INTERIM NATIONAL PRIORITISATION OF AUSTRALIAN PLANTS AFFECTED BY THE 2019-2020 BUSHFIRE SEASON

Epicormic regeneration in Eucalyptus on the South Coast of NSW ©Anne Kerle

Research for the Wildlife and Threatened Species Bushfire Recovery Expert Panel

Version 1.3

Research prepared by Rachael Gallagher, Macquarie University (MU), with grateful assistance from those listed below.

Programming expertise was provided by Stuart Allen (MU) and Samuel Andrew (CSIRO).

The development of the prioritisation criteria (Appendix 1) was led by Tony Auld (NSW Department of Planning, Infrastructure & Environment - DPIE) with assistance from David Keith (DPIE/University of New South Wales - UNSW), Berin Mackenzie (UNSW), Mark Ooi (UNSW), Tom le Breton (UNSW) and Rachael Gallagher (MU).

Data resources were provided by Sue Fyfe (Department of Agriculture, Water and the Environment - DAWE), Fiona Wood (DAWE), Jason Ferris (DAWE), Robert Godfree (CSIRO), Nunzio Kerr (CSIRO), Linda Broadhurst (CSIRO/Centre for Australian National Biodiversity Research - CANBR), Tony Auld, Berin MacKenzie, David Keith, Mark Ooi, Cory Merow (University of Connecticut - UC), Thymios Nikolopoulos (UC), Colin Yates (WA Department of Biodiversity, Conservation and Attractions – DBCA), Carl Gosper (WA DBCA), Sarah Barrett (WA DBCA), Michelle Waycott (SA Herbarium), Andrew Thornhill (SA Herbarium), Jason Highham (SA), Angela Duffy (SA), Rachael Alderman (Tasmania), Daniel Falster (UNSW), Kang He (UC), Elizabeth Wenk (UNSW), Caitlin Baxter (UNSW), Edward Liew (Royal Botanic Gardens & Domain Trust, Sydney - RBGDT); Angus Carnegie (NSW Department of Primary Industries - DPI); Keith McDougall (DPIE), and Vanessa Adams (University of Tasmania).

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Anne Kerle and Mike Fleming provided the front and back cover images.

The Bushfire Recovery Expert Panel and the Threatened Species Commissioner reviewed and refined the approach and delivery of this research.

ABBREVIATIONS

ALA	Atlas of Living Australia
APNI	Australian Plant Name Index
AOO	Area of Occupancy
AusTraits	The AusTraits Plant Trait Database http://traitecoevo.github.io/austraits.build/
AWAP	Australian Water Availability Project http://www.bom.gov.au/jsp/awap/
FFRD	NSW Fire Response database
NIAFED	National Indicative Aggregated Fire Extent Dataset
PAA	Preliminary Analysis Area (IBRA regions)
PPPM	Poisson Point process modelling
SPRAT	Commonwealth Species Profile and Threats Database

APPENDICES

Appendix 1. Framework for prioritising impact assessments for plants following the 2019-2020 bushfires

Appendix 2. Interim assessment by taxon. See INTERIM_ASSESSMENT_ver1_3.xls

Appendix 3. Metadata for column names in Appendix 2

Appendix 4. Proposed management actions for all taxa assessed HIGH or MEDIUM risk. See MANAGEMENT_ACTIONS_BY_TAXON.csv

Summary

During the 2019-2020 bushfire season, over 10 million hectares of Australia burned. In the aftermath, a continent-wide prioritisation framework to locate species most at risk of extinction is being deployed across all c.25,000 Australian plants. Prioritisation is based on a framework developed in consultation with experts in plant and fire ecology and endorsed by the Wildlife and Threatened Species Bushfire Recovery Expert Panel. This Interim Assessment details the proportion of Australian plant species at risk of impact from the 2019-2020 fire season. All taxa listed under the federal *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or under state legislation are assessed. Also assessed are all endemic plant taxa in these states and two specific vegetation groups: subalpine (treeless) and rainforest.

Of the 19,004 plant species assessed for this Interim Assessment, 1,335 were listed under the EPBC Act, and 4,622 were listed under state-based species protection legislation. 8% of EPBC Act taxa had more than 50% of their range burned during the 2019-2020 fire season. 155 EPBC Act taxa were prioritised as having high or medium level impacts (12% of EPBC Act taxa; 7% high; 5% medium). Of the prioritisation criteria assessed, D (60 species; 5% of species), J (50 species; 4% of species) and E (32 species; 2% of species) had the highest proportions of EPBC Act taxa listed as high risk. This assessment was based on an intersection of the NIAFED layer within the PAA against DAWE range maps and preliminary assessment against of the 11 criteria.

Endemic species were also assessed in each state or territory: 1,320 in NSW, 408 in Victoria, 488 in South Australia, 8,952 in Western Australia, 3,629 in Queensland, 543 in Tasmania and 6 in the ACT. The number of endemic plants in each prioritisation category varies between states (Table ES1). Many of these taxa are not currently listed under any environmental legislation (14,270; 75% species). These assessments were based on intersection of the NIAFED layer within the PAA against: (1) cleaned occurrence records from the Australasian Virtual Herbarium; and (2) modelled ranges based on climate and soil conditions.

Table ES1. Intersection of species ranges against the National Indicative Aggregated Fire Extent Database (NIAFED) within the Preliminary Analysis Area (PAA). The range of values given reflects the use of these different distribution data sources. All results are subject to change in the Final Prioritisation Assessment.

Taxon group	Count	Plant taxa with range data available	Plant taxa impacted by 2019-2020 fires (%)	Plant taxa impacted by 2019-2020 fires (count)	Plant taxa with range > 90% burnt	Plant taxa with range > 50% burnt	Plant taxa with range > 30% burnt
EPBC Act	1335	1333	44%	585	35 (3%)	90 (7%)	148 (11%)
NSW endemics	1320	1158	77 - 93%	888 – 1079	47-98 (4-8%)	277-290 (24-25%)	460-594 (40-51%)
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Listed Qld	935	802	16 – 44%	129 – 353	0-2 (<1%)	3-10 (<1%)	28-36 (3-4%)
Listed Tas	462	374	58 – 78%	218 – 293	0 (0%)	1-3 (<1%)	11-23 (3-6%)
Listed ACT	13	13	31 – 77%	4 – 10	0-1 (0-8%)	0-1 (0-8%)	1-2 (8-15%)

Alpine	413	385	94 – 99%	361 – 380	1-2 (<1%)	4-7 (1-2%)	66-67 (17%)
Rainforest	1585	1585	41 – 96%	646 – 1514	1-5 (<1%)	13-18 (1%)	71 (4%)
Total	**19004**	**15777**	**39 – 75%**	**6082 – 11887**	**76-136 (<1%)**	**442-495 (3%)**	**1061-1070 (7%)**

BACKGROUND

Over the 2019-2020 bushfire season, more than 10 million hectares of Australia burned. In order to effectively manage the impact of this unprecedented bushfire season, affected species and locations need to be prioritised based on objective criteria which capture inherent risk. This Interim Assessment provides the first snapshot of the impact of the 2019-2020 bushfires and other interacting threats, such as drought, disease and herbivory, on native Australian plant species at a national scale.

Note that although a national coordinator for plant assessment was engaged in March 2020, Australian plant scientists have worked collaboratively to create both the framework for prioritising impact assessments and the resources required to assess taxa.

TAXONOMIC AND SPATIAL SCOPE OF THE INTERIM PRIORITISATION

Taxonomy

Nomenclature follows the Australian Plant Census. For each taxa, the Australian Plant Name Index (APNI) taxon ID has been maintained, as has the SPRAT identifier.

Quantifying plant species ranges

The distributional range of plant taxa was estimated from multiple different resources: (1) Cleaned occurrence records from the Australasian Virtual Herbarium (AVH; https://avh.chah.org.au/); (2) Point process models of species range built from climate and soil data; (3) 'Range-bagging' models built from climate and soil data; (4) Area of occupancy (AOO) in a 2km x 2km grid resolution; and, for EPBC Act taxa, (5) DAWE regulatory maps. Approaches (2), (3), and (4) are collectively known as 'modelled ranges' hereafter.

Using a collection of approaches to quantify taxon ranges provides an estimate of the uncertainty associated with different resources. The number of taxa with data in each taxon group are shown in Table 1 and details for each taxon group stated below.

Table 1. Number of plant taxa with range data from three different sources: DAWE, Australasian Virtual Herbarium, and modelled ranges.

Taxon group	Count	DAWE regulatory maps	Clean AVH occurrence records	Models of species range
EPBC Act listed	1335	1333	1161	1162
NSW endemics	1320	230	1146	1146
WA endemics	8952	372	7366	7364
Vic endemics	408	69	325	325
SA endemics	488	65	405	405
Qld endemics	3629	209	3001	3002
Tas endemics	543	74	506	506
ACT endemics	6	2	4	4
Listed NSW	701	352	574	574
Listed WA	436	391	388	388

Listed Vic	1771	144	1418	1418
Listed SA	807	111	679	679
Listed Qld	935	268	783	783
Listed Tas	462	95	363	363
Listed ACT	13	11	11	11
Subalpine	413	11	385	385
Rainforest	1585	72	1583	1583
Total	**19004**	**1333**	**15602**	**15602**

EPBC Act listed plant taxa

Ranges for this taxon group were quantified using range maps licensed from the *Species and Communities of National Environmental Significance Database* maintained by DAWE. These range maps are used to regulate the impacts on taxa listed under the EPBC Act and were therefore considered to be the primary source of range information for these taxa. The impact of fires on EPBC Act taxa what not assessed using cleaned AVH records or modelled ranges.

State listed taxa and endemics; subalpine treeless vegetation; rainforest taxa

This group includes: (1) Taxa listed under state legislation; and (2) Taxa endemic to the state based on the APC; (3) Taxa from subalpine treeless vegetation (Doherty et al. 2015); rainforest taxa. Note that species may overlap between these four categories. Ranges for this taxon group were assessed using cleaned occurrence data from the AVH and modelled ranges. Point occurrence data (latitude and longitude coordinates) were downloaded from the *Atlas of Living Australia* (ALA) application programming interface http://api.ala.org.au/ for all taxa listed in the kingdom Plantae in December 2019. Occurrences were filtered to exclude any records of taxa with no ratified name according to the Australian Plant Census (CHAH 2010) or of non-native origin, or taxa with cultivated status, and/or flagged geographic issues in the ALA. Individual records lacking a vouchered specimen for verification and/or collected prior to 1950 were also excluded (Fig. 1). The final dataset consisted of 3,014,394 occurrence records for 22,326 species.

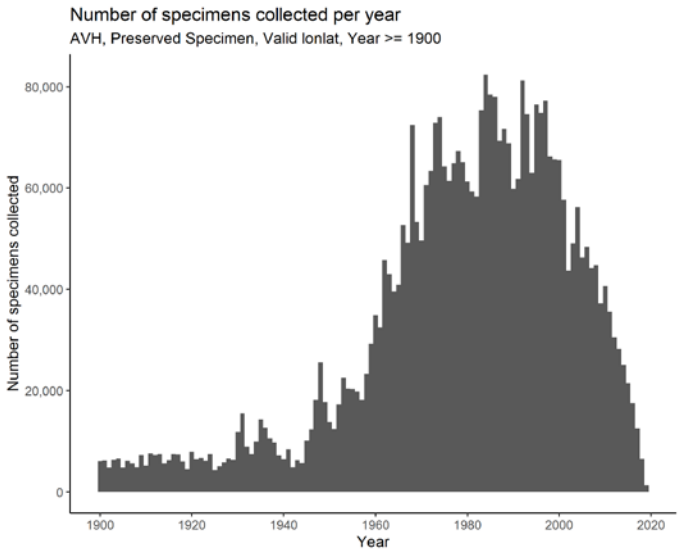

Figure 1. Number of vouchered specimens in the Australasian Virtual Herbarium (AVH) since 1900 with valid latitude and longitude coordinates. Note that most collections occur after 1950.

Using these cleaned occurrences, species range maps were built by from the environmental conditions across the range of the taxa (climate and soils) using Poisson Point process modelling (PPPM; (Warton & Shepherd 2010; Renner & Warton 2013) or, for a limited number of taxa, range bagging (Drake 2015) or by calculating an area of occupancy (AOO). PPPMs were applied to all taxa with 10 or more unique occurrence records at a 10km x 10km grid cell resolution and were using regularized down-weighted Poisson regression based on 20,000 background (pseudo-absence) points. Predictions were limited to a spatial domain that encompassed ecoregions from Dinerstein et al. (2017) occupied by the species across its Australian range.

PPPMs and range bagging were trained on mean annual temperature (°C), mean diurnal temperature range (°C), annual precipitation (mm), precipitation seasonality (coefficient of variation), annual mean radiation (W m-2), aridity index, bedrock depth (m), soil bulk density (fine earth) in kg/m3, clay mass fraction (%), silt mass fraction (%), and pH. Climate data was accessed from WordClim2 (Fick & Hijmans 2017) http://www.worldclim.org/v2/, except for aridity which was created by at CGIAR Consortium for Spatial Information (CGIAR-CSI) and accessed at https://cgiarcsi.community/data/global-aridity-and-pet-database/. Gridded soil data is described in Hengl et al. (2017) and provided by International Soil Reference and Information Centre at https://www.isric.org/explore/soilgrids. Soil data was averaged across the top 30cm of the soil profile and aggregated to 10km x 10km grid cell resolution.

Fire extent

The National Indicative Aggregated Fire Extent Database (NIAFED) was used to quantify the extent of the 2019-2020 bushfire season http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B9ACDCB09-0364-4FE8-9459-2A56C792C743%7D; Fig. 2). The NIAFED layer was only applied within the Preliminary Analysis Area (PAA; Fig. 2) as recommended by the Expert Panel.

