Australian Koala Foundation
A.C.N. 010 922 102

18th May, 2009

Hon. Bernard Teague
c/o Submissions
2009 Victorian Bushfires Royal Commission
GPO Box 4358
Melbourne VIC 3001

Dear Commissioner,

On behalf of the Australian Koala Foundation (AKF), we hereby submit our research to the 2009 Victorian Bushfires Royal Commission. We have made this submission because of the immense impact of the fires on local koala populations, and in the hope that our knowledge will help to protect both koalas and human life into the future. We have taken particular care to recommend solutions that should be seen as real and important steps for protection of the landscape in that region.

Since 1996 the AKF has been researching and collaborating with forestry companies in the Strzelecki Ranges. We have also conducted extensive research into blue gum plantations in Victoria, and undertaken extensive GIS mapping of the Strzelecki Ranges via our Koala Habitat Atlas, which seeks to rank and identify prime koala habitat in landscapes. As such, we are confident the AKF is able to make a significant contribution to developing an understanding of the Churchill Fire's impact on this unique koala population. We believe this submission will also shed light on the nature of fire in a highly damaged landscape, with particular regard to plantation forestry.

In this submission, a review of fire research and actual fire reports shows that while fires may break out more often in eucalypt forests, the movement of fire into areas of pine plantation significantly increases the size and intensity of the fire. In a disturbed and fragmented landscape, where the juxtaposition of eucalypt plantations, pine plantations and preferred koala habitat is common, the features of eucalypt and pine plantations may in turn provide feedback effects. These feedback effects may be a significant factor in determining the severity and extent of bushfires. The AKF believes there are lessons to be learnt from these fires for better land-use planning and management.

This submission presents a simple strategy to address the previously mentioned Terms of Reference. By the application of sound landscape-planning practices, designed to eliminate the juxtaposition of incompatible land-uses, wildfire risks to koalas can be greatly reduced. These practices are also appropriate in the protection of human life and property.

Our scientists, Mr. David Mitchell and Dr. Douglas Kerlin, the authors of this document, would be available to you should you require them for evidence.

Yours sincerely,

Deborah Tabart OAM
Chief Executive Officer

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

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Submission to the
2009 Victorian Bushfires Royal Commission

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Cartoon by Nicholson from "The Australian" newspaper.
21st Jan 2003: www.nicholsoncartoons.com.au

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

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Preface

The Australian Koala Foundation (AKF) is the principal non-profit, non-government organisation dedicated to the conservation and effective management of the wild koala and its habitat. Due to the widely reported impacts of the Victorian bushfires on local koala populations, the AKF considers it appropriate to make this submission to the Royal Commission. This submission directly addresses the 'causes and circumstances of the bushfires,' and leads towards suggested recommendations for 'land-use planning and management' (Terms of Reference 1 and 7 respectively). These recommendations also indirectly address other Terms of Reference which relate to "measures taken to control the spread of the fires and measures taken to protect life and private and public property" and "the preparation and planning for future bushfire threats and risks, particularly the prevention of loss of life" (Terms of Reference 3 and 6 respectively).

This submission has been prepared by Mr. David Mitchell, Landscape Ecologist at the AKF. David has over 30 years of experience working in the spatial industries. As well as conducting research into high resolution remote sensing technologies and modelling field and vegetation data, David provides analysis and advice on soils, geology and landscape fragmentation, and is a skilled mapper of forest communities. He has been integrally involved in koala research conducted by the AKF in the Strzelecki Ranges since 1996.

This submission was reviewed by Dr. Douglas Kerlin, Chief Ecologist at the AKF, and is presented by Ms. Deborah Tabart OAM, Chief Executive Officer at the AKF.

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

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Koala
Foundation
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Introduction

The crescent of southeastern Australia extending from the vicinity of Brisbane to that of Adelaide, within approximately 300 km of the coastline and including the island of Tasmania, is arguably the region most susceptible to fire on the planet (Cunningham 1984). Fires are a natural part of the Australian landscape. Since European settlement, the extent and severity of wildfires in southeast Australia has increased. In the 1939 Royal Commission into the Black Friday bushfires, Charles Edward Lane-Poole, Inspector General of Forests for the Commonwealth of Australia, provided the following testimony (ABC 2005):

> *"In regard to the first matter mentioned by you, that is whether fires were more serious in the blackman's time or less serious then than in the whiteman's time, that has been gone into rather thoroughly, and we have reached the conclusion that fires in the blackman's country were very small in comparison with those in our day.*
>
> *Fires were less frequent in those days than they are now. [From charcoal analysis in peat] it is quite evident that fires today occur frequently and that they were very infrequent before the white man's settlement came. The fires before the Whiteman's settlement were not of the intensity nor did they occur as frequently as they have done since the white man settled the country."*

These wildfires appear to be increasing in frequency (e.g. 1851, 1898, 1926, 1939, 1944, 1962, 1969, 1983, 2003, 2005, 2006/7, and 2009) and severity. Without urgent action to reduce global greenhouse emissions, the landscapes of south-eastern Australia will become drier and hotter and more prone to catastrophic fires (McAlpine and Ryan 2009). The increase in frequency and severity also corresponds to a period of unprecedented landscape change resulting in a generally severely disturbed landscape in southeast Australia.

The AKF would contend that a major factor contributing to the increasing extent and severity of wildfire is this juxtaposition of incompatible land-uses throughout the landscape. For example, the increasing intrusion of urban development into areas

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian
Koala
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of natural vegetation often results in the placement of properties with high asset value adjacent to areas that foster frequent fire regimes. In the past, urban development was typically surrounded by a cleared rural buffer that would offer some degree of protection. However, more recent developments have often resulted in a reduction in the width of any buffer, or the removal of the buffer altogether. Research has shown that the probability of home destruction emerges as a simple linear and decreasing function of distance from the bushland-urban boundary (Chen and McAneney 2004). The Bushfire Cooperative Research Centre (2007) suggest the risk of large forest fires that threaten major population centres in Australia was likely to increase due to the build up of fuels, climate warming, and increases in populations at risk in the urban fringe.

A similar situation occurs with respect to pine plantations within and adjacent to native eucalypt forests. Both types of land-use are susceptible to fire, and when both land-uses are adjacent, can result in the rapid and uncontrollable spread of wildfire via feedback effects. Under conditions of extreme fire risk, the ignition of spot fires is unavoidable. The phenomenon of spotting is considered to occur more commonly in eucalypt forests than in coniferous plantations (New South Wales Rural Fire Service 2005). However, once a fire has developed, movement of the fire into areas of pine plantation provide a substantial increase in fuel (Burdon and Chilvers 1994); pines are highly flammable and dense pine stands have the capacity to burn hotter than native eucalypt vegetation (Williams 2007). It is not difficult to imagine that as the fire moves from eucalypt vegetation into plantation areas, the intensity of the fire and the probability of crowning behaviour increases significantly in response to increases in available fuel.

