FORUM ARTICLE

A unified approach to conservation prioritisation, reporting and information gathering in New Zealand

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Abstract: The biodiversity conservation task in New Zealand is considerable and complex, and effective prioritisation of conservation work, informative reporting, and efficient, well-targeted data gathering are essential. We propose an approach to biodiversity assessment for organisations implementing biodiversity conservation work in New Zealand that unifies (1) biodiversity conservation work prioritisation, (2) reporting on trend and difference made to biodiversity, and (3) gathering relevant biodiversity data for both. We argue that prioritisation and reporting are reciprocal assessment activities that share information needs and are best served by a common framework that links the current state of biodiversity and expectations of future persistence with pressures (e.g. habitat clearance, weeds and pests) and human conservation activities ('biodiversity conservation work', e.g. legal protection, pest control, restoration). We describe ideas that might underpin the approach, including diminishing returns, irreplaceability, and vulnerability. We distinguish reporting of net achievement (biodiversity change or trend) from reporting of difference made to biodiversity by conservation work, and argue that the latter is a basis for both prioritisation and reporting in operational conservation organisations. A unified approach to prioritisation and reporting would help clarify management organisations' total requirements for biodiversity inventory, monitoring and research; different organisations could develop and apply the approach in a variety of ways, but a shared approach to gathering the essential information would benefit all stakeholders.

Keywords: conservation assessment; conservation management; difference-made reporting; diminishing returns; inventory and monitoring; vulnerability

Introduction

Slowing the decline in New Zealand's indigenous biodiversity is a major and complex endeavour. A variety of private and public New Zealand organisations (central and local government agencies, conservation NGOs and trusts) currently allocate their resources to different types of biodiversity conservation work, including pest and weed control; native species cultivation, rearing, translocation and reintroduction; land reservation; engagement in RMA processes, public relations; and education. Many organisations also need to report periodically on biodiversity state and trends and the effects of conservation work and other human activities on them, and must gather information to do so. Stakeholders are increasingly requesting information on trends and the difference being made, in search of assurance that conservation funding is being wisely spent.

Prioritisation of conservation work and reporting on conservation achievement are both core conservation assessment activities, but are often conceived of and approached without a unifying logic. Therefore, information systems for reporting and prioritisation are often separated, and have uneven funding and maintenance. Here, we propose a unified approach to (1) prioritisation of biodiversity conservation work, (2) reporting of contribution to and progress towards a high-level goal, and (3) identifying the core biodiversity data and information required for both purposes.

The central theme of this article is that prioritisation and reporting are reciprocal assessment activities (i.e. 'flip sides of the same coin') that can be addressed within a single, common conceptual framework that links biodiversity, pressures from threats, and human management interventions ('conservation work'). We also suggest that a unified approach to prioritisation and reporting should clarify organisations' total requirements for biodiversity inventory, monitoring, and research, and bring efficiencies.

A second theme describes key ecological ideas needed for such an approach to be conceptually robust and operationally valuable. These include principles originating in international research, and local innovations reflecting New Zealand's distinctive biodiversity challenges. A third theme emerges: that effective biodiversity assessment would benefit from a shared approach to data gathering that would allow prioritisation and reporting to be developed, adapted, and implemented in diverse ways to meet users' various needs, while providing the necessary common contextual foundation.

Many of the ideas we present have received little attention in the New Zealand ecological literature and outside government agency work teams. We suggest the linked issues of conservation work prioritisation, reporting, and data requirements pose some demanding challenges, both theoretical and practical, that deserve more thorough consideration and wider engagement from the New Zealand ecological community. We hope this forum article will encourage further discussion and innovation.

Ideas and principles from international research

Principles of prioritisation from systematic conservation planning

Some of the building blocks of a common conceptual framework for conservation assessment in New Zealand are found in an area of research pioneered in Australia, now known as systematic conservation planning (SCP) (Margules & Pressey 2000; Moilanen et al. 2009). SCP was stimulated by realisations of retreating opportunity for representative protection of natural areas, the opportunity costs of 'ad hoc' reservation (Pressey 1994), and the inadequacy of scoring approaches for prioritisation (Margules et al. 1988; Pressey & Nicholls 1989).

Until quite recently, SCP focused almost solely on the design of networks of legally protected areas. New Zealand clearly needs a broader focus, because legal protection, though important, is insufficient alone to save much of its biodiversity. Here, the core challenge is how to make the greatest possible positive difference to biodiversity through a variety of conservation actions (including but not limited to establishment of protected areas) that alleviate and mitigate diverse and chronic pressures such as exotic pests, weeds, land clearance, and climate change. Although this is a more complex and difficult problem than simply 'where should we place our new reserves?', the ideas and principles developed in SCP seem appropriate for New Zealand's broader spectrum of conservation activities. Perhaps the most relevant of these ideas are (1) comprehensiveness and representativeness, (2) consideration of context and diminishing returns, and (3) irreplaceability and vulnerability.

Comprehensiveness, representativeness, context, and diminishing returns

The SCP idea of comprehensiveness and representativeness encapsulates the objective of persistence of the full variety of biodiversity, ideally at all levels of organisation (Austin & Margules 1986; Margules & Pressey 2000; Moritz 2002). This objective is reflected by the words 'a full range' in Goal 3 of the New Zealand Biodiversity Strategy ('NZBS'; DOC & MfE 2000) and we think the idea of comprehensiveness and representativeness is now well embedded in New Zealand conservation organisations, and itself requires little elaboration.

