

## A prioritisation of threatened species monitoring in Australia

### In brief

Preventing species from going extinct is the major goal of conservation management. Approximately 1900 species are listed as threatened under Australia's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Monitoring is a critical component of any management program and helps us to understand the status, distribution and trends of threatened species. However, recent research found that 1176 of the 1938 species listed under the EPBC Act are yet to be monitored. Many of those that have been monitored have not been monitored well, for example, monitoring may have only been undertaken for a few years in the past, or not across the full range of the species.

We estimated that monitoring all EPBC Act listed threatened species adequately to detect small to moderate declines (80% chance of detecting a 20% change) would cost \$307 million per year. Through cost sharing (where one program can monitor multiple species at a site) it is estimated that this could be reduced to \$179 million per year. If we take out species that are already being monitored,

the total estimated additional cost is \$74 million per year.

Before Australia reaches the point where all threatened species are monitored, choices will need to be made about which species are monitored. We developed a framework for prioritising investment in threatened species monitoring which accounts for extinction risk, surrogacy (species that are indicators for others), statistical power and monitoring cost.

Applying the framework to EPBC-listed species, we found that the top

30 priority species for monitoring were 20 birds, eight plants and two mammals. Of these, 17 currently have no monitoring. Commencing monitoring programs for these species is a very high conservation priority given their risk of extinction, relative cost and potential role as surrogates for other species.

Our approach can be applied to many species, is data-driven and cost-efficient. Using the framework, decision-makers can make efficient and informed prioritisation choices that maximise conservation outcomes.

*The short-nosed sand plover (Charadrius mongolus) was one of the top 30 ranked EPBC listed species based on extinction risk, surrogacy and cost. Image: Imran Shah CC BY-SA 2.0 Flickr*





## Background

Preventing species extinctions in Australia is one of the most pressing environmental challenges of our times. Approximately 1900 species are listed as threatened under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Efficient and cost-effective monitoring programs are needed to understand the status, distribution and trends of threatened species, as well as to inform effective conservation actions for those species most vulnerable to extinction.

Recent studies have found that threatened species monitoring in Australia is generally inadequate.

Of threatened vertebrates, 21–46% are not monitored at all, and even fewer threatened plants and invertebrates have ongoing and well-designed monitoring programs. This means that the status and trends of a large proportion of Australia's most imperilled species are largely unknown. General frameworks are needed that estimate the costs of rigorously monitoring Australia's threatened species and for prioritising monitoring efforts, given limited financial resources for conservation.

Decision-makers should consider a range of factors when choosing between species for monitoring. First, they might consider the

extinction risk faced by a particular species. Second, some species will be more expensive to monitor than others, for example, those found in remote locations or needing specialised equipment or expert personnel for detection. Third, decisions about which species to monitor might depend on their surrogacy potential, that is, what the trend of a particular species might indicate about the trends of similar or related species occurring in the same location. While there have been recent attempts at combining this type of information into general frameworks for the prioritisation of conservation resources, none have done so to prioritise the monitoring of Australia's threatened species.



*The Wet Tropics subspecies of the yellow-bellied glider (Petaurus australis) was one of the top 30 ranked EPBC listed species that are yet to be monitored with cost sharing. Image: David Cook, CC BY-NC 2.0, Flickr*





## Research aims

We aimed to develop a framework for prioritising investment in threatened species monitoring which accounts for extinction risk, surrogacy, statistical power and monitoring cost. To do this, we:

1. reviewed the available literature to compile databases on traits, preferred survey methods and sampling effort;
2. quantified extinction risk for species based on intrinsic ecological traits;
3. estimated the ability of species to act as surrogates for others in monitoring, taking into account threats, ecology, habitat requirements and geographic range; and
4. estimated the cost of detecting changes in population with a high level of accuracy.



*Threatened orchids (Caladenia caudata pictured) were some of the highest-ranked species and overall, receive little monitoring. Image: DPIPWE*

## What we did

We considered all 1893 species listed as threatened with extinction under the EPBC Act. Plants represented the majority (1374), and were followed by birds (156), mammals (134), invertebrates (66), reptiles (63), fish (59) and amphibians (41). We did not include species that can only be monitored at sea.

