



Climate risk assessment of potential threatened species for the living plant collections in the Melbourne Gardens, Royal Botanic Gardens Victoria

Dave Kendal, University of Melbourne & University of Tasmania

dave.kendal@utas.edu.au

© Dave Kendal

Clean Air and Urban Landscape hub of the National Environmental Science Program
School of Ecosystem and Forest Sciences, The University of Melbourne
School of Technology, Environments and Design, University of Tasmania

First printed Jan 2018.

This work is joint copyright with the University of Melbourne and the Royal Botanic Gardens Victoria. It may be reproduced in whole or in part for study or training purposes subject to an acknowledgement of the source and no commercial use or sale. Reproduction for other purposes or by other organisations requires the written permission of the copyright holders.

School of Ecosystem and Forest Sciences
The University of Melbourne
500 Yarra Boulevard
VIC 3010 AUSTRALIA
T: +61 3 8344 02

Table of Contents

Table of Contents.....	ii
Executive Summary.....	iii
Project background.....	1
Climate assumptions	1
Threatened species lists analysed	1
Climate analysis	2
Narrow range species.....	3
Results.....	4
Implications and Recommendations for the Melbourne Gardens.....	11

Executive Summary

The Royal Botanic Gardens Victoria (RBGV) has successfully launched their Landscape Succession Strategy 2016 – 2036 (LSS), and recently completed a report on the risk of increasing temperatures to the existing living plant collections. A key opportunity exists for the Melbourne Gardens by continuing to contribute to plant conservation by growing rare and threatened species within the living collection through a changing climate. This project builds on the work of the previous living collection climate risk assessment by identifying threatened plant species that could be suitable for adding to the living collection. Two climate projections were used that included urban heat and climate change in 1) an emissions limited Representative Concentration Pathway (RCP) scenario (RCP4.5) by 2050, and 2) a business as usual climate scenario (RCP8.5) by 2070.

A list of 20,199 threatened species were obtained from the International Union for Conservation of Nature (IUCN) Red List, Australia's national Environment Protection and Biodiversity Conservation (EPBC) Act, Victoria's Flora and Fauna Guarantee (FFG) Act, the Victorian government's Department of Sustainability and Environment (DSE) Advisory List, as well as the statutory lists for all other states and territories. Of these, a total of 12,145 species (60.1%) were able to be assessed. A simple colour coding flag scheme was used to indicate species risk in future climates. For example, a red flag was used to indicate species where Melbourne's temperature projection was warmer than 97.5% of known occurrences of the species.

Many species were identified as potentially well suited (green flagged) to each future climate scenario: 3,322 in the emissions limited scenario and 2,991 in the business as usual scenario. Many species from warmer climates overseas and in Australia were found to be at low risk in future climates. Unsurprisingly, species from cooler climates (such as Tasmania) had relatively few species well suited to future climates. Of the 635 threatened species currently in the living collection, 299 species were identified as at high risk in the business as usual climate scenario (RCP8.5) by 2070.

The information contained in this report and the associated spreadsheet could be used in conjunction with strategic planning to protect existing collections or develop new ones. This may require coordination with other botanic gardens to continue to conserve species at risk in the current living collection by transfer of material to more suitable locations, and to source new species to be conserved in the Melbourne Gardens living collection.

Project background

This report is an addendum to the *Assessment of the climate change risk to the living plant collections in the Melbourne Gardens, Royal Botanic Gardens Victoria* (hereafter living collection assessment) report, and should be read in conjunction with that report to obtain for full details of the methodology used.

The Royal Botanic Gardens Victoria (RBGV) has successfully launched their Landscape Succession Strategy 2016 – 2036 (LSS), and recently completed a report on the temperature risk of the existing living collection. A key opportunity for the Melbourne Gardens is to continue to contribute to plant conservation through the living collection in a changing climate. This project builds on the work of the living collection risk assessment, by identifying threatened plant species that could be suitable for adding to the living collection.

Climate assumptions

The current climate and future climate projections used were the same as the main living collection assessment (Table 1). Historic climate data was obtained from BIOCLIM which has an approximate model of climate from 1950. Current climate was calculated using nearby weather station data which include both urban heat and climate change. Future climate projections were based on published climate maps for 2050 in an ‘emissions limited climate scenario’ (RCP4.5), and 2070 in a ‘business as usual’ climate scenario (RCP8.5). (Note these scenarios were named moderate and extreme respectively in the living collection assessment.) The emissions limited scenario assumes a further 1.7 °C increase in mean annual temperature to 18.0 °C, and the business as usual scenario assumes a further 3.0 °C increase in mean annual temperature to 19.3 °C.

