ECOLOGICAL SOCIETY OF AUSTRALIA
ESA

The Ecological Society of Australia Ltd (ESA, www.ecolsoc.org.au) is the peak group of ecologists in Australia, with over 1200 members from all states and territories. Our members work in universities and other research institutions, government departments, NGOs, private industry and consultancies. We are a national not-for-profit organisation formed in 1959.

Submission to:
The Royal Commission into National Natural Disaster Arrangements
16th April 2020

Summary

"*Managing fire is not rocket science, it is much more complex than that*"- Malcom Gill (Australian fire ecologist, co-editor of *Fire and the Australian Biota* 1993)

The ESA welcomes the opportunity to comment on the need to deal with the present and increasing threat of bushfire, informed by the best science available. Australia is a world leader in the fields of modelling and quantifying bushfire behaviour, bushfire risk management, bushfire impacts on natural ecosystems and they ways in which nature recovers after fire. We draw upon this substantial scientific legacy to provide an overview of the science that is applicable to this Royal Commission.

Critically, any examination of the 2019/20 bushfire season must be anchored in an understanding of the fire weather conditions of this past season. The Bureau of Meteorology recorded that:

a. Much of eastern Australia in 2019 was the driest on record for the three-year period January 2017 to December 2019. Mean national rainfall was 100 mm lower than the previous driest three-year period (1965-67);
b. 2019 was the warmest year on record for Australia; and
c. Severe fire weather conditions (national annual accumulated Forest Fire Danger Index) throughout 2019 were the highest they have been since national records began in 1950.

These were unprecedented conditions. Indicators are that prolonged drought, linked to climate change, has increased the flammability of the parts of the landscape we could previously rely on being damp enough to slow down/extinguish past bushfires (Nolan et al. 2020). Fire behaviour in the 'Black Summer' fires has taken experienced staff by surprise due to extremely low humidity and record high temperatures.

Based on the expertise of our membership, we pay attention to current evidence about land management, hazard reduction measures, biodiversity protection, and indigenous burning practices and stress the following critical messages:

1. Hazard reduction burning reduces the intensity and spread of bushfires and enhances fire suppression activities under limited circumstances. Its effectiveness is lowest on days of extreme fire weather when most loss of life and property occurs.

2. Hazard reduction burning is most effective when targeted strategically within 500 m of the asset to be protected, and may be ineffective if, after conducted, vegetation is retained within 40 m of the asset.
3. Inappropriate fire regimes and hectare-based fuel reduction targets can threaten the existence of plant and animal species and ecosystems. Regional-scale planning that identifies the most suitable mix of post-fire age-classes is necessary to maintain ecological values and to ensure the resilience of ecosystems to fire. There should be no hectare-driven targets for burning in Australia's ecosystems.
4. Hazard reduction burning is just one method of reducing risk. Other strategies may offer a better return on investment when it comes to reducing risk to assets and life.
5. Traditional land and fire management practices of Indigenous Australians are nuanced, sensitive, and targeted to particular objectives. Such approaches should be incorporated into future fire management practices, noting that 'one-size-fits-all' is not possible, and approaches will be bespoke for each region of Australia.
6. All prescribed burning should be accompanied by monitoring and research, ideally in an adaptive management framework that enables learning while doing, and particularly when EPBC-listed species and ecological communities might be impacted.

We note that "resilience" is only used in the Terms of Reference in the human and socio-economic context; there should be a greater awareness of the need to balance these objectives with those of environmental resilience.

Further information is provided below in relation to the Terms of Reference (TOR parts b, e, f and g).

TOR b: Australia's arrangements for improving resilience and adapting to changing climatic conditions, what actions should be taken to mitigate the impacts of natural disasters, and whether accountability for natural disaster risk management, preparedness, resilience and recovery should be enhanced, including through a nationally consistent accountability and reporting framework and national standards.

To improve Australia's preparation for and management of natural disasters, we recommend the following:

1. Development of national environmental standards for monitoring and evaluating environmental change and biodiversity recovery actions, and adequate resourcing for such monitoring;
2. Investment into forecasting research and applications that can provide near-term and seasonal predictions of how disaster risk is likely to impact society, economy and biodiversity;

3. Research into alternative environmental management options (e.g. habitat restoration, species translocations for managing native species at risk from wildfires) that complement hazard reduction burning which has limited effectiveness at reducing bushfire risk and protecting biodiversity.

Effective monitoring is a critical part of improving resilience, adapting to change and predicting future risk. To inform effective mitigation of natural disasters, Australia must develop national environmental standards for monitoring and evaluation of environmental change and recovery actions, which enable data to be incorporated into national datasets in a timely fashion, and allow data to be made publicly discoverable, accessible and reusable (Tulloch et al. 2018). National standards will increase data interoperability and ensure that different jurisdictions deliver and assess natural disaster risk management, preparedness, resilience and recovery activities efficiently and effectively. Australia does not have reliable, comprehensive and publicly available environmental information systems to map, monitor, forecast and report on environmental conditions and disaster risk, particularly as it relates to biodiversity and species conservation (Lindenmayer et al. 2015, 2017, Sparrow et al. 2019). Much of Australia's ecological monitoring data exists in institutional silos, and monitoring is done using disparate methods that are not standardised across space or time (Scheele et al. 2019). This means that there is no comprehensive database of species and ecosystem responses to fire that could assist governments and practitioners in managing Australia's ecosystems with regards to wildfire and prescribed fire. Such data are critical for producing near-term and seasonal forecasts of the likely impacts of natural disasters on society, the economy and biodiversity (Tulloch et al. submitted). Near-term (within 6 months of the prediction) forecasts enable efficient operationalisation of limited resources to the places and activities that would most benefit from actions (e.g. hazard reduction burning, biodiversity conservation management) *before* a disaster occurs.

