ISSUE 1: Prescribed burning - Effectiveness

Qualification of opinion to be offered on Issue 1:
As an ecologist interested in the impact of fire upon fauna, I have examined the scientific and unrefereed 'grey' literature pertaining to the effectiveness of Prescribed Burning in mitigating bushfire risk. However, I must stress that fire behaviour is not my area of expertise. Nevertheless, in my professional life I have been called upon to critically examine the scientific literature on the effectiveness of Prescribed Burning in mitigating bushfire risk, since it is meant to underpin ecological fire management policy. I therefore offer the following responses to Issue 1 based upon a critical examination of the scientific literature, rather than from my own empirical research on the topic.

QUESTION 1: Is prescribed burning effective to mitigate bushfire risk?

Expert Opinion:

The overwhelming evidence from the scientific literature is that prescribed burning has the potential, under certain circumstances, to mitigate bushfire risk through the reduction in availability of fuels.

QUESTION 1(a): In what <u>circumstances</u> and with what <u>limitations</u>? Comment on the significance of extreme fire weather, high intensity fires, large (landscape-size) fires and fuel accumulation post-burn (including time frames) and any other relevant factors.

Expert Opinion (on the significance of extreme fire weather, high intensity fires, large (landscape-size) fires)*:*

The scientific literature suggests that prescribed burning has the potential to mitigate bushfire risk when fire weather conditions are low to moderate, but has limited impact, if any, in significantly mitigating ignition risk, rate of spread or area burnt under conditions of extreme fire weather, which is when high intensity, large scale fires occur. Its primary value is in assisting in control when conditions moderate. Wildfires on extreme weather days account for the vast majority of area burnt. A range of authors (e.g., Morrison et al. 1996, Moritz et al. 2004, Bradstock 2008), have noted that the ability of prescribed burning to aid in fire suppression efforts during such extreme conditions is negligible. Thus, the very time when many hope that prescribed burning can aid in fire suppression efforts is actually the period during which it is least likely to be effective.

Basis for Opinion:

- Fernandes and Botelho (2003, p.122) postulate that 'because fire behaviour increases in a non-linear fashion with the decrease of fuel moisture and the increase of wind speed, which additionally vary in a much wider range than fuel properties, the influence of these factors on fire behaviour will increasingly prevail over the effect of fuel characteristics in more severe weather scenarios.'

- King et al. (2006, p.537) also comment that 'observations from a range of studies suggest that as fire weather conditions become more extreme, with dramatic declines in fuel moisture and increases in wind speed, the fuel effects on fire behaviour are greatly diminished. Under these conditions, firebrands can promote fire spread, with unplanned fires being capable of igniting recently burnt areas, as well as extensive areas of less flammable vegetation'. This indicates that prescribed burning may have little influence on high intensity fires during extreme fire weather. Presumably it is this type of wildfire that is of greatest concern to land managers (not just those that burn in moderate conditions).

- Bradstock (2008, p.811) discusses the correlation between extreme fire weather and high intensity fires and comments that 'maximum severity in each case is associated with severe fire weather – particularly high wind speeds in association with high temperatures plus low fuel moisture and relative humidity. Effects of weather on severity predominate over effects of terrain and vegetation type and condition [where condition is presumably a reference to fuel load], as found elsewhere in temperate vegetation (e.g., Moritz et al. 2004)'.

- In their work in Californian shrublands, Moritz et al. (2004, p.70) argued that during extreme fire weather, in particular, "Santa Ana" wind conditions 'fire may spread through all age classes of fuels, because the importance of age and spatial patterns of vegetation diminishes in the face of hot, dry winds (Bessie and Johnson 1995, Moritz 2003)'.

- From unpublished simulation modelling (referred to in Bradstock et al. (2005)), the authors suggested that low-moderate rates of prescribed burning 'acted to reduce the predicted mean size of unplanned fires, <u>albeit to a limited degree</u>' (not a significant result).p.418

- Bradstock (2008) comments that 'droughts are inextricably linked with recent large fires (e.g. 10^3 – 10^5-ha size range) in temperate regions' p.809. Note that references supporting this statement are government reports (Esplin et al. 2003, Ellis et al. 2004).

- Moritz et al (2004) noted that 'Rotational prescription burning to maintain a landscape mosaic of different age classes is thought to inhibit large fire development; however, the present study suggests that this strategy will be ineffective.' P.71

- A contrary view is offered by Conroy (1996, p.91) who notes as a pers. obs. in his paper that 'there are many examples …. where wildfires have been contained or where the impact of wildfires on assets, species … has been greatly reduced as a result of prescribed burns'. Six examples are listed 'where wildfire runs were effectively contained under extreme weather conditions as a result of prescribed burns'. However, the author provided no details regarding weather, terrain, or time since prescribed burn relating to these examples.

Expert Opinion (on fuel accumulation post-burn (including time frames))*:*

1. There appear to be few rigorous data sets documenting the rates at which fuels accumulate following prescribed burning , nor how such accumulation rates might be affected by climate change.
2. Management prescriptions tend to be based on anecdotal case studies, rather than long-term data sets. Data sets are typically only cover a small proportion (e.g. 10-20 years) of often very long successional processes (50-200 years).
3. Since habitats differ in soil nutrient and moisture levels (factors affecting plant growth rates), and litter decomposition rates, it is foolish to generalise across habitats, when determining fuel accumulation rates. Some habitats (e.g. grasslands, heathlands) will generate fuels much more rapidly than other habitats. Nevertheless, generalisations are commonly made across habitats to justify the frequency of prescribed burning for hazard reduction purposes.

4. Several studies stress the short-lived effectiveness of fuel reduction burning (2-4 years). However, "effectiveness" is rarely defined in terms of ability to mitigate bushfire risk, but rather in terms of reducing fuel loads below certain estimates expressed in tonnes/ha.
5. Virtually no consideration appears to be given to the possibility that over time frequent prescribed burning will select for those plant species best able to tolerate and regenerate quickly after fire, and therefore most rapidly replenish ground level fuels. There is some evidence where burning has increased fuel levels in the medium term by promoting a shrubby understorey.

Basis for Opinion:

- Using a space-for-time substitution approach, Morrison et al. (1996) is one of the few studies that have measured the dynamics of fuel loads after low-intensity fires, 'such as are typical of the fuel-reduction burns usually prescribed' (p.167) in Ku-ring-gai Chase NP (close to Sydney) by harvesting all of the fine fuel components (litter, leaves, and branches <6mm diameter) in each of 10 randomly located plots at 12 sites (each a differing age-since-last fire). Two widespread habitats in the area were sampled: shrublands and woodlands. An acceptable level of hazard in the sclerophyll vegetation of southern Australia has been considered to be fine fuel loads of about 8-10 $t.ha^{-1}$ (Hodgson 1968, Gill et al. 1987, McCaw et al. 1992). Morrison et al. (1996) developed fuel accumulation models from their chronosequential data which suggested that potentially severe fire hazards (fine fuel loads ≥10 $t.ha^{-1}$) can reappear in shrubland communities after 3.5 years and woodland communities after 1.5 years.

- McCarthy and Tolhurst (2001) suggest that 'the highest probabilities of a previous fuel reduction burn (FRB) being helpful to subsequent suppression operation occur in the first four years following the FRB, with decreasing probabilities up to about age 10 years' p.2/3. Note that the results of this study are based on biased, incomplete and qualitative data – see Question 2 below for an assessment of the methods/results for this study. Nevertheless, this report appears to have been widely cited when discussing the effectiveness of prescribed burning in SE Australian forests as being ≤4 years (e.g., Fernandez and Botelho 2003, Boer et al. 2009).

- Fernandes and Botelho (2003) conclude that the 'fuel accumulation rate frequently limits prescribed fire effectiveness to a short post-treatment period (2-4 years)' p.117. However, this statement comes with a qualification that 'the operational effectiveness of prescribed fire inferred from case studies is largely anecdotal, and most of the examples of success that are available refer to recently (up to 4 years) treated areas' p.123. Fernandes and Botelho (2003) also note that 'post-treatment recovery can be so fast that fuel management may be futile or even counter-productive in some vegetation types' p.122.

- In Californian shrublands, Moritz et al. (2004) identified that instead of increasing sharply with age, the majority of shrublands exhibited a hazard of burning near a constant rate (about 2.7% per year). 'Historical fire patterns and quantitative measures of hazard therefore refute the common assumption that fire probabilities in shrublands are strongly driven by vegetation age, and that large fires are necessarily caused by a build-up of older fuels' p.70.

- In South African shrublands, Seydack et al. (2007) presents strong correlational evidence suggesting that fire spread is substantially constrained in vegetation younger than 5-6 year.

- Boer et al. (2009) concluded that prescribed burning significantly reduced the incidence and extent of unplanned fires over the first six years (inhibitory period) post prescribed burning in temperate eucalypt forests of south west WA.

