ECOLOGICALLY SUSTAINABLE FIRE MANAGEMENT: AN ADVISORY CODE FOR BRISBANE'S WESTERN SUBURBS

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Front page. Native bushland in Mt. Coot-tha Forest before burning and with grassy weed invasion 18 months after burning.
Pictures by C. Hosking

This document is dedicated to the late Dr. Chris Baldock, our first reviewer. Chris lived with his family in Bardon amongst the trees on the slopes of Mt. Coot-tha forest. As the Director of *AusVet Animal Health Services,* Chris Baldock worked across a wide range of species, including livestock, aquatic animals, wildlife, plant and human health. He was an unparalleled international force in the application and promotion of epidemiology. Chris shared an intrinsic love, appreciation and understanding of Brisbane's unique and vulnerable natural environment.

May the spotted gums always flower
On the hillsides where they tower

And the breezes rustle on the decks
Where you sat and watched the birds

Your native shrubs and pathways
Ensure you'll be remembered always.

EXECUTIVE SUMMARY

Increasing pressure on biodiversity due to the rapid expansion of urbanisation in Brisbane's suburbs has stimulated residents to seek ecologically sustainable fire management practices. In the development of this *Advisory Code* recommendations for ecologically sustainable fire management are focused on protecting biodiversity in *addition* to protecting life and property. The recommendations are seen as "value adding" for existing practices and protocols and for maintaining the essential biodiversity without in any way increasing the risks to life and property.

The local terrain, variation in plant communities and climate are factors considered pivotal to developing and implementing methods for ecologically sustainable fire management. A key recommendation of the Advisory Code is the introduction of *micro-mosaic patch burning* (MMPB) methods in the suburbs where bushland can be burnt in small mosaic patches and strips at intervals. Preceding burning programs, *in situ* surveys would be carried out to identify areas of important forest interior, microhabitats such as logs, tree-hollows and fire-sensitive vegetation communities including watercourses such as gullies, where burning would not be conducted. Deliberate burning of ridge-tops and hilltops would also be avoided because these are habitats supporting "threatened ecological communities" (legally recognised in NSW) where many invertebrate species perform "hill-topping" behaviour and where some vertebrates routinely find their prey. The seasonal timing of deliberate burning requires that special consideration is given to the immobile stages of many animals; most invertebrates are then in diapause and many reptiles are hibernating in winter, the time currently selected for burning. The autumn months are recommended for fuel reduction burns when generally fuel is not as dry.

"Green fire breaks", both natural and planted, are flagged for protection or introduction to reduce the intensities of fires near properties, to minimise the chances of wildfires transiting between separate fire prone vegetation and to allow the natural regeneration of dry rainforest vegetation communities that were originally present in many areas. There is a management need to recognise that after fire, green fire breaks that contain less flammable vegetation and patches of native bushland are prone to replacement by invading weeds and exotic grasses, particularly green panic and molasses grass. Fire breaks to protect life and property, where bushland abuts urban developments, can be created by either micro-mosaic patch (or strip) burning or slashing, poisoning and removal of flammable exotic vegetation.

Recommendations in this Advisory Code are made while recognising that fires are at times intense and their velocity sufficiently extreme to over-ride all precautions and fire-fighting practices. That most fires are deliberately lit is universally known. Adequate precautions and enforcement of existing regulations, including total fire bans by appropriate authorities, are recommended to minimise the threats. They are especially important in areas without town water in Brisbane's western suburbs. Better education for children and the general public is needed, to enable them to recognise fire as a *threatening process to biodiversity* and to foster an understanding that the southern Australian climate, vegetation and risks are currently completely different to those in Queensland. This information should be introduced through the media, local government authorities and schools via *co-coordinated fire educational programs,* similar to those in New South Wales.

ECOLOGICALLY SUSTAINABLE FIRE MANAGEMENT

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1. Background: the state of change

The western suburbs of Brisbane in southeast Queensland (SEQ) are unique in possessing a diverse suite of geographic, vegetative and wildlife features. Some of these features adjoin the Protected Areas of Moggill State Forest, Anstead Bushland Reserve, Mt. Coot-tha Forest, Brisbane Forest Park and Nature Refuges, Voluntary Conservation properties and rehabilitated areas. These suburbs are acknowledged as being the 'Green' areas of Brisbane and valued for their scenic amenity, as carbon sinks and for wildlife habitat and biodiversity.

The purpose of this Code is to provide a reference document with recommendations for fire managers, biologists and the community. It provides a framework for 'ecological fire management', to reduce the impacts of fire on biodiversity without increasing risks to life and property. It highlights differences between fire management needs in the western suburbs of Brisbane and those in some other parts of Australia. The Code recognises that each ecological community needs individual assessment to determine an appropriate regime before controlled burning. This Code recommends the replacement of 'macro-mosaic' hazard reduction burning' (up to and more than *ca* 30 ha) in the western suburbs with 'micro-mosaic' patch burning (1-2 ha) as an equally effective method of fuel reduction burning. Micro-mosaic patch burning means selecting defined strips and small patches for controlled seasonal burns.

In the moister parts of Australia some plant and animal communities benefit from total or long-term fire exclusion while others benefit from frequent or relatively infrequent burning. When certain animal and plant communities are at risk of becoming permanently disrupted or destroyed if burnt, fire should be completely excluded in order to preserve that community. Ecological communities requiring both frequencies are represented in the western suburbs.

Residents, authorities and other parties working in or visiting this area are asked to consider this Code carefully and encourage an on-going debate towards improving local fire management.

1.1 Human land use

Land use has changed the natural conditions of this area and today it contains a complex landscape mosaic that reflects the social demands placed upon it. The area is now a matrix of urban and urban rural development with patches of parks of varying-size and native bushland intercepted by corridors of roads, creeks and rivers.

Fire in Australia has a complex history and there are no definitive answers for how it can be managed safely or how it was managed before European occupation. Before Aboriginal occupation natural fires occurred infrequently and randomly, mostly from lightning strikes and rarely from solar radiation or spontaneous combustion [31]. Aboriginal people later introduced fire regimes that influenced many native plants and animals. With the arrival of Europeans, practices changed again and fire has since been used as a land management tool in a very different way. Ecosystems in the western suburbs are now significantly fragmented and degraded, reduced in area and natural biodiversity, and extensively invaded by exotic organisms.

1.2 Exotic invasions

In the past, emphasis has been placed on prescribed burning as a means of reducing fuel load but in this area of Brisbane, prescribed broad-scale burning does not always adequately reduce fuel load and may, in fact, increase flammability due to invasions by highly flammable exotic grasses. This post-fire phenomenon is well known in central Queensland [8].

The Code recognises that different ecological communities require different timing and intensity of fuel reduction regimes. It recommends the preservation and planting of 'green fire breaks' and suggests minimising the height of the combustion layers to provide 'cool' (Appendix ~~5~~) burns as hot fires may do more harm than good [3]. The Code emphasises the importance of variation in fire frequency that is compatible with individual plant communities.

1.3 Regional climate change

The Code recognises that as anthropogenic and natural global warming processes [9] increase, temperatures and associated drying in the western suburbs may occur that would exacerbate the risk of wildfire from the vigorous exotic grasses that are abundant along roadsides and underneath forests. Prolonged and increasing frequencies of drought in SEQ have led to an observed increase in the incidence of uncontrolled fires between 1997 and 2005 in Brisbane's western suburbs (unpubl. obs.)

2. Application of the Code

This Code seeks to introduce *an advisory Code* acceptable to the Community (land owners and users, the general community, members of environmental groups) and local authorities (Council, EPA, Fire Authorities, electricity providers). It can be applied as a recommended management strategy to private and public land in the western suburbs of Chapel Hill, Kenmore, Kenmore Hills, Brookfield, Upper Brookfield, Pullenvale, Bellbowrie, Anstead and Moggill (Appendix 1).

2.1 Purpose of the Code

This Code supplements existing information available relating to fire prevention and management, from Federal, State and Local Government sources including information supplied by the SEQ Fire and Biodiversity Consortium [32.] It is intended to add value to fire management in the western suburbs to protect life, property and the environment, by providing -

- An increase in community awareness, education and an understanding of fire risks and management.
- A management strategy for fires that is compatible with all local land uses.
- A 'bottom up' approach method for managing fires, meaning that it is compatible with the needs and wishes of the Community.
- A contrast between the threats and effective risk abatement in this district when compared with other parts of Australia.
- A basis for introducing communication and cohesion between all Stakeholders.
- Methods that will protect the area's exceptional biodiversity and scenic amenity *in addition* to protecting life and property.