Nevertheless, prioritising conservation work to achieve comprehensive and representative protection (idea 1) requires attention to two key dimensions of context (idea 2): namely complementarity and scarcity. Complementarity is a measure of the novelty added by a new member to an existing set (Vane-Wright et al. 1991), and informs prioritisation by accounting for relatedness among biodiversity components. In SCP, actions that add most to total conserved diversity are preferred to those that protect the most diverse components. Sarcity context informs conservation prioritisation by identifying biodiversity components for which additional protection will make a greater marginal contribution to overall comprehensiveness and representativeness. The logic is that actions that secure scarce biodiversity are more valuable because they have larger marginal benefits than actions that secure more common biodiversity.

'Diminishing returns' describes a pattern in which biodiversity value or benefit added (or lost) is non-linear, and marginal value diminishes with successive additions. It applies in both complementarity and scarcity contexts. For example, in the complementarity context, if we are seeking to protect all community types (a notional 'full range'), and have so far protected just one type, the added (i.e. 'marginal') benefit of protection decreases both with each additional community type protected and with the similarity of the added community type to preceding types (e.g. overlap in environmental character and/or component species). In the scarcity context, more benefit (e.g. increased security of all community types) is gained from improvement (e.g. increased area protected) in a scarce (e.g. reduced or degraded) community type than from a similar-sized improvement in a common and widespread type.

While not understating the importance of diminishing returns with respect to complementarity (which is relatively well developed in the literature, e.g. Vane-Wright et al. 1991; Justus & Sarkar 2002; Wilson et al. 2009; Leathwick et al. 2010), our focus below is on diminishing returns with respect to scarcity.

Diminishing returns with respect to scarcity

The curve of diminishing slope that links benefit to scarcity in Fig. 1 is often called a 'value' or 'benefit' function in the literature (Arponen et al. 2005; Moilanen 2007). It can apply to loss as well as gain, and to multiple levels of biodiversity organisation. For example, it would apply *within* a single rail species (e.g. takahē *Porphyrio mantelli*), where the scarcity axis of Fig. 1 would represent total population size. Because extinction risk from stochastic processes attenuates rapidly, each successive takahē added to the population would provide

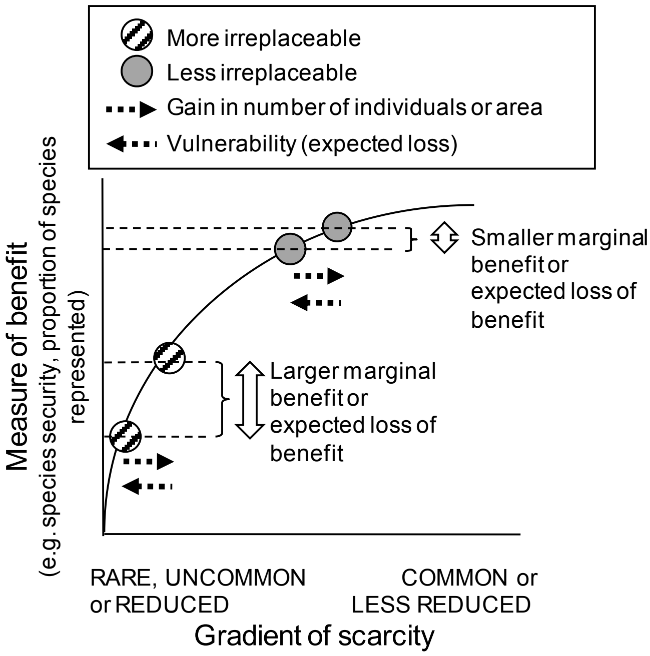

Figure 1. Pictorial representation of 'diminishing returns': the idea that value or benefit added (or lost) is non-linear with respect to scarcity. There is a greater marginal benefit (the movement up the vertical axis) for the same magnitude of gain (left-to-right movement represented by arrows) in a biodiversity component (e.g. species or community type) that is rare (hatched symbols at left) than in a common component (grey symbols at right). Irreplaceability is a proxy for the marginal value or benefit contributed by an increment protected; therefore, the scarcer biodiversity component on the left is more irreplaceable than the biodiversity component on the right.

less benefit (e.g. a smaller contribution to population viability) than its predecessors: the birth of a 10th takahē chick would provide less marginal benefit than the 9th, and the 100th chick less than the 99th. Conversely, loss of a single takahē would represent a more serious loss if only five birds remained rather than 500 or 5000.

At the next level up, diminishing returns would apply *among* New Zealand rail (Rallidae) species, with the horizontal axis of Fig. 1 representing a gradient from scarce to common. Gain or loss of 10 endangered takahē clearly results in a more significant change in benefit (vertical change, e.g. in the security of all rail species) than the gain or loss of 10 pūkeko (*Porphyrio porphyrio*, which are common and unthreatened) at the right.

Diminishing returns would also apply at the ecosystem or habitat level of biodiversity organisation; for example, the species–area relationship describes the diminishing number of species added with increasing habitat area. Shapes of diminishing returns curves may vary, but the general principle appears both intuitive and widely applicable in biological systems.

