Threatened Species Recovery Hub

National Environmental Science Programme

Cactus Dryandra (*Banksia anatona*). Image: Australian Network for Plant Conservation

Appendix 2
Threat Abatement Strategy Results

This document is an appendix from: April E. Reside, Michelle Ward, C.J. Yong, James E.M. Watson, Andrew Rogers, Ruben Venegas Li and Josie Carwardine. (2021) A knowledge synthesis to inform a national approach to fighting extinction - Final Report. NESP Threatened Species Recovery Hub Project 7.7 report, Brisbane.

November 2021

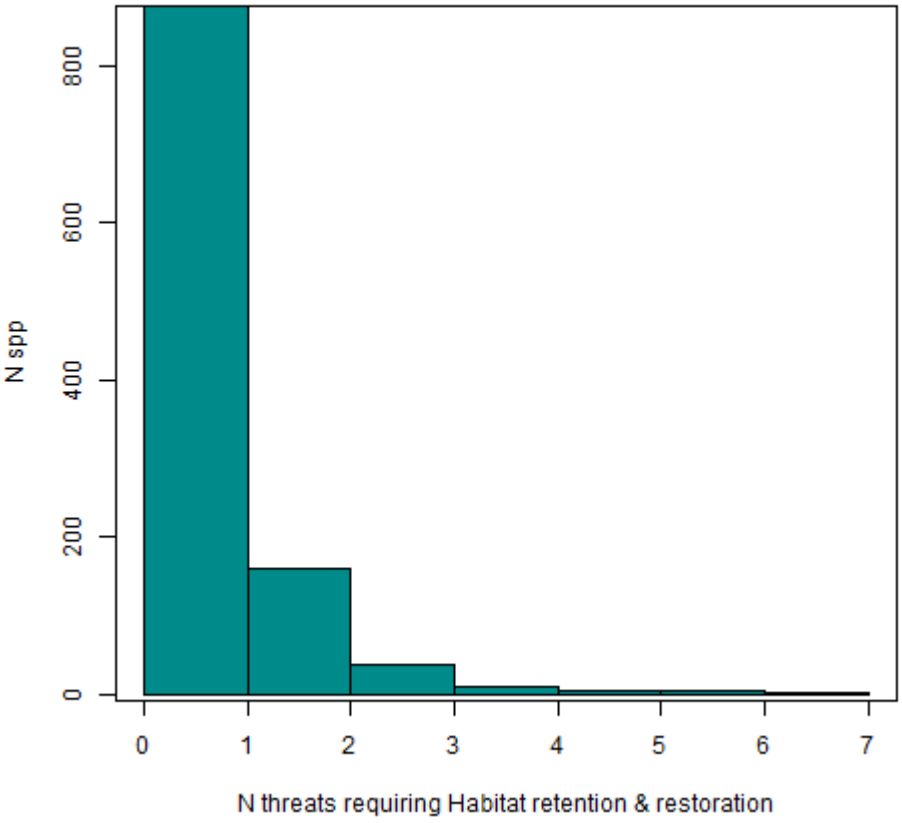
The University Of Queensland AUSTRALIA

CSIRO

Habitat retention & restoration

"Habitat retention and restoration" was the most frequently assigned Threat Abatement Strategy, and was assigned to address a range of threats. In a small proportion of cases, it was assigned to address multiple threats to an individual species (Figure 1).

Two species had 7 threats for which HRR was required: Freshwater Sawfish (*Pristis pristis*), and Eastern Hooded Plover (*Thinornis rubricollis rubricollis*).



Appendix 2 Fig. 1. Histogram of the number of threats, per species, that were assigned 'habitat retention and restoration' as the Threat Abatement Strategy.

Appendix 2 Table 1. The number of species per taxonomic group and threat status that required 'habitat retention and restoration' as the Threat Abatement Strategy.

	VU	EN	CR	EX (rediscovered)	Total	% total in group
Bird	32	22	10		64	67.37
Fish	13	13	4		30	73.17
Frog	11	5	8		24	64.86
Invertebrate	5	14	15		34	62.96
Mammal	32	17	2		51	53.68
Plant	386	360	111	2	859	66.85
Reptile	17	13	3		33	63.46
Total	**496**	**444**	**153**	**2**	**1095**	

Habitat retention and restoration was most often assigned where the direct link to habitat loss, fragmentation and degradation could be made (n=824, Table 2). The next most frequently associated threats requiring this Threat Abatement Strategy were other natural system modifications, namely erosion and salinity. Often it was further required for alteration to surface water flows and infiltration.

Appendix 2 Table 2. The different threats that were addressed through the action 'habitat retention and restoration', and the frequency in which 'habitat retention and restoration' was assigned to each threat.