It is not the purpose of this Code to suggest changes to fire fighting practices. There will always be the need for brigades and trained fire fighting personnel, all currently in place, to prevent fires from threatening life or property.
The dependence of the Community on State, Municipal, Rural and volunteer fire brigades is in no way understated and this Code does not intend to discourage or modify actions needed by authorities to prevent losses to life and property.

2.2 Organisation of the Code

Fire Management involves managing wildfires, reducing the occurrence of wildfires and the use of controlled burning to achieve specific fire and other management objectives. This is reflected in the organisation of the Code with the contents being presented in 10 sections. The first four sections provide a background to the Code, its application, purpose, organisation and list of stakeholders. The fifth section defines how fires start and the sixth explains what is different about managing fire in the western suburbs as compared with southern Australia. The seventh section explains how land use affects fire management while section eight discusses the impact of fire on environmental protection. Section nine discusses the management of vegetation to control fires and section 10 discusses education and management. Recommendations are provided in Appendix 2.

3. Why an Advisory Code?

This Code has been developed in response to residents concerns and lack of understanding of fire risks and management in the western suburbs of Brisbane. It recognises that fires started outside of buildings, when accompanied by long periods without rain, high temperatures and high wind velocities are at their most hazardous. These conditions are the most likely combinations to result in wildfire and damage to life, property and ecosystems.

The Code focuses on community awareness, prevention, and risk minimisation and emphasises the need for environmental management to take into account 'local' conditions of climate, land use and vegetation. It also highlights the important differences between fire management and ecology in this part of SEQ and the southern states of Australia. For example, Brookfield, Upper Brookfield and Pullenvale contain a variety of vegetation communities [39], including dry rainforest (*microphyll vine forest* [42]), moist gullies and riparian zones (remnant *notophyll vine forest* [42]) that act as natural firebreaks (fire shadows [42]) and should be considered as such. These are features not shared with most of the fire-prone districts in Victoria, ACT and South Australia where the plant communities and climate differ.

Deliberate burning of large areas is not appropriate in an area that is relatively small, fragmented and therefore environmentally compromised. Residents, authorities and other parties working or visiting this area are asked to consider this Code carefully and encourage an on-going debate towards improving and continually learning about local fire management practices. Much new information has become available in recent years about managing fire to protect the environment without detracting from strategies to protect life and property.

The most pressing needs in the western suburbs are for better public communication and awareness of fire ecology and how fires get out of control in this area of SEQ. Members of the community do *not* want local authorities making relevant decisions and taking actions with major environmental impacts without appropriate communication with community groups.

4. Who are the Stakeholders?

Parties that are involved in and/or concerned with fire management of the western suburbs are:

- All landowners and residents.
- Community members and groups (e.g. Moggill Creek Catchment Group, (MCCG), The Hut Environmental & Community Association (THECA), Pullen Pullen Catchments Group (PPCG).
- Members of Neighbourhood Watch.
- Tenants.
- Businesses.
- Schools.
- Retirement settlements.

- Brisbane City Council (BCC).
- Queensland Parks and Wildlife Service (QPWS).
- Rural Fire Brigade (RFB).
- Electricity provider-Energex.

5. How do most Wildfires start?

Uncontrolled fires start from:

5.1 Human causes

- Landowner carelessness and lack of understanding in outdoor fire use including burning of timber, garden and household wastes.
- Discarding ignited cigarette butts.
- Escape of fire from controlled burns on private and public land.
- Poor seasonal choice for starting fires. Intentional burning is difficult to control when temperatures and wind velocities are high and when there has been no recent rain.
- Failure to extinguish 'hazard reduction' or ecological burns.
- Failure to consider flammability of vegetation, particularly grass, when deliberately burning outdoors.
- Electricity malfunctions, such as arcing powerlines in strong winds, trees touching live wires and ignition of ground-level vegetation from falling molten aluminium alloy.
- Spraying of roadside grasses with herbicide – a predisposing source of igniting dead vegetation.
- Mower, slasher and trail bike exhaust and sparks from blades hitting rocks may ignite dry grass when it is being cut.

5.2 Natural causes

- In the western suburbs the occurrence of 'dry' lightning strikes is rare. This is the only natural cause of fire that has been identified in the western suburbs.

6. What is 'different' about managing bushfires in Brisbane's Western Suburbs?

Fires regularly break out in the western suburbs but the cause is often overlooked as reflecting the past historic use of fire in farming and rural activities. However land use has changed as people with different requirements have moved into the area. Where fire was also recognised as principally a threat to life and property, fire is now accepted as having major detrimental impacts on the environment as well having some benefits.

6.1 Climate

It is generally recognised that the most serious threats exist during severe drought conditions and that the time of year most at risk in the western suburbs differs from many other parts of Australia due to the local climate. In SEQ the fire season (season when there is greatest risk of fire) tends to be much less severe than in southern Australia because it is not subject to the coincidence of high fuel loads, high temperatures, high wind velocities and low humidity [24]. While fires can get out of control throughout the year, and these predisposing conditions occasionally occur, the driest and windiest months in the western suburbs are from late August until November. These months are most prone to serious fires and are periods when fire-lighting precautions and restrictions must be applied more seriously. Climate change, [9] accompanied by lower rainfall and environmental conditions dryer than previously, may exacerbate this seasonal effect. For example, at a Moggill Creek locality between August and October 2002 – 2004, rainfall averaged 34 mm, compared with 54 mm for the same months averaged over 34 years [14]. It is worth noting comments by Mackey et al. (2002) [18] that "fire, climate and vegetation are interdependent phenomena and should not be examined linearly or in isolation from one another".

6.2 Vegetation

The natural environment of the western suburbs is in many ways different from other parts of suburban Brisbane. Watercourses, riparian vegetation and hillsides sometimes contain rainforest and these act as natural barriers to fire. Relatively recent planting of fire-retardant plant species, for rehabilitation on council-owned and private land, has enhanced the effectiveness of these barriers and provided refuges for wildlife from both fire and human disturbance.

The presence of extensive areas of highly flammable exotic grasses in these suburbs, particularly on acreage properties and in protected areas, means that different management is required because, if burnt, they will rapidly return with increasing density and fuel load, as has been noted in northern Australia [5].

6.3 Land use and water availability

Many parts of the western suburbs within 13-20 km of the City centre (particularly Upper Brookfield) do not have access to town water and the residents are dependent on stored rainwater. Limited water supplies justify a different approach to fire management with more precautions required especially in situations when fires must urgently be extinguished. Householders do not have sufficient water pressure, access to nearby hydrants or the volume of water needed for fighting fires on their properties. Residents without pressurised water nearby must wait until local authorities can attend.

The quantity of rainwater stored is not sufficient for fire emergencies and delays in providing sufficient water to extinguish threatening blazes should be taken into consideration before deliberate burning off is approved and undertaken.

Local authorities are reluctant to extinguish fires in bushland unless there is an immediate threat to life and property. This is influenced by the need to reduce the unavoidable delays in refilling tankers from hydrants in the absence of access to 'town water'.

Clearly the community requires an improved flow of information about fire risks, threats, causes and predisposing conditions. The strategies for education about fire have been recognised as lacking [43] and must be up-graded at least to the levels of those in other states. At the same time, the differences between fire management strategies and reasons why they should be different must be documented and widely disseminated.

7. How can land use affect fire management?

Land usage in the western suburbs is primarily:

- Urban residences with buildings, garden, trees and fences.
- Acreage residences.
- Equestrian activities, livestock paddocks.
- Small-scale crop farming.
- Protected areas and other ecological (environmental) communities.
- Rehabilitated and protected vegetation on private land.
- Parks and other public lands.

Multiple land use is a feature of the western suburbs of Brisbane. These multiple uses include mixed residential and rural lands with livestock, farms, domestic animals, environmental protection and recreational pursuits such as bush-walking, mountain-bike riding, bird watching, horse-riding and bushland rehabilitation.
Residents and landowners co-exist with essential, but limited, awareness of each other's needs. In addition to 'a place to live', the fauna and flora are also important to most residents and are often the reasons why people have chosen to settle in the area. A change by residents from earlier practices of clearing of bushland and farming, to preserving and replanting bushland, has resulted in recent improvements in biodiversity of the area.

For the first time in many years koalas and platypus are regularly sighted in these suburbs approximately 15 km from the GPO (D. Sands & C. Hosking, personal observations).

Differing land uses can influence the way that fire becomes a threat, the way it is managed and the precautions needed to minimise outbreaks. For example, livestock grazing that encourages dense and dry pastures with exotic grasses greatly increases the 'fuel load' of grasslands.

Fires from grasslands, crops and pastures provided with concentrated sources of fuel pose threats to life and properties during periods of drought and high winds. Exotic grasses often colonise native forests and greatly increase fuel loads beneath trees and the intensity and height of the flammable layer [10]. In some areas of Queensland and northern Australia fires in tall exotic grasses have caused local extinction of trees or markedly reduced their densities [10]. People with equestrian interests must be aware of these factors and the need to control growth of pasture grasses near buildings and neighbouring properties, especially near bushland, and to minimise the likelihood that their grasses will invade adjoining lands.

