BUSHFIRE RECOVERY PROJECT

5

BUSHFIRE SCIENCE REPORT NO. 5: DOES PRESCRIBED BURNING OF NATIVE FORESTS REDUCE THE RISK TO INFRASTRUCTURE FROM BUSHFIRES?

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This report is one of a series of Bushfire Science Reports prepared by the Bushfire Recovery Project (see www.bushfirefacts.org). The reports aim to present the latest evidence from the peer-reviewed scientific literature about bushfires, climate change and the native forests of southern and eastern Australia.

Reports in the Bushfire Science series are:

No. 1 How does climate affect bushfire risks in the native forests of south-eastern Australia?

No. 2 How do the native forests of south-eastern Australia survive bushfires?

No. 3 What are the relationships between native forest logging and bushfires?

No. 4 What are the ecological consequences of post-fire logging in the native forests of south-eastern Australia?

No. 5: Does prescribed burning of native forests reduce the risk to infrastructure from bushfires?

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INTRODUCTION

Managing the risk of bushfires is a complex planning and land management issue in south-eastern Australia 1, where the human population is concentrated and bushfires have the potential to reach higher intensities than in other parts of Australia. The frequency and severity of dangerous bushfire conditions has increased in Australia over the last 50 years and future climate projections indicate that dangerous fire weather conditions will continue to increase, particularly in south-eastern Australia (see Bushfire Science Report No. 1 at www.bushfirefacts.org). At the same time, Australia's human population is projected to increase 2 with continued urban expansion into fire prone areas. Given this context, there is considerable interest in what scientific research has to say about the role of prescribed burning in the management of bushfire risk. Here, we summarise key research findings in relation to five questions:

1. What is prescribed burning and how effective is it?
2. Does prescribed burning of native forests reduce the risk of dwelling-related infrastructure loss?
3. What are the ecological consequences of prescribed burning?
4. What are the constraints on prescribed burning as a method for reducing bushfire risk?
5. What additional strategies are available to reduce infrastructure loss?

KEY POINTS

- Fire weather is the most important factor determining fire intensity, fire severity, rate of fire spread, the area burned and the probability of containment.
- Most house losses occur on days when the fire danger rating is severe or higher.
- When fire danger is severe or higher, the effectiveness of previous fuel treatment diminishes. Under more moderate forest fire danger rating, most fuel treatment is effective at changing bushfire behaviour for only around five years.
- The location of fuel reduction is more important in reducing infrastructure loss than how much prescribed burning occurs in the landscape, with proximity of the treatment to infrastructure being a key factor.
- Under projected fire weather conditions, the effectiveness of prescribed burning and other fuel treatment is likely to be further substantially reduced.
- All landholders and land use planning agencies share responsibility for reducing the exposure of valued assets to bushfire risk.
- Multiple strategies are required to reduce the risk of infrastructure loss due to bushfire; risk can be reduced but not eliminated.

1. What is prescribed burning and how effective is it?

Prescribed burning is the deliberate and lawful application of fire under specified conditions to a pre-determined area and at a time, intensity and rate of spread designed to meet specified management objectives. Prescribed burning is typically conducted under weather and fuel conditions considered by government agencies to enable safe management of the burn, i.e., generally outside of the fire season. The resulting burns can be more frequent and of lower intensity than bushfires, which generally occur in more extreme fire weather conditions and seasons. The objectives of prescribed burning vary from property protection, to management of ecologically important areas or species. The most common objective of prescribed burning is to reduce risk to human life and property by reducing the occurrence, extent and intensity of future unplanned bushfires. In this case, it is also referred to as hazard reduction or fuel reduction burning. Where prescribed burning aims to achieve ecological objectives rather than hazard reduction objectives, it is referred to as “ecological burning”. Whether prescribed burning is effective or not needs to be assessed against the prescribed burn objectives.

