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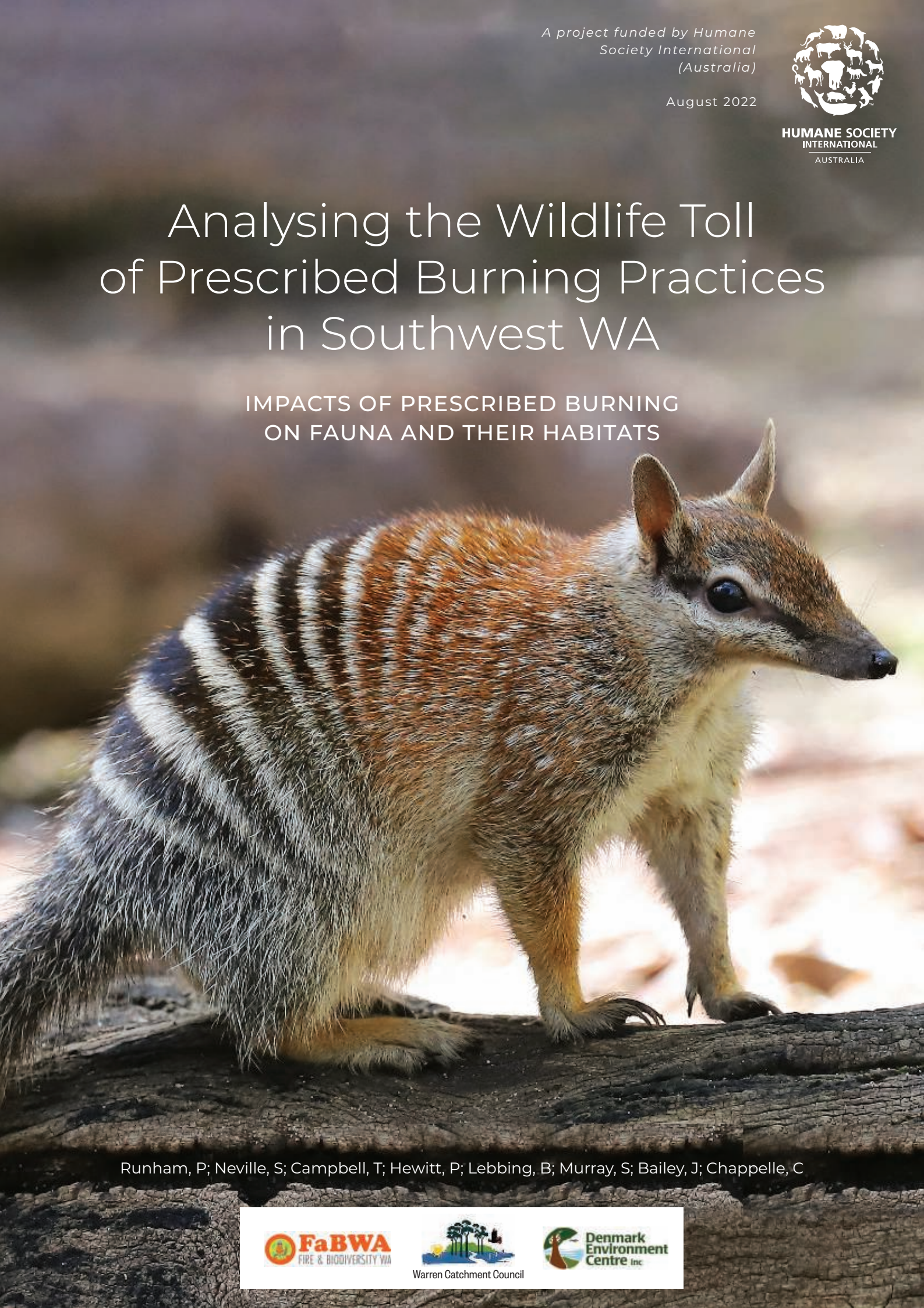
HUMANE SOCIETY INTERNATIONAL AUSTRALIA

Analysing the Wildlife Toll of Prescribed Burning Practices in Southwest WA

IMPACTS OF PRESCRIBED BURNING ON FAUNA AND THEIR HABITATS



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FaBWA FIRE & BIODIVERSITY WA

Warren Catchment Council

Denmark Environment Centre Inc

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Acknowledgments from the project team

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Numbat *Myrmecobius fasciatus*

1 Executive Summary

On Thursday the 25th of March 2021 a prescribed burn conducted by the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) tore through 1,800 hectares of forest approximately 25 kilometres east of Manjimup in Southwest Western Australia.

The blaze was witnessed by Bill Smart, whose farm neighbours the Weinup block within the DBCA's Perup land management zone. Bill described a helicopter dropping incendiaries for two hours, creating an "inferno"[1] throughout the area known as one of the most important habitats for Critically Endangered numbats. It's within one of just 36 internationally recognised Global Biodiversity Hotspots[2] and home to a raft of other threatened species and ecosystems.

If it wasn't for Bill this burn may have gone unnoticed, as many others on isolated blocks must.

The burn understandably placed a spotlight on the scientific credibility and suitability of methods being used by DBCA throughout their managed forest regions, particularly aerial incendiaries. The stated aims of the prescribed burning program include maintaining biodiversity and mitigating the severity of bushfires[3] - on the face of it they weren't being met.

Across the southwest of Western Australia, DBCA aims for a total burn target of 200,000 hectares of native forest per year, with the key efficiency and effectiveness measures being the average cost per hectare burnt and the proportion of planned burns achieved by area[4]. Along with the suitability of methods used, Humane Society International felt that the appropriateness of what appeared to be simplistic and arbitrary targets should also be scrutinised.

To that end we put out a tender for the wildlife toll of prescribed burning practices in Southwest Western Australia to be analysed, seeking to understand the impacts the prescribed burning regime is having on wildlife and their habitats and identify opportunities for improvement.

We wanted to know about the:

- biodiversity impacts and suitability of burn intervals and intensities for wildlife habitats (i.e. numbat dens), Threatened Ecological Communities, and threatened flora species;
- ability of wildlife (including mammals, birds, reptiles, amphibians and invertebrates) to avoid fire and escape fire zones in prescribed burns conducted by WA's DBCA;
- whether prescribed burns performed in this manner may be causing more wildlife suffering and biodiversity loss than the wildfires they are intended to prevent; and
- differences between the techniques used and traditional Indigenous burning practices.

While the focus of the study was the Perup burn and nearby reference sites, findings were to be conservatively extrapolated to approximate the potential extent and severity of impact on biodiversity and wildlife these practices are causing across Southwest Western Australia.

A consortium of Denmark Environment Centre, Warren Catchments Council, and Fire and Biodiversity WA were selected to lead the project. With scrutiny on prescribed burning practices intensifying in Western Australia and nationally, we release *Analysing the Wildlife Toll of Prescribed Burning Practices in Southwest WA* – this report makes clear there is much to do and no time to waste.

1.1 Report Conclusions

Following an intense few months in the field and many hours of desk work, the research team came to 12 strong conclusions about the 2020-2021 fire season and Western Australia's prescribed burn program. They are presented below in an abridged format that may not fully encapsulate the detail or framing intended by the research team, though every effort was made. The full conclusions and discussion should be referred to and can be found from page 25.

1. In the 2020-2021 fire season, prescribed burns had a greater impact than wildfires on fauna and flora.
2. The current Western Australia prescribed burning regime results in a reduction of vegetative diversity and has a deleterious effect on fauna habitats.
3. Regular and frequent prescribed burning results in permanent changes to fungal community composition and subsequently their ecological functions.
4. Fires of even Low-Moderate Severity such as that at Weinup can profoundly alter fauna habitat structure over a period exceeding two to three years.
5. A significant proportion of other prescribed burns will result in similar levels of fauna habitat alteration or destruction that persist over periods of several years.
6. Landscape scale prescribed burning will undoubtedly have immediate and persistent impacts on invertebrate biomass, biodiversity and ecological functions.
7. Where prescribed burning impacts restricted, discontinuous or rare habitats, there is a high probability of species loss and irreversible changes to biodiversity.
8. The estimates of fauna impacted by the Weinup fire indicate it will have killed, displaced or otherwise impacted a substantial number of animals including threatened species.
9. There are substantial changes to fauna assemblages in burnt and unburnt habitats. Threatened species were documented only in unburnt habitats during this study, whilst introduced mammals are known to exploit habitats soon after disturbance.

[1] https://www.abc.net.au/news/2021-05-02/prescribed-burn-decimates-numbat-habitat-wa/100110960
[2] https://www.conservation.org/priorities/biodiversity-hotspots
[3] https://www.dpaw.wa.gov.au/management/fire/prescribed-burning
[4] https://www.dbca.wa.gov.au/publications/annual-report-2020-21/agency-performance-service-9

10. The number of animals impacted across southwest Western Australia in each fire season is very high – conservatively in the tens of thousands of individuals.
11. Current target prescribed burning frequencies are inappropriate in the context of habitat preferences for many fauna species and likely to lead to a reduction in fauna diversity.
12. The undeniable conclusion of this report is that we do not understand the degree to which prescribed burning is impacting biodiversity and natural environments, but we can see prescribed burning is unequivocally resulting in reductions to biodiversity values.

These 12 conclusions overwhelmingly suggest that the way prescribed burns are being carried out, combined with the Department's high and somewhat arbitrary burn targets, could be leading to them doing more damage to biodiversity than what they are trying to prevent.

1.2 HSI Commentary

Analysing the Wildlife Toll of Prescribed Burning Practices in Southwest WA finds that the Weinup burn was relatively moderate in severity in comparison to other prescribed burns analysed, and that it's likely a significant proportion of prescribed burns conducted in Southwest Western Australia will result in similar or more severe levels of fauna habitat alteration and destruction.

This is a distressing conclusion considering several hundred species and thousands of animals are thought to have been impacted by the Weinup prescribed burn, including up to 65 numbats and 289 other individuals across five threatened species. The burn likely caused significant suffering and an unacceptable impact on the conservation of threatened species. With so much at stake from both a biodiversity and animal welfare standpoint, we simply must do better.

While the DBCA claims the methodologies they use allow individual animals to escape fire and mitigate impacts, the large number of small to medium sized animals that have limited capacity to move to safety are not properly accounted for. The claim also presumes neighbouring habitats are not at carrying capacity and potentially unable to support more animals.

The research team also found that prescribed burns are being conducted too frequently in DBCA managed forests and are detrimental to ecosystem diversity, and thus their quality as habitat for wildlife, across enormous areas. Current practices are not giving ecosystems adequate time to recover, causing prolonged impacts lasting anywhere from several years to permanently. These impacts go well beyond causing immediate damage and suffering to wildlife, threatening fungi communities that perform vital ecosystem functions. Yet there is no indication that impacts on fungi communities are considered in prescribed burning practices design.

The report also finds that much more care needs to be taken around particularly important habitat sites such as numbat burrows. When a Critically Endangered species with such a highly restricted distribution is known to inhabit an area, it is unacceptable that prescribed burns result in the destruction of hollow logs they need to survive. Yet the number of hollow logs counted in unburnt habitat transects were three times greater than those found in burnt habitat.

When the outlook is this dire for a species, poor fire management can quickly lead to extinctions.

Bird nests were similarly found to be more prevalent in unburnt areas, and tree hollows were seven times more numerous in unburnt habitat—presumably due to the destruction of those in burnt areas during the fire. It was determined that poorly managed burns may be not only harming threatened native species, but providing an advantage to invasive species such as foxes and potentially tipping ecosystems out of balance and further hampering recovery. These burns are meant to be positive for wildlife, however the report makes clear that's not the case.