Properties in the western suburbs are often acreage with varying amounts of bushland near to, or sharing boundaries with, Brisbane Forest Park, Mt. Coot-tha Forest (Taylor Range), National Parks and State Forests. Some of the government-owned land has been partly preserved in its natural state or allowed to regenerate for forestry, recreation, biodiversity, scenic amenity, as water catchment and to protect water quality.

The western suburbs have bushfire brigades that are well trained to extinguish fires and quickly attend to emergencies. The metropolitan brigades are based locally and also respond quickly. However, because there is more bushland managed by government and municipal authorities than elsewhere in urban Brisbane, there are often more impacts on the nearby environment from their fire management practices. These actions have raised community concerns on several occasions when fires, accidentally or intentionally started, were seen to have had detrimental impacts on the bushland, fauna and flora, close to residential properties.

8. Impact of fire on environmental protection.

With the rapidly escalating urban spread in the area, wildlife habitats are becoming increasingly fragmented and degraded, leading to a loss of the biodiversity and ecosystem health upon which human life is ultimately dependent. This Code recognises that these western suburbs are collectively ‘biodiversity hotspots’, providing habitats for most of the non-coastal fauna and flora in the suburbs of Brisbane.

The ecological communities are of considerable State and National conservation significance, warranting careful, scientifically planned fire management in order to avoid local losses and extinctions [17]. Several rare and threatened vertebrate (e.g. koala, spotted-tailed quoll, collared delma) and invertebrate (Richmond birdwing butterfly) animal species [11] occur in the area.

8.1 Riparian zones.

Without human intervention most riparian vegetation was not fire prone [40] and acted as a natural fire barrier. Any burning of watercourse vegetation has a major impact on the quality of water flowing into downstream watercourses and rivers – often only in the short term but it may directly affect water quality and the aquatic fauna. In addition, the more often vegetation is burnt, the more it becomes fire-prone [5] as plants and weeds adapted to burning displace fire-sensitive and fire-retardant species. This phenomenon has been observed by the authors at a site on Mt. Coot-tha burnt in October 2003 (see cover photos).

8.2 Plants.

Some plants respond positively to fire (e.g. banksias, some eucalypts and some acacias) and are dependent on cycles of fire for their reproduction and growth architecture. These include plants that regenerate vegetatively or by seed and provide a place where animals can shelter and sustain themselves after fire. Other plants are not resistant to fires and are very susceptible to being burnt [37]. They may decline in abundance and density, or be completely exterminated if they fail to reproduce.

8.3 Vertebrate animals.

Direct affects on wildlife include:

- Death from radiated heat and/or smoke inhalation and/or asphyxiation
- Confusion and stress
- Reduction or complete removal of cover or shelter
- Destruction of nests or lairs
- Removal of social and territorial markers
- Changes in food availability, for example a short-term abundance of prey for predators and carrion feeders, followed by long term scarcity [24].

Most birds are mobile and can often escape fires but they must find suitable unburnt places to reside and reproduce. Animals, depending on species, are generally adapted to particular vegetation types and many can survive varying frequency of fire, providing there is suitable unburned habitat nearby for refuge.

Some less mobile species are particularly susceptible to detrimental impacts of fire, suffering local extinctions. This includes many insects and some reptiles that are not able to escape, such as those that live under logs or bark of trees and those that are immobile during cool weather [17, 20].

8.4 Invertebrate animals.

Although invertebrates make up 99% of the animal kingdom [26] very few fire management documents have taken into consideration their environmental needs. Many vertebrate animals are totally dependent on invertebrates as food and as part of their food chains or symbiotic interactions. All plants need invertebrates to maintain pollination, seed production, architecture, and participate in disposal of dead plant materials. Winter is the time of the year when insects are not often seen and may be dependent on shelters to carry them through cool weather until the temperatures rise sufficiently to support their feeding, development and reproduction. Winter burning reduces the quality and availability of plants for feeding by insects in spring, at a time when most food is required prior to pupation or development leading to adult emergence. Burning bushland in winter has had major impacts on the immobile stages of insects. Many are in diapause. Local extinctions of insects often follow winter burning in the western suburbs of Brisbane.

Recent surveys of terrestrial invertebrates by the Queensland Museum [33] have shown the presence of many rare species near Brisbane, including some not previously known in the region. The authors of this study note the value of invertebrates as environmental indicators. With the increasing knowledge of invertebrates, especially from the Queensland Museum surveys, it is clear that fire management must take account of the needs of the over-wintering stages of invertebrates, to avoid major impacts on them and the vertebrates and plants that are inter-dependent on them.

Managing fire for vertebrates alone restricts conservation efforts to relatively few well-known species and overlooks the needs of the vast majority of members of the animal kingdom. In particular, deliberate burning of bushland should take into consideration the needs of invertebrates to avoid noncomitant impact on all other animals and plants [41]. As food for other organisms, pollinators and other essential components of the environment, the needs of invertebrates are equally important to those of vertebrates [1]. Invertebrate and reptile faunas need to be able to persist without local extinction. A study in a tropical eucalyptus open forest [44] has shown that an area left unburned for 23 years contained a higher diversity of reptiles. It also demonstrated that there was a substantial set of plant and animal species that were disadvantaged by a regime of high fire frequency. This is also likely for ground-dwelling invertebrates as they share similar habitats. This is important to note when considering hazard reduction burns on private or public land.

Most work on impacts of fire on invertebrates in Australia has been carried out in tropical savannas and grasslands, for example by Anderson et al. (2005) [2]. The work has also concentrated on ants, a group of Hymenoptera often occupying terrestrial systems where they are protected from incineration. The tropical ecosystems differ considerably from temperate systems where diapause in immature stages is not such a prominent feature as is the case in temperate parts of Australia.

Diapause and immobile protracted development are the most important means by which insects survive cool temperatures in temperate Australia but they are also most prone to exposure to the detrimental effects of fire.

Hills, summits, ridges and watercourses are sensitive areas used by a wide range of invertebrates [23] as part of their essential life systems and these should be protected as much as possible from any kind of mechanical damage or ignition. The loss or degradation of hilltops is listed as a Key Threatening Process for insects in New South Wales [23]. Many insect species use hilltops and ridges in all states of Australia as places to find mates and to compete – a prerequisite for genetic mixing. They are also places where birds seek insects as a source of food. The vegetation and landform on hilltops and ridges should be maintained as intact as possible and should be excluded from burning whenever practicable. Tracks and fire trails should not be made on these sensitive areas. Therefore this Code recommends that prescribed burns that are intended to burn downhill are always ignited 20 metres or more below the ridgeline or hilltop.

The importance of conserving invertebrates has only recently been recognised in the management of farming systems [22] but has received surprisingly little attention in the metropolitan management of ecosystems for other fauna and flora, despite their inter-dependencies. Such a focus is overdue but has had a very promising start with recent surveys by Queensland Museum in a project promoted by Brisbane City Council.

8.5 Soils and Nutrient Cycling.

Fire can have significant indirect effects on soils such as reduction of soil moisture and organic matter, increased water run-off rates-particularly on slopes (leading to increased turbidity and nutrient loads in streams), soil erosion and seed destruction. These changes are generally relatively short-term because ecological processes will act to re-establish the pre-fire conditions [24]. It is during re-establishment, however, that opportunistic weeds will also rapidly re-colonise. Exotic grasses, when burnt, are known to reduce the important nitrogen content of soils [10] and subsequent nutrition of regrowth.

9. Managing vegetation to control fires

Brisbane's western suburbs are of critical nature conservation value. This Code provides a basis for fire management while preserving the area's bushland that is essential habitat for its biodiversity. Climate and vegetation are the factors directly affecting the levels of risk when fires get out of control. Some types of vegetation burn naturally at regular intervals (e.g. coastal heathlands) and other vegetation types rarely burn. Some kinds of vegetation burn irregularly, slowly, or not at all and even dense stands of these pose no risks, or very low risks to life, property and wildlife in the environment they share.

The term ‘micro-mosaic patch burning’ has been used by CSIRO invertebrate specialists and is introduced here to quantify the smaller areas required for controlled burning where faunal habitat is compromised and is localised.
Long, dry grass is the most serious local threat and it should be kept slashed, grazed or mown within 60 metres of a house. Slashed (not burnt) firebreaks and mown road reserves are desirable in all areas used for grazing and particularly when close to houses. The benefits of prescribed burning of bushland in the western suburbs are greatly reduced by the detrimental re-colonisation by grasses. Useful when grown as stock feed, most introduced grasses are highly flammable and increase risk of losing control in the event of fire, especially when grown on slopes.

