To Burn, or Not to Burn

A Critical Perspective

By Emeritus Professor Don Bradshaw

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West Perth, WA 6005

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2 Delhi St
West Perth, WA 6005

Don.Bradshaw@uwa.edu.au

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Introduction

The manipulation of fire by early humans, some 200,000 years ago, had a major impact on their fitness and survival. It provided warmth and protection from carnivores and enhanced the digestibility of many foodstuffs. It also opened the possibility of modifying the surrounding landscape to facilitate access and the hunting of game. Its sophisticated use over millennia by Australian Aborigines to support their lifestyle is only now being fully appreciated.

The coming of Europeans to Australia was followed by a significant increase in landscape burning, as large tracts of land were cleared for grazing and agriculture. The increase in population size was also associated with an exponential increase in fires. Some early disastrous fires led the settlers to call for a need to control wildfires and 'burning off' became common in all states with its primary function being to protect human life and property, along with the developing timber industry. After a century of disastrous fires, foresters became locked into a cycle of burning the flammable undergrowth produced by their last burn, fortified by the simple modelling concept of 'fuel load' used by American foresters in pine plantations. Burning to reduce fuel loads became common in all States, with its primary function being to protect human life and property, along with the developing timber industry.

Our addiction to fossil fuels, however, and the steady increase in carbon dioxide levels in the Earth's atmosphere since the Industrial Revolution has brought about a fundamental warming of the whole planet… and with this an increase in the likelihood of fires. With the associated drying of the environment, due to declining rainfall, many of these are likely to be 'megafires' such as the devastating wildfires that swept through parts of eastern Australia in 2020[1]. These are thought to have killed or displaced as many as a billion animals, and killed who knows how many plants?

Atmospheric carbon dioxide levels have reached a point that has not been seen for 50 million years in the Eocene era, when the world was much hotter than now and covered with the lush vegetation that was to become our coal. The chances of lowering CO_2 levels are slim, given the attitude of multinational fuel companies and their lobbyists, so what can we do to avoid being incinerated in the coming years?

We need to understand fire, and the rôle that it has played in our development. We need to understand that the region we are most concerned about is a world biodiversity hotspot, defined as a region of high biodiversity undergoing habitat deterioration and destruction.[2] [3] We need to know the scientific research that has focussed on the use of fire in our region before we can come up with options for the future.

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[1] Driscoll, D. *et al* (2024). Biodiversity impacts of the 2019-2020 Australian megafires. *Nature,* **635,** 898-905.

[2] Mittermeier R A, Robles-Gil P, Hoffmann M, Pilgrim J D, Brooks T M, Mittermeier C G, Lamoreux J L & Fonseca G (eds.) (2004). Hotspots Revisited: Earth's Biologically Richest and Most Endangered Ecoregions, Mexico City: Cemex.

[3] Myers N, Mittermeier R A, Mittermeier C G, de Fonseca G A B & Kent J (2000). Biodiversity hotspots for conservation priorities. *Nature* (Lond.), 403, 853-858.

History of Fire in the Southwest

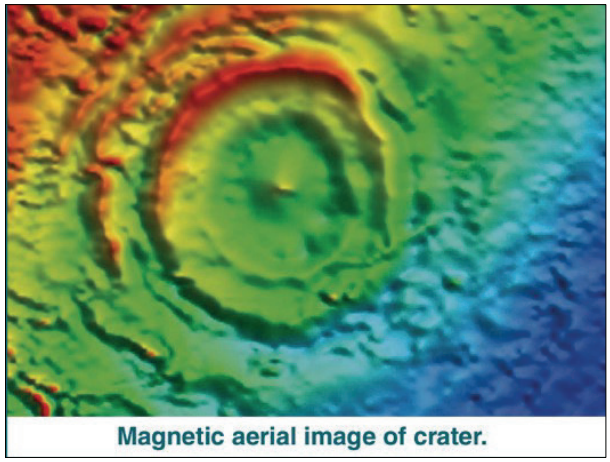

Figure 1: Meteorite crater at Yallalie between Moora and Badgingarra (Wikipedia Commons)

What is the history of fire on our planet? Wildfires are usually started by lightning from electrical storms. Are we able to go back in time to see how common they were in the past? Thanks to carbon fragments, we can.

A meteor struck Western Australia between the towns of Moora and Badgingarra some 70 million years ago, leaving a large deep crater 12km in diameter. The Yallalie crater has functioned as a sink over that time, collecting water, plants, debris and charcoal fragments from wildfires.

Fire frequency

By sinking cores down through the centre of the crater, it is possible to build up a picture over time how frequent the fires were.

Professor John Dodson and colleagues have been able to construct a timeline from pollen grains, showing what plants were living there over time and, from the charcoal fragments, the recent fire history.[4] They found that fires recurred every 10-14 years during 3 million years ago at Yallalie.

We also have some idea of the frequency of hot fires in the jarrah forest south-east of Perth prior to the arrival of colonists in 1829. Burn scars were counted and aged in jarrah trees by Neil Burrows and colleagues and published in 1995[5]. To quote from the paper,

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[4] Atahan P, Dodson J R & Itzstein-Davey F (2004). A fine-resolution Pliocene pollen and charcoal record from Yallalie, south-western Australia. *Journal of Biogeography,* **31,** 199-205.

[5] Burrows N, Ward B & Robinson A D (1995). Jarrah forest fire history from stem analysis and anthropological evidence. *Australian Forestry*, 58, 7-16.

… Prior to European settlement the incidence of fire injury was very low with the average interval between injurious fires being about 81 years. Following European settlement, the frequency of fire injuries increased, and the average interval decreased to about 17 years. The pre-European fire regime in the drier jarrah forest and the forest margin was probably one of frequent, non-injurious, low intensity fires set mainly in summer and autumn, with occasional long intervals between fires ending in high intensity, injurious fires...

This fire frequency in the Perth region contrasts with a longer frequency of 80-100+ years in the Tingle forests along the south coast.[6]

The fire frequency near Perth fell to 17 years not long after settlement by Europeans, reflecting the widespread use of fire in clearing. The current burning frequency now is closer to every 6 years and it is interesting to speculate on the impact this has had on forests and their inhabitants that, before European arrival, only experienced severe fires approximately every 80 years.

Fire intensity

The figure of 81 years for fires in the jarrah forest near Perth was determined by counting fire scars caused by high temperatures i.e. large wildfires. They do not reflect Aboriginal burning practices, which were always cool fires.

There is a move to re-introduce Aboriginal burning instead of departmental prescribed burning of bushland, but what do we know about it? Firstly, we are told by Elders today that they never burned the forests, especially the Tingles, nor the banksia woodlands, where they collected nectar. They burnt around their campsites, along paths and in other areas to encourage marsupials to graze on the regrowth of grasses after fire.

A recent study in the Denmark area of the southwest explored traditional burning methods and compared them with prescribed burning.[7] They found that the overall aim of Elders was to repair or maintain the 'health of the Country'. This contrasts to the aim of prescribed burning of reducing the fuel load on the ground. Noongar Elders considered a total of 17 separate factors when planning a fire. These were: *fire effects on vegetation; fire placement; land stewardship, care, cleaning up Country, controlling space; landscape pattern, patch size; fuel load; control; site preparation; vegetation type; fuel composition/species; fuel consumption, degree, and speed.* This compares with only four factors considered by Shire staff and volunteer firefighters responsible for prescribed burning, which were *fire intensity, danger, risk, and destructive potential.*

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[6] Hassell C W & Dodson J R (2003). The fire history of south-west Western Australia prior to European settlement in 1826-1829. In: Abbot I & Burrows N (eds.) *Fire in ecosystems of south-west Western Australia: Impacts and management.* Leiden: Backhuys. pp: 71-85.

[7] Rodrigues U, Lullfitz A, Lester Coyne, Averil Dean, Aden Eades, Ezzard Flowers, Lynette Knapp, Carol Pettersen, Treasy Woods & Hopper. S D (2022). Indigenous Knowledge, Aspiration, and Potential Application in Contemporary Fire Mitigation in Southwest Australia. *Human Ecology,* **50,** 963-980.

Are Australian Plants Adapted to Fire?

A fossilised *Banksia* cone was discovered some years ago in the Kennedy Range, 90 km east of Carnarvon and estimated to be 40 million years old. It was given the name *Banksia archaeocarpa* but its cone looks very little different from present day *Banksia prionotes* cones. This was seized on by some as evidence of a significant fire regime in WA 40 million years ago – as it is commonly thought that the woody fruits of banksias and other Australian plants are adaptations to fire.

Figure 2: Fossilised cone of *Banksia archaeocarpa* (Courtesy Ken McNamara)

There is no scientific evidence for this, however, and it is more likely that the hard leaves and fruits of Australian plants are a result of impoverished soils lacking in phosphorus.[8] [9] [10]

'Adaptation' is a word that is much used, and misused. We use it casually to describe how a person or a thing is well-fitted to its task. A comfortable seat, for example, is well designed and suits certain-sized people. A workman is 'very adaptable' and able to carry out a range of repairs – electrical, plumbing etc.

Many attributes of plants and animals are also considered to be adaptations to their environments, developing over time through the process of evolution. Shiny leaves in desert plants that reflect the sun's rays, wings and feathers that enable birds to fly, and the colours of many insects that camouflage them when on plants, are some examples.

This usage of the word obviously differs, in that it assumes the attribute has been brought about by Natural Selection - by definition, the differential survival and reproduction of only those individuals that possessed this feature.

It also implies that there was a factor militating against those individuals that did not possess the attribute – for example, very hot rays from the sun or predation by sharp-eyed birds. This is what is called the 'selective force' that has favoured the spread of the attribute through the population.

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[8] Bradshaw S D, Dixon K W, Hopper D S, Lambers H & Turner S R (2011). Little evidence for fire-adapted traits in Mediterranean Climate regions. *Trends in Plant Science*, 16, 69-76.

[9] Beadle N C W (1962). An alternative hypothesis to account for the generally low phosphate content of Australia soils. *Australian Journal of Agricultural Research*, 13, 434-442.

[10] Hopper S D (2003). An evolutionary perspective on south-west Western Australian landscapes, biodiversity and fire: a review and management implications. In: Abbott I & Burrows N (eds.) *Fire in ecosystems of south-west Western Australia: impacts and management.* Leiden: Backhuys. pp: 9-35.

Care must be taken, therefore, in not describing every difference or process as an adaptation. Plants, for example, flower when pruned, but we do not conclude they are adapted to secateurs! Similarly, some plants germinate and flower after fire, but this does not necessarily mean that they are adapted to fire.

Figure 3: An example of epicormic sprouting in the Bald Island marlock, *Eucalyptus conferruminata*, following a violent windstorm rather than fire
(From Bradshaw et al, 2011)

Epicormic sprouting has been considered as an adaptation to fire, but a violent windstorm experienced by the Bald Island marlock triggered its resprouting (see Figure 3).

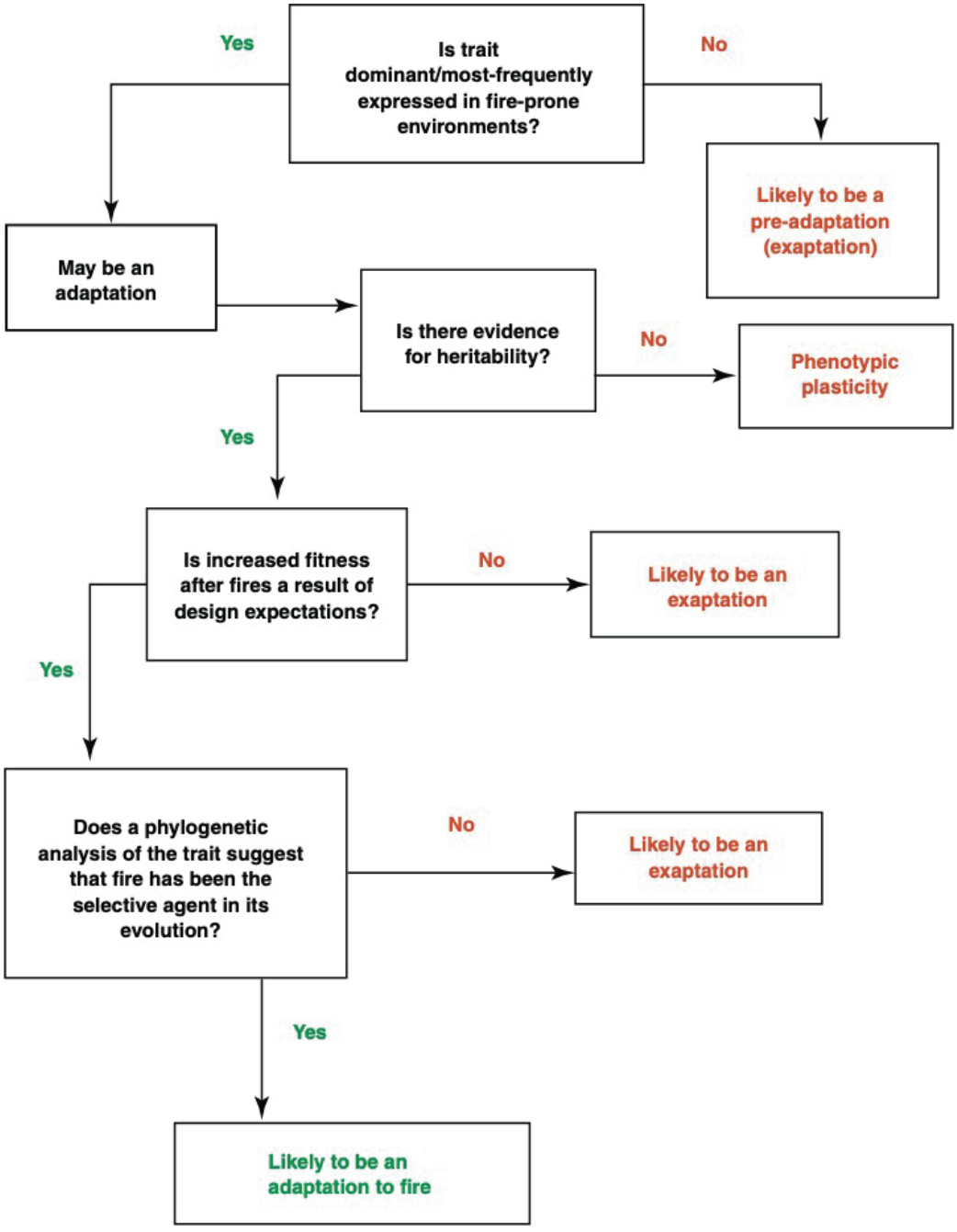
To be considered as a true adaptation, evidence is needed that the trait is heritable and that it has evolved by Natural Selection to cope with a persistent environmental pressure. This is not always easy to come by and is why the term should be used sparingly when considering the structure and function of plants and animals.