Improved data collection and access not only requires the development of clear, science-based national standards, but also necessitates adequate resourcing to collect and collate monitoring data against these standards using common assessment methods. All prescribed burning should be accompanied by monitoring and research, ideally in an adaptive management framework (e.g. Hauser et al. 2019) that enables learning while doing, and particularly when EPBC-listed species and ecological communities might be impacted.

Investment into this should realise considerable benefits in relation to:

- greater consistency of natural disaster assessment processes and outcomes, because data from other like cases can be more readily drawn upon to inform decisions on future disasters;
- cost savings for businesses engaged in disaster forecasting and management, as well as for the Australian Government, as administering preparation and review of material becomes faster and easier;
- accountability for disaster risk management decisions, and;

- improved outcomes for species and ecosystems impacted by natural disaster through enabling improved collaboration between science and government, adaptive learning and management (Hauser et al. 2019). Such processes would be enhanced through the development of an agency tasked specifically with protecting and managing biodiversity in the face of disasters, e.g. a Biodiversity Disaster Risk Agency.

TOR e: the findings and recommendations (including any assessment of the adequacy and extent of their implementation) of other reports and inquiries that you consider relevant, including any available State or Territory inquiries relating to the 2019-2020 bushfire season, to avoid duplication wherever possible

Bushfires such as the Black Saturday fires (Victoria, February 2009) have been extensively dissected by a previous Royal Commission and its recommendations provide much context for interpreting the recent Black Summer fires, and how one might respond to them. Recommendations from the Black Saturday Royal Commission relevant to the current fire season's events include:

1. Broad hectare targets for hazard reduction burning were recommended following the Black Saturday fires (e.g. 5% of Crown Land in Victoria should be burnt each year). Hectare targets were subsequently found to be "unachievable, affordable or sustainable" and "ineffective in achieving the primary intent of the Bushfires Royal Commission recommendations to ensure the protection of human life and community safety" (Bushfire Royal Commission Independent Monitor 2013).
2. The state-wide hectare target recommended for Victoria created a perverse incentive for land management and fire agencies to treat large areas in remote locations (that represented a low risk to life and property), rather than smaller, more costly and difficult burns in places where they would provide better protection of human assets (Handmer and Keating 2015). Furthermore, "hectares treated objective puts a significant constraint on the capacity for communities and stakeholders to have their views genuinely incorporated into decision-making because the directive to burn a certain number of hectares overrides all other considerations. Hence there is a disincentive to genuinely engage communities and stakeholders" (Handmer and Keating 2015).
3. A primary cause of failure to achieve hazard reduction targets has been the brief and shrinking fire-weather window in which agencies can safely conduct hazard reduction burning, without causing damage to the very assets they are attempting to protect. Several studies (e.g. Jolly et al. 2015; Quinn-Davidson and Varner 2012) have demonstrated, and senior fire managers from multiple states have reiterated (Kinsella and Jackson 2020), that failure to achieve hazard reduction hectare targets is due to being constrained by an ever decreasing window of opportunity in which to safely conduct burning.

TOR F i) land management, including hazard reduction measures

The latest science underpinning estimates of the efficacy of hazard reduction burning indicates:

1. Hazard reduction burning can only reduce the intensity and spread of bushfires, and aid suppression activities, in limited circumstances

The primary value of hazard reduction burning is generally accepted as a tool to assist in fire control when fire weather conditions are moderate to benign, but not in catastrophic weather conditions seen in the 2019/20 fire season (e.g. Boer et al. 2009, McGaw 2013). Indeed, the links between fuel loads and rate of spread of bushfires are not always evident. Burrows (1999), for example, meticulously conducted replicated fire experiments in jarrah forest fuels in Western Australia and found no relationship between fuel load and rate of spread. These findings have been supported by later studies (e.g. Cheney et al. 2012; Zylstra et al. 2016).

2. Its effectiveness in altering fire behaviour is greatest in approximately the first 6 years after burning in many forest types and can diminish significantly after that.

The capacity for hazard reduction burning to reduce fuels to have a measurable impact on fire behaviour is limited to the immediate period (i.e. ~6 years) following treatment (e.g. Fernandes and Botelho 2003, Cary et al. 2009; Bradstock et al. 2010; AFAC 2015; Penman and Cirulis 2019). This minimal efficacy of recent hazard reduction burning in mitigating spread has been apparent in the wildfires of the past season. The Gospers Mountain fire in the Wollemi National Park, which appears to be the largest Australian forest fire resulting from a single ignition, was ignited and grew to a very large fire burning in 6-yr-old fuels (Philip Zylstra, *unpublished data*). This is not unusual.