We then modelled the extinction risk of species using data about intrinsic ecological traits. We collated trait data from published scientific papers, online databases and Commonwealth listing advice. We also estimated the ability of each species to act as surrogates for others. Species were assumed

to be good surrogates if they were subject to the same threats, had the same habitat requirements and behavioural ecology and occurred in the same place.

We estimated the total monitoring cost for each species. To do this, we collated time-series data for as many species as possible and estimated the number of monitoring sites needed to provide a good chance (80% statistical power) of detecting small to moderate declines in populations over the next 20 years. Using this information, we predicted the number of monitoring sites needed for all species listed in the EPBC Act, and estimated the total monitoring

costs, given preferred sampling methods and recommended levels of survey effort.

Once we estimated extinction risk, surrogacy values and monitoring costs, we identified which species are already receiving monitoring in Australia. We then ranked species that are not yet monitored by their cost efficiency, which we measured as a combination of extinction risk, surrogacy and monitoring cost. We accounted for cost sharing between species (i.e., detecting multiple species with the same method at sites), which allowed us to estimate the total cost of monitoring, and rank those yet to be monitored at all.





## Key findings

### Overall monitoring efforts

Scheele et al (2019) and Lavery et al (2021) found that 1176 species listed under the EPBC Act are yet to be monitored. Plants receive the least monitoring, despite being the most numerous threatened species. Invertebrates, birds and fish also showed large gaps in monitoring compared to vertebrates. We found that within

the threatened categories, more species listed as Vulnerable are yet to be monitored compared to those listed as Endangered and Critically Endangered.

### Modelling extinction risk

Plant and invertebrate species showed the highest predicted risk of extinction based on our compiled list of traits. Of the 30 highest-

ranked species for extinction risk, 16 were plants, 12 invertebrates and two frogs. Eighteen of these are currently ranked as Critically Endangered and 12 as Endangered. Only five of the top-ranked species for predicted extinction risk are already being monitored. Orchids and invertebrates dominated the highest-ranked species primarily due to their small distributions.

**Table 1:** Top 30 EPBC listed species with the highest predicted extinction risk based on intrinsic ecological traits. Please see the project 7.5 report "A prioritisation of threatened species monitoring in Australia" for full details of how these lists were generated including the underlying assumptions.

Group	Common name	Scientific name	Already monitored?
Plant	Thick-stem fairy fingers	<i>Caladenia campbellii</i>	No
Plant	Kilsyth South spider orchid	<i>Caladenia</i> sp. Kilsyth South (G.S.Lorimer 1253)	No
Plant	Robust fingers	<i>Caladenia tonellii</i>	No
Plant	Bald-tip beard orchid	<i>Calochilus richiae</i>	No
Plant	Western leek orchid	<i>Prasophyllum favonium</i>	No
Invertebrate	Hairy marron	<i>Cherax tenuimanus</i>	No
Invertebrate	Lord Howe Island stick insect	<i>Dryococelus australis</i>	No
Invertebrate	Southern pink underwing moth	<i>Phyllodes imperialis smithersi</i>	No
Invertebrate	Lord Howe flax snail	<i>Placostylus bivaricosus</i>	No
Invertebrate	Mount Lidgbird pinwheel snail	<i>Pseudocharopa ledgbirdi</i>	No
Invertebrate	Whitelegge's pinwheel snail	<i>Pseudocharopa whiteleggei</i>	No
Invertebrate	Harvey's mealybug	<i>Pseudococcus markharveyi</i>	Yes
Invertebrate	Alice Springs fig snail	<i>Semotrachia euzyga</i>	No
Plant	Charming spider orchid	<i>Caladenia amoena</i>	No
Plant	Dwarf spider orchid	<i>Caladenia pumila</i>	No
Plant	Sagg spider orchid	<i>Caladenia saggicola</i>	No
Invertebrate	Margaret River burrowing crayfish	<i>Engaewa pseudoreducta</i>	No
Invertebrate	Southern sandstone cave cricket	<i>Micropathus kiernani</i>	No
Frog	Beautiful nursery frog	<i>Cophixalus concinnus</i>	No
Plant	Black-clubbed spider orchid	<i>Caladenia atroclavia</i>	No
Plant	Rosella spider orchid	<i>Caladenia rosella</i>	No
Plant	Bearded orchid	<i>Calochilus psednus</i>	No
Plant	Shortspike midge orchid	<i>Corunastylis brachystachya</i>	No
Plant	Brindabella midge orchid	<i>Corunastylis ectopa</i>	Yes
Plant	Wyong midge orchid	<i>Corunastylis insignis</i>	Yes
Invertebrate	Stoddart's land snail	<i>Quintalia stoddartii</i>	Yes
Invertebrate	Macdonnell Ranges land snail	<i>Sinumelon bednalli</i>	No
Frog	Kroombit tinker frog	<i>Taudactylus pleione</i>	Yes
Plant	Coast spider orchid	<i>Caladenia conferta</i>	No
Plant	Windswept spider orchid	<i>Caladenia dienema</i>	No



