain a mosaic of differently aged vegetation communities	Burn every 3 years early in the dry season
Dry sclerophyll forest		Conduct low intensity fuel reduction burns to maintain a mosaic of differently aged vegetation communities	Burn every 3-5 years early in the dry season
Riparian communities		Exclude fire, protect at margins	Conduct fuel reduction burns in adjacent vegetation where appropriate
Weed dominated communities		Variable (See section 4.1.9)	Increase fire frequency in dry sclerophyll forests infested with rubber vine to 2-4 year intervals

5. DISCUSSION

5.1 The role and establishment of fire monitoring plots

Monitoring plots can provide a range of information to land managers. Before any attempt is made to establish even a simple set of monitoring plots, however, the following issues need to be addressed:

- What questions is the monitoring program attempting to address?;
- What level of detail will be required to provide sufficient answers to the question(s)?; and
- Who will be responsible for the establishment of the plots, collection of data and reporting/dissemination of findings?

In the past some monitoring programs have not adequately addressed these questions, resulting in a poorly designed and executed fire monitoring strategies.

The Queensland Department of Environment has, in the past 2 years, formulated a guide to establishing vegetation monitoring sites in the conservation reserves of this region (Bell 1995, Williams 1996). The latter of these two documents stems from lengthy consultation with QDE parks staff (management and rangers), CSIRO researchers and ACTFR staff. It provides details regarding site selection, plot establishment and monitoring methodology including photography. Although the document makes every attempt to incorporate as much scientifically valuable information as possible, its primary purpose is to provide practical fire management information requiring minimal time in the field (Williams 1996). Should more detailed data be required, then there will also need to be a commensurate increase in resource and time allocation for experimental design considerations, data collection, data analysis and so on. It is believed the approach adopted by Williams (1996) will be adequate for the needs of the Townsville-Thuringowa Landcare Association with respect to fire management in the region, so no further discussion of this topic is considered necessary here.

5.2 General discussion

This report is the first to evaluate and prescribe burning practices for conservation in the major vegetation communities in the Townsville and Thuringowa Shires. These recommendations are based on literature review and the experiences and knowledge of people with a range of expertise from our local community. The establishment of long-term fire monitoring experiments, which investigate the responses of different species and vegetation communities to fire, is vital to validate and confirm the suitability of the burning regimes recommended here. Research into local Aboriginal burning practices is also essential (R. Butler, pers. comm.).

The rate of change in the distribution, floristics and structure of vegetation communities since the cessation of Aboriginal burning regimes is of major environmental concern (Stanton 1980). This appears to result directly from reductions in fire frequency (R. Butler, pers. comm.), which has encouraged the expansion of relatively fire-sensitive vegetation communities into fire-dependent communities (Bowman 1988, Cheney 1996). Local infestations of Rubber vine (*Cryptostegia grandiflora*) and other exotic weeds have also been attributed to lowered fire frequencies (J. Brown, pers. comm).

A major issue to arise from the discussions conducted during this study was the need for pro-active fire management on land outside conservation reserves. Although the regulation and responsibility of land-owners with respect to fire management are not addressed here, there is widespread concern that private land holders are not practising regular fuel reduction burns in dry sclerophyll woodlands and natural grasslands, thereby decreasing land conservation values and increasing the risk of high intensity wildfire.

In particular, there is a need for more intensive land management planning on cattle properties to facilitate the use of appropriate burning regimes in the future (A. Grice, pers. comm.).

Fire management in the Townsville and Thuringowa Shires would ideally involve a complementary network of burning regimes structured from short and long term objectives relevant to the different land uses, which promoted ecosystem conservation. To achieve this goal we need increased public education and awareness on the beneficial role of prescribed burns and fire management, combined with ongoing research and communication of findings.

To conclude, fire plays an essential role in land conservation within the Townsville and Thuringowa Shires. By taking a pro-active, carefully planned and managed approach to local fire management issues, it is hoped that fire will be used more wisely for this purpose.

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