Landscape prescribed burning: a south west Australian perspective

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Introduction
We share experiences and learnings from the south west forest region of Western Australia where there exists a long and well documented history of landscape prescribed burning. The Mediterranean-type climatic region comprises a mosaic of forests, woodlands, plantations, wetlands and shrublands interspersed with towns, farmland, industries and infrastructure. It is the most developed and populous region of the state. Since the mid-1960s, an average of 9% of the 2.5 M ha of public land in the region has been prescribed burnt per annum (Figure 1). The annual average area burnt by bushfire is about 0.9% and bushfire losses have been low compared with other similar bioregions. Detailed accounts of the role of prescribed burning in managing the bushfire threat are provided elsewhere (Sneeuwjagt 2011; Burrows and McCaw 2013; McCaw 2013; McCaw and Burrows 2019; Howard *et al*. 2020).

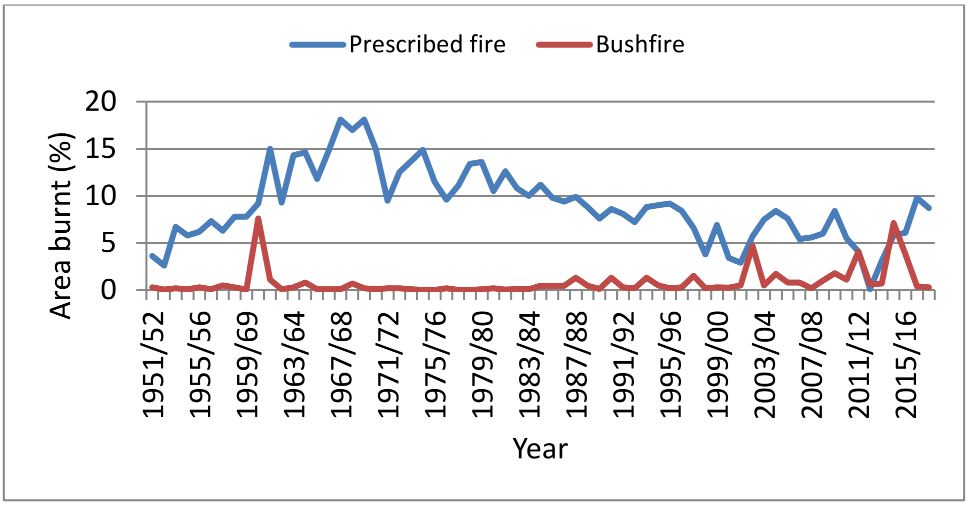

Figure 1: Annual proportion of the 2.5 M ha of public land in the south west Australian forest region burnt by prescribed fire and bushfire 1951/52-2017/18. (Source: Departmental annual reports).

Landscape prescribed burning done properly is not designed to stop bushfires (although in some circumstances it can) - it is designed to make them less damaging, easier, safer and cheaper to put out, and to enhance and complement other policy, planning, mitigation and community protection measures. Experienced fire and land managers, firefighters, and bushfire scientists who work closely with them, are in no doubt that the scientific, experiential and historical evidence demonstrates that prescribed burning, done properly, is the cornerstone to mitigating the bushfire threat. This is based on the following evidence.

<u>Bushfire behaviour science:</u> Reducing fuel load and simplifying fuel structures by regular burning reduces the speed, intensity, flame size and ember production of bushfires (Cheney *et al*. 2012; McCaw *et al*. 2012) making them less damaging and easier and safer to put out. In mature forests, crown fires cannot be sustained if the surface and near surface fuels are at low levels as a result of fuel reduction burning. Long unburnt fuels, if it is possible to retain them as such, carry high fuel loads, and when dry, they are highly flammable. While the hazard rating of the elevated fuels (understorey shrubs) may decline with age, the surface, near surface and bark fuels reach and maintain high loads and Extreme (structural) hazard rating levels. It is the accumulation of dead fine fuel in the surface and near surface fuel layers that drives forest fires because these layers form the base of the 'fuel ladder', they can be very dry, and can reach very high loadings if left unburnt (Burrows 1994; McCaw *et al*. 2002; McCaw *et al*. 2012).