QUESTION 1(b): *how* and *when* can prescribed burning affect fire intensity, burn severity and assist in suppression?

Note that this question is largely answered in comments made for QUESTION 1(a) above and QUESTION 2 below. However, some additional points are noted below.

Expert Opinion on *how:*

- The scientific literature suggests that prescribed burning has the potential to reduce the intensity and severity of a fire at the site of the prescribed burn through reduction in available fuels. It is thought to assist in suppression activities under moderate conditions by slowing the rate of spread of a fire and providing safer regions from which to undertake suppression activities.

Expert Opinion on *when:*

- As stated in my response to QUESTION 1(a), prescribed burning is of most value under low to moderate fire weather conditions. King et al. (2006) comment that 'prescribed burning programs should be developed … for maximum effectiveness during more moderate weather conditions' p.537. Fernandes and Botelho (2003) argue that the best results of prescribed fire application are likely to be attained in 'climates where the likelihood of extreme weather conditions is low' p.117.

QUESTION 2: How is the effectiveness of prescribed burning measured? Describe the principal models and methods by which effectiveness is or may be assessed.

Expert Opinion on How is the effectiveness of prescribed burning measured?

1. I have failed to find an unambiguous definition of "effectiveness" of prescribed burning that could be applied following a treated area being challenged by wildfire. Although many purported methods of assessing the effectiveness of prescribed burning have been advocated (13 in the "Report to the Enquiry into the 2002-2003 Victorian Bushfires" INF.018002.0216), fire management plans rarely state explicitly the level of wildfire mitigation that they anticipate will be achieved by a prescribed burn or under what fire weather conditions. Instead, post-hoc analyses tend to seek correlations between the extent of prescribed burning and declines in the total area burnt by wildfire, and assume a causal relationship between these two variables, while failing to control for long-term weather trends. Without a transparent and agreed definition of "effectiveness", and rigorous examination of causal relationships, it is impossible to measure the effectiveness of prescribed burning.

2. Rigorous, quantitative empirical examination of the effectiveness of prescribed burning is rare in both the scientific and grey literature. This is very puzzling, given the resources devoted annually to prescribed burning and the fact that knowledge of its effectiveness is fundamental to all fire modelling and planning.

3. More commonly, anecdotal evidence regarding the effectiveness of prescribed burning is gathered following a wildfire. Such evidence is not always gathered in an impartial, systematic or rigorous manner, and sometimes it is biased towards cases where prescribed burning is perceived to have been 'effective'. Fire history prior to prescribed burning is often ignored or unknown. The results of such analyses are rarely subjected to independent peer review, or published in the refereed scientific literature. Nevertheless, they commonly form the basis for future state-wide prescribed burning policy.

4. Alternatively, simulation models are developed in an attempt to predict the likely effectiveness of prescribed burning under various scenarios. Such models enable consideration of the likely impact of prescribed burning on fire behaviour over temporal and spatial scales much greater than that currently available in empirical data sets. However, such models are only as good as the data upon which they are based and most current models are severely constrained by a shortage of data on long-term fire history (extent and severity mapping), logging history and fuel loads on the ground. The predictive power of such models are rarely rigorously tested or validated on novel data sets, nor are the findings of such tests published in the refereed scientific literature.

5. As with all mathematical models, the predictive power of fire behaviour simulation models is constrained by the quality of the data upon which they are based, the assumptions they make and the number of parameters they are able to include in calculating their predictions.

6. Although the creators of such models may highlight the limitations of their models and the lack of empirical validation, the predictions arising from such simulations are often cited in agency policy documents as if they were empirical studies, and commonly lack the cautious qualifications given by the original authors. For example, findings from the simulation modelling of levels of prescribed burning in button grass moorlands in South West Tasmania

(King et al . 2006, 2008) have recently been used by DSE to justify levels of prescribed burning throughout a wide variety of very different habitat types in Victoria (draft Guidelines for Landscape Mosaic Burning). Such inappropriate and simplistic application of the findings arising from single simulation models developed for other habitats should be avoided.

7. Cary et al. (2009), in their comparison of five different fire behaviour simulation models from around the world, caution against reliance upon a single model. Each model makes different assumptions and consequently has different strengths and limitations.

8. It is imperative that those attempting to use the insights offered by these fire behaviour simulation models to develop prescribed burning policy fully understand the assumptions and limitations of these models. This is often quite difficult as the structure of the models is commonly expressed in complex mathematical formulae that are unintelligible to many policy developers. For example, models of fire behaviour by King et al. (2006, 2008) which have recently been used to justify levels of prescribed burning throughout a wide variety of different habitat types in Victoria (draft Guidelines for Landscape Mosaic Burning), fail to take any account of fires spreading by firebrands (spotting). Since spotting is widely recognised as a common and fundamental method of fire propagation and spread under severe fire weather conditions, its absence from the model severely limits the conditions under which the model's predictions could be relied upon, if one really wanted to predict the behaviour of a fire or the effectiveness of a prescribed burn.

Basis for Opinion:
Empirical studies:

- Effects of prescribed burning were investigated by Grant and Wouters (1993) for 4 cases of unplanned fire in the Little Desert and Grampians areas of western Victoria. Prescribed burns were strategic in nature, (i.e. along tracks or boundaries) and ranged from 50-100m to 200-500m in width. All prescribed burns were between 4 months - ~2.5 years before current wildfire event. Prescribed burns aided fire fighters in stopping each of the 4 unplanned fires.

- McCarthy and Tolhurst (2001) carried out a study on the effectiveness of earlier Fuel Reduction Burns (or wildfires) in assisting suppression of 114 unplanned fires, which were selected from the 90/91 to 97/98 Victorian fire seasons. The 114 fires were not sampled randomly (McCarthy and Tolhurst 2001, p.6), instead it was 'biased towards fires for which there was some influence of a previous FRB' as reported in DSE's FIRES database. Thus, their estimate for strong inhibitory effect of FRB (or earlier wildfire) over the first four years in assisting the suppression of a current wildfire risks being an overestimate of the effectiveness of prescribed burning. Although the authors concede the results of their study are 'derived from a biased dataset', they also suggest that the 'qualified conclusions ... are generally correct from a Statewide perspective' and that 'qualified results from the present study can be immediately used to guide policy development and on-ground operation practice' p.26

- Moritz et al. (2004) conducted 'fire frequency analysis' of several hundred wildfires (mapped fire histories from 10 different landscape units) over a broad expanse of Californian shrublands in order to 'examine critically the assumption of age dependency in controlling shrubland fire regimes, since it is the basis of many fire management activities in these ecosystems' p.68. Their goal was to quantify the relationship between stand age and the hazard of burning. Instead of increasing sharply with age, the majority of shrublands exhibited a hazard of burning near a constant rate (about 2.7% per year). 'Historical fire patterns and quantitative measures of hazard therefore refute the common assumption that fire probabilities in shrublands are strongly driven by vegetation age, and that large fires are necessarily caused by a build-up of older fuels' p.70.

- Finney et al. (2005) studied the influence of prescribed burning treatments on fire severity quantified from before and after Landsat satellite imagery for two large wildfires (that combined to ~186,000k ha burned) in Arizona that burned under severe weather conditions. This study had severe methodological limitations in the quality of the data on which it was based and profound statistical weaknesses in its analyses, greatly compromising the robustness of its conclusions.

- Seydack et al. (2007) carried out a long-term investigation of the effects of differing fire management regimes spanning over 70 years including fire exclusion and suppression (1951-1974), prescribed compartment burning (1975-1985) and natural fire zone management (1986-2002). The study area encompassed ~170,000 ha of shrublands across a mountain range in Southern Africa. The authors investigated the relationship between the extent of annual area burnt (ha) and the following variables: (a) mean annual minimum temperature, (b) winter precipitation, (c) summer precipitation, (d) annual precipitation, (e) extent of burning in last 6 years and (f) extent of burning in last 15 years. Annual area burnt of all fires (unplanned + anthropocentric) and unplanned fires only were most strongly related to mean annual minimum temperature which in turn was associated with hotter more extreme fire weather and increased thunderstorm/lightning activity (increased ignitions). During the period of natural fire zone management (1986-2002), there was a higher incidence of larger fires (>3000 ha) than in earlier management periods but the extent of area burnt per year is not greater than previous periods (it is actually less than over the prescribed burning period).