Threat	N	Justification
agriculture (cropping)	3	Habitat loss and degradation resulted from this land use
Agriculture and aquaculture (plantations/ forestry)	4	Habitat loss and degradation resulted from this land use
Alteration to surface water flows and infiltration	57	Restoring native vegetation is recommended for restoring hydrology regimes in many contexts
Alteration to surface water flows and infiltration:run-off	4	Restoring native vegetation is recommended for restoring hydrology regimes in many contexts
climate change & severe weather	6	In many cases, improving habitat quality and extent through restoration is the best available option for helping species persist in the face of climate change
climate change & severe weather: altered rainfall patterns	8	In many cases, improving habitat quality and extent through restoration is the best available option for helping species persist in the face of climate change
climate change & severe weather: storms & flooding	6	Habitat restoration can stabilise habitat areas in the face of storms and floods, e.g. through mangroves, and also create new habitat above the higher sea level.
climate change & severe weather: storms & flooding (stronger cyclones/storms)	2	Habitat restoration can stabilise habitat areas in the face of stronger cyclones and floods, e.g. through mangroves, and also create new habitat above the higher sea level.
climate change (sea-level rise)	8	Habitat restoration can stabilise habitat areas in the face of sea-level rise, e.g. through mangroves, and also create new habitat above the higher sea level.
Disease	1	Disease was listed as a threat to the Koala, but there was no advice other than "Research mechanisms to reduce the impacts of disease". In this case we decided the best course of action was to improve their habitat quality and extent, as habitat loss and degradation could increase stress and susceptibility to disease.
Disease in aquatic system	4	Controlling other threats, particularly habitat degradation, is recommended for some species impacted by disease, particularly for aquatic pathogens, where improving water quality can improve species chances in the face of disease threat.
Disease in terrestrial system	2	Controlling other threats, particularly habitat degradation, is recommended for some species impacted by disease
Effluent and wastewater	2	Habitat restoration was recommended for preventing, and in some cases addressing, the threat of Effluent and wastewater
Energy production and mining	26	Habitat loss and degradation resulted from this land use
Habitat loss, fragmentation and degradation	824	Habitat restoration is required to address habitat loss, fragmentation and degradation.
Habitat shifting and alteration	2	In many cases, improving habitat quality and extent through restoration is the best available option for helping species persist in the face of climate change

Human intrusion	1	This threat relates to recreational boat moorings impact on spawning habitat damaging habitat for the red handfish; therefore, habitat restoration was recommended to address it.
Inappropriate disturbance regimes	6	Habitat restoration actions should include restoring ecological functions of the landscape and ameliorate impacts of inappropriate disturbance regimes
Increased frequency/severity of droughts	1	In many cases, improving habitat quality and extent through restoration is the best available option for helping species persist through drought
Invasive invertebrate (bee/ wasp)	1	Little advice was provided on the nature of the threat of bees on Hooded Plover; so improving habitat quality and extent was considered the best option for increasing their persistence.
Invasive vertebrate (cane toad)	8	In many cases, little on-ground action can be done to ameliorate the threat of cane toads to threatened species, except where the threatened species can be sheltered in toad-free refuges such as islands. On mainland Australia, decommissioning waterholes across dry areas is likely to be the best option. Otherwise, controlling all other threats is recommended.
Invasive vertebrate (rodents)	38	Little advice for controlling rodents on mainland (focus is on islands); in some cases, advice is to restore ground layer where rats are a threat (e.g., Mitchell's Rainforest Snail)
invasive vertebrate (sugar glider)	1	At present the impacts of Sugar Gliders on Orange-bellied Parrots are limited; advice is to control other threats.
Nutrient loads	4	Habitat restoration was recommended for preventing, and in some cases addressing, the threat of increased nutrient loads.
Other natural system modifications	313	Habitat restoration actions should include restoring ecological functions of the landscape and ameliorate impacts of other natural system modifications
Other natural system modifications: erosion	14	Habitat restoration was recommended for preventing, and in some cases addressing, the threat of unsustainable erosion.
Other natural system modifications: inappropriate habitat management	2	Habitat restoration actions should include restoring ecological functions of the landscape through appropriate habitat management
Other natural system modifications: salinity	15	Habitat restoration was recommended for preventing, and in some cases addressing, the threat of salinity
Pollution	3	In cases where pollution entering swamps is a threat to rare orchids, habitat restoration was considered the best option to address this.
Problematic native species (fish)	1	Controlling other threats, particularly habitat degradation, is recommended for some species impacted by native fish.
Problematic native species (goanna)	1	Goannas are considered a low threat to malleefowl, and without many feasible actions available to directly address this threat, controlling other threats such as habitat degradation was considered the best option.
Problematic native species (plant)	6	Habitat restoration actions can include management of problematic native plant species.

problematic native species/diseases	2	Controlling other threats, particularly habitat degradation, is recommended for some species impacted by disease, particularly for aquatic pathogens, where improving water quality can improve species chances in the face of disease threat.
Small/restricted population	17	Increasing habitat quality, extent and connectivity can be done through restoration, and can be one option to increase the population size for some species.
Temperature extremes	2	For some fish species, increasing riparian cover through restoration can shade streams to mitigate the threat of temperature extremes.
Transportation and service corridors	4	Habitat loss and degradation resulted from this land use
Urban and commercial development and maintenance	2	Habitat loss and degradation resulted from this land use