Experience: There are numerous examples in south west WA, some well documented (e.g. Underwood *et al*. 1985; Cheney 2010; Sneeuwjagt 2011; Batini and Pasotti 2018), where prescribed burning has greatly assisted early suppression because of the reduced fire behaviour associated with younger, lighter fuels. Conversely, there are recent documented examples where a lack of prescribed burning made it difficult and dangerous for firefighters, including the Lower Hotham, the Northcliffe and the Waroona fires (Ferguson 2016).

History: Almost 60 years of fire history data show that when the area of prescribed burning trends down, the area burnt by bushfire trends up (Boer *et al*. 2009) (Figures 1 & 2) because bushfires are more difficult to put out in older fuels. The area burnt by bushfire escalates when the area of prescribed burning in the region falls below about 8% per annum for an extended period (Figure 2). Burning 8% per annum results in about 40% of the regional bushland carrying fuels 0-5 years old, conferring a significant advantage to firefighters when bushfires break out (Sneeuwjagt 2011; Burrows and McCaw 2013).

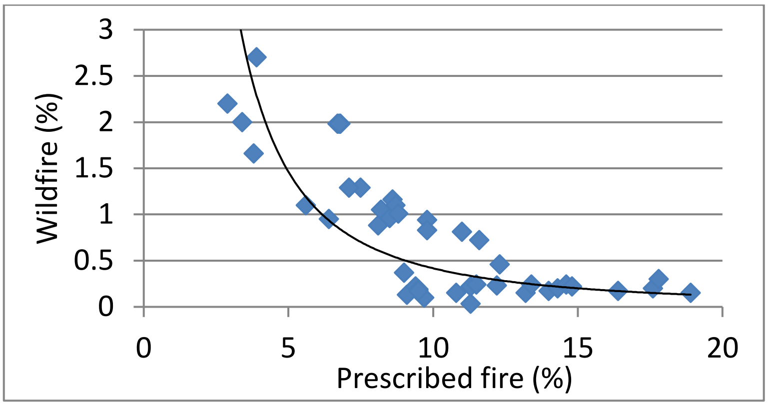

Figure 2: Relationship between prescribed burning area (single year) and bushfire area (mean of next 5 years). (Source: Sneeuwjagt 2011 + updates)

To be effective, prescribed burning must also be strategic – that is, done in the right places to protect communities, infrastructure, industry and high conservation values by intercepting fire runs under the worst fire weather conditions (Howard *et al*. 2020). The prescribed burning cells need to be large enough to ensure a sufficient area for the spread of a bushfire to be slowed and controlled. Burns must be bounded by roads or tracks to enable rapid access by firefighters. Burning must be done to appropriate standards of fuel removal and fire intensity. Burns that are too patchy may not slow a bushfire. Burns that are too intense, as well as being difficult to manage, can scorch the overstorey, causing rapid initial fuel re-accumulation due to leaf fall, or in some forest types, they can stimulate the regeneration of dense scrub, increasing the elevated fuel hazard.

Prescribed burning – how and why it works

The purpose of a prescribed burning program is not to stop bushfires, but to assist with their safe suppression. To understand this, it is necessary to understand the complex and dynamic 'art' and science of bushfire suppression, which can't be adequately replicated by computer simulations. There are a variety of suppression strategies and tactics that can be used in space and time, depending on current and forecast weather, fuels, topography, fire behaviour around the fire's perimeter, fire shape, access to the fire, fire position in the landscape and available firefighting resources. Firefighters rarely make a direct attack on the head fire - it's usually too 'hot'. Instead, they implement other strategies including a variety of direct, indirect and parallel attacks – the options, and likelihood of early success, are greater if the fire is burning slower and at a lower intensity with lower spotting potential because it's burning in young, light fuels. Appliances will be more effective on slower moving, lower intensity fires and it is only on these fires that water bombers are effective. Fire intensity varies around the fire's perimeter, affording suppression opportunities – there will almost always be a place on the fire’s perimeter that can be attacked – even under severe fire weather conditions - and if fuels are young and fuel loads light, this opportunity widens significantly.

