MINI-REVIEW

Hitting the target and missing the point: target-based conservation planning in context

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Abstract

Conservation planning is often informed by quantitative targets: these are minimum amounts of the distribution of a species, vegetation type, or other biodiversity feature intended for protection. Targets are set for the global reserve system, and are also used at national and local levels to plan for both on- and off-reserve conservation. Understandably, the conservation community holds a range of opinions about target-based approaches to conservation planning. One school of thought is that the approach is inadequate, inflexible, and even counterproductive in many socioecological systems. We investigate the perceived limitations of target-based conservation planning, and find that most have resulted from poor communication and misuse of targets, leading to misconceptions and misunderstandings. Here we put target-based conservation planning in context by: (1) summarizing reported limitations of the approach and differentiating between those that are real and those that are misconceived; (2) identifying ways that some of the real limitations have, and can, be overcome, and (3) comparing target-based conservation planning to alternative conservation prioritization approaches. We hope to stimulate further discussion that will guide and improve target-based conservation planning.

Introduction

As conservation scientists, we may dream of conserving all the remaining biodiversity on Earth. But social and economic constraints beget the need for conservation prioritization: deciding what to protect and where and how to protect it (Soulé & Sanjayan 1998; Andelman & Fagan 2000; Possingham *et al*. 2006; Ferrier 2002; IUCN 2003; Brooks *et al.* 2006). The concept of target-based conservation planning evolved in the 1980s to assist with these difficult decisions (Tear *et al.* 2005). A conservation target is an explicit goal that quantifies the minimum amount of a particular biodiversity feature that we would like to conserve through one or several conservation actions (Possingham *et al.* 2006). For example, we often aim to design a reserve system that protects enough habitat to maintain the viability of particular species, and protects a minimum extent of each vegetation type (Burgman *et al.* 2001; Lombard *et al.* 2003).

While target-based conservation planning was originally developed to solve simple reserve system problems, it is now applicable to a range of on- and off-reserve situations (e.g., Carwardine *et al.* 2008). Conservation targets can be calculated in ways that differentiate between features according to the relative importance and urgency of their protection (e.g., Lombard *et al.* 2003). Targets are a key component of conservation policy of many countries (IUCN 2003; Commonwealth of Australia 2005; Convention on Biological Diversity 2006) and several conservation decision-support tools are based on targets (Sarkar *et al.* 2006). Supporters of the approach claim that it is useful in practice for providing flexible options upon which planners and stakeholders can base their negotiations and decisions (Cowling *et al.* 2003a).

Skeptics of the approach have raised a number of concerns about the use of targets in conservation planning. The six most commonly reported limitations are that: (1) setting conservation targets result in perverse outcomes (Soulé & Sanjayan 1998; Woinarski *et al.* 2007); (2) conservation plans based on targets will be inadequate; (3) conservation plans based on targets will be inflexible and override expert judgment (Agardy *et al.* 2003); (4) conservation plans based on targets will be unachievable; (5) the approach fails in intact landscapes; and (6) the approach cannot consider complex factors such as climate change, ecological processes, threats, and socioeconomic criteria (Woinarski *et al.* 2007). A review of the published literature would suggest that the use of targets in conservation planning is internationally accepted as best practice (Pressey *et al.* 2003; Tear *et al.* 2005; TNC & WWF 2006; Sarkar *et al.* 2006; Possingham *et al.* 2006; Smith *et al.* 2006). Hence, an evaluation of these concerns is imperative.

In this article, we clarify the nature and role of target-based conservation planning by (1) investigating the above-reported limitations and distinguishing between real and perceived limitations; (2) summarizing past, recent, and potential future developments of the approach which help to overcome its limitations; and finally, (3) comparing target-based conservation planning with alternative approaches to conservation priority setting.

Limitations of target-based conservation planning: perceived and real

We observe six reported limitations of target-based conservation planning that recur through personal communications and the published and gray literature. Below, we clarify the factual and misconceived elements of each of these limitations, and the source of misconceptions where they occur.

1. Setting a conservation target will result in perverse outcomes (e.g., Soulé & Sanjayan 1998; Young, cited in McDonald 2004; Woinarski *et al.* 2007).

The concern that society will use targets as a justification to neglect or destroy the untargeted proportion of a feature has arisen through confusion about the role of conservation targets. First, target-based conservation planning is incorrectly associated with the outdated Western ideology that biodiversity will be conserved only in reserves and all remaining land (especially if under private tenure) will be degraded or destroyed. While modern day conservation targets can be used to ensure that a minimum amount of a biodiversity feature is protected in a reserve, they say nothing about the remainder of the landscape. The same can be said of nontarget-based approaches to selecting reserve networks—regardless of the approach used to select reserves, the fate of biodiversity outside reserves is of paramount importance, and will typically be determined through a diversity of instruments, including laws and policies on land clearing, fishery quotas, and best-practice farming (Pressey *et al.* 2003; Possingham *et al.* 2006).