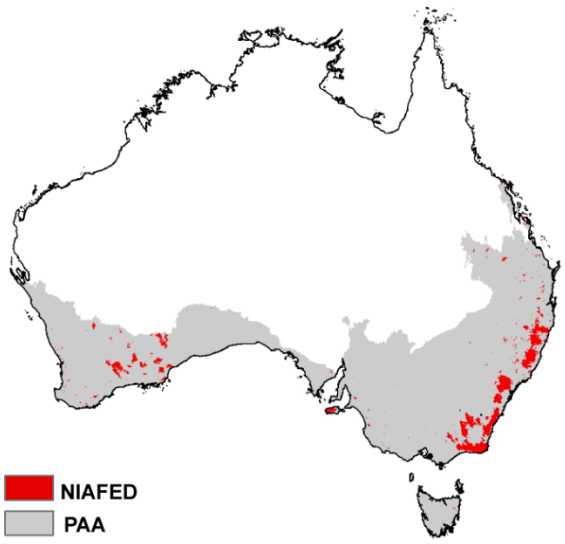

Figure 2. National Indicative Aggregated Fire Extent Database (NIAFED) was used to quantify the extent of the 2019-2020 bushfire season inside the Expert Panel Preliminary Analysis Area (PAA).

The NIAFED layer has several known issues which should were considered in interpreting the data. These include (according to the metadata record for the dataset):

"1. The dataset draws data together from multiple different sources, including from state and territory agencies responsible for emergency and natural resource management, and from the Northern Australian Fire Information website. The variety of mapping methods means that conceptually the dataset lacks national coherency.

2. The limitations associated with the input datasets are carried through to this dataset. Users are advised to refer to the input datasets' documentation to better understand limitations.

3. The dataset is intentionally precautionary and the rulesets for its creation elect to accept the risk of overstating the size of particular burnt areas. If and when there are overlapping polygons for an area, the internal boundaries have been dissolved.

4. The dataset shows only the outline of burnt areas and lacks information on fire severity in these areas, which may often include areas within them that are completely unburnt. For the intended purpose this may limit the usability of the data, particularly informing on local environmental impacts and response. This issue will be given priority, either for future versions of the dataset or for development of a separate, but related, fire severity product.

5. This continental dataset includes large burnt areas, particularly in northern Australia, which can be considered part of the natural landscape dynamics. For the intended purpose of informing on fire of potential environmental impact, some interpretation and filtering may be required. There are a variety of ways to do this, including by limiting the analysis to southern Australia, as was done for recent Wildlife and Threatened Species Bushfire Recovery Expert Panel's preliminary analysis of 13 January 2020. For that preliminary analysis area, boundaries from the Interim Biogeographic Regionalisation of Australia version 7 were used by the Department to delineate an area of southern Australia encompassing the emergency bushfire areas of the southern summer. The Department will work in consultation with the expert panel and other relevant bodies in the future on alternative approaches to defining, spatially or otherwise, fire of potential environmental impact.

6. The dataset cannot be used to reliably recreate what the national burnt area extent was at a given date prior to the date of release. Reasons for this include that information on the date/time on individual fires may or may not have been provided in the input datasets, and then lost as part of the dissolve process discussed in issue 2 above.

7. Fire extents are downloaded daily and datasets are aggregated. This results in an overlap of polygon extents and raises the issue that refined extents are disregarded at this early stage.

CAVEATS FOR INTERPRETING BURNT AREA STATISTICS

Multiple types of distribution data were used to estimate burnt area for all taxa: herbarium records, rage maps and - for EPBC Act listed taxa - DAWE regulatory maps. As a precaution, the largest estimate of area burnt was used to assess taxa against the prioritisation framework. All sources of data have known issues, including:

- Distributional ranges estimated from herbarium collection data may underestimate the full extent of known occurrences for a taxon due to sparse sampling across the range. This underestimation may be more pronounced for taxa with manuscript names (i.e. new taxa without databased records) or for taxa which are difficult to detect in the field. Other sources of occurrence data may be available from state agencies which may alter burnt area statistics. The likelihood of an omission error (underestimation of range) may increase as true range size decreases.

- Modelled ranges likely result in commission errors (overestimation of range size) as environmental conditions at known sites are extrapolated across space

- DAWE regulatory maps may not capture the full known extent of distributions. This is not unique to this source of range data, but as DAWE maps were preferred over other sources of burnt area data for EPBC Act taxa some species may have their impact underestimated. This is a known issue for some species of national significance in the Stirling Ranges National Park in Western Australia.

THE PRIORITISATION FRAMEWORK

The Framework targets species' life-history traits that make plant species prone to population declines or local extinctions if they occur within the spatial footprint of 2019-2020 bushfires. The identification of species potentially at risk as a result of these fires involves three components:

1. Identifying potential mechanisms of decline.
2. Identifying where in the landscape these mechanisms are most likely to have an impact.
3. Identifying the species and most exposed to risks associated with these mechanisms.

The Framework consists of eleven criteria (A-K) which are intended to identify plant species at the greatest potential risk of population declines or local extinctions following the 2019-2020 bushfires and to prioritise such species for field impact assessments and actions.

A. Interactive effects of fire and drought

B. Short fire intervals (impacts of high fire frequency)

C. Post-fire herbivore impacts

D. Fire-disease interactions

E. High fire severity

F. Weed invasion

G. Elevated winter temperatures or changed temperature regimes

H. Fire sensitivity

I. Post-fire erosion

J. Cumulative exposure to high risks

K. Other plausible threats or expert-driven nominations

Criteria have been assessed in full, or in part, for this Interim Assessment. States and territories provided lists of high priority taxa from their own fire recovery work and these are listed under Criteria K if not listed elsewhere. The curation of data to assess all Australian plant species is ongoing. A Final Assessment to the Expert Panel will assess all species against the complete set of prioritisation criteria.

The highest risk ranking obtained via any single criterion is determined to be the overall risk ranking as the risk mechanisms may operate independently or interact in complex ways, and hence the criteria are not additive. Species should be assessed against all criteria where possible.

Priorities for field inspections, monitoring and conservation action may be guided by a simple categorisation of impact:

HIGH – Very likely at risk. Require an urgent assessment of initial impacts and post-fire monitoring of recovery where impacts are significant.

MEDIUM – Likely to be at risk. Assessment of initial impacts and post-fire monitoring are recommended.

LOW – Unlikely to be at risk. Post-fire monitoring may be conducted opportunistically during sites visits or by other groups (externals, universities, citizen science).

NONE – Not known to be burnt in the 2019-2020 fires or not expected to be at risk.

PROPOSED MANAGEMENT ACTIONS

Management actions are provided for all criteria and are grouped into three types:

- Immediate – essential actions to undertake in the short-term
- Measured – to be undertaken before the 2020-2021 fire season
- Universal – actions which should be applied when managing threatened or sensitive species against a background suite of potential threats

Most actions allow the gathering of specific evidence on population size and inferred or continuing threats and/or decline which is required to list species under the EPBC Act and NSW BC Act using IUCN Red List criteria. It is intended that the immediate management actions scored against each taxon in Appendix 4 will guide the prioritisation of recovery actions and funding. Management actions for each criterion are outlined in Table 2.

GENERAL RECOMMENDATIONS

1. **Actions undertaken towards recovery should not jeopardise species.** For instance, strict hygiene protocols should be obeyed when visiting sites to avoid the spread of plant diseases or weed propagules. It is critically important to allow natural systems to recover after fire without seeding or planting interventions in the immediate to medium term. Post-fire recovery can take months or years (and even longer for some species). The focus in the first 12 months after the fires should be on eliminating threats to natural recovery rather than on translocation (which itself needs to be well planned and thought out).

Table 2. Proposed management actions for taxa listed under the prioritisation criteria. Actions are listed as immediate, measured (before the 2020-2021 fire season) and universal.

	Criteria										
Management Action	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**Urgency of action**
Field inspections – damage and threats			x	x		x		x	x		Immediate
Germplasm collection			x	x						x	Immediate
Field inspections - resprouting assessment	x	x			x						Immediate
Field inspections - seedling emergence assessment	x	x			x					x	Immediate
Disease – field assessments and emergency germplasm collection of cuttings where resprouting is affected				x							Immediate
Exclude forestry impacts	x	x			x			x		x	Immediate
Alleviate herbivory		x	x							x	Immediate
Field inspections - recovery assessment							x				Medium-term
Irrigation	x										Medium-term
Carefully-planned translocation	x	x	x	x	x		x	x	x	x	Medium-term
Weed control						x			x	x	Medium-term
Exclude prescribed fire	x	x	x	x	x	x	x	x	x	x	Medium-term
Rapid response to wildfire	x	x	x	x	x	x	x	x	x	x	Medium-term
Alleviate pollinator competition from feral bees and European wasp		x	x			x				x	Medium-term / Ongoing
Minimise mining impacts	x	x	x	x	x	x	x	x	x	x	Ongoing
Illegal collecting or over-collecting of germplasm or plants	x	x	x	x	x	x	x	x	x	x	Ongoing
Habitat disturbance from human activities	x	x	x	x	x	x	x	x	x	x	Ongoing

Criteria are: **A** Interactive effects of fire and drought; **B** Short fire intervals (impacts of high fire frequency); **C** Post-fire herbivore impacts; **D** Fire-disease interactions; **E** High fire severity; **F** Weed invasion; **G** Elevated winter temperatures or changed temperature regimes; **H** Fire sensitivity; **I** Post-fire erosion; **J** Cumulative exposure to high risks. Note that species listed under Criterion K will likely need some of the management actions outlined as well as actions identified by experts nominating the taxa.
Management actions are: Immediate actions are essential actions to undertake in the short-term; **Medium-term** actions are to be undertaken before the 2020-2021 fire season; **Ongoing** actions should be universally applied when managing threatened or sensitive species against a background suite of potential threats.

2. **Germplasm collection should be limited to species at immediate risk of local extinction.** Significant collecting of seed may jeopardise the replenishment of seedbanks. The resilience of many species to fire is dependent upon the maintenance of persistent soil or canopy seed banks. Seed banks allow post-fire seedling recruitment and the magnitude of the seed bank (along with fire-related factors such as heat and smoke) and post-fire rainfall govern the magnitude of post-fire seedling recruitment. Canopy seed banks may be exhausted by a single fire (where all plants are burnt). Soil seed banks likely provide some buffer against successive fires due to residual seeds surviving in the soil after a fire without germinating, but soil seed banks too can be exhausted in a single fire. For population persistence, seed banks need to be sufficiently replenished after a fire and before the next fire occurs. While the length of time required varies between species, an approximation is to allow three times the primary juvenile period between fires. Seed collection (e.g. for ex situ conservation or other restoration activities) prior to adequate post-fire replenishment of in situ seed banks may limit species' persistence capacity, especially as more frequent fire is predicted under a changing climate. Consequently, there should be no seed collection for any species until its seed bank has been sufficiently replenished to enable population recovery in the event of a subsequent fire. Cases of urgent ex situ conservation may be an exception, in which case seed collection should be carried out so as to minimise impacts on in situ seed bank accumulation.

3. **Translocation needs to be well-planned and appropriate.** Seed addition and supplementary planting (translocations) should only be considered (as a long-term option) if it is demonstrated that species fail to recover effectively at a site. Decisions to proceed with translocation should be based on rigorous post-fire site assessments of recovery and should follow appropriate national guidelines on translocation (ANPC 2019).

4. **All taxa in high and medium categories require inspections at some time to assess active threats.** The spatial analysis approach applied in the Interim Assessment will not identify all threats present across the range of a species.

5. **Applicants for recovery funding should refer to the Prioritisation Framework to guide their application but is not definitive or exhaustive.** The criteria in the Prioritisation Framework reflect the need to collect data on information which is required for statutory listing of taxa, particularly under IUCN Red list criteria adopted under the EPBC Act and NSW BC Act (e.g. population size, threat information, decline).

INTERIM APPLICATION OF THE PRIORITISATION FRAMEWORK

Each criterion, methods used to assess and risk categorisation across taxon cohorts (EPBC Act, state listed species, state endemics, subalpine species, rainforest species) are detailed below. All taxon level data, including proportion of range burnt and assessment against each criterion is available in Appendix 2 (see Appendix 3 for an explanation of column names). Note for many taxa, particularly in Qld, SA and Tasmania data on fire response traits was not able to be collated

for the Interim Assessment. This may affect the risk ranking of taxa against several criteria such as B and J which rely on trait-based information. This will be revised for the Final Assessment.

For context, Table 3 details the extent of species ranges affected by the 2019-2020 bushfire season and Table 4 shows which criteria are contributing to the greatest number of high risk classifications.

Table 3. Intersection of species ranges against National Indicative Aggregated Fire Extent Database (NIAFED) layer within the Preliminary Analysis Area (PAA). Ranges of EPBC Act taxa were quantified using the DAWE regulatory maps only. All other taxa were assessed against both cleaned AVH occurrence data and modelled ranges where available. The range of values given reflect the use of these different range size estimates. For % of taxa with range > 30.50 or 80% burnt, this is a percentage of the total number of taxa with data available e.g. 35/1333 = 3%. Note that this table does not contain 35 species listed under Criterion K which were identified in consultation with state agencies after conclusion of the spatial and trait-based prioritisation.

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Listed SA	807	684	51 – 89%	349 – 587	3-4 (<1%)	18-20 (3%)	31-38 (5-6%)
Listed Qld	935	802	16 – 44%	129 – 353	0-2 (<1%)	3-10 (<1%)	28-36 (3-4%)
Listed Tas	462	374	58 – 78%	218 – 293	0 (0%)	1-3 (<1%)	11-23 (3-6%)
Listed ACT	13	13	31 – 77%	4 – 10	0-1 (0-8%)	0-1 (0-8%)	1-2 (8-15%)
Subalpine	413	385	94 – 99%	361 – 380	1-2 (<1%)	4-7 (1-2%)	66-67 (17%)
Rainforest	1585	1585	41 – 96%	646 – 1514	1-5 (<1%)	13-18 (1%)	71 (4%)
Total	**19004**	**15777**	**39 – 75%**	**6082 – 11887**	**76-136 (<1%)**	**442-495 (3%)**	**1061-1070 (7%)**

Table 4. Risk categories across eleven criteria in the Prioritisation Framework across all assessed taxa.

Criteria	A	B	C	D	E	F	G	H	I	J	K	Total
High	176	115	30	472	204	2	9	14	115	254	35	**709**
Medium	263	297	21	393	279	6	16	20	128	296	0	**1103**
Low	6389	9242	232	4377	10090	7899	223	318	5622	657	0	**11469**
None	8949	5274	18556	12653	5204	7870	18596	18649	9912	4332	0	**19004**
Data deficient	3227	4076	165	1109	3227	3227	160	3	3227	13465	18969	**18973**

CRITERION A. Interactive effects of fire and drought

Pre-fire drought can: i) reduce internally stored resources of resprouter plants that are critical in sustaining post-fire regeneration; and ii) reduce pre-fire reproductive output, impacting on the size of the seed bank available for post-fire recruitment.