The question of what constitutes ‘fuel’ becomes an issue when fires are used to reduce the ‘fuel load’. ‘Fuel’ is best described as “The dead biomass (leaves, bark, woody debris) produced by plant photosynthesis that has yet to decompose” [18]. Unfortunately in SEQ there has been a tendency to manage fires not only for ‘fuel reduction’ but to allow hot fires to also consume the decomposing litter – a major threatening process for small ground vertebrates, invertebrates and the seed bank.

Any benefits from reducing fuel loads by deliberately burning introduced grasses are rapidly reduced by enhanced growth, which follows, leading to subsequent increased fire intensities [8]. Hazard reduction burns sometimes exacerbate the fire problem, for example, they often encourage weed re-growth (especially *Panicum maximum*) during moist weather, adding to the fuel load during the next cycle of dry weather. Value as a firebreak is then short-lived and burning is not worth conducting to reduce fire risks. Lunt and Morgan (2002) [16] mention that despite the fact that the effects of grassland fire regimes on fauna have been poorly studied, frequent burning is widely perceived as having negative impacts on many fauna, particularly small species that are less mobile and threatened species such as legless lizards. They suggest intermittent light grazing as an alternative to frequent burning.

9.1 Fire-prone Vegetation.

One of the greatest fire risks in these suburbs comes from introduced grasses and weeds that have become dominant on some properties, along roadsides and in protected areas. Mt. Coot-tha Forest suffers from severe infestations of highly flammable introduced grasses. A study in a Queensland Brigalow woodland showed that the exotic Buffel Grass and Parthenium Weed invasions were facilitated by wildfire and controlled burning, producing a positive feedback between the grass and fire [8]. The study concluded that other management approaches such as low intensity burning [21] of the grasses and follow up application of herbicide would be preferable to high intensity fires that kill trees and increase exotic grass cover.

Unlike coastal heathlands or other woodlands with low under-shrubbery, woodlands of the western suburbs contain few highly flammable native shrubs, grasses and sedges.

After being burnt these native plants near ground-level are rapidly replaced by the much more competitive and flammable introduced grasses such as Guinea grass (*Panicum maximum* var. *maximum*), green panic (*Panicum maximum* var. *trichoglume*), molasses grass (*Melinis minutiflora*) and Lantana *(Lantana camara:* when it is dry*)*. Molasses grass is well known for its detrimental flammable characteristics during dry weather [35] and is a serious predisposing condition for uncontrolled fires due to the heat and height of flames generated by highly flammable oils in the leaves. In the western suburbs it has been noted that after it is burnt it readily re-grows and out-competes native grasses and sedges (C. Hosking, personal observations).

Recent studies in the Northern Territory [10, 30] have shown that some African grasses, introduced into northern Australia to increase cattle production, transform native ecosystems as well as nutrient cycling and fire regimes. Most importantly, mission grass (*Pennisetum polystachion*) increases fuel loads by five times when compared with native grasses and carries flames into the canopies of trees not naturally affected by fire. Increases in the fire intensities have subsequently caused a reduction in area of fire sensitive forest habitats, including monsoon vine thickets similar to those in the western suburbs of Brisbane. In addition, soil nutrition (nitrogen) is reduced affecting nitrogen availability and recycling following exotic grass invasions. Similar effects are known for buffel grass [8] and are likely to resemble effects of invasions by *Panicum maximum* and molasses grass in SEQ. That is, these invading grasses in the western suburbs increase fuel loads, carry flames much higher in bushland; destroy native vine thickets and lower soil nutrient levels.

The foliage of fire-prone and fire-dependent species of plants is readily ignited during bushfires. Such species predominate in SEQ and are the most common components of eucalypt, acacia and some casuarina woodlands, and in coastal and sub-montane heathlands (wallum) and grasslands [25]. Effects of burning these plants vary with the species. Some species depend on fire for their continued survival. Fire destroys the leaves, twigs and bark, and regrowth takes place from the living stems and seeds are released.

Other plants survive burning by regrowing from undamaged rootstock or rhizomes. The vegetative parts of many Australian plant species die when burnt, but their seeds remain viable and are able to disperse and germinate in cycles alternating between growth, maturation, seed set, burning and seed germination. Other plants share different parts of this cycle and their communities predominate where fire has been part of the inland landscape for thousands of years. The cycles and time between fires can be very important for some plants that must fruit before being burnt. Without adequate time to produce seeds, fires can destroy populations of plants that are unable to re-grow from underground rootstocks (e.g. some *Boronia* spp).

9.2 Managing vegetation near residences.

The flammability of trees can be greatly reduced by removing fallen or stored timber and branches, loose leaves and twigs. When fire-prone trees are present on a property, removal of branches at low levels and maintaining general household hygiene (cleaning gutters, stored timber away from buildings etc.) will greatly reduce risks. Large eucalypts and acacias with low branches near homes can have their branches removed from the trunks to a height of 3 m - greatly reducing the carrying capacity and intensity of fire. Eucalypt species with smooth bark (e.g. *E. tereticornis,* (a critical koala food tree*)* and *Corymbia citriodora*) can be pruned to prevent their ability to act as fuel while being retained for wildlife. Smooth barked trees with low branches removed can reduce fire velocity provided that other flammable materials have not built up close to ground level. A perimeter of lawn near the house with plantings of fire-retardant native species (Appendix 4) acts as an effective firebreak. These types of fire breaks do not completely prevent fires from reaching a home but they do reduce the intensities of flames. Tree planting close to roof alignments and gutters should be avoided.

Some species able to regenerate (vegetatively or by seed) can be managed by intentional use of fire; others such as most rainforest plants are not able to survive or re-grow after fire and are liable to extinction. Plant communities supporting the latter should never be intentionally burnt [40, 41] (Appendix 4).

9.3 Watercourse vegetation as natural fire barriers.

In the western suburbs where eucalypt woodlands dominate, dry and moist watercourses are major mechanical barriers. The vegetative characteristics of the base of slopes provides natural barriers that stop fires moving from one slope to another, as do rocky outcrops towards the crests of slopes. Riparian areas are often edged with moist, native vegetation that inhibits the spread or transmission of fire. These are the ‘natural firebreaks’ that have protected plants and animals in areas where fire is a natural part of a landscape’s ecology. They should always be left unburnt [17, 20].

9.4 Making firebreaks and mechanical barriers.

Fires may be intentionally lit for ‘firebreaks’, ‘hazard reduction’, ‘fuel’ reduction’, ‘ecological’, ‘prescribed’, ‘edge’, ‘mosaic’ and ‘micro-mosaic patch’ burning. These terms refer to reducing the amount of combustible materials close to property. For extinguishing these types of intentionally lit fires knapsack sprayers are essential tools because vehicles cannot always gain access to a burning edge (e.g. preventing burning watercourse vegetation) in the absence of access tracks.

Barriers to stop or slow fires can be constructed of cleared strips and tracks using mechanical equipment. In tracts of bushland, they are essential to allow access and entry for personnel, equipment and water storage. They are needed to extinguish fires before they approach residential areas and to carry out prescribed burning for environmental purposes.

Fire trails must be maintained to allow entry by vehicles to areas of difficult access. However, they should be constructed with prior planning to avoid damage to sensitive plant and animal communities.

Raking is often used for creating fire breaks “dry fire fighting’, to prevent large fires from occurring [31] .To prevent the ignition of fallen hollow logs, standing dead or live trees (often containing hollows that provide habitat), litter-raking and removal of highly flammable material should precede every prescribed burn. They should also be kept free of weeds wherever possible. However, conditions more typical of southern states in summer, when wind strength is high, humidity is low and ground moisture and vegetation are dry (for example during periods of drought) can at times occur in SEQ and the western suburbs. At these times, ‘spot’ fires from wind-borne ignited vegetation increase the threat of fire crossing boundaries. In very high winds such fires may become destructive regardless of the nature of vegetation. It must be remembered that under certain extreme weather conditions the proximity and nature of vegetation is less relevant once a fire has become established.

9.5 Green fire breaks

It has been recognised “vegetation can contribute to a home’s survival during bushfire” and “that certain types of gardens and plants will inhibit the spread of fire across a property better than others” [31]. Therefore *green firebreaks* around the perimeter of buildings can be maintained, these being; (i) lawns and/or (ii) fire retardant plants and hedges. Lawns and fire retardant plant species, tree pruning, weed management and other plant buffer zones can stop fire entering a property or greatly slow its progress. *Fire retardant plants* do not stop fires from igniting surrounding vegetation or nearby dwellings but they *do reduce the intensity of fire*. These plant communities *will* burn if the landscape is dry and winds are high but they do not normally burn unless subjected to out-of-season fires. Green fire breaks also reduce the likelihood of fires reaching the surrounding canopy and tree tops. If already present near proposed dwelling sites, fire retardant native plants and/or rainforest plants act as a natural barrier/green firebreak and should never be intentionally cleared or burnt [20, 40, and 41]. Notable authors on this topic were Cuong Tran and Clyde H. Wild (2000) [37].

