

Priorities and paradigms: directions in threatened species recovery

Sue V. Briggs

NSW Department of Environment and Climate Change, c/- CSIRO Sustainable Ecosystems, GPO Box 284, Canberra ACT 2601, Australia

Keywords

Threatened species; threats; population paradigms; recovery priorities; cost-effectiveness.

Correspondence

Sue V. Briggs, NSW Department of Environment and Climate Change, c/- CSIRO Sustainable Ecosystems, GPO Box 284, Canberra ACT 2601, Australia. Tel: +61 262421621; fax: +61 262421555. E-mail: sue.briggs@csiro.au

Received: 12 September 2008; accepted 10 February 2009.

doi: 10.1111/j.1755-263X.2009.00055.x

Abstract

Recovering threatened species is a key challenge for conservation managers, policy makers, and researchers. This article describes a practical framework for assigning priorities for recovery of threatened species according to cost-effectiveness of recovery strategies for species groups. The framework has the following steps: (1) determine the conservation goal—persistence in the wild of the largest number of threatened species with the funds available; (2) assign threatened species to species recovery groups according to their characteristics and threats—small-population species that require actions at sites and declining-population species that require actions across landscapes; (3) identify the recovery strategies and their component actions for the species groups; (4) cost the recovery strategies for the species groups; (5) determine the cost-effectiveness of the recovery strategies for the species groups—the number of species recovered divided by the cost of the strategies; (6) assign priorities to the recovery strategies according to their cost-effectiveness; (7) allocate funds to the recovery strategies that maximize the number of threatened species recovered for the funds available; and (8) undertake the funded recovery strategies and actions. The framework is illustrated with an example.

Introduction

Recovering threatened species presents substantial challenges. Over 1,350 taxa (including some geographically defined taxa) are listed as *Threatened* or *Endangered* at continental scale in the United States, and almost 1,600 taxa are listed as *Critically Endangered*, *Endangered*, or *Vulnerable* at national level in Australia. Worldwide, over 16,000 species are classified as *Critically Endangered*, *Endangered*, or *Vulnerable* by the IUCN (2008a). Resources for threatened species are limited and all recovery actions cannot be undertaken for all threatened species (Mann & Plummer 1992; Marris 2007; Joseph *et al.* 2008). In many instances, only the most threatened, politically sensitive, charismatic, or other highly valued species receive adequate or any funding for recovery through formal assignment of priorities or other processes (see Metrick & Weitzman 1998; Miller *et al.* 2002; Restani & Marzluff 2002; Garnett *et al.* 2003; Mace *et al.* 2007; Joseph *et al.* 2008).

Regardless of the criteria used, assigning priorities for recovery of species without considering cost-effectiveness is inefficient (Murdoch *et al.* 2007; Joseph *et al.*, in press). Failure to consider cost-effectiveness of recovery actions implies that the budget is large enough to fund recovery of all species (Joseph *et al.* 2008, in press). This assumption is untrue. Recovery programs based on this assumption waste resources and potentially lead to loss of more species. Priorities for funding recovery of threatened species should maximize cost-effectiveness, to recover the maximum number of species per dollar available (Possingham *et al.* 2002a, 2002b; Marris 2007; Wilson *et al.* 2007; Joseph *et al.*, in press), i.e., maximize the sum of persistence probabilities over time according to the funds available. Recovery is defined as reducing extinction risk to negligible by applying recovery actions so that the species persists in the wild, where the probability of the species recovering without the actions is zero (or close to zero) and the probability of the species recovering with the actions is one (or close to one). Persistence

is defined as persistence over time such that the risk of extinction of the species is negligible, i.e., the probability of persistence over time is one or close to one.

Priorities need to be assigned so that funds for recovery of threatened species are used cost-effectively. This article describes a simple and practical framework for assigning priorities for recovery of threatened species based on benefits and costs of recovery strategies for groups of species. An example is used to illustrate the framework. The term “threatened species” is used in the main body of the article to comprise *Threatened*, *Critically Endangered*, *Endangered*, and *Vulnerable* species listed by a jurisdiction or identified by the IUCN (2008b). In the example, “threatened species” means species listed as *Critically Endangered*, *Endangered*, or *Vulnerable* under the NSW Threatened Species Conservation Act (NSW Government 1995). *Critically Endangered*, *Endangered*, and *Vulnerable* species listed under the NSW Threatened Species Conservation Act face a high or greater risk of extinction in New South Wales in the medium term or sooner (NSW Government 1995).