## Key findings (continued)

### Surrogacy values

The ranking of species was highly sensitive to their level of surrogacy potential. Based on surrogacy scores alone, the top 30 ranked species were all plants.

This is due to the sheer number of plants on the EPBC list, and our assumption that surrogacy cannot occur across taxonomic groups. Of the top 30 species ranked for surrogacy values, five are listed

as Vulnerable, 12 as Endangered and 12 as Critically Endangered. Almost half of these top 30 species are already being monitored.

**Table 2:** Top 30 ranked EPBC listed species based on the surrogacy scores. Please see the project 7.5 report *"A prioritisation of threatened species monitoring in Australia"* for full details of how these lists were generated including the underlying assumptions.

Group	Common name	Scientific name	Already monitored?
Plant	White lace orchid	<i>Phreatia paleata</i>	Yes
Plant	Hanging fork fern	<i>Tmesipteris norfolkensis</i>	No
Plant	Norfolk Island caterpillar orchid	<i>Phreatia limenophylax</i>	Yes
Plant	Norfolk Island water fern	<i>Blechnum norfolkianum</i>	Yes
Plant	Shieldfern	<i>Lastreopsis calantha</i>	Yes
Plant	Mountain procris	<i>Elatostema montanum</i>	Yes
Plant	Pyramid mulla-mulla	<i>Ptilotus pyramidatus</i>	No
Plant	Pungent leek orchid	<i>Prasophyllum olidum</i>	No
Plant	Graveside leek orchid	<i>Prasophyllum taphanyx</i>	No
Plant	Spider net grevillea	<i>Grevillea thelemanniana</i>	No
Plant	Stirling Range beard heath	<i>Leucopogon gnaphalioides</i>	No
Plant	Hairy coprosma	<i>Coprosma pilosa</i>	Yes
Plant	Yellow mountain bell	<i>Darwinia collina</i>	No
Plant	Green mistletoe	<i>Ileostylus micranthus</i>	No
Plant	Norfolk Island clematis	<i>Clematis dubia</i>	Yes
Plant	Norfolk Island euphorbia	<i>Euphorbia norfolkiana</i>	Yes
Plant	Netted brakefern	<i>Pteris zahlbruckneriana</i>	Yes
Plant	Evan's Norfolk Island daisy	<i>Senecio evansianus</i>	Yes
Plant	Shade tree	<i>Melicope littoralis</i>	No
Plant	Norfolk island mahoe	<i>Melicytus latifolius</i>	Yes
Plant	Native cucumber	<i>Zehneria baueriana</i>	Yes
Plant	Pink mountain bell	<i>Darwinia squarrosa</i>	No
Plant	Mossman fairy orchid	<i>Oberonia attenuata</i>	No
Plant	Stirling Range latrobea	<i>Latrobea colophona</i>	No
Plant	Swamp starflower	<i>Calytrix breviseta subsp. breviseta</i>	No
Plant	Maroon-flowered Daviesia	<i>Daviesia glossosema</i>	No
Plant	Giant hypolepis	<i>Hypolepis dicksonioides</i>	Yes
Plant	King's brakefern	<i>Pteris kingiana</i>	Yes
Plant	Wongan eremophila	<i>Eremophila ternifolia</i>	No
Plant	Blue top sun-orchid	<i>Thelymitra cyanapicata</i>	No



## Key findings (continued)

### Ranking all species

When we combined extinction risk, surrogacy and cost, we found that the top 30 ranked species included 20 birds, eight plants and two mammals. Of these, 13 are already being monitored to some extent.