3. It is most effective when targeted strategically within 500 m of the asset to be protected, and may be ineffective if, after conducted, vegetation is retained within 40 m of the asset.

Fuel reduction through mechanical means (e.g. clearing of native and exotic vegetation) close to houses (within 40 m) was more effective at reducing their loss in the Black Saturday fires than undertaking hazard reduction burning distant from the house (Gibbons et al. 2012). This study concluded that the levels of fuel reduction required to reduce house losses are unlikely to be feasible at every house for logistical and environmental reasons. Because of this, infrastructure protection is not guaranteed by hazard reduction burning. Infrastructure is more likely to be saved from wildfire where trees and shrubs have been thinned or removed to a distance of 30-40 m, the grass is mown and the garden kept green. "A shift in emphasis away from broad-scale fuel-reduction to intensive fuel treatments close to property will more effectively mitigate impacts from wildfires on peri-urban communities" (Gibbons et al. 2012).

Penman et al. (2014) found that planned burning at the interface between assets and the forest was the most cost effective means of reducing risk to those assets. Florec et al. (2019) found that planned burning close to assets in the urban interface in WA was more effective at reducing damage (i.e. loss of houses) than burning in the more distant landscape. Local-scale solutions are necessary to design effective prescribed burning to protect assets in local communities.

In Tasmania, in relation to using prescribed burning to protect ecological assets, King et al. (2006) found that burning 3% of buttongrass moorland in a strategic configuration was likely to reduce the area of fire-sensitive alpine vegetation burnt annually by the same amount as burning ≥ 10% of moorland in a random pattern.

Thus, a key issue relating to prescribed burning is that it is not necessarily the amount of burning that reduces risk, but where it is applied. We support an approach based on applying planned burning where it is demonstrated that it will have greatest benefit in reducing risk to life, property and ecological assets. We do not support hectare-driven targets for burning in Australia's ecosystems.

4. Its effectiveness is lowest on days of extreme fire weather when most loss of life and property occurs, but it can assist suppression efforts on more benign days.

The value of hazard reduction burning is primarily to assist with the suppression of fire under moderate to benign fire weather conditions. Wildfires on severe or extreme weather days, however, account for the vast majority of area burnt, property losses and fatalities. Shane Fitzsimmons (NSW RFS Commissioner) noted that the ability of hazard reduction burning to aid in fire suppression efforts during such extreme conditions is negligible (Hayman 2020). This is supported by scientific evidence. Bradstock (2008) concluded that "maximum severity [of wildfire] 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……" Moritz et al. (2004) suggest that during extreme fire weather "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".

5. It is infeasible in landscapes dominated by improved pasture or crops.

Bushfires have been shown to burn through farmland dominated by pasture or crops, as occurred in 2015 near Gawler in South Australia where 91 houses were destroyed, and was also seen in Buchan, Victoria on New Year's Eve 2019 where 1/3 of houses in the rural town were destroyed. The extent of burning required to reduce risk of wildfire makes hazard reduction burning infeasible in landscapes reliant on crops and pasture as their dominant income (Gill 2005). In agricultural lands, grazing or ploughing in paddocks offers an alternative way of reducing overall fuel loads, especially in relation to pasture grasses (Gill et al. 2013). In agricultural landscapes, native vegetation is rare, often less than 10% of the land area, so is particularly valuable, while also being difficult to manage fire within. In contrast, ploughing and grazing paddocks is routine, and ploughing on farmland can achieve total fuel reduction and is closer to the assets that people want to protect from fire.

6. Hazard-reduction burning can have both positive and negative effects on natural ecosystems, but negative effects will be substantial if fire return intervals are short enough to have some effect on unplanned fire.

Plant and animal communities in Australia have evolved with fire regimes of different fire severity, frequency, extent and season. Fire can be necessary for the maintenance of some native vegetation communities (e.g. coastal heathlands, temperate grasslands), but can also cause the destruction of others (e.g. alpine peatlands). It is dangerously naive to claim that all Australian bush needs fire or has uniformly evolved to cope with fire. There are examples where too frequent, too intense or too extensive fires have contributed to the local extinction of native species (e.g. Bowman et al. 2014). Indeed, generalisations like "Most of Australia was burnt about every 1-5 years depending on local conditions and purposes" (Gammage 2011) are not accurate and are **not** supported by science (Murphy et al. 2013).

Repeated burning every six years could reduce some unplanned fire in some ecosystems, but this frequency of burning will have substantial ecological costs. For example, out of 20 broad ecosystem types in South Australia, five had minimum recommended fire interval of less than 6 years, and all of these were grassy ecosystems. Most ecosystems have a minimum threshold of 15-20 yrs between fires to prevent species losses. In NSW, minimum fire interval guidelines (Table 3A in Fire Management Guidelines 2004) suggest complete fire exclusion from rainforest and alpine ecosystems, and a minimum interval of 25 yrs for wet sclerophyll forest, with other eucalypt forests having minimum return intervals of 5-7 yrs. **It is not a reasonable trade-off to burn so frequently that there are major biodiversity losses in return for only very marginal, if any, benefit in asset protection during extreme weather conditions.**

7. Hazard reduction burning is just one method of reducing risk to life and property. Other strategies may offer a better return on investment, when it comes to reducing risk.

