Threatened Species Recovery Hub

National Environmental Science Programme

Fire-affected invertebrate priority species and management response
Interim Report

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Cover image: *Ogyris halmaturia* female on *Melaeluca gibbosa* Kangaroo Island. Image: R. Glatz

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Executive summary

The 2019-20 wildfires had severe impacts on many Australian species, and many of these fire-affected species now need targeted management to facilitate their recovery. Because they are relatively well-known groups, researchers could rapidly and robustly assess the impacts of the 2019-20 fires on vertebrate and plant species (Ward *et al.* 2020; Gallagher *et al.* in press; Legge *et al.* in review). However, the impacts of these fires on Australia's invertebrate fauna are far more challenging to assess. Furthermore, given that there are far more invertebrate than vertebrate species, and many invertebrate species have very small ranges, it is reasonable to assume that far more invertebrate species than vertebrate species will have been severely affected by the 2019-20 fires.

This project sought to compile a justified list of the most fire-affected invertebrate species, based initially on spatial analysis that estimated the proportional *overlap* of species' ranges (derived from a vetted collation of many distributional databases) with the extent of fires of varying severity. From available literature and expert knowledge, we then compiled information on ecological and other traits for all species with high fire overlap, to inform an assessment of the likely *impact* of these fires on individual species, and to identify conservation management priority responses. We will report these results at national, state/territory and regional level.

Our collation of databases included nearly 60,000 invertebrate species, of which about half had sufficient records (3+) to derive alpha hull range polygons. For the species with one or two records, we used only those point locations to assess fire overlap. The number of species that we found had distributions that significantly overlap with the 2019-20 wildfires is given in Table 1, and the number with high overlap with moderate and severe fires in Table 2.

Table 1. Interim tallies of invertebrate species for which at least 50% of their distribution overlapped with fires.

% distributional overlap with fire	Total no. of species		
	Species with 3+ records (alpha hull range)	Species with only 1 or 2 records (point locations)	Total
100	15	982	997
90-99.9	27	-	27
80-89.9	60	-	60
70-79.9	74	-	74
60-69.9	168	-	168
50-59.9	259	542	801
Total with at least 50% fire overlap	**603**	**1524**	**2127**

The analyses undertaken in this project, and the compilation of relevant ecological, threat and management information, will form a foundation from which responsible agencies can subsequently assess the conservation (threatened) status of fire-affected invertebrates. Informed by this project and in a collaboration with IUCN, a subset of fire-affected invertebrate species has already been assessed for Red Listing.

This report provides an interim update on project progress. Due to the complexities of collation and vetting of diverse databases, it has taken longer than initially anticipated to complete the pivotal task of deriving fire overlap values for a very large suite of invertebrate species. That analysis is now complete, allowing us to progress the other (dependent) components of this project, with such further assessment to be completed by June 2021.

Table 2. Interim tallies of invertebrate species for which at least 20% of their distribution overlapped with moderate or severe fires.

% distributional overlap with moderate – high severity fire	Total no. of species		
	Species with 3+ records (alpha hull range)	Species with only 1 or 2 records (point locations)	Total
100	0	425	425
90.99.9	0	-	0
80-89.9	2	-	2
70-79.9	0	-	0
60-69.9	2	-	2
50-59.9	8	162	170
40-49.9	58	-	58
30-39.9	141	-	141
20-29.9	476	-	476
Total with at least 20% moderate – high severity fire overlap	**687**	**587**	**1274**

Introduction

The 2019-20 wildfires of eastern and southern Australia were exceptional in their severity and extent (Boer *et al.* 2020; Bowman *et al.* 2020; Lindenmayer and Taylor 2020; Wintle *et al.* 2020), with consequently severe impacts on many components of biodiversity (Ward *et al.* 2020; Collins *et al.* 2021; Godfree *et al.* 2021; Gallagher *et al.* in press; Legge *et al.* in review). Many threatened species were much affected by these fires, such that they are now more imperilled, and many species not previously considered threatened have become threatened because of the impacts of these fires (Ward *et al.* 2020). A major effort has been made by national and state/territory agencies, conservation NGOs and the community to help recover many fire-affected species (e.g., https://www.environment.gov.au/biodiversity/bushfire-recovery). For such effort to be most beneficial and effective, it is important to identify and prioritise those species (and ecological communities) that have experienced the most loss and whose persistence is now most tenuous, to implement the most appropriate post-fire management actions for those species, and to provide where possible formal recognition of their imperilment.