Framework for assigning priorities for threatened species recovery

The framework for assigning priorities for threatened species recovery has three elements. The first step in the framework is to place threatened species in recovery groups according to the characteristics of the species and the threats they face. Many species suffer from similar threats and thus require similar recovery strategies. The second step is to identify recovery strategies for the species recovery groups. Recovery strategies typically include several recovery actions. The third step is to assign priorities to the recovery strategies according to their cost-effectiveness to ensure persistence of the greatest number of threatened species for the funds available.

Species recovery groups

Species recovery groups are groups of threatened species with similar characteristics subject to similar threats that require similar recovery strategies. Given & Norton (1993) assigned threatened plant species in a region of New Zealand to five groups based on their characteristics, and Burgman *et al.* (2007) assigned threatened Australian plants into four groups with similar threat syndromes.

I assigned threatened species to two broad recovery groups according to their characteristics and threats using modified versions of the small- and declining-population paradigms of Caughley (1994). The small-population paradigm deals with the effect of smallness

as a threat in itself on the persistence of a population; the declining-population paradigm deals with the causes of falling population size (threats) and their cure (recovery actions). Small populations are at risk from smallness itself due to chance events, catastrophe and environmental stochasticity, and loss of genetic variation and social structure (Caughley 1994; Caughley & Gunn 1996). Declining species have falling population sizes and are at ongoing risk from the threats causing the decline (Caughley 1994; Caughley & Gunn 1996). Threats need to be removed from small populations that have declined as well as from declining populations that are not (yet) small. Any species that declines to low levels becomes subject to risks from smallness; a species whose numbers fall below the minimum viable population size is at imminent risk of extinction (Caughley 1994).

These paradigms were used to place species into two recovery groups. Small-population species have specific habitat needs, narrow ranges, low numbers and small local populations, and are subject to local threats at site scale. Small-population species are usually plants or sedentary fauna such as flightless birds or invertebrates. Declining-population species occur across the landscape and are often mobile, either migratory or nomadic. Declining-population species have larger ranges and/or are more widespread than small-population species. They are declining due to threats at landscape scales, often habitat loss or degradation. Declining-population species are usually mammals, birds, or fish. Wide-ranging species with specific habitat needs at sites during a stage of their life cycle are placed in both groups.

Recovery strategies

The two species recovery groups require different recovery strategies (Table 1). Recovery strategies (e.g., site protection) comprise one or more recovery actions (e.g., fencing and signs). Small-population species require protection and management at sites to ameliorate threats, and may also require population augmentation to reduce the risk of local, and ultimately complete, extinction by chance events or loss of genetic heterozygosity. Declining-population species require management at landscape or seascape scales, usually involving amelioration of threats and rehabilitation of habitats. Declining species that fall to low numbers become subject to smallness as a threat in itself, and they require management of key habitat elements and possibly population enhancement to avoid risk of extinction.

Recovery strategies and actions for small-population species are mainly site protection by fencing and signs (or by more subtle means where the species is subject to illegal collecting) and site management to restore

Table 1 Recovery strategies for the two recovery groups of threatened species. Recovery strategies are groups of recovery actions. Small population species are sedentary species, usually with specific habitat requirements, narrow ranges, small local populations, and are subject to local threats. Declining population species are mobile species with larger ranges and/or distributions, and are declining due to threats, often habitat loss or degradation at landscape scales. Some species may be assigned to both groups. In addition to the recovery strategies listed below, both groups of species may require targeted research, education, regulations and planning advice, surveys and monitoring, recovery coordination, reviews of conservation status, and conservation covenants to protect and/or manage habitats. The recovery strategies were adapted from the New South Wales Priority Action Statement for threatened species (NSW Department of Environment and Climate Change 2007)