Combination of irreplaceability and vulnerability into a single measure of priority

In SCP, 'irreplaceability' serves as a proxy for marginal biodiversity value (i.e. benefit added or subtracted), whereas 'vulnerability' is a proxy for urgency: the risk that a biodiversity component will be gone tomorrow if not conserved today (Margules & Pressey 2000). In general, biodiversity that is both irreplaceable (a high proportion of what remains of its type) and vulnerable (imminently threatened with loss) is considered a top priority for conservation. An irreplaceable biodiversity component at little or no risk of loss is recognised as significant, but need not be prioritised to receive scarce conservation resources. This logic is sound and widely applied in SCP, but a single measure of priority combining the two dimensions has been slow to emerge.

A general method for combining irreplaceability and vulnerability to determine priority can be arrived at by way of the diminishing returns curve in Fig. 1 (Overton et al. 2010). Marginal benefit (vertical gain in Fig. 1) from a gain in a scarce biodiversity component exceeds that of the same gain in a common component, so scarce biodiversity is more irreplaceable. At the same time, vulnerability (expected loss or degradation over some defined time period) is the predicted horizontal movement right to left on Fig. 1. When scarce and more common biodiversity components are equally vulnerable, more benefit would be lost from the expected loss or degradation of more irreplaceable biodiversity. This formulation of priority is found in the Vital Sites and Actions (VSA) framework of Overton et al. (2010).

Effectiveness, cost, and difference made

In practice most conservation organisations do not prioritise biodiversity per se. Rather, they aim to prioritise their conservation work by choosing how to allocate resources among diverse opportunities for different conservation actions. These potential actions differ in many ways, but most importantly in their effectiveness (i.e. in the benefit they return for securing biodiversity) and their cost. Together, these attributes determine the cost-effectiveness of an action (i.e. the biodiversity benefit per dollar spent).

Effectiveness of biodiversity work as difference made

A logical basis for determining relative effectiveness across a diversity of conservation work was introduced by Stephens et al. (2002), in their Measuring Conservation Achievement (MCA) method. MCA demonstrated that conservation actions (called 'projects') could be prioritised on the basis of the difference made to a common measure of benefit (called 'site value'). In MCA, difference made was formulated as the sum of two benefits from conservation work: the benefit from loss averted, plus the benefit from gains made. Thus, projects were prioritised not on expected net achievement (trend, gain or loss) relative to the current state, but on their *additional* benefit relative to a business-as-usual scenario of expected ongoing loss under a suite of current and future pressures. The combination of diminishing returns, irreplaceability, and vulnerability in Fig. 1 extends this logic by providing a general approach to quantifying effectiveness (i.e. 'difference made') while simultaneously accounting for non-linearity.

This general approach is shown in Fig. 2. The principle applies to various levels of biodiversity organisation but again takahē provide an illustrative example at the species level. Without management, takahē (an irreplaceable and vulnerable biodiversity component represented by a symbol to the left of the horizontal axis) are expected to become even rarer. In Case 1 (top of Fig. 2), we assume they are managed (perhaps with pest control and captive breeding) so that precisely all loss is avoided but the population has not increased at the end of that period. Therefore, conservation management made a positive difference, which is the loss averted, although there has been no net population change. Case 2 (centre of Fig. 2) describes a more positive scenario: management not only averts all loss expected without management, but also increases the population above its initial size. Here, difference made by management is the benefit of loss averted plus the benefit of gains made. Case 3 (bottom of Fig. 2) describes a common New Zealand scenario where not all examples (e.g. populations of a species, sites supporting a habitat or community type) receive conservation management. Consequently, there is an overall decrease or decline despite management in a few places, but not to the extent expected with no management at all. Again, management would make a positive difference despite a net decrease (e.g. lower numbers of takahē overall), and the difference made is the consequent loss of benefit averted. As in Stephens et al. (2002), in all three of our notional cases, 'difference made' is the difference in some measure of benefit (e.g. security of species) with and without conservation management.

Cost-effectiveness as 'difference made per dollar'

Going one step further and dividing the expected difference made by cost enables prioritisation on the basis of expected difference made per dollar (cost-effectiveness). This allows the most cost effective work to be identified and prioritised for action (Stephens et al. 2002).

One implication clarified by considering diminishing returns when determining difference made is that added benefit (the amount of vertical movement in Fig. 2) declines with each additional increment of conservation gain achieved (horizontal movement in Fig. 2). Hence, the relative priority of undertaking additional work also decreases. In practice, this means that as a conservation organisation improves the security of a particular biodiversity component (e.g. reserving more hectares of a particular community type), the benefit per unit output from this work decreases with its success.