The most trying suppression challenge occurs when the wind shifts and a long flank fire becomes a wide head fire. Therefore, containment work on the ‘pressure flank’ is always a priority. This is more likely to succeed in young, light fuels when flank fire intensity is relatively low, even under severe weather conditions. If part of the fire is burning in very light fuels as a result of prescribed burning, then if resources are stretched, it can be ignored and resources deployed to higher priority areas around the fire perimeter, or to defending properties, or dispatched to other fires in a multiple fire situation.

Properly done and strategically located, prescribed burning provides ‘anchor points’ for firefighters. These low fuel areas are very important for initiating indirect suppression strategies including back burning. Attempting to back burn in old, heavy fuels against old, heavy fuels is a slow, demanding, dangerous and risky operation. Back burning in young, light fuels surrounded by young, light fuels is much safer, more likely to be successful and requires less resources. Low fuel areas are also very important for ‘tying in’ containment lines, enabling faster, more efficient suppression. The speed of construction of containment lines is crucial in the battle against a growing fire. Fire suppression is a race between rate of fireline construction and containment versus rate of perimeter growth of the bushfire. Fires burn slower in younger, lighter fuels, not only improving the likelihood of early detection and suppression, but increasing the odds of firefighters getting the upper hand.

Severe fire weather conditions don’t last very long in the life cycle of a bushfire – when diurnal fire weather conditions ease (and they always do), and if the fire is burning in young, light fuels, there is a larger window of opportunity for safe suppression, than if it’s burning in old, heavy fuels.

There are two other critical ways in which well planned fuel reduction programs assist with bushfire control. The first is that it allows fires to be suppressed in the lead-up days to extreme conditions. Firefighters are nearly always overwhelmed when “Extreme’ or 'Catastrophic' conditions (i.e. hot, dry, windy weather) affect fires that have already been burning in the landscape from previous days. The presence of low fuel areas makes it more likely that these fires can be contained and controlled before these extreme conditions occur. The second is that when there are multiple fires on the same day, as occurred during the Cyclone Alby crisis in WA in 1978. Fire controllers can set up a ‘triage’ response. Fires burning into 0 to 3 year old fuels can be temporarily ignored, while effort is placed on the most threatening fires. This allows the best use to be made of resources.

Regardless of fire weather conditions, to firefighters, fuel load matters. It affects fire intensity (heat energy output) and flame size around the fire’s perimeter, and the size of the suppression windows in space and time. Also, containment line break outs such as hop overs and spot fires, are much easier to control in light fuels than in heavy fuels. The fuel load burning behind the flame zone, which is greater in older fuels, is critical for suppression difficulty because total heat output acts in a number of ways. It is an input to convection which increases wind speeds in the flame zone, boosting spotting and fire behaviour. It increases the likelihood of high energy release rates and deep flaming, conditions that can trigger a transition to a dangerous and unpredictable ‘plume-driven’ fire. It increases the likelihood of re-ignition and breaching of the containment line by burning across it or by blown embers or by hop-overs. Radiation from glowing combustion adds to the heat load on firefighters and increases the time that the burnt ground can be used for safe refuge. It substantially decreases the effectiveness of water and other suppressants /retardants applied from the ground or from the air. Heavy fuel also hinders fireline construction and in some fuels make it impractical.