TABLE 1 – CLIMATE AVERAGES FOR MELBOURNE FOR HISTORIC, CURRENT, AND PROJECTED VALUES FOR MODERATE AND EXTREME CLIMATE SCENARIOS.

Variable	Mean annual temp.	Mean max of hottest month	Mean min of coldest month	Annual precip.	Precip. of the driest quarter
Historic values (BIOCLIM: pre 1950)	14.8 °C	26.2 °C	5.7 °C	675 mm/year	137 mm/year
Current values (1995 - 2014)	16.3 °C	27.2 °C	7.5 °C	612 mm/year	133 mm/year
Emissions limited climate future (RCP4.5 at 2050)	18.0 °C	28.9 °C	8.8 °C	687 mm/year	141 mm/year
Business as usual climate future (RCP8.5 at 2070)	19.3 °C	30.8 °C	10.3 °C	613 mm/year	124 mm/year

Threatened species lists analysed

Lists of threatened plants were obtained from the International Union for Conservation of Nature (IUCN) Red List, Australia’s national Environment Protection and Biodiversity Conservation (EPBC) Act, Victoria’s Flora and Fauna Guarantee (FFG) Act, the Victorian government’s Department of Sustainability and Environment

(DSE)¹ Advisory List, as well as the statutory lists for all other states and territories (Table 2). These lists were mainly restricted to vascular plants, although non-vascular plants on the FFG list were included in the analysis. There were consistent categories of Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable and Rare used across the lists, although the specific definition of each category varies from list to list. In Victoria, the FFG Act has a single category of threatened only, which is supplemented by the DSE advisory list with species (including some not listed under the FFG) in different categories. In Western Australia, species can also be included on priority lists (1-4) which include poorly known and near threatened species. For the purposes of this report, the term species refers to taxonomic entities able to be listed, and can include subspecies or populations as defined under the relevant piece of legislation.

Climate analysis

The methods described in the living collection assessment were followed, with the addition of an improved spatial sampling method, and the use of Global Biodiversity Information Facility (GBIF) data only (urban tree inventories were not included as per earlier report). For each species, the GBIF database was searched for occurrence records. GBIF records were aligned with the resolution of the climate data (2.5° arc minutes)², and duplicate records removed. This resulted in a better representation of the spatial extent of the species rather than a bias for species with many occurrence records from one location, or a small area.

For each species, envelopes were calculated for Mean Annual Temperature (BIOCLIM1), and Annual Precipitation (BIOCLIM12). The limits of the temperature and precipitation envelopes were calculated as the 2.5th and 97.5th percentiles of the distributions. For mean annual temperature, additional risk thresholds at the 10th and 20th percentile and 80th and 90th percentile of the distributions were calculated (Fig. 1). These risk levels were colour coded (Table 2).

TABLE 2 – TEMPERATURE RISK COLOUR CODING SCHEME.

Rating	Metric	Description
Green	Melbourne's temperature is within the middle 80% of all the climates at all locations where the species occurs (i.e. Melbourne's temperature is between the 20 th percentile and the 80 th percentile)	Species is not considered vulnerable in this temperature scenario
Yellow	Melbourne is warmer than 80% of locations where the species occurs (i.e. Melbourne's temperature is between the 80 th percentile and 90 th percentile)	The species is slightly vulnerable in this temperature scenario
Orange	Melbourne is warmer than 90% of the locations where this species is found (i.e. Melbourne's temperature is between the 90 th percentile and 97.5 th percentile)	The species is moderately vulnerable in this temperature scenario
Red	Melbourne is warmer than 97.5% of the locations where this species is found (i.e. Melbourne temperature is greater than the 97.5 th percentile)	The species is very vulnerable in this temperature scenario
Aqua	Melbourne is colder than 80 - 90% of locations where this species is found. (i.e. Melbourne temperature is between the 20 th percentile and 10 th percentile)	The species is slightly vulnerable in this temperature scenario
Blue	Melbourne is colder than 90% of the locations where this species is found (i.e. Melbourne's temperature is between the 10 th percentile and 2.5 th percentile)	The species is moderately vulnerable in this temperature scenario
Purple	Melbourne is colder than 97.5% of the locations where this species is found (i.e. Melbourne's temperature is lower than the 2.5 th percentile)	The species is very vulnerable in this temperature scenario

¹ Former department of Victorian State Government.

² 2.5 arc minutes of a longitude/latitude degree equals about 21 km² spatial resolution at the equator.