Second, conservation targets are often informed by (and confused with) ecosystem threat classifications, and both can be misinterpreted to imply that less endangered vegetation types can be cleared. Just as threatened species listing aims to protect endangered and threatened species, ecosystem threat classifications aim to provide extra protection for "endangered" ecosystems (e.g., in Australia, those with < 10% remaining), and ecosystems "of concern" (those with < 30%), but have been criticized for failing to protect ecosystems "not of concern" (those with > 30% remaining). Conservation planners often use ecosystem threat classifications to set larger targets for more threatened features (Lombard *et al.* 2003; Pressey *et al.* 2007), and such information on retention of features might become even more relevant when planning for both on- and off-reserve management using multiple-use zoning: for example, in native rangelands we might vary the amount of each vegetation type kept in reserves and under sustainable grazing, depending upon their threat status. Neither conservation targets nor ecosystem threat classifications imply that the remainder of each ecosystem can be modified or destroyed, but conservationists must be aware of this perverse interpretation, and communicate the purpose of conservation targets clearly.

2. Target-based conservation planning approaches deliver inadequate conservation plans (e.g., Soulé & Sanjayan 1998; Woinarski *et al.* 2007).

Concerns that target amounts will be inadequate for biodiversity persistence have arisen because conservation targets are sometimes set arbitrarily, and many would argue, too low (Rodrigues & Gaston 2001). Targets are generally defined by either sociopolitical feasibility or requirements for persistence of biodiversity (or a compromise between the two) (Tear *et al.* 2005). Sociopolitical targets—such as protecting 10% to 30% of the historical extent of major vegetation types as recommended by the World Congress on National Parks and Protected Areas (WCED 1987) and the World Conservation Union (IUCN 2003)—lack scientific validity. Their purpose is to use a simple goal to ensure equity of protection and to prevent the mistakes of the past where ecosystems with value for productive or extractive uses were overlooked for conservation (Pressey & Tully 1994).

Targets can be set more objectively by accounting for factors that influence conservation requirements and persistence of biodiversity, for example, natural rarity, life-history characteristics, compositional distinctiveness, biological heterogeneity, exposure and response to natural and anthropogenic threats, and functional importance (Williams & Araújo 2000; Burgman *et al.* 2001; Lombard *et al.* 2003; Pressey *et al.* 2003). Parameterizing some of these analyses can be difficult and expensive, requiring data on life-history characteristics and responses to natural and anthropogenic threats. The process can be simplified using rules of thumb (Nicholson *et al.* 2006) and expert knowledge (Cowling *et al.* 2003a). Regardless of the target-setting approach, uncertainties will exist. Approaches that explicitly include uncertainties are being developed, for example, Halpern *et al.* (2006) find optimal marine reserve systems that are robust to uncertainty in species persistence.

Ultimately, even targets equating to 100% of all known features will not guarantee the persistence of biodiversity in perpetuity: new and unknown challenges and constraints arise due to incomplete information, extinction debts from past loss and degradation of habitat and future threats (Brooks *et al.* 2002). The basic idea behind targets is as much one of equity as adequacy: given uncertainties about adequacy it is precautionary to develop conservation targets that deliver equal chances of persistence (Rodriguez *et al.* 2007a). Target-based conservation planning should be adaptive and targets revised in line with changing ecological conditions, biological knowledge, and social acceptance of conservation (Smith *et al.* 2006; Stewart *et al.* 2007).

3. Target-based conservation planning approaches will fail to identify all important areas (e.g., Agardy *et al.* 2003; Woinarski *et al.* 2007).

All quantitative approaches to conservation planning can fail to identify areas that are known to be important for biodiversity, because of data limitations and our lack of understanding of, and ability to parameterize, nature's intricacies. This is a valid concern only if the quantitative approach is employed without the input of expert intuition. Best practice use of target-based conservation planning tools recommends that decisions should always be guided by and supplemented with expert knowledge and intuition particularly where some elements of biodiversity and aspects of socioecological systems cannot be captured with available data (Cowling *et al.* 2003b, Fernandes *et al.* 2005; Klein *et al.* 2008a). In the same way, the prioritization of threat-listed species recommends that a quantitative phase be complemented with a more qualitative, expert driven phase, which takes into account a broader range of societal values (Miller *et al.* 2006).

Data on the compositional, structural, and functional aspects of biodiversity will be grossly incomplete for the foreseeable future, and hence all quantitative approaches rely on surrogates that provide partial information on biodiversity patterns and processes (Ferrier 2002; Sarkar *et al.* 2006). A healthy debate continues over the most appropriate surrogates for conservation planning, which include spatial information on known species, phylogenetic diversity, vegetation or habitat types, environmental classifications, measures of connectivity, and physical features believed to be associated with ecological processes (van Jaarsveld *et al.* 1998; Andelman & Fagan 2000). In many cases, acting now with the best information is preferable to delaying decisions while more species are lost (Grantham *et al.* 2008). That said, in many of the less well-studied parts of the world, the collection of improved data is a priority and is essential for the estimation of targets and the development of comprehensive conservation plans (Rodriguez *et al.* 2007b).