Under certain conditions, prescribed fuel reduction burning, conducted at appropriate spatial and temporal scales, may improve the safety and effectiveness of fire suppression and mitigate damage from unplanned bushfire *[3-8]*. However, it is not feasible to prescribe general guidelines on appropriate spatial and temporal scales as there are complex contextual factors involved in prescribed burning that need to be taken into account including that: (1) the effectiveness of prescribed burning varies from one region to another *[9]*; (2) the level of acceptable bushfire risk varies across the landscape *[10]*; (3) there are multiple values in a landscape that can have conflicting fuel management requirements *[11]*; (4) there are multiple constraints on prescribed burning that vary from one location to another; and (5) prescribed burning is not risk free *[12]*.

Analysis of 52 years of fire records from 1953-2004 in the eucalypt forests of south-western Australia showed that prescribed fuel reduction burning had significantly reduced the incidence and extent of unplanned fires *[8]*. This study found, however, that to prevent one hectare of bushfire, around four hectares of prescribed burning was needed *[8]*. With more prescribed fuel reduction burning in that region, the total area of forest that burned each year increased, although the burns were conducted under different seasonal and weather conditions from unplanned bushfire. The use of prescribed fire in south-western Australia has been used to suggest targets for prescribed burning in other places based on the assumption that the reported effectiveness of prescribed burning in Western Australia could apply elsewhere *[9]*. However, the available evidence indicates that in most bioregions of south-east Australia, prescribed fuel reduction burning is likely to have less or limited effect on the extent of bushfire *[9,13,14]*.

Prescribed fuel reduction burning can reduce the severity of subsequent bushfires *[15]*, however, its effectiveness depends on fire weather conditions and on how much time has elapsed since the prescribed burn. This is because surface fuel in many eucalypt forests re-accumulates within 3-6 years *[16]*. Fuel hazard may increase in forest over the age of 6 years, compared with long unburned forests *[17]*. Under severe fire weather conditions, the effects of fuel reduction on bushfire behaviour last approximately only five years *[8,13,18]*. In extreme fire weather conditions in the Sydney region, even one year old fuel patches have a lower likelihood of slowing or reducing the intensity of bushfires *[13]*. Furthermore, large areas of prescribed burning would be required to substantially reduce the area burned by unplanned fire *[9,14]*. It is estimated that to reduce the risk of bushfires to people and property by half would require up to 10% of the landscape to be burnt each year *[19]*.

Projections of fire weather conditions for 2050 suggest that the effectiveness of fuel reduction treatment under climate change will be substantially reduced. This is because fire weather conditions determine the extent to which fuel reduction modifies subsequent fire behaviour *[3]*. On days of extremely high-temperature, low humidity and high-wind, the effectiveness of most prescribed burning at stopping large fires is reduced (Thornton 2020). A study following the 2009 Black Saturday fires in Victoria found that under moderate fire weather conditions, fuel age can reduce fire severity in some forest types *[20]*. However, several studies in south-eastern Australia and elsewhere have concluded that fire weather is the most influential factor determining fire severity, rate of fire spread, the area burned and the probability of containment *[9,14,20-23]*.

On days of extremely high-temperature, low humidity and high-wind, the effectiveness of most prescribed burning at stopping large fires is reduced (Thornton 2020)

2009 Marysville

2. Does prescribed burning of native forests reduce the risk of infrastructure loss?

Extreme fire weather that renders prescribed fuel reduction burning ineffective is also the condition when fires can be most destructive to infrastructure *[21]*. Most house losses in bushfires have occurred on days when the Forest Fire Danger Index (FFDI) exceeded 50 (i.e., severe forest fire danger or higher), with 64% of house losses occurring when FFDI was greater than 100 (Figure 1) *[24]*. Historically, the conditions under which house losses due to bushfire have occurred have been rare. Until 2010, only 6 bushfire events accounted for more than 60% of all house losses *[24]*.