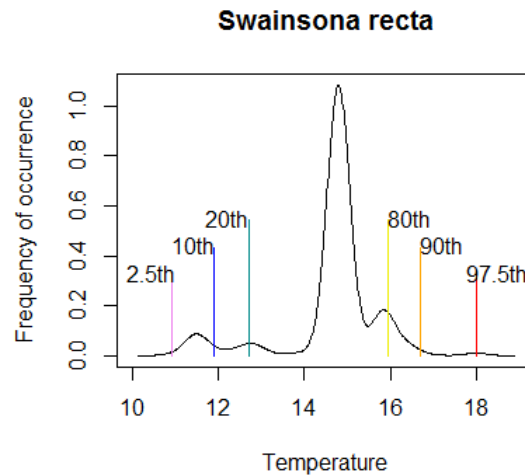


FIG 1 – TEMPERATURE RISK THRESHOLDS USED IN THE ANALYSIS.

Narrow range species

Many of the species in this analysis have relatively few GBIF records. In the living collection assessment, risk thresholds for minimum temperature envelopes were calculated based on the mean values for species with many GBIF records. The method was improved from the previous living collection assessment in this study. First, the potential error in the calculation of mean temperature was determined for species with different numbers of GBIF points. Twenty species were randomly selected, and the mean temperature of a random subsample of 1-100 GBIF points (using 999 permutations) was calculated. The difference in this calculated mean was compared with the mean of all data for each species (Fig 2). This shows that species with fewer than 3 GBIF records have very large errors in their mean calculations. In response to this, only species with at least 3 GBIF records were retained in the analysis, and minimum temperature envelope widths were adjusted based on the number of GBIF records (Table 3). This is a conservative approach that is less likely to identify more risky species as being suitable in future climates.

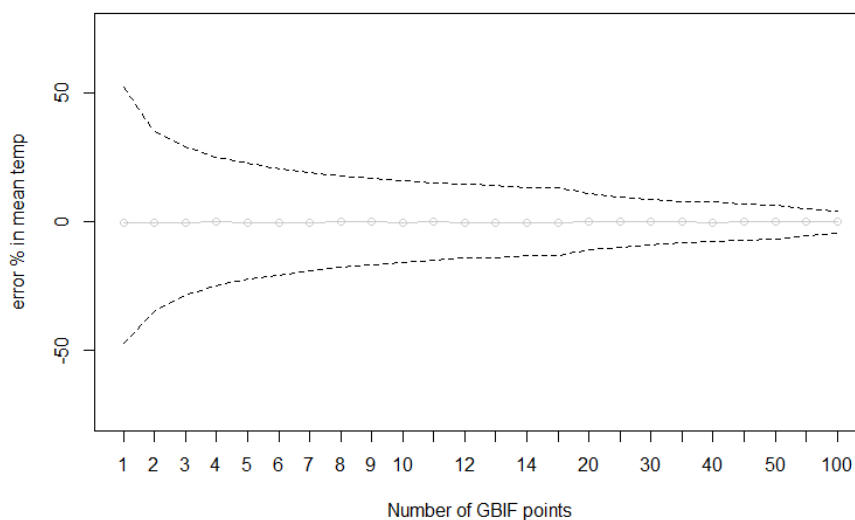


FIG 2 – ERROR IN CALCULATION OF TEMPERATURE MEANS IN SPECIES WITH A SMALL NUMBER OF GBIF POINTS. THE 97.5TH AND 2.5TH PERCENTILES OF THE ERROR ARE SHOWN AS DASHED LINES.

TABLE 3 – ADJUSTMENT TO MINIMUM TEMPERATURE ENVELOPES BASED ON NUMBER OF GBIF RECORDS.

	2.5 TH	10 TH	20 TH	MEDIAN	80 TH	90 TH	97.5 TH	% REDUCTION
>500 GBIF Records	-3.8	-2.4	-1.6	0.0	1.5	2.3	3.5	0.0%
75-500 GBIF Records	-3.7	-2.4	-1.5	0.0	1.5	2.3	3.4	2.5%
25-75 GBIF Records	-3.5	-2.2	-1.4	0.0	1.4	2.1	3.2	7.5%
12-24 GBIF Records	-3.3	-2.1	-1.4	0.0	1.3	2.0	3.1	12.5%
6-11 GBIF Records	-3.1	-2.0	-1.3	0.0	1.3	1.9	2.9	17.5%
3-5 GBIF Records	-2.8	-1.8	-1.2	0.0	1.1	1.7	2.6	25.0%
<3 GBIF Records	Not analysed							

Results

In total, 20,199 unique species were identified across the lists (note some species were found on more than one list). Of these, 635 already occur in the Melbourne Garden’s living collection. A total of 12,145 species (60.1%) were able to be assessed, having at least 3 distinct records in the GBIF database. 3,388 of these species considered to have high quality data with at least 30 GBIF points. The living collection of the Melbourne Gardens contains species representing all threatened species lists. A number plants listed as Extinct are also on the living collection list, such as *Persoonia prostrata* which is listed as Extinct under the EPBC Act. Further analysis of the living collection data and specimens in the Melbourne Gardens are required to confirm the status of these species.