The natural response of koalas to bushfire, being far to slow to outrun the flames, is to ascend into the canopy of the forest. However, under conditions of severe temperatures and crowning behaviour, such a strategy has catastrophic consequences. If the juxtaposition of pine plantations with areas of native koala habitat exacerbates the severity of fires (particularly with respect to crowning behaviour), then better land-use management is clearly of great significance to the conservation of the species.

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akf@savethekoala.com

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In this submission, the AKF will focus on the potential role of forest fragmentation and plantation management in the extent and severity of the February 2009 bushfires. We present this submission to ask the following questions:

1) Did the severely disturbed landscape make the 2009 Victorian bushfires worse and therefore more dangerous to koalas – and humans?
2) What roles do blue gum or pine forest plantations play in bushfire dynamics?
3) Will the planned conversion of eucalypt plantations to pine increase the severity of future bushfires?
4) Are there lessons to be learnt from these fires for better land-use management?

The Churchill Fire of February 2009 and its effect on koalas

Much of the area affected by the Churchill Fire in February 2009 was originally composed of Mountain Ash (*Eucalyptus regnans*). Changing patterns of land-use has resulted in a landscape where eucalypt and non-native pine plantations are interspersed across a heavily-logged area.

Koalas in the Strzelecki Ranges area have been shown to be genetically distinct from other Victorian koala populations and not subject to the same in-breeding depression associated with other Victorian koalas (Seymour *et al* 2001; Houlden *et al* 2002); they therefore provide a unique source of genetic diversity in southern Australian koala populations. The AKF has been conducting koala research with a major forestry company, and conducted extensive research in blue gum plantations since 1996 and is therefore able to make a significant contribution to an understanding of the Churchill Fire's impact on this unique koala population.

The Churchill fire was allegedly deliberately lit in a pine plantation at about 1 p.m. on Saturday 7th February 2009, and quickly spread to the south-south east under the influence of extreme weather conditions. Figure 1 shows the ignition area and the

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
A.C.N. 010 922 102

landscape configuration which consisted of 18 year- and 5 year-old *Pinus radiata* plantations, and a 15 year-old Blue Gum (*Eucalyptus bicosta* or *pseudoglobulus*) plantation. Strips of native vegetation have been reserved within the plantation areas along stream lines. To the east and southeast lies native forest composed of Preferred Koala Habitat (AKF 2008). After the fire burnt through the plantation area this Preferred Koala Habitat was the first of a huge area of native forest impacted by the Churchill Fire (Figure 2).

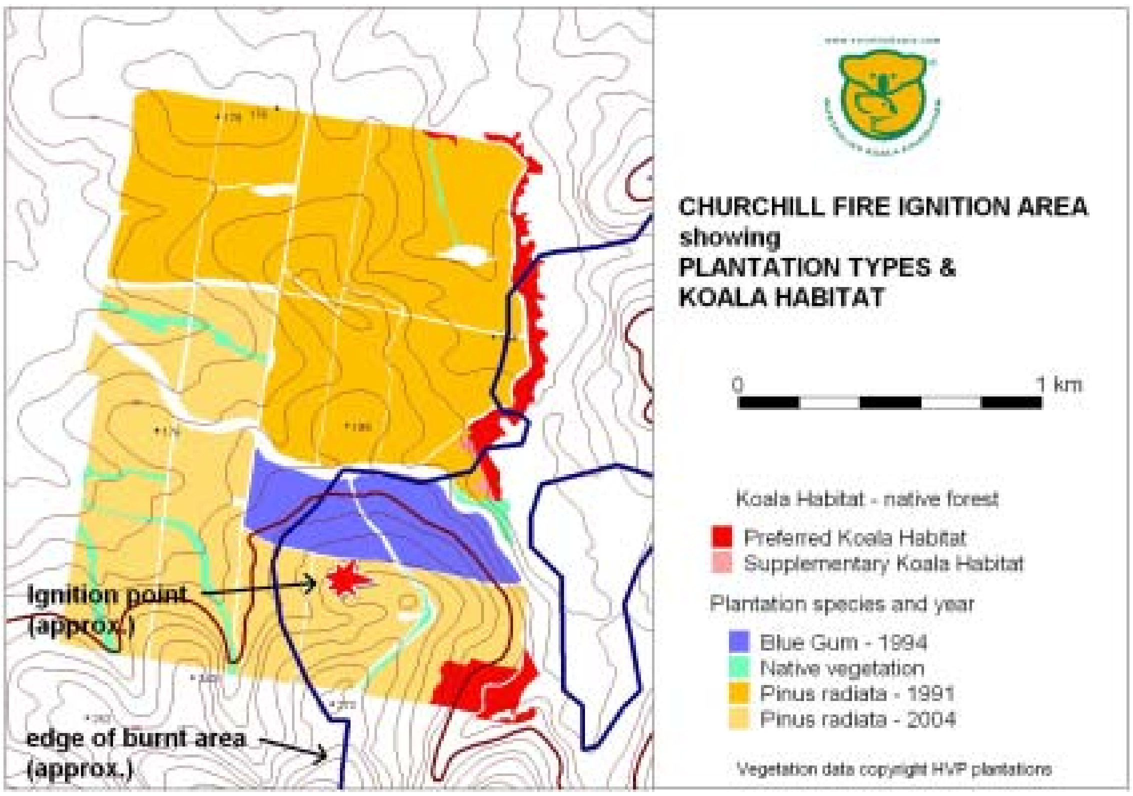

Figure 1: Churchill Fire ignition area showing existing land-use and Koala habitat.

The Strzelecki koala population is significant in the national context. Prior to the granting of a modicum of legal protection under the *Native Game Act* of 1890, koalas in Victoria had suffered severe declines due to hunting, habitat destruction, bushfires and disease (Moyal 2008). Modern koalas in Victoria are thus genetically bottlenecked – the population is broadly a result of reintroductions of animals from overabundant, inbred island populations. The Strzelecki koala population is significant because this population did not undergo historic declines; the population

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
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Fax: 617 3221 0337
akf@savethekoala.com

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is genetically robust. Friends of the Earth land-use researcher Anthony Amis said the Strzelecki koala was the only ``genetically viable" population of koala left in Victoria and South Australia (Charalambous 2009). “We know there were a couple of breeding populations in the Jeeralangs and from what we've heard, hundreds of those koalas were killed,” he said; “if the population goes down, the species as a whole is at great risk and losing this species would be a disaster.”

