Prioritising and evaluating biodiversity projects

Biodiversity is under threat globally, and in almost all nations. Habitat loss and habitat fragmentation occur due to a variety of factors including land use conversion, human population growth, urbanization, roads, and pollution. Invasive species are a threat to endemic species in almost all countries, but particularly in recently settled, and island nations. Rate of loss of species globally is estimated to be approximately 100,000 times higher than the natural background rate (Carroll et al. 1997). Of the 63,837 species assessed in the IUCN Red List of 2012, 3,947 species were described as "critically endangered", 5,766 as "endangered", and more than 10,000 species were listed as "vulnerable". At threat are 41% of amphibian species, 33% of reef-building corals, 30% of conifers, 25% of mammals, and 13% of birds (http://www.iucnredlist.org/news/securing-the-web-of-life accessed 23.3.2013). Almost all countries have set aside areas of habitat for species, particularly conservation reserves, marine reserves and national parks. Nations, regions and organizations take many types of actions to reduce threats, maintain or improve biodiversity. Management of areas, habitats or species require expenditure or incur costs. Worldwide, between US$0.10-0.15 billion is spent annually on the conservation of terrestrial biodiversity (McCarthy et al. 2012). Worldwide, the estimated annual cost of conserving all “known threatened species” is $3.41 - $4.76 billion (McCarthy et al. 2012). Those expenditures and the resources used are scarce, and taxpayers, citizens, funders are all aware there are alternative ways biodiversity conservation dollars might be used. Choice, either tacit or explicit, is required over which places to reserve and which actions to take.

The term conservation biology was first used at a conference held at the University of California in 1978 (http://en.wikipedia.org/wiki/Conservation_biology#Measuring_extinction_rates accessed 21.3.2013). In the 35 years since that conference, many hundreds of researchers and decision-makers have contributed time, effort and intellect developing ways to manage biodiversity. Conservation managers and researchers have wrestled with the challenge of deciding which areas to protect, which species to manage, which projects and plans to implement, since at least the mid-1980s. A wide range of tools, systems and methods have been proposed, developed and applied during the last 25-plus years to aid selection of reserves, projects and plans. More recently, there has been recognition of the importance of evaluating what biodiversity conservation payoffs are delivered by these various initiatives. The plethora of prioritisation and evaluation tools, systems and methods developed originated from diverse backgrounds: park managers intent on finding more systematic ways of selecting reserves; researchers who saw value in applying biology, ecology and mathematics to a policy problem; information scientists, statisticians, and modellers who saw opportunity to develop increasingly sophisticated databases and software to enable searches for optimal sites and actions; decision scientists and economists who saw the importance of quantifying both costs and benefits, however troublesome they may be to measure; and project evaluation practitioners who recognised the need to make tools practical and rigorous if they are to be both used and useful for biodiversity investors.

This Special Issue of Wildlife Research has assembled eight papers that address several aspects of biodiversity prioritization and evaluation. David Towns, Carol West and Keith Broome set the scene for prioritisation and evaluation with a focus on New Zealand's sustained invasive mammal eradication efforts. Via three case studies, they illustrate the nature, risks and scale of the challenge many nations face if they attempt to beat back the threats posed by invasive mammals. New Zealand, the last significant lands mass in the world to be inhabited by humans, has more than thirty introduced mammal species, many of which are serious threats to endemic wildlife and plants. Invasive mammal eradications … 'are aggressive conservation actions that can have wide benefits for biodiversity, but can also be controversial, technically demanding and expensive' (Towns et al. 2012, xxx). Their historical perspective highlights that judicious project choice can occur when there is a clear purpose for eradication efforts, unequivocal evidence of cause and effects of invasive mammals, appropriate technology for invasive mammal eradication, well documented and publicised evidence of benefits and costs, and a deep understanding of the social climate and values of local communities.

Budget-constrained decision makers tacitly or explicitly prioritise biodiversity protection expenditures. Ross Cullen reviews the panoply of approaches to prioritisation that have been advocated, developed, and applied during the last 25 years. Approaches to prioritisation have evolved as researchers from biology, ecology, decision sciences, mathematics, and economics have sought ways to achieve greater output from the resources available for biodiversity conservation. Choice of scale (global, national, regional, or patch) influences availability of data and methods available for prioritisation. Since 1986 availability of data, computing power, and expertise available have all improved globally and in many countries, allowing more sophisticated approaches to prioritisation. Cullen reviews the literature and groups prioritisation approaches into four categories: reserves and reserve selection; prescriptive costed biodiversity prioritisation**;** ranked costed biodiversity projects; and contracted costed conservation actions. Arguably, in 2013, prioritisation attention is focused more on 'action' than on 'place' and increasingly on quantified benefits and costs of biodiversity conservation actions.

Neil Perry addresses the Noah's Ark question of how to allocate limited funds to conservation projects. He notes there are many objectives that could be targeted in conservation projects, including species richness, persistence, taxonomic diversity, representativeness, species charisma, ecological importance and direct utility to humans, but these objectives are incommensurable. As well, there is uncertainty about the future value of species, interactions between species, and the probability of success of conservation projects. Perry argues that under those conditions, the precautionary principle is appropriate, and that decision makers should strive to minimise the maximum regret. When applied to the Noah's Ark problem, the conservation objective should be ecosystem resilience or functional diversity rather than maximising economic benefits.

David Pannell, Anna Roberts, Geoff Park and Jennifer Alexander outline how a practical, rigorous framework can be used for comprehensive evaluation and prioritisation of environmental projects. INFFER (Investment Framework for Environmental Resources) has been developed to assist environmental project investors design projects, select delivery mechanisms and rank projects on the basis of benefits and costs. The authors have drawn upon extensive evaluation experience, decision science and economic theory in the development and field-testing of INFFER. While some alternative evaluation methods are arguably flawed, INFFER provides a practical, effective and accurate tool to support decision-making about environmental projects.