Post-fire drought can negatively impact post-fire recruitment success by reducing seed germination (due to insufficient soil moisture; possibly causing seed mortality in some dormancy

types), seedling survival (through desiccation) and survival of resprouts (through xylem embolism in susceptible new shoots). Risks to mortality may be large if drought occurs in the first autumn-winter after fire or the following spring-summer.

1) *HIGH* – Species with ≥ 50% known sites or habitat burnt in the 2019-2020 fires AND evidence or likelihood of either:
    a) Significant pre-fire drought; OR
    b) Incidence of post-fire drought within 18 months of the 2019-2020 fires.
2) *MEDIUM* – Species with ≥ 30 to < 50% known sites or habitat burnt in the 2019-2020 fires AND evidence or likelihood of either:
    a) Significant pre-fire drought; OR
    b) Incidence of post-fire drought within 18 months of the 2019-2020 fires.
3) *LOW* – Species with > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires AND evidence or likelihood of either:
    a) Significant pre-fire drought; OR
    b) Incidence of post-fire drought within 18 months of the 2019-2020 fires.
4) *NONE* – Either:
    a) No known sites or habitat burnt in the 2019-2020 fires; OR
    b) No evidence or likelihood of pre- or post-fire drought impacts in any known sites or habitat.

Methods

Pre-fire drought was assessed by intersecting species range data with mapping of the accumulated severity of drought conditions in the 12 months prior to December 2019. This time period captures the conditions during the previous growing season and immediately prior to the escalation in bushfire activity. Accumulated severity is based on the Standardised Precipitation Index defined as the number of standard deviations that observed cumulative precipitation deviates from the average (McKee et al. 1993).

Raw data values for accumulated severity were classified into four equal-sized bins across Australia (Figure 3). The upper quartile was assumed to adequately represent areas of significant pre-fire drought and was intersected with species range datasets.

Accumulated drought severity, fire extent mapping and distributional range data were combined to assess against the criterion.

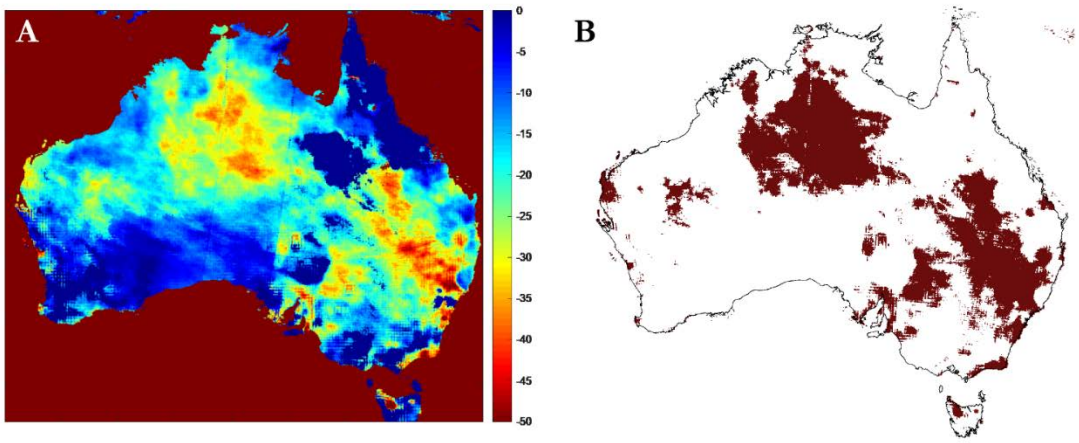

Figure 3. (A) Map showing the values of accumulated severity of drought conditions for December 2019. Lower values the more severe drought; (B) Classification of areas of significant pre-fire drought conditions used to assess against Criterion A.

Assessment outcome

Table 5. Number of taxa in each risk category under Criterion A - Interactive effects of fire and drought

Taxon group	HIGH	MEDIUM	LOW	NONE	Data deficient
EPBC Act	13	13	433	617	259
State listed NSW	34	33	356	188	90
State listed WA	0	0	11	413	12
State listed Vic	33	56	1058	281	343
State listed SA	0	1	468	215	123
State listed Qld	2	4	194	602	133
State listed Tas	1	6	229	138	88
State listed ACT	0	0	5	8	0
NSW endemics	132	185	639	202	162
SA endemics	0	0	214	192	82
WA endemics	1	0	2139	5241	1571
Vic endemics	14	6	109	198	81
Qld endemics	3	3	761	2245	617
Tas endemics	0	0	165	343	35
ACT endemics	0	0	2	3	1
Subalpine taxa	1	2	358	24	28
Rainforest taxa	4	13	896	672	0
Total*	**176**	**263**	**6389**	**8949**	**3227**

* Taxa may be shared between taxon groups and the total is the number of unique species across taxon groups which are listed under each risk category.

Potential revisions for Final Prioritisation Assessment

- Post-fire drought risk will be assessed using long-term rainfall predictions in the PAA prior to the 2020-21 season
- Exploration of other accumulated drought severity approaches, including accumulated severity in 2019-2020 relative to a longer-term climate reference period

PROPOSED MANAGEMENT ACTIONS

Species assessed HIGH or MEDIUM risk under Criterion A (Table 4) are at specific risk from:

- Pre-fire drought affecting post-fire resprouting ability, especially where the 2019/2020 fires were of high severity.
- Post-fire drought conditions affecting seedling recruitment success and resprouting capacity.

Immediate actions

Field inspections – resprouting: Inspections to quantify the number of plants resprouting and the survival of resprouted tissue.

Field inspections – seedling emergence: For obligate seeding species, field inspections to quantify seedling emergence and survival.

Exclude forestry impacts: Enforcement of buffers and use of education and liaison to minimise any damage of logging activities to post-fire recovery

Medium-term actions

Exclude prescribed fire: prescribed burning should be excluded from sites burnt in the last 5 years for non-woody taxa; the last 15 years for woody taxa; or the last 50 years for species which are killed by fire or are long-lived and prone to basal charring.

Ensure rapid response to wildfire: any future wildfires that threaten to burn over recovering sites should be rapidly extinguished.

Irrigation: investigate the feasibility of supplementary watering during plant establishment.

Carefully planned translocation: adding of seed or individual plants propagated ex-situ to populations where recovery is absent or inadequate to allow for species to avoid long-term decline. Requires a thorough independent assessment of feasibility and likelihood of success.

Ongoing actions

Prevent illegal collecting or over-collecting of germplasm or plants: minimise illegal losses via education, fencing, surveillance and enforcement.

Habitat disturbance from human activities: Exclusion of vehicles, bikes and other human disturbance via signage, fencing and negotiations with local users. Prevention of further disturbance via fencing, liaison with relevant utility owners and land managers, and education activities.

Minimise mining impacts: consideration of bushfire recovery in planning, assessment and enforcement.

CRITERION B. Short fire intervals (impacts of high fire frequency)

Exposure to short temporal intervals between successive fires can disrupt the replenishment of seed banks which are essential to post-fire recruitment and population persistence. Species most susceptible include obligate seeders (species that lack regenerative organs and rely entirely on seed germination for post-fire recovery) and resprouters (species with the capacity to generate new shoots from dormant buds post-fire) that suffer high mortality rates. The time required to replenish seed banks post-fire varies. For most species, up to 15 years between successive fires is needed to ensure that a seed bank is sufficiently replenished to maintain future post-fire populations, although some trees (for example) may require longer fire-free periods.

Short intervals between fires may also kill juveniles of resprouting plants before they become large enough to survive subsequent fires. The species that are most susceptible to these risks are resprouters that are slow to develop regenerative structures (i.e. lignotubers, thick bark, rhizomes etc.) or slow to replace mortality due to low fecundity. At least 15 years between successive fires is needed to ensure the juveniles of most plant species can develop their fire-regenerative organs, although some species such as mallee eucalypts may require at least 25 years.

Finally, some long-lived trees may suffer basal scarring where fires (or other factors related to fires such as falling trees or limbs) damage and/or kill bark tissue. This enables subsequent fires to smoulder into heartwood and weaken the structural integrity of the tree, causing mortality, collapse and structural change to the ecosystem. Trees with thin bark are most prone to this impact and replacement depends on fecundity and growth rates. Many rainforest trees and some eucalypts are susceptible and are likely to require at least 50 years between successive fires to enable partial recovery and replacement.

1) *HIGH* – ≥ 25% known sites or habitat both:
    a) burnt in 2019-2020 AND
    b) experienced ≥ 1 fire(s) within either:
        i) the past 5 years for non-woody species; OR
        ii) the past 15 years for woody species (excluding long-lived trees prone to collapse from basal charring); OR
        iii) the past 50 years for long-lived trees prone to collapse from basal charring.
2) *MEDIUM* – ≥ 10% to < 25% known sites or habitat both:
    a) burnt in 2019-2020 AND
    b) experienced ≥ 1 fire(s) within either:
        i) the past 5 years for non-woody species; OR
        ii) the past 15 years for woody species (excluding long-lived trees prone to collapse from basal charring); OR
        iii) the past 50 years for long-lived trees prone to collapse from basal charring.
3) *LOW* – > 0% to < 10% known sites or habitat both:
    a) burnt in 2019-2020 AND
    b) experienced ≥ 1 fire(s) within either:
        i) the past 5 years for non-woody species; OR
        ii) the past 15 years for woody species (excluding long-lived trees prone to collapse from basal charring); OR
        iii) the past 50 years for long-lived trees prone to collapse from basal charring.
4) *NONE* – Either:
    a. No known sites or habitat burnt in the 2019-2020 fires
    b. Non-woody species with none of the known sites or habitat burnt in the 2019-2020 fires also burnt by one or more previous fires in the past 5 years; OR
    c. Woody species (excluding long-lived trees prone to collapse from basal charring) with none of the known sites or habitat burnt in the 2019-2020 fires also burnt by one or more previous fires in the past 15 years; OR
    d. Long-lived trees prone to collapse from basal charring with none of the known sites or habitat burnt in the 2019-2020 fires also burnt by one or more previous fires in the past 50 years.

Methods

Growth form of all species was accessed from the AusTraits database http://traitecoevo.github.io/austraits.build/ and used to characterise species as 'woody' or 'non-woody' as follows:

Growth form	Class
Herb	non-woody
Shrub	Woody
Tree	Woody
Climber	(case dependent)
Shrub/Tree	Woody
Subshrub	Woody
Graminoid	non-woody
Epiphyte	non-woody
Parasite	non-woody
Aquatic	non-woody
Palm	non-woody
Climber/Herb	non-woody
Climber/Shrub	Woody
Climber/Tree	Woody
Fern	non-woody
Geophyte	non-woody
Herb/Shrub	Woody

Growth form data in AusTraits is largely sourced from published floras for each state and the Flora of Australia Online http://www.anbg.gov.au/abrs/online-resources/flora/main-query-styles.html.

Fire history data was sourced from the Global Fire Atlas https://www.globalfiredata.org/fireatlas.html for years 2003-2016. The Global Fire Atlas tracks the daily dynamics of individual fires to determine the timing and location of ignitions, fire size and duration, and daily expansion, fire line length, speed, and direction of spread. Methods are detailed in Andela et al. (2019) and were used to map data on extent (fire size) in the fire season between 2017-2020 (Kang He, unpublished data).

Global fire Atlas data was combined with polygons in the NPWS Fire History – Wildfire and Prescribed Burns dataset https://data.nsw.gov.au/data/dataset/1f694774-49d5-47b8-8dd0-77ca8376eb04. This dataset shows areas burnt since 1903 across NSW and has known limitations to its use in some parts of the state (e.g. Western Division) which fall largely outside the PAA (Fig. 4).

Fire history data, fire extent mapping and distributional range data were combined to assess against the criterion.

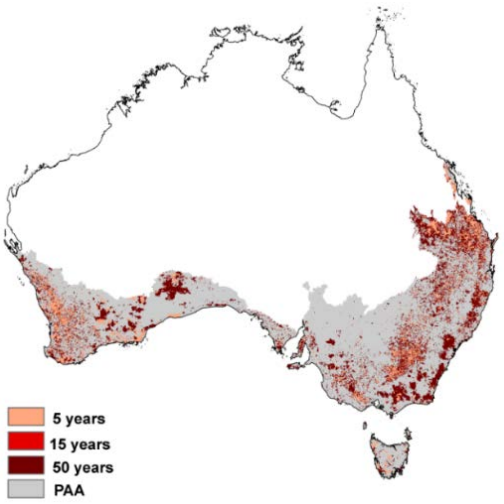

Figure 4. Fire history mapping for three intervals (areas burned in the last 5 years, 15years or 50 years) according to remotely sensed mapping of fire extent from the Global Fire Atlas and polygons in the NPWS Fire History – Wildfire and Prescribed Burns dataset for NSW.

Assessment outcome

Table 6. Number of taxa in each risk category under Criterion B - high fire frequency

Taxon group	HIGH	MEDIUM	LOW	NONE	Data deficient
EPBC Act	5	24	623	367	316
State listed NSW	25	38	342	206	90
State listed WA[1]	0	4	98	322	12
State listed Vic	7	28	1153	240	343
State listed SA	10	11	449	214	123
State listed Qld	5	21	235	541	133
State listed Tas	0	1	237	136	88
State listed ACT	0	0	5	8	0
NSW endemics	77	138	698	245	162
SA endemics	19	28	136	223	82
WA endemics	4	26	4682	2667	1573
Vic endemics	6	11	159	151	81
Qld endemics	4	24	993	1370	1238
Tas endemics	0	0	51	231	261
ACT endemics	0	0	1	4	1
Subalpine taxa	0	0	371	14	28
Rainforest taxa	5	44	1391	145	0
Total[2]	**115**	**297**	**9242**	**5274**	**4076**

[1] Local studies in Western Australia have suggested minimum fire intervals for individual species of: 20-30 years for mallee and mallee-heath communities as occur in the lower elevation parts of the Stirling Range (Gosper et al. 2013); 10-26 years for the quickest and slowest maturing species in montane communities of the Stirling Range (Barrett and Yates 2015); 15-20 years to commence seed bank accumulation, with the fire-sensitive trees then potentially living for centuries if not burnt, for dominant obligate-seeder trees in the Great Western Woodlands such as *Eucalyptus salubris* (Gosper et al. 2018).