Prescribed burning and biodiversity conservation

Largely based on computer modelling and simulations, it has been claimed that to be effective, prescribed burning in forests would need to done be at intervals less than 4 years, but based on vital attributes such as the juvenile period of fire sensitive plants, it is claimed that this will result in local extinctions. This conclusion demonstrates a lack of understanding of the temporal and spatial design of a prescribed burning program, and of the patchiness and variability of low intensity fires burning under mild weather conditions in light fuels. Burning in landscapes with old heavy fuels is challenging, but as a prescribed burning program becomes established, and more of the landscape is carrying younger fuels, the task becomes easier with reduced risk of fire escapes and re-ignitions.

As outlined above, it is not necessary to burn the entire forest region every four years to significantly mitigate bushfire losses. In the south west Australian forest region, about 97% of understorey plant species flower within 3 years of fire (Burrows *et al*. 2008). So called 'fire sensitive' species with longer juvenile periods are able to persist under a regime of frequent, low intensity fires burning in light fuels primarily through three mechanisms.

Firstly, these species occur in the less flammable parts of the landscape, such as riparian zones, broad valley floors with discontinuous fuels and on rock outcrops (Burrows *et al.* 2008). These habitats rarely burn under mild, prescribed burn conditions - especially winter / early spring burns - so often remain long unburnt. However, they are vulnerable to severe summer bushfires in the absence of regular burning in the surrounding, more flammable forest fuels. Rock outcrops are a case in point. They provide a refuge for a suite of fire sensitive plants because fuels are naturally patchy. They can best function as a fire refuge if the surrounding flammable, fire resilient forests are regularly burnt by low intensity fire. On the other hand, they fail as a fire refuge if the fuels in the surrounding landscape build up to high levels because the inevitable summer bushfire will be so intense that it will overwhelm the fire refuge characteristics of the rock outcrop.

Secondly, some fire sensitive plants are killed by moderate intensity fire, but can survive low intensity fire. The relationship between banksia woodlands, the endangered Carnaby's cockatoo, and fire is an interesting case study (Densmore 2018). Because the banksias have a relatively long primary juvenile period - about 6-7 years - and because they can be killed by fire, it was proposed by some that prescribed burning intervals should be more than 15 years to maintain seed supply for the cockatoos. However, this erroneously treats all fire as lethal to the banksias. Intense summer bushfires burning in old, heavy fuel damage and kill many trees over a large area, resulting in a long period of low seed supply while the plants regenerate and mature. Frequent low intensity fires burning in light fuel rarely kill the mature trees, the severity of bushfires is reduced, and there is less disruption of seed flow for the cockatoos.

Thirdly, fuel load and structure in ecosystems of some fire sensitive plant species do not develop sufficiently to sustain low intensity fire under mild weather conditions until well after the plants have reached maturity. Examples include *Melaleuca viminea* and *Banksia quercifolia* thickets. Reproductively immature thickets of these species, which depend on infrequent fire for regeneration, usually do not burn under mild, low intensity prescribed burn conditions (Christensen 1982; Burrows and Middleton 2016).

Space for time and longitudinal studies (e.g. Wittkuhn *et al*. 2011; Burrows *et al*. 2019), demonstrate that prescribed burning (and other fire regimes) may cause changes in species abundance and composition through time, but there have been no long term loss of species richness and no species extinctions that can be attributable to prescribed burning. On the other hand, large bushfires in areas with inadequate prescribed burning have severely impacted populations of threatened species, including noisy scrub birds and quokkas (Comer and Burbidge 2006; Bain *et al*. 2016).

Science to underpin prescribed burning

Impediments to prescribed burning including weather, air quality and lack of capacity and knowledge, can largely be overcome by political support, strong leadership and good science. With regard to the latter, the following research is needed to underpin an effective prescribed burning program:

- Fuel accumulation and fire behaviour models for major fuel types.
- Burning guides for major fuel types.
- Smoke plume dispersal models.
- Continuous fine fuel moisture content prediction systems that account for rainfall.

- Understanding spatial and temporal variability in fuel flammability in the landscape.
- Field studies of patchy, low intensity prescribed fires and the persistence of fire sensitive elements of the biota.

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