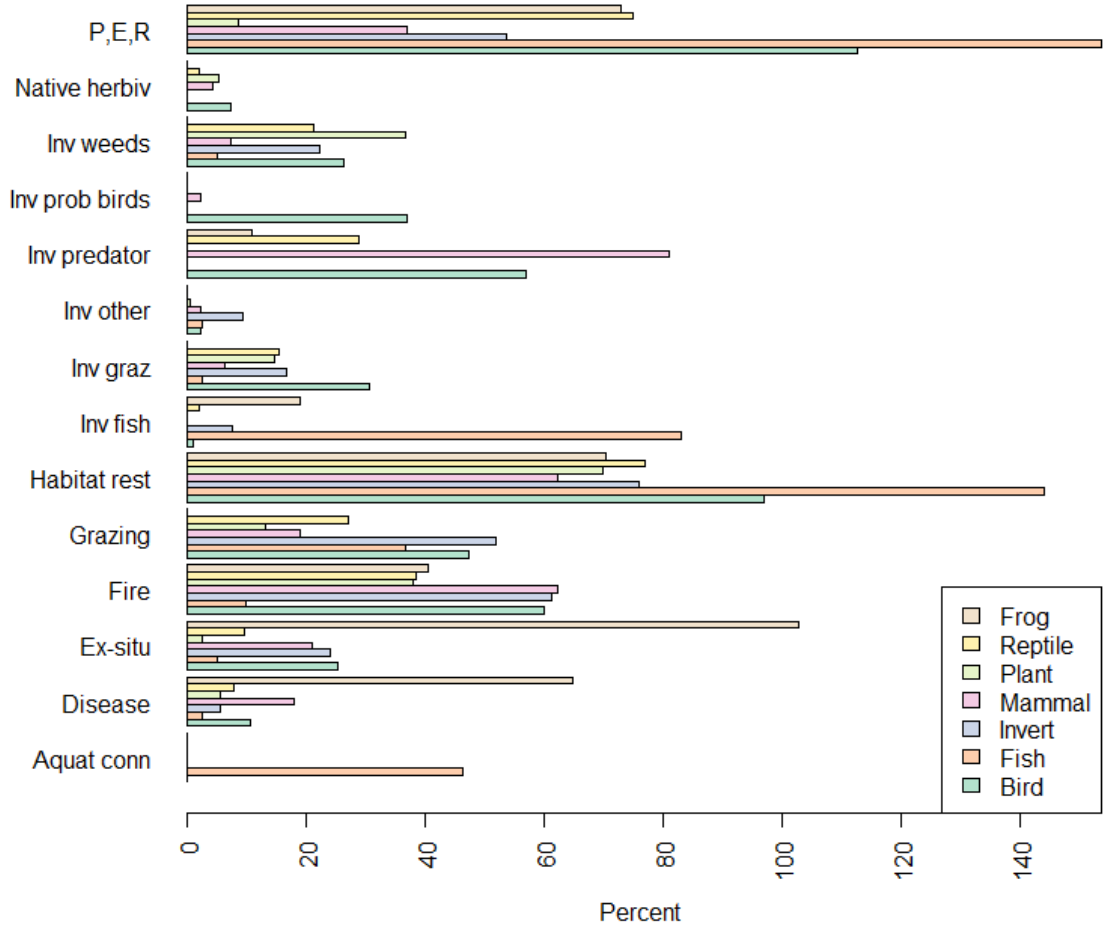
Datasets used for spatial Threat Abatement Strategies

Appendix 2 Table 3. Datasets used to create the spatial cost models that formed the basis of the Threat Abatement Strategies.

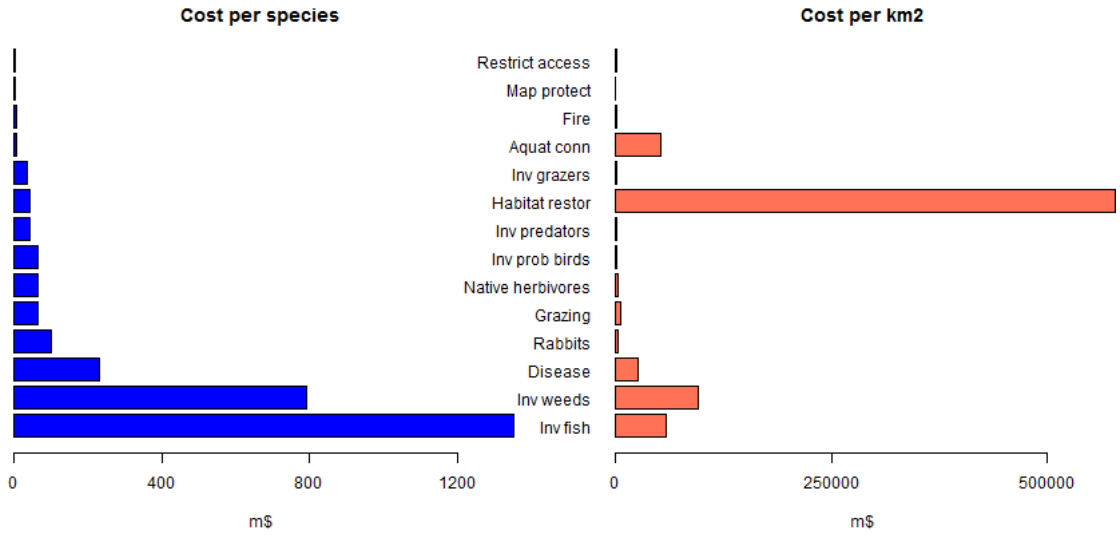
Dataset	Use	Reference	Spatial cost model
NVIS 1750 Version 6.0	Vegetation types	https://www.environment.gov.au/land/native-vegetation/national-vegetation-information-system/data-products	Habitat restoration Fire management Weed management Hydrology management
Catchment Scale Land Use of Australia	Used to locate: - agricultural intensity. - grazing land (Grazing native vegetation, Grazing modified pastures) - forestry land (Production native forests, Wood production forestry, Environmental forest plantation, Other forest plantation, Softwood plantation forestry, Hardwood plantation forestry, Plantation forests)	https://www.agriculture.gov.au/abares/aclump/land-use/data-download	Habitat restoration Grazing management Forestry management
Forest and Woodland Loss	Used to locate cleared land.	Ward et al. (2019)	Habitat restoration
Topographic Ruggedness Index	Used to identify resistance within the landscape. Reclassified so 0-31 = 1 (minimal ruggedness), 31-110 = 2 (medium ruggedness), 110 - 698 = 3 (very rugged)	Gallagher RV. 2020. National prioritisation of Australian plants affected by the 2019-2020 bushfire season – Report to the Commonwealth Department of Agriculture, Water and Environment.	All spatial layers
Travel time to cities	Used directly to estimate travel time	Weiss et al. (2018)	All spatial layers
ARIA	Used to differentiate between rural, remote, and urban environments.	https://www.abs.gov.au/websitedbs/d3310114.nsf/home/remoteness+structure	Fire management Predator management Herbivore management
NVIS Current Version 6.0	Used to extract vegetated areas and differentiate between open or closed canopies.	https://www.environment.gov.au/land/native-vegetation/national-vegetation-information-system/data-products	Weed management Herbivore management
Fox distribution		Pintor et al. (2020)	Predator management
Cat distribution		Pintor et al. (2020)	Predator management
Dingo distribution		Pintor et al. (2020)	Predator management