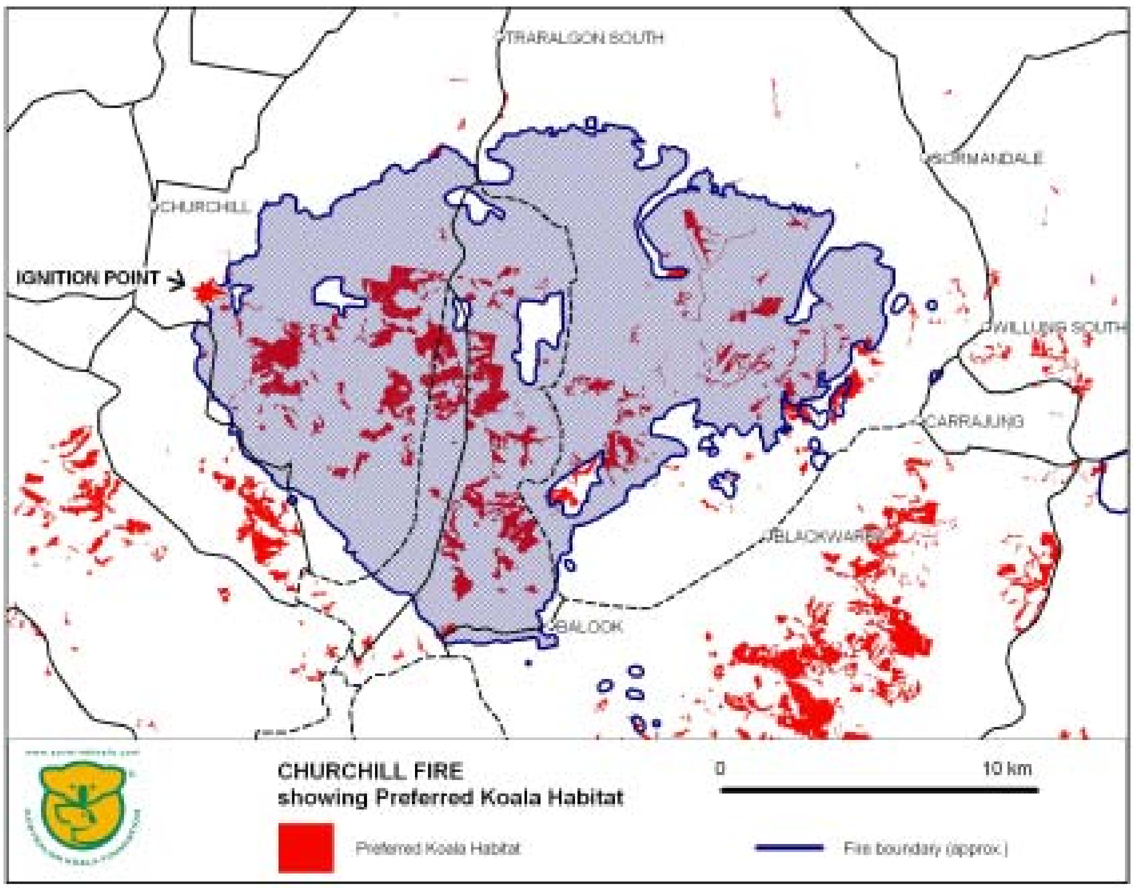

Figure 2: Churchill Fire Boundary and Preferred Koala Habitat.

The population of the Strzelecki koala prior to the fires is unknown, so it is impossible to tell exactly how severe an impact the bushfires had. Estimates suggest that the Churchill Fire resulted in the death of 20-30% of the koala population of the area. At least 75 koalas are known to have been taken in by local wildlife care groups. There is also a fear that the intensity of the fires in the region will retard vegetation regrowth

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
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and result in insufficient habitat for surviving koalas. 23.6% of preferred koala habitat and 11.2% of supplementary koala habitat in the Strzelecki ranges was impacted by the fires.

Background – Previous Research into Fires

Differences in fire behaviour in pine and eucalypt (both native forests and plantations) do not appear to have been studied in tandem. It is therefore necessary to draw together many different studies to reach conclusions about the relative fire susceptibility and fire behaviour of the three land-uses. We will also make mention of fires in grassland areas.

Eucalypt plantation fires

Geddes (2006) described fire behaviour in 28 blue gum plantations (including the Dunmore Fire) which he examined in his role as forestry fire insurance assessor. One Gippsland fire in 2003 burnt about 250 ha of low-quality 10 year old plantation. Fire behaviour "was mild until it exited the blue gums and entered a pine plantation, at which stage fire behaviour became extreme with multiple crown fires" (Geddes 2006). In other fires "[Eucalypt] plantation losses greater than 100 ha only occurred in three cases, losses in other vegetation types exceeded thousands of hectares" (Geddes 2006). Mild fire behaviour in blue gums was a contributing factor in bringing fires under control in 45% of the 28 cases studied, with, in some cases, the fires going out unattended through lack of fuel (Geddes 2006). "About 75% of the fires occurred on days when the FFDI was Very High or Extreme and plantation losses would normally be expected to be severe" (Geddes 2006). Fire behaviour is most severe in younger blue gums with a grassy fuel understory, however Geddes (2006) credits a three year old plantation with saving the township of Mount Barker (WA) in 2000.

McCaw & Smith (undated) describe a fire which burnt from grazed pasture into six year old blue gums in southwest Western Australia during conditions of Extreme fire

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

danger. At the time the report was written no serious losses (greater than 50 ha) had occurred in blue gum plantations due to wildfire, and plantations less than 7 yo have actually contributed to a reduction in the spread and intensity of wildfires (McCaw & Smith undated). However, sufficient fuels may accumulate after this age to cause severe fire behaviour compared to grazed pasture which is often the previous land-use before plantation establishment (McCaw & Smith undated).

Braun (2003) investigated five fires in blue gum plantations in Western Australia. The major finding was that fire intensities were lower in all age groups of blue gums compared to native vegetation and pine plantations, and firebreaks were of inadequate width (15-55 metres wide) to stop fires entering blue gum plantations (Braun 2003). Fire runs of up to 100,000 kW/m intensity were effectively stopped by plantations up to 4 years old (yo), crown fires burning from native forest self-extinguished within 70 m of entering the plantation (Braun 2003). In 6 yo plantations fires were more severe with Extreme fire danger, but again self-extinguished where surface fuels were discontinuous (Braun 2003). In 7-9 yo plantations crown fires from native forest only burned 1.4 ha of plantation to crown height in one fire (Braun 2003). The total area burnt in the five fires was 11,870 ha, with 1.7 ha of blue gums affected by crown fire (Braun 2003).

