Genetic risks to Victorian biodiversity following the 2019/20 bush fire emergency

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Abbreviations

Abbreviations	Description
GRI	Genetic risk index
DELWP	Department of Environment, Land, Water & Planning

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Contents

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Executive Summary

Australia's bush fire crisis over the recent 2019/20 summer was likely the most destructive episode of its type in the nation's history. In Victoria, much of our most pristine landscapes and biodiverse regions were devastated by fires in East Gippsland and the North East of the state. To inform recovery and conservation management responses in the aftermath of this bush fire crisis, **cesar** have assessed risks to genetic health for an initial list of 138 individual taxa identified by DELWP, or the Federal Department of Agriculture, Water and Environment, as being of 'immediate concern'. These assessments update, or add to, a recent review of genetic health status for 1100 species of Victorian flora and fauna that we undertook in 2019. Regrettably, too many of our native species were already at significant conservation risk and this catastrophic event has only increased risk status for many of these species. We also assess the likely ongoing viability of all *immediate concern* taxa against a 9-category Species Risk Level Assessment Matrix that rates *risk of loss* due to the bush fires and *consequence of loss* from a genetic perspective. We found 14 of the *immediate concern* taxa were rated as *high risk* and *high consequence*, and therefore should be considered high priority for impact monitoring and / or interventions to improve genetic outcomes.

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Nature of work

The bush fires that impacted the North East and East Gippsland regions of Victoria, along with many other regions of Australia over the 2019/20 summer, are widely acknowledged to have had devastating effects on our biodiversity.

Although the number of individual plants and animals killed directly or indirectly by these fires may never be known accurately, the scale of the losses was clearly unprecedented. However, in many cases the impact the recent fires have had on genetic health, and prospects for future viability of individual species is considerably less clear. For some species almost the entire known habitat range appears to have been burnt, while for others fire impacts are likely to have caused or increased significant fragmentation of previously cohesive populations, or disruption of metapopulation structures. In some cases, some or all of the largest and most genetically diverse populations are likely to have been lost, escalating genetic risk for the given species as a whole, even though smaller and less diverse populations may have escaped fire impacts. In other situations, the number of individuals lost may have been high, but it may still be inferred that surviving populations likely retain sufficient diversity to sustain reasonable genetic health – at least over the short to medium term.

There was a large random component to the geographic distribution of fire impacts. Some taxa with quite broad distributions were nevertheless affected severely because the extent of the fires was also very broad. This appears to be the case for a whole suite of taxa with distributions that previously extended from far East Gippsland through to mid- or northern-NSW, east of the dividing range. By contrast, some taxa with quite narrow distributions appear to have escaped unscathed – apparently largely by chance (e.g. southern brush-tailed rock-wallaby).

The fires are also likely to have affected certain broad groups of taxa in ways that are both different and less predictable than for other groups. Many birds and other highly mobile species may have escaped the direct fire effects only to succumb to starvation because of a lack of other suitable habitat or alternative habitat already being occupied. Aquatic species may suffer more from ash and other debris washed into waterways by subsequent rainfall than from fire itself, but the extent of these impacts may be harder to estimate. Many - but far from all - native plants are adapted to survive infrequent, cool mosaic burns that were widespread across much of Australia prior to European settlement. However, fire regimes have changed dramatically since then and it can be difficult to assess at what point even fire-tolerant species are no longer able to survive fires that are too intense. Similarly, many plants have adapted so that they need fire to germinate, but there are now several regions in Victoria and other parts of Australia that have experienced multiple intense fire episodes in the last few decades. In these regions soil seed banks may now be severely depleted, and populations of both flora and fauna that contracted to small refugia may have subsequently

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undergone several severe population bottlenecks resulting in greatly reduced genetic diversity that may be far from obvious.

As part of a broad project that aimed to understand how genetic diversity considerations could be incorporated into biodiversity conservation planning, Kriesner *et al.* (2019) developed a Genetic Risk Index (GRI) for flora and fauna in the state of Victoria. The index sought to determine the genetic health of individual species and broadly categorise them into five different risk categories; very high, high, medium, low and uncertain. The GRI was calculated for 1100 flora and fauna species found in Victoria. However, the catastrophic bushfires across East Gippsland and the North East of Victoria are likely to have impacted the GRI for many species, potentially changing their risk category.

