Beyond the interface: the contribution of planned fire to managing environmental values in the broader landscape

Lachlan McCaw
Biodiversity and Conservation Science
Manjimup WA

University of Western Australia
Prescribed Burning Forum
31 July-1 August 2019
Outline

- Heating and impact from fires
- Time since fire and fire intensity
- Contrasting effects of planned and unplanned fire
  - landscape scale
  - local scale
- Trading-off area burnt by planned and unplanned fire
Thermal environment in a bushfire

Heat transfer mechanisms
• radiant heat (flaming)
• convection (crown scorch)
• conduction (soil)

Heat partitioning depends on
• fuel arrangement
• burning conditions
Quantifying bushfires

Heat release

Fire intensity

\[ I = H w r \]

where

- \( H \) = heat yield
- \( w \) = fuel consumed
- \( r \) = rate of spread

Residence & burn out time

Total heat release
Fireline intensity in relation to time since last fire

Jarrah forest, High fire danger, dry summer conditions

Data from Project Vesta experimental fires
McCaw 2013
For Ecol Mgt 294
Quantifying bushfires

Fire severity

- Canopy scorch height
- Defoliation height
- Soil heating depth
- Dead fuel consumption
- Vegetation removal
Perth Hills bushfire, Jan 2005

Biomass change (fire severity) based on Landsat imagery

Fire severity scale

- High
- Moderate
- Low
- Unburnt

Image processing by Dr Li Shu
Dept. Environment and Conservation WA
Perth Hills bushfire, Jan 2005
Comparison of Pickering Brook and Little Darkin sub-catchments

Pickering Brook
prescribed burn in spring 2003
15 months prior to Jan 2005

Little Darkin
Unburnt for 16 years prior to Jan 2005

Prescribed burn in spring 2002
27 months prior to Jan 2005
Little Darkin catchment
Impacts of severe 2005 bushfire

- Stream channel erosion
- Silting up of V-notch weir
- Ash and silt into Mundaring Reservoir
- Impaired stream invertebrate composition

Rates of tree fall following fire

<table>
<thead>
<tr>
<th></th>
<th>Planned fire</th>
<th>Bushfire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees &gt;20 cm</td>
<td>2.1</td>
<td>5.6</td>
</tr>
<tr>
<td>Stems/ha</td>
<td>0.8</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Based on post-fire surveys of *FORESTCHECK* monitoring sites burnt by 2015 Lower Hotham bushfire (n=7) and DBCA planned burns (n=7)
Fire and conservation of ground logs at decadal timescales

Data from FORESTCHECK monitoring
Whitford & McCaw (2019)
Aust For 82
Causes of unplanned fire on public lands

- Lightning ignition dominates area burnt by unplanned fire in south-west WA, other than the Swan coastal plain
- Lightning ignition peaks in summer November to February

Data for area burnt on 6.3 m ha of land for which DBCA has management responsibilities Dongara to Ravensthorpe
Planned and unplanned fire: an inverse relationship

Analysis of 50 years of fire data for the Warren Region (WRE) south-west WA

Boer et al (2009)
Long-term impacts of prescribed burning on regional extent and incidence of wildfires
For Ecol Mgt 259
Beyond the interface: the contribution of planned fire to managing environmental values in the broader landscape

TITLE SLIDE

Thanks to the organisers for the opportunity to present at this forum on prescribed burning. I would like to acknowledge the traditional owners of the land on which we meet today, and the relevance of this to our discussions about how fire is managed on the land.

In my presentation I will be using the term planned fire and prescribed burning interchangeably to describe fires that are lit with a management intent; and the term unplanned fire with the same meaning as bushfire to describe a fire ignited by lightning, accidental cause or arson.

SLIDE 2 OUTLINE

Discussion and debate about the planned use of fire is very often framed in the context of planned fire as a tool for protecting human life, buildings and other assets that are of immediate importance to the wellbeing of the community. This is entirely justified and all of us expect to go about our daily business free from the threat of losing our life or home to bushfire. In some jurisdictions the expectation for minimisation of house loss from bushfire is the primary performance measure applied to planned burning programs.

However, if we shift our field of view away from the urban-bushland interface and look instead at the broader landscape it is clear that there are a range of other values that may be affected by fire. Some of these values make a direct contribution to livelihoods and
economic activity – for example surface water resources, tree plantations, recreation facilities and bee pastures. Other important environmental values include wildlife habitat, carbon storage and landscape amenity.