Fires in *Pinus radiata* plantations

It is evident that wildfires in pine plantations have very different characteristics to fires in eucalypt plantations. In the Bright Fire of November 1982, the fire started in clearfall logging slash with FFDI of 32 (Watson *et al* 1983). Winds increased from the north at 40 km/h with gusts to 60 km/h and FFDI 64, and the fire began spotting (Watson *et al* 1983). This was a very intense fire, with flame heights of 160 m in 43 yo radiata pine, and spot fires started 800 and 1600 metres downwind (Watson *et al* 1983). It was noted that fires burning upslope crowned more readily, with another spot fire starting 1800 metres away (Watson *et al* 1983).

Cruz *et. al*. (2008) reviewed research on previous fires in pine plantations, noting that some fuel complexes are “exceptionally flammable, which in turn allows for high-

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Foundation
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intensity fire spread even under moderate conditions". Billing (1980) found that, at FFDI ratings of 50-60, thinned pine plantations burnt as severely as unthinned plantations. Billing (1983) observed high-intensity crowning in young pine plantations at FFDI ratings as low as 6-7.

In their simulations of fire spread Cruz *et. al*. (2008) found that, at FFDI below 50, fire spread at half the speed in thinned (50% reduction in basal area) compared to unthinned plantations, but at FFDI>50 fire spread approximately 20% faster in thinned plantations due to the dryer surface fuel condition, the quantity of which had increased as a direct consequence of thinning.

Cruz & Plucinski (2007) also investigated the use of models developed by Project Vesta. These models were designed for use in dry eucalypt forest with fuel types being easily measured, it was concluded that the models could not adequately account for ladder and canopy fuels for the prediction of crown fires in pine plantations (Cruz & Plucinski 2007).

Plantations may also pose a risk to adjoining land-uses (Koperberg 2001). Written for NSW where *Pinus radiata* is the preferred plantation species, Koperberg is more than likely referring to pine plantations.

Grassfires

Grassfires have very different behaviour to forest fires. They are characterised by quickly burning fuel, spread rates up to 20 km/hr, rapid response to changes in wind direction, and relatively low flame heights of 5-8 m (Gould 2007). Width of the head fire is also a critical factor in spread rate, and fuel load does not affect the rate of spread although pasture condition (amount of curing) does (Gould 2007).

Billing (1983b) noted that with the prevailing weather conditions the grassland spread of fire was 22 km/hr in the Ash Wednesday Otways Fire. Measured rates of wildfire spread are highest through grassland and slowest through well-managed

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
A.C.N. 010 922 102

eucalypt plantations. Consequently, firebreaks composed of grassland appear to be inadequate fire management actions.

Fires in pine plantations vs. fires in eucalypt plantations vs. fires in native forest

The following is quoted from a NSW Rural Fire Service document (New South Wales Rural Fire Service 2005) with added emphasis:

> *"**There are some significant differences between fires in the native eucalypt forest and those which occur in pine forests**.*
>
> *Basic fire science still holds true in that fuel type, arrangement and quantity together with topography, fuel moisture content, (FMC), and weather all play significant roles in pine forest fires.*
>
> *Pine forests in NSW are mostly in plantations. Even aged forests present different problems for fire fighters and land managers, through the various stages of the forest's development.*
>
> *For example during the first 4 years...all of the young pines would be killed and the fire would in fact be a grass fire.*
>
> *Between 5 and 8 years the trees are maturing ... however **the trees will not be pruned and as a result continuous fuels exist from ground level to the tops of the trees**.*
>
> *From 9 to 16 years... **ground fuels, including logging slash and needle litter increases to around 40 tonnes per hectare**. (Fuel levels in mature eucalypt forests are around 25 t/ha but can be higher).*
>
> ***Crown fires are a common feature of coniferous plantations under extreme weather conditions**. Un-pruned stands will crown more easily than pruned stands, **however the degree of slope will have the effect of nullifying the advantages of pruning**.*

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
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> *The phenomena of spotting, common in eucalypt forests is reduced in coniferous plantations.* ***Spotting will be as little as 1/4 that of eucalypt fuels under the same conditions****.*
>
> *With so much at stake* ***it is necessary to understand the different fire behaviour experienced in pine plantations to that which is more familiar to us in the native forest****."*

In areas where *Pinus radiata* has spread from plantations into adjoining eucalypt forests, pines grow more vigorously than native species (Chilvers and Burdon 1983, Burdon and Chilvers 1994); it seems logical that during development to maturity *P. radiata* will contribute relatively more to higher fuel loads than more parsimonious *Eucalyptus* species. This has been seen in eucalypt forests invaded by *P. radiata* (Burdon and Chilvers 1994). Moreover, "pines are highly flammable and dense pine stands have the capacity to burn hotter than native eucalypt vegetation" (Williams 2007).

Fuel Loads in pine and eucalypt forests

No studies have been published investigating fuel loads in the Strzelecki Ranges area, but other studies in similar wet-sclerophyll eucalypt forests provide some insights.

Birk and Bridges (1989) studied fires in blackbutt forests on the mid-north coast of NSW with similar rainfall (1455 mm/yr) to that of the Strzelecki Ranges. In control plots (where fire was excluded) fuel loads had stabilised after 7 years to 20-25 T/ha. By contrast, in plots with 2- and 4-year control burning intervals litter accumulation was rapid at 4.0 T/yr, such that after 4 yr fuel levels were the same as without prescribed burning (Birk and Bridges 1989).

Australian Koala Foundation
GPO Box 2659 Brisbane
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Fax: 617 3221 0337
akf@savethekoala.com

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Closer to the Strzeleckis, research into fire hazard of thinning slash at four sites in regrowth forest near Orbost measured fine fuel loads of between 17-23 t/ha before thinning, after thinning fine fuel loads increased by 10 t/ha (Buckley & Corkish 1991)

The Bemm River wildfire in 1988, also near Orbost, was an intense fire with FFDI 82, maximum forward rate of spread of between 3.5-4.0 km/hr, and average maximum intensity of about 33,000 kW/m; fuel load was estimated at 20 t/ha (Buckley 1990).

In development of a new fuel load model for eucalypt forests in southeast Queensland, Gilroy and Tran (2006) examined other studies and noted that rates of fuel accumulation in Australian dry sclerophyllous vegetation are known to be low by world comparison. A table in this paper shows that sites in Wombat Forest in the central Victorian highlands carried an average of 18.2 t/ha 20 years post-fire (Gilroy and Tran 2006).

Fuel quantities have a direct effect on the intensity and spread of wildfire, however fuel quantities vary markedly between different areas and types of vegetation. In tall open eucalypt forests dominated by Messmate (*E. obliqua*) and Mountain Ash (*E. regnans*), found in the Otway Ranges, 30-35 t/ha are common, compared to fuel loads of 5-10t /ha in Box/Ironbark forests in drier climates in northern Victoria (Billing 1983b).