The climate risk assessment of these species under different climate scenarios (Tables 4-8 & Figs 3-4) shows that 3,322 species are at low risk (green flagged) in the Melbourne Garden’s emissions limited climate scenario and 2,991 are at low risk in the business as usual scenario. Unsurprisingly, in scenarios where higher temperatures are predicted, fewer species from colder areas (such as Tasmania) and more species from warmer areas (such as Western Australia, New South Wales and Queensland) are well matched to future climates.

TABLE 4 – NUMBER OF THREATENED SPECIES GREEN FLAGGED UNDER EACH CLIMATE SCENARIO

	Current scenario	Emissions limited (RCP4.5)	Business-as-usual (RCP8.5)
<i>All Species</i>	3753	3322	2991
<i>IUCN</i>	1442	1566	1553
<i>EPBC</i>	407	382	300
<i>Vic FFG</i>	86	63	52
<i>Vic DSE</i>	584	401	283
<i>NSW</i>	217	220	146
<i>ACT</i>	0	0	0
<i>Qld</i>	77	186	268
<i>NT</i>	6	6	14
<i>WA</i>	1174	905	716
<i>SA</i>	328	153	109
<i>Tas</i>	113	32	12

TABLE 5 - SUMMARY OF THE NUMBER OF THREATENED SPECIES ASSESSED

		Total species	In Melbourne Gardens living collection	Assessed (GBIF>=3)	GBIF>=75	Not assessed
	ALL SPECIES	20199	635	12145	3388	8054
IUCN	Critically Endangered	2637	20	736	33	1901
	Endangered	3921	63	2066	174	1855
	Extinct in the wild	35	6	20	7	15
	Extinct	116	0	17	1	99
	Vulnerable	5544	76	3077	456	2467
	IUCN total	12253	165	5916	671	6337
EPBC	Critically Endangered	143	6	98	5	45
	Endangered	524	26	456	81	68
	Extinct	37	1	22	4	15
	Vulnerable	588	48	551	167	37
	EPBC total	1292	81	1127	257	165
FFG	FFG total	376	69	340	205	36
DSE advisory list	Endangered	369	40	292	194	77
	Poorly known	318	10	247	196	71
	Rare	857	134	781	652	76
	Vulnerable	518	83	457	343	61
	Presumed extinct	43	2	32	24	11
	DSE total	2105	269	1809	1409	296
NSW	Critically Endangered	58	4	39	7	19
	Endangered	333	23	302	161	31
	Presumed Extinct	33	3	25	19	8
	Vulnerable	230	17	219	107	11
	NSW total	654	47	585	294	69
ACT	ACT total	6	0	6	1	0
QLD	Endangered	225	6	178	37	47
	Vulnerable	484	16	433	99	51
	QLD total	709	22	611	136	98
NT	Critically endangered	4		2	1	1
	Endangered	31	3	21	13	3
	(Listed nationally)	10		7	3	1
	Vulnerable	65	3	44	19	10
	NT total	89	6	74	36	15
WA	Priority 1	1041	6	514	126	527
	Priority 2	805	10	501	66	304
	Priority 3	940	6	780	105	160
	Priority 4	359	6	325	43	34
	Critically Endangered	158	3	117	2	41
	Endangered	131	2	110	3	21
	Presumed Extinct	15		4	0	11
	Vulnerable	135	2	111	2	24
	WA total	3584	35	2462	347	1122
SA	Endangered	188	26	174	112	14
	Rare	440	40	419	341	21
	Vulnerable	196	20	185	138	11
	SA total	824	86	778	591	46
Tas	Endangered	135	14	118	65	17
	Rare	233	30	225	191	8
	Vulnerable	71	15	64	53	7
	Presumed Extinct	19	1	17	15	2
	Tas total	458	60	424	324	34