Recovery strategies	Small pop. species	Declining pop. species	Comment
Site protection	X		At identified sites where species occurs
Captive husbandry/ex-site propagation	X		If required
Translocation/reintroduction	X		If required
Site management—fire, feral animals, weeds, grazing, fertilizer	X	X	At identified sites for small pop. spp.; where required in habitats across the landscape for declining pop. spp.
Removal/management of direct anthropogenic threats	X	X	Removal of direct threats at sites is required for small pop. spp.; management of direct threats at landscape scale (removal if possible) is required for declining pop. spp.
Habitat rehabilitation/management across landscape		X	Habitat management across the landscape is essential for declining pop. spp.; habitat management for small pop. spp. can be coordinated across sites if required

habitat or remove threats (e.g., fire and grazing management, control of feral animals and weeds) (Table 1). Captive husbandry or propagation followed by translocation and rehabilitation may be required. Actions for small-population species are usually species specific. Sometimes actions need to be coordinated across sites, but actions at individual sites often suffice. An example of a small-population species is salt pipewort (*Eriocaulon carsonii*), which occurs at a handful of sites in inland southeastern Australia. Specific actions at these sites such as fencing to control stock grazing are required for its recovery (NSW Department of Environment and Climate Change 2008a).

The main recovery strategies and actions for declining-population species are removal of threats and habitat rehabilitation and management across the landscape (Table 1), such as restoring connectivity and improving habitat condition typically by encouraging participation of landholders in habitat rehabilitation through incentive schemes. Actions for declining-population species are usually applied for the suite of species in a region. Declining-population species can require management at specific nesting or other sites, but management at a few sites alone will not enable their recovery unless degradation or loss of habitat at the sites is the limiting factor for their breeding or survival and their other habitat is not diminished. In these circumstances, declining-population species become small population species where smallness of the breeding population becomes the threat in itself.

The regent honeyeater (*Xanthomyza phrygia*) is an example of a declining-population species; it moves across southeastern Australia with defined breeding areas. Actions across its range to enhance food resources (largely nectar from certain tree species) including in its breeding areas, are required for its recovery (NSW Department of Environment and Climate Change 2008b).

Example of assigning priorities for threatened species recovery

Background information and assumptions

The example region is the Central West Catchment Management Authority area (CW CMA) in New South Wales, Australia. CW CMA covers 85,000 km² (NSW Department of Environment and Climate Change 2008c). Native vegetation covers approximately 40% of CW CMA, comprising around 16,500 km² of native woody vegetation and an estimated 16,500 km² of native non-woody vegetation (the latter figure was adjusted to take account of the large area of “indeterminate” non-woody cover in the CW CMA) (NSW Department of Environment and Climate Change 2008c). Land uses are mostly cropping, grazing by domestic livestock and small urban areas. Broad-scale clearing has ceased, but degradation and loss of threatened species habitats continues at site and landscape scales. The region is typical of an inland catchment area in southeastern Australia.

One hundred and seven terrestrial species (plants and animals) listed as *Vulnerable*, *Endangered*, or *Critically Endangered* in New South Wales (i.e., threatened species) occur in CW CMA (NSW Department of Environment and Climate Change 2008d). The threatened species in CW CMA were assigned to the small-population group and/or to the declining-population group according to their characteristics (NSW Department of Environment and Climate Change 2008d, 2008e) resulting in 59 small-population species, 42 declining-population species, and four species in both groups (two threatened species that very rarely visit CW CMA were excluded from the calculations). Small-population species were estimated to occur at an average of 20 sites each, with an average area of 50 ha per site (total area of 630 km²), based on information in recovery plans (NSW Department of Environment and Climate Change 2008f) and in NSW Department of Environment and Climate Change (2007, 2008d, 2008e), and assuming that approximately half the sites where the species occur are currently recorded. Management at all sites is required for recovery of these species.