[2] *Taxa may be shared between taxon groups and the total is the number of unique species across taxon groups which are listed under each risk category.

Potential revisions for final analysis

- Revise fire return interval times to reflect differences in productivity between regions of Australia, particularly Western Australia. It is well established that the ability of plant species to recover after fire (either to reach reproductive maturity for obligate seeders or replenish resprouting reserves) is correlated with productivity, with more rapid recovery in more productive (wetter, warmer, higher soil fertility) environments.
- Revise lists of long-lived species prone to basal charring in consultation with experts.

PROPOSED MANAGEMENT ACTIONS

Species assessed HIGH or MEDIUM risk under Criterion B (Table 5) are at specific risk from:

- Short fire return cycles which eliminate regenerating plants. Many of the populations of obligate seeding species must mature and replenish seedbanks before further fires lead to local declines and possibly local extinctions. Short intervals between fires may also kill juveniles of resprouting plants before they become large enough to survive subsequent fires.

Immediate actions

Field inspections to assess resprouting: Inspections to quantify the number of plants resprouting and the survival of resprouted tissue.

Field inspections to assess seedling emergence: For obligate seeding species, inspections to quantify seedling emergence and survival.

Exclude forestry impacts: Enforcement of buffers and use of education and liaison to minimise any damage of logging activities to post-fire recovery.

Alleviate herbivory: exclusion or removal of feral grazers, stock and excessive native herbivores by fencing and feral animal control.

Medium-term actions

Exclude prescribed fire: prescribed burning should be excluded from sites burnt in the last 5 years for non-woody taxa; the last 15 years for woody taxa; or the last 50 years for species which are killed by fire or are long-lived and prone to basal charring.

Ensure rapid response to wildfire: any future wildfires that threaten to burn over recovering sites should be rapidly extinguished.

Carefully planned translocation: adding of seed or individual plants propagated ex-situ to populations where recovery is absent or inadequate to allow for species to avoid long-term decline. Requires a thorough independent assessment of feasibility and likelihood of success.

Ongoing actions

Prevent illegal collecting or over-collecting of germplasm or plants: minimise illegal losses via education, fencing, surveillance and enforcement.

Habitat disturbance from human activities: Exclusion of vehicles, bikes and other human disturbance via signage, fencing and negotiations with local users. Prevention of further disturbance via fencing, liaison with relevant utility owners and land managers, and education activities.

Minimise mining impacts: consideration of bushfire recovery in planning, assessment and enforcement.

CRITERION C. Post-fire herbivore impacts

Plants are often at their most palatable and least resilient to herbivore activity (e.g. leaf and shoot removal, trampling and substrate degradation) in the post-fire environment where herbivores have enhanced foraging efficiency and converge on regenerating burnt areas to exploit fresh growth. Concentrations of herbivores may therefore increase mortality of both seedlings and resprouters of palatable plants. In some cases, elevated mortality may lead to local extinction. Effects may be exacerbated when burnt patches are small or have high perimeter to area ratios which promote herbivore incursions in high densities.

1) *HIGH* – Evidence or likelihood of significant post-fire grazing impacts AND $\geq$ 50% known sites or habitat burnt in the 2019-2020 fires.
2) *MEDIUM* – Evidence or likelihood of significant post-fire grazing impacts AND obligate seeder with $\geq$ 30 to < 50% known sites or habitat burnt in the 2019-2020 fires.
3) *LOW* – Evidence or likelihood of significant post-fire grazing impacts AND either:
    a) Obligate seeder with > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires; OR
    b) Resprouter with > 0 to < 50% known sites or habitat burnt in the 2019-2020 fires.
4) *NONE* – Either:
    a) No known sites or habitat burnt in the 2019-2020 fires; OR
    b) No evidence or likelihood of significant post-fire grazing impacts in any known sites or habitat.

Methods

This criterion was assessed for all taxa in subalpine treeless plant communities identified in Doherty (2015) (n = 416 taxa) as this habitat is likely to have significant feral horse populations. This list was further supplemented with taxa identified at risk from post-fire herbivory in NSW compiled by staff in NSW DPIE (n = 43 taxa).

Assessment outcome

Table 7. Number of taxa in each risk category under Criterion C - Post-fire herbivore impacts

Taxon group	HIGH	MEDIUM	LOW	NONE	Data deficient
EPBC Act	2	1	11	1312	9
State listed NSW	23	5	20	648	5
State listed WA	0	0	0	436	0

State listed Vic	7	11	59	1646	48
State listed SA	0	0	17	773	17
State listed Qld	0	3	2	930	0
State listed Tas	0	0	16	428	18
State listed ACT	0	1	2	10	0
NSW endemics	15	2	14	1285	4
SA endemics	0	0	0	488	0
WA endemics	0	0	0	8952	0
Vic endemics	0	0	0	407	1
Qld endemics	0	0	0	3629	0
Tas endemics	0	0	0	543	0
ACT endemics	0	0	0	6	0
Subalpine taxa	9	16	223	5	160
Rainforest taxa	0	1	5	1579	0
Total	**30**	**21**	**232**	**18556**	**165**

*Taxa may be shared between taxon groups and the total is the number of unique species across taxon groups which are listed under each risk category.

Potential revisions for final analysis

- Revise lists of species at risk from herbivory in consultation with experts.

PROPOSED MANAGEMENT ACTIONS

Species assessed HIGH or MEDIUM risk under Criterion C (Table 6) are at specific risk from:

- Browsing or grazing of regenerating tissues by herbivores - particularly ferals - which reduces the likelihood of successful recovery
- Trampling of emerging seedlings and associated habitat damage

Immediate actions

Field inspections – damage and threats: to quantify the damage to standing or recovering plants from the fires or from other threats (e.g. *herbivory*, disease, weed invasion, erosion).

Alleviating herbivory: exclusion or removal of feral grazers, stock and excessive native herbivores by fencing and feral animal control.

Germplasm collection: during field inspections, germplasm collection of seeds and/or cuttings for species at immediate risk of local extinction should be conducted to preserve the species in ex-situ cultivation and allow for reintroduction.

Medium-term actions

Exclude prescribed fire: prescribed burning should be excluded from sites burnt in the last 5 years for non-woody taxa; the last 15 years for woody taxa; or the last 50 years for species which are killed by fire or are long-lived and prone to basal charring.

Ensure rapid response to wildfire: any future wildfires that threaten to burn over recovering sites should be rapidly extinguished.

Carefully planned translocation: adding of seed or individual plants propagated ex-situ to populations where recovery is absent or inadequate to allow for species to avoid long-term decline. Requires a thorough independent assessment of feasibility and likelihood of success.

Ongoing actions

Prevent illegal collecting or over-collecting of germplasm or plants: minimise illegal losses via education, fencing, surveillance and enforcement.

Habitat disturbance from human activities: Exclusion of vehicles, bikes and other human disturbance via signage, fencing and negotiations with local users. Prevention of further disturbance via fencing, liaison with relevant utility owners and land managers, and education activities.

Minimise mining impacts: consideration of bushfire recovery in planning, assessment and enforcement.

CRITERION D. Fire-disease interactions

Plant species from particular genera and families are susceptible to diseases such as *Phytophthora* spp., *Armillaria* spp., Myrtle Rust, Canker fungi and other pathogens. Tissue death caused by these diseases reduces the capacity of plants to acquire resources through their roots and/or leaves. Plants are more sensitive to resource deprivation in the post-fire period and reduced post-fire survival rates have been observed in areas infected by disease, such that fire accelerates disease-related population decline. Resprouting individuals in certain families appear most susceptible to this threat. Disease effects may be exacerbated by drought.

1) *HIGH* – Evidence or likelihood of significant pathogen/disease susceptibility AND $\geq$ 50% known sites or habitat burnt in the 2019-2020 fires.
2) *MEDIUM* – Evidence or likelihood of significant pathogen/disease susceptibility AND $\geq$ 30 to < 50% known sites or habitat burnt in the 2019-2020 fires.
3) *LOW* – Evidence or likelihood of significant pathogen/disease susceptibility AND > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires.
4) *NONE* – Either:
    a) No known sites or habitat burnt in the 2019-2020 fires; OR
    b) No evidence or likelihood of pathogen/disease susceptibility

Methods

Taxa known, or likely to be, susceptible to *Phytophthora* spp. were collated from multiple expert-advised resources (Threat Abatement Plan for Phytophthora; McDougall & Liew, unpublished data; WA DBCA). As a precautionary measure, all taxa in the family Myrtaceae in any of the taxon groups assessed have been listed as likely hosts for this interim assessment. Also, all taxa in the genera named as susceptible in this list were classified as potentially at risk. In total, across both diseases, data was collated for 2,734 taxa.

Disease susceptibility and distributional range data were combined to assess against the criterion.

Assessment outcome

Table 8. Number of taxa in each risk category under Criterion D - Fire-disease interactions

Taxon group	HIGH	MEDIUM	LOW	NONE	Data deficient
EPBC Act	28	39	341	826	101
State listed NSW	64	39	130	445	23
State listed WA	10	11	94	316	5
State listed Vic	74	74	293	1256	74
State listed SA	9	7	136	632	23
State listed Qld	6	15	83	818	13
State listed Tas	1	12	47	394	8
State listed ACT	0	0	3	10	0
NSW endemics	281	174	265	507	93
SA endemics	26	9	97	337	19
WA endemics	71	70	2952	5143	716
Vic endemics	28	15	126	205	34
Qld endemics	5	9	391	3094	130
Tas endemics	0	3	111	425	4
ACT endemics	0	0	2	4	0
Subalpine taxa	1	28	36	344	4
Rainforest taxa	9	23	190	1363	0
Total	**472**	**393**	**4377**	**12653**	**1109**

*Taxa may be shared between taxon groups and the total is the number of unique species across taxon groups which are listed under each risk category.

Potential revisions for final analysis

- Refine lists of susceptible species in consultation with experts, including adding data on susceptibility rankings.
- Incorporate distribution modelling of disease risk where available for key diseases.

PROPOSED MANAGEMENT ACTIONS

Species assessed HIGH or MEDIUM risk under Criterion D (Table 7) are at specific risk from:

- Infection by Myrtle Rust (*Austropuccinia psidii*) and *Phytophtora* spp. which are the two main disease risks assessed for the Interim Assessment. Infection is known to particularly effect young, regenerating tissues.
- Other infectious plant pathogens that may affect recovery, such as *Armillaria* spp. and Canker fungi.

Immediate actions

Field inspections – damage and threats: to quantify the damage to standing or recovering plants from the fires or from other threats (e.g. herbivory, *disease*, weed invasion, erosion).

Disease: Treatment of soil or plants to enhance their ability to cope with diseases. Maintenance of strict phytosanitory measures during site visits to minimise risk of disease transfer and introduction.

Germplasm collection: during field inspections, germplasm collection of seeds and/or cuttings for species at immediate risk of local extinction should be conducted to preserve the species in ex-situ cultivation and allow for reintroduction.

Medium-term actions

Exclude prescribed fire: prescribed burning should be excluded from sites burnt in the last 5 years for non-woody taxa; the last 15 years for woody taxa; or the last 50 years for species which are killed by fire or are long-lived and prone to basal charring.

Ensure rapid response to wildfire: any future wildfires that threaten to burn over recovering sites should be rapidly extinguished.

Carefully planned translocation: adding of seed or individual plants propagated ex-situ to populations where recovery is absent or inadequate to allow for species to avoid long-term decline. Requires a thorough independent assessment of feasibility and likelihood of success.

Ongoing actions

Prevent illegal collecting or over-collecting of germplasm or plants: minimise illegal losses via education, fencing, surveillance and enforcement.

Habitat disturbance from human activities: Exclusion of vehicles, bikes and other human disturbance via signage, fencing and negotiations with local users. Prevention of further disturbance via fencing, liaison with relevant utility owners and land managers, and education activities.

Minimise mining impacts: consideration of bushfire recovery in planning, assessment and enforcement.

CRITERION E. High fire severity

In some plant species, survival of established individuals and/or seed banks may be sensitive to fire severity due to limitations in the insulating capacity of protective tissues (thickness of bark or walls of serotinous fruits). Species that rely on persistence of long-lived standing plants (due to low fecundity) or post-fire regeneration from small serotinous fruits are most susceptible to this mechanism of decline. For long-lived trees, these effects may be cumulative through successive fires (high fire frequency – see B above) that undermine their structural integrity. In such cases, fire severity impacts may be influenced by prolonged basal and internal smouldering rather than canopy consumption (as commonly reflected in fire severity maps). Effects may be exacerbated by drought reducing water content within insulating tissues prior to fires.

1) *HIGH* – Survival of standing plants and/or seed bank is known or suspected to be sensitive to high fire severity AND ≥ 50% of known sites or habitat burnt in the 2019-2020 fires at high severity (i.e. fire likely to cause death or serious damage and recovery is not certain).
2) *MEDIUM* – Survival of standing plants and/or seed bank is known or suspected to be sensitive to high fire severity AND ≥ 30 to < 50% of known sites or habitat burnt in 2019-2020 fires at high severity.
3) *LOW* – Survival of standing plants and/or seed bank is known or suspected to be sensitive to high fire severity AND > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires at high severity.
4) *NONE* – Either:
    a) No known sites or habitat burnt at high severity in the 2019-2020 fires; OR
    b) Survival of standing plants and/or seed bank is largely unaffected by fire severity.

Methods

Note: Data on fire severity were provided in confidence to the Expert Panel and are under publishing embargo. No further details are available at this time.

Fire severity values (0-1) were classified into quartiles and assigned to categories from low, medium, high and very high severity. The number of grid cells in each of these categories was: 35,008 (42%); 27,576 (33%); 12,556 (15%); 7,459 (9%) respectively.

The sensitivity of standing plants or seedbanks to high severity fire has not been assessed for the Interim Assessment. Therefore, results are based solely on exposure to severe fire and not on plants capacity to withstand this risk.

Fire severity mapping and distributional range data were combined to assess against the criterion.