The Department of Environment, Land, Water and Planning of Victoria (DELWP) asked **cesar** to undertake a project to update the Genetic Risk Index for species that were likely to have been affected by the recent summer bushfires. We also plot these *immediate concern* species on a 'genetic' risk assessment matrix to determine which species are likely to need interventions aimed at improving genetic outcomes.

Methods

We assessed, or re-assessed genetic health risks for a range of Victorian flora and fauna taxa considered by DELWP (or in some cases the Federal Department of Agriculture, Water and Environment) to be of immediate concern in the aftermath of the recent bushfire crisis, with a view to informing actions that may be taken by conservation planning decision makers to mitigate or manage those risks. These assessments used the same methodology as our previous assessment's of 1100 species of Victorian flora and fauna species (Kriesner *et al.* 2019) including currently available genetic and demographic data. Fire extent and severity mapping data derived from satellite imagery was supplied by the DELWP. These maps were generated in early February and were used to determine the likely impacts on the GRI. Post-fire animal and plant field surveys, and other ground-truthing of the extent of fire impacts will facilitate more accurate assessments for some of these species and lead to improved species GRI estimates.

Findings

Genetic Risk Index

A total of 138 *immediate concern* taxa were assessed or re-assessed to determine their GRI after the summer fire impacts in East Gippsland and the North East. Fifty-five of the 138 taxa assessed were not included in our previous assessments (Kriesner *et al.* 2019). Some of these

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taxa are regarded as subspecies, while for some others, separate species status has only recently been proposed or accepted and may not yet be widely recognized.

For populations of subspecies considered to be of genetic risk concern, there may be potential – at least in theory – for new genetic variation to be introduced through individuals from a different but related subspecies. However, particularly for subspecies that may not have interbred naturally over extended timescales that predate European settlement, anticipated benefits of increasing genetic diversity may need to be carefully weighed against potential risks including a reduction in fitness from outbreeding depression or an increase in deleterious genetic load (and lack of subsequent purging due to no population growth). For example individuals of both Gippsland and Eastern Water Dragon (*Intellagama lesueurii howittii* and *I. l. lesueurii*) subspecies have been introduced to the Melbourne region through the pet trade (Robertson and Coventry 2019). Feral populations containing hybrids between these two subspecies are apparently now established at some sites along the Yarra River (Robertson and Coventry 2019; p205) but the relative fitness of hybrids in the native range of either subspecies is uncertain (Robertson and Coventry 2019; p205).

For some taxa that have been regarded as distinct species only recently there thus far appears to be little or no demographic or genetic data that recognizes the new distinction. In particular, there appears to be little field data that distinguishes records of the newly proposed Broad-toed Feathertail glider (*Acrobates frontalis*) from *A. pygmaeus* (now Narrow-toed Feathertail Glider). Similarly, we also found little information concerning demographic distributions of the 'Arte', 'Cann' and 'West Snowy' Spiny Crayfish species so have made assumptions based on the potential distribution of *Euastacus* species within relevant sections of these river systems.

As previously, we have used these assessments to assign individual species or taxa to Genetic Risk Index (GRI) categories. A comparison showing distribution of the number of taxa assigned to each of these GRI categories based on assessments made before and after the recent bush fire crisis is shown in Table 1 (below). In determining the most recent GRI category assignments we have slightly revised and raised the uncertainty threshold, resulting in fewer species being rated as 'uncertain'. However, further work to validate and ground truth the parameters that make up the GRI are still pending. Also, minor adjustments to demographic appraisals led to two species being re-assigned to a lower GRI category. Given the 'immediate concern' taxa were selected based on anticipated impact from the fire events, it is not surprising the revised ratings skew towards higher GRI categories.

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Table 1. Genetic Risk Index ratings assigned to species / taxa of 'immediate concern' following 2019/20 bush fire crisis: pre- and post-fire events

Genetic Risk Index category	**Original (pre-fire)**	**New (post-fire)**
Low	5	2
Moderate	15	22
High	20	52
Very high	22	59
Uncertain	21	3
Not assessed	55	-
Total		138

A summary of the extent changes in GRI ratings assigned to individual taxa following assessment of *immediate concern* taxa is shown in Table 2 (full details contained in the GRI spreadsheet file).

