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Introduction

Prioritising and evaluating biodiversity projects

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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, urbanisation, 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 ~100 000 times higher than the natural background rate (Carroll and Meffe 1997). Of the 63 837 species assessed in the IUCN Red List of 2012, 3947 species were described as *Critically endangered*, 5766 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, verified 23 March 2013). Almost all countries have set aside areas of habitat for species, particularly conservation reserves, marine reserves and national parks. Nations, regions and organisations take many types of actions to reduce threats, maintain or improve biodiversity. Management of areas, habitats or species require expenditure or incur costs. Worldwide, the estimated annual cost of conserving all 'known threatened species' is US$3.41–4.76 billion (McCarthy *et al*. 2012). Those expenditures and the resources used are scarce, and taxpayers, citizens and funders are all aware that 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, verified 21 March 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 has been proposed, developed and applied during the past 25+ 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, including the following: 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 prioritisation and evaluation. Towns *et al*. (2013) set the scene for prioritisation and evaluation, with a focus on sustained efforts of invasive-mammal eradication in New Zealand. 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 land mass in the world to be inhabited by humans, has more than 30 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*. 2013, p. 94). 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. Cullen (2013) reviews the panoply of approaches to prioritisation that have been advocated, developed and applied during the past 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 (2013) reviews the literature and groups prioritisation approaches into the following 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 focussed more on 'action' than on 'place', and increasingly on quantified benefits and costs of biodiversity conservation actions.

Perry (2013) 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 among species and the probability of success of conservation projects. Perry (2013) 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.

Pannell *et al*. (2013) outline how a practical, rigorous framework can be used for comprehensive evaluation and prioritisation of environmental projects. Investment Framework for Environmental Resources (INFFER) 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 on 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; however, obtaining that data is often problematic. Shwiff *et al*. (2013) 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, whereas opportunity and damage costs are frequently absent, which is likely to lead to overstatement of investment returns. Monetisation of benefits from biodiversity investments to complete benefit–cost analyses is increasingly possible by 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.

Laycock *et al*. (2013) 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. Moilanen (2013) 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 that it is difficult to sell evaluation to young ecology researchers. Cullen and White (2013) turn the spotlight on evaluation and check how much evaluation is published. They find that 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 (2013) ask whether substantial benefits would be gained from a 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 (2013) 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.

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