Given the vast number of invertebrate species and the very limited range of many species (Harvey 2002; Harvey *et al.* 2011), it is likely that fires burnt much of the distributional extent of many invertebrate species (Hyman *et al.* 2020; Moir 2021). However, for Australia's invertebrate fauna, it is especially challenging to progress the objectives of identifying the most fire-affected species, directing management, and listing as threatened. There are many components of this challenge , including the sheer number of species (ca. 300,000 species), most of which are undescribed (Chapman 2009); limited knowledge of the biology (including responses to fire) and management needs of most species; limited distributional information for most species and with many disparate and uncollated distributional databases; limited knowledge of population trajectories and status; and relative neglect of invertebrates in Australian conservation management (Walsh *et al.* 2012; Braby 2018; Taylor *et al.* 2018; Braby 2019). Furthermore, the complex life histories of many invertebrate species mean that the impacts of fire will vary depending upon what life stages are present (or in what proportion) in the population at the time of fire.

This project sought to address these challenges, in order to deliver a justified list of those invertebrate species most likely to have been severely affected by the 2019-20 fires; to collate information to help guide post-fire management of (and priority research on) these species; and to provide as much evidence as possible to help the responsible agencies to assess the conservation status, and list as threatened, the most fire-affected invertebrates. Where possible, we worked in collaboration with other related projects (such as NESP TSR project 8.3.2 'Effect of fire severity on the response of populations of priority wildlife species'), with the IUCN to undertake a collaborative assessment of the conservation status of an initial subset (108 species) of fire-affected species, and we sought and received invaluable help from many conservation agencies, expert groups and individuals.

Context

An initial priority list of fire-affected invertebrates was developed rapidly following the 2019-20 wildfires to help guide immediate conservation investment (https://www.environment.gov.au/biodiversity/bushfire-recovery/bushfire-impacts/priority-invertebrates). However, as acknowledged in that report, this initial assessment was explicitly provisional as it: (i) did not attempt to undertake a comprehensive assessment across all invertebrate species; (ii) used only two national distributional databases; and (iii) did not include any consideration of fire severity. The current project builds from that initial preliminary assessment.

A subsequent study reported on more detailed analyses of fire overlap values for some invertebrate groups in New South Wales (Hyman *et al.* 2020); and some state agencies have reported on fire overlap and impacts for invertebrate species in their jurisdictions (e.g., https://www.wildlife.vic.gov.au/__data/assets/pdf_file/0030/484743/Victorias-bushfire-emergency-Biodiversity-response-and-recovery-Version-2-1.pdf).

Methodology

A detailed description of the methodology will be provided in the final report. Much of the effort expended on the project to date has been devoted to collating disparate distributional databases, vetting the databases for duplicates, mis-identifications, naming errors, marine species, introduced species, records unattributed to species or records with inadequate geographic precision.

We used the Australian Fauna Directory as the taxonomic standard, although also included undescribed species if these were clearly recognised by a taxonomic authority and linked to a vouchered specimen.

The databases that we used are listed in Table 3. From these databases, we accepted 428,960 records of 58,977 species.

Table 3. Databases included in this project to estimate fire overlap for invertebrate species

Data base	No. of accepted records
Atlas of Living Australia	336,142
Biological Database of South Australia (including some private databases)	1,252
Victoria Biodiversity Atlas	13,136
WA NatureMap	60
Queensland WildNet	10,458
NSW BioNet	9,635
ANIC database	1,575
Western Australian Museum arachnology database	56,702

For the 29,337 species with at least three unique records, we created alpha hull polygons. We intersected these modelled distributions with the GEEBAM fire mapping (Department of Agriculture Water and the Environment 2020), within the Provisional Analysis Area of southern and eastern Australia (https://www.environment.gov.au/system/files/pages/a8d10ce5-6a49-4fc2-b94d-575d6d11c547/files/preliminary-analysis-area-19-jan-2020.pdf) to estimate the proportional distributional overlap of all modelled species with all burnt areas, and then with fires of varying severity (coded as either GEEBAM fire severity class 1 (no data on fire), GEEBAM fire severity classes 2 and 3; or GEEBAM fire severity classes 4 and 5 (=moderate to severe)). For species with only one or two records, we intersected those point locations with the fire mapping, again to estimate the proportional distributional overlap with all burnt areas, and with fires of varying severity.