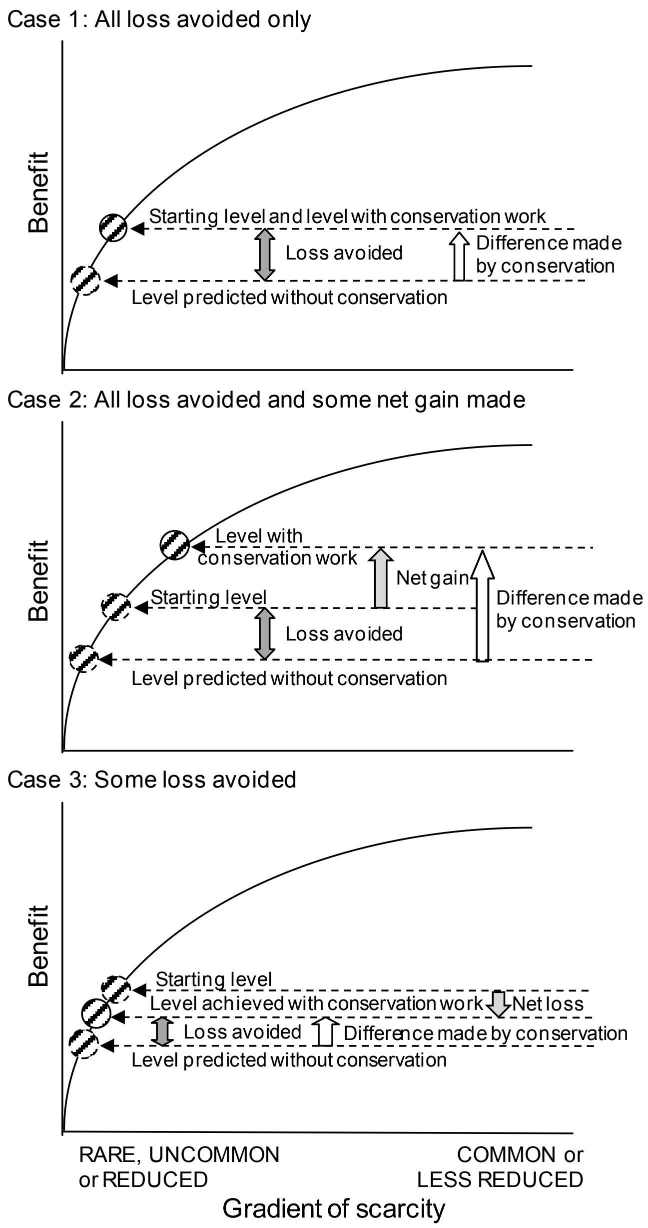

Figure 2. Three scenarios (Cases 1, 2 & 3) showing the difference made by conservation work to protect a relatively scarce and vulnerable biodiversity component (e.g. a species or a community or ecosystem type), assuming there are diminishing returns. In each case, difference made is the benefit retained because loss was avoided by conservation work, plus the net benefit gain from any net increase. Conservation work makes a positive difference in all scenarios despite no trend in Scenario 1 and net decline in Scenario 3.

At some point, Fig. 2 implies, there will be greater benefit in doing different conservation work to secure other, more irreplaceable and vulnerable biodiversity. Another implication of diminishing returns is that further increments of loss (once a certain community type has become rare) result in more loss of benefit than initial declines. This might suggest, perhaps non-intuitively, that there is less incremental benefit in an early intervention to halt early declines than in a later rescue effort, all other things (cost, feasibility, etc.) being equal.

However, because all other things are rarely equal, it may not be more cost effective to switch community, habitat or species targets, or to switch tactics, or to delay interventions. For example, conservation outputs may become cheaper with learning, or there may be economies of scale. Alternatively, early interventions may both avert more loss in total and be cheaper and simpler than rescue efforts after long-term persistence has been further compromised (e.g. population numbers have dwindled, habitats have been fragmented), or socio-economic factors have altered (e.g. land tenure and price, funding availability, and/or opportunities for community engagement). Therefore, difference made per dollar offers important advantages over difference made alone. In fact, there is growing awareness internationally that considering costs is not just helpful but vital for allocating conservation resources in order to halt as much biodiversity decline as possible; some argue this is as important for achieving biodiversity outcomes as incorporating heterogeneity of biodiversity benefits (Stephens et al. 2002; Naidoo et al. 2006).

Information requirements for prioritisation based on 'difference made'

Overall information requirements for implementing a diminishing-returns and difference-made approach to biodiversity prioritisation are implicit in Figs 1 and 2 and the above discussion. First, contextual biodiversity information (describing current scarcity and complementarity) is essential to position biodiversity components on the diminishing returns curve. Second, because prioritisation depends on forecasting to predict future scenarios, information to support robust prediction is required. Furthermore, forecasting has three components: prediction of (1) expected loss (vulnerability) of different biodiversity components without management (business-as-usual), (2) expected losses averted and gains made by various alternative management actions (projects), and (3) expected costs of the different alternatives. Finally, as relative priorities are fundamentally affected by the assumed rate of diminishing returns, appropriate shapes of diminishing returns curves must be determined.

Reporting to make a difference

Difference made as the basis for biodiversity reporting

As the name suggests, systematic conservation *planning* research has been concerned mainly with a priori prioritisation. Reporting on biodiversity has rarely been addressed from this perspective. However, conservation planning and reporting are related problems, and in New Zealand, Stephens et al. (2002), Walker et al. (2008) and, most recently, Overton et al. (2010) have shown the reciprocation of planning and reporting according to SCP principles. We reasoned that fundamental properties of biodiversity such as diminishing returns, and core planning considerations such as vulnerability, were as important for reporting on changes in biodiversity as for responsible prioritisation. Furthermore, we demonstrated that the same SCP-based measure of conservation benefit (i.e. difference made, incorporating context and forecasting) could be used both to choose the actions that provide the greatest benefit at least cost (prioritisation) and to report informatively on biodiversity conservation achievement.