Generally fuel loads greater than 8-10 t/ha are considered to pose a hazard (Good 1996). In Figure 3 *E. delegatensis, E. fastigata* and *E. dalrympleana* can be considered representative of wet sclerophyll forest species occurring in the Strzelecki Ranges, fuel loads rapidly increase for seven years after fire and stabilise at 25-40 t/ha over a period of 20-35 years (Good 1994)

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
A.C.N. 010 922 102

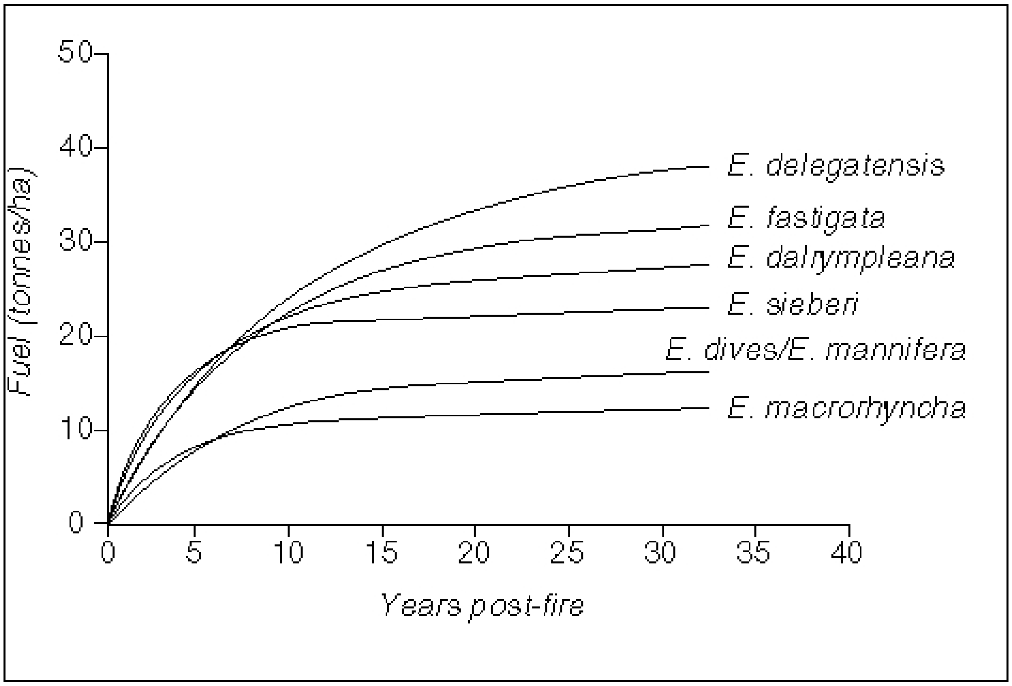

Figure 3: Fuel load accumulation over time for seven Eucalyptus species (Good 1994)

In addition to the fine fuel load usually used to measure fire hazard, coarse woody debris (CWD) and snags (dead tree trunks) on the forest floor are a potential fuel source in severe fires. CWD, snag and litter were reviewed from previous studies for different forest types by Woldendorp and Keenan (2005), their data is reproduced below.

	Conifer plantation	Native hardwood plantation	Woodland	Open Forest	Tall open forest
CWD	66.5	10.3	18.9	50.4	134.1
Snags	5.9	0	24.2	8.6	28.1
Litter	26.2	13.6	14.7	14.3	17.9
total	98.6	23.9	57.8	73.3	180.1

Table 1: Summary of mass estimates (t/ha) for forest floor by forest type (data from Woldendorp and Keenan 2005).

Table 1 shows that native hardwood plantations have the lowest overall forest floor mass and conifer plantations have the highest mass after tall open forests. Native hardwood plantations also had low litter (fine fuel) loads (13.6 t/ha) compared to pine

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian
Koala
Foundation
A.C.N. 010 922 102

plantations (26.2.t/ha). Other forest types also had much lower litter loads than pine plantations.

Hardwood plantation fuel loads were the subject of a further study by Gould (2008). It was found that mid-rotation eucalypt plantations had fuel loads <5t/ha, and that fires in these areas were not intense or difficult to suppress. Fuel loads rose in late rotation stands (10-12 years), where fuel loads >8t/ha were observed. Also, bark shredding adds potential for crown fires. Pine at 8-13 years have fuel loads of 15 t/ha with a ladder layer conducive to starting crown fires (Gould 2008).

Calorific values of fuels also provide a measure of available energy for fire propagation. Mutch (1970) compared leaves of Messmate (Eucalyptus obliqua) and Ponderosa pine. Eucalyptus leaves provided a heat yield of 4,490 cal/g and flame height of 0.9 m compared to 4,371 cal/g and flame height of 0.8 m for pine needles, and eucalyptus leaves had a higher energy release rate (Mutch 1970).

Fire weather and topographic effects

The weather conditions favouring major fires in Victoria, for example Ash Wednesday and the February 2009 fires, typically have two major components. Prior to a southwesterley cold front, hot north to northwesterly winds with low humidity and strong gusts increase the FFDI to Extreme levels, encouraging fires to rapidly run in a southeasterly direction on a narrow front with eastern and western flanks spreading relatively slowly. Fuel moisture levels are extremely low due to the high temperatures and low humidity. With the passage of the front and associated stronger winds, the eastern flank of the fire becomes the frontal crown fire on a very wide front (Billing 1983b).

The greatest influence on the rate of spread of fires is ground slope, in particular when the prevailing wind blows up the slope (CSIRO 2008). For each 10 degree increase in slope, rate of spread doubles, similarly, for every 10 degrees of negative slope the rate of increase halves (NSW Fire Brigades 2009). Slope and aspect have

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

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an indirect effect on fire intensity with reduced moisture levels and hence drier fuels occurring on north and west slopes.

Case studies

Canberra fire 2003

The Duffy fire in Canberra had an estimated intensity of 50,000 kW m-1 and FFDI 105 (Chen and McAneney 2004), and a fire burnt from native forest into the Sydney suburbs of Como and Jannali with FFDI 50. Further, Chen and McAneney (2004) state that "it may also be critical that the conflagration in Duffy was due to the adjoining pine forests, whereas the other fires have been mainly associated with Australian eucalypt bushland."