For all species with high fire overlap (high-severity overlap >20%: Table 2) we used available literature and expert knowledge to populate a Fire Risk matrix of characteristics (traits) considered likely to contribute to the impacts of fire on a species' conservation outlook. We followed the approach used by Legge *et al.* (in review) and https://www.environment.gov.au/biodiversity/bushfire-recovery/bushfire-impacts/priority-animals in a comparable assessment of the impacts of these fires on vertebrates (and spiny crayfish). This approach included scoring of traits associated with pre-existing risk (e.g., threatened status, short-range endemics), immediate risk (e.g., factors related to the likely extent of mortality in fires such as shelter sites used), and post-fire risk (e.g., capability to persist in a burnt landscape, or for rapid post-fire recruitment). Necessarily, this assessment is broad, covering a very large number of diverse groups, many with major knowledge gaps. Where appropriate, to understand potential decline, we used inference from related species or higher-level taxa. Confidence in the allotted traits is reported as either observed, suspected or inferred.

Likewise, where possible for all species with estimated high fire impact, we collated information about threats and management actions (using a set of standardised categories, aligned where possible to IUCN threat and management categories), collected from expert opinion and literature sources. Upon completion of this threat/management database, we will identify, across species, the key threats affecting fire-affected invertebrates and, correspondingly, the key management actions most needed to help recover those species. This will be reported at national level, state/territory and regional level, with the regions comprising the Australian Alps, (East) Gippsland, south coast of New South Wales, Greater Blue Mountains, north coast of New South Wales, south-eastern Queensland, South Australia (Kangaroo Island), Tasmania and Western Australia (with that regional demarcation largely as used by DAWE for regional prioritisation of investment: https://www.environment.gov.au/biodiversity/bushfire-recovery/funding-support/regional-delivery-program). Again, we use inference from related species or higher-level taxa to understand potential threats and actions for data poor species.

We also consider research priorities, based on the recognition that major knowledge gaps may otherwise impair management effectiveness. For most species, there is not enough trait, distributional or life history data to make a robust assessment of fire susceptibility. This is because there may be no living experts working on the species, there may be questions over their distribution and/or taxonomy, or knowledge gaps in their ecology or biology. The lack of knowledge for these species means that some of them may be amongst the most vulnerable and/or fire-impacted species, but the data to confidently evaluate this is lacking. An example of such a species is a native millipede *Dicladosomella anaticula*. This species lives in leaf litter, has limited dispersal capability, is likely a short-range endemic and is known only from a couple of occurrences, both of which burnt. However, in the IUCN workshop the experts could not confidently assess fire impact, as some species of millipede over-summer in deep burrows in the soil, thereby being at least partly protected from fire. It was not known whether this species had any such adaptations. The species was therefore assessed provisionally as Data Deficient. This example is of a species that has many triggers for fire-susceptibility, most will have fewer. In this project, we will undertake an analysis of uncertainty to provide a structured synthesis of the key knowledge gaps that have most impeded the fire-impact assessment, and implications for management, and how these knowledge gaps and uncertainties can best be addressed. Species and higher-level taxa in this 'data deficient' group will be prioritised for research need, using the trait framework. To do this, we will explore different types of uncertainty, such as:

i. which species are likely to have experienced substantial decline, and for which there are no known effective management options. These are candidates for research on management options,

ii. which species are likely to be in decline, and can be acted upon, but we have uncertainty about management efficacy. These are candidates for researching effectiveness of management options', or

iii. species for which recovery is hampered by a lack of data about traits, or locations. These are candidates for researching the traits/behaviour and/or population status of the species.