Investment in early warning mobile phone Apps and educating the public to 'leave early' appears to have contributed to a remarkable drop in fatalities associated with this season's fires (34 in 2020), compared to 173 deaths on Black Saturday, despite over 13 M ha burnt this season compared to 450,000 ha in 2009. "People are unlikely to activate their plans without warnings or with insufficient time" (Handmer et al. 2019).

Other complementary strategies that should be considered include:

a. Improved early detection of ignitions,
b. Enhanced rapid attack/suppression of ignitions (e.g. aerial suppression). A focus on rapid initial attack will allow the suppression of small fires before they become large and will ensure that sufficient resources are available to conduct prescribed burns close to assets, where heavy resourcing is required,
c. Reducing potential sources of ignitions (e.g. putting power lines underground),
d. Other methods of fuel removal (e.g. slashing), and
e. Improved acceptance of the responsibility for fuel management on private land, including consideration of insurance, construction standards, garden design and external sprinklers.

TOR F ii) wildlife management and species conservation, including biodiversity, habitat protection and restoration;

1. Frequent low intensity burns such as hazard reduction burning alters the composition of ecological communities.

Plant and animal species have been eliminated from local areas due to frequent burning (Tolhurst 1996), whether that be by wildfire or prescribed burning (or both). Frequent low intensity burning alters the composition of the understorey plant species in dry sclerophyll forests and in Banksia woodlands (e.g. Hobbs and Atkins 1990). Such regimes can have significant effects on the survival of some species and may lead to local extinction (Tran and Wild 2000). Studies have predicted high risk of extinction of species - such as shrubs that can only regenerate from seed - under typical hazard reduction burning levels (Bradstock et al. 1998; McCarthy et al. 2001) if burning occurs too frequently to enable plants to mature and set seed. In addition, some plant species can only regenerate following a high intensity fire, not the low intensity burns frequently used in hazard reduction.

In many landscapes, wildfires alone are the optimal management policy for biodiversity where objectives are to maximise species richness and abundance, and to minimise extinction. This is because most species are more likely to occur in vegetation that has not been burnt for a long time than in vegetation that has been burnt more recently (e.g. Connell et al. 2017). Giljohann et al. (2015) showed that a policy to annually burn just 5% of a landscape in semi-arid Australia could increase the average probability of extinction for birds, reptiles and small mammals by 7% over 100 yrs compared to the optimal management scenario of only allowing wildfires to burn.

Altering fire frequency, severity or timing through prescribed burning can increase the extinction risk of native species and the intensity and extent of threatening processes such as invasive species. Frequent burning can also encourage growth of highly flammable invasive weeds (e.g. Hobbs and Atkins 1990) and may also increase invasion of habitats by introduced predators such as cats and foxes.

2. Frequent prescribed burning adversely affects fauna species that require dense undergrowth, coarse woody debris and/or leaf litter.

The primary way in which native fauna are affected by prescribed burning is by its effects on their habitat. Frequent prescribed burning has the potential to incinerate critical resources (e.g. hollow logs, hollow-bearing old trees, large clumps of spinifex) essential for the survival and persistence of species. Post-fire changes to habitat can extend over many decades in some ecosystems (e.g. Haslem et al. 2011). Currently, 'Tolerable Fire Intervals' used in fire planning are based primarily on the requirements of plant species. **We strongly recommend to also take into account the responses of fauna species to fire and the habitat components they use (e.g. shrub cover, large logs, tree hollows).**

Frequent prescribed burning causes declines in certain native fauna and flora species that rely on long unburnt vegetation. Frequent prescribed burns have resulted in declines of species that favour shrubby undergrowth (e.g. Golden Whistler) or dense leaf litter (e.g. Red-Winged Fairy-wren, Pilot-bird) (Woinarski and Recher 1997). Research in eastern Australia's protected area estate shows that bird species richness was reduced by 9.1% for every extra fire that occurred (Lindenmayer et al. 2008). The species most adversely affected by fire were those dependent on closed habitats such as forests. Frequent historical prescribed burns also reduced the chance of endangered birds being able to recolonise after fire due to habitat simplification (Lindenmayer et al 2009) – the critical resources they require for shelter from predators and competitors were no longer present in frequently burnt locations.

Too-frequent fire in the South-west Biodiversity Hotspot of Western Australia has led to 60% of the Banksia woodland having been burnt in the last 7 yrs, and the decline of some native Banksia species and the honey possums that depend on them for food and shelter. This is because obligate-seeding Banksias in this area typically require at least 10-20 yrs between fires to reach maximum maturity and flower production (Tulloch et al. 2016, Wilson et al. 2014), and honey possums require more than 20 yrs between fires to recover to pre-fire catch rates and densities (Bradshaw and Bradshaw 2017).

3. Prescribed burning may be required for conservation purposes to maintain populations of some threatened species that are adapted to frequent fire.

Where prescribed burning occurs, it will favour species that require a relatively open understorey. In sites with a long-history of such frequent burning (e.g. due to indigenous fire management), some species may be dependent on such habitat being maintained. Such species include the nationally-listed Critically Endangered northern subspecies of the Eastern Bristlebird, of which only 40 remain. Stone et al. (2018) found that "use of appropriate fire to maintain large contiguous patches with a thick, tall grassy ground layer will be critical for the continued persistence and successful reintroduction of the northern Eastern Bristlebird." It should be noted that a true "ecological burn", as needed to maintain specific components of the habitat for the Critically Endangered northern subspecies of the Eastern Bristlebird, should not be equated with a hazard reduction burn which focuses only on total reduction of fuel and undergrowth to reduce fire risk.