Dasyurus maculatus distribution	Used directly to identify Dasyurus maculatus distribution, and ensure ground baiting was conducted within these areas.	Commonwealth of Australia (2019). Species of National Environmental Significance Distributions.	Predator management
Threatened species distribution		Commonwealth of Australia (2019). Species of National Environmental Significance Distributions.	All spatial layers
Invasive ungulate distribution		Pintor et al. (2020)	Invasive herbivore management
Rabbit distribution		Pintor et al. (2020)	Rabbit management
Phytophthora threat map		Pintor et al. (2020)	Phytophthora management
Surface Hydrology Polygon (National)	Used directly to identify river and stream network, as well as dams and weirs.	https://www.ga.gov.au/scientific-topics/national-location-information/national-surface-water-information	Hydrology management Invasive fish management

Threat Abatement Strategy Results details



Appendix 2 Fig. 2. The Threat Abatement Strategies for each of the taxonomic groups, shown as a percentage of the number of species in that group.



Appendix 2 Fig. 3. The cost of each Threat Abatement Strategy per species and per km 2. Both the Left and Right plots are in the same order

Appendix 2 Table 4. Costs of monitoring threatened species, data from OEH (2013). The values equate to the total annual cost for monitoring a species in New South Wales.

Taxonomic group	Subgroup	Average annual cost/ spp	Max cost/ spp	Min cost/ spp	Average cost for taxonomic group
Plants	Algae, Mosses and Lichens	213.34	213.34	213.34	1160.30
	Aquatic Plants	837.26	837.26	837.26	
	Epiphytes and Climbers	803.59	2052.90	231.74	
	Ferns and Cycads	293.38	436.34	58.00	
	Fungi	4146.33	5337.63	412.42	
	Herbs and Forbs	1085.91	4000.00	269.00	
	Mallees	989.25	3000.00	324.92	
	Orchids	1122.44	12611.50	209.89	
	Shrubs	1037.83	5500.00	141.49	
	Trees	1073.67	6500.00	234.33	
Frogs	Frogs	6582.48	16200.00	1546.25	6582.48
Birds	Birds	15294.00	48020.24	420.24	15294.00
Invertebrates	Invertebrates	2909.44	12000.00	402.76	2909.44
Mammals	Marsupials	20053.07	31378.44	8797.91	13982.98
	Rodents	7912.90	21750.00	1540.88	
Reptiles	Reptiles	10779.23	23133.33	3027.03	10779.23
Threatened Ecological Communities	Threatened Ecological Communities	3546	4200	1000	3546

Extrapolating the cost of monitoring of a species in New South Wales, by taking the average cost for monitoring species in each taxonomic group, we can get a ballpark estimate of how much monitoring might cost for all our threatened species. Important caveats to note are that monitoring in very remote parts of Australia are likely to be more expensive than those in New South Wales, particularly across northern Australia where species new to science are still being discovered with comparative regularity; and that there are no estimates here of monitoring threatened fish species. Future work should estimate the costs of monitoring based on different parts of Australia, and extrapolate the costs in a more nuanced way, e.g. compare the cost of monitoring trees to the number of threatened trees, rather than the monitoring cost averaged across all species within that taxonomic group. Furthermore, monitoring is likely to have some cost sharing, for example, monitoring all threatened species – at least in each taxonomic group – per visit to a site. For example, a bird survey at a site could monitor all the threatened bird species at the site.

Appendix 2 Table 5. Estimated costs of monitoring threatened species in our analysis, based on extrapolations of average annual cost of monitoring species from (OEH 2013) in New South Wales.

Taxonomic group	# spp in our analysis	Average cost/ spp (OEH 2013)	Extrapolated monitoring cost
Plants	1285	1160.3	1,490,985.50
Birds	95	15294	1,452,930.00
Frogs	37	6582.48	243,551.76
Invertebrates	54	2909.44	157,109.76
Mammals	95	13982.98	1,328,383.10
Reptiles	52	10779.23	560,519.87
Total	**1618**		**5,233,479.99**