Table 2. Summary of changes to Genetic Risk Rating category for taxa considered to be of 'immediate concern'

Type of change		**Number of taxa**
Up rated	Low → Moderate	3
	Moderate → High	6
	High → Very high	4
Down rated	Very high → High	2
Previously uncertain	→ Moderate	3
	→ High	12
	→ Very High	6
	Unchanged	47
Not previously assessed	→ Moderate	7
	→ High	16
	→ Very High	29
	→ Uncertain	3
Total		138

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Species Risk Assessments

We also assessed how potential fire impacts may affect the likely ongoing viability of all the *immediate concern* taxa, purely from a genetic perspective, against a 9-category Species Risk Level Assessment Matrix. In this context we have rated the risk that a significant proportion of genetic diversity may have been lost from Victorian populations of the taxa because of recent fire events on the x-axis (low, medium or high), and the likely consequence of potential losses of diversity from both Victorian and other populations for overall genetic health and ongoing viability of the taxa as a whole on the y-axis (also low, medium or high). The number of *immediate concern* taxa assigned to each matrix category is indicated in Figure 1.

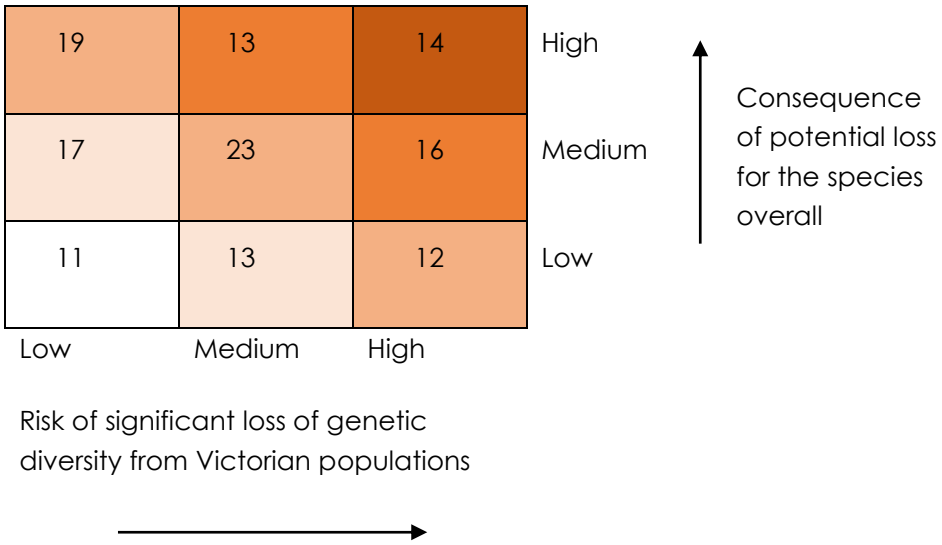

Figure 1. Species Risk Level Assessment Matrix for taxa of 'immediate concern'

Taxa assessed as both *high risk* and *high consequence* are shown in Table 4 with a brief justification for the rating. These are mostly semi-aquatic species or rare plants. Until on-ground field assessments are able to be undertaken, there is considerable uncertainty around the true extent of fire impacts on species in these categories.

Table 4. Species rated as *High Risk – High Consequence*

Common name	**Taxon**	**Comments**	**Doubt**
East Gippsland	*Galaxias*	High scorch fire around nearly all of Arte River catchment. Probably just the very upper	High

Galaxias	*aequipinnis*	reaches escaped. Ash and debris impacts very uncertain.	
Mallacoota Burrowing Cray	*Engaeus mallacoota*	Medium to high scorch fire throughout all, or nearly all of known habitat. Capacity to survive uncertain	High
Arte Spiny Cray	*Euastacus* sp. 1	Not on VBA. As for East Gippsland Galaxias	High
West Snowy Spiny Cray	*Euastacus* sp. 3	Not on VBA. Exact range uncertain, but high scorch fire along most of western side of Snowy River and western tributaries	High
Variable Spiny Cray	*Euastacus yanga*	Had reasonably wide range up NSW coast, but fire impacts likely around nearly all habitat streams. Potentially now highly fragmented with no large populations. Field survey and genetic data priority	High
Long-footed Potoroo	*Potorous longipes*	Large proportion of individuals likely lost. Risk that remaining populations are now critically small	High
Gippsland Banksia	*Banksia croajingolensis*	Likely high scorch fire across entire restricted range. Killed by fire. Seed bank regeneration uncertain	Medium
Betka Bottlebrush	*Callistemon kenmorrisonii*	Single very small population. Very likely badly impacted by intense fire	Medium
Dwarf Bottlebrush	*Callistemon subulatus*	Likely high mortality and seed bank depletion by high scorch fire across much of range in Vic and NSW. Remaining populations potentially now highly fragmented	High
Coast Cassinia	*Cassinia maritima*	Outlier populations near Lake Tyers likely survived, but fire mortality likely very high overall. Remaining populations now likely very fragmented	High
Elegant Cassinia	*Cassinia venusta*	Some plants in NSW likely survived, but likely major fire impact in Victoria. Overall population now likely to be critically small	Medium
Short-leafed Geebung	*Persoonia brevifolia*	Most of population in NSW. Nearly all of distribution burnt. Intensity varied. Some proportion likely survived, but remaining population now likely critically small and further fragmented	High