My choice of photo for this slide is deliberate. It is an image taken from the crest of Mt William looking to the north east along the path taken by the Waroona bushfire on 7 January 2016. This fire was ignited by lightning more than 20 km away. There were two ignitions, one of which was contained successfully by initial attack. The scale and severity of this bushfire is obvious, with the broad swathe of defoliated forest indicating active crown fire. On the evening of 7 January this fire burnt down the Darling escarpment into the settlement of Yarloop resulting in loss of two lives, more than 150 buildings and causing significant and persistent disruption to the community. These impacts were examined in detail by the Special Inquiry led by Euan Ferguson, leading to important changes in the way that rural fire is managed in Western Australia. However, the broader impacts of the Waroona fire on the environment have received much less attention despite the fact that some of these impacts will persist for decades, and perhaps centuries in the case of widespread mortality of mature trees. Its good to see that work done through a PhD program at Murdoch University has looked at some of the impacts of fire on forest structure and composition.

In my presentation today I will briefly examine how fire characteristics affect environmental responses, and why this is important for the choices that we make about the balance between planned and unplanned fires.

SLIDE 3 THERMAL ENVIRONMENT

Heat transfer during a bushfire occurs through three mechanisms:
- radiant heat from flaming and glowing combustion
- convection through heated gases, as reflected in canopy scorch
- conduction of heat into the soil, tree stems and large logs

The partitioning of heat from a fire is strongly influenced by the amount and arrangement of fuel, and the conditions under which the fire is burning – particularly the dryness.

SLIDE 4 QUANTIFYING BUSHFIRES – FIRE INTENSITY

Fire intensity is a variable commonly used to quantify the rate of heat output from a spreading fire. Fire intensity is the product of:
- the amount of fuel consumed in the flaming zone
- the rate of spread of the fire
- heat output of the fuel, regarded as relatively constant

Fire intensity increases as fires spread faster, and when more fuel is consumed.

For larger woody components of fuel such as ground logs and stumps, it may also be important to quantify residence time, burn-out time and total heat release.

SLIDE 5 FIRELINE INTENSITY IN RELATION TO TIME SINCE FIRE

During the late 1990s more than 100 experimental fires were ignited at two sites in the jarrah forest under dry summer conditions of High fire danger. Sites varied in the composition and structure of the understorey shrub layer, and for each experiment ignitions were done in forest representing different time since the last fire, up to two decades since last fire.

The slide shows calculated fire intensities for experiments in each time since fire class, with results for the low shrub site on the left and tall shrub site on the right.

At the tall shrub site fire intensity increased progressively with time since fire up to 16 years.
At the low shrub site increases in fire intensity after 7 years since fire were more gradual, and fires were generally less intense than at the tall shrub site.

The grey band represents the upper range of fire intensity where fire suppression by experienced personnel equipped with trucks and bulldozers or front-end loaders is likely to be effective and practical. That is, about 2000 to 2500 kW/m of fireline intensity. The availability of aerial support may increase this threshold slightly, but becomes limited by the increasing tendency of fires to spread by spotting.

Key points to note here are:
- that opportunities for effective containment of forest fires burning under dry summer conditions become increasingly limited once fuels are 6 years or older since the last fire;
- older fuels will generate more intense fires, with greater heating and thermal impact on vegetation and soil.

**SLIDE 6   FIRE SEVERITY**

Fire severity reflects consumption of organic matter above-ground and below-ground. This includes measures such as:
- extent of scorch and defoliation of the vegetation
- extent of consumption of dead and live organic matter
- depth and degree of soil heating
- combustion of soil organic matter, root systems, peat

Remote sensing imagery is useful in quantifying spatial patterns of fire severity, although the spectral signatures do vary according to the nature of the vegetation and the underlying soil and landform.

In the example shown here the bright red areas represent jarrah forest burned at high intensity in the January 2005 Perth Hills bushfire which caused widespread canopy defoliation by crown fire,
very high levels of bark char and complete removal of the surface litter and understorey layers.

SLIDE 7  PERTH HILLS BUSHFIRE FIRE SEVERITY

Staying with the 2005 Perth Hills bushfire, about 28 000 ha were burnt south and east of Mundaring Weir over the course of five days of active fire spread. Under the influence of easterly winds the fire pushed hard on the urban interface around Roleystone and Pickering Brook. Northerly winds associated with a west coast trough then spread the fire south across Brookton Highway, followed by south-easterly winds which pushed the fire on the northern side of the Mundaring Weir. As the image shows, a large proportion of the area was burnt at high severity.

The Mundaring Weir catchment is an important part of the integrated water supply scheme that supplies water to the Goldfields and eastern Wheatbelt through the pipeline, and avoiding large discharges of silt and ash into the reservoir is a priority for land and water managers.