The most common form of biodiversity reporting undertaken in New Zealand and internationally is 'net achievement' reporting (Stephens et al. 2002), also often called 'state and trend' or 'surveillance-style' reporting (Nichols & Williams 2006; Gardner 2010). This type of reporting is usually tackled by way of repeated measures of attributes (e.g. Lee et al. 2005; Mace & Baillie 2007) but not the concepts and principles used in SCP, such as diminishing returns, context, and vulnerability. 'Net achievement' reporting can provide vital quantitative information on state and trend that is currently lacking, but may also be insufficient on its own for the interpretation, accountability, and learning required by operational conservation organisations attempting to make a difference (e.g. Nichols & Williams 2006).

As an extreme example, in Fig. 3a we show simple net achievement biodiversity reporting that overlooks complementarity and scarcity contexts and diminishing returns. The two circular symbols might, for example, represent two 'selected habitats' from the Convention on Biological Diversity (CBD) headline indicator II ('trends in extent of selected biomes, ecosystems, and habitats'; Mace & Baillie 2007). Because change in extent is measured and reported only in the horizontal dimension of Fig. 3a, the indicator implies (perhaps unintentionally) the same change in each habitat makes an equal contribution to the biodiversity objective. We can see that one habitat has been reduced and another has increased by the same extent, but must guess the contribution of each change to the state of biodiversity. We might well assume that no net change in biodiversity status occurred.

In Fig. 3b, an augmented form of net achievement reporting considers scarcity context and attendant diminishing returns. Scaling gains and losses shows that gain in common habitat provided little difference to benefit, but loss of scarce habitat was a serious setback, and that biodiversity security declined overall. Going further to include complementarity context would be even more informative, showing how observed changes extended or eroded different dimensions of the 'full range' of biological life. We would still need to guess whether and how conservation initiatives contributed to the result (i.e. the difference made), however.

The trends in habitat extent (in Fig. 3a) and in benefit (in Fig. 3b) arise both from change that would have occurred irrespective of conservation and from differences made by conservation work. The two must be disentangled to identify the contribution of conservation work, and the true vulnerability of different habitats and associated potential benefit loss. This requires forecasting of expected loss without conservation action. For example, in Fig. 3c a forecast of vulnerability suggests conservation work avoided loss of the scarcer and more vulnerable habitat, and made an appreciable positive difference despite not halting all decline.

Figure 3 also shows that comparing both effectiveness and cost-effectiveness of past conservation projects also requires combination of change measurement, diminishing returns, and vulnerability forecasting. For example, if the common habitat at the right of Fig. 3b had negligible vulnerability, but had received similar funding to the rarer habitat on the left, reporting would show money had been better spent in the vulnerable rare habitat (which yielded more benefit, and more benefit per dollar, because of diminishing returns). Conversely, if conservation work had failed to avert any forecast loss in the rarer habitat, investment in the common habitat would have been more effective (and cost-effective).

'Robust' reporting and the forecasting conundrum

When operational organisations report state and trend without scaling or forecasting, they depend on inductive reasoning and retrospective analysis to elucidate the importance of observed changes and their likely causes. This approach can lead to incorrect conclusions. In our example of avoided loss of takahē (Fig. 2) decision-makers could be forgiven for assuming conservation management made no difference (Case 1 and Case 3 in Fig. 2), a small positive difference (Case 2), or directly caused net loss (Case 3). In all cases, benefits of conservation management (and effort and resources required