TABLE 6 – SUMMARY OF SPECIES ASSESSMENTS UNDER CURRENT TEMPERATURES

		Purple	Blue	Aqua	Green	Yellow	Orange	Red
	ALL SPECIES	3791	1289	895	3753	587	635	1195
IUCN	Critically Endangered	332	72	54	189	18	12	59
	Endangered	893	247	166	527	68	47	118
	Extinct in the wild	3	2	1	9	3	0	2
	Extinct	4	3	0	4	1	1	4
	Vulnerable	1503	318	187	713	108	79	169
	IUCN total	2735	642	408	1442	198	139	352
EPBC	Critically Endangered	6	9	6	28	7	7	35
	Endangered	34	55	57	189	41	35	45
	Extinct	4	2	1	10	1	2	2
	Vulnerable	93	66	54	180	39	43	76
	EPBC total	137	132	118	407	88	87	158
FFG	FFG total	15	14	15	86	34	79	97
DSE advisory list	Endangered	24	21	18	83	29	60	57
	Poorly known	5	13	17	86	12	49	65
	Rare	10	19	10	246	64	115	317
	Vulnerable	23	19	19	150	41	74	131
	Presumed extinct	0	1	2	19	0	3	7
	DSE total	62	73	66	584	146	301	577
NSW	Critically Endangered	1		3	15	2	6	12
	Endangered	45	39	29	109	21	29	30
	Presumed Extinct	9	2	3	8	1	1	1
	Vulnerable	3	19	24	85	21	25	42
	NSW total	58	60	59	217	45	61	85
ACT	ACT (endangered) total	0	0	0	0	1	1	4
QLD	Endangered	75	66	13	16	7		1
	Vulnerable	205	114	42	61	7	3	1
	QLD total	280	180	55	77	14	3	2
NT	Critically endangered	1	1	0	0	0	0	0
	Endangered	15	3	1	1	1	0	0
	(Listed nationally)	6	1	0	0	0	0	0
	Vulnerable	34	4	1	5	0	0	0
	NT total	56	9	2	6	1	0	0
WA	Priority 1	227	73	45	163	3	3	0
	Priority 2	95	59	55	254	28	7	3
	Priority 3	205	121	98	342	10	1	3
	Priority 4	28	28	41	211	14	3	0
	Critically Endangered	2	14	28	61	12	0	0
	Endangered	2	17	21	62	7	1	0
	Presumed Extinct	0	0	0	4	0	0	0
	Vulnerable	3	9	20	77	2	0	0
	WA total	562	321	308	1174	76	15	6
SA	Endangered	2	2	3	70	34	44	19
	Rare	46	22	19	186	61	68	17
	Vulnerable	14	10	11	72	22	41	15
	SA total	62	34	33	328	117	153	51
Tas	Endangered	0	0	1	26	14	18	59
	Rare	0	0	0	62	35	46	82
	Vulnerable	0	0	0	17	4	12	31
	Presumed Extinct	0	0	0	8	4	0	5
	Tas total	0	0	1	113	57	76	177

TABLE 7 – SUMMARY OF SPECIES ASSESSMENTS UNDER THE EMISSIONS LIMITED SCENARIO (RCP4.5) BY 2050

		Purple	Blue	Aqua	Green	Yellow	Orange	Red
	ALL SPECIES	2768	1036	806	3322	995	1043	2175
IUCN	Critically Endangered	246	80	61	210	22	34	83
	Endangered	646	260	162	594	94	105	205
	Extinct in the wild	2	1	2	8	3	1	3
	Extinct	3	1	2	3	1	1	6
	Vulnerable	1185	337	212	751	153	144	295
	IUCN total	2082	679	439	1566	273	285	592
EPBC	Critically Endangered	3	3	5	25	4	10	48
	Endangered	21	11	17	180	55	61	111
	Extinct	3	2	1	6	3	3	4
	Vulnerable	48	51	31	171	41	60	149
	EPBC total	75	67	54	382	103	134	312
FFG	FFG total	0	9	15	63	22	27	204
DSE advisory list	Endangered	0	16	21	68	22	26	139
	Poorly known	2	2	7	72	26	28	110
	Rare	0	3	9	147	63	98	461
	Vulnerable	1	7	24	101	39	54	231
	Presumed extinct	0			13	3	4	12
	DSE total	3	28	61	401	153	210	953
NSW	Critically Endangered	0	0	1	13	2	3	20
	Endangered	21	22	22	111	23	31	72
	Presumed Extinct	4	3	5	5	2	4	2
	Vulnerable	1	1	7	91	18	24	77
	NSW total	26	26	35	220	45	62	171
ACT	ACT (endangered) total	0	0	0	0	0	1	5
QLD	Endangered	41	36	37	51	6	1	6
	Vulnerable	134	82	63	135	5	4	10
	QLD total	175	118	100	186	11	5	16
NT	Critically endangered	1	1	0	0	0	0	0
	Endangered	12	4	1	3	0	1	0
	(Listed nationally)	2	3	2	0	0	0	0
	Vulnerable	28	7	3	3	3	0	0
	NT total	43	15	6	6	3	1	0
WA	Priority 1	188	41	37	155	60	28	5
	Priority 2	77	18	33	165	97	67	44
	Priority 3	139	70	60	287	131	77	16
	Priority 4	18	10	18	120	74	70	15
	Critically Endangered	1	1	1	71	11	19	13
	Endangered	1	0	6	56	16	21	10
	Presumed Extinct	0	0	0	0	1	3	0
	Vulnerable	1	2	5	51	31	19	2
	WA total	425	142	160	905	421	304	105
SA	Endangered	1	1	2	20	28	42	80
	Rare	10	33	15	92	59	97	113
	Vulnerable	4	9	5	41	22	36	68
	SA total	15	43	22	153	109	175	261
Tas	Endangered	0	0	0	8	9	13	88
	Rare	0	0	0	17	19	50	139
	Vulnerable	0	0	0	6	6	7	45
	Presumed Extinct	0	0	0	1	4	4	8
	Tas total	0	0	0	32	38	74	280