Traits that have evolved due to other environmental pressures are called 'exaptations' [11] rather than 'adaptations'. Australian plants are good examples, possessing many traits that protect them against fire, but have evolved because of other pressures.

A way to decide whether a particular trait is an adaptation, or an exaptation, is to use the following flow sheet (from Bradshaw *et al,* 2011):

[11] Gould, S. J. and E. S. Vrba (1982). "Exaptation - a missing term in the science of form." Paleobiology **8**: 4-15.

Figure 4: Flow Sheet used to decide whether a particular trait is an adaptation to fire, or an exaptation (From Bradshaw *et al*, 2011)



Current Practice of Prescribed Burning

Prescribed burning in Western Australia has its origins in forestry practice. Foresters curate a product, which is timber from trees; other plants growing in forests are potential competitors for their product. Fire has traditionally been used to reduce the level of this competition and to dispose of debris left after logging.

Charles Lane-Poole, however, who was the first Conservator of Forests in Western Australia from 1916-22, supported a total fire exclusion policy. He believed that, left to themselves, forests would achieve a point of balance at which forests would no longer burn.[12] S.L. Kessell, Lane-Poole's successor, favoured control burning of the forests, believing that it would play a large part in forest protection, as well as in silvicultural practice.

Although controlled burning in WA forests has had a long history, it was the disastrous fires in Dwellingup and Karridale in1961 that led to the establishment of the policy of regular prescribed burning with the stated intent:

"…to limit the impact of wildfires on life and property, and to protect valuable timber in State forests."[13]

It was not until 1987 that CALM[14], the Department of Conservation and Land Management (cobbled together from Department of Fisheries and Wildlife and the Forests Department) responded to criticism from environmentalists that frequent fire was damaging forest wildlife by converting prescribed burns into 'environmental burns' with the stroke of a pen:

"The Department will manage prescribed fire and wildfire on lands managed by the Department to protect and promote the conservation of biodiversity and natural values whilst also providing protection for human life and community assets."[15]

The Department's planned fires thus became 'conservation burns' with the justification that the bush 'needed' regular burning for its long-term health. The widespread belief that Australian plants were adapted to fire helped ease any consciences worried that it might prove detrimental to the flora (but see [8] above).

It has yet to be shown, however, that prescribed burning 'promotes the conservation of biodiversity'. Many would say that it does the opposite! One concern is the risk of escapes that burn more flora and fauna than planned.

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[12] Lloyd N & Krasnostein A (2005) of Conference. Historical perspectives on mosaic burning in Western Australia's southwest forests. In: Calver M C E A, ed. 6th National Conference of the Australian Forest History Society, Augusta, WA. Millpress, Rotterdam.

[13] Rodger G J (1961). Report of evidence taken by Mr. G. J. Rodger, B.Sc. appointed on the 27th April, 1961, as a Royal Commission to inquire into and report upon bush fires in Western Australia. Perth, Western Australia: Government Gazette, Perth, Western Australia.pp:734.

[14] CALM has morphed over the years, first to the Department of Environment and Conservation (DEC); then to the Department of Parks and Wildlife (DPAW), then to its latest incarnation, the Department of Biodiversity, Conservation and Attractions (DBCA)!

[15] CALM Annual Report(1987).

Five examples of 'escaped burns'[16]

Layman Forest

The Layman forest, containing two National Parks, 25 km southwest of the town of Nannup, was subject to a DEC planned fire in spring 2010 with ignition occurring on the 16th and 19th of October 2010. DEC's advertised primary objective for the fire was biodiversity conservation with specific reference made to the Critically Endangered (CE) Western ringtail possum (*Pseudocheirus occidentalis*) and two species of fish: the Vulnerable (V) Balston's pygmy perch (*Nannatherina balstoni*) and the Critically Endangered (CE) Western mud minnow (*Galaxiella munda*).[17]

DEC planned to burn a total of 9,772 ha. In addition to the primary purpose, a secondary purpose was strategic protection of nearby housing developments. The intention was to burn 60 – 80% of the riparian and forest areas of *Agonis flexuosa* (peppermint), a species associated with the Western ringtail possum and in so doing "*reduce the risk of a wildfire negatively impacting on the possum population in the two national parks*".[18]

DEC predicted that burning the riparian vegetation at lower intensities than would occur in a summer wildfire would have less of an impact on the vegetation fringing the streams and therefore be less damaging to the two fish species[19].

DEC planned for less than 30% crown scorch across the total forested area (DEC, Prescribed Fire Plan, Layman Ballan, 2007). A cost of $74,373 was attributable to this planned burn. The result:

- The fire burned with a far greater intensity than was predicted and escaped. The total area burned was 12,272 hectares
- More than 90% of the riparian area containing *Agonis flexuosa* was burned and approximately 70% of the forest canopy was fully crown scorched
- **The total cost of the burn and its consequences was $647,982**

The two National Parks are known to provide nesting and feeding habitat for locally endemic and endangered Black Cockatoo species as well as Western ringtail possums (*Pseudocheirus occidentalis*), Quenda (*Isoodon fusciventer*) and Western brush wallabies (*Notamacropus irma*). DEC was also aware of Declared Rare Flora, *Daviesia elongata* and seven species of Priority Flora; *Acacia tayloriana, Astroloma sp. Nannup, Chordiflex gracilior, Hybanthus volubilis, Leptinella drummondii, Darwinia* sp and *Eucalyptus relicta*.

This escaped prescribed burn had a significant detrimental effect on the habitat values of the two National Parks and it will take many years for the forest to recover.

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[16] Details from WAFA Report, 'Who is held Accountable' June 2014, pp21.

[17] DEC, Prescribed Fire Plan, Layman Ballan, 2007.

[18] Hansard: WA Legislative Council, Question on Notice, 2010, p9835.

[19] Hansard: WA Legislative Council, Question on Notice, 2010, p9836.

Fly Brook Forest Block

Fly Brook Forest Block ,15 km west of Pemberton, was subject to a planned burn by DEC in the spring and summer of 2010. They planned to burn 8,328 ha for 'strategic protection' purposes - specifically, the protection of private property, tourism infrastructure, and regrowth of forest, by applying 'fire under prescribed conditions'.

The secondary purpose according to prescription documents was to '*protect and maintain biodiversity values and ecological processes... to achieve a mosaic of fire intensities of burnt and unburnt areas at both a landscape and local scale*'...[20] The result was quite the opposite.

- The prescribed fire escaped into the adjoining D'Entrecasteaux National Park, burning a total 23,442 ha, nearly three times the intended area.[21]
- During the fire, supplies had to be airlifted to people staying in huts on both sides of the Donnelly River who were stranded when the fire burned uncontrolled over the river threatening the huts and cutting off accesses.
- The fire burned at high intensities through more than 15,000 ha of highly biodiverse and ecologically significant bushland.
- **The cost to the taxpayer was $1,273,777.**

The burnt area is known habitat for the threatened mainland quokka (*Setonix brachyurus*). At the time, the mainland quokka was listed as 'Vulnerable' and 'Fauna that is likely to become extinct or is rare'. No details were provided but mortality of quokkas because of the fire was significant and DEC informed the WA Parliament in 2011 that post-fire monitoring of the quokka population would be carried out.

The results of any such monitoring have not been published, but some indication of the probable mortality of quokkas can be gauged from a later Northcliffe wildfire in the summer of 2015. This affected an area of 98,000 ha and resulted in the loss of 77% of known sub-populations of quokkas and the loss of approximately 500 individuals.[22]

It is arguable that the financial cost of the fire, exceeding $1.27 million, might have been better spent on improved response times, safer and more effective use of fire in more appropriate locations, and improved management.

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[20] DEC, Fly Brook DP 008, Aug 2010

[21] Hansard: WA Legislative Council, Question on Notice, No. 4248, 2011

[22] Bain K, Halley M, Barton B, Wayne A, McGilvray A, Wilson I & Wayne J (2016). Survival of quokkas in the 2015 Northcliffe bushfire: understanding the impact of intense and broadscale fire on an important population of quokkas in the southern forest of Western Australia. Perth, WA: WWF-Australia

Figure 5: D'Entrecasteaux National Park scorched by DEC escaped prescribed burn 2010

Margaret River region/Gnarabup bushfire

The bushfire that devastated swathes of Margaret River's iconic coastline over several days in November 2011 stunned and dismayed Western Australians. These feelings were intensified by the knowledge that the wildfire arose from a prescribed burn being undertaken by DEC that was reignited in hot and windy weather. The burn was planned and implemented with the intention of protecting the various communities that were at risk from a large wildfire, but had the opposite effect. Fortunately, no lives were lost.

More than 3,400 ha of coastal heathland and bush were burnt, and 32 houses, including historic Wallcliffe House (see below), nine chalets and four outbuildings were destroyed.

The State Government commissioned Mr Mick Keelty AO to report on the fire and its causes and he concluded that

'…prescribed burning was a complex task and despite exhaustive planning, the implementation of the prescribed burn did not fully take into account the risks associated with re-ignition of the prescribed burn through a flare-up and 'escape' of the fire. With the benefit of hindsight, planning and operational decisions did not adequately take into account the forecast weather conditions for 23 November 2011…'

The Keelty Report (Keelty, 2011)[23] acknowledged that serious mistakes had been made, such as the lack of monitoring of the Ellen Brook burn, particularly through the night on 22 November, and the decision to commence another prescribed burn nearby at Prevelly, using incendiaries dropped by helicopter, despite the challenges being faced with the Ellen Brook burn.

On 23 November 2011, a fire broke containment lines from a prescribed burn in

[23] Keelty, M. J. (2011). Appreciating the Risk: Report of the Special Inquiry into the November 2011 Margaret River Bushfire, WA Perth, WA, WA Government.

Leeuwin-Naturaliste National Park, forcing hundreds to evacuate their homes. Approximately 300 people were expected to register at the Margaret River Cultural Centre. Residents were forced to evacuate over a three-day period, with some residents whose homes remained intact, were unable to return home due to pollution from asbestos and other contaminants spread by the fire. The fire was finally brought under control on 26 November 2011.

Figure 6: Post-fire landscape at Gnarabup

FIgure 7: The remains of historic Wallcliffe House

Much of the Margaret River fire destroyed large tracts of coastal heathland in Gnarabup that supports a rich bird, reptile and invertebrate fauna. Moving away from the coast, large areas of peppermint forest (*Agonis flexuosa*), which is the preferred habitat of the Critically Endangered Western ringtail possum (*Pseudocheirus occidentalis)*, were also destroyed. The Keelty Report makes no mention of damage to wildlife but Ms Uta Wicke, President of the Possum Centre in Busselton, estimated that 90% of the possum population was killed by the fire. Approximately 20 badly- burned possums were found alive by rescue workers, but most of these needed to be euthanised because of the extent of their injuries.

The Ellenbrook area also contains a Threatened Ecological Community (TEC) that had not been burnt since 1982. One Declared Rare flora species, *Caladenia excelsa*, and four Priority flora species (*Acacia subracemosa, Bossiaea disticha* and *Banksia sessilis* var *cordata*) also occur in the area but there are no data available on the impact of the fire.

Millyeannup Coastal Burn 2011

Figure 8: Coastal heath prior to prescribed burn (Figs 8 and 9 courtesy Beth Schultz)

Unlike the quite small Margaret River wildfire, which burnt more than 3,400 hectares of mainly Crown land and destroyed 32 homes, the massive **Milyeannup wildfire burnt 58,128 ha, 6,555 ha in the prescribed burn and 51,573 ha in the escape**. It got no public attention because it burnt mainly bush.

The cost to taxpayers of the Margaret River/Gnarabup and Mileannup fires was $4.191 million (excluding normal time payroll) as at May 31 2012

Figure 9 Scorched landscape after fire

Weinup block, adjacent to Perup Nature Reserve

(DON_100 block)

Figure 10: A numbat in characteristic watching pose

On 25 April 2021, a fire lit by DBCA in the Weinup block, adjacent to Perup Nature Reserve, was catastrophic for the numbat and its habitat. A very hot burn, lit by incendiaries dropped from a helicopter, destroyed approximately 5,000 habitat trees and completely burned the fallen logs housing the termites on which the numbats feed, leaving any surviving animals without food, cover and protection from predators.

It is noteworthy that the fire proceeded against the recommendation of DBCA's own Threatened Species Committee.

Figure 11: Photographs showing burn intensity

Figure 12: Complete incineration of large trees

Figure 13: Flight path of the helicopter dropping incendiaries

The fire was planned at the most critical ecological time for the species and shows a fundamental lack of appreciation of numbat biology. A spokesperson from DBCA stated:

'…the burn was undertaken outside the period where numbats have young in their dens, so the younger animals were mature enough to access refuge areas during and after the fire...'

Numbats mate in January and give birth to young two weeks later. The young remain with the mother and in the den until July and they are not weaned until late October or November (Power *et al.*, 2009).

The fire, in late April, thus coincided with the time that all the females were carrying young, which would have been killed along with their mothers.

Inspections of the site post-burn by Fire and Biodiversity WA found only one marker of a historic numbat den, which was partially burnt, and no evidence of raking or other measures to protect the den. It is therefore considered highly unlikely that the advice from DBCA to the Premier that '…*all known numbat dens that DBCA and adjacent property owners identified prior to the burn were protected*…' is correct.

Satellite imagery prior to and following the burn, using short wave (bare earth) and near infrared (chlorophyll) satellite imagery from Sentinel 2 (see below), enable a measure of the intensity of the burn.