Assessment outcome

Table 9. Number of taxa in each risk category under Criterion E - High fire severity

Taxon group	HIGH	MEDIUM	LOW	NONE	Data deficient
EPBC Act	19	15	677	365	259
State listed NSW	42	47	372	150	90
State listed WA	2	0	100	322	12
State listed Vic	17	44	1165	202	343
State listed SA	2	8	504	170	123
State listed Qld	5	18	253	526	133
State listed Tas	0	2	261	111	88
State listed ACT	0	1	6	6	0
NSW endemics	158	174	654	172	162
SA endemics	3	14	221	168	82
WA endemics	14	10	4747	2610	1571
Vic endemics	11	6	155	155	81
Qld endemics	4	11	1508	1489	617
Tas endemics	0	0	226	282	35
ACT endemics	1	0	2	2	1
Subalpine taxa	1	3	374	7	28
Rainforest taxa	6	8	1394	177	0
Total	**204**	**279**	**10090**	**5204**	**3227**

*Taxa may be shared between taxon groups and the total is the number of unique species across taxon groups which are listed under each risk category

Potential revisions for final analysis

- Integrate data on standing plants and seed bank responses to high fire severity
- Include mapping from other fire severity products if they become available

PROPOSED MANAGEMENT ACTIONS

Species assessed HIGH or MEDIUM risk under Criterion E (Table 8) are at specific risk from:

- High fire temperatures that scorch the soil seedbank and limit recovery via seedling emergence, particularly for obligate seeding species.
- Damage to regenerative organs in resprouting species (e.g. lignotubers, epicormic buds)
- Loss of the canopy-held seedbank

Immediate actions

Field inspections to assess resprouting: Inspections to quantify the number of plants resprouting and the survival of resprouted tissue.

Field inspections to assess seedling emergence: For obligate seeding species, inspections to quantify seedling emergence and survival.

Exclude forestry impacts: Enforcement of buffers and use of education and liaison to minimise any damage of logging activities to post-fire recovery

Medium-term actions

Exclude prescribed fire: prescribed burning should be excluded from sites burnt in the last 5 years for non-woody taxa; the last 15 years for woody taxa; or the last 50 years for species which are killed by fire or are long-lived and prone to basal charring.

Ensure rapid response to wildfire: any future wildfires that threaten to burn over recovering sites should be rapidly extinguished.

Carefully planned translocation: adding of seed or individual plants propagated ex-situ to populations where recovery is absent or inadequate to allow for species to avoid long-term decline. Requires a thorough independent assessment of feasibility and likelihood of success.

Ongoing actions

Prevent illegal collecting or over-collecting of germplasm or plants: minimise illegal losses via education, fencing, surveillance and enforcement.

Habitat disturbance from human activities: Exclusion of vehicles, bikes and other human disturbance via signage, fencing and negotiations with local users. Prevention of further disturbance via fencing, liaison with relevant utility owners and land managers, and education activities.

Minimise mining impacts: consideration of bushfire recovery in planning, assessment and enforcement.

CRITERION F. Weed invasion

Some sites are predisposed to invasion by transformer exotic plants. Fire may provide opportunities for growth of existing exotics or entry of these species into the vegetation (especially where weed sources are within or proximal to burnt areas) and subsequent elimination of native species through competition. Native species that occur mainly in areas where bushland has been fragmented, disturbed by logging or clearing, or affected by runoff from nutrient sources (e.g. urban infrastructure, improved pasture, wastewater or stormwater disposal etc.) are most susceptible to this mechanism, and these factors should be considered in assessing the likelihood of weed impacts below.

1) *HIGH* – Evidence or likelihood of significant weed impacts post-fire AND $\geq$ 50% known sites or habitat burnt in the 2019-2020 fires.
2) *MEDIUM* – Evidence or likelihood of significant weed impacts post-fire AND $\geq$ 30 to < 50% known sites or habitat burnt in the 2019-2020 fires.
3) *LOW* – Evidence or likelihood of significant weed impacts post-fire AND > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires.

4) *NONE* – Either:
    a) No known sites or habitat burnt in the 2019-2020 fires OR
    b) No evidence or likelihood of significant weed impacts post-fire in any known sites or habitat.

Methods

A list of 732 taxa from national and international invasive plant species lists was compiled and occurrence records accessed from the Australasian Virtual Herbarium. These 732 taxa include species on the Weeds of National Significance list (and shortlist), previously declared noxious weeds in NSW, national sleeper weeds and alert lists, and the 100 of the World's Worst Invasive Alien Species list http://www.iucngisd.org/gisd/100_worst.php. Occurrence records for each taxon were limited to the time period 1990-presnet and were buffered by 2km and stacked using the *raster* package in R. Weed species richness in each 2km grid cell was then mapped and areas with ≥ 3 weed species were identified (Fig. 6).

Weed occurrence, fire extent mapping and distributional range data were combined to assess against the criterion.

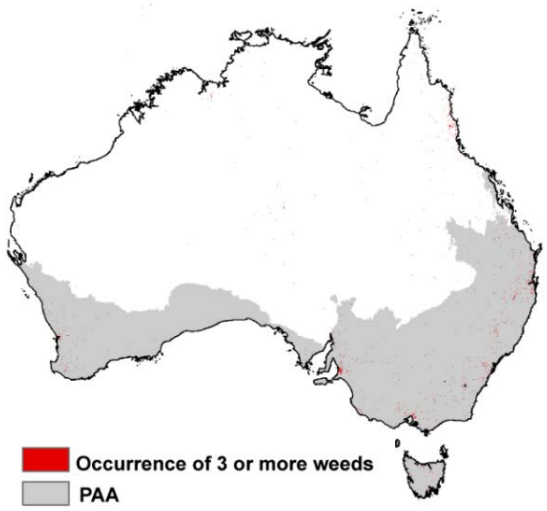

Figure 6. Weed occurrence mapping based on records of 723 known weed species in Australia. Occurrence records were accessed from the Australasian Virtual Herbarium for the period 1990-present in March 2020.

Assessment outcome

Table 10. Number of taxa in each risk category under Criterion F – Weed invasion

Taxon group	HIGH	MEDIUM	LOW	NONE	Data deficient
EPBC Act	0	0	512	564	259
State listed NSW	0	2	308	301	90
State listed WA	0	0	38	386	12
State listed Vic	0	0	1022	406	343
State listed SA	0	0	421	263	123
State listed Qld	0	1	191	610	133
State listed Tas	0	0	231	143	88
State listed ACT	0	0	7	6	0
NSW endemics	2	3	757	396	162
SA endemics	0	0	157	249	82
WA endemics	0	0	3131	4250	1571
Vic endemics	0	0	120	207	81
Qld endemics	0	2	1317	1693	617
Tas endemics	0	0	18	490	35
ACT endemics	0	0	2	3	1
Subalpine taxa	1	0	374	10	28
Rainforest taxa	0	2	1390	193	0
Total	**2**	**6**	**7899**	**7870**	**3227**

*Taxa may be shared between taxon groups and the total is the number of unique species across taxon groups which are listed under each risk category

Potential revisions for final analysis

- Access and integrate data on weed impacts from state and federal agency databases

PROPOSED MANAGEMENT ACTIONS

Species assessed HIGH or MEDIUM risk under Criterion F (Table 9) are at specific risk from:

- Competition from over-abundant species, in particular 'transformer' weed species which can rapidly change habitat upon spread, leading to failure of seedling regeneration.

Immediate actions

Field inspections – damage and threats: to quantify the damage to standing or recovering plants from the fires or from other threats (e.g. herbivory, disease, *weed invasion*, erosion).

Medium-term actions

Weed control: removal and control of weeds that may outcompete plants and impede post-fire recovery.

Exclude prescribed fire: prescribed burning should be excluded from sites burnt in the last 5 years for non-woody taxa; the last 15 years for woody taxa; or the last 50 years for species which are killed by fire or are long-lived and prone to basal charring.

Ensure rapid response to wildfire: any future wildfires that threaten to burn over recovering sites should be rapidly extinguished.

Ongoing actions

Prevent illegal collecting or over-collecting of germplasm or plants: minimise illegal losses via education, fencing, surveillance and enforcement.

Habitat disturbance from human activities: Exclusion of vehicles, bikes and other human disturbance via signage, fencing and negotiations with local users. Prevention of further disturbance via fencing, liaison with relevant utility owners and land managers, and education activities.

Exclude mining impacts: consideration of bushfire recovery in planning, assessment and enforcement.

CRITERION G. Elevated winter temperatures or changed temperature regimes

Seed germination of some plants in alpine and subalpine (or frost-hollow) habitats is reliant on cold stratification during winter. Alpine plant phenology is also affected by temperature. If the 2020 winter is warm, seedling regeneration may be reduced with flow-on effects on seed bank replenishment. Species with short-lived standing plants and/or short-lived seed banks are likely to be most susceptible. Enhanced insolation of fire-blackened soils may exacerbate climatic warming effects. For other species diurnal temperature cycles cue germination and changes to these cycles may delay or reduce germination.

1) *HIGH* – Cold stratification known or suspected to be needed for successful seedling recruitment post-fire AND with $\geq$ 50% known sites or habitat burnt in the 2019-2020 fires.
2) *MEDIUM* – Cold stratification known or suspected to be needed for successful seedling recruitment post-fire AND obligate seeder with $\geq$ 30 to < 50% known sites or habitat burnt in the 2019-2020 fires.
3) *LOW* – Cold stratification known or suspected to be needed for successful seedling recruitment post-fire AND either:
    a) Obligate seeder with > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires; OR
    b) Resprouter with > 0 to < 50% known sites or habitat burnt in the 2019-2020 fires.
4) *NONE* – Either:
    a) No known sites or habitat burnt in the 2019-2020 fires; OR
    b) No evidence that cold stratification is needed for successful seedling recruitment post-fire.

Methods

A list of 415 taxa which occur in subalpine regions known to have been impacted by the 2019-2020 fires (K. McDougall pers. comm.) was collated from Doherty et al. (2015). As a precautionary measure, all taxa in this group were considered to potentially require cold stratification for germination. Data on regeneration capacity (e.g. resprouting, obligate seeding) were collated from AusTraits and the NSW FFRD.

Lists of subalpine taxa, fire extent mapping and distributional range data were combined to assess against the criterion.

Assessment outcome

Table 11. Number of taxa in each risk category under Criterion G - Elevated winter temperatures or changed temperature regimes

Taxon group	HIGH	MEDIUM	LOW	NONE	Data deficient
EPBC Act	1	1	10	1315	8
State listed NSW	2	0	11	688	0
State listed WA	0	0	0	436	0
State listed Vic	2	10	57	1654	48
State listed SA	0	0	17	773	17
State listed Qld	0	0	2	933	0
State listed Tas	0	0	16	428	18
State listed ACT	0	0	1	12	0
NSW endemics	4	2	8	1302	4
SA endemics	0	0	0	488	0
WA endemics	0	0	0	8952	0
Vic endemics	0	0	0	407	1
Qld endemics	0	0	0	3629	0
Tas endemics	0	0	0	543	0
ACT endemics	0	0	0	6	0
Subalpine taxa	9	16	223	5	160
Rainforest taxa	0	0	5	1580	0
Total	**9**	**16**	**223**	**18596**	**160**

*Taxa may be shared between taxon groups and the total is the number of unique species across taxon groups which are listed under each risk category

Potential revisions for final analysis

- Refine lists of species needing cold stratification with input from seedbanks, researchers and state agency staff
- Integrate data on regeneration capacity of taxa (e.g. resprouting, seed banks, obligate seeding)

PROPOSED MANAGEMENT ACTIONS

Species assessed HIGH or MEDIUM risk under Criterion G (Table 10) are at specific risk from:

- Warmer than average winter temperatures in the 2020 winter which may influence cold stratification requirements of alpine/subalpine/frost hollow taxa, growth and phenology.

Immediate actions

None. Actions required during/after winter 2020.

Medium-term actions

Field inspections for recovery assessment: to quantify factors such population size and demography.

Exclude prescribed fire: prescribed burning should be excluded from sites burnt in the last 5 years for non-woody taxa; the last 15 years for woody taxa; or the last 50 years for species which are killed by fire or are long-lived and prone to basal charring.

Ensure rapid response to wildfire: any future wildfires that threaten to burn over recovering sites should be rapidly extinguished.

Ongoing actions

Prevent illegal collecting or over-collecting of germplasm or plants: minimise illegal losses via education, fencing, surveillance and enforcement.

Habitat disturbance from human activities: Exclusion of vehicles, bikes and other human disturbance via signage, fencing and negotiations with local users. Prevention of further disturbance via fencing, liaison with relevant utility owners and land managers, and education activities.

Exclude mining impacts: consideration of bushfire recovery in planning, assessment and enforcement.

CRITERION H. Fire sensitivity

Some plant species have no means of *in situ* persistence through fire events because their standing plants lack protected regenerative organs and there is no seed bank. A single fire may eliminate such species or damage a significant proportion of individuals in the population, which must then rely entirely on dispersal from unburnt populations for re-establishment in the area.

1) *HIGH* – $\geq$ 50% of known sites or habitat burnt in the 2019-2020 fires AND species is either:
    a) A long-lived tree prone to collapse from basal charring; OR
    b) Not a long-lived tree prone to collapse from basal charring AND cannot resprout AND has no seed bank
2) *MEDIUM* – $\geq$ 30 to < 50% of known sites or habitat burnt in the 2019-2020 fires AND species is either:

a) A long-lived tree prone to collapse from basal charring; OR
b) Not a long-lived tree prone to collapse from basal charring AND cannot resprout AND has no seed bank

3) *LOW* – > 0 to < 30% of known sites or habitat burnt in the 2019-2020 fires AND species is either:
    a) A long-lived tree prone to collapse from basal charring; OR
    b) Not a long-lived tree prone to collapse from basal charring AND cannot resprout AND has no seed bank
4) *NONE* – Either:
    a) No known sites or habitat burnt in the 2019-2020 fires; OR
    b) Species is not a long-lived tree prone to collapse from basal charring AND either:
        i) Can resprout; OR
        ii) Has a seed bank.

Methods

A list of 463 rainforest tree taxa greater than 30m in maximum height was accessed from the AusTraits database. For the purposes of the Interim Assessment, these taxa are considered long-lived and prone to collapse from basal charring. A preliminary list of taxa known to resprout or have a soil seedbank was compiled from AusTraits, the NSW Fire Response Register (DPIE), and state agency staff and their contacts (T. Auld, pers. comm.). Data on species with seed banks and resprouting capacity were collated from the NSW FFRD and AusTraits.