Due to the time frame over which the study took place, resources able to be allocated to the project, and limitations on publicly available data, the information and findings presented in this report can lead to only a limited number of conclusions. However the conclusions emphatically indicate that prescribed burning is having substantially harmful effect on both the biodiversity of southwest Western Australia and the welfare and suffering of animals across the region.

1.3 Recommendations

Following the findings of *Analysing the Wildlife Toll of Prescribed Burning Practices in Southwest WA*, HSI makes these six recommendations for urgent consideration by the Western Australian Government and is committed to working with Western Australia's DBCA to see them realised:

1. Conduct an in-depth independent study into the biodiversity and animal welfare impacts of current prescribed burning methodologies in Western Australia to build on this report.
2. Work closely with Traditional Owners regarding fire management across Western Australia. Deep and time-proven traditional knowledge should be front and centre and Indigenous groups and land managers integral in the development of a better system.
3. Scrap inappropriate prescribed burning targets: KPIs on hectares burned and cost need to be abolished in favour of more nuanced and adaptive fire management practices.
4. Urgently review the appropriateness of prescribed burn frequencies for individual ecosystem types to assist wildlife habitat and threatened ecosystem recovery.
5. Cease the use of aerial incendiary devices for prescribed burns: the Weinup burn shows they can quickly lose control and cause severe conservation and animal welfare impacts.
6. Work with the Federal Government to develop a national Threat Abatement Plan for the *Fire regimes that cause declines in biodiversity* Key Threatening Process.

With evidence that the prescribed burning regime is harmful, but a lack of conclusive evidence as to just how harmful, further research with full access to Government data is a priority. If the information needed to make sound management decisions is not available, this program simply cannot be adaptive and scientific. We need to understand the situation and make rapid change.

We recognise that these systems have been in place decades and are not the product of the current Western Australian Government. However, the urgent need to respond and adapt falls on their shoulders – HSI offers our full support in seeing the necessary changes realised.

Shortly after the study underpinning this report was concluded, Southwest Western Australia was once again hit by severe fires that burned tens of thousands of hectares of forest. The unfortunate truth is that we're experiencing the worst-case scenario where prescribed burns are causing more harm than good to threatened species and ecosystems while wildfires continue to rage out of control despite significant prescribed burning.

We know that due to climate change extreme weather events are only going to become more severe and frequent, with many climate change models projecting that the climate in Southwest Western Australia is going to get drier, hotter, and as a result more prone to fire. Addressing this extremely serious situation is a challenge we simply cannot shy away from. It is going to be difficult and take courage to tackle, but it has to be done, and it has to be done now.

Evan Quartermain
Head of Programs and Disaster Response
Humane Society International Australia

Numbat
Myrmecobius fasciatus

Carnaby's cockatoo
Calyptorhynchus latirostris

2 Introduction to the project

2.1 Background and Project Brief

Prescribed burning in Western Australia is currently the principal method used to curb the impact of wildfire. The aims of the programme are to protect infrastructure and biodiversity from losses incurred during a season of more frequent and intense fires during summer and autumn (Steffen et al 2015).

The predominant method for igniting these fires involves edge-burning around the target sites, which are commonly thousands of hectares in size, prior to igniting the remainder using incendiaries from aircraft.[5] The intent as described in DBCA literature is to burn forest at light to moderate intensities leaving a mosaic of burn ages at a landscape scale, with burns deemed to meet the fire severity requirement if less than 50% of the canopy is scorched across the area.[6]

Across the southwest of Western Australia, this State-funded protocol aims at a total burn target of 200,000 hectares of native forest per year across the south-west forest regions managed under the Forest Management Plan.[7] Significant areas of non-forest vegetation types within the target area also undergo prescribed burning each year, including peppermint woodland, coastal heathland and semi-arid woodland. The area in question includes forest comprising significant areas of habitat for native fauna and flora, including formally declared threatened species. Indeed, within internationally recognised classifications this area represents a globally significant biodiversity hotspot, the definition of which requires that an area is characterised by containing 1,500 endemic flora species and that less than 30% of its original extent remains (Myers et al 2000).

The current project originated from the perceived impacts of a prescribed burn conducted at Weinup (DON100) within the Perup Management Zone in March 2021. The 1,798 ha extent of this fire affected habitat known to be supporting the native marsupial species *Myrmecobius fasciatus*, the Numbat. The Numbat has been listed as rare or likely to become extinct under the *WA Wildlife Conservation Act 1950* since 1973, and is rated as Endangered in WA using IUCN criteria (Department of Parks and Wildlife 2017). Anecdotal evidence suggested that habitat for the species across the Weinup block had been decimated, and that up to some 75 animals had potentially perished.

The initial response of government agencies to community concerns was that there was no evidence for the outcomes being suggested, and that it was considered unlikely that individual animals had been killed. However, no data backing these claims was made publicly available, and public interest continued to mount. Consequently, Humane Society International (HSI) released a tender request for a small study into the impacts of prescribed burning on biodiversity, with a particular focus on the fate of Numbats at Weinup.

The successful tender that led to this project incorporated studies to investigate the likely site-specific impacts of the Weinup prescribed burn on the resident biodiversity. The study was restricted to an assessment of likely impacts to the faunal values of the site, and an indication of the wider impact via extrapolation of these results to the broader region.

2.2 Project Aims

The primary aim of this study was to assess of the impact to faunal values of the recent prescribed burn site at Weinup. More broadly, results associated with this portion of the study would then be used to evaluate likely impacts to fauna from prescribed burning across the land region as far as the data would allow.

The aim of the study was to examine the impact of prescribed burning on southwest Western Australian faunal values through:

- Comparison of fauna occurrences and activity within the Weinup burn site and adjacent unburnt sites;
- Comparison of fauna habitat structure within the Weinup burn site relative to adjacent unburnt sites; and
- Extrapolation of these impacts to the wider southwest of WA through assessment of burn severity data available for other prescribed burns across the land region.

2.3 Weinup Study Area

The Weinup study area is located approximately 25km east of Manjimup, in the Upper Warren region of Western Australia (Figure 1). It comprises approximately 1,820 ha of mixed native forest including Wandoo, Jarrah and Melaleuca woodlands. Soils range from sands over consolidated piesolitic gravels, to loamy sands and wetland substrates.

2.4 Project Limitations

This report presents the background, methods and results of a small study of impacts to biodiversity associated with prescribed burning. Given the small scale of the study, and the extensive scope of the subject, there are numerous limitations to, and assumptions in our methods, results and subsequent interpretations that require acknowledgement. These limitations and assumptions are described and detailed in Table 1.

[5] For the WA region in 2020/2021, ~21% of the PB area was hand burnt and 79% aerial, or 36,000 ha vs 137,000 respectively. (from the DBCA_060 dataset, fire_ignit field)
[6] https://www.parliament.wa.gov.au/Hansard/hansard.nsf/0/F8D7FF3BE200510A482586FF001ADD98/$file/C41%20S1%2020210622%20All.pdf
[7] https://www.dbca.wa.gov.au/publications/annual-report-2020-21/agency-performance-service-9.