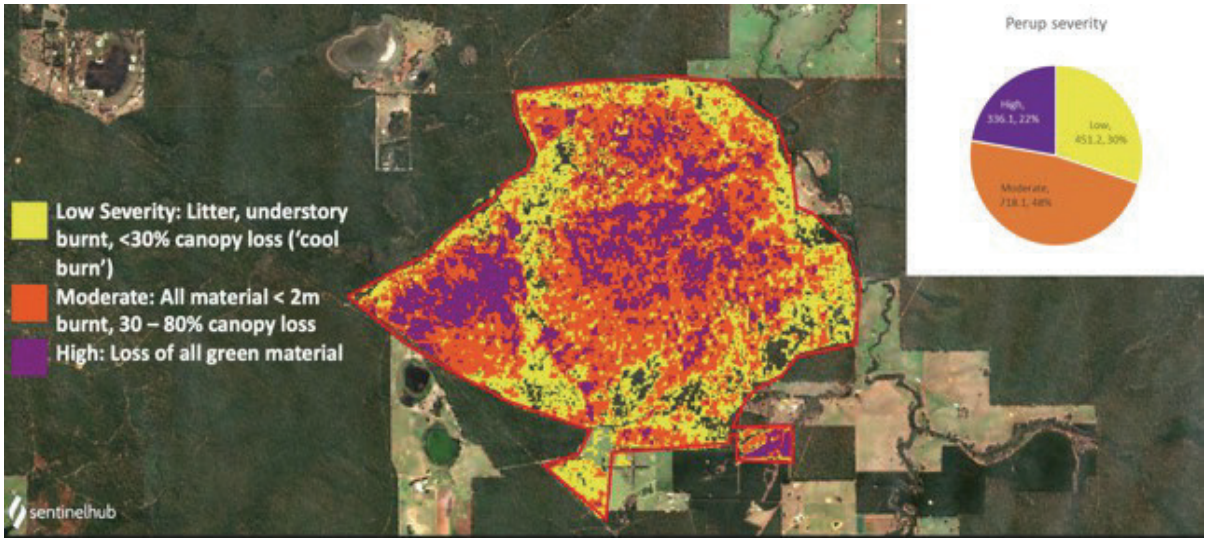

Figure 14: Image obtained by satellite showing the severity of the Weinup Block burn (Courtesy Tristan Campbell)

When the post-burn satellite image is analysed, it shows 22% of the area experienced a high intensity burn (equivalent to a catastrophic level fire), with complete loss of all

green material. A further 48% was moderate, with 30-80% of the canopy lost.

There was intense media interest in the fire and much speculation over the fate of the numbats. It was clear that the size of the numbat population had not been assessed prior to the fire and DBCA agreed to undertake an internal investigation. In a letter to The Leeuwin Group from the Minister, she noted:

'…During the implementation of the burn, there were some areas that experienced higher levels of fire intensity than were planned for. …In this particular case, ***sections of the burn did not go as planned*** *and* ***lessons learnt*** *from the operational review and ongoing forest monitoring will be incorporated into future operations, consistent with DBCA's adaptive management approach*[24] *…'*

A full analysis of the fire and its impact is given in the published report by Runham *et al* (2022)[25].

Numbats are listed on the IUCN's Red List of Threatened Species. The species is one of the world's rarest mammals and has been the focus of an intensive multi-decadal breeding programme at Perth Zoo, aimed at returning animals to their natural habitat.

In 2014 its conservation status was elevated to 'Endangered' with an estimated total population of fewer than 1000 individuals in the wild.[26]

For one of the world's rarest mammals and at the highest level of threat, the actions of DBCA show the critical importance of the Key Threatening Process (KTP) and a Threat Abatement Plan (TAP) as a vital 'check and balance' in the system.

Despite promises of "lesson learnt", similar ignition patterns and thermal impacts continue to be deployed throughout the southwest forests.

In 2024 there were 21 prescribed burns in the southwest forest regions for which the Minister for Environment gave DBCA authorisation to kill any number of 21 listed threatened species, including numbats, quokkas, woylies, Western ringtail possums, chuditch and cockatoos. DBCA has no idea how many animals are killed because it rarely if ever does surveys before or after burns.

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[24] Letter dated 30 June 2021 from the Minister the Hon Amber-Jade Sanderson MLA to Emeritus Professor S.D.Bradshaw

[25] Runham P, Neville S, Campbell T, Hewitt P, Lebbing B, Murray S, Bailey J & Chappelle C (2022). *Analysing the Wildlife Toll of Prescribed Burning Practices in Southwest WA*. . Denmark WA.: Humane Society Internationale.pp:28

[26] Woinarski, J.C.Z., A. Burbidge, and P.L. Harrison. The Action Plan for Australian Mammals 2012. Collingwood, Victoria: CSIRO Publishing, 2014.

Impact on Flora and Fauna of Frequent Burning

The impact of fire on an ecosystem is complex. All parts of the plant are food for animals, as well as providing shelter. The Honey possum is one example that is totally dependent on flowers for food – it eats only pollen and nectar, and principally from species of banksia.

Plants

- A study of flowering and fruiting of *Banksia baueri, B. nutans* and *B. baxteri* in Kwonkgan heathland on the southwest coast of Western Australia showed that all three were extinguished from an area that was burnt twice at an interval of nine years[27]. *Banksia sessilis* flowers freely three to four years after fire but does not set seed until eight years after fire and reaches maximum honey production only after 12-15 years[28]. Burning on a four-year cycle in Kings Park in central Perth led to the demise of Banksia trees and the abandonment of the practice[29].
- Burning at three- or four-year intervals resulted in significant reduction in the abundance of key obligate seeder species in the southwest such as *Acacia browniana* and *Crowea angustifolia*[30].
- Young karri trees (*Eucalyptus diversicolor*) are fire sensitive for up to 25 years[31].
- In jarrah (*Eucalyptus marginata*) and other forests, research suggests prescribed burning on a 5–7-year rotation is likely to permanently simplify the litter flora and invertebrate fauna, with far-reaching effects on forest hygiene[32].
- The Critically Endangered Quairading banksia, *Banksia cuneata,* was subjected to a 'regeneration' burn when it was thought by some (but not all) botanists that the

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[27] S. J. Wooller, R. D. Wooller, K. I. Brown, Regeneration by three species of Banksia on the south coast of Western Australia in relation to Zire interval. Australian Journal of Botany 50, 311-317 (2002).

[28] B. G. Muir, in Fire Ecology and Management in Western Australian Ecosystems, J. Ford, Ed. (Western Australian Institute of Technology, Perth, 1985), pp. 119 -128.

[29] G. Wells, S. D. Hopper, K. W. Dixon, "Fire regimes and biodiversity conservation: A brief review of scientific literature with particular emphasis on southwest Australian studies," (Environmental Protection Authority, Perth, Western Australia, 2004).

[30] N. Burrows, G. Wardell-Johnson, in Fire in Ecosystems of south-west Western Australia: Impacts and Management, I. Abbott, N. Burrows, Eds. (Backhuys Publishers, Leiden, 2003), pp. 225-268.

[31] B. G. Muir, in Fire Ecology and Management in Western Australian Ecosystems, J. Ford, Ed. (Western Australian Institute of Technology, Perth, 1985), pp. 119 -128.

[32] A. York, Long-term effects of frequent low-intensity burning on the abundance of litter-dwelling invertebrates in coastal blackbutt forests of southeastern Australia. Journal of Insect Conservation 3, 191-199 (1999)

few plants left were showing signs of senescence. The fire was lit by the then Department of Environment and Conservation (DEC).

All the mature plants were killed by the fire; there was little regeneration from seed and all of the few seedlings died over the following summer. [33]

Figure 15: The Critically Endangered Quairading (Matchstickl) Banksia (photo Don Bradshaw)

[33] Lamont, Byron B.; Connell, Stephen W.; Bergl, Stephen M. (1991). "Seed bank and population dynamic*Banksia cuneata*: The role of time, Zire and moisture". Botanical Gazette. 152 (1): 114–22.

Animals

Tammar and Woylie

Figure 16: The tammar wallaby*, Notamacropus eugenii*

Figure 17: The Woylie*, Bettongia penicillata*

Proponents of prescribed burning have long maintained that some species of marsupials depend on recurrent fire for their long-term survival. The best known is a study by Per Christensen from CALM of the impact of fire on the Tammar wallaby (*Notamacropus* (formerly *Macropus*) *eugenii*)) and the Woylie (*Bettongia penicillata)*.[34]

The study showed that tammars were agile at avoiding fire, returned to the burnt area soon after, and concluded that

'… It lives in thickets of scrub species which provide periodic intense fires under dry conditions to regenerate as suitable habitat. A fire frequency of 25 to 30 years is necessary to maintain populations of this species…'

This pivotal study recorded the behaviour of radio-tagged tammars and woylies to a deliberately lit fire in the State Forest east of Manjimup. Initial mortality was low and both species remained within their home ranges, escaping the fire either by seeking refuge on small unburnt patches or, to the amazement of the fire fighters, by deliberately doubling back through the flames. Post-fire, the woylies remained within their burnt-out home range, feeding on hypogean fungi whilst tammars fed largely on grasses, but recolonization of the post-fire plant succession was slow.

[34] Christensen P E S 1980. The biology of *Bettongia penicillata* Gray, 1837, and *Macropus eugenii* (Desmarest, 1804) in relation to fire. Perth, WA: Forests Department of Western Australia, Bulletin 91. pp:90

Per's work was responsible for the paradigm that tammars and woylies were 'fire-dependent species', with periodic fire needed to maintain seral stages of the vegetation essential for their survival. In the case of tammars, the ideal habitat was thought to be a closed canopy of heartleaf (*Melaleuca viminea*) that was open and clear at ground level and maintained by a fire interval of 20-25 years.

Figure 18: Melaleuca viminea, thought to be the preferred habitat of the tammar

As the forest at that time was being burned on a 5-7 year cycle the tammar is better described as 'infrequent fire dependent' rather than 'fire dependent'.

Although only one animal was recorded as dying in the fire, post-fire mortality of the two species was very high.

33 woylies died post-fire, with 17 (51%) killed by foxes.
41 tammars died post-fire, with 7 killed by foxes and 5 by Wedgetail eagles.

Twenty five (56%), however, died from 'shock syndrome', which rendered them partially paralysed. Tammars were also found in traps with fore- and hind-limbs paralysed and with dilated pupils. Similar changes associated with shock and restraint have been described in eutherian mammals.

This is one of the few studies where post-fire mortality was documented but shows that post-fire studies are essential when the full impact of prescribed burning is being assessed.

Quokka

The other species claimed to be 'fire dependent' is the quokka, *Setonix brachyurus*. Once so abundant in the southwest of WA that it was gazetted a pest, they were found dying in their thousands in the 1930s from an unknown cause. Quokkas were thought to have survived only on two offshore islands, Rottnest and Bald Island.[35]

Figure 19: Quokka with young

[35] Abbott I (2006). Mammalian faunal collapse in Western Australia, 1875-1925: the hypothesised role of epizootic disease and a conceptual model of its origin, introduction, transmission, and spread. *Australian Zoologist,* **33,** 530-561.

In 1957, however, a small population was rediscovered in Byford, close to Perth,[36] and subsequently, other populations were found deep in the southwest forests.
Regular prescribed burning was implemented by DBCA to manage quokka habitat in the northern WA forests.

Burrows & McCaw (2013)[37] state that

'…vegetation that has died back and collapsed, usually about 20-25 years after fire, is unsuitable habitat for quokkas…' They recommended a 6-8 year burning cycle to maintain the dense thickets.

Bain *et al.* (2015)[38] reported that quokkas in the southern Tingle forest favoured areas with an understorey of *Lepidosperma*, which forms as the forest 'self-thins' many years after fire. Paradoxically, they go on to say:

'However, quokkas occupied habitat with vegetation ages ranging between six months and 50 years and did not show any preference for particular age categories...'

Their data for this are shown in the following figure, where the numbers of sites occupied and unoccupied by quokkas are given for areas ranging in vegetation age from 0.5 to 50 years.

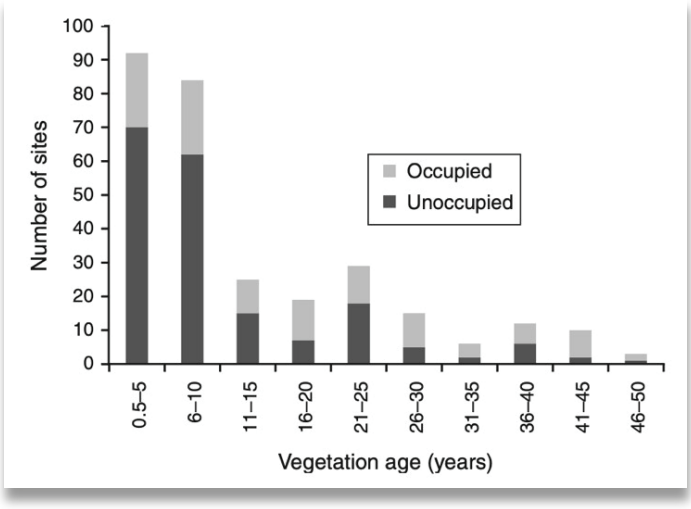


Figure 20: Figure 3 from Bain *et al* (2015) showing habitat preferences by quokkas as a function of fuel age

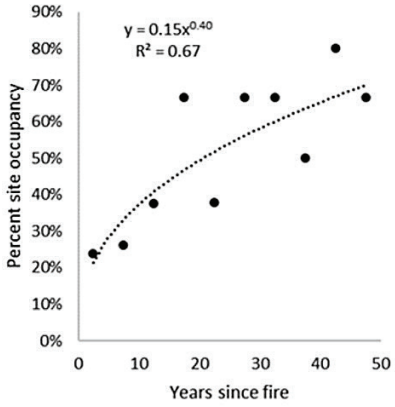
The appropriate way to interpret these data for site preference is by plotting the ratio of occupied to unoccupied sites as a function of vegetation age.

[36] Barker S, Main A R & Sadlier R M F S (1957). Recent capture of the quokka (*Setonix brachyurus*) on the mainland. *Western Australian Naturalist,* **6,** 53-55.

[37] Burrows N & McCaw W L (2013). Prescribed burning in southwesten Australian forests. *Frontiers in Ecology and the Environment,* **11,** 25-34.

[38] Bain K, Wayne A & Bencini R (2015). Risks in extrapolating habitat preferences over the geographical range of threatened taxa: a case study ofthe quokka (*Setonix brachyurus*) in the southern forests of Western Australia. Wildlife Research, 42, 334-342.

Dr Phil Zylstra digitised the data in Bain's paper and showed that the percent occupancy of sites of varying age gives a very different picture (see Figure 21).