Half the remaining native vegetation in the region was estimated to be a potential habitat for the suite of declining-population threatened species in CW CMA at landscape scale (16,500 km²), based on vegetation communities and habitat features (NSW Department of Environment and Climate Change 2008d, 2008e). Thirty percent of this habitat needs to be managed to recover declining-population threatened species in CW CMA. This is estimated from the proportion of potential habitat in CW CMA (50%–80%) that is currently suboptimal for most declining-population threatened species (based on information on habitat condition in Austin *et al.* 2000; Seddon *et al.* 2002; Metcalfe *et al.* 2003; Thackway & Lesslie 2006; and Zerger *et al.* 2009), improving 30% of habitat will raise the proportion of optimal habitat for declining-population threatened species in CW CMA to at least 50% which will provide habitat for 90% of the species (species–area relationship, exponent of 0.15, Rosenzweig 1995), and some declining-population threatened species can use suboptimal habitat (NSW Department of Environment and Climate Change 2008d).

For simplicity, each threatened species was assigned the same value (species value or species weight sensu Joseph *et al.*, in press) and therefore all species had equal weighting. Also for simplicity, the probability of successful implementation of the recovery strategies and their component recovery actions (likelihood of success sensu Joseph *et al.*, in press), and the probability of recovering the species by applying the recovery strategies (biodiversity benefit sensu Joseph *et al.*, in press) were both as-

signed as one for all species. Implementation of the actions in the recovery strategies (Table 1) was assumed to lead to recovery of all species in the recovery groups, so that the probabilities of their persistence over time are all one. Small-population species were assumed to recover if the sites where they occur are protected, habitat at their sites is rehabilitated, threats preventing the recovery of the species at the sites are removed, and captive breeding and/or translocations are undertaken to enhance the population if required. Declining-population species were assumed to recover if limiting threats are removed and active habitat rehabilitation and management are undertaken at landscape scale to improve 30% of their habitat. Species assigned to both groups were included in the calculations for both groups.

Costs of the recovery strategies and component actions were based on information from Stoneham *et al.* (2003), Freudenberger *et al.* (2004), McCosker (2008), and from the web sites of the following organizations and programs: Queensland Department of Natural Resources and Water, Victorian Department of Sustainability and Environment, NSW Department of Environment and Climate Change, West 2000Plus, Western Catchment Management Authority, Murray Catchment Management Authority, Border Rivers-Gwydir Catchment Management Authority, Southern Rivers Catchment Management Authority, Queensland Murray Darling Committee, Adelaide and Mount Lofty Ranges Natural Resources Management Board, Natural Heritage Trust Envirofund, Bush Tender, and Plains Tender.

Assigning priorities to recovery strategies

Priorities for recovery of threatened species were assigned as follows (adapted from Murdoch *et al.* 2007; Wilson *et al.* 2007; Joseph *et al.*, in press) (summarized in Figure 1):

1. Define the conservation goal. The goal is persistence (recovery) of the greatest number of threatened species in the region with the available funds.
2. Assign threatened species to the small-population or declining-population species recovery group based on their characteristics and threats—sedentary or mobile, specific or general habitat requirements, small isolated populations or widespread, subject to specific local or diffuse larger scale threats. Species that are broad ranging with specific habitat needs at a stage of their life cycle may be assigned to both groups.
3. Identify the recovery strategies for the species groups. The recovery strategies may comprise several recovery actions. Only actions that are essential for the species recovery should be identified.