SLIDE 8  COMPARISON OF LITTLE DARKIN & PICKERING BROOK

Focussing in on the southern end of the Mundaring reservoir there are several features of interest:

- The area burnt by prescribed fire in spring 2002 (27 months prior to the bushfire) where the intensity of the fire was very much reduced in the younger fuel;
- The Pickering Brook catchment which was burnt by prescribed fire in spring 2003, which remained largely unburnt in the 2005 bushfire
- The Little Darkin catchment which had been unburnt for 15 years prior to the January 2005 bushfire and experienced high severity fire that caused widespread mortality of mature
wandoo and jarrah trees, and severe heating and exposure of mineral soil

- Gauging stations on the Pickering Brook and Little Darkin were monitored for several years following the January 2005 fire

SLIDE 9  LITTLE DARKIN IMPACTS

Severe fire in the Little Darkin catchment resulted in a variety of adverse outcomes for water quality and stream condition including:

- Heavy erosion of the stream channel
- Transport of silt and ash into the Mundaring Reservior
- Silting up of the V-notch weir at the gauging station from which many tonnes of sediment had to be removed
- Impaired stream invertebrate composition for several years following the 2005 bushfire

None of these impacts were observed in the Pickering Brook catchment as a consequence of the 2003 prescribed burn or the limited area burnt in the 2005 bushfire.

SLIDE 10  TREE FALL FOLLOWING FIRE

Moving from the catchment scale to a more local scale mature trees are a key component of forest ecosystems and have a variety of values - as wildlife habitat, a sources of seed, and for their intrinsic appeal to people.

Trees do fall down during winter storms, and sometimes on still summers days particularly in the karri forest. And the rate of tree fall typically increases for a period following fires, depending on the burning conditions and severity of the fire.

Data gathered as part of the Forestcheck monitoring program indicates that the rate of fall of trees >20 cm diameter is more than twice as great following summer bushfire (2015 Lower Hotham fire) than following planned fires in spring or the latter part of autumn.
SLIDE 11  FIRE AND CONSERVATION OF GROUND LOGS

Ground logs are another component of forest ecosystems that can be affected by the timing and nature of fire. Again, they have a variety of values – invertebrates, reptiles and mammals live in them; they provide nursery sites for plants to establish; and they contain a significant store of carbon.

Detailed inventories of the volume and condition of logs have been done at Forestcheck monitoring sites in the jarrah forest, and we have looked at how this relates to the recorded fire history of each site back to 1937 when the systematic recording first began.

The left hand chart shows the volume of woody log material plotted against the number of bushfires since 1937, and not surprisingly the sites that have been burnt more often by bushfire have lower volumes of logs.

The right hand chart shows the volume of woody log material plotted against the number of prescribed fires since 1937, with the interesting point here being that sites burnt more often by prescribed fire have greater volumes of log material. This suggests that regular mild fires have encouraged the accumulation of woody material, and avoided large losses during bushfire events.

SLIDE 12  CAUSES OF UNPLANNED FIRE ON DBCA MANAGED LANDS

To finish my talk I would like to touch briefly on the topic of the cause and extent of unplanned fires on lands managed by DBCA. Data in this slide show fire cause from 2002 to 2017 on lands between about Dongara in the north and Ravensthorpe in the south-east, including the main forest zone representing an area of about 6.3 M ha.

Over that 15 year period there has been close to 2 M ha of unplanned fire on these lands. Lightning has been the dominant cause of unplanned fire both in the forests and in the woodland and
shrubland ecosystems in places such as Beekeepers Reserve, Waychinicup, Two Peoples Bay and Jilbadgie nature reserves.

Lightning ignition occurs most often in the late spring and summer period between November and February when conditions are dry, fire dangers are elevated, and fires can grow to large size in a short time.

Areas of younger fuel where fire intensities are reduced can play a critical role in limiting both the spread of unplanned ignitions, and in limiting the severity of impacts on a range of values.

SLIDE 13  PLANNED AND UNPLANNED FIRE

The relationship between the extent of planned and unplanned fire in a landscape follows a generally inverse pattern in areas of south-west WA where native vegetation is relatively continuous.

The slide shows this pattern using data from the Warren region over a 50 year period. The Warren region has a mix of tall and open forest, woodland, heathland and other coastal communities.

Greater levels of planned fire resulted in reduced levels of unplanned fire, due to increased effectiveness of fire suppression and to one type of fire substituting for another.

Conversely, reduced levels of planned fire lead to greater levels of unplanned fire.

We do have some choice in where we ourselves along this continuum, and in making that choice we should be thinking about the consequences of different types of fire for a broad range of values in the environment. As touched on by some of the speakers yesterday there are opportunities for putting fire on the land in different ways and we should be open to exploring these.

But I remain convinced, and want to state clearly for the record, that whatever our objectives for managing the land may be, we stand a
better chance of achieving these through planned use of fire than through a passive approach that relies on simply responding to circumstances as they unfold.

ENDS