Appendix 2 Table 6. Costs of captive breeding programs for Australian animals

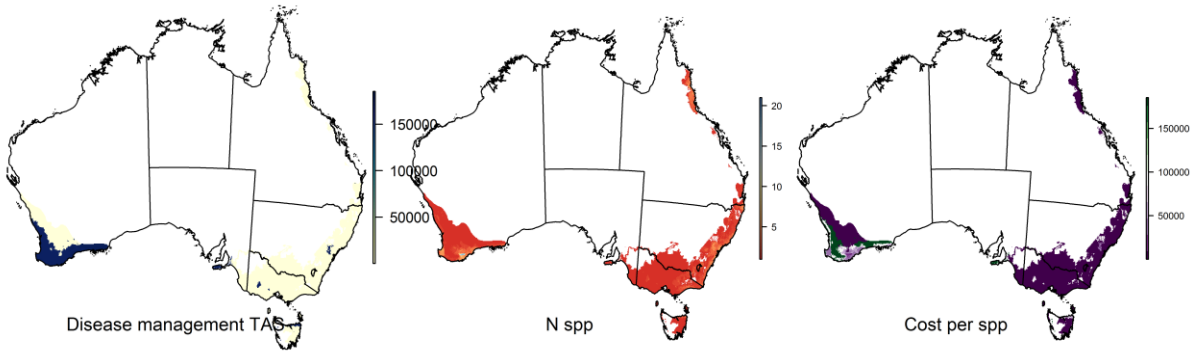
Species	Threat status	total expenditure	N years	total cost(AUD)/ year	Source
Lancelin Island sking	Vu	31000	3	10333.33	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Giant Burrowing Frog	Vu	70000	5	14000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Large Brown Tree Frog	En	80000	5	16000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
New Holland Mouse	Vu	80000	5	16000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Smoky Mouse	En	80000	5	16000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Mallee Emu-wren	En	100000	5	20000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Boodie	Vu	71400	3	23800	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Malleefowl	Vu	74608	3	24869.33333	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Gilbet's potoroo	Cr	150000	6	25000	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Key's Matchstick Grasshopper	En	130000	5	26000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Bilby	Vu	220200	8	27525	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Grassland Earless Dragon	Cr	140000	5	28000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Brush-tailed Rock-wallaby	Cr	150000	5	30000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Lord Howe Island Stick Insects	Cr	150000	5	30000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/

Shark Bay mouse	Vu	155000	5	31000	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Western swamp tortoise	En	327900	10	32790	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Western barred bandicoot	En	406721	12	33893.41667	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Western quoll	Vu	335900	9	37322.22222	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Mala	En	257921	6	42986.83333	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Banded hare-wallaby	Vu	257921	$6	42986.83333	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Dibbler	En	275000	5	55000	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Spotted Tree Frog	En	286000	5	57200	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Numbat	En	480000	8	60000	https://www.dpaw.wa.gov.au/images/documents/about/science/cswa/articles/100.pdf
Northern Corroboree Frogs	En	364000	5	72800	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Baw Baw Frog	Cr	85000	1	85000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Golden-rayed Blue butterfly	Cr	500000	5	100000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Alpine She-oak Skink.	En	545000	5	109000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Southern Corroboree Frogs	En	621000	5	124200	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Reagent honeyeater	En	770000	5	154000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/

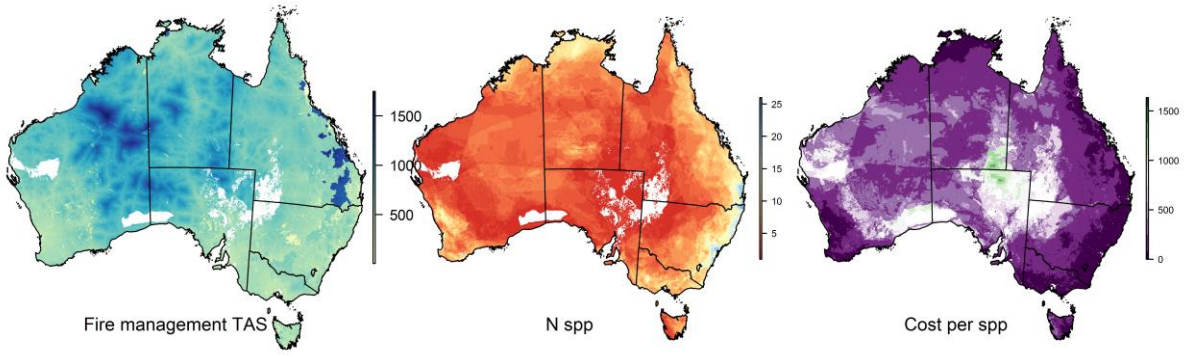
Leadbeater's Possum	Cr	850000	5	170000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Orange-bellied parrot	Cr	855000	5	$171,000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Swift parrot	Cr	880000	5	176000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Helmeted Honeyeater	Cr	1400000	5	280000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Plains wanderer	Cr	1440000	5	288000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Eastern Barred Bandicoots	Ex	2535000	5	507000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Tasmanian Devil	En	2630000	5	526000	https://www.zoo.org.au/fighting-extinction/local-threatened-species/
Victorian Guthega Skink	En	4936000	5	987200	https://www.zoo.org.au/fighting-extinction/local-threatened-species/

Threat Abatement Strategy: cost per species

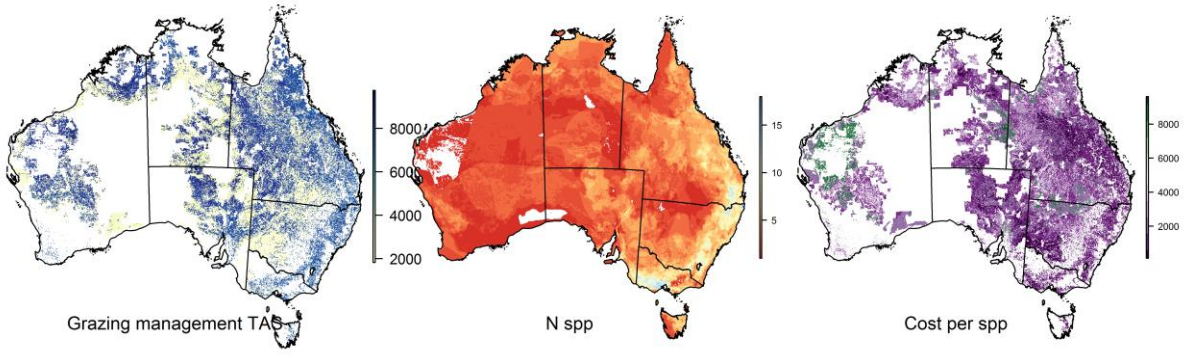
Threat Abatement Strategies differed markedly in the extent in which they were needed, the number of species that required them, the total cost of implementation, and the corresponding cost per species. Here we examine the cost per species for each of the Threat Abatement Strategies.