Caroline Fire 1979

The South Australian/Victorian Caroline Fire (Billing 1980) burnt 3384 ha of *P. radiata* and *P. pinaster* . The FFDI was Extreme. Wind was 46 km/hr with gusts up to 69 km/hr (Billing 1980). The fire spread to the southeast through unpruned and unthinned 16 year-old pine at 4.6 km/hr, with one confirmed report of a spot fire one km in front of the fire front (Billing 1980). The fire spread through native eucalypt forest at 3 km/hr, short-distance spotting enabled a 100 metre jump into a plantation of 8 year-old pine where it spread at 2.9 km/hr(Billing 1980). It then spread through grassland at 5.3 km/hr into open Brown Stringybark (*E. baxteri*) open forest with spotting into an adjacent 13 year-old pine plantation where "a heavy concentration of fuel in a recently thinned section ... caused very severe fire behaviour" with an apparent spread rate of 5.0 km/hr (Billing 1980). In this fire "unthinned intermediate aged stands (9-18 years) formed the majority of the plantation area burnt, and the behaviour of the main head fire in these areas was characterised by a high spread rate (up to 5km/hr) in conjunction with an active crown fire with flame heights on occasion estimated to exceed 40 metres", in another area a "firestorm with flame heights greater than 50 metres was reported (Billing 1980). Billing (1980) further states that "in general it seems that thinned stands ... constitute at least as great a hazard as unthinned stands of the same age".

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
A.C.N. 010 922 102

<u>Otway fires 1983</u>

Billing (1983a) describes problems experienced in protecting a pine plantation split into four blocks in the Otway Ranges. Smaller plantation blocks require a relatively larger firebreak perimeter, and a landscape mosaic composed of grassland and regenerating native forest around the plantations means that it "could never be as efficient or as effective as the protection of a single block of regular shape" (Billing 1983a). This finding has great meaning for the Churchill Fire, where pine plantations of irregular shape and various sizes are juxtaposed within native forest and eucalypt plantations. Billing (1983a) confirms what seems to be an inherent fear by forestry personnel of fuel-reduction burning within pine plantations when he states that "because the external fire breaks were virtually non-existent in some areas, fuel reduction could not be carried out in some areas".

<u>Billo Road fire 2006</u>

The Billo Road fire burnt 10,866 ha including 9526 ha of pine plantation and 1,087 ha of eucalypt forest near Tumut in NSW (Cruz & Plucinski 2007). Significant factors in the fire's spread included extreme dryness of surface fuels and the flammability of unthinned immature (10-15 year-old) *P. radiata* stands, with vertical continuity in the pine allowing the development of crown fires in moderate conditions, including a relatively rare nighttime fire run (Cruz & Plucinski 2007). Fuel loads were 12-16 t/ha in eucalypt forest; fires in these locations were typically surface fires. The following table shows measured fuel loads in each age class in the pine plantation, with generally much higher fuel loads than the neighbouring eucalypt forest.

Fuel complex type	Fuel load (T/ha)					
	Litter	Other fine	Live fuels	Coarse fuel	Canopy live fuels	Total
7 years	0.6	7.7	2.2	0	12	22.5
10 years	3.5	4.6	0	0	10	18.1
15 years	8.2	0.3	0	2.4	10	20.9
15 years (thinned)	8.2	3	0	13	6	30.2
30 years	11	0.6	0	5	10	26.6
post-harvest	11.3	14	0	27	0	52.3

Table 2: Measured fuel loads in Buccleuch State Forest, Tumut NSW (from Cruz & Plucinski 2007)

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
A.C.N. 010 922 102

The fire spread was characterised by crowning upslope runs under the prevailing winds with spotting occurring 250 metres in front of the head fire hampered by inability to access the fire because of surface fuels composed of slash and thinnings. The following photo shows the intensity of crown fire in pine plantation; peak fireline intensity was highest in mature pine (64,000 kW/m) and lowest in pine less than 10 years old (Cruz & Plucinski 2007).

Figure 26. Fire crowning in 15-year old radiata plantation (PRAD04) at 15:59 on 10 December 2006. Stand height is approximately 18 m. (Photo Steve Cathcart).

The Billo Road fire offered an opportunity to assess the effectiveness of the McArthur (1967) Forest Fire Index (FFDI). Although other factors played a role in underestimating the severity of fire propagation spread, Cruz and Plucinski (2007) concluded that FFDI failed to adequately account for the observed fire characteristics and that the Canadian Forest Fire Behaviour Prediction (FBP) System might be more suitable for fire potential prediction in pine forests and lead to better firefighting strategies. It was also noted that “no active fuel management activities were carried out in the pine stands of Buccleuch State Forest” (Cruz & Plucinski 2007).

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
A.C.N. 010 922 102

Berringa Fire 1995

This fire west of Ballarat in dry eucalypt forests was estimated to be fed by surface and bark fuel loads of 15-21 t/ha, including canopy fuels the load was estimated at 27 t/ha (Tolhurst and Chatto 1999). Even when using all available fuel loads in calculating FFDI, FFDI underestimated by a factor of two in its prediction of fire rate of spread (Tolhurst and Chatto 1999).

Dunmore State Forest 1995

This fire burnt 1,349 ha composed of native stringybark forest and 350 ha of blue gum plantations (Crowe and Shelden 2005). Under strong northerly winds the fire spread at up to 3.6 km/h, with flames up to 20 m high, through the stringybark forest which had very high fuel rating. Fire behaviour changed markedly upon entering the plantation areas with flame heights, fire intensity and rate of spread all being substantially reduced. Fire behaviour in the plantation varied according to row direction, different fuel composition, remnant native vegetation and plantation layout (Crowe and Shelden 2005). Patches with rows oriented in the same direction as the prevailing wind suffered greater damage than rows oriented east-west (Crowe and Shelden 2005). Char heights in the native vegetation indicated more intense fire in these areas, adjoining blue gums also had higher char heights compared to blue gums elsewhere, and there was significant short distance spotting from long-unburnt stringybark trees (Crowe and Shelden 2005).

Landscape Planning

Thoughtful landscape planning combines environmental sustainability and the demands made by human social and economic systems (Leitao *et al* 2006).

The comparatively new science of landscape ecology provides spatial methods of measuring and modelling landscape structure, specifically the spatial relationships between different components of a landscape (Blaschke & Petch 1999). Composition and configuration of homogenous or similar patches of the landscape and their

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
A.C.N. 010 922 102

relationship to heterogenous or different types of patches in the landscape has been the driving force behind the development of landscape ecology (Gustafson 1998).

Geographical Information Systems (GIS) provide many useful tools for the landscape planner. These tools may include buffering of specific objects or classes of objects at a specific width (available in most GIS software packages), add-on packages to other GIS software, and specific tools to aid the landscape ecologist, for example FRAGSTATS which offers specific landscape metrics to aid in landscape planning (McGarigal & Marks 1995).