Findings

This interim report marks a major milestone for this project. It has taken many months (appreciably longer than initially predicted) to access, collate and clean the disparate databases made available for our analysis (and additional data bases are still being promised). However, as of end March 2021, we now have fire overlap values for nearly 60,000 invertebrate species, indicating that at least 2000 species have had at least half of their known or modelled distributions burnt (see Table 1). Examples of such species are illustrated in the accompanying photos.

Moggridgea rainbowi Kangaroo Island Micro-trapdoor Spider. Image: J. Marsh

Based on earlier spatial analyses, we have already populated the Fire Risk matrix, and threat/management database, for many (ca. 400) of these species with high fire overlap, and we are now able to attempt to do so for all other species amongst our final list of species with high fire overlap, to the extent possible with available knowledge. This will enable us to derive (by end June 2021) a justified list of priority invertebrates (those with highest estimated impact from fire) and – where possible – priority management and research actions for all of these species, with management and research priorities also aggregated across species to regional and national levels.

Metaballus mesopterus Kangaroo Island Marauding Katydid. Image: Richard Glatz

This information on fire overlap and impact, traits and management and research priorities will be databased in a manner that can be readily accessed and interpreted by agencies responsible for assessment of conservation status to help ensure that those invertebrate species that have been most imperilled by the 2019-20 fires can be given legislative protection through listing as threatened.

Ogyris halmaturia Large Eastern Bronze Azure Butterfly. Image: R. Glatz

Discussion

Invertebrates are often neglected in conservation assessment and management relative to other taxonomic groups (Walsh *et al.* 2012). This is in part because there are major deficiencies in knowledge for most invertebrates, and because they generally have lower public support than for more charismatic groups of biodiversity. This project sought to overcome such neglect. The project has been ambitious in scope, with an overall objective of attempting to derive a prioritised list, that is as comprehensive as possible, of invertebrate species most affected by the 2019-20 fire. That objective has now been partly met, through spatial analysis that has estimated the percentage range overlap of ca. 60,000 species with fire extent. The objective will be met fully in the next 2-3 months by complementing that fire overlap analysis with species-based assessment of fire risk and ecological traits, to derive an assessment of the estimate *impact* of fires. Species with estimated highest impact are those most needing conservation management response.

To help guide such conservation response, we have also progressed (and will complete by June 2021) an assessment of the management and research priorities for all species with estimated high fire impact. We note that such assessment of response priorities is constrained by major knowledge gaps for most species, and our assessment of research priorities is designed to systematically identify those actions most needed to address those key knowledge gaps that impede effective management response. To be most useful to the responsible agencies, we provide such management advice, across species, at regional level.

Because of the impacts of the 2019-20 fires, many threatened invertebrate species are now significantly more imperilled (Moir 2021), and many species not previously considered or recognised as threatened are now imperilled. Many such species now merit uplisting (for the relatively small proportion of species of conservation concern that are already listed as threatened) or listing as threatened. Without such listing, these species may be further neglected, and the opportunity to help their post-fire recovery may be lost. A major legacy of this project will be the provision of knowledge databases for all species with high fire impact, in a format as amenable as possible to those agencies or groups responsible for the assessment and listing of threatened species. We have trialled this information provision already through a 5-day workshop in February 2021 held in conjunction with the IUCN to Red List a subset of invertebrate species with high fire overlap. Of 107 invertebrate species considered at that workshop, 25 species were provisionally recognised as eligible for listing as Critically Endangered, 31 as Endangered, 16 as Vulnerable, 6 as Near Threatened, 10 as Least Concern and 19 as Data Deficient, with these assessments indicating that the knowledge base provided was generally adequate to allow for threatened species categorisation. As context to this 5-day workshop that found 72 species were eligible for provisional listing as threatened by the IUCN, we note that this tally exceeds the total number of threatened invertebrates currently listed nationally under the *Environment Protection and Biodiversity Conservation Act* (66 species).

Application of the research

To date, the project has had ongoing reporting of progress and outcomes to, and consultation with and advice from, relevant personnel of the Department of Agriculture, Water and the Environment (DAWE), through frequent online project meetings. We will report our final results to DAWE and state/territory agencies.

One major application of the project to date has been the conservation status assessment by the IUCN of >100 fire-affected invertebrate species. This demonstrated that the information content painstakingly aggregated for this project was generally sufficient to allow fire-affected invertebrate species to meet the criteria for threatened, at global scale.