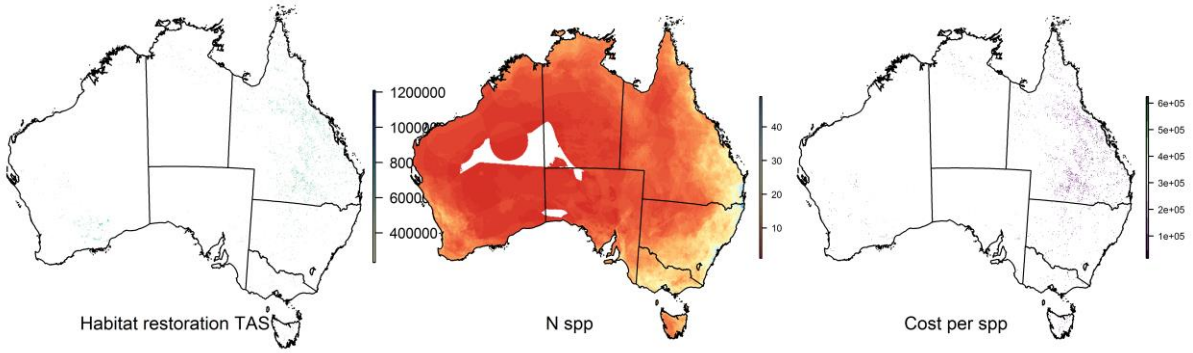
Appendix 2 Fig. 4. Disease management. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



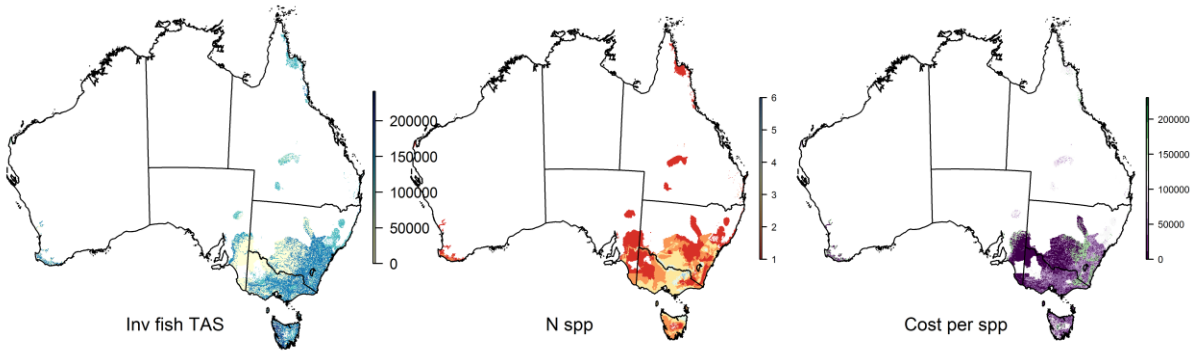
Appendix 2 Fig. 5. Fire management. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



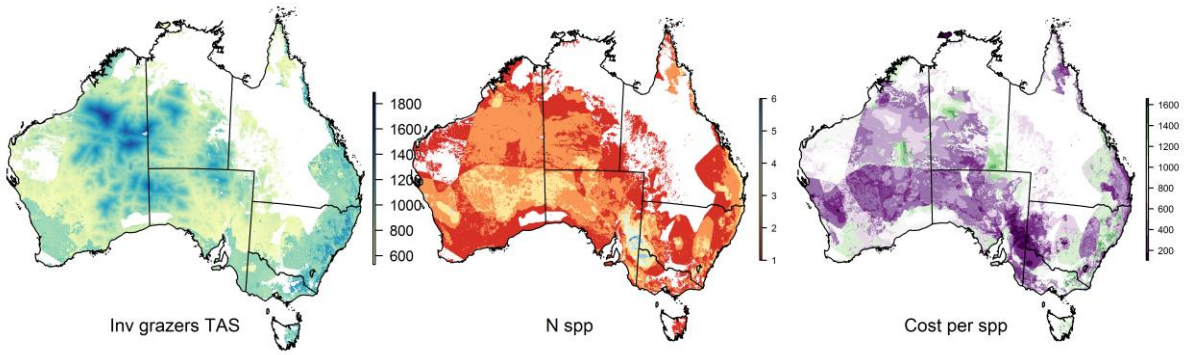
Appendix 2 Fig. 6. Grazing management. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



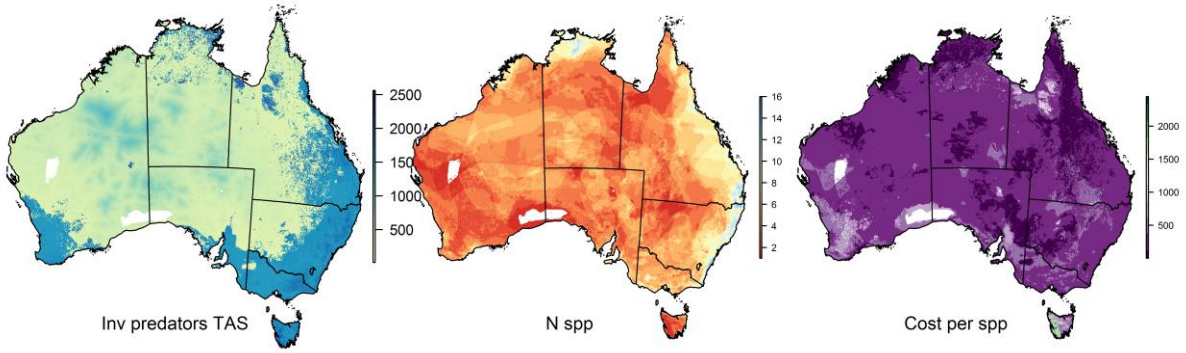
Appendix 2 Fig. 7. Habitat restoration. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy. Far more species require habitat restoration than there is land that was deemed restorable (i.e. cleared and not under an intensive land use)