- Boer et al. (2009), claimed that their study provided the **'first empirical evidence of the effectiveness of prescribed burning for mitigating large unplanned fires in a forested landscape'** p.139. Evidence of the effectiveness of prescribed burning remains fragmented and largely unpublished in the scientific literature. The study analysed a 52-year fire history from a temperate eucalypt forest region of SW Australia covering ~0.93 million ha of open and tall open forest. Their first goal was to quantify the impact of the extent (area burnt) of prescribed burning on the incidence, extent and size distribution of unplanned fires. The second goal of the study was to examine the influence of differing spatial patterns of young (≤6 years post-fire) and old (>6 years post-fire) fuel patches on the (a) frequency of, and (b) area burnt by, unplanned fires. These age-class groupings were based upon a key finding of the study, that prescribed burning reduced the incidence and extent of unplanned fires within the first six years (inhibitory period) after prescribed burning treatment. However, this finding lacks strong statistical support; a review of supporting documents outlining statistical methods (Supplementary material, Appendix 1) suggests that four years (or fewer) may be a more reliable estimate of the inhibitory period. Averaged over 6-year periods, the annual extent of prescribed burning explained 24% (relatively weak effect) of the variation in the mean annual number of unplanned fires and 71% (strong effect) of the variation in the mean extent of unplanned fires. But note that this strong effect for variation in the extent of unplanned fires only has a slope of -0.26, indicating that each unit area reduction in unplanned fire required about four units of prescription fire (i.e., lots of prescribed burning required for small reductions in extent of unplanned fires).

Simulation Modelling:

- A reliance on simulation models was highlighted in a recent paper by Boer et al. (2009) who wrote: 'current understanding of how fuel reduction treatments affect the occurrence and propagation of unplanned fire at a regional scale is based primarily on simulation studies'. 'As a formal validation of the simulated outcomes of long-term prescribed burning strategies is seldom possible (due to a lack of well-documented case studies), the reliability of the modelling results can only be assessed in a qualitative sense by evaluating the (sub) models themselves.' P.133.

- There are a number of different fire behaviour simulation models used around the world that attempt to predict the likely impact of prescribed burning on fire behaviour; some developed for particular regions (e.g. 'FIRESCAPE-SWTAS' King et al. 2006, 'PHOENIX' Tolhurst and Chong, unpublished), others more generic (see recent comparison of five models by Cary et al. 2009).

- King et al. (2006) conceded on p.537 'observations from a range of studies suggest that as fire weather conditions become more extreme, with dramatic declines in fuel moisture and increases in wind speed, the fuel effects on fire behaviour are greatly diminished. Under these conditions, firebrands can promote fire spread, with unplanned fires being capable of igniting recently burnt areas, as well as extensive areas of less flammable vegetation'. Nevertheless, their model did not incorporate either firebrands or fire suppression which is a major limitation in this study.

ISSUE 2: Land Management Objectives

Qualification of opinion to be offered on Issue 2:
As an ecologist actively engaged in studying the impact of fire upon fauna and their habitats, QUESTION 3(a) and QUESTION 4 are within my area of expertise. However, I am unable to address QUESTION 3(b) or QUESTION 5 as they fall outside my area of expertise or reading.

QUESTION 3: How does prescribed burning adversely or positively affect: QUESTION 3(a): the management of ecosystems and the long term status of native plants and animals;

Expert Opinion

The majority of studies investigating effects of fire on fauna and flora have been short-term (a decade or less) and associated with unplanned fire events (e.g., Whelan et al. 2002, Smucker et al. 2005, Kotliar et al. 2007). There is very little quantitative evidence of the effects of prescribed burning on the '**long-term status**' of flora or fauna. Studies that investigate the effects of prescribed burning on the short-term status (e.g. 1 – 3 years post-fire) of flora and/or fauna have not been considered, as they fell outside the scope of the question.

There is a lack of **long-term** quantitative evidence of the positive or negative effects of prescribed burning. There are several reasons this:

1. The practice has been undertaken for a short period of time relative to the time scale of the ecological processes of succession involved, which may run over decades or centuries.
2. Systematic long-term monitoring of the effects on fauna and flora of prescribed burning has been extremely limited in this country (in contrast to studies in southern Africa e.g. Seydack et al. 2007 which have run for 70 years).
3. Studies of the long-term effects of prescribed burning would need to examine both: i) the long-term effects of repeated prescribed burning *per se* and ii) the effectiveness of prescribed burning in protecting habitat when challenged by unplanned fire. Neither issue has been received long-term study in this country.

Despite the lack of **long-term** quantitative evidence of the positive or negative effects of prescribed burning (see Clarke 2008 for a recent review), many authors have speculated on the topic, working from basic first principles in ecology. I list common conclusions below:

1. Some plants and animals require fire to perpetuate their populations. Complete exclusion of fire from their habitats can lead to local extinctions.
2. Flora and fauna have evolved to cope with fires of a particular frequency, intensity and scale. Fires that occur outside an organism's range of tolerances in these various fire characteristics have the potential to cause local extinctions. For example, species could be lost if prescribed burning or unplanned fire was too frequent or too infrequent. Inappropriate fire management is considered a major threatening process to birds (Woinarski 1999, Garnett and Crowley 2000). Keith et al (2002) note that serotinous obligate seeders are also 'a group of species [which] is particularly prone to extinction under frequent fires (Cowling et al. 1990, Morrison et al. 1996, Bradstock et al. 1997)' p.405.
3. Because species differ in their requirements in regard to fire, it is generally assumed that uniformity in fire history across a landscape should be avoided, and that a range of fire regimes should be promoted to cater for the needs of the greatest possible diversity of flora and fauna. Bradstock et al. (2005) postulated that 'large, intense fires may homogenise the

age-class structure in an area and, inherently, are assumed to be detrimental to populations because unburnt remnants may be scarce or absent. Intervention through active burning to create a mosaic of patches of differing time since fire acts in two ways. In the first instance, in the absence of, or interval between, large fires, landscape-level age-class diversity is assumed to increase as a result of small patchy fires. In the second instance, in the event of an intense fire, some recently treated patches may provide refugia.' P.410

4. Although many authors advocate the need for a mosaic of different fire histories across a reserve, virtually nothing is known about the appropriate scale at which that mosaic should be implemented, nor what would be desirable or undesirable compositions of those mosaics in terms of age-classes (Bradstock et al. 2005, Parr and Andersen 2006).
5. Our ignorance in regard to point 4 severely limits the ability of agencies, like DSE, to set SMART (Specific, Measureable, Attainable, Relevant, Time-bound) ecological objectives in regards to the scale or location of prescribed burning to achieve ecological outcomes. This point highlights the pressing need to establish long-term monitoring of the ecological consequences of current prescribed burning practices to ensure we learn from our current practices, and are not in the same ignorant position in the future.

QUESTION 4 1st Part: In what circumstances does the practice of prescribed burning produce a conflict between the protection of conservation values on the one hand and the mitigation of bushfire risk (as that risk affects assets and the safety of human communities) on the other?

Expert opinion:

1. **Urban-bushland interface.** As an increasing number of people choose to live on the urban-bushland interface, an increasing proportion of the public estate is being zoned as **"Asset Protection Zone"** (Department of Sustainability & Environment 2006). It is recognised in the Code (page 14, para 158) that within this zone "intensive fuel management may have significant impacts on a range of ecological processes... and values". Bradstock et al. (1998) concluded that in the Sydney region 27% of the urban-bushland interface would need to be burned annually to achieve average risk levels of uncontrollable fire of 10 days per annum (and 40% burned annually for average risk of uncontrollable fire of 1 day per annum). It is important to remember that such studies are examinations of the impact of prescribed burning on the risk of wildfire: they were not designed to consider the impact of these levels of prescribed burning on biodiversity. Burning 10% or more of the landscape annually would have dramatic effects on vegetation composition and structure, particularly on old-growth elements on which many faunal species depend. If even further protection of human life and assets from wildfire is deemed necessary, still further areas of the public estate surrounding settlements may be zoned **'Strategic Wildfire Moderation Zone'** and subjected to regular lowering of fuel loads through prescribed burning (although not necessarily to same low levels as in an **Asset Protection Zone).** This has the potential to impose inappropriate fire regimes for certain organisms over a much larger proportion of the landscape than has occurred in the past.

2. **Large-scale, extensive prescribed burning in reserves.** Recent large-scale fires in the state over the past decade have led some in the community to call for a major increase in the level of prescribed burning in our reserve systems. Coincidently, DSE has responded by planning and conducting large-scale (>1000 ha) landscape mosaic burns in extensive, often remote areas, of native vegetation in what are defined as **Ecological Management Zones.** According to the Code (p 15) such burns are designed 'to achieve ecologically appropriate fire regimes for native species and/or ecological communities', and are not for asset protection. There is potential for

conflict between the protection of conservation values and the mitigation of bushfire risk, if the latter is the driving force behind the selection of sites for such burns (to placate worried neighbours to a reserve), rather than valid ecological justifications that species would be lost if these large areas were not burnt. Widespread burning which leads to short inter-fire intervals over a large region may pose a threat to species that are sensitive to fire intervals (Gill & Bradstock 1995). Planned burning and associated infrastructure and disturbance may also facilitate weed invasion (Keeley 2006).