With the completion over the period April to June 2021 of our assessment and compilation of research and management priorities for fire-affected invertebrates, a major application of this project will be to help guide responsible agencies to implement those research and management actions, at regional scale, to optimise the recovery of as many fire-affected invertebrate species as possible.

Impact of the research

The project has provided numerous communications products (including much media) that has helped raise the public profile of invertebrates, and the case for their conservation.

The challenges we met in aggregating and vetting many individual devolved distributional databases for invertebrates has revealed major shortcomings in the accessibility of these databases and in their information content (for example, there were many challenges with identifying in these databases introduced, aquatic and other groupings of species; and many mis-identifications). These shortcomings are now more recognised and at least some custodians will better address them.

This project has provided the information required to help the conservation recovery of the most fire-affected species, and to allow responsible agencies to assess and where appropriate formally list the most imperilled species as threatened, thereby providing those species with profile and some statutory protection.

Given that it is likely that at least some invertebrate species suffered more impact than species in any other group from the 2019-20 fires, we hope that the information provided in this project will:

i. help prevent extinctions and achieve the recovery of those invertebrate species whose post-fire persistence is now most tenuous;
ii. help direct priority research (including surveys), including for those invertebrate species that may have been rendered extinct by these fires (and to more formally recognise such loss);
iii. provide agencies with systematic evidence-based advice on the suite of management actions that is most needed, for what species, and where;
iv. make an assessment of the toll taken on biodiversity by the 2019-20 fires as comprehensive as possible;
v. provide a foundation for listing fire-affected invertebrate species as threatened, at appropriate jurisdictional levels;
vi. leave legacy datasets (such as our traits and fire risk databases);
vii. substantially enhance preparedness for any comparable future fire event.

Broader implications

The major impact of this project has been to help redress the conservation bias against invertebrates and other poorly known groups. The project has demonstrated that there are major knowledge gaps for Australian invertebrates, and that these knowledge gaps constrain, but do not preclude, assessments of the likely conservation impacts of the catastrophic 2019-20 fires. We have demonstrated that it is possible to identify those invertebrate species most affected by these fires, and the research and management responses most needed to conserve them.

The analyses undertaken by this project will also help guide responses to any future disturbance of comparable magnitude, and help identify centres of endemism and sites of conservation significance for invertebrates, that may help guide protection prior to, or during, future fires.

Future research priorities

This project faced and responded to the many knowledge gaps that currently constrain the conservation of Australian invertebrates. In our final report we will articulate all of these challenges, and describe the mechanisms that can be used to address them.

We will also identify the key research actions required at national and regional level, that will be most important to undertake to help guide the recovery of fire-affected invertebrates.

Data sets

For this project, we accessed many publicly available distributional databases, and were also granted explicit permission to access databases held by individuals. We collated information from these databases, and this collation was used to develop distributional models for ca. 30,000 species. We anticipate that these distributional models will be made publicly available, although some data contributing to the models may have third party constraints; and we note that there may be substantial curational challenges in maintaining and providing access to this number of models.

We also compiled a template and database of species' ecological and other traits relevant to fire risk. We are investigating whether the Atlas of Living Australia can provide a home for this database, in a manner that allows for access and ongoing updates. We note that the database will also be made available to relevant Commonwealth and state/territory agencies.

Recommendations

This project has provided the evidence base that demonstrates that a large number of invertebrate species have been severely affected by the 2019-20 wildfires in eastern and southern Australia. The recovery of many of these species may now be contingent on targeted research and management, and we provide guidance to responsible agencies and others on those research and management priorities.

Many of the fire-affected species are now imperilled and many of these species should now be listed as threatened. We will provide a knowledge base that will help responsible agencies assess the conservation status of these species.

Conclusion

This project, dealing with some of the most poorly known species in Australia, has had many challenges. We have systematically responded to all challenges, helped particularly by a very substantial degree of collaboration provided by many experts and agencies. This interim report describes that progress, and indicates the pathway we are now following to complete the project by June 2021.

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Ethics statement

This study involved a series of desktop analyses and no animal ethics approval was required.

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Further information:
http://www.nespthreatenedspecies.edu.au

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