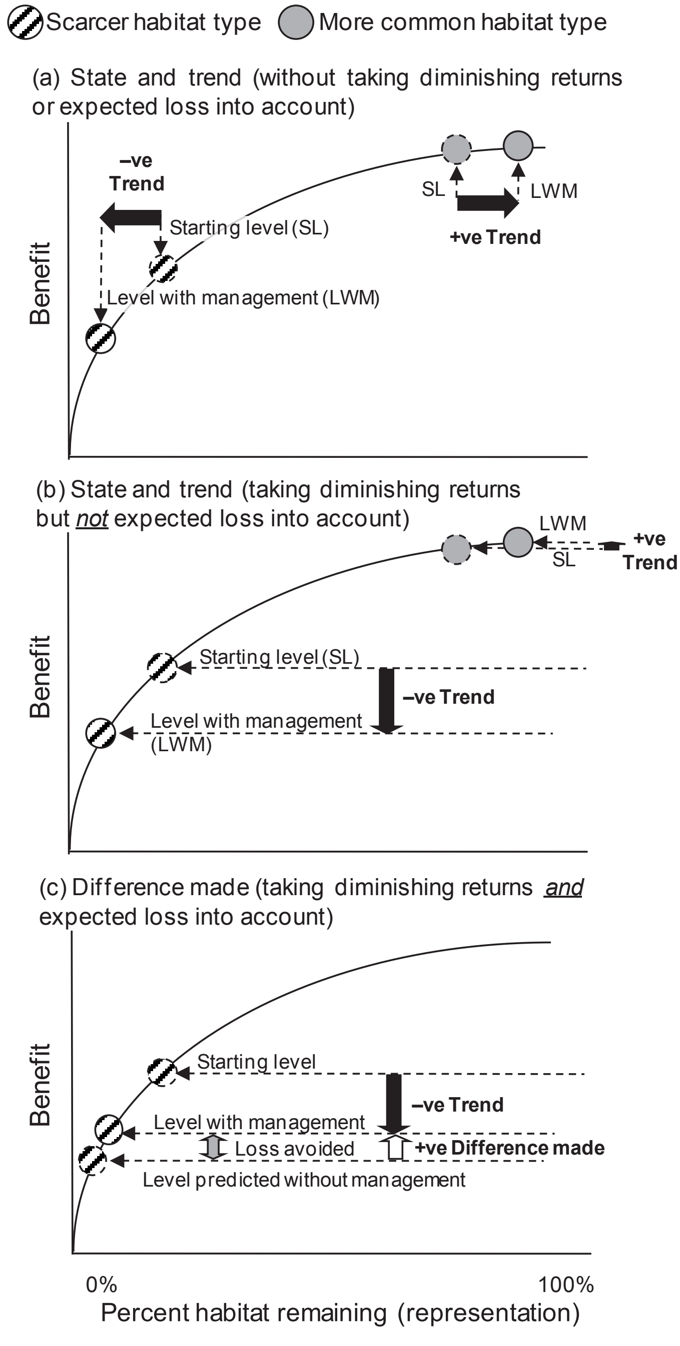

Figure 3. Three modes of biodiversity reporting: (a) state and trend without considering diminishing returns or expected loss; (b) state and trend considering diminishing returns but not expected loss; (c) difference made (accounting for diminishing returns and expected loss). The two circular symbols represent two hypothetical 'selected habitats' from the Convention on Biological Diversity headline indicator II.

to meet conservation goals) would be underestimated through faulty assumptions about loss expected without management. If those underestimates led decision-makers to withdraw or redirect funding, there would be unforeseen loss of takahē, and (assuming a curve of diminishing returns similar to Fig. 2) a sizeable loss of benefit (e.g. takahē persistence probability).

Absence of both forecasting and context in reporting can also mislead stakeholders and decision-makers into *over*estimating benefits. For example, 'hectares of land protected' is used to indicate biodiversity outcomes of high country land reform ('tenure review') in New Zealand (Walker et al. 2008). The indicator implies positive biodiversity achievement when any land is protected (while not reporting land privatised), and implies the same benefit per hectare of land protected no matter how common or little-threatened the biodiversity it supports. Unsurprisingly, the most recent OECD report considered that tenure review brought environmental gains (OECD 2007, p. 5). However, assessment of the difference made by land reform reached the opposite conclusion. Considering both expected loss and diminishing returns, Walker et al. (2008) showed the benefit lost through clearance of rarer biodiversity on privatised lower-elevation land would likely outweigh benefit gained from protection of much larger areas of little-threatened high elevation communities. Because the species and habitats protected were at little risk of loss under any tenure type, and those privatised became more vulnerable, the net difference made by land reform to biodiversity was negative, but hidden by a simplistic trend indicator.

There are also risks in a difference-made approach. Forecasts are always uncertain, and can be manipulated to inflate apparent achievement and/or to defend the continuation of non-beneficial work. Nevertheless, that 'all forecasts are wrong, but essential for robust reporting' need not be the conundrum it appears. Much (if not most) conservation prioritisation and reporting involves at least implicit forecasting. Without forecasting expected loss, no takahē conservation would be done, nor could land reform outcomes be presented as a net gain for biodiversity without assuming (i.e. implicitly forecasting) negligible future lowland biodiversity loss. Therefore, forecasting is essential and normal practice. We suggest the challenge is to make forecasts more transparent and testable.

Forecasting and reporting on conservation goals

Demonstrating additionality (difference made) relative to forecast business-as-usual has become a core requirement for assessment and quality assurance in other environmental reporting spheres (e.g. carbon). Scenario forecasting for biodiversity conservation is becoming increasingly achievable (Pereira et al. 2010), and called for internationally (e.g. Perrings et al. (2011) use the term 'conditional prediction'). Formulations of many high-level conservation goals include it: for example, the idea of difference made to biodiversity relative to business-as-usual is expressed in Goal 3 of the NZBS (reproduced in Fig. 4), and in the international (CBD) 2010 goal to achieve 'a significant reduction of the current rate of biodiversity loss' (depicted in fig. 1 of Mace & Baillie (2007)).

Because it requires forecasting to link changes in biodiversity components to conservation work (and scaling to account for context), difference-made reporting as envisaged by the NZBS and CBD is necessarily more demanding than reporting on state and trend alone. This may be particularly