In each of the practices discussed above, fire management is often implemented with one objective in mind (for example, protecting buildings), without appraising the possible impacts on other objectives. In addition, there is often inadequate knowledge of the effectiveness of the action for achieving the first objective. However, rational decision-making demands that alternative objectives be simultaneously appraised in the face of a management intervention. Given the expense of implementing management, and the substantial cost of reversing impacts on biodiversity, it is important to weigh all of the costs and benefits of management actions before they are implemented.

QUESTION 4 2nd Part: How might that conflict be diminished?

Expert opinion:

- **Constrain or reduce the area of conflict.** Tighter planning laws restricting where humans can live and construct built assets would be one way to limit the extent of the urban-bushland interface, and therefore the need for frequent prescribed burning in **Asset Protection Zones** and **Strategic Wildfire Moderation Zones.** We currently prohibit people from building on flood plains that we can reliably predict will be subjected to a one in 50-100 year catastrophic flood. We could similarly identify areas that we can reliably predict will be subjected to a one in 50-100 year catastrophic fire. Allowing construction of dwellings in such areas is committing the community and the flora and fauna to the perpetual maintenance of **Asset Protection Zones** and **Strategic Wildfire Moderation Zones** through prescribed burning; an expensive and potentially ecologically damaging undertaking.

- **Tighten objectives.** To date objectives of some prescribed burning have become vague as managers claim they are managing fire for 'multiple values or objectives'. While this is undoubtedly true in some circumstances, it is important to recognise that stakeholders place two conflicting demands on current fire management operations, and that the trade-offs between these demands need to be addressed explicitly and transparently (Driscol et al. in prep).

  Multi-criteria optimisation can be used to appraise potential trade-offs (Drechsler 2004). If managers catalogue the full range of potential management actions that can be implemented for a range of budgets, then each set of actions can be graphed based on the extent to which they achieve both conservation and asset-protection goals. For asset-protection goals, the range of actions would encompass different fuel-management options, ignition management, rebuilding assets rather than attempting to protect them, protection by relocating assets, and of using engineering solutions to protect assets in-situ (e.g. Wakefield et al. 2009). The full range of management options could populate biodiversity/asset-protection space as shown in Fig. 1 (below).

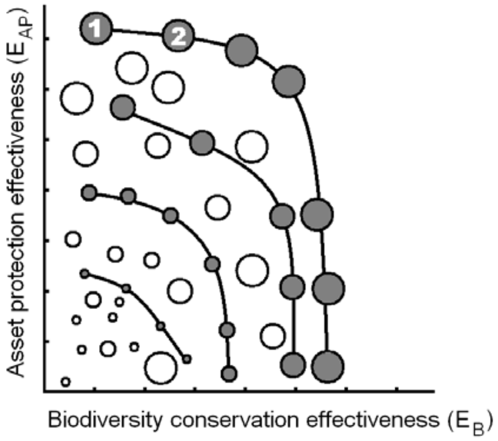

Figure 1 – taken from Driscoll et al. (*in prep*).

In some systems, points in the upper right hand region may be possible (Andersen et al. 2005). From the full set of management strategies, an optimal subset can be identified for different management budgets (points joined by lines in Fig. 1). Management options that do not belong to this optimal set (below and to the left of the grey lines, Fig. 1) are less effective for both biodiversity and asset-protection, and better alternatives are therefore available. On the other hand, for options within the optimal subset, one objective may only be increased with some decrease in the other objective. However, trade-offs that are satisfactory for all stakeholders may be found. For the hypothetical example in Fig. 1, changing from management action suite 1 to suite 2 (indicated by the numbered circles) more than doubles the biodiversity protection, but only slightly reduces asset protection. The definition of the optimal subset therefore not only indicates which of the available strategies are candidate solutions, but also quantifies any trade-offs required if managers wish to increase either objective. This kind of modelling requires good information on the effectiveness of prescribed burning to achieve fire control goals and secondly, good information on the impact of particular fire regimes on flora and fauna.

If large areas of parks are to be burnt for ecological reasons, then the ecological justification and goals for such burning must be made explicit, monitored and reported upon.

- **Change the current reporting procedures for Prescribed Burning**
  The current accounting and reporting system for prescribed burning that fails to distinguish between burning done for Asset Protection reasons, as apposed to Ecological Management reasons (e.g. *Victorian Overview to District Fire Operations Plans* DSE.HDD.0013.2038), allows annual tallies to be inflated by including large-scale burning in locations remote from built assets (e.g. Big Desert or Murray-Sunset National Park). This could be easily remedied by reporting the area burnt in each zone separately. This would remove any temptation for managers or governments to inflate the annual tally through the inclusion of areas burnt for primarily ecological reasons.

- **Improve our understanding of the requirements of flora and fauna in regards to fire** An greatly improved understanding of the life history attributes of species that are strongly influenced by fire may help to avoid detrimental effects on biota, while (possibly) still maintaining fuel loads at manageable levels.

- **Landscape mosaic burning: the need for an evidence-based approach.** Within Victoria, DSE has moved to an approach based on 'landscape mosaic burning', with the goal of burning large blocks of native vegetation annually. This is a marked shift from the prior practice of planned burning based on strips or blocks strategically placed to maximize bushfire mitigation. The intention of this new practice is that it will have benefits by: i) reducing the levels of fuels across broad areas (i.e. fire protection benefits); ii) enhancing a 'mosaic' of different post-fire age-classes (i.e. ecological benefits).

Key aspects of a land mosaics that are known to influence species include (e.g. Bennett et al. 2006):

- the total amount of a particular habitat (or fire age-class) in the mosaic
- the composition of different vegetation types (or fire age-classes) in the mosaic;
- the configuration of different habitats, including patch sizes, connectivity, isolation, and aggregation.

There are NO published empirical data on how these aspects of fire mosaics will affect native plants, animals and ecosystem processes in Victoria – and yet fire management in Victoria has committed to large-scale implementation of this new approach, and a greatly increased burn area each year. Although there is a general aim to achieve a proportional mix of age-classes determined by the life-cycles of plant species regarded as key fire response species, to date, there are **no specific guidelines or goals** for what **kind of mosaic** is desired within each landscape burn.

My point in highlighting these issues is not to imply that landscape mosaic burning is detrimental, but that there is a fundamental need for an evidence-based approach to fire management, coupled with effective monitoring, evaluation and feedback. This has not happened to date. While agencies spend many millions of dollars annually on implementing fire practices, investment in generating knowledge on which to base, and improve, ecological aspects of fire management is minimal.

ISSUE 3: Prescribed burning Risks and Methods

Qualification of opinion to be offered on Issue 3:
As an ecologist interested in the impact of fire upon fauna, I have examined the scientific and unrefereed 'grey' literature pertaining to the effectiveness of Prescribed Burning in mitigating bushfire risk. However, I must stress that fire behaviour is not my area of expertise. Nevertheless, in my professional life I have been called upon to critically examine the scientific literature on the effectiveness of Prescribed Burning in mitigating bushfire risk, since it is meant to underpin ecological fire management policy. I therefore offer the following responses to Issue 3 based upon a critical examination of the scientific literature, rather than from my own empirical research on the topic.

QUESTION 6(a): Comment on the significance of the selection of the size, spatial arrangement and location of treatment areas for prescribed burning in optimising the effectiveness of prescribed burning to mitigate bushfire risk;

Expert opinion

1. Evidence from the literature is equivocal in regard the size of treatment areas for prescribed burning in optimising the effectiveness of prescribed burning to mitigate bushfire risk.
2. There is some evidence that strategically placed treatment areas are more effective in mitigating bushfire risk than random or haphazard placement of treatment areas.

Basis for Opinion:

SIZE

- Boer et al. (2009) quantified the relationship between the extent of area burnt by prescribed fire and unplanned fire (using a 6-year running mean for both variables) in eucalypt forests in southern Western Australia. They concluded that increasing the extent of prescribed fire significantly reduces the extent of unplanned fire. However, the small negative slope (-0.26) for this relationship indicated that the relatively large amounts of prescribed burning must be undertaken to achieve relatively small reductions in the extent of unplanned fires. Each unit area reduction in unplanned fire required about four units of prescription fire over the study period of 52 years. They also concluded that 'mean patch area' of young (≤6 years post-fire) and old (>6 years post-fire) fuel patches was not an important factor influencing the annual incidence or extent of unplanned fires in the landscape.

- King et al. (2008) predicted from their simulation modelling that where significant differences were evident for treatment unit size (≥5% annual prescribed fire), <u>smaller burning unit sizes</u> ('fine-scale fuel mosaics') were found to significantly enhance the reduction in the resultant areas burned by unplanned fires in buttongrass moorlands. They postulated that smaller unit sizes and a deterministic spatial pattern resulted in 'increased discontinuities in the spatial fuel array, which in turn slowed the rate of spread of unplanned fires, and hence reduced fire intensities (Byram 1959)' p.428 (Note that this point relates to 'spatial arrangement' as well).