Habitat occupancy of quokkas significantly increases with years since fire, peaking at 70- 75% 30-40 years after fire. Prescribed burning the forest at a 6–8-year interval would thus generate a thick and flammable undergrowth that is *not* preferred by the quokkas - the reverse of the recommendation by Burrows & McCaw (2013).

Figure 21: Data from Figure 20 expressed digitally

All three species, tammar, woylie and quokka, which have been classified by CALM and DBCA as 'frequent fire-dependent species' (in the sense that they prefer a densely thicketed habitat that is maintained by frequent fire), are more correctly classified as 'infrequent fire dependent'.

Burning of banksia woodland at frequencies less than 16 years has also been shown to disadvantage a mixed reptile fauna with many species absent or diminished at current fire frequencies (6-12 years).[39] A similar pattern is seen with many birds.

Honey possum: a long-term study

Figure 22: Honey possums *(Tarsipes rostratus)* on *B. prionotes*. Photo, John Morhall

[39] L. E. Valentine, A. Reaveley, B. Johnson, R. A. Fisher, B. A. Wilson, Burning in banksia woodlands: how does the fire-free period influence reptile communities. PLOS ONE 7, e3448 (2012).

Mapping population densities of this species over 10 years first alerted us to the danger of the short burning cycle being imposed by DBCA. The tiny 10 g marsupial Honey possum, *Tarsipes rostratus,* is the only non-volant vertebrate that completely depends on nectar and pollen for its survival. Field studies using isotopic turnovers in free-ranging individuals have shown that a 9 g adult consumes 7 mL of nectar and 1 g of pollen per day (virtually its own body mass!). It is essentially ground dwelling, does not burrow or form nests, and is thus extremely vulnerable to fire.[40]

Our study area was located on both sides of Scott River Road, with traplines leading into stands of *Banksia ilicifolia* growing on low sand dunes in ridges through the bushland

Figure 23: Map showing the location of our study site in Scott National Park (from Bradshaw et al (2007)

In November 1993, a local farmer lit a fire that jumped into the National Park and threatened to spread to the populated Molloy Island. CALM decided to avoid this by backburning the Park north of Scott River Road (shown crossing the Park in the above Figure). This effectively killed half our study population of Honey possums.

Remonstrations with the then Director General of CALM, Dr Syd Shea, were met with the response that "they had no idea we were studying Honey possums there." This was despite the fact that we were required to submit a written report to CALM every time we entered and worked in the Park! A spirited discussion between myself and Dr Shea on television ended in a truce with the promise that, if it ever happened again, we would be given warning.

It did happen again, six years later in April 1999 (the same farmer!), and CALM did warn us this time. Honey possums were again incinerated on the north side of the Park,

[40] S. D. Bradshaw, F. J. Bradshaw, Field energetics and the estimation of pollen and nectar intake in the marsupial honey possum, *Tarsipes rostratus*, in heathland habitats of south-western Australia. J. Comp. Physiol. B 169, 569-580 (1999).

leaving our study site consisting of two adjacent areas, one with a population of animals and the other bereft. We had been given a rare opportunity to study how long it would take for the population in the north side to reach its former level, after a fire-free interval of six years (so long as there were no more fires!).

The next Director General, Kieran McNamara, was much more accomodating and very interested in knowing the impact of fire on the fauna. He gave me a personal assurance that the Park would be protected from prescribed burning whilst our study progressed.

We were thus able to carry out the only long-term longitudinal study of the effect of a six-year fire regime on a native animal species in WA.[41]

The following Figure traces the gradual recovery of the population of animals in the burnt area over a 17-year period since the second fire in April 1999. Data are plotted as the ratio of individual recapture-per-unit-effort rates for burnt/unburnt areas as a percentage.

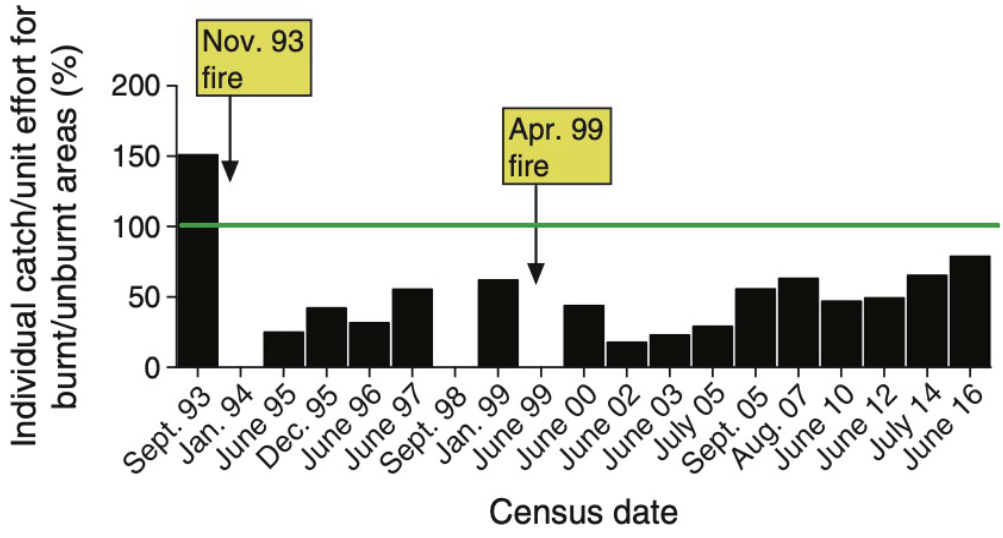


Figure 24: Capture records of Honey possums in Scott National Park from 1993 to 2016 (from Bradshaw & Bradshaw 2017)

Recovery was relatively rapid after the first fire, reaching 60% after six years, but was slower after the second fire.

From these data it is possible to estimate how long it will take for the population to return to pre-burn levels. Estimates can be made from both capture rates (catch per unit effort) and from densities.

[41] S. D. Bradshaw, F. J. Bradshaw, 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 (2017).

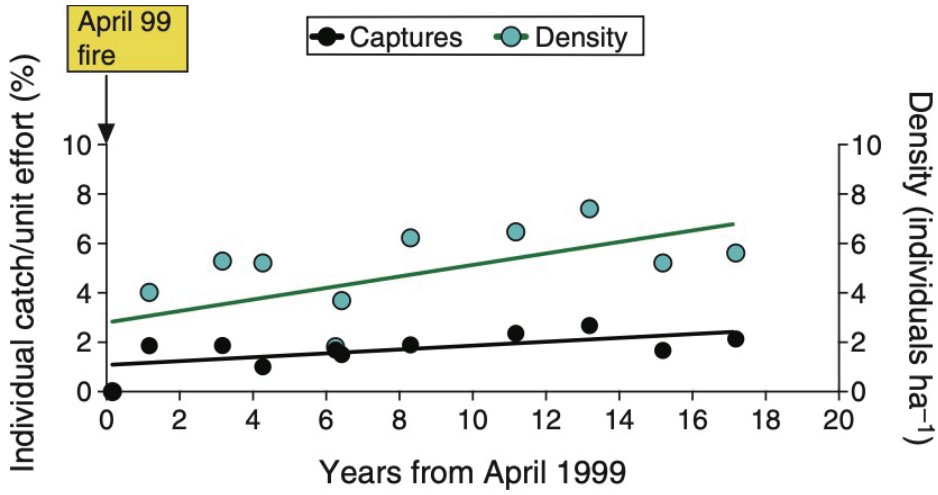


Figure 25: Regressions of catch/unit effort and density data for Honey possums in Scott National Park since the 1999 fire (from Bradshaw& Bradshaw, 2017)

Two regressions are shown in Figure 25 and give estimates of 30.3 years for capture rates and 20.9 years for densities, with an average of 25.6 years.

One can only speculate that, had there been a third fire in 2005, mimicking the current prescribed burning practice of six-year burns, the Honey possum population would probably have crashed entirely.

Effect on *Banksia ilicifolia*

We suggest that the slower recovery after the second fire may also be from the indirect impact of fire on *Banksia ilicifolia* trees, the primary source of food for Honey possums in Scott National Park, which show widespread infection with the fungus *Phytophthera cinnamomi.* We recorded the number of trees in both Sites for 10 years. Our data records of 'alive vs dead' trees (see Table1), show there are many more dead trees in the burnt than the unburnt area (x^2 = 47.09, P<0.001). This suggests strongly that fire exacerbates the effect of the fungal infection.

Burning also exacerbates dieback

Status of *Banksia ilicifolia* trees in study area in 2016

Area	Alive	Dead	A/D Ratio
Burnt	70	103	0.68
Unburnt	86	18	4.77

X^2 = 47.09 P<0.001

Table 1: Showing proportion of live and dead Banksia ilicifolia trees in burnt and unburnt areas in Scott National Park

Honey possum densities in other populations

An extensive trapping survey in banksia woodland 30 km north of Perth found *Tarsipes rostratus* to be the most common of the nine native species recorded, and densities were greatest in areas that had not been burned for 20–26 years.[42]

In the Fitzgerald River National Park on the south coast of Western Australia, capture rates of Honey possums increased to a peak 30 years after fire, with a slight decline in vegetation unburnt for 50–60 years.[43]

Mardo

Another small marsupial, the litter-dependent mardo, *Antechinus flavipes*, is also most abundant in habitats that have not been burned for 40 years and very rare in forests that have been burned five years previously. Christensen & Kimber[44] note

'… population levels are generally very low in the regularly burnt habitat…' and the '… study in dry sclerophyll forest demonstrated the preference of the mardo for an area from which fire had been excluded for a long period...'

Western Ringtail possum: a Critically Endangered marsupial

Figure 26: Western Ringtail possums (*Pseudocheirus occidentalis*), (Photo courtesy DPaW Busselton)

The Critically Endangered Western Ringtail possum, *Pseudocheirus occidentalis, (ngwayir)* is particularly vulnerable to fire as it is a slow-moving canopy-living folivore with a preference for highly flammable oil-rich peppermint trees in which it builds nests, known as 'dreys'.

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[42] B. A. Wilson, J. Kuehs, L. E. Valentine, T. Sonneman, K. M. Wolfe, Guidelines for ecological burning regimes in Mediterranean ecosystems: a case study on Bankisia woodlands in Western Australia. Pacific Conservation Biology 20, 57-74 (2014).

[43] R. D. Wooller, S. J. Wooller, *Sugar and Sand: The World of the Honey Possum*. (Swanbrae Press, Perth, WA, 2014), pp.112.

[44] Christensen P E S & Kimber P C (1975). Effect of prescribed burning on the flora and fauna of south-west Australian forests. Proceedings of the Ecological Society of Australia, **9**, 85-106

A recent study by my friend and colleague, Dr Phil Zylstra, showed how even slow-moving 'cold' burns can prove disastrous for this species.[45]

The population under study contained 22 individuals in an urban reserve at Warrungup Spring, about 80 km south of Perth, near Mandurah. All details of this population were collected by Alison Dixon, a wildlife relocator with more than 20 years' experience working with *ngwayir* (Ring-tailed possum). The population was composed of 17 original individuals and five that had been relocated four years earlier from a development site, 200 m away. The population was established and breeding in a mature remnant patch of Critically Endangered tuart, *Eucalyptus gomphocephala,* and banksia woodland.

On 16th May 2018 DBCA burnt the reserve with the intention of reducing bushfire threat. The light-up pattern focused on patch-burning around *balga* (grass trees). It was conducted in two stages: *balga* skirts (thatch of hanging dead foliage) were ignited individually, then the surrounding vegetation was ignited using a drip torch.

Fire management guidelines for *ngwayir* recommend that a proportion of balga skirts are left *unburnt* to address the second-order effect arising from habitat quality.

First-order effects from the prescribed burn were assessed in a post-fire survey on the evening following the burn, and each subsequent evening for two weeks. The results of the survey were:

- Seventeen individuals were unaccounted for.
- In some cases, bodies of individuals were found, and the presence of flies in higher nest hollows indicated bodies that could not be physically checked.
- Surveys of surrounding property and structures were also conducted over this period to determine whether animals had fled the fire ground, but no survivors were identified.
- No missing individuals were observed to return during the continued weekly monitoring of survivors, and the final direct mortality was determined to be 17 of the 22 individuals, or 77% of the population.

By all accounts this was a 'cool burn', so what went wrong?

Figure 27:
An incinerated Western ringtail possum following the 'cool burn' in Warrungup Springs Nature Reserve in 2018.
(Photo, Alison Dixon)

[45] Zylstra P (2023). Quantifying the direct fire threat to a critically endangered arboreal marsupial using biophysical, mechanistic modelling. *Austral Ecology,* **48,** 1-23.

Modelling fire behaviour

To analyse the causes of the fatalities, Phil used a computer programme he has developed called FRaME, which stands for 'Fire Research and Modelling Environment'.

The programme first models the fire behaviour expected for the event, then the resulting first-order effects on the *ngwayir* (see Figure 28).

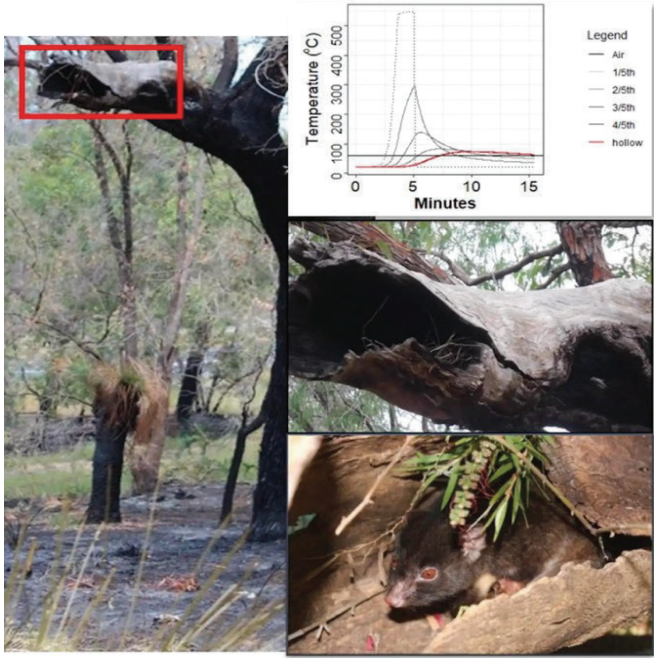

Figure 28: Temperature briefly reached over 500 °C in the tree hollow located above the grass tree (from Zylstra, 2023)

Modelling fire behaviour requires information on the forest structure and species composition, together with the terrain of the site and the weather conditions that were present during the burn. What is known as 'Byram's Fire Intensity' is often calculated as a metric for decision-making in fire management, as it ostensibly represents the heat output of the fire.