These methods were introduced in other states many years ago but in Queensland the methods have only recently received adequate attention [4]. The process involved growing plants which have a low flammability to serve as buffers between sources of fire, such as bushland, and properties or dwellings that are to be protected. Sometimes (perhaps unwittingly) this has been of benefit in several Brisbane suburbs when many fire retardant rainforest species have been planted in bush regeneration projects. The only problem arises when weeds, especially exotic grasses, invade the under-storey and of much less significance, build-up of leaf litter and dead wood beneath the trees. Fortunately, leaves of many rainforest species are low in flammable oils; their leaf litter rapidly decomposes and retains much more moisture than fire-susceptible species. However, where introduced grasses

have invaded and displaced moist understorey plants, fires may ignite the lower canopy of rainforest and at times may burn and kill plants that are otherwise fire-retardant.

Natural stands of deciduous vine thickets (*microphyll vine forests*) containing high biodiversities of fauna and flora (resident and food sources) are examples of naturally occurring green fire breaks in the western suburbs. Deciduous vine thickets occur close to the southeastern range for this type of plant community and contain primarily fire retardant plant species. Green firebreaks are always 'environmentally friendly' even when the planted sites are dissimilar to their native habitats. For example, fire retardant (and decorative) hedges of the native Lilly Pilly (*Acmena smithii*) are sometimes recommended for planting near houses to reduce risks from fire entering from nearby bushland or grassland [13,15]. They can be planted in many ways to protect, or reduce risks to property against fire, and slow the progress of ignition if no attention is immediately available to extinguish a fire – especially useful in areas without town water.

Green firebreaks also act as corridors for small birds, support insect prey for many vertebrates and accumulate moist and decomposing leaf litter as they mature. These corridors have the wider benefit of creating fire-resistant conduits for wildlife movement. In addition, appropriate fire management in certain areas, including reduced frequency or fire exclusion, will facilitate the establishment of rainforest species through natural recruitment.
Several exotic plants, including pasture legumes, are known to be fire retardant but where they have invaded bushland they have replaced native plant species and compromised biodiversity. Many species of native vines are known to be fire retardant but they have not been used in bushland regeneration projects. Vines generally have been avoided, partly because they are difficult to maintain as potted plants in nurseries. The potential for using fire-retardant native vines (such as 'bower of beauty' *Pandorea jasminoides*) is considerable and they should be recognised as part of the rehabilitation process and for planting on fences.

Green firebreaks reduce the intensity and rate of advance of a fire but they cannot be relied upon to prevent the destructive effects of bushfires.

9.6 Seasonal timing and duration for prescribed burns

Fire regimes, rather than single fire events, are of immense importance in determining the overall impacts on all fauna and flora [18]. In Queensland there are no 'dedicated fire seasons' [43] that is, periods of the year for each region when fire risks are lowest. Until recently there was an understandable tendency to start deliberately burning during the cooler months, when the intensities may be managed more easily. This is useful in the southern states (where rainfall is more evenly distributed into winter) but in SEQ, the late winter months tend to be periods when winds are high and when vegetation is unacceptably dry. In the western suburbs, intense fires are least likely to develop during autumn when vegetation is moister, winds are moderate and humidity is high.

Fires can be more easily extinguished in autumn and are most difficult to extinguish between the dry periods when warm, dry weather prevails.

Winter months are also the most unnatural periods for burning vegetation in SEQ, for example, when lightning strikes resulting in fires are very rare. In contrast, lightning strikes are normally associated with summer storms when moisture and humidity prevail and fires are often extinguished naturally before they expand and/or become intense. The unnatural winter fire regime is known to increase the rarity of many invertebrates as well as plants. At that time of the year hibernating reptiles are also detrimentally affected. In addition the majority of terrestrial, woodland and grassland orchids flower and set seed only at that time.

Benefits of prescribed burning in autumn far outweigh any disadvantages from higher temperatures than winter. Conversely, fires lit during winter at a time when fires rarely outbreak in nature, may detrimentally affect plants, animals and particularly, invertebrates and reptiles when they are relatively immobile. For example, fires lit in winter often destroy the over wintering stages of insects on foliage, under bark, in or under logs and in the leaf litter. Almost all local ground orchids flower and produce seeds in the winter months. Winter is the time most often chosen for making firebreaks when temperatures are low and there is less risk of losing control but it is an inappropriate season for the survival of poorly mobile organisms [16]. Choice of any month for fuel reduction burning must take into account the rainfall patterns locally experienced as the variation from year to year is becoming increasingly variable in the western suburbs.

The duration of time periods between fire regimes for prescribed burns need careful timing by taking into account the nature of the vegetation and its adaptation to fire. As a rule of thumb 7 – 15 years are needed between burns in SEQ bearing in mind that some areas such as rainforest should never be intentionally burnt [40]. In the western suburbs the longer period is more likely to resemble the natural sequence between fires. In New South Wales high fire frequency is listed as a *Key Threatening Process* [25] and the threat applies similarly in all Australian states.

There is a need to accept the efforts and costs of extinguishing spot and remote fires as soon as possible after they are observed to avoid them developing into uncontrollable fires. Fires that are allowed to smoulder and are not extinguished occasionally flare up and cause problems. They certainly cause environmental problems – for example, the base of trees may burn slowly and become undermined to the point where a tree will fall. Logs otherwise singed and able to provide shelter for wildlife will eventually burn to ashes if fires are not extinguished. Prescribed burning in winter is prone to result in trapping smoke in inversion layers and increasing urban pollution [43]. Allowing a deliberately lit fire to '*burn itself out*' is not an acceptable practice for the residents of the western suburbs but it may be unavoidable in rural parts of Queensland. It (I) is a predisposing condition for fires getting out of control (2) continues damage to the environment and (3) causes health problems.

10. Education and management

10.1 Can education help reduce risks of uncontrolled fires?

Understanding the causes of uncontrolled fires must be a responsibility for all residents of the western suburbs and the means to obtain a better information flow is recommended in this Code. Fires started on private and public land often threaten flora and vertebrate and invertebrate fauna, unless contained and managed very carefully. All parties must accept the fact that many destructive fires develop after being deliberately lit – not only by arsonists but also by well-meaning people trying to make firebreaks.

It is common sense that every effort must be made to identify and prosecute mature arsonists but greater efforts are needed to educate juveniles on this subject and to prevent fires being inappropriately lit. Damaging fires are often lit during school holidays. Coordinated programs to educate children about the impacts of fire and nature of fire threats must be introduced into schools in Queensland in line with the programs being introduced into the other states [29, 43].

Clearly, the community requires an improved flow of information about fire risks, threats, causes and predisposing conditions. The strategies for education about fire have been recognised as lacking [43] and must be up-graded at least to the levels of those in the other states. At the same time the differences between fire management strategies and reasons why they should differ must be documented and widely disseminated.

This Code recommends introduction into Queensland of *co-ordinated fire educational programs* similar to those introduced into New South Wales [43]. The parties involved must include the Queensland Metropolitan, Bush and Rural fire brigades, Environment Protection Agency (including Queensland Parks & Wildlife Service), and companies delivering electricity.

10.2. Management by local authorities

10.2.1 Building and landscape approvals. As already recognised by local authorities, certain types of native vegetation must be managed if risks of fire to properties are to be reduced. Plant communities, aspects of slopes, common wind directions and the terrain also need to be considered to enable identification of properties with low levels of fire risk as well as those with moderate or high fire susceptibilities. Fire prone species and fire-prone plant communities should be identified, the risk assessed by a suitably qualified ecologist, and plans made accordingly. New property owners and developers need to be provided with the relevant *environmental management* guidelines for their land as a matter of priority. Many seem unaware of information that may be applicable to their property such as the need to exclude fire from protected watercourses (applicable to many areas of Brookfield and including gullies and tributaries), the presence of Vegetation Protection Orders and /or Significant Vegetation requiring protection.

10.2.2 Power lines. Electricity providers often have their wires strung more widely in acreage areas than in urban areas and tree care is not so regularly maintained. Providers of overhead power are inclined to blame trees and vegetation for starting fires when their branches touch live wires. However, the threat of wires touching each other without the influence of trees during high wind turbulence receives far less attention and spacers for live wires are not routinely installed in such threatening areas. Installation of ABC (Aerial Bound Conductors) allows trees to grow around and above the wires. It is acknowledged that recently spacers and ABC have been fitted in many susceptible areas.