Lists of long-lived taxa, taxa which can regenerate, fire extent mapping and distributional range data were combined to assess against the criterion.

Assessment outcome

Table 12. Number of taxa in each risk category under Criterion H - Fire sensitivity

Taxon group	HIGH	MEDIUM	LOW	NONE	Data deficient
EPBC Act	1	1	18	1314	1
State listed NSW	2	2	30	665	2
State listed WA	0	0	0	436	0
State listed Vic	4	0	4	1763	0
State listed SA	0	0	1	806	0
State listed Qld	1	1	22	911	0
State listed Tas	0	0	0	462	0
State listed ACT	0	0	0	13	0
NSW endemics	9	6	7	1298	0
SA endemics	0	0	0	488	0
WA endemics	0	0	0	8952	0
Vic endemics	0	0	0	408	0
Qld endemics	0	2	147	3479	1
Tas endemics	0	0	3	540	0
ACT endemics	0	0	0	6	0
Subalpine taxa	0	0	0	413	0
Rainforest taxa	5	15	303	1262	0
Total	**14**	**20**	**318**	**18649**	**3**

*Taxa may be shared between taxon groups and the total is the number of unique species across taxon groups which are listed under each risk category

Potential revisions for final analysis

- Refine lists of taxa capable of regenerating after fire or long-lived and likely to be at risk of basal charring with input from researchers and federal and state agency staff

PROPOSED MANAGEMENT ACTIONS

Species assessed HIGH or MEDIUM risk under Criterion H (Table 11) are at specific risk from:

- Loss of mature plants, particularly where seeds are held in the canopy with no or limited soil seedbank and no capacity to resprout.

Immediate actions

Field inspections – damage and threats: to quantify the damage to standing or recovering plants from the fires or from other threats (e.g. herbivory, disease, weed invasion, erosion). *Damage inspections are particularly important for rainforest taxa that are long-lived trees prone to collapse from basal charring to assess the scale of tree loss or damage.*

Exclude forestry impacts: Enforcement of buffers and use of education and liaison to minimise any damage of logging activities to post-fire recovery

Medium-term actions

Exclude prescribed fire: prescribed burning should be excluded from sites burnt in the last 5 years for non-woody taxa; the last 15 years for woody taxa; or the last 50 years for species which are killed by fire or are long-lived and prone to basal charring.

Rapid response to wildfire: ensure that any future wildfires that threaten to burn over recovering sites are rapidly extinguished.

Carefully planned translocation: adding of seed or individual plants propagated ex-situ to populations where recovery is absent or inadequate to allow for species to avoid long-term decline. Requires an independent assessment of feasibility and likelihood of success.

Ongoing actions

Prevent illegal collecting or over-collecting of germplasm or plants: minimise illegal losses via education, fencing, surveillance and enforcement.

Habitat disturbance from human activities: Exclusion of vehicles, bikes and other human disturbance via signage, fencing and negotiations with local users. Prevention of further disturbance via fencing, liaison with relevant utility owners and land managers, and education activities.

Minimise mining impacts: consideration of bushfire recovery in planning, assessment and enforcement.

CRITERION I. Post-fire erosion

Intense rainfall events after fires may lead to extensive localised erosion that either covers recovering plants in soil and ash or depletes soil seed banks. In steep terrain, post-fire erosion may dislodge rocks and trees or cause larger scale landslides with associated plant mortality. Effects are likely to be localised and evident in the first few months after a fire. Steep habitats, riparian habitats, peaty habitats and unconsolidated floodplains or sandplains would seem to be potentially vulnerable to erosion.

1) *HIGH* – Evidence or likelihood that species has been impacted by severe post-fire soil erosion leading to mortality of individuals or depletion of soil seed banks AND $\geq$ 50% of known sites or habitat burnt in the 2019-2020 fires.
2) *MEDIUM* – Evidence or likelihood that species has been impacted by severe post-fire soil erosion leading to mortality of individuals or depletion of soil seed banks AND $\geq$ 30 to < 50% of known sites or habitat burnt in the 2019-2020 fires.
3) *LOW* – Evidence or likelihood that species has been impacted by severe post-fire soil erosion leading to mortality of individuals or depletion of soil seed banks AND > 0 to < 30% of known sites or habitat burnt in the 2019-2020 fires.
4) *NONE* – Either:
    a) No known sites or habitat burnt in the 2019-2020 fires; OR
    b) No evidence or likelihood that species has been impacted by severe post-fire soil erosion.

Methods

For the interim assessment, extreme precipitation across the fire grounds was used to approximate erosion potential. However, erosion not only governed by extreme rainfall events (erosivity of precipitation), but by erodability of soils, especially after vegetation cover has been removed. This is especially acute in the Alps, or on slopes where wind and frost are also agents of erosion, particularly at high altitude.

A spatial layer of extreme rainfall between January 15 2020 and March 15 2020 was created using daily rainfall data from the Australian Water Availability Project (AWAP) via http://www.bom.gov.au/jsp/awap/. Methods used to derive the AWAP are described in Jones et al. (2009). Grid cell size was aggregated from 0.05 x 0.05 to 0.1 x 0.1 degrees of latitude using the *raster* package in R. Daily rainfall data was summed for the period between the 15th January to the 15th of March for the years 2000 to 2020. For this period the mean and standard deviation of rainfall was calculated across 2000-2019 (20 years) and 2020 rainfall compared to the mean by calculating how many standard deviations this year was from average. Locations which were 2 standard deviations away from the average rainfall over the previous 20-year period were classified as areas of extreme rainfall (Fig. 7).

Extreme rainfall layers, fire extent mapping and distributional range data were combined to assess against the criterion.

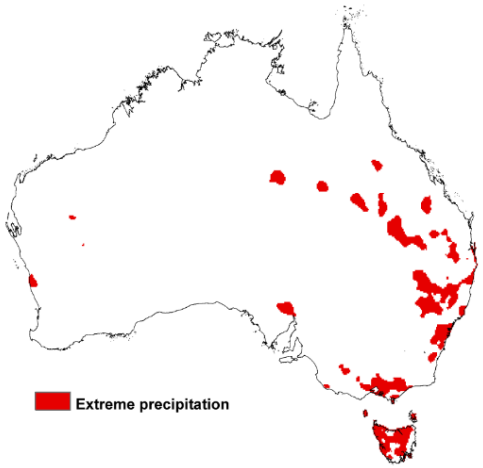

Figure 7. Areas of extreme precipitation in the period January 15 2020-March 15 2020, relative to average rainfall in this time period between 2000 and 2019. Red areas are 2 standard deviations from the mean 2000-2019 conditions.

Assessment outcome

Table 13. Number of taxa in each risk category under Criterion I - Post-fire erosion

Taxon group	HIGH	MEDIUM	LOW	NONE	Data deficient
EPBC Act	13	11	385	667	259
State listed NSW	30	28	314	239	90
State listed WA	0	0	11	413	12
State listed Vic	0	7	1021	400	343
State listed SA	0	0	356	328	123
State listed Qld	0	0	138	664	133
State listed Tas	0	0	263	111	88
State listed ACT	0	0	4	9	0
NSW endemics	114	120	687	237	162
SA endemics	0	0	23	383	82
WA endemics	0	0	1645	5736	1571
Vic endemics	0	0	142	185	81
Qld endemics	0	0	561	2451	617
Tas endemics	0	0	348	160	35
ACT endemics	0	0	1	4	1
Subalpine taxa	1	0	358	26	28
Rainforest taxa	2	1	798	784	0
Total	**115**	**128**	**5622**	**9912**	**3227**

*Taxa may be shared between taxon groups and the total is the number of unique species across taxon groups which are listed under each risk category

Potential revisions for final analysis

- Investigate erosion modelling options from various sources and integrate data products were suitable.

PROPOSED MANAGEMENT ACTIONS

Species assessed HIGH or MEDIUM risk under Criterion I (Table 12) are at specific risk from:

- Loss of the seed bank and standing plants to landslide and erosion of river banks and floodplains, which is related to the topographic position of the populations in the landscape

Immediate actions

Field inspections – damage and threats: to quantify the damage to standing or recovering plants from the fires or from other threats (e.g. herbivory, disease, weed invasion, *erosion*).

Medium-term actions

Exclude prescribed fire: prescribed burning should be excluded from sites burnt in the last 5 years for non-woody taxa; the last 15 years for woody taxa; or the last 50 years for species which are killed by fire or are long-lived and prone to basal charring.

Rapid response to wildfire: ensure that any future wildfires that threaten to burn over recovering sites are rapidly extinguished.

Carefully planned translocation: adding of seed or individual plants propagated ex-situ to populations where recovery is absent or inadequate to allow for species to avoid long-term decline. Requires an independent assessment of feasibility and likelihood of success.

Ongoing actions

Prevent illegal collecting or over-collecting of germplasm or plants: minimise illegal losses via education, fencing, surveillance and enforcement.

Habitat disturbance from human activities: Exclusion of vehicles, bikes and other human disturbance via signage, fencing and negotiations with local users. Prevention of further disturbance via fencing, liaison with relevant utility owners and land managers, and education activities.

Minimise mining impacts: consideration of bushfire recovery in planning, assessment and enforcement.

CRITERION J. Cumulative exposure to high risks

Loss of all mature plants in a species exposes it to risks associated with recruiting new plants to replace those lost. Where fire causes such losses in obligate seeding species, risks include stochastic events, failure or limited successful recruitment of new plants (e.g. through grazing, weed, pathogen and drought impacts). This criterion addresses where the current 2019-2020 fires have exposed obligate seeding species to having significant proportions of their entire known populations as immature plants, as cumulatively the current fires have added to previous fires in other locations that have eliminated all mature plants. Species with canopy seed banks are most at risk as these can be completely exhausted after a single fire event. Species with soil seed banks may have more resilience but there may still be little to no seed bank remaining after a fire in some cases.

1) *HIGH* – Obligate seeder with > 0% known sites or habitat burnt in the 2019-2020 fires AND with ≥ 50% of known sites or habitat comprising immature plants, based on the sum of: a) known sites or habitat that have experienced fires prior to the 2019-2020 fires where recruiting plants are not yet mature AND b) known sites or habitat burnt in the 2019-2020 fires.
2) *MEDIUM* – Obligate seeder with > 0% known sites or habitat burnt in the 2019-2020 fires AND ≥ 30 to < 50% of known sites or habitat comprising immature plants, based on the sum of: a) known sites or habitat that have experienced fires prior to the 2019-2020 fires where recruiting plants are not yet mature; AND b) known sites or habitat burnt in the 2019-2020 fires.
3) *LOW* – Obligate seeder with > 0% known sites or habitat burnt in the 2019-2020 fires AND with > 0 to < 30% of known sites or habitat comprising immature plants, based on the sum of: a) known sites

or habitat that have experienced fires prior to the 2019-2020 fires where recruiting plants are not yet mature; AND b) known sites or habitat burnt in the 2019-2020 fires.

4) *NONE* – Either:
    a) Obligate seeders with no known sites or habitat burnt in the 2019-2020 fires; OR

Obligate seeders with no known sites or habitat comprising immature plants as a result of fires prior to the 2019-2020 fires.

Methods

Fire history data was sourced from the Global Fire Atlas https://www.globalfiredata.org/fireatlas.html for years 2003-2016. Methods are detailed in Andela et al. (2019) and were used to map data on extent (fire size) in the fire season between 2017-2018 (Kang He, unpublished data).

Global fire Atlas data was combined with polygons in the NPWS Fire History – Wildfire and Prescribed Burns dataset https://data.nsw.gov.au/data/dataset/1f694774-49d5-47b8-8dd0-77ca8376eb04. This dataset shows areas burnt since 1903 across NSW only.

Maps were created for three time spans: (1) burns in the five years previous to the 2019-2020 fire season (2018-2014); (2) burns in the 15 years previous to the 2019-2020 fire season (2004-2018); (3) burns in the 50 years previous to the 2019-2020 fire season (1969-2018) (Fig. 8).

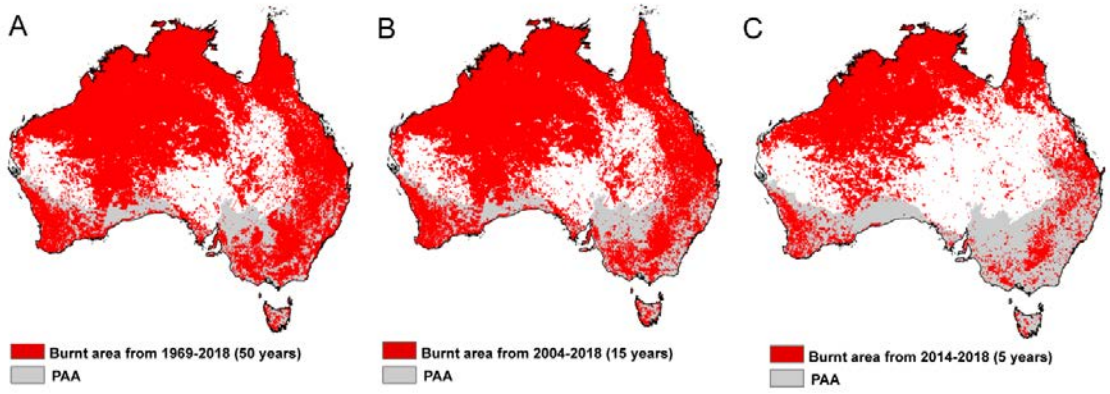

Figure 8. Burnt areas across Australian in three time intervals (5, 15 and 50 years) according to the Global Fire Atlas and the NSW NPWS fire history database. Note that A and B are largely similar as remotely sensed data on fires was available from 2003-current and not for the entire 50 year period.

Data on obligate seeding was collated from AusTraits, NSW FFRD and WA DBCA staff.