- Finney et al. (2005) found that treatment unit size was relatively less important for recent treatments (e.g., 1 year post fire) than for older treatments (up to 9 years post fire). They noted that 'the role of unit size in older treatments may reflect the effects of greater fuel and topographic heterogeneity that partially compensated for fuel recovery by collectively slowing fire movement (Weatherspoon and Skinner 1995). The fine-scale "fingering" of the wildfire produced by such heterogeneity has been shown to increase the proportion of flanking and backing fire within the area as a whole (Finney 2003), thus, reducing fireline intensities and tree crown damage or ignition within the [treatment] unit … larger treatments units also require longer burn times and, thus, better chances that weather will moderate as the fire burns through these areas (e.g., wind shifts, nighttime)' p.1720.

- Burrows (2008) comments on the 'Fire Mosaic Project' (Burrows and Wardell-Johnson 2004) currently being implemented in SW Australian forests. Here they 'aim to test the hypothesis that frequent (2-3 year intervals) introduction of fire into the landscape (patch-burning) will (a) create, maintain and promote fine-scaled habitat mosaics incorporating a range of interlocking post-fire seral stages, and (b) that this mosaic will promote biodiversity and reduce the severity and impact of wildfires.' P.2402. No empirical evidence is provided by Burrows (2008) to support his hypothesis that a fine-scaled habitat mosaic will achieve either of the objectives noted above. Instead, there is a single reference to the book (Abbott and Burrows 2003), with the comment 'there is growing evidence that smaller patches are better than larger ones' p.2396.

SPATIAL ARRANGEMENT

- Boer et al. (2009) concluded that the spatial arrangement of fuel treatments was a key determinant of the annual extent of unplanned fires. After accounting for the effects of time and climate (Keetch Byram Drought Index), Boer et al. (2009) identified that the spatial pattern of young (≤6 years post-fire) and old (>6 years post-fire) fuel patches explained 64% (strong effect) of the residual variation in the annual area burnt by unplanned fire. The strongest variables in this model were the connectance index ('connectance' between like patches in the landscape was arbitrarily set by authors to be <200m) and the perimeter-area ratio of old fuel patches. The annual extent of unplanned fire increased with connectedness of patches of old fuels. Boer et al. (2009) argue that this make sense as 'the more connected the old fuel patches are the greater the area that is subject to potentially high–intensity fire and consequent suppression difficulties' p.141. Boer et al. (2009) note that this highlights the 'challenge facing fire planners.... To keep the connectedness of old fuels low enough to constrain wildfire spread while at the same time, for example, maintaining sufficient connectivity dispersal of organisms that depend on areas of old fuels' p.141.

- Simulations from King et al. (2006) showed that significantly smaller unplanned fire size distributions were predicted for deterministic rather than random spatial patterns, at treatment levels of ≥5% per annum. 'Further, between the 5% and 20% treatment levels, it was predicted that deterministic spatial patterns [strategically placed] would result in a significantly greater reduction in mean annual area burnt [for unplanned fires]' p.537.

- Reinhardt et al. (2008) commented that 'an effective spatial arrangement of fuel treatment units for minimising fire spread is a "herring-bone" pattern on the landscape (Finney 2001).' P.2000. However, 'while this spatial design might be optimum for reducing fire spread, it does not resemble the effects of any historical ecological process or landscape pattern' p.2000.

LOCATION

- King et al. (2006), identified in their simulation study that strategically located treatment units were able to enhance the reduction in the fire risk to vegetation species susceptible to fire (ie fire-intolerant species), compared to areas burnt deterministically (on a rotation basis) or randomly. In this strategically-defined treatment ~3% of buttongrass moorlands were burnt per annum, and prescribed fire was implemented specifically to protect rainforest and alpine plant species by burning primarily around these areas, creating buffers/firebreaks of reduced fuel load.

- Moritz et al. (2004) note that prescription burning and other fuel manipulations should be useful at strategic locations along the urban-wildfire interface (but their results suggest that prescribed burning treatments will be unlikely to prevent large wildfires occurring in natural areas)

- Whelan (2002) suggested application of strategic (rather than broad scale) hazard-reduction burning to park boundaries with 'innovative solutions sought where species listed as vulnerable or endangered occurred' p.1660. Such actions may protect assets (houses) and benefit biodiversity but will not prevent large wildfire within conservation reserves.

- Bradstock et al. (1998) investigated the ability for a strategic 100 m fire zone to protect assets (structures) along the urban interface of northern Sydney and noted that high fire frequencies (~90% of fires ≤5 years apart) would be required to achieve minimum risk (sufficient for uncontrollable fires on an average of 1 day per annum).

QUESTION 6(b): Comment on the significance of the selection of the size, spatial arrangement and location of treatment areas for prescribed burning in minimising adverse ecological impacts of prescribed burning

SIZE

Expert opinion:

Plants possess many adaptations to regenerate after fire on the same site (e.g. epicormic buds, hard seed coats, lignotubers etc). Consequently, it matters little to many plants whether the area burnt is 1 ha or 10,000 ha – they will regenerate on site. By contrast, animals have few adaptations to survive fires and, if they do, they must be able to obtain the resources they need in terms of food, water and shelter within dispersing distance of the refuge in which they survived the fire. Consequently, the extent of an area burnt is likely to be of much more profound importance to animals than to plants (Clarke 2008). If prescribed burns are too large in area and uniform in severity some animals are likely to become locally extinct and recolonisation of the interior of such burnt patches will be slow or non-existent. The extent and uniformity of coverage of prescribed burns should take into account the habitat needs and home range dimensions of the least tolerant (and therefore most vulnerable) organisms in the region to ensure their species' survival in the region is not jeopardised by the prescribed burn.

Basis for opinion:

- Bradstock et al. (2005) noted that 'in the event of species that require fine-scale patchiness (i.e. burnt and unburnt patches) at the level of individual home ranges, the size of burnt patches may be an important criterion for any management program' p.410. Bradstock et al. (2005) also commented that 'Among vertebrates the size of territories occupied by individuals varies with body size (Kelt and Van Vuren 1999). Thus a particular fire-mosaic that suites the territory size and shape of one species will not necessarily suit the requirements of another cohabiting species' p.411.

- Keith et al. (2002) suggest that 'the effect of fire size on predation [of plants] is likely to be greatest in habitats where ubiquitous mobile predators already exert a significant influence on ecosystem dynamics, as in temperate grassy woodlands and semi-arid regions with an abundance of feral or domestic herbivores' p.412.

- Vickery (2002) reported that prescribed fire temporarily reduced seed predation (by moth larvae) on the northern blazing star (*Liatris scariosa* var. *novae-angliae*), a rare grassland perennial endemic to the northeastern United States, from ~90% to ~16% in the year after fire. Prescribed fires >13 ha helped reduce predation rates, but fires smaller than 6 ha did not, suggesting that dispersal of adult moths from unburned source areas was spatially limited.

- Burrows (2008) notes that 'there is a growing evidence that smaller patches are better than larger ones (Abbott and Burrows 2003)' p.2396.

SPATIAL ARRANGEMENT

Expert opinion:

The juxtaposition of differing seral stages appears to be important for certain animals that exploit multiple seral stages in the normal course of their daily lives. Consequently, if prescribed burns are too large in area and uniform in severity such animals are likely to become locally extinct as they will be unable to meet their daily needs in the resulting habitat made up of just a single seral stage. In some habitats variations in local topography and moisture gradients will affect fire behaviour and automatically create a natural mosaic of different seral stages that will meet the needs of such species. Artificially creating patchiness through prescribed burning may be perceived negatively by some fauna as fragmentation of the habitat. A precautionary approach would be to aim for finer, rather than coarser grained, mosaics to best cater for such species. However, finer grained mosaics are less likely to be as effective in mitigating bushfire risk.

Basis for opinion:

- An example of a species that requires multiple seral stages is the mala (*Lagorchestes hirsutus*). This species apparently requires a mosaic of small burnt/unburnt patches which allows for foraging in burnt patches and shelter from predators in adjacent unburnt patches (Bolton and Latz 1978). Whether prescribed fire can deliver such mosaics may also depend on other aspects of the fire regime (e.g., intensity and season of burn, etc).

- Reinhardt et al. (2008) argued that 'fuel treatment regimes should be designed and implemented at the landscape level to utilise important spatial configurations and landforms as fire breaks and to integrate the spatial distribution of biophysical settings comprising that landscape with the fire regime to ensure ecosystem sustainability' p.2002.

- Parr and Andersen (2006) comment that 'fine-scale patchiness may not necessarily have positive biodiversity outcomes; some animals perceive it as fragmentation rather than (positive) heterogeneity (Sullivan and Sullivan 2001)' p.1615.