Generally, highly ranked species were inexpensive to survey because relatively few sites are needed to detect population trends with high levels of statistical power. Highly ranked species also tended to be good surrogates for others. We estimated that to monitor all

1893 species listed as threatened under the EPBC Act would cost around \$307 million annually. When we removed species that are already being monitored from the calculation, the cost was reduced to \$148 million.

**Table 3:** Top 30 ranked EPBC listed species based on extinction risk, surrogacy and cost. Please see the project 7.5 report “A prioritisation of threatened species monitoring in Australia” for full details of how these lists were generated including the underlying assumptions.

Group	Common name	Scientific name	Already monitored?
Bird	Great knot	<i>Calidris tenuirostris</i>	Yes
Plant	Small-flowered snottygobble	<i>Persoonia micranthera</i>	No
Plant	Cactus dryandra	<i>Banksia anatona</i>	No
Bird	Short-nosed sand plover	<i>Charadrius mongolus</i>	No
Bird	Far eastern curlew	<i>Numenius madagascariensis</i>	Yes
Bird	Greater sand plover	<i>Charadrius leschenaultii</i>	Yes
Plant	Bayonet spider orchid	<i>Caladenia gladiolata</i>	No
Bird	Curlew sandpiper	<i>Calidris ferruginea</i>	Yes
Plant	Woolcock’s spider orchid	<i>Caladenia woolcockiorum</i>	No
Plant	Pink-lipped spider orchid	<i>Caladenia behrii</i>	No
Bird	Red knot	<i>Calidris canutus</i>	No
Plant	Isoglossa	<i>Isoglossa eranthemoides</i>	Yes
Mammal	Dibbler	<i>Parantechinus apicalis</i>	Yes
Plant	Large-fruit groundsel	<i>Senecio macrocarpus</i>	Yes
Bird	Kangaroo Island glossy black-cockatoo	<i>Calyptorhynchus lathami halmaturinus</i>	Yes
Bird	Orange-bellied parrot	<i>Neophema chrysogaster</i>	Yes
Plant	Albany cone-bush	<i>Isopogon uncinatus</i>	No
Plant	Maxwell’s grevillea	<i>Grevillea maxwellii</i>	No
Plant	Pungent leek orchid	<i>Prasophyllum olidum</i>	No
Plant	Graveside leek orchid	<i>Prasophyllum taphanyx</i>	No
Plant	White lace orchid	<i>Phreatia paleata</i>	Yes
Plant	Wild’s Daintree spleenwort	<i>Asplenium wildii</i>	No
Plant	Hanging fork-fern	<i>Tmesipteris norfolkensis</i>	No
Plant	Midlands buttercup	<i>Ranunculus prasinus</i>	No
Plant	Norfolk Island caterpillar orchid	<i>Phreatia limenophylax</i>	Yes
Plant	Norfolk Island water fern	<i>Blechnum norfolkianum</i>	Yes
Plant	Tonsil orchid	<i>Vrydagzynea grayi</i>	No
Plant	Australian chingia	<i>Chingia australis</i>	No
Mammal	Leadbeater’s possum	<i>Gymnobelideus leadbeateri</i>	Yes
Plant	Black-tipped spider orchid	<i>Caladenia anthracina</i>	No



## Key findings (continued)

### Ranking of species with cost sharing

If species belong to the same taxonomic group (e.g., birds, mammals, fish), and if they can be detected using the same sampling methods, then the cost

of monitoring can be shared among them. We estimated that the annual cost of monitoring all species listed under the EPBC Act with cost sharing would be \$179 million.

If we take out species that are already being monitored, this total

estimated cost was reduced to \$74 million. The top 30 ranked species under this scenario were mostly plants, with a few exceptions: two mammals (both listed as Vulnerable) and five birds (four Vulnerable and one Critically Endangered).

**Table 4:** Top 30 ranked EPBC listed species that are yet to be monitored with cost sharing. Please see the project 7.5 report *"A prioritisation of threatened species monitoring in Australia"* for full details of how these lists were generated including the underlying assumptions.