TABLE 8 – SUMMARY OF SPECIES ASSESSMENTS UNDER THE BUSINESS AS USUAL SCENARIO (RCP8.5) BY 2070

		Purple	Blue	Aqua	Green	Yellow	Orange	Red
	ALL SPECIES	2036	970	722	2991	740	1274	3412
IUCN	Critically Endangered	155	113	61	206	37	37	127
	Endangered	451	245	198	573	122	143	334
	Extinct in the wild	0	2	1	7	3	3	4
	Extinct	3	0	2	2	1	1	8
	Vulnerable	914	363	229	765	170	182	454
	IUCN total	1523	723	491	1553	333	366	927
EPBC	Critically Endangered	3	0	3	18	8	5	61
	Endangered	12	10	9	132	31	70	192
	Extinct	1	2	3	3	1	5	7
	Vulnerable	28	33	26	147	32	75	210
	EPBC total	44	45	41	300	72	155	470
FFG	FFG total	0	4	4	52	22	29	229
DSE advisory list	Endangered	0	5	8	62	23	29	165
	Poorly known	1	1	4	59	17	34	131
	Rare	0	0	5	70	44	113	549
	Vulnerable	0	1	7	85	27	52	285
	Presumed extinct	0	0	0	7	5	3	17
	DSE total	1	7	24	283	116	231	1147
NSW	Critically Endangered	0	0	0	5	6	6	22
	Endangered	5	16	18	82	20	52	109
	Presumed Extinct	1	3	3	8	2	2	6
	Vulnerable	0	1	1	51	24	43	99
	NSW total	6	20	22	146	52	103	236
ACT	ACT (endangered) total	0	0	0	0	0	0	6
QLD	Endangered	22	28	24	86	5	5	8
	Vulnerable	82	78	39	182	20	18	14
	QLD total	104	106	63	268	25	23	22
NT	Critically endangered	1	0	1	0	0	0	0
	Endangered	9	4	2	4	1	0	1
	(Listed nationally)	2	0	1	4	0	0	0
	Vulnerable	21	8	4	6	2	2	1
	NT total	33	12	8	14	3	2	2
WA	Priority 1	166	30	27	130	35	62	64
	Priority 2	70	10	15	129	37	80	160
	Priority 3	109	43	49	244	52	141	142
	Priority 4	18	1	5	86	25	89	101
	Critically Endangered	1	0	1	47	12	18	38
	Endangered	1	0	0	45	13	11	40
	Presumed Extinct	0	0	0	0	0	0	4
	Vulnerable	1	1	1	35	12	26	35
	WA total	366	85	98	716	186	427	584
SA	Endangered		1	2	11	6	34	120
	Rare	4	10	17	68	26	87	207
	Vulnerable	1	4	6	30	13	30	101
	SA total	5	15	25	109	45	151	428
Tas	Endangered	0	0	0	5	4	12	97
	Rare	0	0	0	4	13	23	185
	Vulnerable	0	0	0	3	1	9	51
	Presumed Extinct	0	0	0	0	2	4	11
	Tas total	0	0	0	12	20	48	344

Visual representation of the number of green and red flagged species (Fig 3-4) shows that, across most lists, the proportion of threatened species at risk in Melbourne’s future climate increases as temperatures rise. The only exceptions to this pattern are Queensland and Northern Territory species, where fewer threatened species will be at risk in future climates if they were grown under similar temperature projections as Melbourne.