LOCATION

Expert opinion:

The ability to apply prescribed fire events in locations that minimise adverse affects to biodiversity requires at a minimum, accurate fire history mapping (timing, location and severity) and a good understanding of flora and fauna responses to fire. Unfortunately both are lacking in most fire-affected environments. Detailed fire history mapping is essential if one is to avoid destruction of vital habitat elements through prescribed burning, particularly those that may take decades to develop (e.g. hollow logs on the ground). Our research in the mallee indicates that it takes over 50 years for a mallee stem to develop a hollow that could be used by an animal. However, reliable fire history mapping in the region only goes back around 37 years (Clarke et al. unpubl data). This severely constrains the ability of current fire planning to identify the location of key habitat assets and plan for their protection.

Spatially explicit data bases on the distributions of key focal species and key elements of their habitats are woefully out of date in this state. The last systematic survey of the state's flora and fauna was carried out over 20 years ago (associated with the Land Conservation Council Reports), and, given the unprecedented period of climate change and habitat degradation the state has endured in that period, data collected in the 1970s and 1980s cannot be assumed to be a reliable indicator of the location or status of flora and fauna at the start of the 21st Century. Fire planners need to know what biological assets they are attempting to conserve and where they are located. Current data sets are inadequate for the task.

QUESTION 7: (1st part) What are the <u>major risks</u> associated with the <u>conduct and management</u> of prescribed burning (operational, political, economic and environmental)?

Qualification of opinion to be offered on QUESTION 7:
As an ecologist, I am qualified to offer an expert opinion only on the environmental risks associated with the management of prescribed burning.

Expert Opinion (on Environmental Risks)

1. **Ignorance of the needs of flora and fauna.** Our ignorance of the current distributions and needs of flora and particularly fauna in regards to fire means we run a very real risk of inadvertently causing local extinctions through the application of inappropriate fire regimes.

2. **Broad application of simplistic, ecologically-dubious generalised burning prescriptions for ecological purposes.** The setting of targets across this State for the proportions of a habitat type that should be in particular fire-age classes is currently based upon a model (Tolhurst and Friend 2001, Department of Sustainability & Environment 2002, and 2004) using a particular theoretically-derived distribution of fire-age classes (the negative exponential distribution), first defined for boreal forests in North America (Van Wagner 1978, Johnson and Van Wagner 1985, Weir et al. 2000). It recommends that the desired fire-age class structure in all 157 habitats is to have preponderance of younger fire-age classes. It is now the guiding paradigm for ecological fire management across <u>all</u> vegetation communities in the state of Victoria, ranging from semi-arid shrublands to temperate rainforests. The uniform application of this ecologically-untested and dubious recommendation is likely to be ecological inappropriate in many habitats in Victoria (Clarke 2008) where substantial proportions of the biota rely on a large proportions of the landscape being long-unburnt.

3. **Too frequent or too large fires.** If fire occurs too frequently or on a scale or intensity that is greater than that which flora and fauna have evolved to cope with, this could result in irreversible loss of species and ecological communities. Topography and natural moisture differentials make some parts of the landscape more likely to burn than others. Unbounded, landscape-scale prescribed burning on a regular basis runs the risk of repeatedly burning some parts of the landscape too frequently. Detailed fire severity mapping of all prescribed burns and accompanying on ground surveys of flora and fauna will be needed to determine the magnitude of this phenomenon and its consequences.

4. **Prescribed burns that escape.** Prescribed burns that escape control lines (e.g. 2005 Wilsons Promontory fire – meant to burn 20 ha, actually burnt >6000 ha, Southern Murray-Sunset fire- meant to burn 700 ha, actually burnt 20,000 ha) can pose a real threat to environmental values. Increased public pressure to conduct more prescribed burning on public land to mitigate the threat of wildfire can result in agency staff attempting prescribed burning under weather conditions that are less conducive to maintaining control. Under such weather conditions, there is an increased risk that an "escaped" prescribed burn could inflict the very damage it is intended to prevent. The potential for long-lasting or irreversible ecological damage increases as the size of the reserve in which a prescribed burn escapes decreases. This is because a greater proportion of the entire reserve is likely to be affected by the fire, reducing the likelihood that remaining unburnt habitat will contain sufficient refuges/sources for re-colonisation by fauna and flora.

5. **Blacking-out unburnt areas after a fire has passed** Unburnt areas remaining after back-burning or after a fire front has passed may be deliberately burnt as part of ongoing fire-suppression management. Burning out is likely to have substantial impacts on biodiversity by removing unburnt refuges (Penman et al. 2007, Lindenmayer et al. 2009). Patches of forest with low-flammability characteristics may routinely remain unburnt (Clarke 2002) and these may provide important refuges for species that otherwise would not survive in the more regularly burnt surrounding landscape (Gandhi et al. 2001).

6. **Changing climatic conditions.** Increased incidence of prolonged periods of drought heighten public fears of catastrophic bushfires, leading to increased pressure for more prescribed burning, due to a perception that this measure profoundly reduces bushfire risk. Such climatic conditions mean that the window in which agencies can safely conduct prescribed burning will be smaller. Unfortunately, those very same climatic conditions also depress animal and plant populations placing them in the least robust state to recover from the immediate effects of prescribed burning and raise the risk of the prescribed burn causing lasting ecological damage. However, depending on the effectiveness of prescribed burning in averting or ameliorating the likelihood of large scale catastrophic fires, in could be argued that the damage done by prescribed burning could be the lesser of two evils. This highlights the imperative to gather solid empirical evidence to i) determine the effectiveness of prescribed burning in averting or ameliorating damage caused by large-scale catastrophic fires; ii) to identify any long-term detrimental ecological effects of prescribed burning.

7. **Unrealistic expectations of the effectiveness of prescribed burning.** In my opinion the general public's expectations regarding the effectiveness of prescribed burning to avert or ameliorate the likelihood of large-scale catastrophic fires do not match the scientific evidence available on this matter. The latter suggests that prescribed burning has minimal effect under extreme fire weather conditions and that massive proportions of the public estate would have to be treated annually to achieve the levels of protection some expect. This mismatch between public expectations and the best available knowledge regarding prescribed burning has the potential to lead to following undesirable outcomes:
   - i) Human life and property will be placed in danger as people assume local prescribed burning offers a level of protection during a wildfire that science suggests it will not deliver.
   - ii) Ecological damage will be done through extensive prescribed burning, with little or no gain in security from wildfire.
   - iii) Personnel and funds will be devoted to one fire prevention practice (prescribed burning) at the expense of other, potentially more effective, strategies.

8. **Too infrequent fires.** If fire occurs too infrequently in habitats that require it for regeneration, this could result in irreversible loss of species and ecological communities. Recent widespread fires suggest that even with all our modern fire prevention and suppression techniques we are a long way from being able to totally exclude fire from many habitats, so this risk is minimal. However, there are isolated examples of parts of the state that may genuinely require more fire for sound ecological reasons (e.g. Yanakie Isthmus of Wilsons Promontory).

Basis for opinion:

- Boer et al (2009) quantified the relationship between the extent of area burnt by prescribed burning and unplanned fire (using a 6-year running mean for both variables). They reported that increasing the extent of prescribed burning significantly reduces the extent of unplanned fire. However, the small negative slope (-0.26) for this relationship indicates that the relatively large amounts of prescribed burning must be undertaken to achieve relatively small reductions in the extent of unplanned fires. Each unit area reduction in unplanned fire required about four units of prescription fire over the study period of 52 years. A similar pattern, where large annual extents of prescribed fire were required to achieve relatively smaller reductions in unplanned fires size was also found King et al (2006). Thus, Boer et al. (2009) and King et al (2006) identified that to achieve very modest decreases in the extent of unplanned fires requires an aggressive prescribed burning strategy (i.e. disproportionately high annual extents of prescribed fire) which is likely to result in the loss of large extents of longer unburnt habitat from the landscape. This is likely to cause a major environmental risk, by threatening those faunal species that rely on this older habitat, and putting at risk of local extinction any plant species with long periods to maturity after fire.