Landscape ecology methods have been used to model the interactions between different forest types, harvest regimes, and fire suppression in northern Wisconsin, USA over a 250 year simulation period (Sturtevant *et al* 2004). In mixed hardwood and pine forests, moderate disturbance increased the abundance and connectivity of conifers and increased the likelihood of crown fires due to the ladder effect previously identified in conifers; in contrast low disturbance levels reduced the proportion of conifers with a consequent reduction in fire risk (Sturtevant *et al* 2004). In a similar paper Gustafson *et al* (2004) used landscape modelling to identify specific locations where interacting factors of land type and management strategies increased fire risk. Figure 4 shows the results of two modelling scenarios including on the urban-forest interface where the fire risk has been reduced by a factor of 10 through the use of appropriate management strategies to guide landscape management policy (Gustafson *et al* 2004)

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
A.C.N. 010 922 102

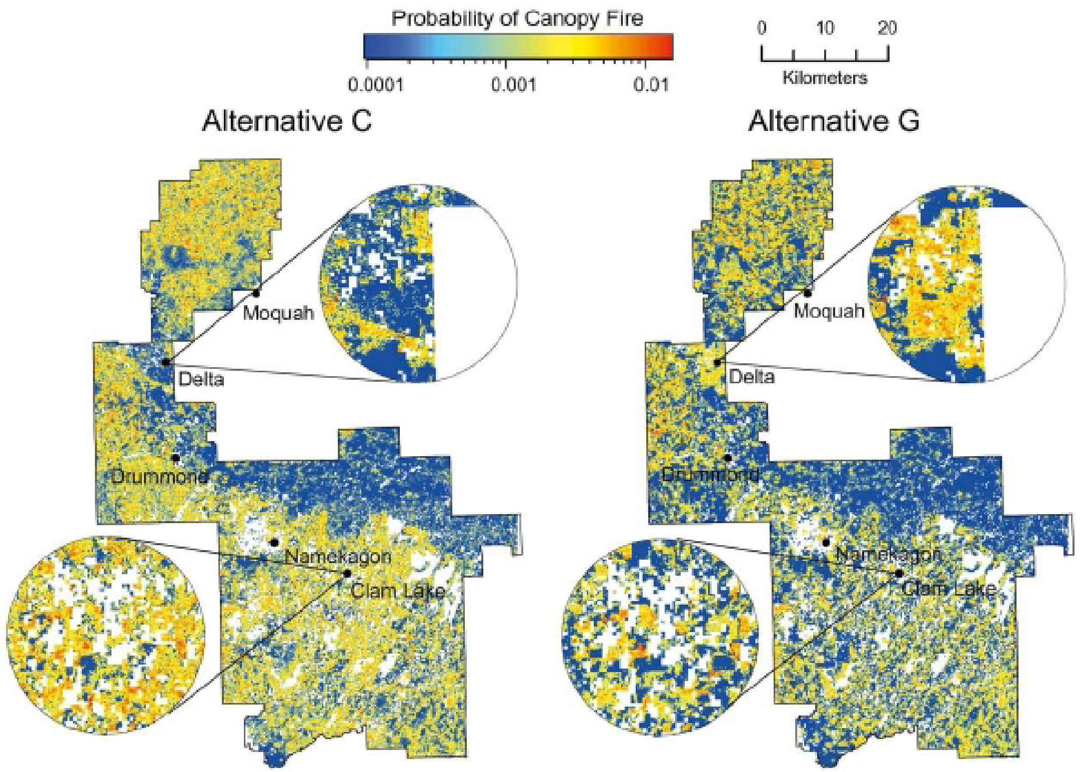

Figure 4. Maps showing the probability (per decade) of canopy fire across the 50 replicate simulations for four alternatives, selected to show the range of canopy fire risk. The alternatives are displayed left to right and top to bottom in descending order of mean fire probability (see Table 6). Insets show the 5 km radius area analyzed around two towns in the urban-wildland interface having markedly different response to the 'no-harvest' alternative.

Figure 4: Maps showing probability of canopy fire with two different management scenarios (Taken from Gustafson *et al* 2004).

Discussion

Much of the area in the Strzelecki Ranges affected by the fires of February 2009 was originally vegetated by stands of Mountain Ash (*Eucalyptus regnans*). However, increasing demand for timber production has resulted in the historical conversion of much of this area to a complex landscape mosaic, comprising a number of irregularly shaped blue gum and pine plantations, surrounding blocks of native vegetation. Based on our 13 years of research in the Strzelecki Ranges, the AKF believes that the evidence presented in this submission suggests that this disturbed and fragmented landscape was a factor in increasing the severity of the February 2009 bushfires contributing to make the fires more dangerous to humans, and a critically important population of koalas.

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian
Koala
Foundation
A.C.N. 010 922 102

Evidence suggests that spotting rates in eucalyptus forests are higher than those observed in pine plantations (New South Wales Rural Fire Service 2005); however under conditions of extreme fire risk, the ignition of spot fires is also unavoidable in plantations. While fire is restricted to eucalypt plantations however, the fire is far more manageable. In part, this is because fuel loads are lower in eucalypt plantations. It was found that in late rotation stands (10-12 years) fuel loads >8t/ha were observed; pine at 8-13 years have fuel loads of 15 t/ha with a ladder layer (Gould 2008). Similarly, native hardwood plantations have the lowest overall forest floor fuel mass and conifer plantations have the highest mass after tall open forests (Woldendorp and Keenan 2005). Mild fire behaviour in blue gums was a contributing factor in bringing fires under control; in some cases, fires went out unattended through lack of fuel (Geddes 2006).

However, once fires enter areas of pine plantation, the severity of the fire has been shown to increase dramatically. Often, prescribed burning does not occur within pine plantations. Pine vegetation is highly flammable, and pine stands have the capacity to burn hotter than native eucalypt vegetation (Williams 2007). This flammability in turn allows for high-intensity fire spread even under moderate conditions (Cruz *et. al*. 2008). Crown fires are also a common feature of coniferous plantations under extreme conditions (New South Wales Rural Fire Service 2005). Chen and McAneney (2004) state that "it may also be critical that the conflagration in Duffy was due to the adjoining pine forests." While fires may break out more often in eucalypt forests, evidence suggests that the movement of fire into areas of pine plantation significantly increases the size and intensity of the fire.

The planned conversion of large areas of relatively slow-growing eucalypt plantations to faster growing pine plantations could exacerbate these problems in the future. As previously stated, pine plantations have large relative fuel loads, and the nature of fires in pine plantations include a capacity to burn hotter than native eucalypt plantations and an increased probability of crowning behaviour.