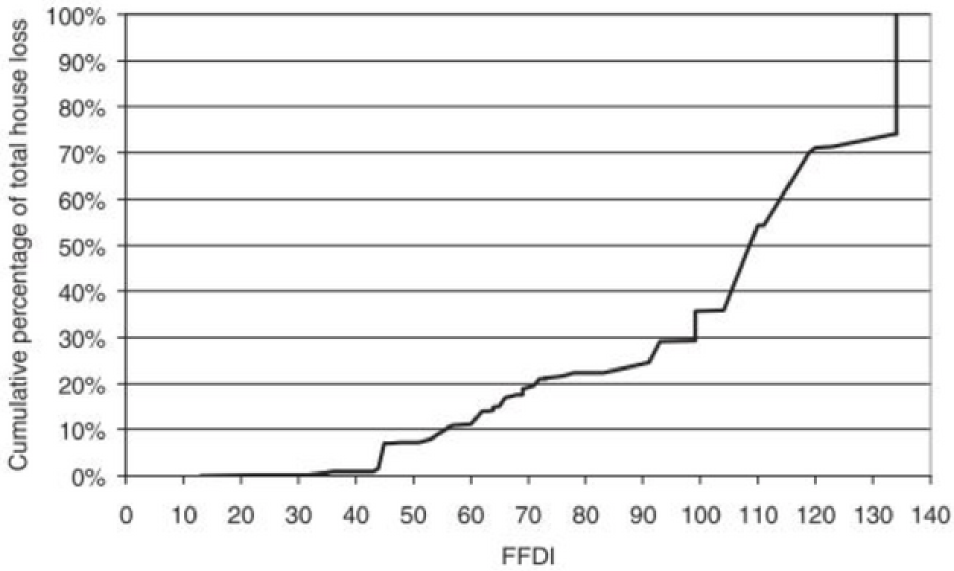

Figure 1 from 24. House loss and Forest Fire Danger Index (FFDI). FFDI 50-75 = severe fire danger, FFDI 75-100 = extreme fire danger, FFDI> 100 = catastrophic fire danger.

The 2019-2020 'Black Summer' megafires of eastern Australia were unprecedented in terms of infrastructure loss and area burned, although not loss of life. Over 3,000 houses were destroyed and 33 people were killed *[25]*. In 2019, large areas of Australia had their highest accumulated FFDI for December on record (Figure 2) and overall, Australia experienced the highest accumulated FFDI on record *[26]*.

Until the 2019-2020 megafires, the 'Black Saturday' fires in Victoria in February 2009 were the worst on record in Australia for infrastructure loss with over 2,000 houses lost. It remains the worst Australian bushfire on record in terms of lives lost *[27]*. A Royal Commission held following the Black Saturday fires recommended that Victoria commit to a rolling annual target for prescribed burning of 5% across all public land *[28]*. However, a review of this area-based target in 2015 identified flaws in adopting an inflexible target-based approach and instead proposed a risk-based approach. This means linking the amount of prescribed fuel reduction burning to the amount of risk reduction rather than an arbitrary area burnt target *[28]*.