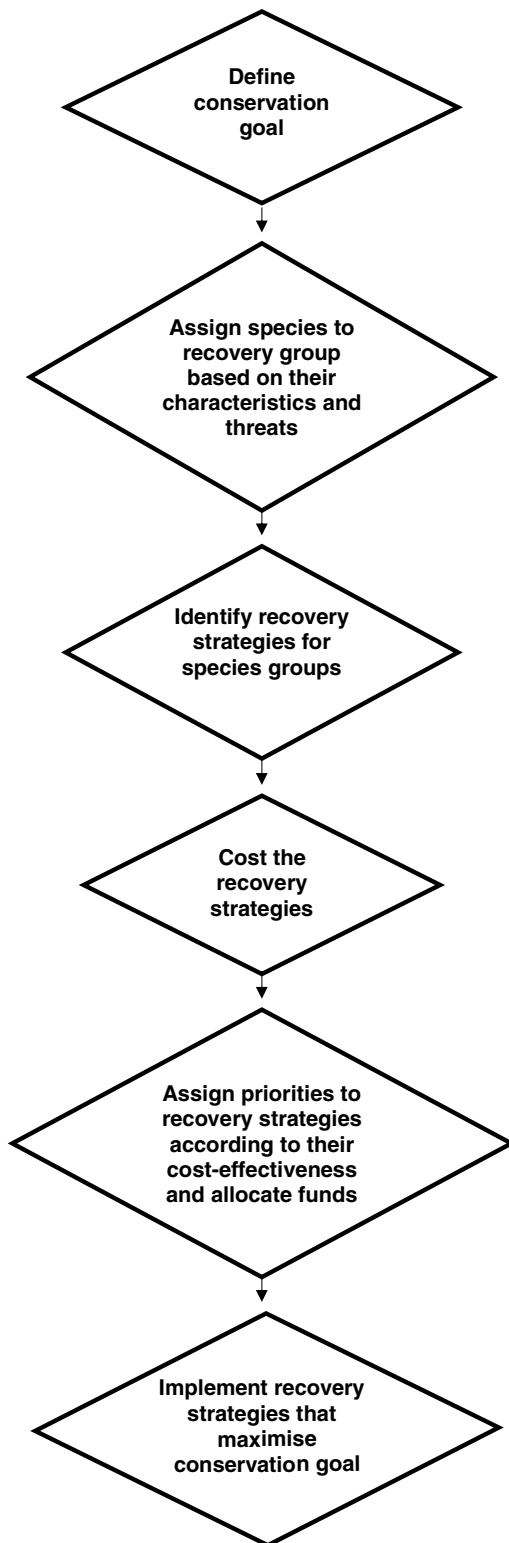


Figure 1 Summary of framework for assigning priorities to recovery strategies for threatened species. Cost-effectiveness is the number of species recovered from the actions in the recovery strategy divided by the cost of the actions.

4. Cost the actions in the recovery strategies for the small- and declining-population species groups.
5. Determine the cost-effectiveness of the recovery strategies for the species groups, i.e., the number of species recovered from the actions in the recovery strategy divided by the cost of the actions.
6. Assign priorities to the recovery strategies for the species groups according to their cost-effectiveness.
7. Allocate funds to the recovery strategies and actions that maximize the number of threatened species recovered per dollar spent, i.e., the strategies and actions that ensure persistence of the greatest number of species in the region for the available funds.
8. Undertake the recovery strategies and actions according to the allocated priorities.

Calculations

Recovery costs for the 63 small-population threatened species (includes four species in both groups) are calculated as follows. Each species is estimated to occur at 20 sites with an average area of 50 ha per site (total area of 630 km²). Fencing 50% of the sites for all species (1,890 km fencing) at AU\$2,000 per km equals AU\$3.8 million. Signage at 50% of the sites for all species at \$5,000 per site equals AU\$3.2 million. Fox, pig, and/or rabbit control at all sites for 15 species at \$5 per ha per year equals AU\$75,000 per year. Weed control at all sites for 30 species at AU\$10 per ha per year equals AU\$300,000 per year. Breeding or propagation programs and/or translocation for six species at AU\$200,000 per species per year equals AU\$1.2 million per year. Incentive funds provided at 10% of sites for all species (6,300 ha) at AU\$100 per ha per year equals AU\$630,000 per year. Incentive funds are required at a minority of sites for small-population species because their area requirements are relatively small, landholders often (but not always) view their protection favorably and are willing to forgo income from small areas of their land, and many sites with small-population species are on public land. Five people required to administer the recovery program and undertake landholder and community consultation at AU\$100,000 per person per year equals AU\$500,000 per year. The total cost over 3 years is therefore AU\$15.2 million. This equates to an average cost per species of AU\$420,000.