Most community groups have representatives competent to work with electricity authorities to ensure that tree pruning is not overdone but at the same time can prevent branches from touching wires.

10.2.3 Health problems. Smoke from fires left smouldering causes health problems, for example respiratory conditions such as asthma and toxic impacts to lungs. These particularly affect young children and the aged [43]. The importance of avoiding health problems from smoke haze from deliberate burns cannot be over-estimated and is only briefly referred to in this Code. However, health problems can be reduced if serious efforts are made to extinguish fires that are deliberately lit. The duration of smoke production, concentrations, movement and direction and retention in air inversion layers all have relevance to health and can be minimised if fires deliberately lit are always extinguished.

10.2.4 Total fire bans. In Queensland, declarations of total fire bans for periods when weather conditions indicate all fires are hazardous have not been properly addressed as in some other states. Although provisions are in place for councils to introduce bans there has been an apparent reluctance by authorities, especially municipal councils, to declare '*total bans'* on the lighting of fires in regions of this State.

'Total fire bans' need to be implemented by the State authorities and advertised during periods of serious fire risk, especially in the western suburbs (and other regions of metropolitan Brisbane). The region can be easily defined by including the name of suburb, for example, Brookfield, Upper Brookfield and Pullenvale, but it has not been adequate to wait until a council representative decides to declare a ban.
Penalties for all breaches should be upgraded accordingly (e.g. for throwing lighted cigarette butts out of vehicles).

As in other states all fires, including those of less than 2 m, would not be permitted during bans. The enforcement must be extended on a regional basis, to include local and state authorities (e.g. main roads, forestry), businesses and members of the community. There is no doubt that fire-lighting restriction and issue of permits must be implemented when needed and stringently enforced. The community will no longer accept 'turning a blind eye' to breaches and predisposing threats such as long grasses and weeds along roadsides.

10.2.5 Breaches and Regulations. Regulations covering fire lighting are not always routinely enforced in Queensland. Fires lit without a permit being issued often get out of control. Fire has, until recently, been used more widely without restrictions and local impacts from bushfires have not been as devastating as the southern states. Authorities often ignore breaches including people throwing out lighted cigarettes from cars and illegally lighting fires. People responsible have often been given a simple warning instead of prosecution. Moreover, environmental impacts of fire have not been widely recognised as resulting in serious disruption of ecosystems and sometimes - permanent losses of natural resources.

10.2.6 Neighbourhood Watch Fire Spotters*.* Concerned Community members would report all fires lit in the open to a nominated person in *Neighbourhood Watch* who would relay the observation to the appropriate metropolitan or rural fire brigade. In this way Neighbourhood Watch takes the responsibility for a report and individuals are not regarded as personally criticising other neighbours, especially when fires may have been appropriately and legally started.

This concept is proposed as parallel to the appointment of 'Fire Patrol officers' in New South Wales, except that these appointees would be authorised on a regional basis following appropriate training. Neighbourhood Watch has already operated informally and effectively in this way and their actions taken have saved considerable losses of property.

10.3 Mt. Coot-tha Forest.

This protected area, previously known as the Taylor Range, is approximately 1500 ha in size and abuts many properties in the western suburbs. It is an ecologically critical, regenerated bushland patch that connects to the larger protected area of Brisbane Forest Park. It plays an essential role in the area's biological conservation. The neighbouring *unprotected* mosaic of the western suburbs that contains residences as well as patches of native bushland, habitat corridors and roads and creeks are equally essential to this biological conservation and need to be viewed ecologically as part of the protected areas.

Historically Mt. Coot-tha Forest was degraded due to early mining, logging and dairy farming. It is currently fragmented, invaded by weeds (mostly exotic grasses and lantana) and threatened by high impact recreational pursuits and edge effects. Therefore any fire regime must be conducted with great consideration and caution.

Large areas of perhaps thousands of hectares have been, and are currently being, burnt in rural areas of Queensland often by farmers using fire as a management tool. These practices are not suitable for Mt. Coot-tha forest because it is a unique biodiverse ecosystem of only 1500 hectares that is situated within an urban mosaic.

It is noted that a Fire Management Plan for Mt Coot-tha was published by Brisbane City Council in 1995. It is also noted that the Mt. Coot-tha Forest Management Plan (Brisbane City Council 2003) briefly discusses Fire Management.

After prescribed fires, many species of fauna must be able to move from burnt areas to areas containing sufficient food and shelter if the species are to survive. Low intensity micro-mosaic (small patches of 1-2 ha) burning with essential follow-up treatment of weed regrowth will effectively and safely reduce fire hazards near residential areas while not obliterating the Forest's surprisingly high level of biodiversity that includes invertebrates [33].

Burning in this manner will also maintain a shifting pattern of small regrowth areas allowing a range of plant successional stages to exist so there will be some capacity for ecological community survival.

Mt Coot-tha is now principally open eucalypt woodland separated into slopes by moist gullies edging watercourses. Before logging in the late 1880s and early 1900s, the watercourse and riparian vegetation were mostly rainforests. After logging and weed invasions, exotic plants and fire-prone native species replaced the original native vegetation. Following efforts in some areas by bushcare groups to revegetate with original plant species, some fire retardant species now have the ability to restrict movement of fire between separated areas.

Although not well known, there are several species of insects (specimens held in the British Museum and the Australian National Insect Collection) that are only known from Mt. Coot-tha Forest and are not known to occur in any other locality (E.D. Edwards, ANIC pers. comm. 2005). In addition, the legless lizard (*Delma torquata*), endemic to SEQ, inhabits undisturbed dry open forests including Mt Coot-tha and is listed as vulnerable under Queensland and Commonwealth legislation. This reptile is a diurnal, thigmothermic insectivore [27] and hot fire is listed as a key threatening process for this fragile species [17]. Other examples of significant species currently present in the Forest are the koala (*Phascolarctos cinereus)*, powerful owl *(Ninox strenua)* and greater glider *(Petauriodes volans)* (C. Hosking, personal observations). These species highlight the conservation significance of the area and the care that should be taken with fire management, particularly the intensities, extent, areas burned/left unburned and seasonal timing.

Current fire management practices tend to prevent regrowth of the important plants and encourage the growth of fire-adapted flammable species in and near the watercourses and beneath the eucalyptus understorey. It is noted that the areas identified as "fire exclusion forest" on all blocks on Mt Coot-tha in the Fire Management Plan for Mt Coot-tha have not always been excluded from burning [38]. The vegetation associated with watercourses needs to be excluded from prescribed burning practices to enable the slow regeneration of fire retardant species. In turn, these will act as barriers to fire moving from one segment of the reserve to another. Guidelines are provided in Appendix 3.

There is much recent discussion regarding Aboriginal fire practices that suggests traditional burning carried out by Aboriginal people was of a finer spatial scale than the more recent indiscriminate and frequent use of fire by Europeans [5]. It is further suggested that the frequency and areal extent of Aboriginal burning may well have been overestimated and European burning underestimated [19]. This questions the validity of the present large patch-burning regime of 20-50 hectares currently being practiced in Mt. Coot-tha Forest [34]. Gott (2005) noted in reference to south eastern Australia that "there is little detail in the early observations that enable us to reconstruct the burning regimes applied by the Aborigines". However, Murray (1802) referred to by Gott noted; "About 6 pm (the Aborigines) doused their fire at once, although it must have covered near an acre of ground". These comments imply micro-mosaic burning that was promptly extinguished. Additionally, much of the original (pre-human and pre-European) vegetation of Mt. Coot-tha Forest no longer exists or is rare (for example fire-dependent *Banksia* species), and this Code suggests that each 'Block' of Mt. Coot-tha, as it is presented by authorities, should be assessed individually to ascertain its appropriate fire regime. It must be remembered that this forest is locally unique, ecologically compromised and still regenerating from complete clearing approximately 60 years ago. Today it is a regenerated bushland patch that is probably entirely different from what evolved during Aboriginal times. Could the most appropriate fire applications for this area today be actually very little with the exception of some prescribed strip burning near residences? That some vegetation is fire-adapted may not necessarily mean that fire has to be applied at regular intervals to maintain ecological integrity.