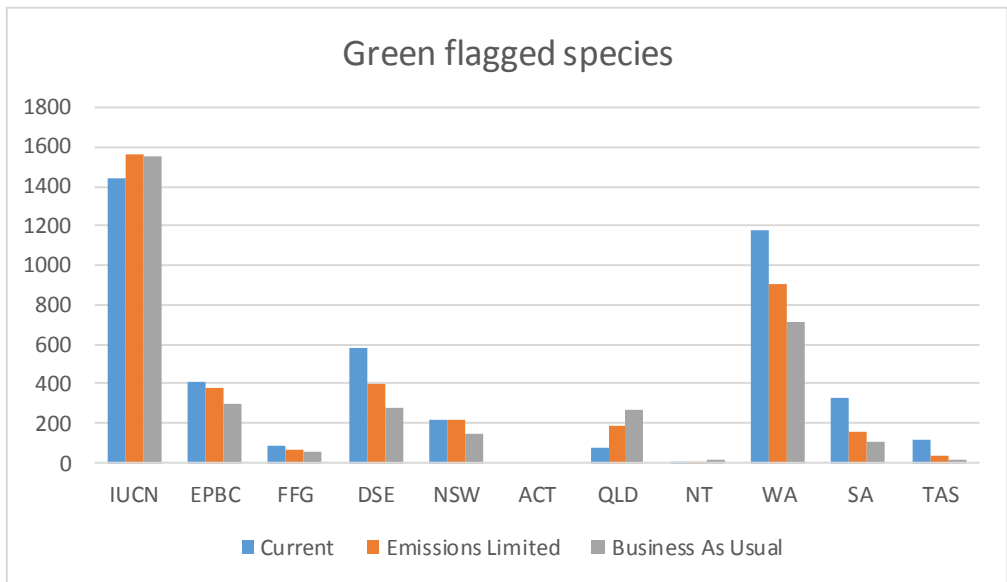


FIG 3 – NUMBER OF GREEN FLAGGED SPECIES FROM DIFFERENT THREATENED SPECIES LISTS, IN DIFFERENT CLIMATE SCENARIOS.

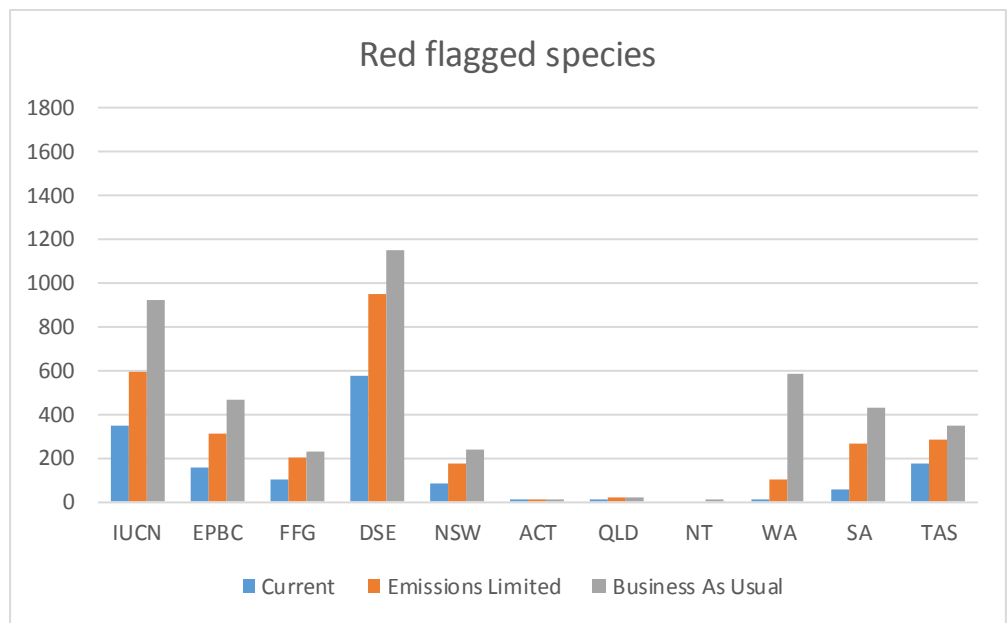


FIG 4 – NUMBER OF RED FLAGGED SPECIES FROM DIFFERENT THREATENED SPECIES LISTS, IN DIFFERENT CLIMATE SCENARIOS.

For the full list of potential species, see the dataset/spreadsheet as provided in electronic copy. A sample of the data can be seen below which contains species with more than 10 GBIF records listed as Critically Endangered on the IUCN red list, that are green flagged for Melbourne’s temperatures in the business as usual climate scenario by 2070:

<i>Abutilon eremitopetalum</i>	<i>Gastrochilus calceolaris</i>	<i>Paphiopedilum micranthum</i>
<i>Acanthophoenix rubra</i>	<i>Glyptostrobus pensilis</i>	<i>Patellifolia webbiana</i>
<i>Arachnothryx chimboracensis</i>	<i>Halfordia papuana</i>	<i>Paulownia kawakamii</i>
<i>Badula reticulata</i>	<i>Iris atropurpurea</i>	<i>Philodendron pogonocaule</i>
<i>Blakea granatensis</i>	<i>Jasminum azoricum</i>	<i>Pouteria subsessilifolia</i>
<i>Chassalia laikomensis</i>	<i>Juniperus bermudiana</i>	<i>Quercus hintonii</i>
<i>Columnea asteroloma</i>	<i>Limonium sventenii</i>	<i>Rhipsalis mesembryanthemoides</i>
<i>Costus barbatus</i>	<i>Maytenus eggersii</i>	<i>Solanum lidii</i>
<i>Crambe sventenii</i>	<i>Mimosa mensicola</i>	<i>Sorindeia calantha</i>
<i>Cycas szechuanensis</i>	<i>Molinadendron hondurense</i>	<i>Torreya taxifolia</i>
<i>Dendropanax hondurense</i>	<i>Mollinedia gilgiana</i>	<i>Viburnum hondurense</i>
<i>Eugenia gilgii</i>	<i>Ocotea monteverdensis</i>	