For obligate seeding species which were burnt in the PAA in 2019-2020, the % of the entire range burnt in the previous 5 years (for non-woody taxa), 15 years (woody taxa) or 50 years (long-lived trees) was calculated. This % was added to the % burnt in the PAA in 2019-2020 to assign species into risk categories. Note that local studies in Western Australia have suggested minimum fire intervals for individual species of: 20-30 years for mallee and mallee-heath communities as occur in the lower elevation parts of the Stirling Range (Gosper et al. 2013); 10-26 years for the quickest and slowest maturing species in montane communities of the Stirling Range (Barrett and Yates 2015); 15-20 years to commence seed bank accumulation, with the fire-sensitive trees then potentially living for centuries if not burnt, for dominant obligate-seeder trees in the Great Western Woodlands such as *Eucalyptus salubris* (Gosper et al. 2018).

Assessment outcome

Table 14. Number of taxa in each risk categories under Criterion J - Cumulative exposure to high risks

Taxon group	HIGH	MEDIUM	LOW	NONE	Data deficient
EPBC Act	19	25	48	296	947
State listed NSW	64	52	144	143	298
State listed WA	5	3	1	321	106
State listed Vic	48	73	147	155	1348
State listed SA	3	10	52	163	579
State listed Qld	10	9	30	505	381
State listed Tas	2	11	30	110	309
State listed ACT	0	1	2	6	4
NSW endemics	124	101	111	172	812
SA endemics	0	0	4	152	332
WA endemics	46	22	231	2131	6522
Vic endemics	2	0	1	110	295
Qld endemics	2	6	3	1322	2296
Tas endemics	0	0	3	141	399
ACT endemics	0	1	0	3	2
Subalpine taxa	9	16	38	11	339
Rainforest taxa	19	66	47	88	1365
Total	**254**	**296**	**657**	**4332**	**13465**

*Taxa may be shared between taxon groups and the total is the number of unique species across taxon groups which are listed under each risk category

PROPOSED MANAGEMENT ACTIONS

Species assessed HIGH or MEDIUM risk under Criterion J (Table 13) are at specific risk from:

- Future exposure to fires that kill recovering individuals of obligate seeding taxa from previous fires. Specifically, plants will be considered immature if they were burnt in 2019-2020 or anywhere across the range of the taxa in the last 5 years for non woody species, 15 years for woody species or 50 years for long-lived trees.
- The cumulative risk of fire across the range and through time.

Note that of the 11 taxa listed exclusively under Criteria J in this prioritization, three (*Aldrovanda vesiculosa, Caesalpinia bonduc, Centranthera cochinchinensis*) were removed from consideration as very high priorities for immediate actions as most of their range falls outside the PAA in northern Australia.

Immediate actions

Field inspections to assess seedling emergence: For obligate seeding species, inspections to quantify seedling emergence and survival.

Germplasm collection: during field inspections, germplasm collection of seeds and/or cuttings for species at immediate risk of local extinction should be conducted to preserve the species in ex-situ cultivation and allow for reintroduction.

Forestry impacts: Enforcement of buffers and use of education and liaison to minimise any damage of logging activities to post-fire recovery.

Alleviate herbivory: exclusion or removal of feral grazers, stock and excessive native herbivores by fencing and feral animal control.

Medium-term actions

Exclude prescribed fire: prescribed burning should be excluded from sites burnt in the last 5 years for non-woody taxa; the last 15 years for woody taxa; or the last 50 years for species which are killed by fire or are long-lived and prone to basal charring.

Rapid response to wildfire: ensure that any future wildfires that threaten to burn over recovering sites are rapidly extinguished.

Weed control: Removal and control of weeds that may outcompete natives and impede post-fire recovery.

Carefully planned translocation: adding of seed or individual plants propagated ex-situ to populations where recovery is absent or inadequate to allow for species to avoid long-term decline. Requires an independent assessment of feasibility and likelihood of success.

Ongoing actions

Prevent illegal collecting or over-collecting of germplasm or plants: minimise illegal losses via education, fencing, surveillance and enforcement.

Habitat disturbance from human activities: Exclusion of vehicles, bikes and other human disturbance via signage, fencing and negotiations with local users. Prevention of further disturbance via fencing, liaison with relevant utility owners and land managers, and education activities.

Minimise mining impacts: consideration of bushfire recovery in planning, assessment and enforcement.

CRITERION K. Other plausible threats or expert-driven nomination

Other plausible threats not addressed by A-J above may arise and this criterion is designed to capture their effects on species impacted by the 2019-2020 fires. Taxa identified as having had

approximately 50% or more of their range burned and other known threats by state agencies have been included under this criterion.

1) *HIGH* – Evidence or likelihood that species has been significantly impacted by one or more plausible threats not addressed by A-J above AND ≥ 50% of known sites or habitat burnt in the 2019-2020 fires.
2) *MEDIUM* – Evidence or likelihood that species has been significantly impacted by one or more plausible threats not addressed by A-J above AND ≥ 30 to < 50% of known sites or habitat burnt in the 2019-2020 fires.
3) *LOW* – Evidence or likelihood that species has been significantly impacted by one or more plausible threats not addressed by A-J above AND > 0 to < 30% of known sites or habitat burnt in the 2019-2020 fires.
4) *NONE* – Either:
    a) No known sites or habitat burnt in the 2019-2020 fires; OR
    b) No evidence or likelihood that species has been impacted by any plausible threats not addressed by A-J above.

Assessment outcome

35 taxa from across Australia have been provisionally listed under Criteria K due to documented fire impacts from field inspections or local knowledge of state agencies. All taxa are assessed to be HIGH risk.

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APPENDICES

Appendix 1. Framework for prioritising impact assessments for plants following the 2019-2020 bushfires

Tony D Auld, David A Keith, Berin DE Mackenzie, Mark KJ Ooi, Tom Le Breton, Rachael V Gallagher

Version 2.1, 20th March 2020

Intended application

The purpose of this framework is to identify plant species at the greatest potential risk of population declines or local extinctions following the 2019-2020 bushfires and to prioritise such species for field impact assessments and actions. Data obtained during field assessments on the extent of any impacts can then be used to determine what, if any, further actions or interventions are required to recover particular species and whether their risk prioritisation should change.

It is intended that the criteria can be applied to all plant species affected by the 2019-2020 fires, including threatened plants, rare or restricted species, state or territory endemics that are listed in a particular jurisdiction but are not listed nationally. Application should initially be at a national scale to capture the relative impacts of the fires on the species.

Conceptual basis

This framework targets species' life-history traits that make plant species prone to population declines or local extinctions if they occur within the spatial footprint of 2019-2020 bushfires. The identification of species potentially at risk as a result of these fires involves three components:

1. Identifying potential mechanisms of decline, i.e. factors (A-J) below and their interactions;
2. Identifying where in the landscape these mechanisms are most likely to have an impact; and
3. Identifying the species and ecological communities most exposed to risks associated with these mechanisms.

Risk groups

Priorities for field inspections, monitoring and conservation action may be guided by a simple categorisation of impact:

- *HIGH* – Very likely at risk. Require an urgent assessment of initial impacts and post-fire monitoring of recovery where impacts are significant.

- *MEDIUM* – Likely to be at risk. Assessment of initial impacts and post-fire monitoring are recommended.
- *LOW* – Unlikely to be at risk. Post-fire monitoring may be conducted opportunistically during sites visits or by other groups (externals, universities, citizen science)
- *NONE* – Not burnt in the 2019-2020 fires or not expected to be at risk.

Possible: could add VERY HIGH at $\geq$ 70% throughout

Risk categorisation framework

Species can be assessed against the following set of criteria which are structured around the most significant mechanisms likely to drive plant population decline and extinction in relation to fire. These mechanisms include:

A. Interactive effects of fire and drought
B. Short fire intervals (impacts of high fire frequency)
C. Post-fire herbivore impacts
D. Fire-disease interactions
E. High fire severity
F. Weed invasion
G. Elevated winter temperatures or changed temperature regimes
H. Fire sensitivity
I. Post-fire erosion
J. Cumulative exposure to high risks

The highest risk ranking obtained via any single criterion is determined to be the overall risk ranking as the risk mechanisms may operate independently or interact in complex ways, and hence the criteria are not additive. Species should be assessed against all criteria where possible.

Mechanisms of impact and assessment criteria

A. Interactive effects of fire and drought

Pre-fire drought can: i) reduce internally stored resources of resprouter plants that are critical in sustaining post-fire regeneration; and ii) reduce pre-fire reproductive output, impacting on the size of the seed bank available for post-fire recruitment.

Post-fire drought can negatively impact post-fire recruitment success by reducing seed germination (due to insufficient soil moisture; possibly causing seed mortality in some dormancy types), seedling survival (through desiccation) and survival of resprouts (through xylem embolism in susceptible new shoots). Risks to mortality may be large if drought occurs in the first autumn-winter after fire or the following spring-summer.

5) *HIGH* – Species with $\geq$ 50% known sites or habitat burnt in the 2019-2020 fires AND evidence or likelihood of either:
    c) Significant pre-fire drought; OR
    d) Incidence of post-fire drought within 18 months of the 2019-2020 fires.
6) *MEDIUM* – Species with $\geq$ 30 to < 50% known sites or habitat burnt in the 2019-2020 fires AND evidence or likelihood of either:

c) Significant pre-fire drought; OR
d) Incidence of post-fire drought within 18 months of the 2019-2020 fires.

7) *LOW* – Species with > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires AND evidence or likelihood of either:
    c) Significant pre-fire drought; OR
    d) Incidence of post-fire drought within 18 months of the 2019-2020 fires.
8) *NONE* – Either:
    c) No known sites or habitat burnt in the 2019-2020 fires; OR
    d) No evidence or likelihood of pre- or post-fire drought impacts in any known sites or habitat.

B. Short fire intervals (impacts of high fire frequency)

Exposure to short temporal intervals between successive fires can disrupt the replenishment of seed banks which are essential to post-fire recruitment and population persistence. Species most susceptible include obligate seeders (species that lack regenerative organs and rely entirely on seed germination for post-fire recovery) and resprouters (species with the capacity to generate new shoots from dormant buds post-fire) that suffer high mortality rates. The time required to replenish seed banks post-fire varies. For most species, up to 15 years between successive fires is needed to ensure that a seed bank is sufficiently replenished to maintain future post-fire populations, although some trees (for example) may require longer fire-free periods.

Short intervals between fires may also kill juveniles of resprouting plants before they become large enough to survive subsequent fires. The species that are most susceptible to these risks are resprouters that are slow to develop regenerative structures (i.e. lignotubers, thick bark, rhizomes etc.) or slow to replace mortality due to low fecundity. At least 15 years between successive fires is needed to ensure the juveniles of most plant species can develop their fire-regenerative organs, although some species such as mallee eucalypts may require at least 25 years.

Finally, some long-lived trees may suffer basal scarring where fires (or other factors related to fires such as falling trees or limbs) damage and/or kill bark tissue. This enables subsequent fires to smoulder into heartwood and weaken the structural integrity of the tree, causing mortality, collapse and structural change to the ecosystem. Trees with thin bark are most prone to this impact and replacement depends on fecundity and growth rates. Many rainforest trees and some eucalypts are susceptible and are likely to require at least 50 years between successive fires to enable partial recovery and replacement.

1) *HIGH* – ≥ 25% known sites or habitat both:
    a) burnt in 2019-2020 AND
    b) experienced ≥ 1 fire(s) within either:
        i) the past 5 years for non-woody species; OR
        ii) the past 15 years for woody species (excluding long-lived trees prone to collapse from basal charring); OR
        iii) the past 50 years for long-lived trees prone to collapse from basal charring.
2) *MEDIUM* – ≥ 10% to < 25% known sites or habitat both:
    a) burnt in 2019-2020 AND
    b) experienced ≥ 1 fire(s) within either:
        i) the past 5 years for non-woody species; OR

ii) the past 15 years for woody species (excluding long-lived trees prone to collapse from basal charring); OR

iii) the past 50 years for long-lived trees prone to collapse from basal charring.

3) *LOW* – > 0% to < 10% known sites or habitat both:
   a) burnt in 2019-2020 AND
   b) experienced ≥ 1 fire(s) within either:
      i) the past 5 years for non-woody species; OR
      ii) the past 15 years for woody species (excluding long-lived trees prone to collapse from basal charring); OR
      iii) the past 50 years for long-lived trees prone to collapse from basal charring.
4) *NONE* – Either:
   e. No known sites or habitat burnt in the 2019-2020 fires
   f. Non-woody species with none of the known sites or habitat burnt in the 2019-2020 fires also burnt by one or more previous fires in the past 5 years; OR
   g. Woody species (excluding long-lived trees prone to collapse from basal charring) with none of the known sites or habitat burnt in the 2019-2020 fires also burnt by one or more previous fires in the past 15 years; OR
   h. Long-lived trees prone to collapse from basal charring with none of the known sites or habitat burnt in the 2019-2020 fires also burnt by one or more previous fires in the past 50 years.

C. Post-fire herbivore impacts

Plants are often at their most palatable and least resilient to herbivore activity (e.g. leaf and shoot removal, trampling and substrate degradation) in the post-fire environment where herbivores have enhanced foraging efficiency and converge on regenerating burnt areas to exploit fresh growth. Concentrations of herbivores may therefore increase mortality of both seedlings and resprouters of palatable plants. In some cases, elevated mortality may lead to local extinction. Effects may be exacerbated when burnt patches are small or have high perimeter to area ratios which promote herbivore incursions in high densities.

4) *HIGH* – Evidence or likelihood of significant post-fire grazing impacts AND ≥ 50% known sites or habitat burnt in the 2019-2020 fires.
5) *MEDIUM* – Evidence or likelihood of significant post-fire grazing impacts AND obligate seeder with ≥ 30 to < 50% known sites or habitat burnt in the 2019-2020 fires.
6) *LOW* – Evidence or likelihood of significant post-fire grazing impacts AND either:
   c) Obligate seeder with > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires; OR
   d) Resprouter with > 0 to < 50% known sites or habitat burnt in the 2019-2020 fires.
5) *NONE* – Either:
   c) No known sites or habitat burnt in the 2019-2020 fires; OR
   d) No evidence or likelihood of significant post-fire grazing impacts in any known sites or habitat.

D. Fire-disease interactions

Plant species from particular genera and families are susceptible to diseases such as *Phytophthora* spp., *Armillaria* spp., Myrtle Rust, Canker fungi and other pathogens. Tissue death caused by these diseases reduces the capacity of plants to acquire resources through their roots and/or leaves. Plants are more sensitive to resource deprivation in the post-fire period and reduced post-fire survival rates have been observed in areas infected by disease, such that fire accelerates disease-related population decline. Resprouting individuals in certain families appear most susceptible to this threat. Disease effects may be exacerbated by drought.