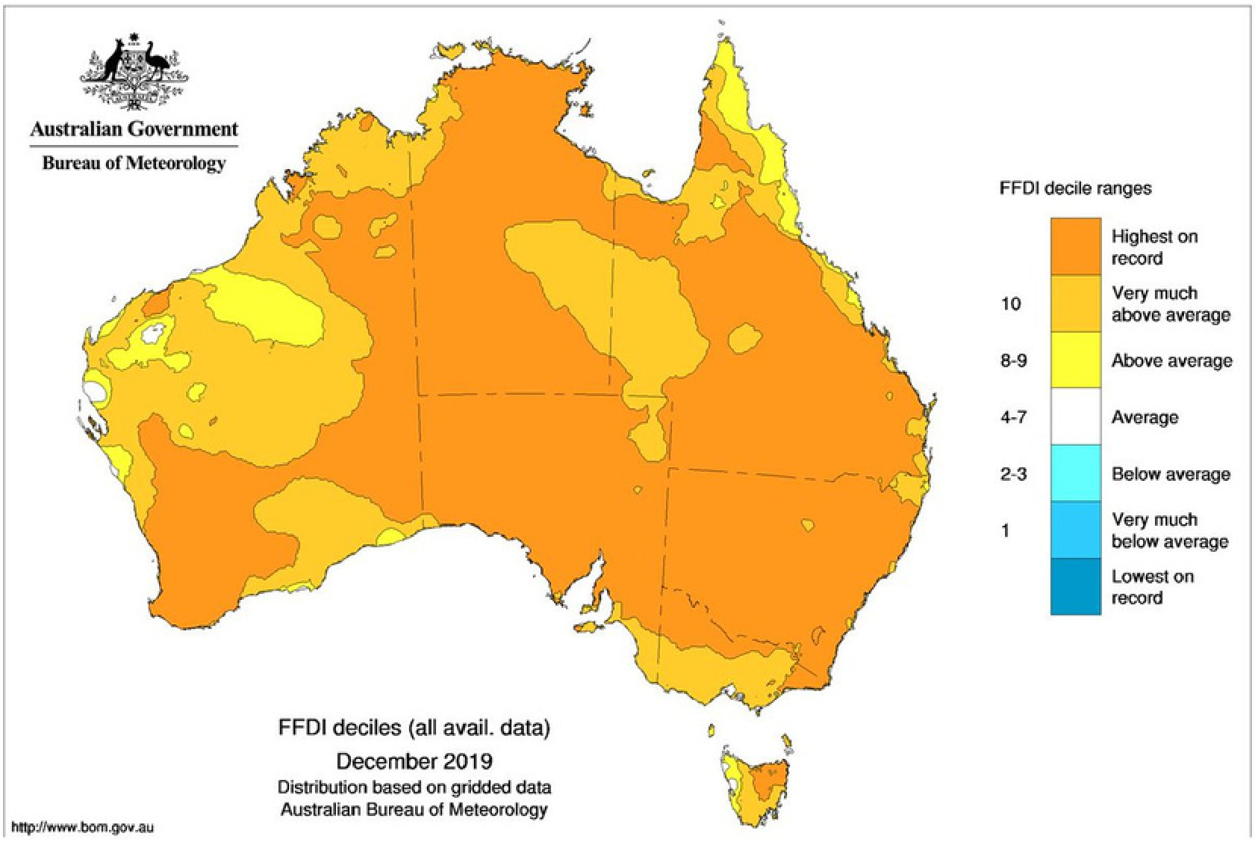

Figure 2 The accumulated FFDI for December 2019 was more than twice the average for December over large areas of Australia Source: Bureau of Meteorology (2020) Special Climate Statement 73 – extreme heat and fire weather in December 2019 and January 2020. http://www.bom.gov.au/climate/current/statements/scs73.pdf

To reduce infrastructure loss, the most effective use of prescribed fire may be to apply it to the immediate proximity of assets

Research shows that the spatial arrangement and location of fuel reduction is more important than how much of the landscape is prescribe-burnt in reducing infrastructure loss *[13,29]*. Fuel levels around infrastructure and the ignitability of buildings are important in determining the impact of fire *[28,30]*. To reduce infrastructure loss, the most effective use of prescribed fire may be to apply it to the immediate proximity of assets *[31,32]*. This is because the density of embers and amount of radiant heat, which are the principal causes of house loss, are greatest close to the fuel source *[33]*. Reducing fuel close to houses also creates a defensible space in which fire suppression has a better chance of being successful, except in extreme fire weather conditions *[31]*.