An assessment of the threatened species in the current living collection (n=635) shows that many of the species are at risk from increasing temperatures; 45% of these red flagged in the business as usual scenario by 2070 (Table 9).

TABLE 9 – SUMMARY OF SPECIES ASSESSMENTS OF THREATENED SPECIES IN THE CURRENT LIVING COLLECTION

	Purple	Blue	Aqua	Green	Yellow	Orange	Red	Not assessed
<i>Current temperature</i>	33	41	29	246	53	81	123	29
<i>Emissions Limited (RCP4.5 by 2050)</i>	13	27	22	178	59	90	217	29
<i>Business as usual (RCP8.5 by 2070)</i>	6	12	18	119	52	100	299	29

EPBC listed species that occur in the living collection, and already are at high risk (red-flagged) in the emissions limited climate scenario by 2050:

<i>Acacia caerulescens</i>	<i>Eucalyptus nicholii</i>	<i>Pomaderris cotoneaster</i>
<i>Acacia glandulicarpa</i>	<i>Grevillea bedgoodiana</i>	<i>Pomaderris subplicata</i>
<i>Astelia australiana</i>	<i>Grevillea celata</i>	<i>Pomaderris vacciniifolia</i>
<i>Asterolasia phebaliioides</i>	<i>Grevillea floripendula</i>	<i>Prostanthera discolor</i>
<i>Callistemon wimmerensis</i>	<i>Grevillea rivularis</i>	<i>Prostanthera galbraithiae</i>
<i>Callitris oblonga</i>	<i>Lachnagrostis adamsonii</i>	<i>Prostanthera staurophylla</i>
<i>Correa lawrenceana var. genoensis</i>	<i>Muehlenbeckia australis</i>	<i>Senecio psilocarpus</i>
<i>Daviesia laevis</i>	<i>Nematolepis squamea subsp. coriacea</i>	<i>Spyridium furculentum</i>
<i>Dianella amoena</i>	<i>Nematolepis wilsonii</i>	<i>Westringia crassifolia</i>
<i>Diuris fragrantissima</i>	<i>Ornduffia calthifolia</i>	<i>Xerochrysum palustre</i>
<i>Dodonaea procumbens</i>	<i>Phebalium daviesii</i>	<i>Zieria citriodora</i>
<i>Eucalyptus cadens</i>	<i>Poa sallacustris</i>	
<i>Eucalyptus crenulata</i>		

Implications and Recommendations for the Melbourne Gardens

This study has identified thousands of threatened plant species listed in Victoria, Australia, and around the world that are known to occur in places with temperatures similar to Melbourne's predicted future climate. This should provide useful information to aid future plant selection and living collections planning within Melbourne Gardens.

The information provided in this report and the associated spreadsheet could be used in conjunction with strategic planning for protecting existing collections or developing new ones. There are threatened species currently in the living collection identified as at risk from increasing temperatures, and conversely, there are possibilities for accessing threatened species at lower risk to include within the living collection holdings.

The magnitude of the changes indicated by this study suggests that better coordination of response to plant conservation with other botanic gardens would be beneficial and is an increasing imperative to meet the objectives of the Global Strategy for Plant Conservation – namely Target 8: “At least 75 per cent of threatened plant species in ex situ collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes”. In particular, at risk species that are currently conserved in the Melbourne Garden's living collection may need to be duplicated or transferred elsewhere for protection i.e. grown in locations that are several degrees cooler than Melbourne. However, new threatened species from warmer climates (i.e. several degrees higher) than Melbourne may also be at risk from increasing temperatures in their current location and could be conserved by introducing them to gardens that are presently cooler such as the Melbourne Gardens.

A key issue in responding to these changes is effective plant material collection and supply. For species at risk, new plant material could be collected from warmer provenances of the species native range. New plant material may also be able to be sourced from other botanic gardens, or from specialist plant nurseries. Nonetheless, it is likely that some plant material (especially from highly threatened species) may be very difficult or indeed impossible to obtain for certain species identified as at low risk in future climates.