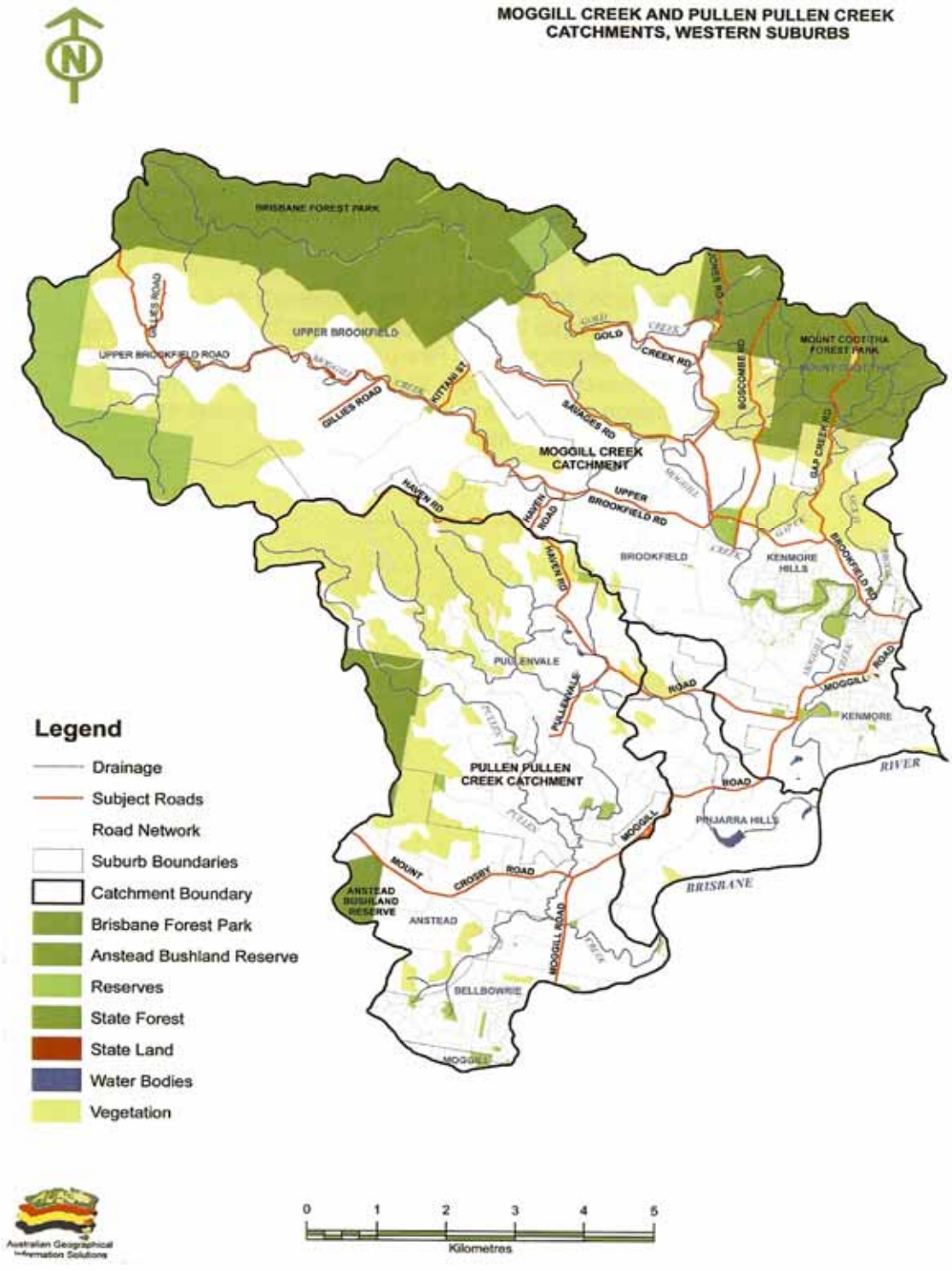
Within these blocks some patches will require complete fire exclusion while others could require cool burning with post-fire treatment of weedy regrowth. Where the Forest abuts onto urban areas, a narrow perimeter firebreak requiring more frequent cool burning and/or control of weed regrowth will adequately address the issue of the protection of life and property.

The Code recognizes that this conservative micro-mosaic-burning regime is likely to more closely emulate the historical Aboriginal fire management, (although their reason to burn hilly eucalypt woodlands is questionable) and will require increased initial resources in terms of time and labour. This recommended approach is, however, essential if the ecological integrity of Mt. Coot-tha Forest and all the 'ecosystem services' it provides are to be sustained for future generations. Further, the high costs associated with some past control efforts may be reduced [6]. Prescribed burning of small areas is far less labour-intensive and is less likely to result in fire breakouts.

The proposed changes to fire management practices for Mt. Coot-tha Forest Park, if implemented, could serve to set a precedent and provide an example to private landholders by demonstrating ecologically sustainable fire management. Fire practice and fire management in the western suburbs requires a paradigm shift towards more ecologically based, precautionary, community education-oriented management that is flexible and can adapt to new information as it becomes available.

APPENDIX 1

Australian Geographical Information Solutions AUSGIS 2005.
Map of western suburbs and catchments



APPENDIX 2

Recommendations for management and improving community awareness

Building and landscape approvals

- For proposed building developments engage ecologists to assess *environmental* fire risk and biogeographical features.

Power lines

- **Regular inspections** of aerial powerlines, installation of spacers or aerial bundle conductors in high wind areas and aesthetically acceptable tree pruning where necessary.

Hygiene around homes and buildings

- Remove leaves from roofs and gutters, timber from near buildings, and comply with other requirements as supplied by local authorities.

Fire management precautions.

- **Introduction of** advertised bans on lighting of any fires in the western suburbs during high and extreme fire danger periods. These should override all other provisions such as permits issued by fire wardens.
- **Fire Spotters.** A coordinated team of 'Fire Spotters' to be appointed through the district Neighbourhood Watch program.
- **Do not start burning without a permit**. A Fire Warden to issue a permit before any fire is lit if the *area or height* of the fire is likely to exceed 2 m in any direction [6].
- **During dry conditions.** When mowing/slashing, have on standby a 15-L backpack containing water to spot-spray any potential fires started by sparks.
- **Notify all neighbours** of adjoining properties at least 24 hours before any burning is conducted. A person starting a fire can be liable for damage to property and the environment of others.
- **Water storage.** Adequate and accessible water supplies, such as a 20,000-litre storage tank, suitable delivery equipment (tankers, knapsack sprays) and access to swimming pools is recommended. It is important that no plastic tanks, pipes or fittings should be situated where they could be burnt (and hence rendered useless) in the event of a fire.
- **Enforcement** of restrictions to the lighting of fires in the open by community members and a revision of practices used by local authorities.

Prescribed burning.

- **Guidelines** to be distributed to, and practiced by - municipal, state, community and other local authorities and groups.
- **Never light a fire unless it can be completely extinguished.** Many destructive fires result from the escape or flare-up of controlled burns. It should be monitored continuously for at least 48 hours to ensure that it is extinguished [32].
- **Practice great care and planning** when burning near boundaries of National Parks and State Forests.
- **Do not burn for "fuel reduction" if there is a risk** the fire cannot be controlled *and* extinguished or that important habitat is threatened. Investigate other hazard reduction options such as cutting, mowing and poisoning with manual removal.
- **Don't burn during 'extreme', 'very high' or 'high' fire danger periods** *even when a permit has been issued*. Defer burning when 'moderate' fire danger periods have been declared and do not burn if town water is unavailable unless a fire service authority is on standby. Seasonal timing of hazard reduction burns is important to minimize fire intensity [32].
- **Don't burn during dry or windy weather or during periods of prolonged drought.** Threats are greatest when winds are strong, or vegetation is dry, *regardless of the time of the year*. Stumps, logs and areas around trees that are burning must all be extinguished to avoid trees smoldering at their base and later falling – a safety hazard and risk to fauna.
- **Avoid 'hot' fires**. Slow-moving ignition fronts with burning dead leaves and twigs near ground level are adequate and not so environmentally detrimental. Hot fires that cause trees to fall or die also change the forest architecture and allow more light to reach the understorey, further encouraging weed grass regrowth.
- **Extinguish flames when they exceed 1 – 1.5 m**. Grass, twigs on the ground and very low shrubs should be the target and not the higher understorey, which if burnt or singed, can create a greater fuel load by increasing dead wood, and killing leaves and branches which fall and accumulate
- **Don't aim to burn more than 1-2 ha at any one time, especially near residential properties**. In outer rural areas up to 20-30 ha have been burnt in the past but such burns should be avoided in Brisbane's western suburbs. Burning smaller areas does not reduce the effectiveness of the area as a firebreak and destroys shelter for poorly mobile fauna to a much lesser extent [16]. 'Micro-Mosaic' burns are acceptable when restricted to within identifiable boundaries with maximum areas of 1-2 ha.

- **Don't burn up-hill**. Burning across a slope and from top to bottom is always preferable. Fire always increases in intensity as it ascends and is more likely to burn the canopy and cause 'crown fires' – the most difficult to control. For example, travelling up a 10^{o} slope, with a prevailing wind, fire travels faster, increasing by a factor of two [19].
- **Don't burn vegetation along watercourses, ridgetops or known faunal corridors**. Watercourses, corridors for fauna such as creeks and gullies, and green fire breaks should be kept unburned within at least 30 m to retain and enhance the barriers
- **Cut, poison and remove fire-prone weeds**. Some examples are molasses grass and panicum. It is safer to re-plant if possible with fire-retardant species and gives a longer-term alternative to most prescribed burning programs.