FIGURE 1—SITE LOCATION MAP

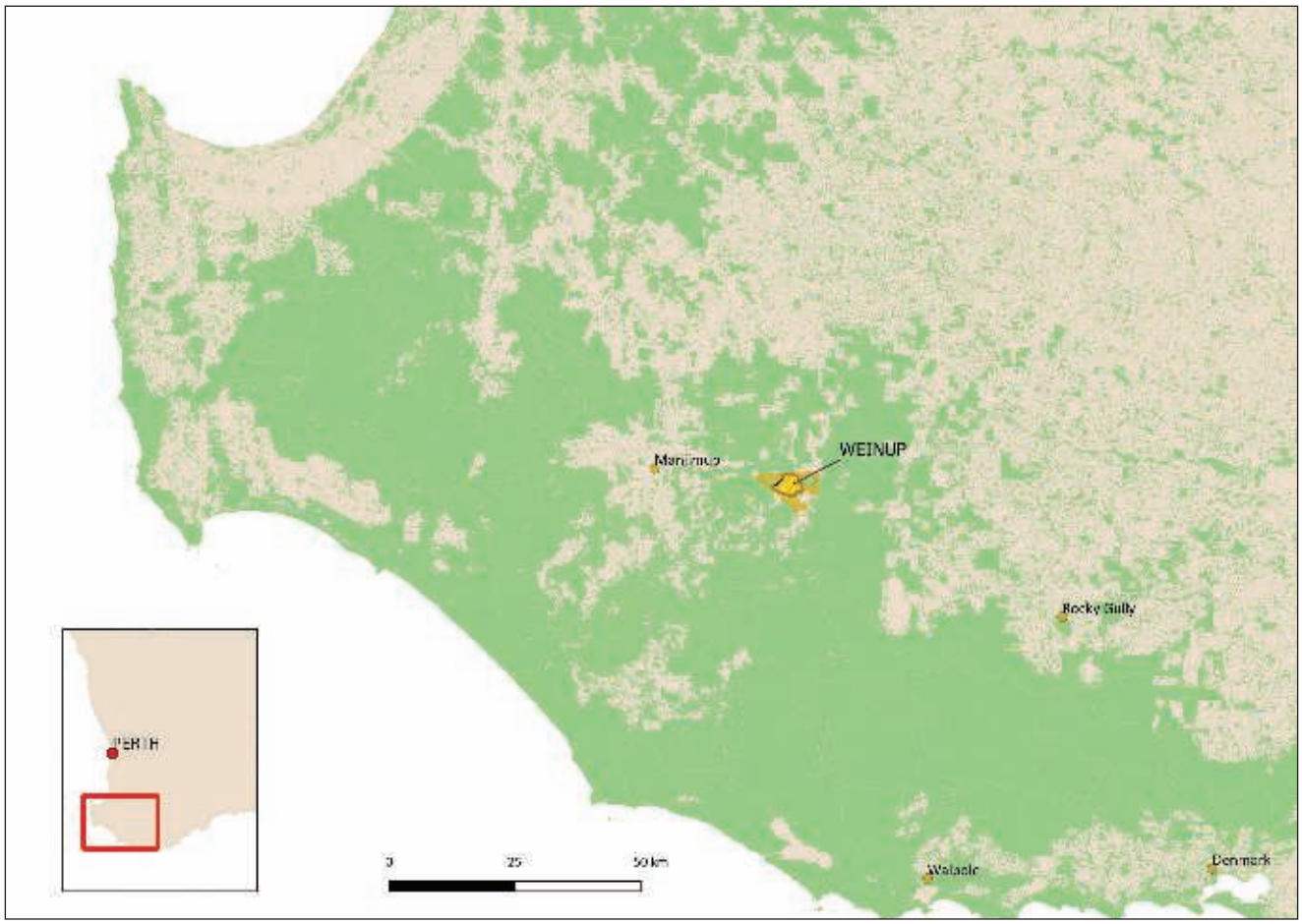


TABLE 1—LIMITATIONS AND ASSUMPTIONS OF THE STUDY

Limitation: Element	Context and impact
Resourcing	
Time	The initial timeframe for completion of the study, including preparation and planning, execution (particularly of the field survey), analysis and reporting, was three months. We have exceeded that time frame by a large margin due to the complexities of the study and what we set out to achieve. While we acknowledge the limitations imposed by the timeframe, we are satisfied with the scope of the work produced in the timeframe permitted.
Financial	The financial support provided by HSI in funding this project is acknowledged. We note here also that there was substantial in-kind support provided by other sources. The limitations imposed by financial restrictions were accommodated in the scope of the study and its execution, but were a significant factor in the small scope of the field survey.
Personnel	The expertise of only a small number of personnel contributing to the study was of relevance to the subject matter. For many of the volunteer brigade, their experience of the subject matter was minimal to limited. While this presented specific challenges in the field, adequate supervision was available to mitigate its effect on data collection.
Methodology	
Habitat Assessment	Sites were selected as far as possible to reflect the habitats available. However, it was not possible to compare habitats directly between burnt and unburnt sites, as the former had not been seen or described prior to the burn. This factor represents a significant limitation to our identification of fauna habitats in the burn area.
Camera Trapping	Camera traps were sited on qualitatively selected transects. Given more resources, additional cameras would have been sites at specifically selected habitat features and over a greater number of areas.
Fauna Sampling	Fauna survey normally comprises the completion of systematic sampling activities including avifauna censusing, pit-trapping for vertebrate and invertebrate fauna, and hand-foraging. Time and financial constraints did not permit the full suite of techniques to be utilised for this study. We therefore consider our fauna sampling to be a significant limitation to the study with regard to compiling a fauna inventory.
Fire Analysis	The analysis uses severity measures based on globally accepted generic classification levels of dNBR, rather than locally derived measures. Comparisons of drone imaging verses the generic classification levels for Weinup indicate that the generic severity classifications are conservative for the Weinup block.
Analysis and Results	
Habitat Assessment	The lack of vegetation descriptions and / or ground-truthing of habitats within the burn area limited our ability to make strict comparisons between these and unburnt sites. However, we have made no attempt to complete statistical analysis of burn effects on habitats within the treatments (burnt vs unburnt). We acknowledge that our habitat comparisons have been conducted in a simple empirical context.
Fauna Sampling	Our limited fauna sampling yielded limited results on the basis of which we have made a number of interpretations. We are aware that some proportion of the differences we have noted may be a result of differences in habitat types between the two treatments (burnt vs unburnt) that we were unable to identify. However, the fauna species we have focussed on are known to utilise most of the habitats in the broader area, and we consider any such effects to be minimal.
Trace Identification	The range of trace records documented included diggings and scats. The available personnel generally had insufficient experience to identify diggings associated with individual species. Similarly, detailed content and / or genetic analysis of the scats collected would have enabled increased detection of individual species but was not permitted due to time and financial constraints. We have mitigated the impact of this by using these elements solely as proxies for indicators of fauna activity.
Impact Extrapolations	We have significant discomfort related to the extrapolations of impacts to fauna numbers from Weinup to the broader southwest of WA. Habitats and species distributions across the southwest, including within documented prescribed burn areas, are highly variable. Attempts to calculate numbers of individual fauna affected yielded extremely high numbers that we have very low confidence in. Consequently, we have limited our extrapolations to impacts on fauna densities and the broader biodiversity values.

3 Methods

3.1 Review of Biodiversity Literature and Fauna Data

The species assemblage that could be expected to occur in the Weinup block and surrounding areas was compiled using a search of the DBCA's Nature Base database. The parameters of the search incorporated an area within a 20km radius centred (WGS84 Coordinates: 116.436, -34.272), roughly central to the Weinup block (see Figure 2). The data search queried the number of species for the following taxa:

- Flora;
- Fungi;
- Vertebrate fauna including mammals, avifauna, herpetofauna, amphibians and fish; and
- Invertebrates.

The biodiversity data analysis included consideration of the potential impact of the Weinup prescribed burn on the:

- Total number of species affected across all taxonomic kingdoms, including flora, fauna and fungi;
- Total number of species affected within each familial level fauna taxon, including mammals, avifauna, herpetofauna, amphibians, fish and invertebrates;
- Number of threatened species recorded within the search area for each taxon; and
- Number of taxa endemic to the region, or greater area of south west Western Australia.

3.2 Field Studies

3.2.1 Site Selection

Sites were selected within the Weinup burn area and in external unburnt areas predominantly on the basis of accessibility and habitat representation. Habitat representation was determined during a single preliminary visit to site and on publicly available satellite imagery. Habitat classification primarily included consideration of predominant flora assemblages, landscape position and the presence of seasonal and / or perennial wetlands.

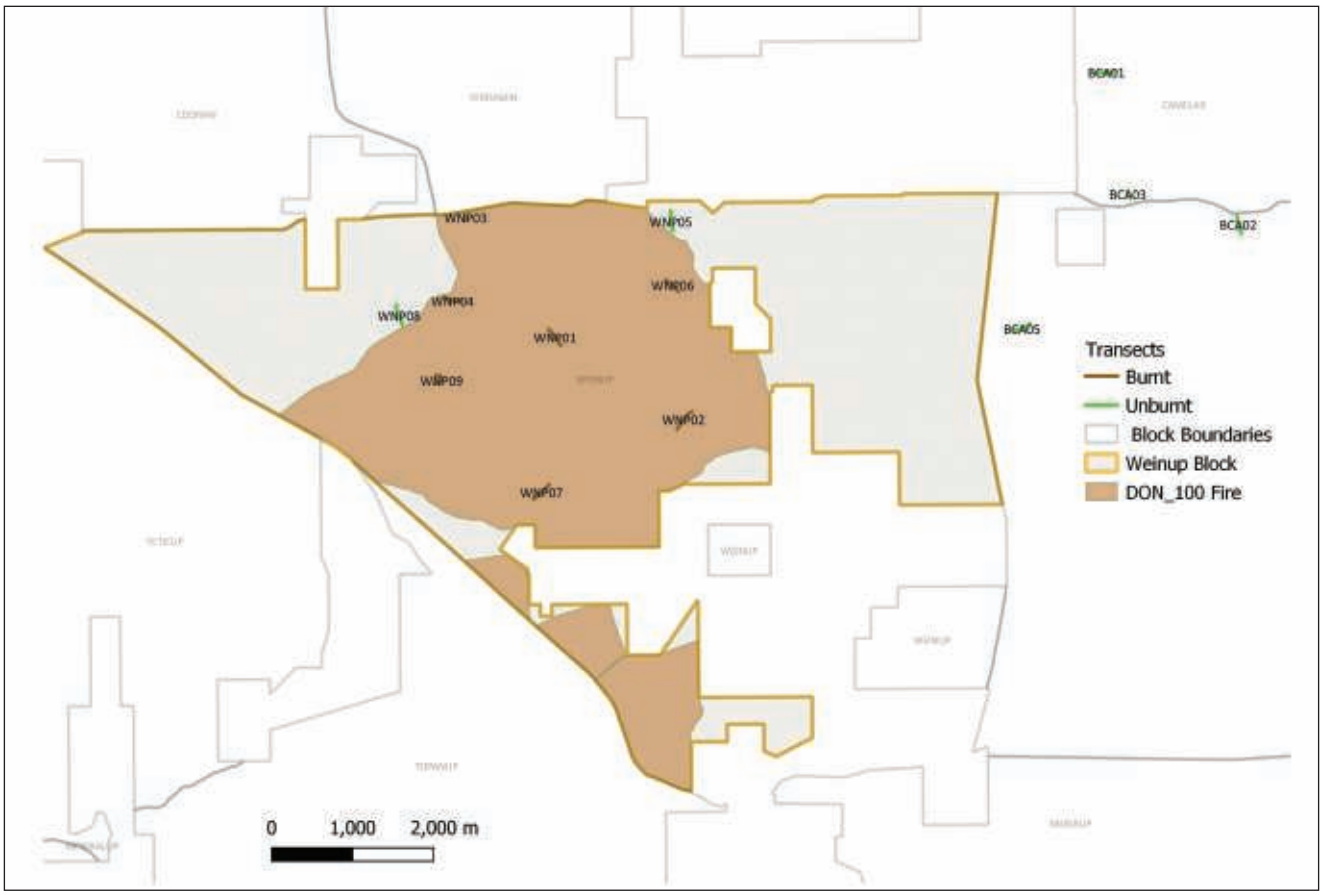
Each site comprised a transect containing between four and seven sample points. Sampling at each site included:

- Assessment of the fauna habitat structure and burn impacts;
- Installation of remote camera traps; and
- Evaluation of fauna activity via the presence of trace records.

3.2.2 Fauna Transects

Transects used to record fauna trace records were spatially based on the camera transects. Each transect was assessed by between two and five people during establishment of the camera trapping transects. Personnel walked each transect at a person-to-person spacing of two to five metres depending on vegetation density.

FIGURE 2—FAUNA TRANSECT LOCATIONS



3.2.3 Fauna Habitat Assessment

Fauna habitats were assessed based on the broad vegetation assemblages and percentage coverage across four strata:

- Ground level: soil, leaf litter and timber debris at the substrate surface;
- Sedges, grasses, low shrubs and logs to 1 metre above the substrate;
- Shrubs between one and three metres in height; and
- The overarching canopy of woodlands and wetlands.

Fauna habitat assessments were averaged for each stratum within each site. The mean values were then used to compare habitat structure across the four strata between burnt and unburnt areas in a simple empirical manner. Analysis of habitat structure was subsequently based on an assessment of the difference between percentage cover at each stratum across burnt versus unburnt habitat.

3.2.4 Camera Trapping

Thirteen sample sites were installed for the survey period (Table 2) with each site comprising between four and seven cameras deployed over transects ranging from approximately 200 metres to 350 metres in length. Seven of these were installed in the burnt area within Weinup block, with an additional six transects placed in areas of unburnt habitat. Two of these latter transects were located in areas of Weinup unburnt since either 2019 (WNP08), or approximately 40 years (WNP05). The remaining transects were sited in nearby Boyicup – Camelar and had not been subjected to fire since 2004/2005.

Each camera was set to take a three second video upon triggering, with a triggering interval of 30 sec. Cameras were set such that specific habitat features of interest, including potential denning sites (hollow logs, burrows, grass tree skirts etc.), runways (fallen trees, trackways or runnels), and foraging areas were captured. Where no such features were present the cameras were set as far as practicable to avoid incidental triggering caused by sunlight variation or incidental movements of plants and leaf litter.

Most records from camera traps were categorised according to species. However, where species level identification was uncertain, records were allocated to broader fauna groups. Hence, videos may have yielded records of particular species (M. fulginosus, T. vulpecula, or V. rosenbergei), birds (avifauna – Passeriformes), small mammals (Dasyuridae or Rodentia) or invertebrates.

3.2.5 Fauna Trace Records

Traces were recorded by each team member as they were encountered, classified according to type, and designated a unique record number. The trace records recorded were to include:

- Tracks;
- Scats;
- Diggings;
- Hollows (Logs / Fallen Timber);
- Food items / debris;
- Hollows (Standing Trees / Stags);
- Nests;
- Burrows / Dens; and
- Other traces (including, sightings, fauna remains, calls etc).

The likely origin of many trace records with regard to the fauna group responsible was not able to be determined with great certainty. Many diggings could only be resolved as bioturbators: typically, small to medium-sized marsupials such as potoroids (woylies) or peramelids (bandicoots). Track records likewise could often only be identified as one of the abovementioned taxa, or as a macropod (kangaroos or wallabies). Confidence in scat identifications was often indeterminate due to the age of the trace, or to the familiarity and knowledge of the personnel. Further content and/or molecular analyses would be required to confirm tentative identifications.

Consequently, analysis of records was restricted to categorisation according only to trace type and used as a proxy for assessment of fauna activity levels across the burnt and unburnt sites. To permit comparison across sites with differing levels of sample effort, the number of records per site were normalised by calculating the number of records per 100 metres of linear habitat sampled.

3.3 Animal Impact Extrapolation

We have in part followed the methods of the WWF Report (van Eeden et al 2020), which used estimates of animal density per hectare. At the fine scale for the Weinup Fire, fauna density data was unavailable for most fauna categories as designated in van Eeden et al (2020). Consequently, density estimates were derived only for a select group of threatened fauna for which spatial data was available. A specific set of impact values subsequently used were based on the most relevant data available from the literature and applied to the Weinup fire extent. The total number of individuals impacted for a given species across the burn area were subsequently calculated by multiplying the density value by the proportion of the burn area estimated to represent suitable habitat for the species.