Prescribed fuel reduction burning in the bushland-urban interface is challenging to manage, particularly in relation to the risk to infrastructure *[34]*, and more expensive than burning in remote areas, but is more effective at reducing infrastructure loss *[35]*. One of the arguments for concentrating fuel reduction in the bushland urban interface is that a high percentage of bushfire ignitions occur around human population centres *[32,36]*. The distance from infrastructure over which fuel management may be required to reduce the risk of infrastructure loss varies depending on the ignitability of houses *[30]*, housing density *[31,37]* and vegetation type *[31]*.

Over the last decade, Tasmania, Victoria, Queensland and Western Australia have adopted a strategic risk reduction approach to prescribed fuel reduction burning *[10,38-40]*. In New South Wales and South Australia, bushfire risk reduction is planned at local and regional scales *[41]*. In this approach, managing fuel is just one of the tools for reducing risk and prescribed fuel reduction burning is tailored to different parts of the landscape according to the level of risk to human life and property. Adopting a risk reduction approach to prescribed burning has been enabled by advanced risk assessment software using robust fire-spread models *[42]*.

3. What are the ecological consequences of prescribed burning to reduce the spatial extent of bushfires?

Fire is a natural feature of the Australian environment and is an important land management tool that is widely used to maintain the diversity and function of an ecosystem over time within the ecological tolerances of that ecosystem *[43]*. This is often called ecological burning. Australia’s plants and animals are adapted to fire regimes rather than fire per se *[44,45]* (see Bushfire Science Report No. 2). A “fire regime” includes the typical fire intensity, seasonality and frequency of fire experienced at a given location. However, each species has limits of tolerance to fire regimes *[46]*. Plant life history traits, including the time to reach reproductive maturity and time to senescence have been used to estimate the lower and upper limits of recommended fire intervals *[47]*.

Prescribed fuel reduction burning is not the same as ecological burning. For prescribed fuel reduction burning to reduce the spatial extent of unplanned fires, very large increases in the total extent of area burned would be required *[4]*. Increasing the area of prescribed fuel reduction burning to this extent would represent a fundamental shift in the frequency, intensity and seasonality of fire regimes, with major implications for managing biodiversity *[4,48,49]*. Inappropriate fire regimes have the potential to have wide-ranging adverse environmental impacts including reducing the resilience of forests that are normally fire-tolerant *[50]*, plant extinction *[49,51]*, animal extinction *[52,53]*, increased predation of small native mammals *[54]*, and loss of key habitat structure such as hollow-bearing trees *[55]*.

Ideally, strategies for prescribed fuel reduction burning would be able to incorporate detailed knowledge of ecosystems and the likely effects of the fire regime on component species *[43]*. However, a fire-mosaic that suits one species will not meet the habitat needs of all species *[53,56,57]*. The dilemma is threefold. First, our knowledge of fire regime-biodiversity interactions remains incomplete *[58,59]*. Second, fire regimes are changing due to climate change, land use change, the introduction of flammable pasture species, and fire suppression. Third, under climate change, the fire free intervals that will permit species to persist are likely to change *[60]*.

4. What are the constraints on prescribed burning as a method for reducing bushfire risk?

Prescribed burning is an important land management tool in the fire-prone landscapes of Australia. However, there are inherent risks in the use of fire and its use is becoming increasingly complex and difficult. Over the last 50 years, there has been an increase in the number of days with dangerous weather conditions for bushfires (Figure 3). Climate change projections point to ongoing increases in the number of dangerous fire weather days (See Bushfire Science Report No. 1), as well as reducing the number of suitable periods to conduct prescribed burning

Acknowledgement of the ecological risks and uncertainties that come from prescribed burning in the landscape has led to the formulation of an ecological risk framework as part of the National Burning Project by the Australasian Fire and Emergency Services Authorities Council Limited *[48]*. Work is under way in Australia to develop prescribed fuel reduction burn planning processes that reduce the adverse environmental impacts *[11,62,63]*. However, much more work is needed before we can accurately model the impacts of prescribed burning on biodiversity, fire refuges, habitat values, carbon stocks, greenhouse gas pollution, soils, and water quality *[4,48,63-66]* in a spatially explicit way. An additional challenge will be to include the impacts of climate change *[67]*.