The core issue, however, is that there was no mechanistic relationship between Byram's intensity and the effect fire has on a possum drey, or tree hollow located several metres above the ground.

Slow moving 'cool' fires produce jets of very hot vertical flames when they encounter a grass tree (*Xanthorrhea preissii*). If these lie below a possum drey or tree hollow, the rapid rise in temperature will prove lethal for any possum sheltering there.

The figure from Phil Zylstra's paper shows that temperatures in the tree hollow would have reached as high as 500°C, however briefly, and incinerated any possum sheltering above.

Birds

Splendid Fairy wren

Splendid Fairy wren, *Malurus splendens,* was studied by Ian Rowley and Mike Brooker, who found that optimum densities require fire intervals of at least 12 years between fires. In addition, these must not occur during the winter/spring breeding season. [46]

Figure 29: Splendid Fairy Wren

Red-winged Fairy wren

Figure 30: The Red-winged Fairy wren

The results were similar for the Red-winged Fairy wren, *Malurus elegans,* studied by Eleanor Russell and Ian Rowley. They documented the long-term impact of an escaped prescribed burn in 1998 on a population of wrens living in karri forest close to Manjimup.

The authors concluded: *"Our estimates suggest that in this 7-to-9-year cycle, populations would not recover to their pre-fire levels. If fires recur consistently at this interval, populations will decline with each successive fire and eventually disappear."*[47]

Mallee fowl

The endangered Mallee Fowl, *Leipoa ocellata,* is particularly fire sensitive, with optimal fire intervals of 20- 40 years for mallee heath and >55 years for mallee vegetation having been identified for their long-term survival.[48]

Figure 31: Mallee fowl

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[46] Rowley, I. and M. G. Brooker (1987). The response of a small insectivorous bird to fire in heathlands. *Nature Conservation: The Role of Remnants of Native Vegetation*. D. A. Saunders, Arnold, G.W., Burbidge, A.A. & Hopkins, A.J.M. Sydney, Chipping Norton: Surrey Beatty**:** 211-218.

[47] Russell, E. and I. Rowley (1998). "The effects of fire on a population of red-winged Fairy-wrens *Malurus elegans* in Karri forest in southwestern Australia*." Pacific Conservation Biology* **4**: 197-208

[48] Parsons, B. C. and C. R. Gosper (2011). "Contemporary fire regimes in a fragmented and an unfragmented landscape: implications for vegetation structure and persistence of the fire- sensitive malleefowl." *International Journal of Wildland Fire* **20**: 184-194.

Carnaby's cockatoo

The iconic Carnaby's cockatoo is another species facing an uncertain future. Perth Zoo was inundated with starving cockatoos in November 2024 following an extensive prescribed burn of banksia woodland by DBCA that destroyed a large area of flowering banksias.

Carnaby's White-tailed black cockatoo, *Zanda* (formerly *Calyptorhynchus*) *latirostris*, migrate to the Wheatbelt to breed, where they rely on hollows in old eucalypt trees for nesting. Hollows are rare and often used by other birds, and by feral bees. Old marri trees with hollows, used by Black cockatoos for breeding, average 220 years in age and need to be protected against fire.[49]

Figure 32: Carnaby's cockatoo

The reliance of many iconic Australian fauna species on long-unburnt habitat for their survival is summarized in the following table:

[49] Johnstone, R. E., et al. (2013). "The breeding biology of the Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* Gould in south-western Australia. I. Characteristics of nest trees and nest hollows." *Pacific Conservation Biology* **19**: 121-14.

Table 2: Critical fire interval for long-term survival of iconic fauna species in Western Australia

Species	Critical Fire Interval
Tammar wallaby	25-30 years
Woylie	25-30
Honey possum	25.6
Quokka	30-40
Western Ringtail possum	>11
Numbat	25-30
Splendid Fairy-wren	>12
Red-winged Fairy-wren	>12
Mallee Fowl	20->55

Does Prescribed Burning Prevent Wildfire?

Given the dependence of so many species on keeping fire away from their habitats, it is reasonable to ask: how effective is prescribed burning in preventing wildfires?

Repeated requests to Government Ministers over the past decade have routinely been answered by citing a study by Mattius Boer and colleagues on the incidence of fire over a 52-year period in the Warren district of southwest WA. The paper reported a significant negative correlation between prescribed burning (PB) and both the number and extent of wildfires.[50] Their statistically significant correlation is shown in the next figure:

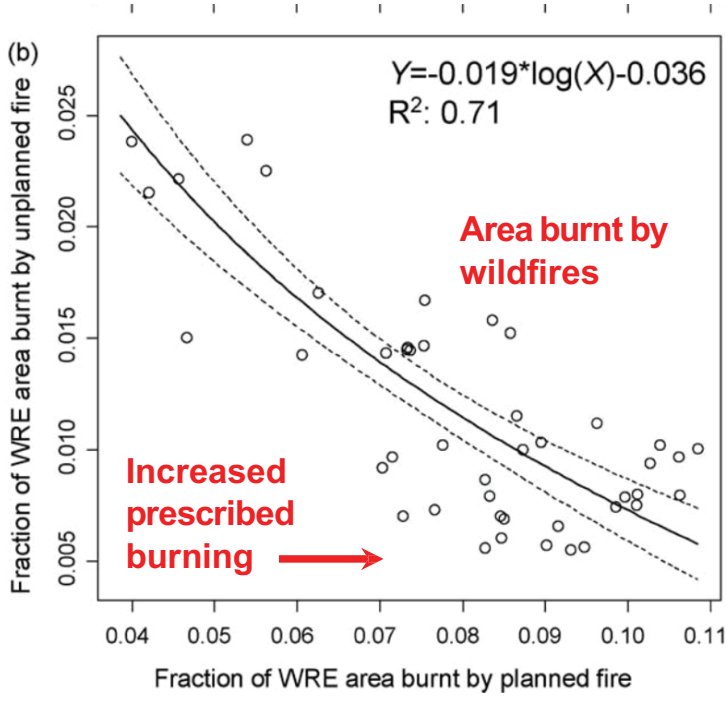


Figure 33: Negative correlation between area subjected to prescribed burning and area burnt by wildfires (from Boer et al 2009)

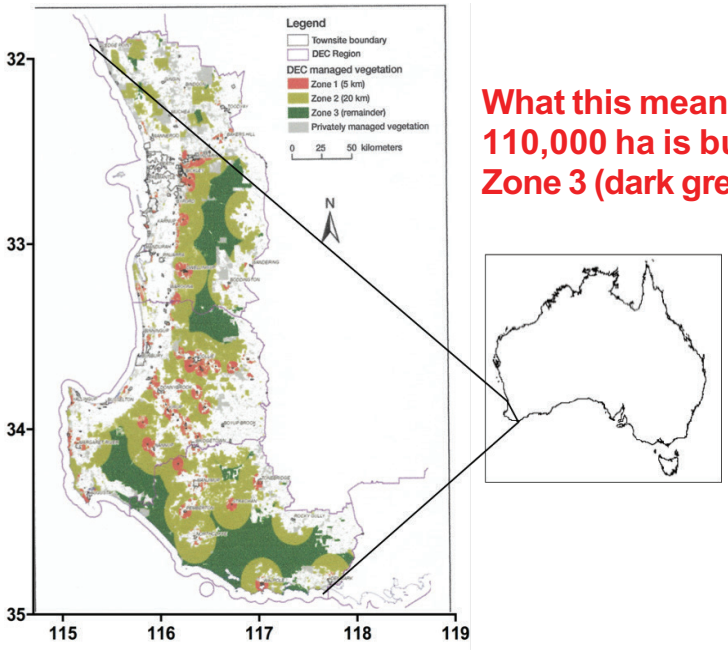
This looks convincing – more prescribed burning leads to fewer wildfires.

The slope of the line, however, is -0.26, which means that the 'leverage' is poor. 1/0.26 equals roughly 4. This means that approximately 4 ha need to be burned to 'protect' 1 ha of bushland.

[50] Boer M M, Sadler R J, Wittkuhn R, McCaw W L & Grierson P F (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 & Management.,* **259,** 132-142.

Effectively, 200,000 ha aimed to be burned by DBCA every year in the southwest forest regions 'protects' only 50,000 ha. That is a lot of burning to protect one quarter of the bush from wildfire!

In addition, 110,000 ha of the 200,000 ha is also in DBCA's Management Zone 3, the area with the highest level of biodiversity.



What this means:
110,000 ha is burned annually in Zone 3 (dark green) on a 6-year cycle

Figure 34: Showing extent of Land Management Zone 3 in the southwest biodiversity hotspot in WA (from Bradshaw et al 2018)

We decided that we needed to scrutinise Boer's paper, given that it was always put forward as the justification for the practice of frequent prescribed burning. It was also clear that the public is convinced prescribed burning is protecting them from devastating wildfires, such as those seen in the eastern states in 2019 and 2020.

Close inspection of Boer's paper revealed several flaws. First, wildfires had not been accounted for or 'masked' in their analysis. To illustrate, an area that had been burnt 50 years earlier by a prescribed burn but only one year earlier by a wildfire was treated as if it was 50 years unburnt. The effects of climate change were also not accounted for and recent increases in wildfire were attributed to a lack of prescribed burning - instead of the result of the drying of vegetation and its subsequent increased flammability.

The most serious error in Boer *et al*'s paper, however, was the way in which the correlation between prescribed burning (PB) and wildfires (WF) was calculated. Six-year concurrent averages were used in calculating their regressions instead of year-by-year steps. The use of averages causes the temporal link between prescribed burning and wildfires to be lost so that, statistically, half the wildfires will have occurred **before** the prescribed burning! The following figure shows the correct way to calculate the regression, stepwise, from year to year, and compares this with the Boer paper's method, using the average over a 6-year window that was progressively moved through the data.

Calculating the Regression

- Showing the correct yearly stepwise way to assess the impact of a prescribed burn (PB) on subsequent wildfires (WF)
- Boer *et al* (2009) incorrectly graphed the average of PB and WF numbers over a 6-year window

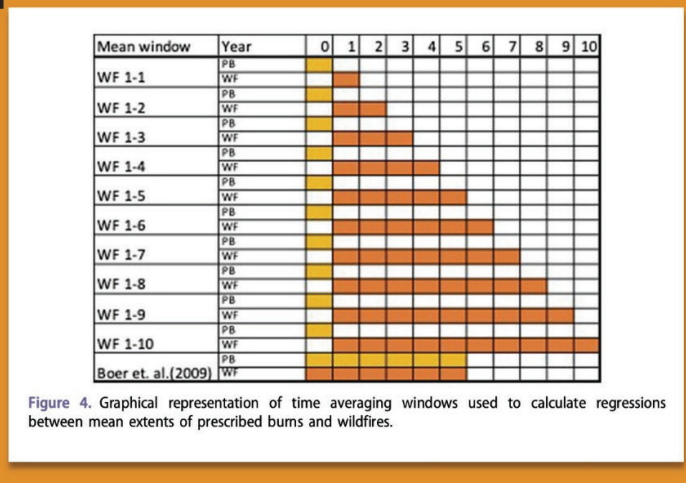
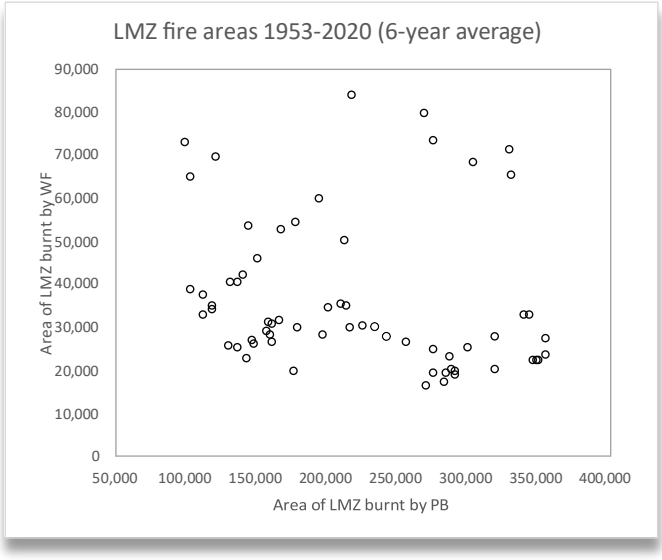


Figure 4. Graphical representation of time averaging windows used to calculate regressions between mean extents of prescribed burns and wildfires.



When these errors are corrected and more recent data to 2022 added (data in Boer's paper only go to 2003), the negative correlation between prescribed burning and wildfires disappears completely.[51]

Figure 35: Regression showing lack of correlation between area of land management zone burnt by wildfire as a function of area prescribe burned (fom Campbell et al. 2022)

Another paper by Phil Zylstra and colleagues (Zylstra *et al.*, 2022)[52] measured the flammability of southwest forest vegetation over time. They found that flammability initially increased after a prescribed burn, due to the prolific growth of native and exotic understorey plants, which peaked 20-25 years post-fire.

[51] Campbell T, Bradshaw S D, Dixon K, W. & Zylstra P (2022). Wildfire risk management across diverse bioregions in a changing climate. *Geomatics, Natural Hazards and Risk* **13,** 2405-2424.

[52] Zylstra P, Bradshaw S D & Lindenmayer D B (2022). Self-thinning forest understoreys reduce wildfire risk, even in a warming climate. Environmental Research Letters, 17 044022.

Beyond this, however, flammability again declined, and the authors attributed this to 'self thinning' as the post-fire dense understorey died off. This result was consistent with already-published understorey dynamics, and the results of the "Project Vesta" experiments which showed that understorey height and cover are the primary drivers of fire spread and severity. In other words, long-unburnt tracts of forest that have *not* been prescribed burned are *less* likely to initiate wildfires.

The authors concluded that the current burning regime was effectively maintaining the forests in a highly flammable state.