We were unable to source reliable density data for reptiles and birds specific to Weinup. We have therefore relied on the density values provided in van Eeden et al (2020) to calculate the number of individuals impacted. We note here that there is a limited basis for estimating the number of individuals of either group within a given habitat type within Weinup due to the spatial variation of different habitat types and species preferences. However, the small range of lower and upper density estimates provided for birds suggest that there is likely to be little variability in species and individual numbers across the Warren region. Conversely, the lower and upper density estimates for reptiles represent an enormous

TABLE 2—FAUNA TRANSECT DETAILS

Transect	Date established/ surveyed	Date closed	NIghts open	Length (m)	Camera number	Personnel number
Transects—Burnt						
WNP01	30/08/2021	13/09/2021	14	350	7	4
WNP02	30/08/2021	13/09/2021	14	350	7	4
WNP03	01/09/2021	13/09/2021	12	200	4	2
WNP04	31/08/2021	13/09/2021	13	350	6	5
WNP06	14/09/2021	01/10/2021	17	350	7	3
WNP07	14/09/2021	01/10/2021	17	350	7	3
WNP09	15/09/2021	01/10/2021	16	350	7	4
Total			**103**	**2,250**	**45**	
Transects—Unburnt						
WNP01	30/08/2021	13/09/2021	14	350	7	4
WNP02	30/08/2021	13/09/2021	14	350	7	4
WNP03	01/09/2021	13/09/2021	12	200	4	2
WNP04	31/08/2021	13/09/2021	13	350	6	5
WNP06	14/09/2021	01/10/2021	17	350	7	3
WNP07	14/09/2021	01/10/2021	17	350	7	3
WNP09	15/09/2021	01/10/2021	16	350	7	4
Total			**88**	**1,900**	**35**	

differential, and it is possible that the true numbers of herpetofauna individuals present lie somewhere within this range. In either case, a conservative approach would require consideration of the lower bounds as the most accurate available representation of actual animal numbers across Weinup.

It should be noted that, as with van Eeden et al (2020), our definition of individual animals being 'impacted' does not imply that all animals were killed. Rather, the definition refers to individual animals that could have been affected by one or more of a multitude of impact types. These impacts include being killed and being displaced to adjacent areas, as well as experiencing the loss of shelter, food and other resources.

Regarding the prescribed burn impacts on fauna across the broader southwest of Western Australia, fauna density values were taken directly from van Eeden et al (2020). Numbers of fauna impacted were then calculated by multiplying by the total area of prescribed burns by the area burnt by wildfire, and the total fire area. We have a low degree of confidence in the resultant numbers of mammalian fauna impacted and believe the results to be a large overestimation. This view is based on our inability to account for the wide variability in fauna habitats and species distributions across the southwest region. In utilising the suggested densities and numbers of individuals therefore, we have taken a conservative approach in considering fire impacts on fauna. This dictates that, while the upper bounds are provided in accordance with the previously established methodology, in the absence of more complete data and analysis, the lower bounds are accepted as the most accurate available representation of potential animal numbers across the region. The list of fires in each fire season provides a basis for estimating the potential impact on animals for each fire and the season as a whole. Fires below 25 ha in size were excluded from this extrapolation at the broad scale for the entire fire season.

3.4 Fire Data

3.4.1 Fires in the 2020-2021 Fire Season

The geographic extent of prescribed burns and wildfires for the 2020/2021 fire season (from 01/07/2020 to 30/06/2021) was extracted from DBCA's publicly available DBCA Fire History dataset [DBCA_060] [8]. This dataset provides the spatial extent of each fire, along with information such as the date and type of fire, and the area of the fire in hectares. The Weinup Fire is denoted DON_100, and the fire boundary was taken from the DBCA dataset.

3.4.2 Analysis

In addition to the location and extent of fires for the 2020/2021 fire season, the spatial distribution of fire severity for each fire was each also calculated, as a measure of the proportion of vegetation burnt. The Difference Normalised Burn Ratio (dNBR) fire severity data has been shown to be consistently the best performing satellite index of burn severity for open forests and woodlands in Australia (Tran et al 2018). For this project, dNBR were calculated from the difference in Normalised Burn Ratio data from mosaiced cloud-free Sentinel-2 satellite data for the month preceding and immediately after each fire event.

3.4.3 Weinup Fire Characterisation

The dNBR data for the DON_100 block were compared against the vegetation data from the field program and the percentage canopy loss estimated using the AusCover vegetation height and structure dataset as a pre-fire baseline (Scarth et al 2012).

As the classification of fire severity from dNBR is somewhat dependent on vegetation type, the canopy loss assessment was restricted to the DON_100 block. For the remainder of the DBCA_060 fire dataset, dNBR is used to provide a relative indication of severity.

[8] DBCA-060: DBCA Fire History [Internet]. Perth, Australia: Department of Biodiversity, Conservation and Attractions; 2021. Available from: https://catalogue.data.wa.gov.au/dataset/dbca-fire-history

4 Results

4.1 Biodiversity Literature and Data Review

4.1.1 Fauna and Flora Assemblage

The results of Nature Map search indicated that the total number of species potentially impacted by the prescribed burn within the Weinup block included 1,208 taxa (Table 3). This total included 754 flora species, 156 fungi and 298 fauna species. Five of the flora species recorded within a 20km search area radius are considered locally endemic (i.e. occur nowhere else). The relatively small number of invertebrates documented is likely to underrepresent the number of species present and is likely due to sampling inadequacy.

4.1.2 Threatened and Endemic Flora, Fauna and Fungi

The Nature Map search yielded a total of 41 species of elevated conservation significance. This total included 18 plants, four fungi and 19 fauna species.

4.2 Field Studies

4.2.1 Survey Effort

The total field-based survey effort is presented in Table 4. Survey activities were slightly higher in the burnt area of Weinup, which comprised 54.6% of the transect distance walked, 56.6% of the camera trap nights, and 56.3% of the habitat assessments completed.

4.2.2 Vegetation and Fauna Habitats

Two predominant habitats were documented across the Weinup burn area and the broader surrounding survey sites in Weinup block and Boyicup-Camelar. These primarily comprised:

- Medium forests and woodlands of mixed jarrah (*Eucalyptus marginata*) and wandoo (E. wandoo) woodlands over varied understoreys on sands and patches of lateritic gravels with limited outcropping; and
- Open to closed paperbark (*Melaleuca spp.*) woodlands over tea tree shrublands and sedgelands on clays, loams and sands in seasonally inundated wetlands and swamps.

There was no evidence of habitats associated with riverine vegetation units, although one transect (WNP05) was located on the upper slopes of the Perup River valley. Though vegetation here was notably denser and contained potentially more flora species it was not considered riverine.

Scattered patches of *Allocasuarina spp*. trees were apparent across some of the transect sites. However, none of these were considered sufficiently substantial to warrant inclusion as separate habitat, as they typically comprised a scattering of trees within dominant jarrah woodland. Granite outcropping was not observed across any of the study sites, although these may have been present in areas not ground-truthed.

TABLE 3—KINGDOMS POTENTIALLY IMPACTED BY THE WEINUP PRESCRIBED BURN

Taxon	Number of Species	Threatened Species	Endemic Species
Flora	754	18	5
Fungi	156	4	–
Fauna (Total)	298	10	–
Mammalia	34	10	–
Avifauna	103	8	–
Herpetofauna	20	0	–
Amphibians	12	0	–
Fish	1	1	–
Invertebrate	128	0	–
Total	**1,208**	**41**	**5**

TABLE 4—SURVEY EFFORT COMPLETED FOR FIELD STUDIES

	Walked Transect Distance (m)	Camera Trap Nights	Habitat Assessments
Burnt Habitat	8,300	672	45
Unburnt Habitat	6,900	516	35
Totals	**15,200**	**1,188**	**80**

4.2.3 Fauna Habitat Structure

Comparisons of living and non-living habitat structure observed across the burnt areas with those in unburnt habitats showed greatly reduced levels of complexity across all four strata assessed.

The substrate cover in the burn area (Table 5) typically comprised a high proportion of bare ground, with leaf litter and other organic debris absent to limited. Where leaf litter was present it was restricted to dead leaves and other debris associated with the burn in March 2021. Unburnt habitat (Table 6) exhibited much greater patchiness of leaf litter and organic debris distribution, with bare ground representing between 8.4% and 57.1% of total surface area.

Similarly, habitat structure within the mid-level strata (1m and 3m heights) was extremely simplified in the burnt areas compared to the unburnt. Burnt sites had very low estimated percentages of ground cover, with only one value (WNP06 at 1m) exceeding those recorded for unburnt sites. However, the low vegetation that had emerged at this site since the March burn was dominated by introduced weeds, particularly in the northern section of the transect. Ten values for these strata indicated less than 6% ground coverage, while a further three yielded coverage values of less than 20%. By comparison, the unburnt areas ranged from a low coverage of 19.3% to a high of 57.1%.

The canopy layer in the burnt areas ranged between 3.1% and 47.1% coverage compared with values of 40% to 65% in the unburnt habitat. However, it should be noted that canopy structure in the burnt areas was predominantly epicormic regrowth in the six months post-fire. The same stratum in the unburnt areas comprised a much wider range in limb sizes and ranged from new growth elements through to established older limbs as well as dead limbs.

Similarly, non-living habitat elements were evident in far greater proportions in unburnt habitat (habitat – presumably due to the destruction of those in burnt areas during the fire (Table 7).

Numbers of hollow logs counted in unburnt habitat transects were three times greater than those found in burnt habitat, with many logs in burnt areas that may have supported hollows destroyed by fire. Nests were similarly more numerous in unburnt areas, while tree hollows were found to be seven times more numerous in unburnt habitat – presumably due to the destruction of those in burnt areas during the fire.

4.2.4 Camera Trap Records

Camera trapping yielded a total of 62.65 animals per 100 camera trap nights in the burn zone, and 34.88 animals in the unburnt habitats (Table 8). The fauna recorded in the burn zone were disproportionately represented by large mobile

TABLE 5—FAUNA HABITAT STRUCTURE (BURNT) ESTIMATED AS MEAN PERCENTAGE GROUND COVERAGE ACROSS VEGETATION STRATA

Site	Vegetation Stratum Height*				Scorch Height (m)
	Bare Ground	1m	3m	Canopy	
WNP01	61.2 (50 – 90)	2.1 (0 – 4)	0 (0 – 1)	10.0 (8 – 13)	15.0
WNP02	67.1 (50 – 90)	5.3 (0 – 20)	1.9 (0 - 5)	17.9 (5 – 50)	7.6
WNP03	67.5 (50 – 90)	2.8 (2 – 5)	>1.0 (0 – 1)	45.0 (40 – 50)	11.1
WNP04	66.7 (50 – 90)	2.5 (0 - 10)	0.5 (0 - 1)	36.7 (20 - 40)	8.0
WNP06	28.6 (10 – 40)	68.9 (2 - 90)	1.1 (0 - 4)	18.6 (10 - 30)	10.6
WNP07	62.9 (50 - 90)	14.6 (2 - 30)	13.6 (0 – 40)	47.1 (30-60)	4.7
WNP09	68.6 (40 - 90)	17.4 (2 - 40)	0.6 (0 - 2)	3.1 (0 – 10)	13.6

** Values in parentheses are range of values across sites.*

TABLE 6—FAUNA HABITAT STRUCTURE (UNBURNT) ESTIMATED AS MEAN PERCENTAGE GROUND COVERAGE ACROSS VEGETATION STRATA

Site	Vegetation Stratum Height*				Scorch Height (m)
	Bare Ground	1m	3m	Canopy	
BCA01	25 (10 - 40)	36.7 (10 - 90)	19.3 (5 - 30)	48.3 (40 - 70)	N/A
BCA02	48.6 (40 - 60)	34.3 (20 - 50)	25.7 (10 - 40)	40.0 (20 - 60)	N/A
BCA03	32.5 (0 - 70)	47.5 (20 - 70)	20.0 (10 - 40)	65.0 (60 - 70)	N/A
BCA05	57.1 (0 - 90)	34.3 (10 - 70)	31.7 (2 - 60)	40.0 (20 - 60)	N/A
WNP05	8.4 (0 – 30)	57.1 (40 - 70)	22.9 (10 - 30)	45.7 (30 - 60)	N/A
WNP08	38.9 (10 - 90)	42.9 (20 - 70)	35.7 (20 - 40)	42.9 (30 - 60)	5.9

** Values in parentheses are range of values across sites.*

species (kangaroos and emus), which accounted for nearly 80% of all records. The Brush-tailed Possum accounted for 14.0% of records in the burn area, while small fauna species, including birds and skinks were recorded in small numbers. Importantly, no threatened fauna species were recorded in burnt habitats, while foxes were more prevalent.