4. Prescribed burning may be required for conservation purposes to protect populations of some threatened species not adapted to frequent fire.

Targeted prescribed burning may be necessary in strategic locations to protect important ecological assets and populations of threatened species from frequent fire. The planning for such strategic burning requires detailed knowledge of the location of these key assets, their vulnerability to bushfire, and the effectiveness of preventative burning in reducing risk under various wildfire conditions. Other solutions may be easier to implement and should be considered as alternatives in some circumstances. For example, sprinkler systems have successfully protected ancient Wollemi Pines in New South Wales (Morton 2020) and Pencil Pines in Tasmania (Blackwood 2019) from recent wildfires, with only a minimal investment in infrastructure.

5. Where frequent burning is necessary and unavoidable, the needs of vulnerable species should be addressed through proactive conservation approaches and monitoring

We highlight the need for regional-scale planning that identifies the most suitable mix of post-fire age-classes necessary to maintain ecological values and to ensure the resilience of the system to fire. Prescribed burning can then be undertaken within this context, with much greater confidence that it can reduce risk to human life and property without compromising other values that society recognises.

In locations where frequent hazard reduction burning is applied on a broad scale, there are several ways to maintain and track the responses of biodiversity, although it is unlikely that all species will persist under frequent burning due to the requirements of many species for longer-unburnt periods (Tulloch et al. 2016):

a. Maintain unburned areas within the fire footprint, as patchy fires are critical for the recovery of several EPBC-listed species e.g. southern populations of the Eastern Bristlebird (Lindenmayer et al. 2009);
b. preserve a range of microhabitats, including those associated with retained logs, to maintain shelter and food for invertebrate biodiversity (Andrew et al. 2000);
c. ensure that insurance populations exist for threatened fauna and flora likely to be impacted by such burning, including the use of National Seed and Gene Banks and captive populations, and;
d. develop and maintain monitoring protocols at sites undergoing hazard reduction burning and nearby non-burnt sites to evaluate impacts on EPBC-listed species, as well as broader flora and fauna. This will require the development of National Standards for assessing the impacts of fire on Australia's biodiversity.

TOR G any ways in which the traditional land and fire management practices of Indigenous Australians could improve Australia's resilience to natural disasters.

Indigenous communities have different reasons for burning the bush and it should be recognised that fire was not primarily for hazard reduction. Rather, the rationale for burning of the bush included (a) to promote the production of critical resources (e.g. plants and animals for food), (b) to enable ease of travel through dense bush and (c) for ceremonial reasons.

Indigenous communities did not burn everywhere and large tracts of land were intentionally not burnt (e.g. Prober et al. 2016). Indigenous burning was usually small in its scale of application and characterised by its "selectivity rather than it's ubiquity" (Prober et al. 2016). Their nuanced, sensitive and targeted application of fire in the landscape to achieve particular objectives has much to commend it.

"Traditional land and fire management practices of Indigenous Australians" could be incorporated into future fire management practices, but this needs to be nuanced for each region of Australia, especially given the significant cultural, ecological and historical differences that exist between northern Australian Aboriginal Clans and those of south-eastern Australia. Cultural burning practices differ from region to region; they are place-based, steeped in deep local knowledge. Therefore, practices that work well in the savannahs of northern Australia may be totally inappropriate in the tall forests of south-east Australia. One indigenous burning regime does not fit all landscapes of Australia.

It is necessary that a clear separation is needed between the cultural and social benefits of reviving or using traditional practices, and the instrumental and environmental benefits that may be derived from burning. It should not be assumed that in today's landscape context - with 25 million humans settled across much of the landscape, serviced by networks of infrastructure like roads and powerlines, where fuel layers have changed with the introduction of flammable weed species like Buffel Grass, and under a climate regime that is rapidly becoming more fire-prone and unpredictable - that these are one and the same.

The ability to acknowledge Indigenous methods of land management on the Indigenous Land estate (e.g. Indigenous Protected Areas), joint-managed estate, as well as other public and private estate is possible and will encourage greater cross-jurisdictional collaboration and awareness of traditional land and fire management practices. Inclusion of Indigenous Australians and Indigenous Bio-cultural Knowledge (IBCK) should involve Indigenous people in leadership positions as well as knowledge-sharing between Indigenous owners of Country and non-Indigenous participants (Ens et al. 2016). The Akwe Kon Guidelines (2004) provide important guidance in successful implementation of Indigenous land management. One example of incorporation of appropriate use of Indigenous land management practices is the 'Hotspots' fire & biodiversity program developed by the NSW Nature Conservation Council in collaboration with NSW Rural Fire Services, and another is the reintroduction of 'cultural burning' and carbon emission abatement programs in northern Australia.

Recognition of the Indigenous voice will require:

- Greater acknowledgement of Indigenous Bio-cultural Knowledge (IBCK) and the role it currently plays in land management, especially on the Indigenous Land estate.
- Indigenous consultation, acknowledgement and involvement with fire management planning and delivery, ensuring 'free, prior and informed' consent.