- There are significant risks in fire managers not really understanding how a management technique might affect biodiversity. For example, Parr and Andersen (2006) note that 'conservation managers in Australia have struggled to operationalise patch-mosaic burning effectively (despite its widespread support). For example, management plans typically lack details on the scale and distribution of patchiness that is considered desirable and on how fire managers intend to achieve this patchiness. Without such detail, it is unlikely that management aims will be achieved or that outcomes of management can even be effectively assessed (Andersen 1999)' p.1613

- Some agencies are using the minimum and maximum tolerable fire intervals derived from the vital attributes of a select group of key fire response species (all plants) to generate an ideal (desirable) age-class distribution for each particular vegetation community. Their aim is to determine the desirable proportion of a vegetation type to have in each time-since-last-burnt age-class. The approach (e.g. Tolhurst and Friend 2001) has been to insert the estimates of minimum and maximum tolerable fire intervals (derived from the vital attributes of a select group of plants) into a single mathematical model (based on a homogenous negative exponential distribution) that will generate 'ideal' age-class distributions for that vegetation type. The use of this particular distribution assumes the time since last burnt does not influence the probability of ignition (flammability) (Johnson and Gutsell 1994). While this assumption may hold for some vegetation types, it seems unrealistic for many in which the probability of ignition is likely to change along with changes to the litter layer (Good 1996; Tolhurst and Friend 2001; Mackey *et al.* 2002). Furthermore, it is exceedingly unlikely that all vegetation types will share a *common pattern* to their probability of ignition over time since last burnt. Bradstock *et al.* (2005, p.241) cautioned against 'predicating intervention solely on the basis of time-since-fire distributions, particularly where the intent is to stabilise or manipulate such distributions to conform to some ideal.'. Nevertheless, the same mathematical model was applied to 157 vegetation types in Victoria (Fire Ecology Working Group 2002). Gill and McCarthy (1998), while advocating a negative exponential distribution, cautioned that 'There appears to be no single type of probability-distribution function to apply universally to intervals between fires at any one point of a landscape.' . Similarly, Williams *et al.* (1994) stressed that fire prescriptions were not necessarily 'portable' from one site to another, because the responses to fire will vary between sites and plant communities. Nevertheless, the Department of Sustainability and Environment (2002) claimed that irrespective of variance in flammability, they anticipated 'relatively high proportions of young age-classes' and 'relatively small areas of very old-age classes' when defining the 'idealised' distribution of age-classes for *all* Victorian vegetation types. Cool temperate rainforests, that include genera like *Nothofagus,* require long periods free of fire to become established (Busby 1986), whereas many heathland species do not (Gill 1999). It is hard to envisage 'relatively high proportions of young age-classes' and 'relatively small areas of very old-age classes' being the ecologically sound age-class distribution pattern across *all* vegetation types in any state. Furthermore, the approach seems to ignore the possibility of one vegetation type (e.g. wet sclerophyll forest) under-going a state shift into a different vegetation type (e.g. cool temperate rainforest) in very low or very high frequency of burning.

- Whelan (2002) identified backburning as a potential threat to biodiversity although no empirical data were provided: 'although information is scanty, anecdotal reports suggest that large proportions of the landscape in some national parks were burned by back-burning rather than by the main run of the wildfire' p.1661. He considers the next big challenge for conservation in fire-prone regions to be 'preventing wildfires from occurring too frequently and extensively, without the use of hazard-reduction burning across the whole landscape and with limited but strategic back-burning' p1661

- Reinhardt et al (2008) note that 'fuel treatments that involve prescribed fire carry risks of escape and of greater than intended fire effects including post-fire insect attacks of residual trees (Ganz et al. 2003), consumption of organic soils, and unwanted smoke production' p.2002

- Seydack et al. (2007) note that 'prominent causes of anthropogenic fires involved runaway fires during fire break burning …. and prescribed burning' p.86. Indeed results from their study identified that during the management period in which suppression of all fires was practiced (1950-1975), an estimated 59.6% of the area burnt was deliberately ignited by humans, with most stemming from runaway burns during fire break prescribed burning activities. Seydack et al. (2007) consider that the natural fire zone management (i.e., suppress all anthropocentric fires, no prescribed burning) appears to be conducive to the maintenance of [plant] biodiversity as it appears to deliver fire regimes (fire-return intervals) that are suitable for the maintenance of the range of shrubland species.

- Prescribed burning undertaken too frequently risks homogenisation (and simplification) of landscape into a single early seral stage threatening many bird species (Woinarski and Recher 1997; Woinarski 1999)

QUESTION 7: (2nd part) What measures (including planning and conduct of prescribed burning and the use of other land management practices) might reduce those risks? **(ENVIRONMENTAL ONLY)**

Expert Opinion:

1. **Ignorance of the needs of flora and fauna.**
   Detailed, extensive long-term monitoring of the responses of flora and fauna to both prescribed and unplanned fire is fundamental to the "learning-by-doing"/adaptive management approach advocated, but not always implemented by DSE and Parks Victoria. Such monitoring does not need to be conducted on an annual basis at each location. Much could be learnt quickly by application of a space-for-time substitution methodology on a broad scale across the state. This should be accompanied by ongoing 5-yearly surveys that re-visit sites in major habitat types subjected to different fire regimes. Monitoring of flora and fauna is already a stipulated requirement under the Code of Practice (paras 237-241, page 21), but currently levels of monitoring are grossly inadequate for the task. Detailed monitoring would enable both the refinement of local burn objectives and prescribed burning practices in light of responses detected by monitoring. Current research suggests that seeking broad State-wide prescriptions is simplistic and ecologically unwise, since the local fire history is critically important in determining ecologically sensible management actions.

2. **Broad application of simplistic, ecologically-dubious generalised burning prescriptions for ecological purposes.**
   The setting of targets across this State for the proportions of a habitat type that should be in particular fire-age classes should be based on the best empirical data (<u>not</u> a single common theoretical curve) and recommendations tailored for each habitat type according to the identified seral stages found within that habitat type and our knowledge of the habitat requirements (spatial and temporal) of fauna, as well as flora occurring in that habitat type. Insights gained from 1 (above) will be crucial to setting these recommendations and an adaptive management approach will be needed to monitor and refine their effectiveness in delivering the desired ecological resilience.

3. **Too frequent or too large fires.**
   i) Insights gained from 1 (above) will refine our understanding of inappropriate fire regimes and enhance our ability to set robust ecological objectives for prescribed burning.
   ii) The ecological and fire mitigation effectiveness of unbounded, landscape-scale prescribed burning must be assessed. This requires a commitment to undertake <u>fire severity mapping of all fires on an annual basis</u> and accompanying on ground surveys of flora and fauna will be needed to determine the efficacy of this approach. Current research suggests that strategically placed prescribed burns (that can be smaller) are more effective in reducing the impact of unplanned fires than randomly, unbounded landscape-scale prescribed burning.
4. **Prescribed burns that escape.** Greater resources are needed to ensure that all the necessary prescribed burning can be completed under the safest possible weather conditions and that the risk of prescribed burns escaping control lines is minimised.
5. **Blacking-out unburnt areas after a fire has passed** Unless unburnt areas pose an immediate threat <u>during a fire</u> as a source of future ignitions, such areas should be protected from fire as significant ecological refuges and sources of future re-colonists (flora and fauna). Policies that target such areas for subsequent prescribed burning in

the years following a major wildfire make no ecological sense, have the potential to cause irreversible loss of species and ecological communities and should be abandoned.

6. **Changing climatic conditions.** Gather solid empirical evidence to i) determine the effectiveness of prescribed burning in averting or ameliorating damage caused by large-scale catastrophic fires; ii) identify any long-term detrimental ecological effects of prescribed burning.
7. **Unrealistic expectations of the effectiveness of prescribed burning.** Disseminate the best available information on the conditions under which prescribed burning is effective through a fully-resourced education program.
8. **Too infrequent fires.** Gathering data for point 1 above will also highlight where more fire is needed in the landscape for ecological reasons.

Basis for opinion:

- Parr and Andersen (2006) capture some of the important actions that management can take to reduce environmental risk: (1): 'Any patch-mosaic burning procedure should incorporate an effective feedback process involving systematic monitoring (see Andersen 1999, Schreider et al. 2004). Effective feedback requires timely and accurate mapping of burned areas, combined with monitoring both of fire heterogeneity and effects on biota' *at multiple scales* p.1616. (2): 'Without a more analytical and systematic approach to PMB, leading to formalized fire policy that managers can effectively implement, it is unlikely that management aims will be met because the process of adaptive management cannot be fulfilled: actions to achieve strategic aims will remain unarticulated, and feedback for their continual refinement will be ineffective (Andersen 1999)' p.1616.

- Lindenmayer et al. (2008) argue that 'management strategies may need to be tailored specifically to a given area (such as a particular national park or reserve) rather than attempt to uncritically apply a generic management 'recipe' loosely aimed at conserving biotic assemblages (Andersen et al. 2005)' p.405.

- Bradstock et al. (2005) highlight the need for a better understanding of the effects of fire on fauna: 'There is little quantitative, comparative information about sizes, shapes, age structures or configuration of patches in relation to performance of animal population' p.411.

- Bradstock (2008) comments that 'adaptive management of fire regimes rather than fire events is required, based on an understanding of risks posed by particular regimes to biota' p.809.

- Keith et al. (2002) consider that 'to help achieve biodiversity conservation goals ..... focus should especially be directed at groups of species with ecological traits which render them most susceptible to decline under different fire regimes' p.401. They argue that 'a good strategy to conserve all populations would be based on detailed knowledge, management action and monitoring of a few, particularly those species or groups of species which have traits that render them most susceptible to decline across any of the possible fire regimes' p.406.