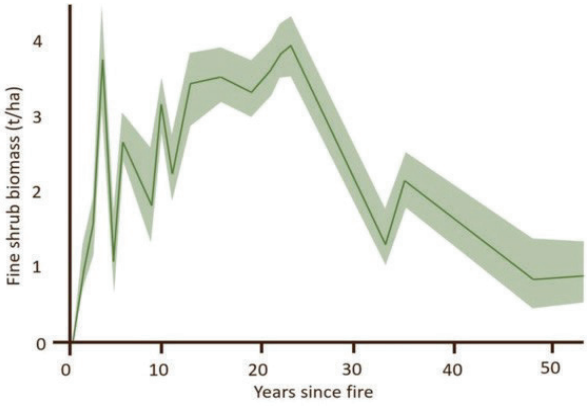


Figure 36: Showing change in shrub biomass in a jarrah forest with time after fire (from Burrows 1994)

This was not 'music to DBCA's ears' and their scientists have been obsessed with trying to discredit our 2022 paper. This is despite the fact that 'thinning' in old-growth forests is well known by foresters and has been demonstrated and published by DBCA scientists.

Figure 36 shows the dramatic reduction of understorey with time after a burn in a jarrah forest.

Burrows & McCaw (2013) also state that …*"vegetation that has died back and collapsed, usually about 20-25 years after fire …"*[53]

The argument is over whether these old forest areas are also less flammable.

In our 2022 'thinning paper' we estimated flammability (known as Probability of Ignition at a Point or PIP), based on the extent of the understorey vegetation. The Bushfire CRC "Project Vesta" experiments were pivotal in showing that understorey height and cover are the primary drivers of fire spread and severity, not accumulated litter levels as is usually thought.[54]

This means that long-unburnt tracts of forest that had *not* been prescribed-burnt are *less* likely to initiate wildfires.

[53] Burrows N & McCaw W L (2013). Prescribed burning in southwestern Australian forests. *Frontiers in Ecology and the Environment,* **11,** 25-34.

[54] https://www.bushfirecrc.com/resources/product/project-vesta-fire-dry-eucalypt-forest

The following Figure (b) is from our 2022 paper and shows the slow increase in 'Fire Likelihood' after a burn, peaking at about 35 years, and then declining.

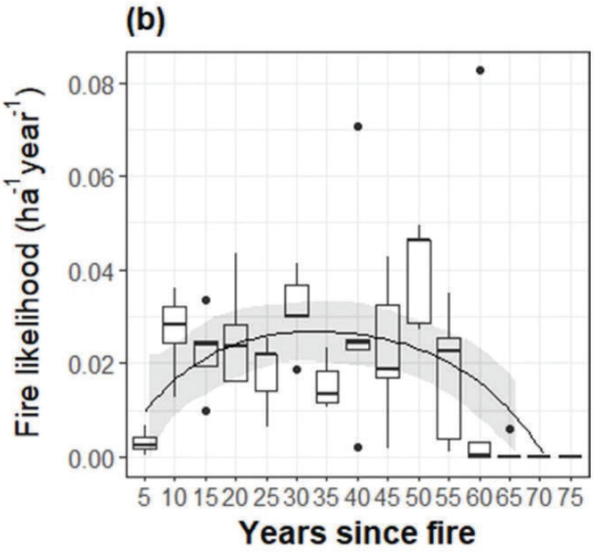


Figure 37:
Change in Fire Liklihood with time after a fire (from Zylstra et al 2022)

This is what DBCA has been intent on debunking as it shows that regular prescribed burning is maintaining the forests in a highly flammable state and increasing the chance of wildfires.

A letter to the Director General of DBCA, alerting him to this research, was met with the following response:

'…The arguments of Zylstra et al (2022) that flammability declines with forest age hinge on sparse and unreliable data derived from repeated sampling of a handful of unique and unrepresentative places, and do not correspond with practical experience and observation…'

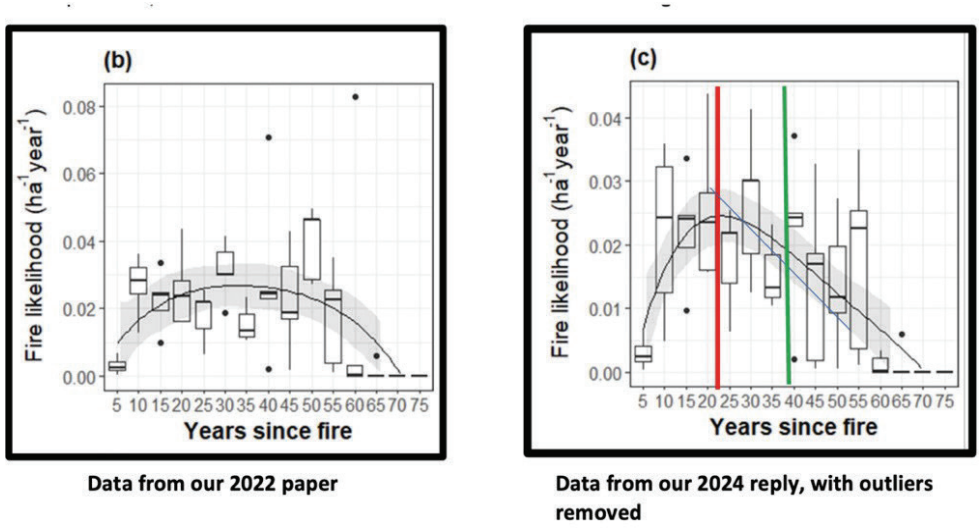
This obviously came from advice given to the Director General by his staff and it was followed by a new publication that was highly critical of our work.[55] The authors argued that 'rounding down' of very small areas in the forest introduced a systemic bias towards reduced flammability. They forgot, however, that just as many areas are 'rounded up' by the software as 'rounded down' and the overall effect of the statistical procedure is not to introduce bias, but rather to increase the 'noise' in the data.

A second look. We tested their second criticism, that the very small number of long-unburnt areas in the forest act as 'outliers' biasing the data set, by removing them.[56]

[55] Miller B P, Fontaine J B, Tangney R, McCaw L, Cruz M G & Hollis J J (2024). Comment on 'Self-thinning forest understoreys reduce wildfire risk, even in a warming climate'. *Environmental Research Letters,* **19,** 068001.

[56] Zylstra P J, Lindenmayer D B & Bradshaw S D (2024). Reply to Comment on 'Self-thinning forest understoreys reduce wildfire risk, even in a warming climate'. *Environmental Research Letters,* **19,** 058001.

The effect is quite dramatic and strengthens our conclusion as seen from the Figures below. (b) is our original data set and (c) with 'outliers' removed. The reduction in flammability, peaking at 22 years, is much more marked with the so-called 'outliers' removed. There is a significant fall by 39 years after fire, declining to pre-fire levels by 55-60 years.

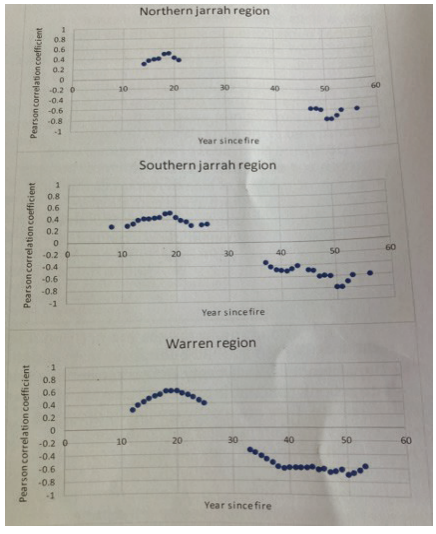


Data from our 2022 paper

Data from our 2024 reply, with outliers removed

Figure 38: Fire liklihood after a fire showing original prediction from Zylstra et al 2022, compared with the change after 'outliers' are deleted (from Zylstra et al 2024)

Analysis of Pearson Correlation Coefficients from Campbell *et al.* (2022)[38] also shows flammability peaking at 20 years after fire in three forest regions, and then declining by 40-50 years.



There can be no further doubt about the reliability of our data, and of our conclusions. This leaves DBCA in a difficult position. Through our publications in peer-refereed international journals, we have shown that Australian plants are not adapted to fire, that prescribed burning does not inhibit wildfires, that long-unburnt forest areas have low flammability, and that frequent prescribed burning maintains the forests in a highly flammable state. The evidence that biodiversity, which DBCA is responsible for maintaining, is declining, due to the repetitive burning and destruction of habitats, is also overwhelming.

Figure 39: Pearson correlation coefficients showing change in flammability with time after fire (from Campbell et al 2022)

To continue burning 45% of the forests at less than six years will only serve to maintain an unacceptable situation. Wildfires will become more likely and biodiversity levels will continue to decline.

Smoke and Human Health

Fires produce smoke, which is composed of particulate matter. The larger particles are about 10 microns in size (PM_{10}) and the smaller, 2.5 microns in size ($PM_{2.5}$). Both are a health hazard with $PM_{2.5}$ being the most dangerous. A micron (or micrometre) is a millionth of a metre and a human hair is about 50 microns in diameter. Breathing in these tiny particles can have severe consequences, especially for people who may have pre-existing lung and breathing problems, such as asthma. Babies and pregnant women are particularly susceptible to smoke pollution. Inhalation of PM_{10} leads to inflammation of the airways whilst $PM_{2.5}$ particles enter the bloodstream, causing obstructions that may provoke heart attacks and strokes. Evidence shows there is no safe threshold of exposure to either PM_{10} or $PM_{2.5}$.[57]

National Environment Protection Measures (NEPM) are laid down for ambient air quality but, paradoxically, prescribed burning is exempted, along with bushfires, which are classified as 'exceptional events'. Monitoring of air quality in five sites around Perth from 2018-2021 found, however, that prescribed burns exceeded NEPM limits far more often than wildfires for the same period. This is seen from data in Table 3:[58]

Table 3: Levels of PM_{10} and $PM_{2.5}$ particles compared between wildfires and prescribed burns

Year	**PM_{10}**		**$PM_{2.5}$**	
	Wildfire	PB	Wildfire	PB
2018	5	15	3	17
2019	5	5	7	11
2020	1	11	4	25
2021	2	17	4	34
Totals	**13**	**48**	**18**	**87**

Borchers Arriagada *et al* (2020) estimated that between 2002 and 2017 there were 21 premature deaths from prescribed burning , with 140 hospitalisations for cardiovascular and respiratory problems and 63 emergency department visits by people with asthma.

The health impacts from prescribed burning are an order of magnitude greater than those from wildfire. This alone should guide a review of the current prescribed burning regime. Such a review was recommended by the EPA in 2023, and called for by The Leeuwin Group when fronting a recent Senate Committee.

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[57] Nicolas Borchers Arriagada, Andrew J Palmer, David MJS Bowman and Fay H Johnston *Med J Aust* 2020; 213 (6): 280-281. || doi: 10.5694/mja2.5054

[58] Kelsey, P (2024) *Prescribed Burning Fact Sheets*, South-West Forests Defence Foundation Inc.

Unfortunately, the Senate Committee did not agree, opting instead for a 10-year study of the Impact of prescribed burning - to be carried out by DBCA!
Rather like putting the fox in charge of the hen house!

Greenhouse Gas Emissions

Records of fires are available from the 1950s of fires in the southwest forests from which it is possible to estimate emission of greenhouse gases (GHG), primarily CO_2 and methane (CH_4). The proportion of the southwestern Australian forest region of ~2.5 million ha burnt each year is shown in the figure below, comparing prescribed burning (PF in this figure) with wildfire (WF).

The figure makes it very clear that prescribed burning vastly exceeds the area affected by wildfire, with the following table giving a ratio of 6.5 for PF:WF.

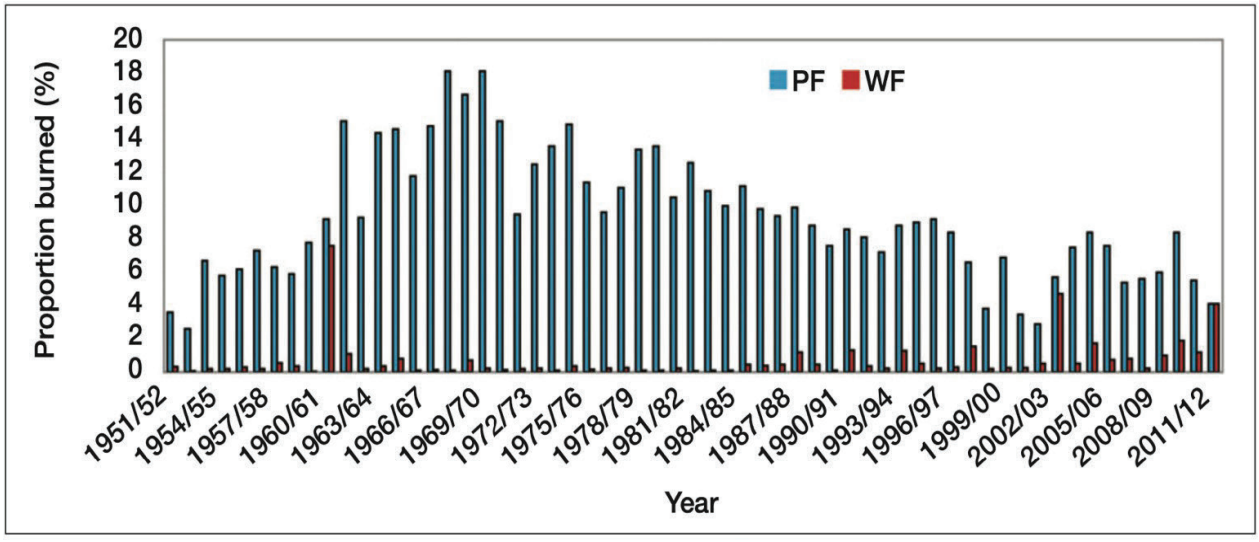

Figure 40: Frequency of wildfires and prescribed burns in southwest WA from 1951 to 2012 (from CALM Annual Report 2012)

These data can be transformed into actual areas burnt and are compared in the Table 4 for two time periods: 1981-2002 and 2002-2023.

Table 4: DBCA Burning Data

Period	Prescribed Burns (PB)	Wildfires (WF)	Ratio PB/WF
1981-2002	4,548,456 ha	293,796 ha	15.48
2002-2023	3,293,325	911,603	3.61
Totals	**7,841,781**	**1,205,399**	**6.50**

Using methodologies from the IPCC (2006)[59] and Volkava *et al*. (2019)[60] the estimated GHG emissions from both prescribed burns and wildfires can be calculated and compared.