Investment in Indigenous land management is smart not only from an environmental perspective but also from an economic perspective. Analyses of the Social Return on Investment of the Indigenous Protected Area (IPA) and Working on Country (WoC) programs show that these are delivering around three-fold investment returns (Social Ventures Australia 2016). A targeted review into how the land and fire management practices can better reflect Indigenous people, knowledge and country is a necessary step towards achieving this goal (Ens et al. 2012, 2015).

For further information
The ESA welcomes the opportunity to provide further information to this Royal Commission or to discuss our submission in more detail. We may be contacted using the details below:
Email: executiveofficer@ecolsoc.org.au
Phone: (07) 3076 4064

Submission prepared on behalf of the ESA by its Policy Working Group and approved by the Vice-President (Public Policy and Outreach) and President, 16 April 2020.

References

AFAC (2015). Overview of prescribed burning in Australasia. Report for the National Burning Project – Subproject 1. Australasian Fire and Emergency Service Authorities Council Limited. March 2015.

Andrew N, Rodgerson L, and York A (2000) Frequent fuel-reduction burning: the role of logs and associated leaf litter in the conservation of ant biodiversity. *Austral Ecology*, 25, 99-107.

Blackwood F (2019). Wilderness bushfire grows to 20k ha, but sprinklers help spare ancient Tasmanian vegetation. *ABC News*, 7 Jan 2020. https://www.abc.net.au/news/2019-01-07/gell-river-fire-threatens-tasmanian-eucalypt-plantation/10688530

Boer MM, Sadler RJ, Wittkuhn RS, McCaw L, and Grierson PF (2009) Long-term impacts of prescribed burning on regional extent and incidence of wildfires—evidence from 50 years of active fire management in SW Australian forests. *Forest Ecology and Management,* 259, 132-142.

Bowman DMJS, Murphy BP, Neyland DLJ, Williamson GJ, and Prior LD (2014) Abrupt fire regime change may cause landscape-wide loss of mature obligate seeder forests. *Global Change Biology,* 20, 1008-1015.

Bradshaw SD and Bradshaw FJ, 2017. Long-term recovery from fire by a population of honey possums (*Tarsipes rostratus*) in the extreme south-west of Western Australia. *Australian Journal of Zoology,* 65, 1-11.

Bradstock RA, Bedward M, Kenny BJ, and Scott J, (1998) Spatially-explicit simulation of the effect of prescribed burning on fire regimes and plant extinctions in shrublands typical of south-eastern Australia. *Biological Conservation*, 86, 83-95.

Bradstock RA (2008) Effects of large fires on biodiversity in south-eastern Australia: disaster or template for diversity? *International Journal of Wildland Fire,* 17, 809– 822.

Bradstock RA, Hammill KA, Collins L, and Price O (2010) Effects of weather, fuel and terrain on fire severity in topographically diverse landscapes of south-eastern Australia. *Landscape Ecology*, 25, 607–619.

Burrows ND (1999) Fire behaviour in Jarrah forest fuels. CALMScience 3(1), 31–84.

Bushfire Royal Commission Independent Monitor (2013) Annual Report July 2013. Victorian Government, Melbourne.

Cary GJ, Flannigan MD, Keane RE, Bradstock RA, and Davies ID (2009) Relative importance of fuel management, ignition management and weather for area burned: evidence from five landscape-fire-succession models. *International Journal of Wildland Fire*, 18*,* 147–156.

Cheney NP, Gould JS, McCaw WL, and Anderson WR (2012) Predicting fire behaviour in dry eucalypt forest in southern Australia. *Forest Ecology and Management,* 280, 120–131.

Connell J, Watson SJ, Taylor RS, Avitabile SC, Clarke RH, Bennett AF, and Clarke MF (2017) Testing the effects of a century of fires: requirements for post-fire succession predict the distribution of threatened bird species. *Diversity and Distributions,* 23, 1078– 1089.

Ens EJ, Finlayson M, Preuss K, Jackson S, and Holcombe S (2012). Australian approaches for managing 'country' using Indigenous and non-Indigenous knowledge. Ecological Management and Restoration, 13(1), 100-107.

Ens EJ, Pert P, Clarke PA, Budden M, Clubb L, Doran B, Douras C, Gaikwad J, Gott B, Leonard S, Locke J, Packer J, Turpin G, and Wason S (2015). Indigenous biocultural knowledge in ecosystem science and management: Review and insight from Australia. Biological Conservation, 181, 133-149. http://www.sciencedirect.com/science/article/pii/S0006320714004339

Ens EJ, Scott ML, Rangers YM, Moritz C, and Pirzl R (2016). Putting indigenous conservation policy into practice delivers biodiversity and cultural benefits. Biodiversity and Conservation, 25(14), 2889-2906.

Fernandes PM and Botelho HS (2003) A review of prescribed burning effectiveness in fire hazard reduction. *International Journal of Wildland Fire,* 12, 117–128.