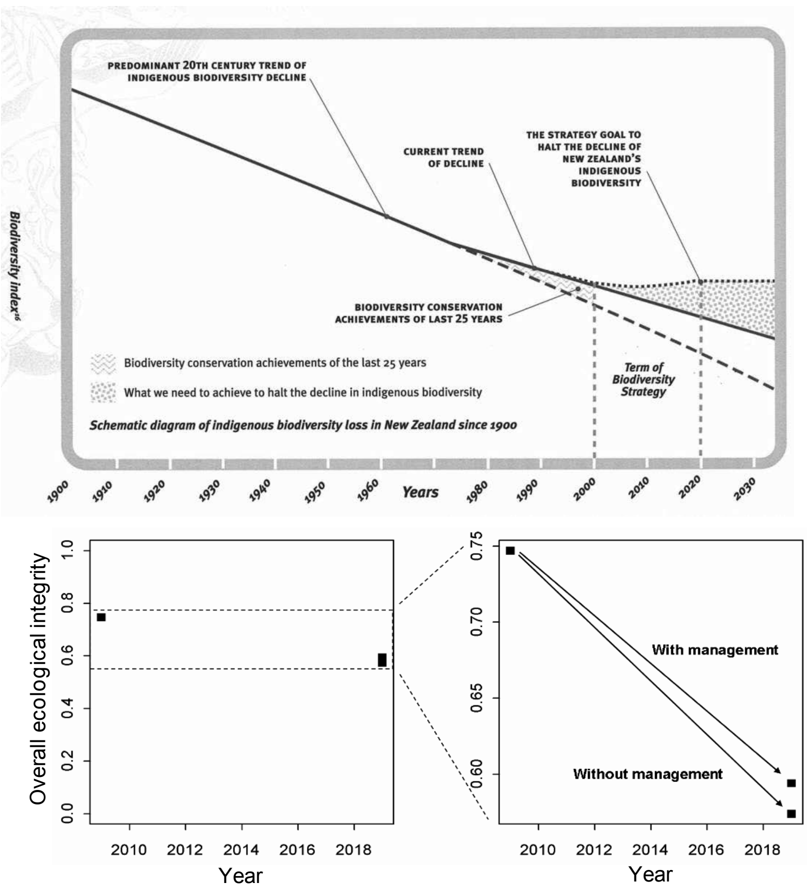

Figure 4. The upper figure reproduces the 'Goal to halt indigenous biodiversity decline in the 21st century New Zealand' from the New Zealand Biodiversity Strategy (DOC & MfE 2000). A similar figure illustrates the international Convention on Biological Diversity biodiversity target for 2010 (fig. 1 of Mace & Baillie 2007, p. 1407). The lower figure shows change in 'ecological integrity', and difference made by conservation management, predicted in a demonstration run of the Vital Sites and Actions (VSA) model (reproduced from Overton et al. 2010). Ecological integrity (a scaled measure of conservation benefit, a 'Biodiversity Index' as in the upper figure) is plotted for 2009 and 2019 (i.e. 10 years in the future). The lower-left figure uses a *y*-axis scaled from 0 (nil) to 1 (100% or perfect ecological integrity) to portray the amounts of decline. The lower-right figure expands a portion of the *y*-axis.

so in New Zealand, where the improvement of forecasts requires characterising the functional relationships linking biodiversity, especially diverse threats (including invasive species), and multiple potential conservation actions. Nevertheless, combined state, trend, and difference-made reporting is likely to be realisable both here and elsewhere. For example, Fig. 4 shows the first data-derived estimate of progress and difference made in relation to NZBS Goal 3. The estimate is an output from a demonstration run of the Vital Sites and Actions (VSA) framework of Overton et al. (2010) for New Zealand. Using simple but explicit models of functional relationships, VSA predicted that terrestrial ecological integrity (EI; an operational measure of the state of biodiversity that incorporates diminishing returns) across New Zealand would decline from 0.75 to 0.57 (where 1.0 is 100% EI) in the next 10 years without conservation management. With implementation of pest and weed control, the predicted decline was slightly less; the estimated difference made by management was 11% of predicted decline in EI. The figure clearly communicates a situation of ongoing decline, within which conservation work makes a difference but falls far short of what would be required to halt decline and achieve the goal.

A 'difference-made' approach to biodiversity inventory and monitoring

The ability to derive both prioritisation and reporting from the same difference-made approach also has implications for the efficiency of organisations' assessment systems and processes. Many inventory, monitoring and research requirements would be shared: for example, monitoring biodiversity with and without management would enable prediction of expected loss in the absence of conservation and the effects of conservation work (needed for both prioritisation and reporting), as well as conservation outcomes (for reporting). At a still higher level, a combined difference-made framework should help to clarify conservation organisations' overall biodiversity information requirements by setting out the essential ingredients of decision-making and reporting, and illuminating gaps (Gardner 2010).

Different approaches would highlight different data and research priorities. Nevertheless, the general utility of a clear high-level conceptual approach can be illustrated by the VSA framework (Overton et al. 2010; left-hand side of Fig. 5). In VSA, pressures on biodiversity cause vulnerability and lead to future biodiversity patterns, while conservation management actions affect future biodiversity patterns by reducing pressures. The framework identifies three types of essential information for conservation prioritisation and reporting (Fig. 5 I, II and III), illustrating how the requisite information includes pressures and conservation work as well as biodiversity pattern and status. Predictive models a and b in Fig. 5 link the three types of data in VSA, and provide explicit forecasting of expected loss. The first model-set (biodiversity-loss models) predicts effects of pressures on biodiversity (Fig. 5a), and the second set (management–pressure models) predicts effects of conservation work in moderating pressure (Fig. 5b). The two model-sets highlight the reliance of both difference-made prioritisation and reporting on knowing the functional relationships between species (or community types) and relevant pressures, and between conservation management actions and pressures; they also explicitly identify the relationships requiring definition.

Because VSA incorporates diminishing returns (similar to Figs 1 and 2), design of information gathering – and resource allocations – will emphasise inventory of scarce species or community types and their key threats, and focus on 'management monitoring' and research to better understand the functional relationships connecting scarce biodiversity to relevant threats and conservation actions. Lower priority would be placed on general monitoring designs (e.g. grid-based plots) that predominantly sample common and widespread species but provide little information on those that are neither abundant nor widespread.