GHG can be calculated using the formula in Figure 41, which estimates a figure of 40 tonnes/ha CO_2 for prescribed burns and 79 tonnes/ha for wildfires. The difference is the result of the increased patch area and fraction of biomass consumed in wildfires. This difference is more than compensated for, however, by the dominance of prescribed burns over wildfires. Prescribed burning over the period 1981-2023 resulted in a total of almost 314 million tonnes of CO_2 compared with 9.5 million tonnes from wildfires.

GHG emission calculations for 1 ha of prescribed burn and 1 ha of wildfire

The principal greenhouse gases of concern are carbon dioxide, methane and nitrous oxide.

Emission equation[2]: $E_i = A * P * M * CF * EF_i$

where	E_i	GHG emission (g) due to gas i
	A	Fire area (ha)
	P	Patchiness
	M	Biomass available for burning (t/ha)
	CF	Combustion factor = fraction of biomass burnt
	EF_i	Emission factor = g of gas i emitted per kg of matter burnt
and	i is	CO_2 for carbon dioxide
		CH_4 for methane
		N_2O for nitrous oxide

Parameter values:

A = 1 ha

P = 0.65 for prescribed burn (PB), 0.8 for wildfire (WF)[8]

M = 20.2 t/ha for litter < 6mm, 72.7 t/ha for coarse wood debris (CWD)[3]

CF = 0.6 for litter in PB, 0.9 for litter in WF, 0.3 for CWD in PB, 0.5 for CWD in WF[3]

EF_{CO2} = 1640 g/kg for litter, 1479 g/kg for CWD[9]

EF_{CH4} = 0.9 g/kg for litter, 10.9 g/kg for CWD[3]

EF_{N2O} = 0.072 g/kg for litter, 0.038 g/kg for CWD[3]

The different GHGs have different potentials for contributing to global warming. This is expressed as global warming potential (GWP). To calculate the CO_2-equivalent emissions for a GHG, the mass of gas emitted is multiplied by the GWP.

GWP = 1 for CO_2, 34 for CH_4, 298 for N_2O[9]

Using the emission equation, the parameter values and the GWP, the CO_2-equivalent GHG emissions are:

40 t/ha for prescribed burning and 79 t/ha for wildfire.

Figure 41: Equation used to calculate Greenhouse Gas Emissions (GHG) from fires (From Kelsey, P. Fact Sheets 2024)

Prescribed burning of 200,000 ha every year in the southwest biodiversity hotspot thus results in the emission of approximately 8 million tonnes of CO_2, equivalent to almost 10% of Western Australia's total emissions of 83 million tonnes of GHG.

[59] Intergovernmental Panel on Climate Change (IPCC) (2006) IPCC Guidelines for National Greenhouse Gas Inventories Chapter 4: Forest Land.

[60] Volkova, L, Roxburgh, SH, Surawski, NC, Meyer, CM & Weston, CJ (2019) Improving reporting of national greenhouse gas emissions from forest fires for emission reduction benefits: An example from Australia. *Environmental Science and Policy*, 94 49-62

Fire on Soil and its Microbiome

Fire can seriously modify soils, depending on the intensity and frequency of the fire. One generally assumes that ash from a fire is rich in nutrients, but this is often far from the case. Concentrations of essential plant nutrients, such as nitrogen, phosphorus, potassium and calcium, can be seriously depleted following fires, which also markedly affect the water permeability of the soil.

Two trials in the jarrah forest north of Perth found that a hot fire (600-1200 kW/m) resulted in the loss of 46% of the soil nitrogen compared with a cooler fire (30-283 kW/m) with a loss of only 23% of the nitrogen.[61] Interestingly, phosphorus levels were unaffected.

Long-term changes to soil with frequent fire were reviewed by Pellegrini et al. (2017),[62] who analysed data from 48 world-wide sites in savanna grasslands, broadleaf forests and needleleaf forests spanning up to 65 years, during which time the frequency of fires was altered at each site. They found that frequently burned plots experienced a decline in surface soil carbon and nitrogen that was non-saturating through time, having 36% (±13%) less carbon and 38% (±16%) less nitrogen after 64 years than plots that were protected from fire.

The study predicted that the long-term losses of soil nitrogen that result from more frequent burning may in turn decrease the carbon that is sequestered by net primary productivity by about 20% of the total carbon that is emitted from burning biomass over the same period.

When it comes to the effect of fire on soil fauna, not all experts are in agreement. An early study by Springett (1976)[63] concluded that … "*Prescribed burning on a five to seven year rotation is likely to permanently simplify the litter fauna and flora, with far reaching effects on forest and hygiene*" and that hot autumn burning may be less detrimental to the soil and litter invertebrates than hot spring burning.

This was disputed by Abbott (1984)[64] who found …"The total number of taxa and the density and biomass of that part of the invertebrate fauna studied did not differ significantly between plots" (burnt and unburnt), although his study involved only a moderate fire.

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[61] Ward, S.C. & Ainsworth, G.L. (1991) The effect of controlled burns on nitrogen and phosphorus in rehabilitated bauxite mines. Perth: Alcoa Australia Ltd.

[62] Pellegrini A F, Anders Ahlström, Sarah E. Hobbie, Peter B. Reich, Lars P. Nieradzik, A. Carla Staver, Bryant C. Scharenbroch, Ari Jumpponen, William R. L. Anderegg, James T. Randerson & Robert B. Jackson (2017). Fire frequency drives decadal changes in soil carbon and nitrogen and ecosystem productivity. *Nature,* 553, 194-198.

[63] Springett J A (1976). The effect of prescribed burning on the soil fauna and on litter decomposition in Western Australian forests. *Australian Journal of Ecology*, 1, 77-82.

[64] Abbott I (1984). Changes in the abundance and activity of certain soil and litter fauna in the jarrah forest of Western Australia after a moderate intensity fire. *Journal of Soil Research,* **22,** 463-469.

York (1994)[65] was critical of Abbott's experimental design and concluded … "that areas subjected to frequent low-intensity fires had significantly lower numbers of spiders, ticks and mites, pseudoscorpions, woodlice, springtails, bugs, beetles, ants and insect larvae in the leaf litter compared with adjacent unburnt areas." He also found that frequent burning can lead to a significant reduction in topsoil moisture levels.

Robinson & Bougher (2003) found that frequent fire was inimical to soil fungi, having a negative impact on the physical environment in which fungi persist.[66]

The rôle of 'bioturbators' in the forest

Figure 42 - A quenda, Isoodon fusciventer, one of the forest's important bioturbators (courtesy Wikipedia commons)

Numerous studies, reviewed by Letey (2001),[67] have shown that fire makes soil water repellent, leading to a decrease in infiltration and greater runoff of water. Another important factor is the absence nowadays of the many small marsupials that once lived in the forests and were serious agents enhancing soil turnover as 'bioturbators'.[68] The soil turnover capacity of these digging mammals is substantial. While foraging for the underground fruiting bodies of ectomycorrhizal fungi, Woylies (*Bettongia penicillata**)*** can displace 9.2–26.5 kg of soil per day, with an average soil turnover of 4.8 tonnes per individual per year.[69] The similar-sized Southern brown bandicoot (*Isoodon fusciventer*) displaces 10.7 kg of soil per day while foraging, with an estimated soil turnover of 3.9 tonnes per year.

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[65] York A (1999). Long-term effects of frequent low-intensity burning on the abundance of litter-dwelling invertebrates in coastal blackbutt forests of southeastern Australia. *Journal of Inse Conservation,* **3,** 191-199.

[66] Robinson R M & Bougher N (2003). The response of fungi to fire in Jarrah (*Eucalyptus marginata*) and Karri (*Eucalyptus diversicolor)*. *In:* Abbott I & Burrows N (eds.) *Fire in Ecosystems of South-west Western Australia: Impacts and Management.* Leiden: Backhuys. pp: 269-290

[67] Letey J (2001). Causes and consequences of fire-induced soil water repellancy. *Hydrological Processes,* **15,** 2867-2875.

[68] Valentine L E (2014). Ecosystem services of digging mammals. *In:* Lambers H (ed.) *Plant Life on the Sandplains in southwest Australia, a Global Biodiversity hotspot.* Perth: UWA Publishing. pp: 255-262
Valentine L E, Anderson H, Hardy G E S J & Fleming P A (2013). Foraging activity by the Southern brown bandicoot (*Isoodon obesulus*) as a mechanism for soil turnover. *Australian Journal of Zoology,* **60,** 419-423.

[69] Garkaklis M J, Bradley J S & Wooller R D (2004). Digging and soil turnover by a mycophagous marsupial. *Journal of Arid Environments,* **56,** 569-578.

Bioturbators also facilitate seedling growth. Leone Valentine and her collaborators found soil from the mound created by bandicoots when digging accelerated the growth of seedlings when compared with soil that had not been 'engineered'[70].

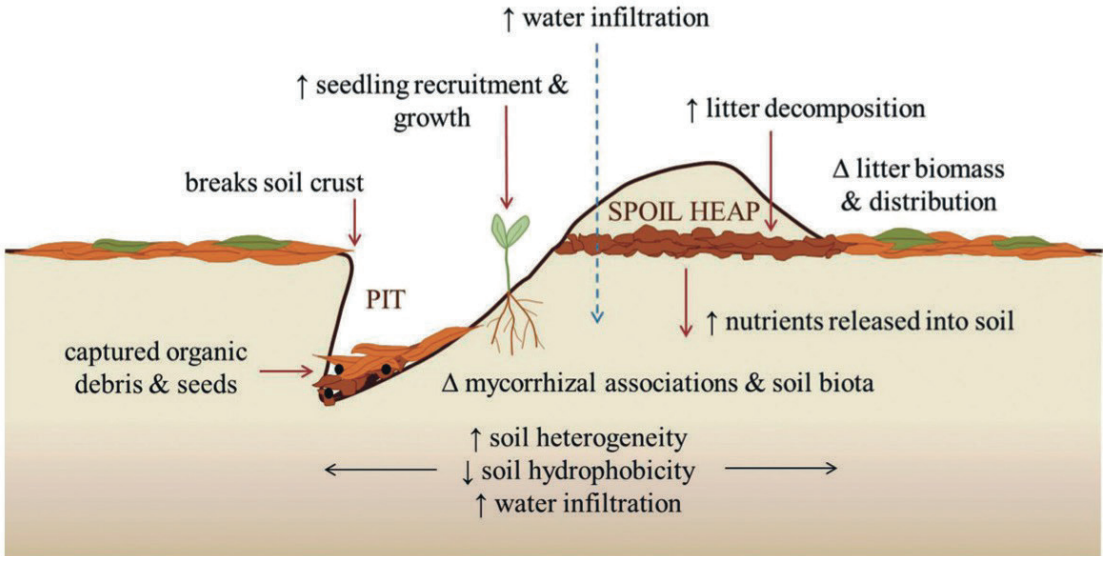

Figure 43: Diagrammatic reprersentation of the impact of bioturbators such as the quenda on the soil (from Valentine L E (2014). Ecosystem soil digging mammals.
In: Lambers H (ed.) *Plant Life on the Sandplains in southwest Australia, a Global Biodiversity hotspot.*
Perth: UWA Publishing. pp: 255-262

Politics of Prescribed Burning

There is perhaps no other topic in Australia that raises blood pressures so effectively as prescribed burning![71] The average 'man in the street' is convinced that if the bush is not burned regularly there will be a huge conflagration in which he will lose his home and perhaps even his life; the Government is not backward in reinforcing this message. Critics of the current practice are labelled as 'greenies', 'ivory tower academics' etc. and there is much smoke and mirrors but little light in the many letters published in *The West Australian*, Perth's only daily newspaper.

Many biologists on the other hand are seriously concerned at the effect that frequent fire has on ecosystems, which, in the past, were subjected to infrequent large fires from lightning strikes.

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[70] Valentine L E, Ruthrof K X, Fisher R, Hardy G E, Hobbs R J & Fleming P A (2018). Bioturbation by bandicoots facilitates seedling growth by altering soil properties. *Functional Ecology,* **32,** 2138-2148.

[71] Wardell-Johnson G, Wardell-Johnson A H, Schultz B, Dortch J, Robinson T, Collard L & Calver M (2018). The contest for the tall forests of Western Australia and the discourses of advocates. *Pacific Conservation Biology*. doi.org/10.1071/PC18058

The level of resentment and occasional vitriol levelled at anyone who opposes or even criticises prescribed burning is alarming and testifies to the unwillingness of proponents of the practice to enter into any discussion on its merits and possible defects. The following is from the Bush Fire Front (BFF):

'…The Bushfire Front has observed environmental activists, and green academics busy in WA recently, organizing seminars and rallies, writing letters to newspapers, issuing press releases, phoning talk-back lines and badgering the State's firefighters and land managers…'

The opposition from DBCA to the paper published by Phil Zylstra and colleagues in 2022 in *Environmental Research Letters*,[72] who showed that forests 'self thin' and become less flammable 30-40 years after a prescribed burn, has been unrelenting (described in more detail in pages 36-37). 'Thinning' of long-unburnt forests is well known to foresters, and was even mentioned by Charles Lane-Poole, the first Director of Forests in 1921. Neil Burrows, former DBCA scientist, also showed this dramatically in his PhD thesis[73] plotting the marked decline in finer shrub biomass some 25 years after a fire (see page 36).

The following quote, however, is from Mr Roger Underwood, now a vehement vocal opponent of our 2022 'thinning paper':

'Very long-unburnt stands in the karri forest, for example, eventually become quite open, with grass or dense bracken and only an occasional specimen of the taller, longer-lived acacias or hakeas as remnants of the original scrub layers.'

(Underwood, RJ and Christensen, PES (1981). 'Forest fire management in Western Australia.' Special Focus No. 1, Forests Department of Western Australia, p. 19.)

Mr Bernie Masters, an ex-Liberal parliamentarian, living in Busselton and long-time President of the Busselton Naturalists' Club, started the ball rolling, denouncing our paper as 'arrant nonsense', obvious to anyone whose mind had not been corrupted by a university education. He commented in the May 2022 of the Club's Newsletter:

'…Three Australian researchers - Philip Zylstra, Don Bradshaw and David Lindenmayer recently published a review of the likelihood and timing of fires in WA's forests. Entitled 'Self-thinning forest understoreys reduce wildfire risk, even in a warming climate', their paper can best be described as a folly – lacking common sense and drawing foolish conclusions…'

In his Presidential Address, Mr Masters said he would welcome a response from the authors. When we requested, however, that it be published in the Club's Bulletin, he refused. We persisted, and a letter from us to the Club's Committee resulted in Masters withdrawing as President and the publication of our response in the next issue of the Busselton Naturalists' Club Bulletin.