Fire Management Guidelines (2004). Guidelines for Ecologically Sustainable Fire Management - NSW Biodiversity Strategy. Bushfire Research Unit. https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Biodiversity/ecologically-sustainable-fire-management-guidelines.pdf

Florec V, Burton M, Pannell D, Kelso J, and Milne G (2019) Where to prescribe burn: the costs and benefits of prescribed burning close to houses. *International Journal of Wildland Fire,* doi.org/10.1071/WF18192

Gammage B (2011) The Biggest Estate on Earth. How Aborigines Made Australia. Allen and Unwin, Sydney.

Gibbons P, van Bommel L, Gill AM, Cary GJ, Driscoll DA, Bradstock RA, Knight E, Moritz MA, Stephens SL, and Lindenmayer DB (2012) Land management practices associated with house loss in wildfires. *PLoS ONE,* 7(1), e2912.

Gill AM (2005) Landscape fires as social disasters: an overview of "the bushfire problem." *Global Environmental Change B Environmental Hazards*, 6, 65 – 80.

Gill AM, Groves RH, and Noble IR eds. (1993) Fire and the Australian Biota. Australian Academy of Sciences, Canberra.

Gill AM, Stephens SL, and Cary GJ (2013). The worldwide "wildfire" problem. *Ecological Applications*, 23, 438-454.

Giljohann KM, Mccarthy MA, Kelly LT, and Regan TJ (2015) Choice of biodiversity index drives optimal fire management decisions*.* *Ecological Applications*, 25, 264-277.

Handmer J and Keating A (2015) Bushfire fuel management targets: options analysis. In: Review of performance target for bushfire fuel management on public land. Inspector-General for Emergency Management, Victorian Government, Melbourne.

Handmer J, Van der Merwe M, and O'Neill S (2019) The risk of dying in bushfires: a comparative analysis of fatalities and survivors. *Progress in Disaster Science*, OI: 10.1016/j.pdisas.2019.100015

Haslem A, Kelly LT, Nimmo DG, Watson SJ, Kenny SA, Taylor RS, Avitabile SC, Callister KE, Spence-Bailey LM, Bennett A F, and Clarke MF (2011) Habitat or fuel? Implications of long-term, post-fire dynamics for the development of key resources for fauna and fire. *Journal of Applied Ecology,* 48, 247-256.

Hauser CE, Southwell D, Lahoz-Monfort JJ, Rumpff L, Benshemesh J, Burnard T, van Hespen R, Wright J, Wintle B, and Bode M (2019) Adaptive management informs conservation and monitoring of Australia's threatened malleefowl. *Biological Conservation,* 233, 31-40.

Hayman R (2020). RFS Commissioner says hazard-reduction burns made his organisation 'public enemy number one'. *ABC News*, 8 Jan 2020. https://www.abc.net.au/news/2020-01-08/nsw-fires-rfs-commissioner-weights-in-on-hazard-reduction-debate/11850862

Hobbs RJ and Atkins L (1990) Fire-related dynamics of a Banksia Woodland in South-Western Western Australia. *Australian Journal of Botany*, 38, 97-110.

Jolly WM, Cochrane MA, Freeborn PH, Holden ZA, Brown TJ, Williamson GJ, and Bowman DMJS (2015) Climate-induced variations in global wildfire danger from 1979 to 2013. *Nature Communications,* 6, 7537.

King KJ, Cary GJ, Bradstock R, Chapman J, Pyrke AF, and Marsden-Smedley JB (2006). Simulation of prescribed burning strategies in south west Tasmania, Australia: effects on unplanned fires, fire regimes and ecological management values. *International Journal of Wildland Fire,* 15, 527-540.

Kinsella E and Jackson W (2020). What are hazard reduction burns, are we doing enough of them, and could they have stopped Australia's catastrophic bushfires? *ABC Ne*ws, 10 Jan 2020. https://www.abc.net.au/news/2020-01-10/hazard-reduction-burns-bushfire-prevention-explainer/11853366

Lindenmayer DB + 68 authors (2017). Save Australia's ecological research. *Science*, 357(6351), 557-557.

Lindenmayer DB, Burns EL, Tennant P, Dickman CR, Green PT, and Keith DA (2015). Contemplating the future: Acting now on long-term monitoring to answer 2050's questions. *Austral Ecology,* 40(3), 213-224.

Lindenmayer DB, MacGregor C, Wood JT, Cunningham RB, Crane M, Michael D, Montague-DR, Brown D, Fortescue M, Dexter N, Hudson M, and Gill AM (2009) What factors influence rapid post-fire site re-occupancy? A case study of the endangered Eastern Bristlebird in eastern Australia. *International Journal of Wildland Fire,* 18, 84–95.

Lindenmayer DB, Wood JT, Cunningham RB, MacGregor C, Crane M, Michael D, Montague-Drake R, Brown D, Muntz R, and Gill AM (2008) Testing hypotheses associated with bird responses to wildfire. *Ecological Applications,* 18, 1967-1983.

McCarthy MA, Possingham HP, and Gill AM (2001) Using stochastic dynamic programming to determine optimal fire management for *Banksia ornata*. *Journal of Applied Ecology,* 38, 585-592

McCaw WL (2013). Managing forest fuels using prescribed fire: a perspective from southern Australia. *Forest Ecology and Management,* 294, 217–224

Moritz MA, Keeley JE, Johnson EA, and Schaffner AA (2004) Testing a basic assumption of shrubland fire management: how important is fuel age? *Frontiers in Ecology and Environment,* 2, 67–72.