In contrast, unburnt habitats yielded lower proportions of kangaroos and emus, at less than 63% of all records. Conversely, the Brush-tailed Possum accounted for 15.6% of records in unburnt habitats, and threatened fauna species, including the Western Brush Wallaby, Woylie and Chuditch accounted for 19% of records. Small avifauna and reptiles were not recorded in unburnt habitats, presumably due to greater vegetative obstruction in camera fields of view. Foxes also were not documented in unburnt habitats.

4.2.5 Fauna Activity Trace Records

Total fauna activity in the burnt habitats was markedly lower, at less than 50%, than that in unburnt habitats (Table 9). While fauna tracks were recorded more frequently in burnt habitat, scat numbers were recorded just over half as frequently, while diggings were recorded at less than one quarter the frequency of unburnt habitats. Food debris and other traces including fauna remains and sightings were recorded at similar frequencies across both burnt and unburnt areas.

4.3 Prescribed Burn Extents and Severity

4.3.1 Weinup Fire (DON_100)

According to the DBCA Fire History Dataset, the Weinup Fire covered an area of 1798ha in four parts, of which the major fire comprised 1619.5ha. The severity classification levels of the DON_100 fire in the Weinup Block are shown in Figure 3 (overleaf) below. Colours correspond to globally accepted generic classification levels of dNBR, and are considered conservative, as several studies have shown that Australian open resprouter forests have lower dNBR values for equivalent severity (Tran et al 2018). The overall severity pattern is consistent with DBCA's internal review of the fire, with lower severity 'edging' burns done by hand and the core ignition performed with aerial incendiaries. With median dNBR of 0.30, this fire would overall be classified as a low to moderate severity fire on the generic global dNBR classification scale. It should be noted the edge burn is far less severe than most of the interior. On this basis, and given its proximity to adjacent habitats, this is the area we would expect animals to first recolonise.

Previous work in conjunction with DBCA to calibrate satellite burn severity with on-ground field data in Jarrah forests (Walz et al 2007) defined moderate severity fires as those where the upper understorey is partially or completely charred by fire, and high severity fires as where the top canopy is affected by fire.

TABLE 7—FAUNA HABITAT FEATURES PER 100M OF LINEAR HABITAT

	Hollow log	Tree hollow	Nest	Burrow	Total
Burnt	0.01	0.01	0.02	0.02	**0.06**
Unburnt	0.03	0.07	0.06	0.02	**0.18**

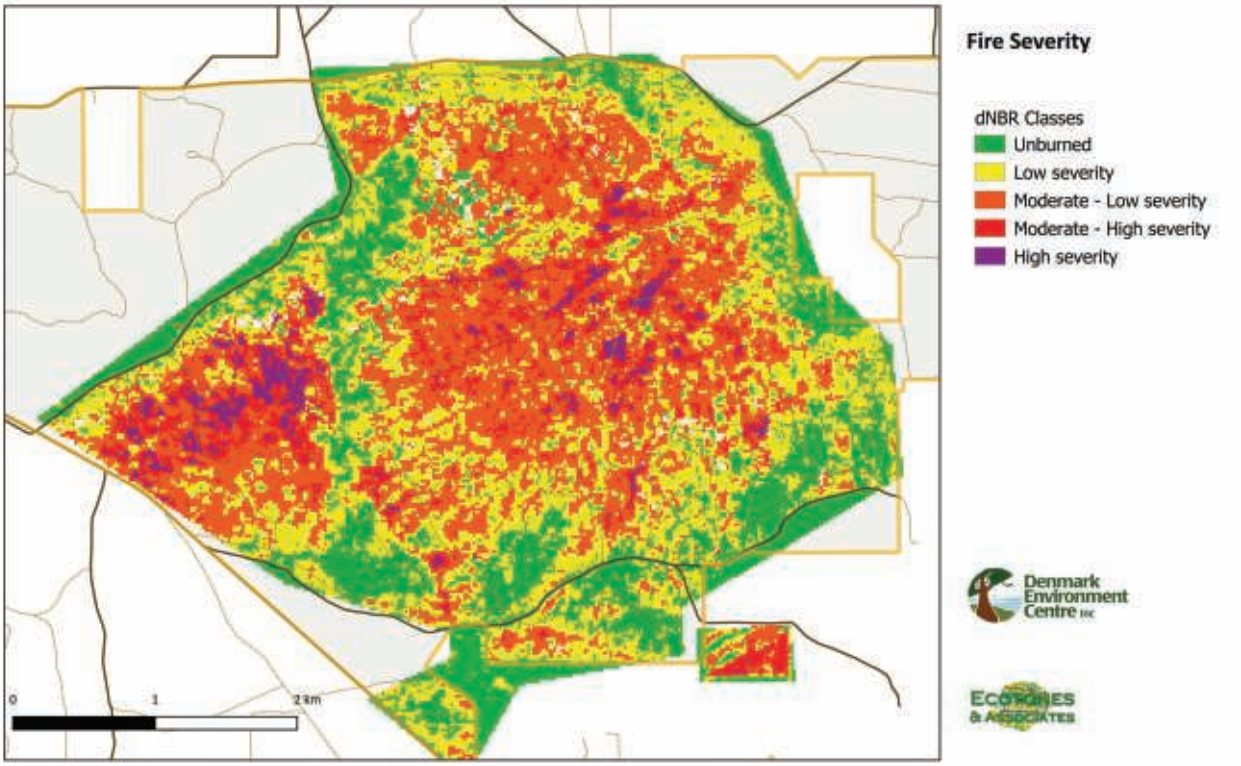
TABLE 8—CAMERA RECORDS OF FAUNA BY BURN STATUS EXPRESSED AS NUMBER OF INDIVIDUALS RECORDED PER 100 CAMERA TRAP NIGHTS

	Burnt		Unburnt	
	Count	%	Count	%
Avifauna (excluding Emus)	2.68	4.3%	0.78	2.2%
Emu	9.08	14.5%	2.52	7.2%
Chuditch	0.00	0.0%	1.74	5.0%
Grey Kangaroo	40.92	65.3%	19.38	55.6%
Western Brush Wallaby	0.00	0.0%	1.55	4.4%
Woylie	0.00	0.0%	3.49	10.0%
Brush-tailed Possum	8.78	14.0%	5.43	15.6%
Fox	1.04	1.7%	0.00	0.0%
Skink (Egernia)	0.15	0.2%	0.00	0.0%
Totals	**62.65**	100.0%	**34.88**	100.0%

TABLE 9—TRACE RECORDS OF FAUNA ACTIVITY PER 100M OF LINEAR HABITAT

	Track	Scat	Digging	Food item	Other	Total
Burnt	0.40	0.27	0.28	0.04	0.02	1.01
Unburnt	0.25	0.50	1.26	0.03	0.02	2.06

FIGURE 3—WEINUP FIRE SEVERITY MAP (DNBR)



A comparison of the median dNBR for field transects versus drone imagery (Figure 4 and Figure 5) and estimated canopy loss for all transects in the Weinup block (Figure 6) indicates that the generic severity classifications are indeed conservative for the Weinup block. Using the Jarrah forest classifications, transect WNP001 for instance would be classed as moderate to high severity (whereas this transect is classed as low to moderate severity with the generic dNBR classifications). WNP002 and WNP006 would likewise be classed as moderate to high severity. Transects WNP003, WNP004, WNP007 and WNP008 would be classed as moderate severity (compared with low severity with the generic dNBR classifications).

4.3.2 The 2020-2021 Fire Season

With the prescribed burns in the southwest region for the 2020/2021 fire season having a median dNBR of 0.24 (or low severity if generic classifications are used), the Weinup prescribed burn was more severe than the average prescribed burn for the year. By comparison, the average wildfire dNBR for the same period was 0.41 (or low to medium severity). However, the histogram distributions of dNBR shown in Figure 7 show that several prescribed burns and a significant area of prescribed burns were of similar to, or higher severity than Weinup (71 of prescribed burns (35%) or 68,800 ha (40% by area)). While further work is required to calibrate dNBR severity across different vegetation communities in the SW region, this initial severity estimate indicates that Weinup was not an unusually severe prescribed burn for the 2020/2021 season.

Figure 8 shows the locations of wildfires and prescribed burning in the 2020/21 fire season, as well as fire severity. It illustrates both the scale of the prescribed burn program vs wildfires, and the severity of the prescribed burns.

FIGURE 4—WEINUP BLOCK POST-FIRE IN THE VICINITY OF SITE WNP01 (TRANSECT MEDIAN DNBR 0.35)

FIGURE 5—SWAMP IN THE VICINITY OF SITE WNP09 (TRANSECT MEDIAN DNBR 0.77)