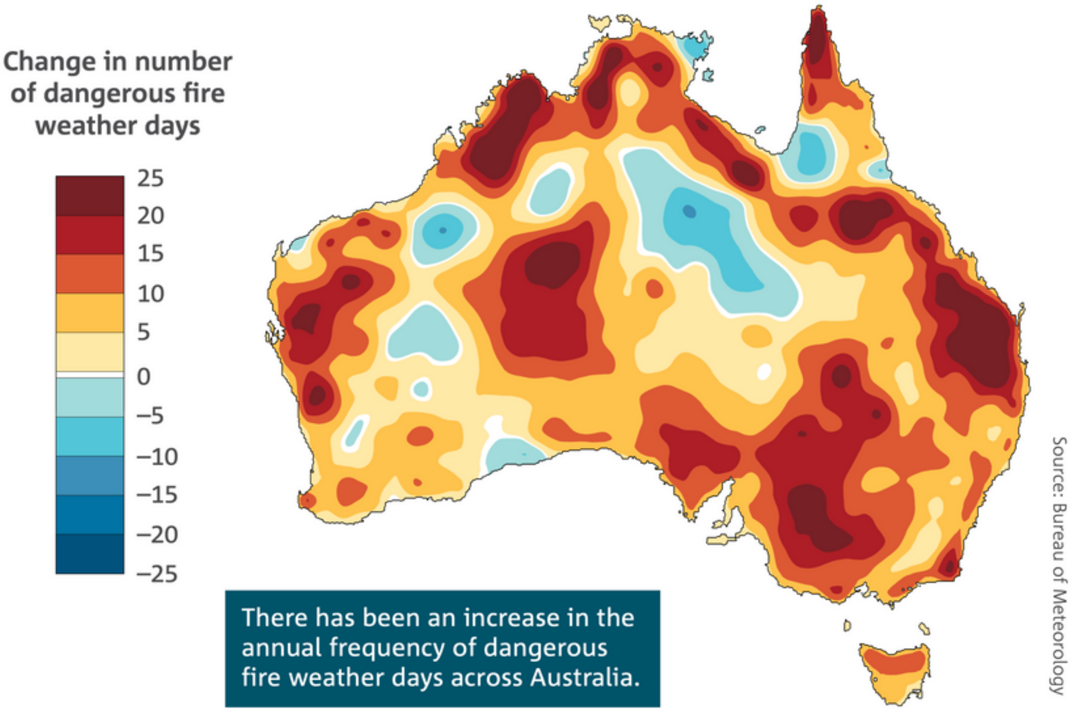

Figure 3. The number of days with dangerous weather conditions for bushfires based on the change in the annual (July to June) number of days between the two periods: July 1950 – June 1985 and July 1985 – June 2020 that the Forest Fire Danger Index exceeds its 90th percentile, which is an indicator of dangerous fire weather conditions for a given location. Source: Bureau of Meteorology / CSIRO (2020) State of the Climate. http://www.bom.gov.au/state-of-the-climate/

However, much more work is needed before we can accurately model the impacts of prescribed burning on biodiversity, fire refuges, habitat values, carbon stocks, greenhouse gas pollution, soils, and water quality in a spatially explicit way.

Climate change impacts and environmental considerations are not the only constraints on prescribed burning. Public health risks due to smoke, water quality management, greenhouse gas emissions, economic risks due to smoke, the opportunity to burn safely, the distribution of people and infrastructure, physical constraints, risks associated with escaped fires, and availability of resources and skilled personnel all impose constraints on prescribed burning *[3,9,12,42,68]*.