In a landscape where the juxtaposition of eucalypt plantations, pine plantations and preferred koala habitat composed of native forest is common, fuel loads and fire

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
A.C.N. 010 922 102

behaviour of native forest and pine plantations may in turn provide feedback effects, resulting in an increase in the severity and extent of bushfires. Fires become more difficult to manage and control. It has been shown that smaller plantation blocks require a relatively larger firebreak perimeter, and a landscape mosaic composed of grassland and regenerating native forest buffers around the plantations “could never be as efficient or as effective as the protection of a single block of regular shape” (Billing 1983a). Thus there are lessons to be learnt from these fires for better land-use management.

In developing different landscape models with GIS software, it also follows that the effects of fire can be incorporated into different landscape scenarios, for example fire spreading along corridors, or buffer widths designed to reduce the possibility of ember attack.

In preparing this submission AKF has not had time to use sophisticated landscape analysis tools, but the fact that Preferred Koala Habitat was affected more than Supplementary Koala Habitat bears investigation. Preferred Koala Habitats are usually on more fertile soils in valleys and foothills, this is also the location of pine plantations in the Strzeleckis as shown in the example in Figure 1.

An example of landscape planning using FRAGSTATS or other packages might be to examine the spatial relationships between, say, areas of Preferred Koala Habitat and pine plantations (land-uses) in the context of wildfire. Landscape metrics useful in these types of analyses would include total length of common edge and distance between different land-uses. These metrics can then be statistically analysed to discover if indeed there are any meaningful relationships between these land-uses and fire damage and even koala deaths. Additionally, further analyses accounting for rates of spread and fuel loads of fires in eucalypt plantations, pine plantations and grasslands on different slopes and aspects may contribute to planning decisions regarding rehabilitation of severely burnt areas.

This submission now presents a simple strategy to address the previously mentioned Terms of Reference. By the application of sound landscape-planning practices designed to eliminate the juxtaposition of incompatible land-uses wildfire risks to

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation
A.C.N. 010 922 102

Koalas can be greatly reduced, these practices can also be applied in the protection of human life and property.

This submission has been backed up by a review of fire research and actual fire reports which will show that where pine plantations adjoin native forest, and particularly Koala habitat, these areas should be separated by buffers to enable better control of fire and its spread. We propose that these buffers can be effective even if they are planted with *Eucalyptus* species in a plantation situation. Fires in eucalypt plantations appear to be milder, and more easily managed than pine forest fires. For example, Figure 5 shows how the Churchill Fire ignition area might benefit from thoughtful landscape planning at no economic cost to the plantation owner. The total amounts of pine and eucalypt plantation remain the same, and Preferred Koala Habitat is separated from pine by less fire-susceptible eucalypt plantations.

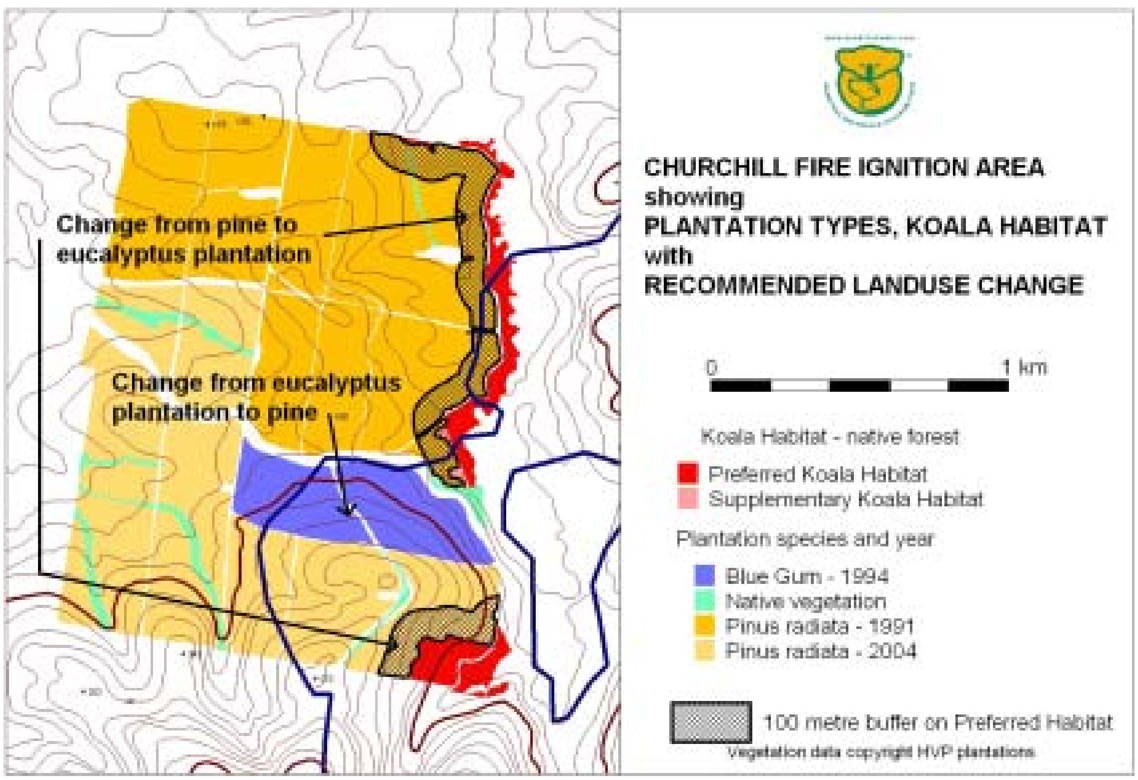

Figure 5: Churchill Fire ignition area with reconfigured land-use. Pine plantations and Preferred Koala habitat are now separated by less fire-susceptible eucalypt plantation.

Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian
Koala
Foundation
A.C.N. 010 922 102

Recommendations

1 Change land-use practices so that pine plantations are not planted adjacent/within areas of native forest and should be separated from native forest by substantial buffer zones

2 Existing pine plantations adjacent/within native forest need more proactive fuel reduction on a par with native forest fuel reduction.

3 After harvesting, existing pine plantations within/adjacent to native forest should be replanted with the aim of compatible landscape outcomes as a priority.

Pine plantations should be separated from areas of Preferred Koala Habitat. and we have shown that eucalypt plantations provide the best means of separating these incompatible land uses. The width of the buffer will vary depending on slope, aspect and prevailing winds on High and Extreme Fire danger days, but would probably vary from 100 metres on easterly to southeasterly aspects to 500 metres or more on fire-prone northerly to southwesterly aspects.

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Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation

A.C.N. 010 922 102

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Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation

A.C.N. 010 922 102

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Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com

Australian Koala Foundation

A.C.N. 010 922 102

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Australian Koala Foundation
GPO Box 2659 Brisbane
QLD Australia 4001
Ph: 617 3229 7233
Fax: 617 3221 0337
akf@savethekoala.com