FIGURE 6—TRANSECT MEDIAN DNBR VERSUS PERCENTAGE CANOPY LOSS FOR TRANSECTS WITHIN THE WEINUP BLOCK

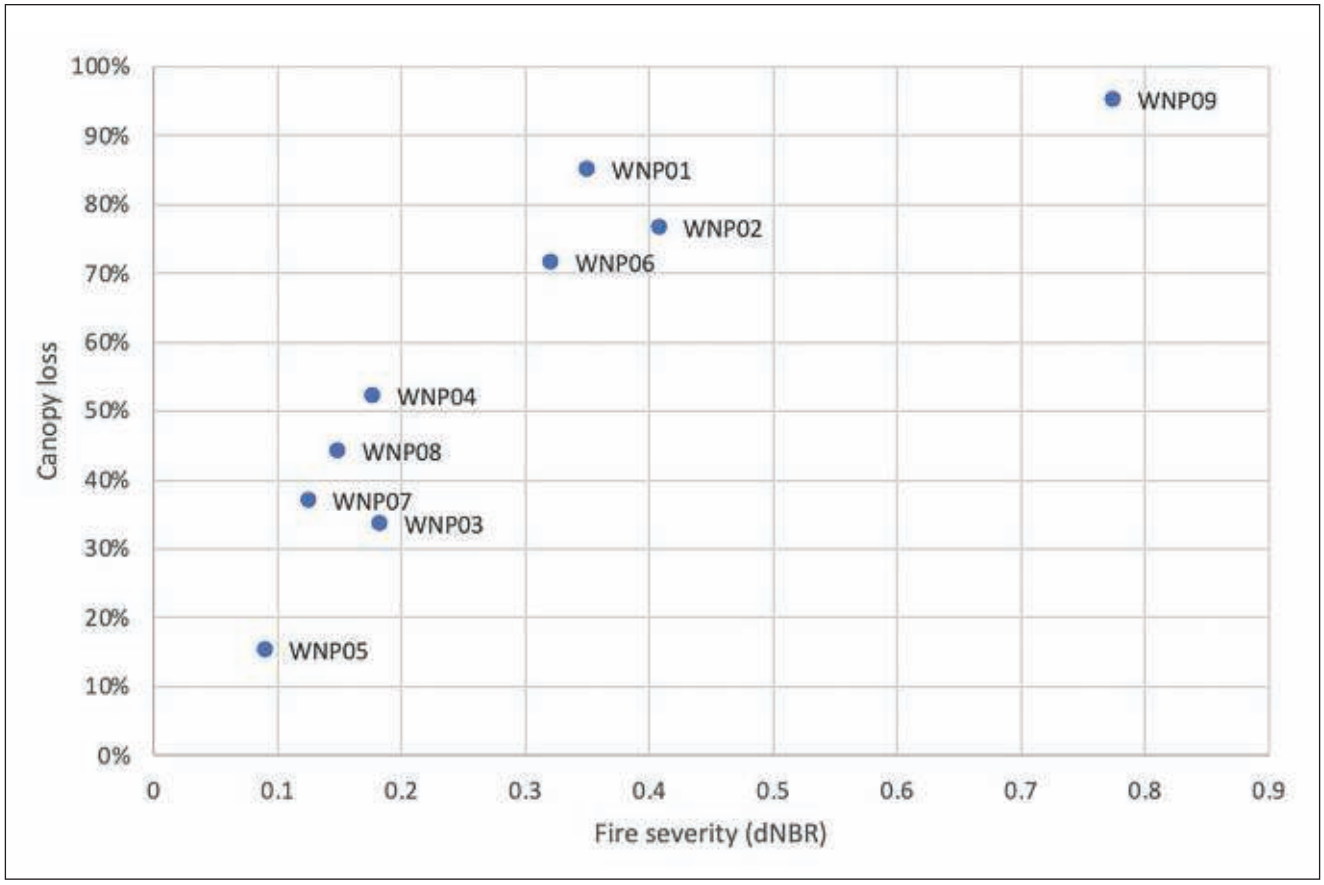


FIGURE 7—FIRE SEVERITY OF 2020/21 PRESCRIBED BURNS AND WILDFIRES BY NUMBER OF FIRES AND AREA BURNT

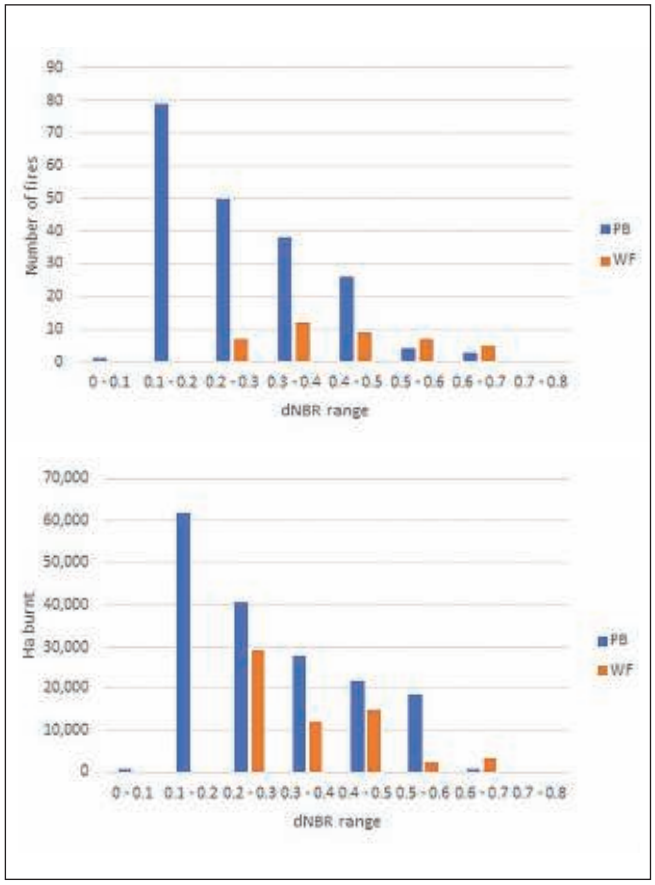
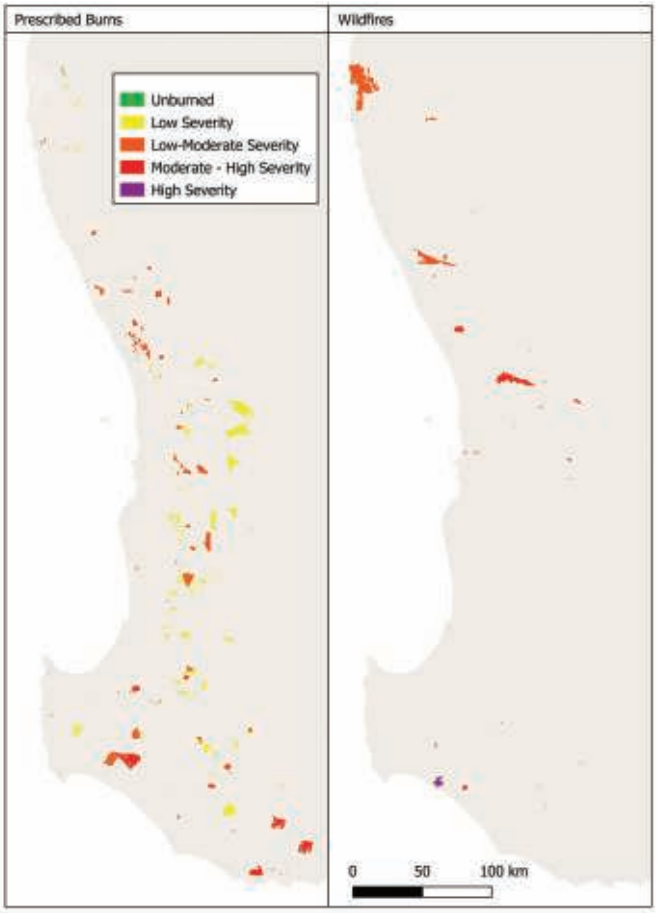


FIGURE 8—FIRE SEVERITY IN THE 2020-2021 FIRE SEASON



4.4 Prescribed Burn Impacts

4.4.1 Estimated Animal Density – Weinup

Fauna species densities derived for the burn area at Weinup block ranged from a low of 0.0006 Chuditch per hectare (lower bound), to a high of 0.14 Quokkas per hectare (upper bound) (see Table 10)[9]. The primary species that lead to this study, the Numbat, had suggested densities ranging from a low of 0.005 to a high of 0.036 animals per hectare. Our confidence in these density estimates is relatively high, as they are derived from studies carried out in similar habitats, often in close proximity to Weinup, and frequently by DBCA as part of its species' management.

4.4.2 Estimated Fire Impact – Weinup

The numbers of individual mammals impacted by the burn were calculated so as to allow for differences in area of each species occupancy within Weinup (Table 11). These differences are related to the suitability of the habitats presumed to have been available prior to the burn and species habitat preferences as detailed in the literature. The numbers of animals impacted by the fire ranged from an estimated low of one individual for the Chuditch, to an estimated high of 90 individuals for both the Phascogale and Western Ringtail Possum. Our calculations support public discussions of the fire throughout 2021, indicating that up to 65 Numbats may have been impacted by the burn. It seems likely that the lower bound of nine individual numbats impacted would be an underestimate. In total, this would suggest that between 93 and 354 individual animals, representing six threatened species, were impacted by the Weinup burn. We note here that this total excludes other mammal species that could be considered likely to use the habitats of the area, including native rodents, microbats, kangaroos, and several species of carnivorous marsupials for which we were unable to locate suitable data.

Numbers of avifauna and herpetofauna individuals impacted by the fire yielded ranges in excess of 16,000 to 23,000 birds, and over 33,000 to 359,000 reptiles, across 103 and 20 species respectively. In the context of avifauna there is a reasonable likelihood that due to their relative mobility, large numbers of individuals may have escaped. However, this would be dependent on the rate of spread of the fire and does not preclude impacts to individuals due to other factors related to the destruction of their home ranges. In addition, the impact on nesting avifauna at the time of the Weinup burn needs to be considered. This includes threatened species such as the threatened Forest Red-Tailed Black Cockatoo (*Calyptorhynchus banksii naso*). The majority of reptiles in contrast are relatively

TABLE 10—DENSITY ESTIMATES (# OF INDIVIDUALS / HA) FOR WEINUP BLOCK

	# of individuals / ha		Suitable Habitat	References
Mammals	**Lower Bound**	**Upper Bound**		
Numbat	0.005	0.036	100%	Dept of Parks and Wildlife (2017).
Chuditch	0.0006	0.003	100%	Dept of Environment and Conservation (2012).
Phascogale	0.009	0.05	100%	Soderquist, T. and Rhind, S. (2008), Rhind 2006
Quokka	0.08	0.14	20%	Bain, K. (2015)
Western Ringtail Possum	0.05	0.2	25%	Dt of Parks and Wildlife (2017).
Woylie	0.009	0.03	100%	Wayne et. al. (2011); Calmont, J.P. (2010), Smith et al (2020)
Birds	9.1	12.9	N/A	van Eeden et al (2020)
Reptiles	18.76	200.0	N/A	van Eeden et al (2020)

TABLE 11—ESTIMATED FIRE IMPACTS # OF INDIVIDUALS– WEINUP BLOCK

	Number of Individuals	
Mammals	**Lower Bound**	**Upper Bound**
Numbat	9	65
Chuditch	1	5
Phascogale	16	90
Quokka	29	50
Western Ringtail Possum	22	90
Woylie	16	54
Sub Total (Mammals)	**93**	**354**
Birds	**16,362**	**23,194**
Reptiles	**33,370**	**359,600**

[9] Note that these fauna do not include very numerous species such as Western Grey Kangaroos.

sedentary and would have limited means of escape, so it is likely that the majority would have perished. Considered conservatively, should even the lower of the two measures for these species be overestimated, the data suggests very large numbers of individuals from these two groups would have been impacted by the Weinup prescribed burn.

4.4.3 Estimated Animal Density – Southwest WA Forests

Species densities presented here (Table 12) are taken directly from the calculations and data reported in van Eeden et al (2020). It may be possible that these densities are appropriate for habitats in which individual species, or even groups of species, are present. However, fauna habitats and consequent species distributions are not contiguous across southwest Western Australia. Lower and upper density estimates of 0.01 to 0.1 carnivorous marsupials (dasyurids) per ha are potentially accurate across some proportion of the fire zones analysed in Section 3.3.2, but these limits fail to account for areas in which dasyurid species are completely absent, or for different habitats that favour one species over another. Additionally, the 'Possums' grouping in Western Australia represents a problematic pseudo-taxon, in that it would necessarily include the Brush-tailed possum, Western Ringtail possum, Pygmy possum and Honey possum. These are four species with highly divergent ecologies, and at least two of the four heavily favouring quite specific habitats of Agonis flexuosa woodland (Western Ringtail) and coastal heath (Honey possum). The former is known to utilise jarrah woodland habitats, but in far lower densities than its favoured habitat, while the honey possum is absent from most tall woodlands. Thus, applying a uniform density range for these species across the southwest is likely to greatly exaggerate their numbers in most habitats subjected to prescribed burning. Similar concepts can be applied to groups including the bandicoots, which favour dense, ground-level vegetation and are absent from more open habitats such as wandoo woodlands.