APPENDIX 3

Recommendations for prescribed burning in Coot-tha Forest Park.

In addition to the above guidelines the following are recommended:

- Ecologically assess each individual 'Block' on Mt. Coot-tha to determine its appropriate fire regime.
- Develop a 'block-by-block' flexible fire management plan to include the following:

a. Conduct flora and fauna surveys.

b. Conduct habitat surveys.

c. Conduct surveys to identify fire-exclusion patches.

d. Practice Micro-mosaic patch burning of 1-2 hectares.

e. Conduct cool burns (i.e. never allow flames to reach canopies or >3 m above ground level).

f. Exclude ridge-tops from burning-ignite 20m down from ridgeline or hilltop.

g. Avoid burning or conduct litter-raking of critical understorey habitat areas such as fallen logs and branches. Manually remove weeds from these areas.

h. Avoid burning surveyed micro-habitats (for example lomandras and sedges) known to support over-wintering fauna.

i. Follow-up after burning with weed controls such as spraying regrowth, taking care to avoid spraying native species.

j. Burn during times that are least ecologically damaging. This is Autumn when invertebrates are mobile, the young of birds and other fauna have matured and flora is more able to regenerate after fire.

k. No burning when there has not been recent rain (>3 months) and when therefore the weedy grass understorey is dry and highly flammable.

l. Use backpack equipment to extinguish wildfires in less easily accessible areas of the Park as soon as fire is detected.

m. Maintain fire breaks by methods such as slashing/mowing/poisoning or cool burning where residential areas with a fire risk border the Protected Area.

APPENDIX 4.

Selected fire-retardant native plant species [a] for the western suburbs

Scientific Name	Common name	Type/height	Response when burnt
*Acmena smithii**	Lilly pilly	Tree 6-20 m	[b]
Acronychia laevis	White acronychia	Tree 3-12 m	[b]
*Capparis arborea**	Native caper bush	Tree 3-10 m	[c]
Croton insularis	Queensland cascarilla bark	Tree 2- 5 m	[b]
*Cryptoccarya triplinervis**	Three-veined laurel	Tree 6-15 m	[b]
Cupaniopsis parvifolia	Tuckeroo	Shrub/Tree 3-10 m	[b]
*Dianella caerulea**	Blue flax lilly	< 0.5 m	[c]
*Elaeocarpus obovatus**	Hard quandong	Tree 3-30 m	[c]
Elaeodendron australe*	Red olive plum	Tree 3- 8 m	[c]
*Ficus coronata**	Sandpaper fig	Shrub/tree 1- 4 m	[c]
*Ficus fraseri**	White sandpaper fig	Shrub/tree 1- 5 m	[b]
*Ficus platypoda**	Rock fig	Tree 6 m +	[b]
Flindersia australis	Crow's ash	Tree 6 m +	[b]
Flindersia bennettiana	Bennett's ash	Tree 6 m +	[c]
*Glochidion ferdinandi**	Cheese tree	Tree 6 m +	[b]
Harpullia pendula	Tulip wood	Tree 6-12 m	[b]
Jagera pseudorhus	Foambark	Tree 6- 9 m	[c]
*Lomandra hystrix**	Creek matt rush	< 1.0 m	[c]
*Macaranga tanarius**	Macaranga	Tree - 6 m	[c]
Mallotus discolor	Yellow kamala	Tree 3-17 m	[c]
Mallotus philippensis	Red kamala	Tree 3-17 m	[c]
Notelaea longifolia	Mock olive	Tree 3- 7 m	[c]
Olea paniculata	Native olive	Tree 4-30 m	[b]
Owenia venosa	Rose almond	Tree 3-18 m	[c]
Syzygium australe	Creek lilly pilly	Tree 6-24 m	[b]

* Listed by Greening Australia as 'fire retardant' or 'fire resistant' [13].
* Many low flammability plants are also listed on the Brisbane City Council Website: www.brisbane.qld.gov.au/BCC:STANDARD::pc=PC677

[a] Plants with 'low flammability': not easily ignited by bushfires with moderate intensities.

[b] Fire retardant but mostly unable to regenerate after fire.

[c] Often capable of regeneration from root-stock after fire.

APPENDIX 5.

Definitions of terms used

Back burning. To remove the fuel in front of an advancing wildfire [24].

Bushfire. Fire burning in bushland after it has been started naturally or by humans.

Cool burn. Low intensity (<500kW m $^{-1}$).

Dedicated fire seasons. Periods during the year when prescribed burning is considered to be safest and least likely to have non-target impacts on an ecosystem.

Ecological burn. Fire used to manipulate/modify the environment [28].

Edge burn. An edge occurs where there is an abrupt transition between two dissimilar ecosystems, for example forest edge and road or houses.

Firebreak. An area that is prepared to prevent, or slow, an advancing fire front. The removal of one of the three elements in the combustion triangle (heat-oxygen-fuel).

Fire adapted. Animals that prefer a certain stage of post-fire plant regeneration and are able to escape incineration by moving away, or sheltering, during intense fires. Plants that are able to germinate from heat-affected seed or regenerate vegetatively after being burnt, or when burnt at appropriate intervals and during appropriate seasons.

Fire dependent. Animals that require impacts by fire on vegetation, food plants and habitats to sustain their reproduction. Plants that require some impact by fires to release or germinate seeds, to regenerate vegetatively, or to maintain their natural architecture.

Fire frequency. The average number of years between bushfires, ideally differing for specific ecosystems.

Fire intensity. The heat generated above ground during combustion.
Intensity classes: unburned, low (<500 kW m $^{-1}$, medium (500–2500 kW m $^{-1}$) and high (>2500 kW m $^{-}$1)

Fire prone. Animal and plant populations unable to survive impacts by fire and unable to sustain reproduction in burnt habitats.

Fire regime. Local history of fire, frequency, intensity and season of burning. Strategy for prescribed or controlled burning programmes [28].

Fire resistant. Plants that can survive some exposure to fire or can regenerate from seed or suckers.

Fire retardant. Plants with 'low flammability': not easily ignited by bushfires with moderate intensities but often killed if they are burnt.

Fire sensitive. Animals that are not capable of moving away, or sheltering from, intense fires. Plants that are unable to regenerate vegetatively or germinate from residual seeds after being burnt.

Hazard/fuel reduction burning. Prescribed burning. Application of fire within predetermined boundaries to reduce combustible materials to make wildfires easier to manage [28].

Macro-mosaic burning. Mosaic burning of *larger areas* (up to and more than *ca* 30 ha).

Micro-habitat. Different parts of a habitat that an individual encounters in the course of its activities: also a small habitat, for example decomposing fallen timber for collared delma.

'Micro-mosaic' patch burning. Mosaic burning of *small-defined areas* that take into account the micro-habitats of fauna and flora.

Mosaic patch burning. Prescribed burning of randomly-selected patches of bushland inter-dispersed with unburnt areas, strips or corridors for wildlife.

Prescribed burn. Fire that is legally started for some defined management purpose to achieve one or more of a range of objectives [24].

Wildfire. An uncontrolled bushfire.

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While raising two sons she has completed a Diploma of Applied Science (with Distinction) in Nature Conservation and a Bachelor of Applied Science (Protected Area Management) at the University of Queensland. She is also a volunteer wildlife carer/ rescuer and is currently undertaking Postgraduate studies at UQ in Landscape Ecology. Chris has a special interest in suburban ecology, environmental rehabilitation, nature conservation, threatened species and the development and application of management strategies for educational and community programmes. She has played a prominent role in organising field days and displays for community groups, writes articles for the local media and provides environmental advice to community members. Chris is a Committee member of MCCG (Moggill Creek Catchment Group) and a member of ONARR (Orphaned Native Animals Rear and Release).

Don Sands worked with CSIRO as an insect ecologist and taxonomist for more than 30 years. Don holds MSc and PhD (University of Queensland) degrees in entomology. He is author or joint author of more than 110 entomological research publications and 4 books. Before moving to the western suburbs of Brisbane in 1978, Don gained experience in bush fire control and management as an Honorary Fire Patrol Officer in New South Wales. Don is well known for his community work on the Richmond Birdwing butterfly. He is now focussing on conservation and management of flora and fauna, particularly insects. In 2001 he was awarded an Order of Australia Medal for his contributions to entomology, horticulture and conservation, in Australia and the Pacific region. He is a member of the Moggill Creek Catchment Group and a foundation member of The Hut Environmental & Community Association at Chapel Hill.