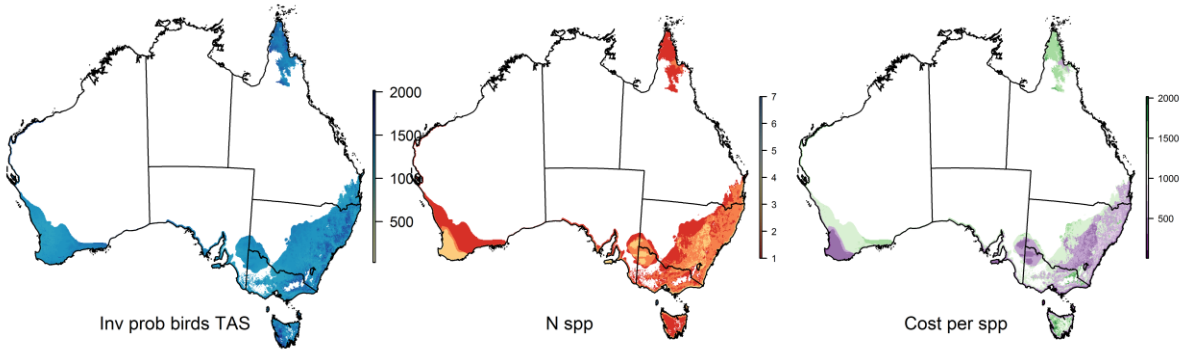
Appendix 2 Fig. 8. Invasive fish management. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



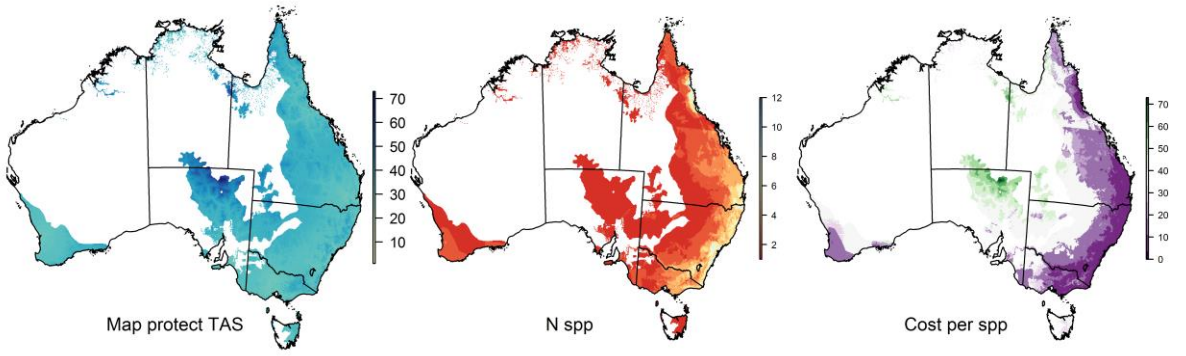
Appendix 2 Fig. 9. Invasive grazer (large herbivore) management. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



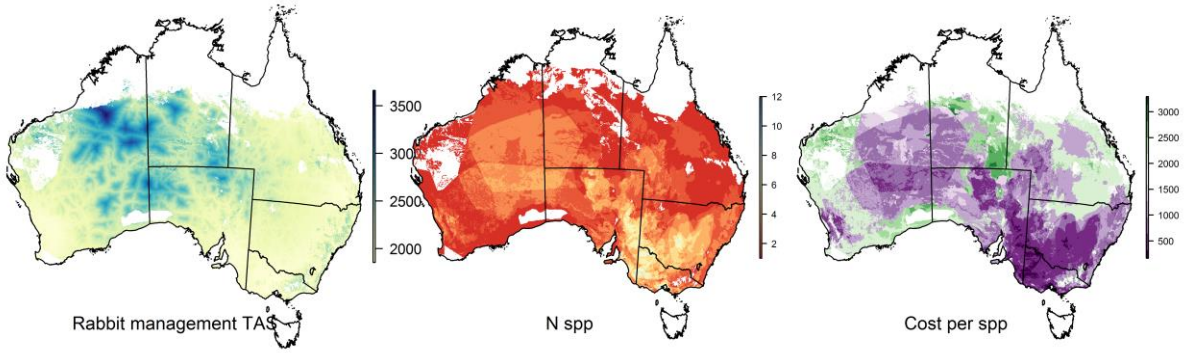
Appendix 2 Fig. 10. Invasive predator management. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