Morton A (2020). 'Dinosaur trees': firefighters save endangered Wollemi pines from NSW bushfires. *The Guardian*, 15 Jan 2020. https://www.theguardian.com/australia-news/2020/jan/15/dinosaur-trees-firefighters-save-endangered-wollemi-pines-from-nsw-bushfires

Murphy BP, Bradstock RA, Boer MM, Carter J, Cary GJ, Cochrane MA, Fensham RJ, Russell-Smith J, Williamson GJ, and Bowman DMJS (2013) Fire regimes of Australia: a pyrogeographic model system. *Journal of Biogeography,* 40, 1048-1058.

Nolan RH, Boer MM, Collins L, Resco de Dios V, Clarke H, Jenkins M, Kenny B, and Bradstock RA (2020) Causes and consequence of eastern Australia's 2019-20 of megafires. *Global Change Biology,* 26, 1039-1041.

Penman TD, Bradstock RA, and Price OF (2014) Reducing wildfire risk to urban developments: simulation of cost-effective fuel treatment solutions in south-eastern Australia. *Environmental Modelling & Software,* 52, 166–175.

Penman T and Cirulis B (2019) Cost effectiveness of fire management strategies in southern Australia. *International Journal of Wildland Fire*. doi: 10.1071

Price OF, Penman TD, Bradstock RA, Boer MM, and Clarke H (2015). Biogeographical variation in the potential effectiveness of prescribed fire in south-eastern Australia. *Journal of Biogeography*, 42, 2234-2245.

Prober SM, Yuen E, O'Connor MH, and Schultz L (2016) Ngadju kala: Australian Aboriginal fire knowledge in the Great Western Woodlands. *Austral Ecology*, 41, 716-732.

Quinn-Davidson LN and Varner JM (2012) Impediments to prescribed fire across agency, landscape and manager: an example from northern California. *International Journal of Wildland Fire*, 21, 210–218.

Scheele BC, Legge S, Blanchard W, Garnett ST, Geyle H, Gillespie G, Harrison P, Lindenmayer DB, Lintermans M, Robinson NM, and Woinarski JCZ (2019) Continental-scale assessment reveals inadequate monitoring for vertebrates in a megadiverse country. *Biological Conservation*, 235, 273-278.

Social Ventures Australia (2016). Social Return on Investment – Consolidated report on Indigenous Protected Areas. 06 May 2016. https://www.niaa.gov.au/resource-centre/indigenous-affairs/social-return-investment-–-consolidated-report-indigenous-protected-areas

Sparrow B, Guerin G, and Lowe A (2019) The need for a nationally consistent ecosystem monitoring framework for Australian rangelands. doi:10.32942/osf.io/f3q42.

Stone ZL, Tasker E, and Maron M (2018) Grassy patch size and structure are important for northern Eastern Bristlebird persistence in a dynamic ecosystem. *Emu - Austral Ornithology,* 118, 269-280.

Tolhurst K (1996) 'Effects of fuel reduction burning on flora in a dry sclerophyll forest'. In: Fire and Biodiversity: The Effects and Effectiveness of Fire Management. Proceedings of a Conference held 8-9 October 1994, Footscray, Melbourne, published as Biodiversity Series, Paper No 8 Biodiversity Unit, Department of Environment, Sport and Territories, Canberra, 1996, pp 97-107

Tran and Wild C (2000) The Review of Current Knowledge and Literature to Assist in Determining Ecologically Sustainable Fire Regimes for the South East Queensland Region. Griffith University and the Fire and Biodiversity Consortium, August 2000.

Tulloch AIT, Auerbach N, Avery-Gomm S, Bayraktarov E, Butt N, Dickman CR, Ehmke G, Fisher DO, Grantham H, Holden MH, Lavery TH, Leseberg NP, Nicholls M, O'Connor J, Roberson L, Smyth AK, Stone Z, Tulloch V, Turak E, Wardle GM, and Watson JEM (2018) A decision tree for assessing the risks and benefits of publishing biodiversity data. *Nature Ecology & Evolution,* 2, 1209-1217.

Tulloch AIT, Hagger V, and Greenville AC (submitted) Ecological forecasts to inform near-term management of threats to biodiversity. *Global Change Biology*.

Tulloch AIT, Pichancourt JB, Gosper CR, Sanders A, and Chades I (2016) Fire management strategies to maintain species population processes in a fragmented landscape of fire-interval extremes. *Ecological Applications*, 26, 2175-2189.

Wilson BA, Kuehs J, Valentine LE, Sonneman T, and Wolfe KM (2014) Guidelines for ecological burning regimes in Mediterranean ecosystems: a case study in Banksia woodlands in Western Australia. *Pacific Conservation Biology*, 20, 57-74.

Woinarski JCZ and Recher HF (1997) Impact and response: a review of the effects of fire on the Australian avifauna*. Pacific Conservation Biology,* 3, 183-205.

Zylstra PJ, Bradstock RA, Bedward M, Penman TD, Doherty MD, Weber RO, Gill AM, and Cary GJ (2016) Biophysical mechanistic modelling quantifies the effects of plant traits on fire severity: species, not surface fuel loads determine flame dimensions in eucalypt forests. *PLoSOn*e, 11(8), e0160715