4.4.4 Estimated Fire Impact – South West WA Forests

The numbers of individual animals impacted by prescribed burning in southwest Western Australia are presented in Table 13 (overleaf). Confidence in these numbers is low due to concerns relating to the high levels of variability in both habitat and species distributions across the region. We consider it likely that inclusion of all species densities across all fire areas included in this analysis has yielded unrealistic overestimates of the numbers of individual animals impacted. The results following therefore are applicable only to prescribed burns where habitats are appropriate to the taxa discussed.

Notwithstanding this, for any given prescribed burn in southwest Western Australia, lower bound estimates of individual fauna impacted range from one dingo per 1000 ha, to 91 birds per 10 ha and 1876 reptiles per 100 ha. The upper density estimates for birds and reptiles suggest total individuals impacted to number 129 birds and 2000 reptiles would be impacted for every 10 ha burnt.

Among native mammals, density estimates suggest between one and ten carnivorous marsupials (*Dasyuridae*), from four to 30 bandicoots, and nine to 87 macropods (kangaroos and wallabies) will be impacted per 100 ha burnt. Upper and lower density estimates could not be derived for some species groups such as bats and possums, where estimates indicate ten and 32 individuals would be impacted respectively for every 10 ha burnt.

We repeat that we consider the values in Table 12 to be excessive. However, these results and the interpretation presented in the paragraph above indicate that, irrespective of the discrepancies that may be inherent in the results, the numbers of individual animals impacted by these prescribed burns would be extremely large. This raises questions relating to the potential magnitude of any overestimates presented in these results. As with interpretations of the numbers of individuals impacted at Weinup, we must by necessity assume a conservative position in considering these results and suggest that the lower bounds shown in Table 13 (overleaf).potentially represent the most accurate estimate of animals impacted by prescribed burning and wildfire in southwest Western Australia.

TABLE 12—DENSITY ESTIMATES (# OF INDIVIDUALS / HA) – SOUTH WEST FORESTS (REFERENCE: VAN EEDEN ET AL (2020)

Mammals	**Lower Bound / ha**	**Upper Bound / ha**
Dasyurids	0.01	0.1
Bats	0.1	0.1
Bandicoots	0.042	0.3
Dingo	0.001	0.001
Echidna	0.01	0.01
Macropods	0.09	0.875
Native Murids (Rats / Mice)	0.2	0.2
Possums	3.2	3.2
Birds	9.1	12.9
Reptiles	18.76	200
Frogs	No data	

TABLE 13—ESTIMATED FIRE IMPACT 2020-2021 – SOUTHWEST WESTERN AUSTRALIA

	Prescribed Burn		Wildfire		Total	
	Lower	Upper	Lower	Upper	Lower	Upper
Dasyurids	1,580	15,804	618	6,176	2,198	21,980
Bats	15,804	15,804	6,176	6,176	21,980	21,980
Bandicoots	6,638	47,412	2,594	18,527	9,231	65,939
Dingo	158	158	62	62	220	220
Echidna	1,580	1,580	618	618	2,198	2,198
Macropods	14,224	138,284	5,558	54,038	19,782	192,323
Murids	31,608	31,608	12,352	12,352	43,960	43,960
Possums	505,726	505,726	197,626	197,626	703,352	703,352
Birds	1,438,158	2,038,707	562,000	796,681	2,000,158	2,835,388
Reptiles	2,964,817	31,607,862	1,158,585	12,351,649	4,123,402	43,959,511
TOTAL	**4,980,293**	**34,402,946**	**1,946,188**	**13,443,905**	**6,926,480**	**47,846,851**

Baudin's black cockatoo
Calyptorhynchus baudinii

5 Discussion & Conclusions

5.1 Prescribed Burning at Weinup and Across Southwestern WA

The prescribed burn analysis presented in this report shows that the Weinup fire, while classified overall as only Low-Moderate Severity overall, ranged in severity from Unburned or Low, up to High Severity. However, fire severity mapping shows that significant areas burned at Moderate Severity or above – intensities sufficient to denude much of the block, rendering it unsuitable for most fauna.

Analysis of the burns experienced in the 2020/21 fire season shows that approximately one third of the prescribed burns for the season were likely to be of similar to higher severity than Weinup, or 40% of all prescribed burns by area. We can expect therefore that many of the fires in that season (and in others) will have caused similar or greater damage. The 2020/21 fire season analysis also shows that prescribed burns (rather than wildfires) made up the bulk of the fires by area and could therefore be expected to have caused the bulk of the impacts on flora and fauna. In terms of numbers, wildfires in general were of higher severity, with a range in overall severity from Low-Moderate to High Severity (there were no wildfires classed as Low Severity). While significant numbers of prescribed burns were Low Severity, there were also prescribed burns that rated Moderate to High Severity. In terms of areas burnt, more were burnt at Medium to High Severity in prescribed burns than in wildfires.

It is reasonable to conclude that in the 2020-2021 fire season, prescribed burns would have had a greater impact than wildfires on fauna and flora.

5.2 Effects of Prescribed Burning on Biological Groups

5.2.1 Flora and Vegetation

This study did not directly look at impacts to the diversity of flora and vegetation at Weinup. However, assessment of the vegetation in the context of fauna habitats indicated that most of the understorey strata six months post-fire was yet to show signs of recovery. This was apparent at all sites, whether identified as sclerophyllous woodlands (Jarrah, mixed Jarrah/Wandoo or pure Wandoo), or seasonal wetland (*Melaleauca preissiana*) woodlands. The application prescribed burning using a uniform methodology across approximately 1,800 ha resulted in uniformly open substrates with few signs of emergent growth and mid-level vegetation exhibiting little to no sign of regrowth. The canopy was overwhelmingly dominated by early epicormic growth on Jarrah and Melaleuca trees. The immediate result of the 2021 burn therefore has been a reduction of the vegetative and fauna habitat diversity across the site. Later seral stages will inevitably result in a temporary increase in floral diversity, although the timeframe over which such an increase might occur is uncertain. There is also an increased risk that these early seral stages may be preceded or accompanied by an influx of weed species, as had already occurred at WNP06.

Significantly, growth in much of the woodland immediately west of the 2021 burn area (Site WNP08), which was burnt during a less severe prescribed fire in 2019, was still epicormic, and only low levels of understorey variability were apparent. Recovery of the vegetative biodiversity and resilience, as well as the fauna habitats across the 2021 burn zone, can therefore be expected to require a minimum of several years. Consequently, the prescribed burn at Weinup has reduced the diversity of the vegetation assemblages in the immediate short term. Under the current prescribed burn regime employed by DBCA of sub-six-year burn intervals it is therefore considered unlikely that pre-burn levels of diversity will be re-established.

During field work it was noted that the hollow, buttressed bases of larger trees were significantly charred. Consequently, a proportion of these had fallen, or appeared likely to fall in coming months. Subsequent observations in December (Bill Smart pers. comm. 2021), now suggest that Wandoo trees (both in pure and mixed stands) are dying off throughout the study area. In most areas, Wandoo die-off is associated with Wandoo Crown Decline (WCD), which has been related to several factors, including altered fire regimes – particularly hot fires (Gaynor 2008; Wandoo Recovery Group 2006). Should these issues at Weinup be related to the severity of the 2021 fire (and earlier burns), then another direct link between prescribed burning and reduction in vegetative diversity.

Extrapolation of the situation at Weinup would suggest similar prescribed burn impacts on vegetative diversity and associated fauna habitats elsewhere in southwest Western Australia. The results presented here indicate a reduction in vegetative diversity of dry sclerophyllous and seasonal wetland woodlands that is likely to persist for at least several years. Such dry woodlands would historically have been adapted to minimum fire intervals of 80 to 100 years, so that burn intervals of less than six years are potentially detrimental to the persistence of some of the fire-resistant species comprising these assemblages (Bradshaw et al 2018). The literature further demonstrates that obligate seeding flora species that occur in most habitat types are killed by intense fire (Barret et al 2009). Where this occurs successive fires before a population produces more seed will reduce the available seedbank, and potentially push species towards localised extinctions. Where flora assemblages include obligate seeding species, fire frequencies exceeding 12 years may be required to maintain viable recruitment cycles (Muir 1985).

Additional concern regarding the uniform application of aerial ignition methods to large areas of forest by necessity requires consideration of other vegetation complexes. Several known habitat types, including riverine vegetation, permanent wetlands and those associated with granite outcrops act as refugia for these species, and require minimal exposure to prescribed burning at far greater intervals (Barret et al 2009).

Moreover, prescribed burning of peat swamps that have formed over an estimated five millennia is known to irreversibly alter these habitats by permanently removing organic material that the flora of these systems depend upon for survival. Application of aerially ignited prescribed burning at the landscape scale (as occurred at Weinup) prevents the adequate protection of these habitat types. Consideration of these factors unfailingly leads to the conclusion that the current Western Australian prescribed burning regime will result in a reduction of vegetative diversity and the fauna habitats that vegetative assemblages provide. This is an effect that several our authors have witnessed firsthand in south coastal wetlands and shrublands, and in peat swamps near Denmark.

On the basis of this study and the available literature we conclude that the current Western Australia prescribed burning regime must result in a reduction of vegetative diversity, and have a deleterious effect on the fauna habitats the vegetative assemblages provide.

5.2.2 Fungi

The scope of this study did not extend to assessment of prescribed burn impacts on the 156 fungal species likely to occur in the area, which therefore remain uncertain. Robinson et al (2008) found microflora species richness to be similar burnt and unburnt karri forest habitats. However, burnt sites were characterised by a mycoflora assemblage substantially different from that found in unburnt areas, with 19 of 332 species being considered to be present directly as a result of fire. The successional change in the community subsequently altered significantly every year following the fire to the end of the five-year study, at which point the assemblage was still considered to be fundamentally different from those found in unburnt areas. Studies have further indicated that impacts of dieback (Phytophthora cinnamomi) within five years of fire are increased due to surviving flora species being stressed, and due to soil conditions favouring pathogenic reproduction (Barret et al 2014).

Many fungi inhabit near-surface substrates and above-surface woody debris and perform a vital function in converting organic material into nutrients available to flora and fauna. While the study by Robinson et al (2008) suggests no reduction in fungal diversity in association with fire, the substantial and persistent changes in community composition indicate a significant disruption to the characteristic ecological functioning of the karri forest. The widespread distributions of native fungi and their close association with floral species in Western Australian environments would suggest that ecological functioning of fungal species would be disrupted wherever prescribed burning occurs. Moreover, the failure of the fungal assemblages to return to the status quo at five years post-burn would indicate that prescribed burning intervals of even six years will result in profound and permanent changes to fungal assemblages and their ecological roles.

The available literature suggests that regular and frequent prescribed burning is likely to result in permanent changes to fungal community composition and subsequently permanent changes in the associated ecological functions of fungal assemblages.

5.2.3 Fauna Habitats

Field assessments demonstrated that the prescribed burn at Weinup resulted in extremely simplified fauna habitats even six months after the fire. Profound differences were apparent in fauna habitat structures across all strata in burnt areas and included the loss or alteration of virtually all microhabitat and macrohabitat features. Unburnt habitats were characterised by patchy distribution of leaf litter, sedges, reeds and grasses, fallen timber and hollow logs that provide ground-level shelter and foraging areas for macroscopic invertebrate fauna through to medium small-l to medium-sized reptiles and mammals. These structures and strata were uniformly absent from the Weinup burn area.