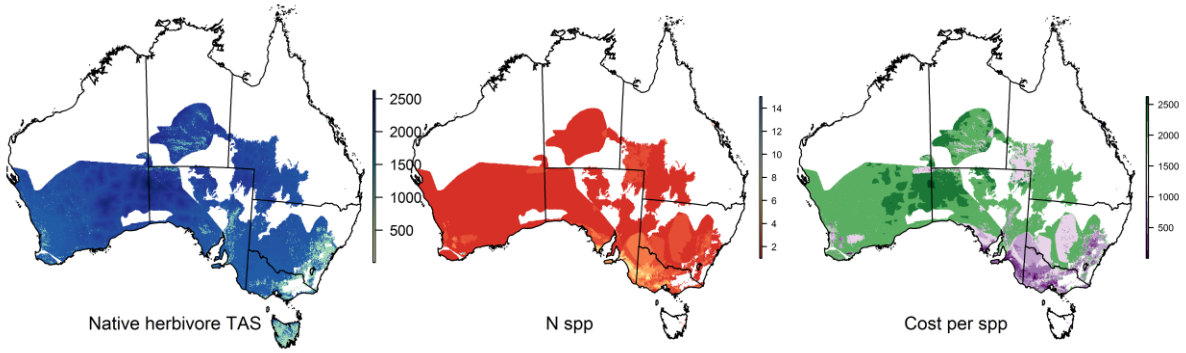
Appendix 2 Fig. 11. Invasive and problematic bird management. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



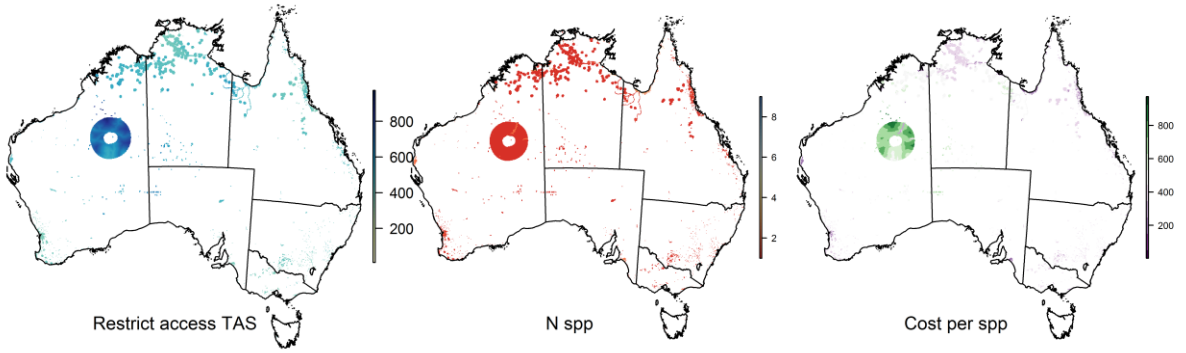
Appendix 2 Fig. 12. Map and protect refugia. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



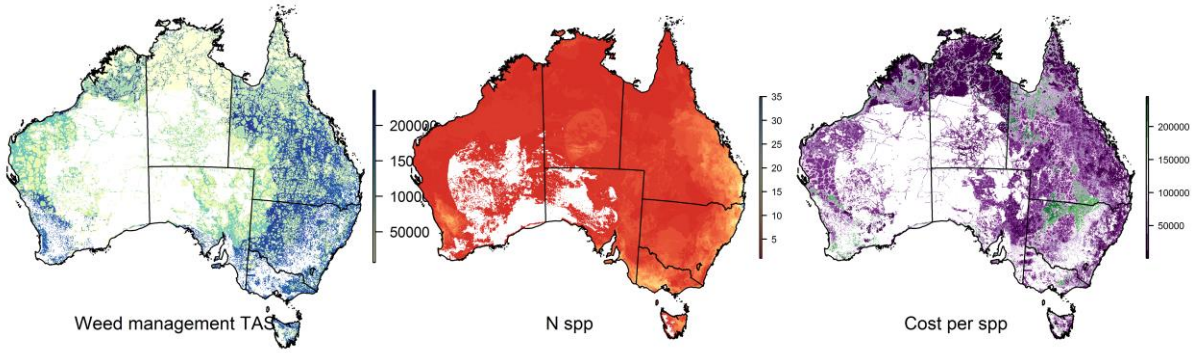
Appendix 2 Fig. 13. Rabbit management. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



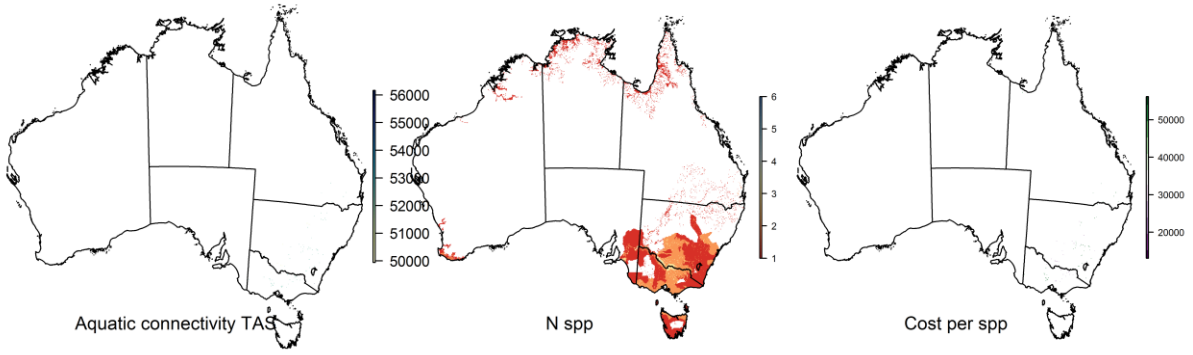
Appendix 2 Fig. 14. Problematic native herbivore management. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



Appendix 2 Fig. 15. Restrict access to critical sites. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



Appendix 2 Fig. 16. Weed management. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.



Appendix 2 Fig. 17. Aquatic connectivity. Right: Threat Abatement Strategy, middle: the number of species requiring this Threat Abatement Strategy, left: the cost per species requiring this Strategy.

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

This project is supported through funding from the
Australian Government's National Environmental Science Program.

Threatened Species Recovery Hub

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