Group	Common name	Scientific name	Already monitored?
Mammal	Pilbara leaf-nosed bat	<i>Rhinonicteris aurantia</i> (Pilbara form)	Yes
Bird	Antipodean albatross	<i>Diomedea antipodensis</i>	No
Bird	Hooded robin (tiwi islands)	<i>Melanodryas cucullata melvillensis</i>	Yes
Plant	Mount Compass oak-bush	<i>Allocasuarina robusta</i>	Yes
Mammal	Yellow-bellied glider (Wet Tropics)	<i>Petaurus australis Wet Tropics subspecies</i>	Yes
Bird	Shy albatross	<i>Thalassarche cauta cauta</i>	Yes
Bird	Hooded plover	<i>Thinornis rubricollis rubricollis</i>	No
Plant	Ralston's leionema	<i>Leionema ralstonii</i>	No
Plant	Mount Compass swamp gum	<i>Eucalyptus paludicola</i>	No
Plant	Brandy Mary's leek orchid	<i>Prasophyllum innubum</i>	No
Bird	Buller's albatross	<i>Thalassarche bulleri</i>	No
Plant	Wingello grevillea	<i>Grevillea molyneuxii</i>	Yes
Plant	Mt Barney bertya-shrub	<i>Bertya ernestiana</i>	No
Plant	Torrington pea	<i>Almaleea cambagei</i>	No
Plant	Granite Belt phebalium	<i>Phebalium whitei</i>	Yes
Plant	Granite kardomia	<i>Kardomia granitica</i>	Yes
Plant	Torrington beard-heath	<i>Leucopogon confertus</i>	Yes
Plant	Frankston spider orchid	<i>Caladenia robinsonii</i>	Yes
Plant	Lilac leek orchid	<i>Prasophyllum colemaniae</i>	No
Plant	Granite boronia	<i>Boronia granitica</i>	Yes
Plant	Macnutt's wattle	<i>Acacia macnuttiana</i>	Yes
Plant	Crescent-leaved homoranthus	<i>Homoranthus lunatus</i>	No
Plant	Ovenden's ironbark	<i>Eucalyptus caleyi subsp. ovendenii</i>	No
Plant	Dwarf spider orchid	<i>Caladenia pumila</i>	No
Plant	Small helmet orchid	<i>Corybas montanus</i>	No
Plant	Snowy River westringia	<i>Westringia cremnophila</i>	No
Plant	Mountain mouse bush	<i>Homoranthus montanus</i>	Yes
Plant	Bordered heath	<i>Epacris limbata</i>	Yes
Plant	Bunya Mountains bluegrass	<i>Bothriochloa bunyensis</i>	No
Plant	Black-clubbed spider orchid	<i>Caladenia atroclavia</i>	No





## Implications

Despite its great economic wealth, relatively good governance and world-class scientific expertise, Australia does not adequately invest in the management or monitoring of its most imperilled species.

Cost-efficient monitoring will improve our understanding of the status and trends of species, while informing management decisions about them. Our prioritisation approach can be applied to a large number of species and is data-driven, not relying on expert opinion. We showed that by combining both transparent expenditure and extinction risk, decision-makers can make rational, efficient and informed prioritisation choices about which species to monitor that maximise conservation outcomes.

Regardless of the approach and method that we used, plants consistently ranked highly in the top set of indicator species. Plants make up the majority of listed threatened species, score highly for surrogacy and are abundant at monitoring sites, meaning that fewer sites are

required to detect declines.

Within other groups, the species that provided the greatest benefit for many other species tended to rank highly for monitoring prioritisation.

To our knowledge, this was the largest number of species used in continental-scale modelling, and the first such attempt to focus on monitoring. We estimated that monitoring all of Australia's species listed under the EPBC Act, so that we can detect small to moderate declines with high (80%) power, would cost \$179–307 million per year, depending on the extent of cost-sharing.

Until all species can be effectively monitored, prioritisation methods that maximise efficiency will be necessary. This is due to the limited availability or allocation of resources toward conservation. Our approach provides an estimate of how much it might cost to monitor all species listed under the EPBC Act in Australia, and provides a way to rank species when only the strictest budgets are available to monitor them.



Monitoring helps us to understand the status, distribution and trends of threatened species. Macquarie University PhD student Tom Pyne, undertaking a flora survey in Ku-Ring-Gai National Park NSW. Image: Rachel Gallagher

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## Further Information

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