Similarly, unburnt areas had a patchy distribution of taller sedges, woody shrubs across the dryer sclerophyllous woodland areas, and dense stands of sedges and thickets of low- to medium-height acacias and other shrubs where the *Melaleuca pressiana* dominated woodlands of seasonally inundated swamps occurred. In burnt areas these same habitats were reduced to uniformly open substrates, open understoreys (with remnant woody stems where thickets had been), and scorched tree trunks devoid of bark. Thus, the burnt areas had also lost the elements utilised by small- to medium-sized semi-arboreal fauna, microbats and birds, as well as the dense thickets used by medium sized mammals as shelter. Higher up, many of the tree hollows were scorched or burnt out, and many of the larger trees with hollowed, buttressed bases were girdled, indicating that they may be subject to ongoing environmental stress.

Fires of even Low-Moderate Severity such as that at Weinup are shown here to profoundly alter fauna habitat structure over a period exceeding two to three years.

Given the relatively moderate severity of the Weinup burn compared with other prescribed burns included in this analysis, it is probable that a significant proportion of prescribed burns (i.e. those at least as intense as Weinup) will result in similar levels of fauna habitat alteration or destruction. Depending on the season in which a burn is conducted, and the adequacy of any rainfall, we may expect that fauna suitably adapted to open habitats and independent of fine habitat structure will return. However, the re-establishment of functional habitats in terms of ground-level habitat structures, fine-scale elements that provide shelter and regeneration of food-plant and fungal species will in all likelihood require several seasons. This is borne out by assessment of WNP08 which was burnt two years previously with less severity than DON_100, as indicated by satellite assessment of the 2019/20 fire season burn severity prescribed burning. At that site non-living habitat features were still apparent at ground level and vegetative regeneration was in progress. However, ground and mid-level strata were more uniformly dense in comparison to unburnt habitat, while epicormic growth remained predominant on

trees. These factors indicate that recovery of vegetation and fauna habitats extends beyond 2–3 years even where prescribed burning has taken place at less severity than Weinup, and the majority of other prescribed burns included in this analysis (see Section 3.3.2).

It is reasonable to conclude that a significant proportion of prescribed burns (i.e. those at least as intense as Weinup) will result in similar levels of fauna habitat alteration or destruction that persist over periods of several years.

5.2.4 Invertebrate Fauna

Impacts to invertebrate species were not directly assessed during the field component of this study, although the data search yielded a total of 128 species recorded from Weinup and the surrounding area. However, the true number of invertebrate species is likely to be much higher, given the diversity typically associated with eucalypt forests, and it is probable that several hundred species would have been impacted by the burn (Majer et al 2000; Majer et al 2003). A uniform effect of the Weinup fire was the near-complete removal of fine-scale habitat structure, including leaf litter, bark from tree trunks and, in many areas, the leafy canopy. Consequently, the assumption remains that due to loss of the suite of habitats invertebrates occupy, their diversity would be similarly reduced by an unknown quantity across the area. It is reasonable to conclude that these losses will be compounded during the recovery period of the fine-scale habitats occupied by invertebrates. The implication is that the prescribed burn at Weinup would have had an immediate negative impact on the biomass and biodiversity of the burn area that would then persist for several seasons.

Most invertebrate taxa are generally considered to be widely distributed throughout southwest Western Australia (Majer et al 2000; Majer et al 2003). It is therefore possible that impacts to many species may be localised due to the scale of prescribed burns, although this does not imply that local impacts are negligible or insignificant. Certainly for the invertebrate communities inhabiting areas subjected to prescribed burning this is not the case. Moreover, not all species are widespread, and the southwest of western Australia is also known to support numerous short-range endemic (SRE) invertebrates (Harvey 2002). These are species or taxa that have naturally small distributions often in disjunct or relictual habitats, typically with limited dispersal capabilities, and are particularly susceptible to habitat disturbances. In contrast to effects on other invertebrates that will eventually recolonise burnt environments, impacts to SRE species due to prescribed burning would potentially result in their permanent loss and irreversible reductions in biodiversity. Additionally, burning of peat swamps results in the complete and permanent destruction of known SRE habitat.

Landscape scale prescribed burning will undoubtedly have immediate and persistent impacts on invertebrate biomass, biodiversity and ecological functions.

Where prescribed burning impacts restricted, discontinuous or rare habitats, there is a high probability of species loss and irreversible changes to biodiversity.

5.2.5 Vertebrate Fauna

Estimates presented in this report suggest that many thousands of individual animals were impacted by the Weinup prescribed burn. The DBCA state that the methodology they use leaves routes open to neighbouring habitats to assist individual animals in escaping the fire, thereby mitigating such impacts. However, this does not account for the large number of species comprising small to medium sized animals that have limited capacity to move sufficient distances to safety. Moreover, it presumes that neighbouring habitats, should individual animals be able to access them, are not at carrying capacity and therefore will be capable of supporting additional animals. Significantly, in addition to the general reptile, avifauna and mammal population at Weinup, a substantial number of Threatened fauna individuals are likely to have been impacted. Estimates suggest that up to 65 Numbats may have inhabited the burn zone, along with a potential maximum of 289 other Threatened individuals across five species. As with the general vertebrate fauna population, there is a possibility that an undetermined number of individuals may have escaped. By October 2021 – eight months after the prescribed burn at Weinup – only one group of Numbats had been observed at a previously occupied area (Bill Smart, Pers. Comm.). In the absence of further data (none has been made publicly available), it is difficult to accept assertions by DBCA and other agencies (ABC, 2021) that no animals were harmed during the burn.

The estimates of fauna impacted specifically by the Weinup fire indicate with some confidence that this fire will have killed, displaced or otherwise impacted a substantial number of animals, including individuals belonging to Threatened species.

Analysis of the vertebrate fauna study results yielded several patterns which indicate important differences in the composition of the vertebrate fauna communities present in the burnt versus unburnt habitats. The compositional differences between the vertebrate fauna communities in each area point to a change in biodiversity potentially relating to the prescribed burn. Species known to exploit such habitats were recorded more commonly in the burnt areas. These include kangaroos, which forage on emergent grasses after rain, and foxes, which can exploit the lack of shelter for prey species (Grigg et al, 2007). Conversely, threatened species were documented only in unburnt habitats, where shelter and food resources were more readily available. These differences were further supported by the substantially greater numbers of trace records in unburnt areas, indicating higher levels of residence (scats) and foraging activity (diggings). Such patterns have also been found elsewhere, where species including the house mouse (*Mus musculus*) and fox (*Vulpes vulpes*) are the are amongst the dominant mammals exploiting early successional mining rehabilitation sites in the jarrah forest (Grigg et al, 2007).

Community composition revealed substantial changes to fauna assemblages in burnt versus unburnt habitats, with Threatened species documented only in unburnt habitats, whilst introduced mammals are known to exploit habitats soon after disturbance.

Extrapolation of the results at Weinup to the greater southwest region is complicated, as reflected in the results relating to fauna densities and numbers impacted by the total prescribed burn area (Sections 3.4.3 and 3.4.4). Data relating to these variables for vertebrate fauna in the southwest are sparse and patchy due to extensive anthropogenic disturbance and high habitat variability. Additionally, where data relating to species presence or absence for vertebrates is available it is typically restricted to a limited number of small areas over relatively short temporal spans. In the Southern Jarrah Forest for instance, systematic vertebrate survey data is not available for 95% of 2.6 million hectares (Hearn et al 2002). This means that impacts to individual fauna, or numbers of fauna are difficult to determine, as has been shown elsewhere (Jolly 2022; van Eden 2021).

Notwithstanding the above it is possible to infer the impacts to fauna assemblages associated with prescribed burn across larger areas, based on what is known from Weinup. Many of these impacts relate to the alterations to habitats and food resources on which different fauna depend. Less mobile ground fauna are unlikely to return to post burn habitat until sufficient ground level cover is available, while the return of a full suite of arboreal fauna will depend on emergence of sufficiently old upper strata (3m+ and canopy) to provide hollows and substantial lateral growth for vegetative shelter and elevated commuting through the environment. The post-fire succession at Weinup would suggest that certainly in eucalypt and melaleuca woodlands, these conditions are likely to take several years to re-emerge. These timeframes, or greater ones, are supported by studies indicating that herpetofauna species abundance decreases with fire frequencies of less than 16 years (Valentine et al, 2012) and that a number of mammal species have been shown to achieve maximum abundances when fire intervals are in excess of 20 to 30 years (Bradshaw et al, 2018). Given this knowledge, it is probable that regular burning at current target frequencies of six years will result in a reduction in vertebrate fauna diversity, and potentially the total loss of some species.

We can conclude that while the numbers discussed in this report may be overestimates, it is certain that the number of animals impacted across the southwest in each fire season is very high and likely includes tens of thousands of individuals.

The current target prescribed burning frequencies are inappropriate in the context of habitat preferences of a proportion of vertebrate fauna species and are likely to lead to a reduction in vertebrate fauna diversity.

5.3 Conclusions: Impacts of Prescribed Burning on Biodiversity

Consideration of the wider programme would suggest that prescribed burning in its current form in Western Australia will result in increasingly detrimental impacts on biodiversity. These impacts, which are potentially or even likely to be cumulative, stem from several factors, including burn intensities, spatial extents, and frequencies in particular. Importantly, this study demonstrates that when compared with wildfire prescribed burns are commonly of similar intensity but far more extensive and are conducted with high regularity over relatively short timeframes. It is the latter factors that potentially represent the greatest threat to biodiversity.

Immediate impacts of prescribed burning activities are obvious at burn sites such as Weinup, which was of only moderate severity relative to other prescribed burns. In all cases, leaf litter and organic debris are removed. Loss of this material on a regular basis directly impacts the availability of resources for decomposers (fungi and invertebrates) in the environment, disrupting at least some nutrient cycling and their availability to flora. It also reflects a loss of fine-scale habitats that provide shelter and food resources for ground dwelling fauna species, from invertebrates to small reptiles. As fires become more intense loss of vegetation and habitats for larger fauna occurs, compounding impacts to their food sources such invertebrates, fungal bodies and small vertebrate fauna, and the new growth, flowers and nectar of plants. Where burns impact the forest canopy layer virtually all species diversity and biomass are removed until such time as the initial seral stages of the floral succession begin. Subsequent recovery of the full suite of biodiversity will then progress through stages that may result in temporarily increased species diversity, although these are unlikely to be representative of a sustainable, relatively stable ecosystem. Thus, recovery to a fully representative level of biodiversity will presumably only occur once the seral succession is complete and naturally sustainable and only if that is allowed to occur.

The information and data presented in this report can lead to only a limited number of conclusions, including that prescribed burning is having substantially harmful effects on the biodiversity of southwest Western Australia, and a substantial impact on animal welfare. This was a small study of limited scope, yet it provided numerous indications that not only had the biodiversity at Weinup been seriously negatively impacted but also suggested that the burn has disrupted much of the ecosystem function governed by flora, fungi and the various fauna communities and assemblages. Furthermore, we found evidence that these effects are not restricted to the immediate timeframe of the fire, but that initial reduction of biodiversity values will be supplanted by transient changes to species diversity that are do not necessarily reflect a sustainably functioning ecosystem. The scope of this study did not permit us to define a timeframe over which these changes will persist.

However, the situation at Weinup six months after the burn indicates that biodiversity values are unlikely to return to status quo at least for several years. The comparative severity of most prescribed burns in comparison to Weinup suggests that this will be the case for most areas so burned in the past.

The undeniable conclusion of this report is that we do not understand the degree to which prescribed burning is impacting our biodiversity and natural environments. We can see that prescribed burning is unequivocally resulting in transient reductions in our biodiversity values that then become persistent alterations over the extent of the prescribed burn target areas. While the temporal persistence of these changes has not been defined, we can assuredly say that it is likely to be measured in years and should burning occur at the target frequency of four to six years, then the changes are extremely likely to be permanent.

Western woylie
Bettongia penicillata ogilbyi

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