- Keith et al. (2002) highlight the importance of need for <u>variable fire frequencies</u> (set within the bounds of lower and upper thresholds defined by key life history attributes) to maintain plant diversity. Drawing on work from a range of papers, Keith et al. (2002) give an example of how two groups of heathland plants ((1) woody resprouters in the understorey that may take up to 15 years to develop fire resistant organs and (2) dominant shrubs: obligate seeders with bradysporous seed banks) can be maintained: 'by promoting variability in fire frequency between certain thresholds, apparent conflicts may be resolved and full diversity may be maintained' p.410.

QUESTION 8: Are hectare targets a good measure of whether the land management objectives (including for mitigation of bushfire risk) are being met? If not, what are better or complimentary measures?

Expert Opinion:

1. Hectare targets have the following serious weaknesses:
   i) Hectare targets are a simplistic measure of activity (i.e. area treated), rather than of outcomes (reducing fire risk or achieving ecological objectives). We could treat lots of hectares but still not reduce fire risk profoundly, if fuel loads within treated areas are not substantially reduced, or regenerate thicker than before in a short period of time.
   ii) In reporting Hectare Targets agencies commonly lump together prescribed burns in different Fuel Management Zones that may have been carried to achieve very different objectives (e.g., large scale burning in the Big Desert for ecological purposes should not be credited in the same way as small scale strategic Asset Protection burning in the Dandenong Ranges).
   iii) Hectare targets are unlikely to be useful unless they are specified for each fire-prone vegetation community in a region. The difficulty or value, in terms of bushfire mitigation, of burning 1 ha of box-ironbark forest or grassland compared to 1 ha of Foothills Forest are vastly different and reporting totals on the same scale (i.e. hectares) in a state-wide annual tally is misleading.
   iv) Hectare targets ignore the strategic importance of some prescribed burns versus others and treat them all as of equal value in bushfire mitigation, which is clearly not the case.
   v) It is my understanding that reporting of hectare targets is not allowed to include areas burnt by accident when prescribed burns escape control lines. This can lead to the ludicrous situation in which a region may have accidently burnt 20,000 ha more than they intended, but still be required to do additional burning to meet their assigned target of "controlled" burning for the year (or the life of the Fire Plan).
   vi) Annual state-wide prescribed burning targets don't currently appear to be adjusted downwards to taken into account the extent of the state burnt in recent wildfires. Not adjusting the annual state-wide prescribed burning targets creates pressure to then burn the few remaining unburnt parts of the state, at a time when they are probably performing a vital ecological function as a refuge and source of re-colonists.
2. Better or complementary measures:
   i) Fuel reduction targets could be expressed as a percentage of the target area in which fuel levels are maintained below some desired threshold for that habitat type. The process of setting the percentage of the target area to be burnt and the threshold targets should be evidence-based, specific to each particular vegetation community and be associated with explicit and transparent SMART fire mitigation or ecological objectives. The process must be based on ongoing stakeholder consultation. The implementation of this approach would require more sophisticated monitoring and mapping of changes in fuel levels, but be of more value in assessing changes in the distributions of fuels across the landscape. Such an holistic approach would monitor increases and decreases in fuel levels both inside and outside treated areas.
   ii) Targets for different Fuel Management Zones should be reported separately and not combined.
   iii) Targets for different vegetation communities should be reported separately and not combined.

iv) Areas burnt by accident, when prescribed burns escape control lines, should be reported annually for each region. (The figures I have seen only report the proportion of prescribed burns that escape control lines (a small number), rather than the total area burnt by escaped prescribed burns (often a big number)).

Basis for opinion:

- The effectiveness of prescribed burning in mitigating the effects of unplanned fires will almost certainly vary by vegetation community (Morrison et al. 1996) and remains unquantified for all fire-prone ecosystems with a few exceptions (Boer et al. 2009).

- King et al. (2006) note that it is likely to be the annual proportion of hectares burnt by prescribed burning, rather than the number of hectares *per se*, that may be important in determining the risk of unplanned fire in the landscape.

- The spatial patterning of prescribed burning treatments has been identified as a key determinant of the annual extent of unplanned fires (Boer et al. 2009). In simulations of prescribed burning strategies, King et al. (2006) also demonstrated that strategically located prescribed burning treatment units were able to enhance the reduction in the risk of unplanned fire to vulnerable plant species. Thus strategic placement of prescribed burning treatments, rather than random burning of the landscape to satisfy some hectare target, may achieve bushfire mitigation goals with far less area burnt (although scant empirical evidence exists for this scenario, as well). Here, a simple 'hectare target' would be an ineffective and futile method of reducing bushfire risk.

- In their simulation work King et al. (2006) identified that for linear increases in the prescribed burning treatment level, there is a diminishing effectiveness in reducing the mean annual area burnt by unplanned fires. For example, a prescribed burning treatment of 5% (~20,000 ha p.a.) is predicted to reduce the annual area burnt by unplanned fire by about 2500 ha (random spatial pattern) or 4000 ha (deterministic spatial pattern). By doubling the extent of prescribed burning to the 10% treatment level, additional reductions in the extent of unplanned fires are predicted to be only ~2,000 ha (i.e., a very poor return).

- Burning large areas to satisfy arbitrary hectare targets are unlikely to prevent high intensity wildfires burning under extreme weather conditions, as in these situations, 'effects on fire behaviour are greatly diminished' (King et al 2006, p.537). Furthermore, Fernandes and Botelho (2003) argue that the best results of prescribed fire application are likely to be attained in 'climates where the likelihood of extreme weather conditions is low' p.117. In other words, in conditions of extreme fire weather, the variation in the amount of hectares burnt by prescribed burning may have little influence over wildfires.

- Burrows (2008) raises an alternative measure that is used for SW Western Australian forests where areas identified for fuel reduction burning are based on fuel hazard levels: 'managers aim to maintain fine surface fuel quantity (dead leaves, twigs, bark and floral parts <6mm in diameter) below about 8-9 t ha^{-1} .... for jarrah forests .... over about 60-70% of the forest area' p.2403. The interval between prescribed burning varies across the forest region from about 6 to 10 years. Note that the author provides no empirical evidence of whether such methods are achievable or effective for (1) aiding in the suppression efforts of large wildfires or (2) enhancing the persistence of native biota.

- Reinhardt et al. (2008) argue that 'fuel treatments in wildlands should focus on creating conditions in which fire can occur without devastating consequences [(loss of human life, housing, etc)], rather than on creating conditions conducive to fire suppression' p.1998. They go on to suggest that 'by reducing the flammability of structures [(e.g., houses)], wildland-urban interface (WUI) fuel treatments can be designed such that an extreme wildfire can occur in the WUI without having a residential fire disaster' p.1999. Reinhardt et al. 2008 suggest that recent reports from the US (e.g., Cohen 2000, 2003, Graham 2003, USDA Forest Service 2007) provide details of how extreme fire behaviour conditions can overwhelm the ability to protect ignition-vulnerable homes even with adjacent fuel treatments: 'it was not the high intensity wildfire encroachment that resulted in most of the home destruction. Unconsumed tree canopies existing between the wildfire and totally destroyed homes indicated that destroyed homes ignited directly from firebrands and/or surface fires contacting the structure. In such situations, destruction in the WUI is primarily a result of the flammability of the residential areas themselves, rather than the flammability of the adjacent wildlands' p.1999.

ISSUE 4: Prescribed burning in Victoria

QUESTION 9: Suggested modifications to current prescribed burning practices in Victoria

Expert opinion

1. I strongly advocate the need for an **evidence-based approach to fire management and planning**. Measures to reduce the risk of wildfire, either current or future proposed measures, must have a sound scientific base. This is consistent with claims by agencies such as DSE of the need for an 'adaptive management approach'. However, I am greatly concerned that key aspects of an adaptive management approach in relation to fire ecology are inadequate. Management actions at regional levels often have poorly defined goals, or may be based on little or no scientific evidence; and monitoring of the outcomes of fire management practices (from both a fire mitigation and ecological perspective) is limited, at best.

2. A scientific, evidence-based, approach to fire management in Victoria would include:

- clear, specified SMART goals for management actions based on a scientific framework;
- monitoring the outcomes of actions in terms of fire risk and ecological changes; and
- evaluating and modifying practices in the light of new knowledge.

3. An evidence-based approach to fire management requires a commitment to ongoing advancement of knowledge – by monitoring, by empirical research and modelling, and by incorporating this new knowledge in a decision framework. This requires a commitment to ongoing funding for research. Given the large budgets committed to fire management in Victoria, including increased effort in prescribed burning, it is reasonable to expect that a modest proportion, at least 10-20%, be committed to enhancing the knowledge base to make such open-ended management more effective.

4. I believe there is an urgent need for an independent, external and transparent cost-benefit analysis of the effectiveness of all fire prevention and suppression methodologies in mitigating the risk of catastrophic wildfire in this state (beyond just prescribed burning). I therefore fully support paragraph #70 in the Witness Statement of Liam Gerard Fogarty (DSE employee).

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