5. What other strategies are available to reduce the risk of infrastructure loss?

It follows from the literature reported above, that prescribed burning of native forests that are remote from infrastructure will not significantly reduce the risk of infrastructure loss. At the same time, high frequency burning of large parts of the landscape would have significant ecological impacts. Rather, it is the fuel levels around infrastructure and the ignitability of buildings that are important. Risk reduction is therefore a shared responsibility between regulatory authorities, planning authorities, public land managers and private land managers. The actions of public land managers and private landholders in managing fuel close to infrastructure, including residential dwellings, is extremely important in reducing the risk of infrastructure loss *[31]*. Additional strategies for mitigating risk of infrastructure loss due to bushfire include:

- Land use planning and urban design to reduce exposure to bushfire hazards [*1,22,24,31,69];*
- Identifying the most appropriate fuel management strategy for different vegetation types;
- Infrastructure design and construction to reduce vulnerability to bushfire *[24,30,37];*
- Fuel management in the bushland urban interface *[31];*
- Mechanical fuel reduction in asset protection zones *[31,70]*;
- Targeted arson reduction programmes *[71]*; and
- Improved powerline safety *[71]*.

Conclusion

Dangerous fire weather conditions and increasing bushfire risks will become increasingly common (See Bushfire Science Report No. 1). Targeted prescribed burning to reduce fuel hazard in the vicinity of human settlements and infrastructure will be a necessary strategy for managing these increasing fire risks. With respect to landscape scale burning, the current available scientific evidence from forest and woodland ecosystems indicates that under less severe fire weather conditions (i.e. FFDI <50) prescribed burning can reduce fire severity, although the fuel treatment effect is short-lived (around five years). Even under moderate fire weather conditions, reducing the extent of bushfires through prescribed burning requires large increases in the total extent of area burned and that would represent a fundamental shift in the frequency, intensity and seasonality components of fire regimes from natural conditions with wide-ranging adverse environmental impacts. All landholders and land use planning agencies share responsibility for reducing their exposure to bushfire hazard. Importantly, it needs to be recognized that bushfire risk, especially under a rapidly changing climate, can be reduced but not eliminated.

Targeted prescribed burning to reduce fuel hazard in the vicinity of human settlements and infrastructure will be a necessary strategy for managing these increasing fire risks

Definitions

Prescribed burning: the deliberate and lawful application of fire under specified conditions to a pre-determined area and at a time, intensity and rate of spread required to meet management objectives. The objectives of a prescribed burn can vary from protection of property to sustainable management of ecologically important areas or species. The most common objective is to reduce risk to human values by reducing the occurrence, extent and intensity of future unplanned bushfires. Prescribed burning is typically conducted under weather and fuel conditions that will enable safe management of the burn (generally outside the fire season). The resulting burns can be more frequent, smaller and low to moderate in intensity compared to bushfires that tend to occur in more extreme fire weather conditions and seasons. As prescribed burns are a deliberate management intervention, the public expect adverse impacts to be minimised. Prescribed burning is also referred to as hazard reduction burning, planned burning, controlled burning, and fuel reduction burning.

Back burning: a fire-fighting method used to try to contain an active bushfire. It works by setting fires in front of a moving bushfire from containment lines such as roads or areas where the fuel has been raked away by hand.

Ecological burning: the application of fire in nominated areas to achieve specified ecological objectives. For example, prescribed ecological burning is an important tool in managing the habitat of some of Australia's rarest birds in the arid zone and tropical savannas. The Night Parrot, Gouldian Finch and the Carpentarian Grasswren, all need long-unburnt habitat. Effective placement of prescribed burns can protect long unburnt habitat from unplanned fire.

Cultural burning:"the myriad ways that fire exists in a cultural context to achieve the same or different objectives as contemporary fire management. The cultural values and practices that manifest as cultural burning are underpinned by the fundamental intent to care for country." Oliver Costello cited in [72]

Deliberate arson: the malicious and unauthorised use of fire. It can attract large fines and prison sentences.

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