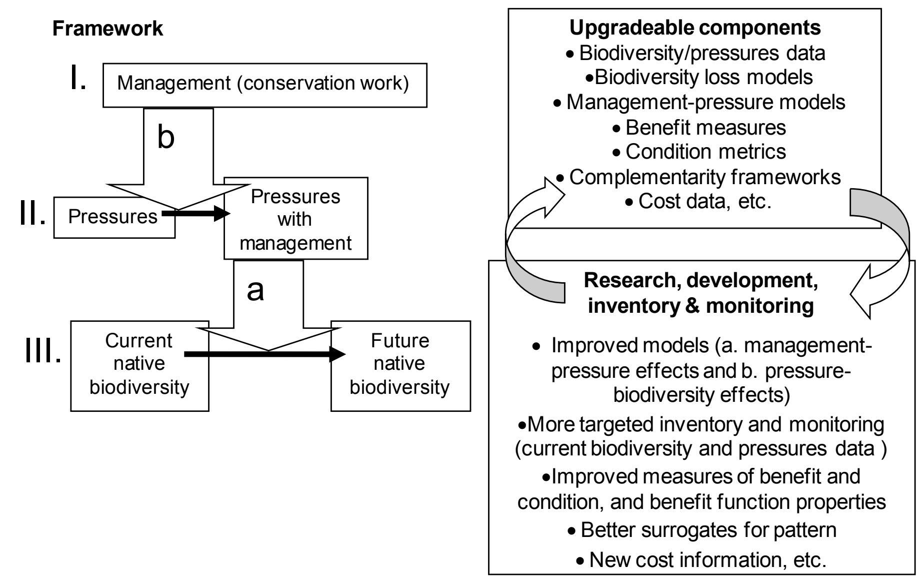

Figure 5. The Vital Sites and Actions framework (Overton et al. 2010) (left), and potential improvements to operational components of its implementation (right), showing areas of ongoing research, development, inventory and monitoring that would contribute to usefulness and effectiveness, without altering the framework.

Conclusion: an approach as a starting point

So far, we have shown how principles from international systematic conservation planning, and local advances on them, potentially unify the prioritisation, reporting, and information-gathering aspects of biodiversity assessment in a general 'difference-made' approach. In concluding, we suggest such an approach could also provide a stable logic to integrate future research and development advances, allow innovation of implementation processes and tools to suit the diverse needs of users, and connect investments in the collection and organisation of underpinning data.

Integrating future research and development

A durable approach to biodiversity assessment should also be flexible enough to accommodate improved quality and comprehensiveness of biodiversity information, as well as ecological understanding of interactions among biodiversity, pressures, and conservation work (e.g. Ferrier & Drielsma 2010; Grantham et al. 2010). This outcome can be achieved by conceiving the approach as a framework of operational components that are 'upgradeable' in that they may be replaced by an array of alternatives. For example, operational components in the VSA framework (listed in boxes on the right of Fig. 5) would accommodate inventory, monitoring and research advances, such as different monitoring designs and data types; improved models linking conservation work, pressures, and biodiversity; innovative surrogates for ecological pattern and complementarity; and alternative benefit functions representing essential biodiversity and ecosystem goals (e.g. security, persistence, variety, ecosystem services) and the effectiveness of conservation work in achieving them (Overton et al. 2010).

Diverse implementations and interfaces: common data needs

Conservation prioritisation and reporting are both important for halting New Zealand's biodiversity decline, but take place within a complex social context. Efforts to improve biodiversity assessment have been gathering momentum nationally (Lee et al. 2005) and internationally (Perrings et al. 2011). SCP-based tools are also progressing and more conservation professionals are being trained to use them. Nevertheless, examples of successful operational implementation remain elusive (Knight et al. 2008). Possible barriers limiting uptake and use include: (1) preference for symbolic reporting and non-transparent prioritisation; (2) alienation of potential users by top-down, 'black box' implementations of complex SCP concepts and tools; and (3) paucity of relevant biodiversity information at appropriate scales, limiting usefulness of and user confidence in SCP-based reporting and prioritisation outputs, especially if implemented too early. We offer no solution to the first barrier, but suggest that user–researcher partnerships could overcome the second and third.

Potential now exists for innovation of more interactive, intuitive and/or versatile biodiversity assessment interfaces that better fit the diverse practical, social, and institutional situations where they are used. For example, Ferrier & Drielsma (2010) noted that users rarely demand or expect optimal plans in prioritisation, but readily adopt interactive tools for exploring implications of alternative, spatially explicit, configurations of management. Partnerships between end-users and researchers should facilitate a diversity of appropriate prioritisation and reporting interfaces through development of purpose-specific tools and adaptive testing of prototypes. On the other hand, we suggest that overcoming the third, 'information inadequacy' barrier would be facilitated by unity among users and research providers, rather than diversity. In part, this is because the need to consider context (such as scarcity and complementarity) in planning conservation, and in reporting on achievement, means that broad coverage is essential. Furthermore, the alternative – a scenario where individual organisations independently develop biodiversity databases and models for their own prioritisation and/or reporting systems and needs – may be more costly in sum, and the usefulness of outputs more compromised by resource, and hence data, limitations.

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