Recovery costs for the 46 declining-population species (includes four species in both groups) are calculated as follows. Thirty percent of the remaining habitat for declining population species is managed for their recovery through incentive schemes for landholders. The incentive schemes pay for management actions to improve habitats to recover declining population species at landscape

scale, usually management or exclusion of grazing by domestic stock, retention and management of native vegetation, revegetation and regeneration, fire management, weed and erosion control, and control of exotic herbivores and carnivores. Incentive funds for habitat management across 30% of remaining habitat of declining population species (4,950 per km) at AU\$200 per ha per year equals AU\$99 million per year. Five people required to administer the incentive scheme costed at AU\$100,000 per person per year equals AU\$500,000 per year. The total cost over 3 years is therefore AU\$298.5 million. This equates to an average cost per species of just under AU\$6.5 million.

Discussion

In the example provided, the greatest number of threatened species are recovered most cost-effectively by first allocating funds to recovery of small population species. Small population-species can be recovered for less than 10% of the cost of recovering the declining-population species in the example. This is mainly because declining-population species require landscape scale actions over large areas for their recovery whereas small-population species require actions over small areas at sites. In addition, actions for declining-population species are more expensive per ha (approximately AU\$600 over 3 years) than actions for small population species (approximately AU\$240 over 3 years) because costs of recovery actions at landscape scale involve higher forgone opportunity costs from production. These findings accord with those of Wilson *et al.* (2007), who found that actions which targeted specific threats were more effective for recovering threatened species than land acquisition (a landscape scale action) in areas with Mediterranean climates (similar to the climate in Central West CMA). Boyd *et al.* (2008) found that worldwide, one-fifth of threatened species require actions at single sites, two-thirds require management at a network of sites, almost one-fifth require site actions with some broad scale actions and a few species require broad scale actions alone. These authors concluded that site management should be the cornerstone for threatened species conservation, with management at landscape (or seascape) scales also required.

If there are insufficient funds for recovery of all small population species, then priorities among the species can be determined according to the value or weight (*sensu* Joseph *et al.*, in press) of individual species (where these differ), the likelihood of successful implementation of the recovery actions and the probability of recovery of the species (see Joseph *et al.*, in press), detailed costings of recovery actions for individual species, and the number of

species that can be recovered by the same actions at sites. Actions such as slashing, grazing management, and fertilizer control to recover several threatened grassland plant species would receive priority over a more expensive action such as captive propagation to recover one species. Some recovery actions may be cheaper or more expensive than estimated. Species may recover faster than expected, or be more difficult to recover than expected. In these situations, priorities may be re-assigned after review. If more funds are available than are required to recover small population species, then incentive schemes to recover habitat for declining population species can be undertaken, starting with the cheapest areas to run such schemes (assuming declining population species benefit equally from investment in cheaper areas as in more expensive areas).

Costs of recovering declining population species are related strongly to costs of incentive schemes for habitat management at landscape scale. If the incentive payments for habitat management for declining-population species were AU\$5 per ha per year (as in some extensive rangeland areas), rather than AU\$200 per ha per year as in the example, then the cost of recovering declining population species over 3 years would be AU\$9 million (around \$18 per ha), rather than almost \$300 million (around \$600 per ha). Costs of incentive schemes are less on lower value land, because forgone opportunity costs from production are less.

Funds are always insufficient for recovery of all threatened species, hence priority-setting frameworks are needed. The article provides a simple and practical framework for allocating priorities for recovery of threatened species, based on species characteristics and costs of recovery. The framework can be used to determine priorities for threatened species recovery for any region using generally available information and simple calculations. The sooner we implement cost-effective and transparent means of allocating priorities for recovery of threatened species, the greater the likelihood of maximizing the number of threatened species that are conserved.

Acknowledgments

I thank R. Southgate, P. Shaughnessy, L. Joseph, T. Celebrezze, and two referees for their comments on the manuscript and Liana Joseph for access to her submitted manuscripts. Costs of actions and incentive payments were accessed from the relevant web sites in December 2007, except the Queensland Department of Natural Resources and Water and the Border Rivers-Gwydir CMA web sites that were accessed in May 2008. This article was written in a personal capacity. Its contents do not

represent the official policy of the NSW Department of Environment and Climate Change, the NSW Government, or any other agency or organization.