5) *HIGH* – Evidence or likelihood of significant pathogen/disease susceptibility AND $\geq$ 50% known sites or habitat burnt in the 2019-2020 fires.
6) *MEDIUM* – Evidence or likelihood of significant pathogen/disease susceptibility AND $\geq$ 30 to < 50% known sites or habitat burnt in the 2019-2020 fires.
7) *LOW* – Evidence or likelihood of significant pathogen/disease susceptibility AND > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires.
8) *NONE* – Either:
    a) No known sites or habitat burnt in the 2019-2020 fires; OR
    b) No evidence or likelihood of pathogen/disease susceptibility

E. High fire severity

In some plant species, survival of established individuals and/or seed banks may be sensitive to fire severity due to limitations in the insulating capacity of protective tissues (thickness of bark or walls of serotinous fruits). Species that rely on persistence of long-lived standing plants (due to low fecundity) or post-fire regeneration from small serotinous fruits are most susceptible to this mechanism of decline. For long-lived trees, these effects may be cumulative through successive fires (high fire frequency – see B above) that undermine their structural integrity. In such cases, fire severity impacts may be influenced by prolonged basal and internal smouldering rather than canopy consumption (as commonly reflected in fire severity maps). Effects may be exacerbated by drought reducing water content within insulating tissues prior to fires.

5) *HIGH* – Survival of standing plants and/or seed bank is known or suspected to be sensitive to high fire severity AND $\geq$ 50% of known sites or habitat burnt in the 2019-2020 fires at high severity (i.e. fire likely to cause death or serious damage and recovery is not certain).
6) *MEDIUM* – Survival of standing plants and/or seed bank is known or suspected to be sensitive to high fire severity AND $\geq$ 30 to < 50% of known sites or habitat burnt in 2019-2020 fires at high severity.
7) *LOW* – Survival of standing plants and/or seed bank is known or suspected to be sensitive to high fire severity AND > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires at high severity.
8) *NONE* – Either:
    a) No known sites or habitat burnt at high severity in the 2019-2020 fires; OR
    b) Survival of standing plants and/or seed bank is largely unaffected by fire severity.

F. Weed invasion

Some sites are predisposed to invasion by transformer exotic plants. Fire may provide opportunities for growth of existing exotics or entry of these species into the vegetation (especially where weed sources are within or proximal to burnt areas) and subsequent elimination of native species through competition. Native species that occur mainly in areas where bushland has been fragmented, disturbed by logging or clearing, or affected by runoff from nutrient sources (e.g. urban infrastructure, improved pasture, wastewater or stormwater disposal etc.) are most susceptible to this mechanism, and these factors should be considered in assessing the likelihood of weed impacts below.

5) *HIGH* – Evidence or likelihood of significant weed impacts post-fire AND $\geq$ 50% known sites or habitat burnt in the 2019-2020 fires.
6) *MEDIUM* – Evidence or likelihood of significant weed impacts post-fire AND $\geq$ 30 to < 50% known sites or habitat burnt in the 2019-2020 fires.
7) *LOW* – Evidence or likelihood of significant weed impacts post-fire AND > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires.
8) *NONE* – Either:
    c) No known sites or habitat burnt in the 2019-2020 fires OR
    d) No evidence or likelihood of significant weed impacts post-fire in any known sites or habitat.

G. Elevated winter temperatures or changed temperature regimes

Seed germination of some plants in alpine and subalpine (or frost-hollow) habitats is reliant on cold stratification during winter. Alpine plant phenology is also affected by temperature. If the 2020 winter is warm, seedling regeneration may be reduced with flow-on effects on seed bank replenishment. Species with short-lived standing plants and/or short-lived seed banks are likely to be most susceptible. Enhanced insolation of fire-blackened soils may exacerbate climatic warming effects. For other species diurnal temperature cycles cue germination and changes to these cycles may delay or reduce germination.

5) *HIGH* – Cold stratification known or suspected to be needed for successful seedling recruitment post-fire AND with $\geq$ 50% known sites or habitat burnt in the 2019-2020 fires.
6) *MEDIUM* – Cold stratification known or suspected to be needed for successful seedling recruitment post-fire AND obligate seeder with $\geq$ 30 to < 50% known sites or habitat burnt in the 2019-2020 fires.
7) *LOW* – Cold stratification known or suspected to be needed for successful seedling recruitment post-fire AND either:
    c) Obligate seeder with > 0 to < 30% known sites or habitat burnt in the 2019-2020 fires; OR
    d) Resprouter with > 0 to < 50% known sites or habitat burnt in the 2019-2020 fires.
8) *NONE* – Either:
    c) No known sites or habitat burnt in the 2019-2020 fires; OR
    d) No evidence that cold stratification is needed for successful seedling recruitment post-fire.

H. Fire sensitivity

Some plant species have no means of *in situ* persistence through fire events because their standing plants lack protected regenerative organs and there is no seed bank. A single fire may eliminate such species or damage a significant proportion of individuals in the population, which must then rely entirely on dispersal from unburnt populations for re-establishment in the area.

5) *HIGH* – ≥ 50% of known sites or habitat burnt in the 2019-2020 fires AND species is either:
    a) A long-lived tree prone to collapse from basal charring; OR
    b) Not a long-lived tree prone to collapse from basal charring AND cannot resprout AND has no seed bank
6) *MEDIUM* – ≥ 30 to < 50% of known sites or habitat burnt in the 2019-2020 fires AND species is either:
    a) A long-lived tree prone to collapse from basal charring; OR
    b) Not a long-lived tree prone to collapse from basal charring AND cannot resprout AND has no seed bank
7) *LOW* – > 0 to < 30% of known sites or habitat burnt in the 2019-2020 fires AND species is either:
    a) A long-lived tree prone to collapse from basal charring; OR
    b) Not a long-lived tree prone to collapse from basal charring AND cannot resprout AND has no seed bank
8) *NONE* – Either:
    c) No known sites or habitat burnt in the 2019-2020 fires; OR
    d) Species is not a long-lived tree prone to collapse from basal charring AND either:
        iii) Can resprout; OR
        iv) Has a seed bank.

I. Post-fire erosion

Intense rainfall events after fires may lead to extensive localised erosion that either covers recovering plants in soil and ash or depletes soil seed banks. In steep terrain, post-fire erosion may dislodge rocks and trees or cause larger scale landslides with associated pant mortality. Effects are likely to be localised and evident in the first few months after a fire. Steep habitats, riparian habitats, peaty habitats and unconsolidated floodplains or sandplains would seem to be potentially vulnerable to erosion.

5) *HIGH* – Evidence or likelihood that species has been impacted by severe post-fire soil erosion leading to mortality of individuals or depletion of soil seed banks AND ≥ 50% of known sites or habitat burnt in the 2019-2020 fires.
6) *MEDIUM* – Evidence or likelihood that species has been impacted by severe post-fire soil erosion leading to mortality of individuals or depletion of soil seed banks AND ≥ 30 to < 50% of known sites or habitat burnt in the 2019-2020 fires.
7) *LOW* – Evidence or likelihood that species has been impacted by severe post-fire soil erosion leading to mortality of individuals or depletion of soil seed banks AND > 0 to < 30% of known sites or habitat burnt in the 2019-2020 fires.
8) *NONE* – Either:
    c) No known sites or habitat burnt in the 2019-2020 fires; OR

d) No evidence or likelihood that species has been impacted by severe post-fire soil erosion.

J. Cumulative exposure to high risks

Loss of all mature plants in a species exposes it to risks associated with recruiting new plants to replace those lost. Where fire causes such losses in obligate seeding species, risks include stochastic events, failure or limited successful recruitment of new plants (e.g. through grazing, weed, pathogen and drought impacts). This criterion addresses where the current 2019-2020 fires have exposed obligate seeding species to having significant proportions of their entire known populations as immature plants, as cumulatively the current fires have added to previous fires in other locations that have eliminated all mature plants. Species with canopy seed banks are most at risk as these can be completely exhausted after a single fire event. Species with soil seed banks may have more resilience but there may still be little to no seed bank remaining after a fire in some cases.

5) *HIGH* – Obligate seeder with > 0% known sites or habitat burnt in the 2019-2020 fires AND with $\geq$ 50% of known sites or habitat comprising immature plants, based on the sum of: a) known sites or habitat that have experienced fires prior to the 2019-2020 fires where recruiting plants are not yet mature AND b) known sites or habitat burnt in the 2019-2020 fires.
6) *MEDIUM* – Obligate seeder with > 0% known sites or habitat burnt in the 2019-2020 fires AND $\geq$ 30 to < 50% of known sites or habitat comprising immature plants, based on the sum of: a) known sites or habitat that have experienced fires prior to the 2019-2020 fires where recruiting plants are not yet mature; AND b) known sites or habitat burnt in the 2019-2020 fires.
7) *LOW* – Obligate seeder with > 0% known sites or habitat burnt in the 2019-2020 fires AND with > 0 to < 30% of known sites or habitat comprising immature plants, based on the sum of: a) known sites or habitat that have experienced fires prior to the 2019-2020 fires where recruiting plants are not yet mature; AND b) known sites or habitat burnt in the 2019-2020 fires.
8) *NONE* – Either:
    b) Obligate seeders with no known sites or habitat burnt in the 2019-2020 fires; OR
    c) Obligate seeders with no known sites or habitat comprising immature plants as a result of fires prior to the 2019-2020 fires.

K. Other plausible threats or expert-driven nomination

Other plausible threats not addressed by A-J above may arise and this criterion is designed to capture their effects on species impacted by the 2019-2020 fires. Taxa identified as having had approximately 50% or more of their range burned and other known threats by state agencies have been included under this criterion.

HIGH – Evidence or likelihood that species has been significantly impacted by one or more plausible threats not addressed by A-J above AND $\geq$ 50% of known sites or habitat burnt in the 2019-2020 fires.

5) *MEDIUM* – Evidence or likelihood that species has been significantly impacted by one or more plausible threats not addressed by A-J above AND ≥ 30 to < 50% of known sites or habitat burnt in the 2019-2020 fires.
6) *LOW* – Evidence or likelihood that species has been significantly impacted by one or more plausible threats not addressed by A-J above AND > 0 to < 30% of known sites or habitat burnt in the 2019-2020 fires.
7) *NONE* – Either:
    c) No known sites or habitat burnt in the 2019-2020 fires; OR
    d) No evidence or likelihood that species has been impacted by any plausible threats not addressed by A-J above.

Appendix 2. INTERIM_ASSESSMENT_Ver1_3.xls.

Appendix 3. Column names and explanations for Appendix 2

Genus	Genera of assessed taxon
Taxon	Taxon name according to the Australian Plant Name Index
EPBC	Taxa listed on the EPBC Act. 0 = no, 1 = yes
BC Act	Taxa listed on the NSW BC Act. 0 = no, 1 = yes
WA state listed	Taxa listed on the WA Biodiversity Conservation Act 2016. 0 = no, 1 = yes
Victoria state listed	Threat status on Flora and Fauna Guarantee Act 1988. 0 = no, 1 = yes
SA state listed	Taxa listed on the SA National Parks and Wildlife Act 1972 0 = no, 1 = yes
Qld state listed	Taxa listed on the QLD Act 0 = no, 1 = yes
ACT state listed	Taxa listed on the Act 0 = no, 1 = yes
Tas state listed	Taxa listed on the Tasmanian Act 1972 0 = no, 1 = yes
Endemic NSW	Endemic to NSW according to Australian Plant Census. 0 = no, 1 = yes
Endemic SA	Endemic to South Australia according to Australian Plant Census. 0 = no, 1 = yes

Endemic WA Endemic to Western Australia according to Australian Plant Census. 0 = no, 1 = yes

Endemic Vic Endemic to Victoria according to Australian Plant Census. 0 = no, 1 = yes

Endemic Tas Endemic to Tasmania according to Australian Plant Census. 0 = no, 1 = yes

Endemic Qld Endemic to Queensland according to Australian Plant Census. 0 = no, 1 = yes

Endemic ACT Endemic to ACT according to Australian Plant Census. 0 = no, 1 = yes

A_ranking Risk ranking under criterion A

B_ranking Risk ranking under criterion B

C_ranking Risk ranking under criterion C

D_ranking Risk ranking under criterion D

E_ranking Risk ranking under criterion E

F_ranking Risk ranking under criterion F

G_ranking Risk ranking under criterion G

H_ranking Risk ranking under criterion H

I_ranking Risk ranking under criterion I

J_ranking Risk ranking under criterion J

K_ranking Risk ranking under criterion K

BC Act status Threat status on the NSW Biodiversity Conservation Act as of March 2020

SA state listing status

Threat status on the SA National Parks and Wildlife Act 1972 as of March 2020

Vic state listing status

Threat status on Flora and Fauna Guarantee Act 1988 as of March 2020

WA state listing status

Threat status on the WA Biodiversity Conservation Act 2016 as of March 2020

In PAA according to AVH occurrences

Flag for presence in PAA using clean AVH occurrence

In PAA according to modelled range

Flag for presence in PAA using modelled range data (either PPPM, range bagging or AOO)

In PAA according to DAWE range maps

Flag for presence in PAA using DAWE regulatory maps

Modelled range area

Size of the range according to models

Modelled range area burnt

Area of range burnt according to intersection with modelled range and NIAFED fire extent data

Modelled proportion of range area burnt

Proportion of range burnt according to intersection with modelled range and NIAFED fire extent data

Number of occurrences AVH

Number of clean AVH occurrence records for the taxon

Number of AVH occurrences burnt

Area of range burnt according to intersection with AVH occurrences and NIAFED fire extent data

Proportion of AVH occurrences burnt

Proportion of range burnt according to intersection with AVH occurrences and NIAFED fire extent data

DAWE range size Size of the range according to models

DAWE range in PAA

Area of range inside the PAA

DAWE range in NIAFED and PAA

Area burnt according to an intersection with DAWE range maps and NIAFED fire extent data

DAWE proportion range burnt

Proportion of range area burnt according to an intersection with DAWE range maps and NIAFED fire extent data

Epicormic regeneration in Eucalyptus on the South Coast of NSW ©Anne Kerle