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[72] Zylstra P, Bradshaw S D & Lindenmayer D B (2022). Self-thinning forest understoreys reduce wildfire risk, even in a warming climate. *Environmental Research Letters,* **17** 044022.

[73] Burrows N D. 1994. Experimental development of a fire management model for jarrah (*Eucalyptus marginata* DOBBN ex Sm) forest. PhD, Australian National University.

Our response concluded with the following:

'*…Mr Masters stated that "The authors are well known in academic and forestry circles as being strongly opposed to prescribed burning."* This is incorrect and we have published several papers advocating the evidence-based application of prescribed fire in parts of the landscape where it can be beneficial. We have argued that prescribed burning should be focused on the preservation of life and property and that the frequent burning of bushlands remote from habitation should be discontinued. The evidence that it protects against wildfires is contested and the negative impacts on wildlife have been well documented (Bradshaw et al., 2018).[74] Professor Zylstra also has extensive experience in planning and conducting prescribed burns...'

Mr Bernie Masters was just the first of a long line of detractors, ex-foresters and bushfire 'experts' who weighed into the 'debate.' After the publication of our 2024 paper (see [52] above), rejecting conclusively the criticisms by Miller *et al* (in their 2024 paper, see [53] above), one of the authors still refuses to accept that they may have erred[75]. This makes it very clear that the opposition to any criticism of prescribed burning is visceral, verging on a religious belief that cannot be questioned.

As discussed earlier, prescribed burning was established as a policy following the devastating fires in Dwellingup and Karridale in 1961 that wiped out both towns. The 1961 Royal Commission recommended that prescribed burning be implemented

'…to limit the impact of wildfires on life and property, and to protect valuable timber in State forests[76]…'

The one recommendation that says anything about burning does not mention life and property:

"(20) The Forests Department make every endeavour to improve and extend the practice of control burning to ensure that the forests receive the maximum protection practicable consistent with silvicultural requirements"(p.59)

There was no intention that the burning might also benefit or protect native plants and animals.

As outlined on page 10, it was not until 1987 that CALM responded to the criticisms from environmentalists that frequent fire was damaging forest wildlife. They did this by inventing 'conservation burns':

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[74] Bradshaw S D, Dixon K W, Lambers H, Cross A T, Bailey J & Hopper S D (2018). Understanding the long-term impact of prescribed burning in Mediterranean-climate biodiversity hotspots, with a focus on southwestern Australia. *International Journal of Wildland Fire,* **27,** 643-657.

[75] *Pers comm.*

[76] Rodger G J 1961. Report of evidence taken by Mr. G. J. Rodger, B.Sc. appointed on the 27th April, 1961, as a Royal Commission to inquire into and report upon bush fires in Western Australia. Perth, Western Australia: Government Gazette, Perth, Western Australia.pp:734.

'…the Department will manage prescribed fire and wildlife on lands managed by the Department to protect and promote the conservation of biodiversity and natural values whilst also providing protection for human life and community assets[77]*…'*

The current Government agency, DBCA, thus has a dual responsibility – the protection of life and property, and the conservation of biodiversity – both of which through regular prescribed burning. Many would say this is an impossible task, resembling the Judgement of Solomon![78]

Professor Don Driscoll and his colleagues have tried to identify the challenges embodied in DBCA's remit and the research needed to address them.[79] Their paper concludes:

'… Developing ecologically sustainable fire management practices will require sustained research effort and a sophisticated research agenda based on carefully targeting appropriate methods to address critical management questions…"

Suffice it to say that 15 years after this paper was published, little has changed. The Bushfire Front (BFF), an organisation of foresters, works hard to support DBCA with statements, such as the following on its website[80]:

"Prescribed burning to mitigate bushfires severity is an essential component of WA's forest fire management. The purpose is not to prevent bushfires, but to make bushfires easier, cheaper and safer to control, and to minimise the damage that they do. Over decades it has been demonstrated that a well-managed burning program is no threat to our envirionment or to our biodiversity.

However, prescribed burning is controversial. Some academics and environmentalists oppose the burning program. They advocate that it be curtailed, or shut down. No credible reasons are put forward to support this position. They ignore the facts. The purpose of this paper is to present the facts of prescribed burning, as we understand them, based on intimate knowledge of the science, and decades of world firefighter experience. Our aim is to ensure any decisions by government about the burning programme are based on this credible science and hard-won experiences, not on theory, computer models or ideology.

Attempts by some environmentalists and academics to undermine or curtail the burning programme is inhumane and irresponsible, but worse they ignore the facts. We urge everyone who is interested or concerned about this issue to read, and understand the fact, and to contact the Bushfire Front if more information is needed.

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[77] CALM Annual Report, 1987

[78] https://en.wikipedia.org/wiki/Judgement_of_Solomon

[79] Driscoll D A, Lindenmayer D B, Bennett A F, Bode M, Bradstock R A, Cary G J,Clarke M F,Dexter N, Femsham R F, Gil M I, James S, Kay G, Keith D A,MacGregor C, Russell-Smith J, Salt D, Watson J E M,Willims R J & York A (2010). Fire management for biodiversity conservation:Key research questions and our capacity to answer them. *Biological Conservation*, **143**, 1928-1939.

[80] https://www.bushfirefront.org.au/wp-content/uploads/2024/05/BFF-Prescribed-Burning-The-Facts.pdf

The prejudice towards 'academics and environmentalists' is obvious. There is no attempt to enter into a discussion over the science of burning; with 'fire-fighting experience' masquerading as science.

No one doubts that foresters have amassed a great deal of knowledge about the lighting and fighting of fires, but that does not make them experts on the long-term impacts of those fires on native plants and animals. Also, as we have seen above, their claim that prescribed burning of bushland areas mitigates wildfires is based on a flawed analysis of fire records. The fact that prescribed burns affect seven times the area affected by wildfires should also make them realise that any victory claimed in the fight to prevent wildfires is pyrrhic.

Don Driscoll and colleagues went on to analyse the biodiversity impact of the 2019-2020 megafires in eastern Australia, and recommended rapid wildfire suppression in areas frequently burnt. This led to the rapid publication of a near hysterical pamphlet from the BFF, sent to all government Ministers and agencies, entitled: "A Critique of the 'Response Only' Bushfire Strategy for Southwest WA", ridiculing and highlighting the alleged danger of the following media release:

'…It's time to fund new early detection and rapid suppression firefighting technology and stop senselessly torching vulnerable ecosystems… more effective fire management will better safeguard our communities, and… stop the rapid loss of WA's ecosystems and wildlife in destructive and failing prescribed burns…'

A recent letter in *The Age* from Professor David Lindenmayer and Drs Phil Zylstra and Chris Taylor argues that pre-burning is no magic bullet for controlling fires. Fires that tore through the Grampians in Victoria recently, burnt through 31,000 ha of land that had all been subjected to prescribed burning.

Similarly, Marysville was subjected to intensive pre-burning in 2008 but was razed by Black Saturday 2009 fires. People forget that fire is incandescent gas and, if conditions are appropriate, fire can easily traverse a farmer's bare paddock.

To date, the WA Government has chosen to ignore the groundswell of concern from the scientific community and members of the public over the impacts of prescribed burning on native ecosystems, with DBCA receiving massive funding to support the practice.

Spectacular failures, however, such as the Weinup burn, east of Perup Nature Reserve, in 2021 that incinerated scores of numbats, and the catastrophic escape burns in Margaret River, Prevelly and Gnarabup in 2011, have the potential to influence government policy.

In not listening, DBCA could be accused of breaching the Public Sector Code of Ethics, which states, "we

- Act honestly and uphold the trust placed in us by the community
- Use our position and authority for the purpose intended
- Provide objective and timely advice to the government of the day."

A recent paper by Zylstra & Wardell-Johnson (2024) makes clear the fine line that government employees are meant to follow:

"Government employees and recipients of Government funds have been shown to be under greater pressure than in any other work environment to defend policy through intellectual suppression (Driscoll et al., 2021). Those subject to political interference may be 'rewarded or penalized on the basis of complying with opinions of senior staff regardless of evidence' (Driscoll et al., 2021). These rewards and punishments are highly consequential, defining the success or failure of individual careers subject to Government funding (Driscoll et al., 2021; Martin, 1999). This is particularly relevant in Australian fire research, as all fire management agencies are signatories to a position statement that the scientific question of prescribed burning efficacy has been answered (Australasian Fire Authorities Council, 2021). Prescribed burning doctrine is therefore treated not just as policy, but as orthodox 'truth'.

It is in this context that Campbell et al. (2022) demonstrated the fundamental flaws in the primary study underpinning Government prescribed burning policies in south- western Australia.

At the same time, Zylstra et al. (2022) showed that these policies were not simply ineffective mitigation measures, but actual drivers of increased fire risk.

The Government response to Zylstra et al. (2022) argued that all evidence for a declining trend in long-unburnt forest should be excluded from analysis due to hypothetical and untested issues of data quality (Miller et al., 2024). When the analysis was replicated with these issues accounted for, however, the declining trend in flammability for long-unburnt forest was strengthened, rather than weakened (Zylstra et al., 2024). This reanalysis showed that the only way for prescribed burning to minimise fire frequency to the same level as it naturally occurs in long- unburnt forests, would be to burn annually."

An Answer to the Question[81]

The debate centres on the practice of regular burning, at short intervals, of Western Australia's south-western forests. No-one is questioning the need for the reduction of the fuel load around towns and properties.

When asking the question 'To Burn, or Not to Burn?' in conservation-held land, however, the following facts must be considered:

- 80% of the fires in the southwest of WA are prescribed burns
- The claim that prescribed burning prevents wildfires is false.
- The impact of wildfires has been overestimated. Less than 10% of fires in the south-west of WA are started by lightning, with southwest WA having one of the lowest lightning-strike-frequencies in Australia.
- Escaped burns have had disastrous and expensive impacts on both infrastructure and wildlife.
- Smoke from the fires is harmful to human life and health.
- Carbon-dioxide released when vegetation is burnt significantly contributes to WA's greenhouse gas emissions.
- Many of WA's iconic birds and mammals, such as fairy wrens, honey possums, quokkas, and numbats, are dependent on long-unburnt areas in the forest. Their survival is threatened by too frequent burning.
- The long-term impact of frequent fire on soil microbes and ecosystems is poorly understood but, along with the virtual absence of mammalian bioturbators in forests today, soil health has declined.

It is very diffcult to come up with any beneficial effects of the practice, other than it provides employment to a vast workforce.

[81] Penman T D, Christie F J, Anderson A N, Bradstock R A, Cary G, Henderson M K, Price O, Tran C, Wardle G M, Williams R J & York A (2011). Prescribed burning: how can it work to conserve the things we value? *International Journal of Wildland Fire,* **20,** 721-733.

The Leeuwin Group, which was established in 2012 to advise Government and its agencies on environmental matters, does not oppose prescribed burning, only questions its current practice. It recommends that DBCA:

- Abandon the 110,000 ha per year target of prescribed burning in Land Management Zone C (LMZ3) but retain existing targets in Land Management Zones A and B. The 110,000 ha target has no scientific basis and negatively impacts biodiversity in bushlands remote from habitation.
- Focus prescribed burning on protecting life and infrastructure associated with townsites, as prescribed burning within 0.5 km of assets has been shown to be more effective than burning 8 km away.[82] [83]
- Divert and increase existing funding to establishing rapid response units (e.g. detection, satellite imagery, mapping, water bombing with drones) that will detect and suppress wildfires rapidly before they can become established. Recent research has also found that large water bombers are not as effective as small aircraft and ground crews with heavy equipment in fighting fires; but they provide excellent photo opportunities for fire administrators and politicians!
- Undertake a public relations campaign on risk management to encourage landholders in fire-prone bushland areas to assume responsibilty for their property and their decision to live in such areas.
- Undertake research to identify persons likely to commit arson and ensure children are educated in school about the problem.
- Develop strategies for the protection from wildfire of long-unburnt tracts of bushland and biodiversity-rich sites such as wetlands, granite outcrops and peat swamps.

It is hoped from recent meetings with the new Director General of DBCA that there will be a willingness to engage in discussion with The Leeuwin Group of scientists who question the objectivity of some of the advice he receives from his officers.

The ‘science’ of prescribed burning must be decided and based on peer-reviewed publications in internationally recognised journals, not on ‘in house’ tracts promoting prejudiced views.

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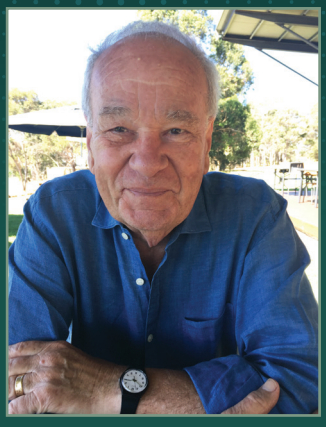
[82] Gibbons, P., Van Bommel, L., Gill, A. M., Cary, G., Driscoll, D. A., Bradstock, R., Knight, E., Moritz, M. A., Stephens, S. L. & Lindenmayer, D. 2012. Land management practices associated with house loss in wildfires. *PLOS ONE*, 7, e29212.

[83] Price O F & Bradstock R A (2012). The efficacy of fuel treatment in mitigating property loss during wildfires: Insights from analysis of the severity of the catastrophic fires in 2009 in Victoria, Australia. *Journal of Environmental Management,* **113,** 146-157.



Emeritus Professor Don Bradshaw PhD, FAIBiol.

Don Bradshaw held the Foundation Chair in Zoölogy at the University of Western Australia for 28 years before his retirement in 2005. His work on the many endangered marsupials living on Barrow Island and his long-term study of the tiny nectarivorous Honey possum in the extreme southwest of WA have given new insights into the adaptive physiology of the Australian fauna. Since retirement, his focus has been on conservation of the many rare and endangered species in WA's threatened biodiversity hotspot and the threats posed by frequent fire. He is a Membre Correspondant du Muséum d'Histoire Naturelle in Paris, was elected a Fellow of the Zoological Society of London in 1985 and awarded the Kelvin Gold Medal of the Royal Society of Western Australia in 2010. In 2015, he was awarded a Special Commendation Whitley Award by the Royal Zoological Society of NSW … *"for the promotion of knowledge and conservation of Australasian fauna through many outstanding publications over an extended time period."*