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Monkey Mint-bush	*Prostanthera walteri*	Likely a large proportion of individuals lost. Was already highly fragmented, now even more so	Medium
Snowy River Westringia	*Westringia cremnophila*	Existing populations were already critically small and very likely further badly impacted	Low

Taxa rated as *Medium Risk – High Consequence* include the Giant Burrowing Frog (*Heleioporus australiacus*) and Forrester's Bottlebrush (*Callistemon forresterae*) where it is likely a reasonable proportion of individuals in Victoria either evaded fire impacts, or (in the latter case) potentially survived low-scorch fire. However, losses were likely still significant and of major consequence because global populations of these species were already critically small or highly fragmented.

Taxa rated as *High Risk – Medium Consequence* include the Eastern Ground Parrot (*Pezoporus wallicus*) and Eastern She-oak Skink (*Cyclodomorphus michaeli*) that both appear likely to have suffered devastating losses within Victoria based on fire intensity mapping. While viable populations of these species likely still persist in Tasmania and NSW respectively, Victorian populations likely contain genetic diversity of considerable significance in the broader context.

Many of the taxa in these latter two categories may warrant high priority for further field surveys and obtaining genetic data to clarify their risk status.

The risk assessments for this report were primarily based on satellite mapping of fire extent and canopy burn intensity as of early February 2020 for East Gippsland (extending to around Eden, NSW) and northern Victoria (extending to around Tumut /Jindabyne, NSW), and other fire intensity mapping for NSW from approximately two weeks prior to the end of January. Subsquent events that we have not accounted for here may have had further major impacts. For example, populations of some aquatic taxa may suffer very large impacts if heavy rainfall were to wash large amounts of ash and sedimentation significantly downstream even if their habitat is not immediately adjacent to areas that were burnt, while subsequent burning of critical habitat may have impacted other species – in particular Victorian populations of Eastern Bristlebird (*Dasyornis brachypterus*). Such impacts could push several additional taxa into the High Risk – High Consequence category. Field surveys over the next 6 months should provide information that can be used to further evaluate all *immediate concern* species.

Conclusions

We have updated the GRI for 138 Victorian taxa considered to be of *immediate concern* from the recent catastrophic bush fires in eastern Australia based on fire extent and severity

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maps generated in early February by the Department of Environment, Land, Water and Planning, Victoria. The genetic risk status for many taxa of *immediate concern* has been greatly impacted by the bush fires and generally elevated their genetic risk status. The Species Risk Assessment Matrix was used to evaluate the risk of loss against the consequence of loss for species level genetic diversity. Taxa in the *High Risk – High Consequence* category are likely to be at great risk of losing genetic diversity and adaptive potential within only a few generations. In the absence of management intervention, isolated populations of these taxa may also be at risk of inbreeding within relatively short time frames. They should therefore be among the highest priorities for field monitoring and potential interventions aimed at improving genetic outcomes in our management response to the recent bush fire crisis. However, until more detailed information is available from on-ground surveys, the true extent of fire impacts and persistence of local populations is highly uncertain for many taxa. Taxa in the *Medium Risk – High Consequence*, and *High Risk – Medium Consequence* categories should also be considered of significant concern for conservation management. Management interventions aimed at improving genetic outcomes, or at least assessments of the extent of genetic diversity that remains among surviving populations, should also be considered for taxa in these categories.

Acknowledgments

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