Frameworks for economic evaluation need data on measured benefits and costs but obtaining that data is often problematic. Stephanie Shwiff, Aron Anderson, Ross Cullen, Piran White and Steven Shwiff identify the types of benefits and costs that are assigned to biodiversity projects and examine some of the newer techniques used to estimate their magnitudes. They note that financial costs are most often reported in evaluations, but opportunity and damage costs are frequently absent, likely leading to overstatement of investment returns. Monetisation of benefits from biodiversity investments to complete benefit cost analyses, is increasingly possible using a range of estimation methods. Incorporation of the spatial economic impact of biodiversity conservation projects can be incorporated through regional economic analysis and strengthen evaluations.

Helen Laycock, Dominic Moran, Dave Raffaelli, and Piran White examine the effectiveness and efficiency of species actions plans (SAP) within the UK. Cost effectiveness analysis, cost utility analysis and threat reduction assessment are used to assess the effectiveness and efficiency of 380 individual SAP. Of those techniques, cost effectiveness analysis was found to offer the best combination of ease of data collection and accuracy of data content. Subsequent statistical analysis is completed and reveals that both biological and operational factors affect cost, efficiency and effectiveness. Invertebrate plans tended to be less effective, whereas vertebrate plans were less efficient. The most successful SAP concerned species with short generation times and narrow distributions. Operational success is linked to concise and focussed SAP with clear lines of responsibility for implementation.

Spatial conservation prioritisation tools have been developed for tasks such as reserve selection and expansion. Atte Molainen demonstrates how existing, publicly available software, Zonation, can be applied to two new tasks, planning impact avoidance and biodiversity offsetting. Zonation can identify areas of highest and lowest conservation value in one analysis. Impact avoidance for development projects can be implemented by focusing environmentally harmful activities into low conservation-priority areas. By running a spatial prioritisation that integrates where species are, what features are damaged by development and the difference made by remedial action, Zonation can identify areas where extra conservation effort will maximally compensate for (offset) damage. The process of offsetting using Zonation is illustrated using a hypothetical example from the Hunter Valley, Australia.

Evaluation of biodiversity conservation is not an easy sell. Possingham (2012), himself an evaluation pioneer, observes it is difficult to sell evaluation to young ecology researchers. Ross Cullen and Piran White turn the spotlight on evaluation and check how much evaluation is published. They find a Web of Science search using the terms ‘biodiversity’, ‘project’ and ‘evaluation’ brings up 304 records since 2000. Clearly, some evaluation is occurring, but Cullen and White ask if substantial benefits would be gained from greater application of interdisciplinary approaches to evaluation. They select three recent articles on biodiversity evaluation, and examine their reference lists to determine the extent of interdisciplinarity in published studies of evaluation. The near absence of overlap between references cited in the three papers leads them to conclude that biodiversity project evaluation is currently developing along at least three, relatively distinct, pathways rather than as a genuinely interconnected research theme. Cullen and White argue that biodiversity conservation evaluation is unlikely to fulfil its potential unless biodiversity researchers seek to develop a more integrated community, and particularly to learn from researchers in other disciplines where evaluation has a longer history.

Biodiversity project prioritisation and evaluation can contribute to better-targeted and more cost-effective conservation action. The overall goal for the Special Issue is to inform readers of the paramount importance of project selection and evaluation, to review the range of selection and evaluation methods available, and to provide some insights on their merits, their challenges, potential, and where they are best applied. We hope this set of eight papers delivers on that objective.

Ross Cullen (Lincoln University, New Zealand), Piran White (University of York, UK),

References

Carroll, C.D., and Meffe, G.K. (1997). *Principles of conservation biology*. Sunderland, Mass: Sinauer

Cullen, R. (2012). Biodiversity protection: A 25 year review. *Wildlife Research*

Cullen, R. and White P.C.L. (2013). Interdisciplinarity in biodiversity project evaluation: a work in progress. *Wildlife Research*

Laycock, H.F., Moran, D., Raffaelli, D.G., and White, P.C.L. (2012). Biological and operational determinants of the effectiveness and efficiency of biodiversity conservation programs. *Wildlife Research*

McCarthy, D., Donald, P.F., Scharlemann, J.P.W., Buchana, G.M., Balmford, A., Green, J.M.H., Bennun, L.A., Burgess, N.D., Fishpool, L.D.C., Garnett, S.T., Leonard, D.L., Maloney, R.F., Morling, P., Schaefer, H.M., Symes, A., Weidenfeld, D.A. and Butchart, S.H.M. (2012) Financial costs of meeting global biodiversity conservation targets: current spending and unmet needs. *Science* 338, 946-949

Moilanaen, A. ((2012). Planning impact avoidance and biodiversity offsetting using software for spatial conservation prioritisation. *Wildlife Research*

Pannell, D.J., Roberts, A.M., Park, G., and Alexander, J. (2013). Designing a practical and rigorous framework for comprehensive evaluation and prioritisation for environmental projects. *Wildlife Research*

Perry, N. (2013). The precautionary principle, uncertainty and the Noah's Ark problem. *Wildlife Research*

Possingham, H. P. (2012) How can we sell evaluating, analyzing and synthesizing to young scientists?. *Animal Conservation* **15**, 229-230.

Shwiff, S.A., Anderson, A., Cullen, R., White, P., and Shwiff, S.S. (2012). Assignment of measurable costs and benefits to wildlife biodiversity conservation projects. *Wildlife Research*

Towns, D.R., West, C.J., and Broome, K.G. (2012). Purposes, outcomes and challenges of eradicating invasive mammals from New Zealand islands: an historical perspective. *Wildlife Research*