References

- Austin, M.P., Cawsey E.M., Barry S.C. *et al.* (2000) *Establishing priorities for conservation and revegetation by predicting pre-1750 vegetation*. CSIRO Wildlife and Ecology, Canberra. Available from: <http://www.csw.csiro/publications/search.htm>. Accessed 20 January 2009.
- Boyd, C., Brooks T.M., Butchart S.H.M. *et al.* (2008) Spatial scale and the conservation of threatened species. *Conserv Lett* **1**, 37–43.
- Burgman, M.A., Keith D., Hopper S.D., Widyatmoko D., Drill C. (2007) Threat syndromes and conservation of the Australian flora. *Biol Conserv* **134**, 73–82.
- Caughley, G. (1994) Directions in conservation biology. *J Anim Ecol* **63**, 215–244.
- Caughley, G., Gunn A. (1996) *Conservation biology in theory and practice*. Blackwell Science, Cambridge, MA.
- Freudenberger, D., Harvey J., Drew A. (2004) Predicting the biodiversity benefits of the Saltshaker Project, Boorowa, NSW. *Ecol Manage Restor* **5**, 5–14.
- Garnett, S., Crowley G., Balmford A. (2003) The costs and effectiveness of funding the conservation of Australian threatened birds. *BioScience* **55**, 658–665.
- Given, D.R., Norton D.A. (1993) A multivariate approach to assessing threat and for priority setting in threatened species conservation. *Biol Conserv* **64**, 57–66.
- IUCN. (2008a) *Summary statistics for globally threatened species*. International Union for the Conservation of Nature and Natural Resources, Gland. Available from: <http://www.iucnredlist.org/static/stats>. Accessed 17 November 2008.
- IUCN. (2008b) *2001 categories and criteria (version 3.1)*. International Union for the Conservation of Nature and Natural Resources, Gland. Available from: http://www.iucnredlist.org/info/categories_criteria2001. Accessed 17 November 2008.
- Joseph, L.N., Maloney R.F., O'Connor S.M. *et al.* (2008) Improving methods for allocating resources among threatened species: the case for a new national approach in New Zealand. *Pac Conserv Biol* **14**, 154–158.
- Joseph, L.N., Maloney R.F., Possingham H.P. Evaluating costs, benefits and probability of success for threatened species management: a project prioritisation protocol. *Conserv Biol* in press.
- Mace, G.M., Possingham H.P., Leader-Williams N. (2007) Prioritizing choices in conservation. Pages 17–34 in D.W. Macdonald, K. Service, editors. *Key topics in conservation biology*. Blackwell Publishing, Oxford.
- Mann, C.C., Plummer M.L. (1992) The butterfly problem. *Atlantic Monthly* **269**, 47–70.
- Marris, E. (2007) What to let go. *Nature* **450**, 152–155.
- McCosker, J. (2008) Management of eucalypt woodlands in central Queensland. *Ecol Manage Restor* **9**, 2–3.
- Metcalf, L., Sivertsen D.P., Tindall D., Ryan K.M. (2003) Natural vegetation of the New South Wales wheat-belt (Cobar-Nyngan, Gilgandra, Nymagee-Narromine-Dubbo 1:250,000 vegetation sheets). *Cunninghamia* **8**, 253–284.
- Metrick, A., Weitzman M.L. (1998) Conflicts and choices in biodiversity preservation. *J Econ Perspect* **12**, 21–34.
- Miller, J.K., Scott J.M., Miller C.R., Waits L.P. (2002) The Endangered Species Act: dollars and sense. *BioScience* **52**, 163–168.
- Murdoch, W., Polanski S., Wilson K.A., Possingham H.P., Kareiva P., Shaw R. (2007) Maximising return on investment in conservation. *Biol Conserv* **139**, 375–388.
- NSW Department of Environment and Climate Change. (2007) *Introducing the threatened species priorities action statement*. NSW Department of Environment and Climate Change, Sydney. Available from: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/home.PAS_new.aspx. Accessed 16 November 2008.
- NSW Department of Environment and Climate Change. (2008a) *Austral pipewort—profile*. NSW Department of Environment and Climate Change, Sydney. Available from: <http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10276>. Accessed 17 November 2008.
- NSW Department of Environment and Climate Change. (2008b) *Regent honeyeater—profile*. NSW Department of Environment and Climate Change, Sydney. Available from: <http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10841>. Accessed 17 November 2008.
- NSW Department of Environment and Climate Change. (2008c) *NSW interim native vegetation extent (2008-version 1)*. Report and data prepared by NSW Department of Environment and Climate Change for the National Land and Water Resources Audit, Canberra. Project No. DONR 000397. NSW Department of Environment and Climate Change, Sydney. Available from: <http://www.nlwra.gov.au/products/PN21468>. Accessed 16 November 2008.
- NSW Department of Environment and Climate Change. (2008d) *Biobanking threatened species profile database*. NSW Department of Environment and Climate Change, Sydney. Available from: <http://www.environment.nsw.gov.au/biobanking/biobankingtspd.htm>. Accessed 16 November 2008.
- NSW Department of Environment and Climate Change. (2008e) *Threatened species profiles*. NSW Department of Environment and Climate Change, Sydney. Available from: <http://www.environment.nsw.gov.au/edresources/LINKINGDOCThreatenedSpeciesProfiles.htm> and <http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx>. Accessed 6 December 2008 and 29 January 2009.

- NSW Department of Environment and Climate Change. (2008f) *Recovery plans*. NSW Department of Environment and Climate Change, Sydney. Available from: <http://www.environment.nsw.gov.au/threatenedspecies/recoveryplans.htm>. Accessed 21 November 2008.
- NSW Government. (1995) *Threatened Species Conservation Act*. NSW Government, Sydney. Available from: <http://www.legislation.nsw.gov.au/scanview/inforce/s/1/?TITLE=%22Threatened%20Species%20Conservation%20Act%201995%20No%20101%22&nohits=y>. Accessed 22 October 2007.
- Possingham, H.P., Andelman S.J., Burgman M.A., Medellin R.A., Master L.L., Keith D.A. (2002a) Limits to the use of threatened species lists. *Trends Ecol Evol* **17**, 503–507.
- Possingham, H.P., Ryan S., Baxter J., Morton S. (2002b) *Setting biodiversity priorities: background paper for report 'sustaining our natural resources and biodiversity'*. Prime Minister's Science, Engineering and Innovation Council, Canberra, Australia. Available from: www.innovation.gov.au/ScienceAndResearch/prime_ministers_science.../setting_biodiversity_priorities_doc.aspx. Accessed 27 October 2008.
- Restani, M., Marzluff J.M. (2002) Funding extinction? Biological needs and political realities in the allocation of resources to endangered species recovery. *BioScience* **52**, 169–177.
- Rosenzweig, M.L. (1995) *Species diversity in space and time*. Cambridge University Press, Cambridge.
- Seddon, J., Briggs S., Doyle S. (2002) *Little river catchment biodiversity assessment*. National Parks and Wildlife Service, CSIRO Sustainable Ecosystems, Canberra. Available from: <http://www.environment.nsw.gov.au/projects/ManagingBiodiversityOnFarms.htm>. Accessed 29 January 2009.
- Stoneham, G., Chaudhri V., Ha A., Strappazzon L. (2003) Auctions for conservation contracts: an empirical examination of Victoria's Bush Tender trial. *Aust J Agric Res Econ* **47**, 477–500.
- Thackway, R., Lesslie R. (2006) Reporting vegetation condition using the Vegetation Assets, States and Transitions (VAST) framework. *Ecol Manage Rest* **7**, S53–S62.
- Wilson, K.A., Underwood E.C., Morrison S.A. *et al.* (2007) Conserving biodiversity efficiently: what to do, where and when. *PloS Biol* **5**(9), e223. doi: 10.1371/journal.pbio.0050223.
- Zerger, A., Gibbons P., Seddon J., Briggs S., Freudenberger D. (2009) A method for predicting native vegetation condition at regional scales. *Lands Urban Plan* in press.

Editor: Andrew Knight