4. Target-based conservation planning approaches deliver unachievable conservation plans (e.g., Woinarski *et al.* 2007).

If targets are set ambitiously, it is true that they may be unachievable in the short term due to lack of funds and available land. In such situations, factors like the contributions of areas to meeting targets and the likelihood of success or feasibility of a particular action in an area can be used to schedule conservation actions over time (Noss *et al.* 2002; Pence *et al.* 2003; Pressey *et al.* 2004; Knight & Cowling 2007). Ambitious targets are used to represent longer-term objectives in the face of short-term constraints (Tear *et al.* 2005) for influencing policy and funding by estimating the cost of achieving targets and highlighting current funding shortfalls (Pressey *et al.* 2003). It is possible to set targets using realistic estimates of budgets and societal constraints, although this approach might contrast with the requirements for species persistence and therefore must be communicated with care.

In all cases, the potential availability of conservation areas should be investigated prior to planning because this will affect the types of conservation actions considered (Knight & Cowling 2007). For example, conservation actions on private land such as stewardship programs can be a useful and cost-effective alternative to purchasing land for new reserves (Pence *et al.* 2003; Stoneham *et al.* 2003; Carwardine *et al.* 2008). Regardless of current availability for any action, maps of the relative importance of areas for meeting targets can help determine whether to carry out an action (e.g., purchase for a reserve) in an area if it becomes available (Smith *et al.* 2006; Knight & Cowling 2007).

5. Target-based conservation planning is not applicable to intact landscapes (e.g., Woinarski *et al.* 2007).

Target-based conservation planning was not developed for, and is not limited to, any particular kind of landscape. It has been used successfully for both intact and fragmented landscapes in both the land and the sea (Noss *et al.* 2002; Cowling *et al.* 2003a). The intact Great Barrier Marine Park was re-zoned using a target-based approach, with a minimum of 20% of every marine habitats now contained within no-take areas, and the remainder zoned for commercial uses, including fishing, tourism, and mining (Fernandes *et al.* 2005).

However, targets can have different implications for fragmented and intact landscapes. In fragmented landscapes, most remaining areas might be needed to achieve targets, and priority areas for restoration may be required to increase the range of heavily cleared ecosystems to an adequate target level (Crossman & Bryan 2006). Intact landscapes provide more flexibility for designing conservation areas and more scope for accommodating biodiversity processes (Rouget *et al.* 2003; Fernandes *et al.* 2005; Smith *et al.* 2006; Klein *et al.* 2009). Conservation targets for reserves might be higher in intact landscapes and there could also be a greater need to consider the biodiversity values of off-reserve areas.

6. Target-based conservation planning cannot address complex factors such as off-reserve conservation, multiple actions and benefits, ecological processes, climate change, threats, condition, dynamics, and socioeconomic issues (e.g., Soulé & Sanjayan 1998; Young, cited in McDonald 2004; Woinarski *et al.* 2007).

Most approaches to solving complex problems start simply and evolve; target-based conservation planning is no exception. The approach was originally used for simple problems, that is, to identify potential new reserves that meet a set of conservation targets for minimum expenditure (Kirkpatrick *et al.* 1983; Cocks and Baird 1989). It is continually evolving to address complex factors better, such as considering multiple actions, species persistence requirements, threats, spatial connectivity, and socioeconomics (Burgman *et al*. 2001; Pressey *et al.* 2003; Possingham *et al.* 2006). The main challenges are not in the development of new algorithms, but in defining the problem mathematically and parameterizing it with available data relevant to the conservation requirements of species, vegetation types, and other features. Targets are often an essential component of quantifying short or long-term goals, which is a key part of the problem formulation.

The concern that target-based conservation planning cannot address complex factors is misinformed, and arises for two main reasons. First, the evolution of the approach to address more complex problems is not well known; some of this research is new, and much of it has not been widely disseminated. Second, while the approach can address complex problems, it does so in simplistic ways, and thus a combination of intuitive and quantitative processes is always required in real-world problems (as described in limitation 3). In the next section, we summarize the ways in which target-based conservation planning has and is developing to solve increasingly complex problems.

Developments in target-based conservation planning

While target-based conservation planning focused initially on representing biodiversity pattern, it has evolved to address ecological processes associated with connectivity, population dynamics in fragments, and maintenance of patch dynamics (Briers 2002; Noss *et al.* 2002; Rouget *et al.* 2003; Leroux *et al.* 2007; Pressey *et al.* 2007). For example, Klein *et al.* (2009) met targets for both biodiversity representation and important evolutionary refugia in networks of conservation areas that are connected along waterways (see also Pressey *et al.* 2003). Methods for designing reserve networks that are robust to changing climates are also emerging, such as accounting for adjusted species ranges and dispersal requirements and preferentially meeting targets in areas that are robust to climate changes (Hannah *et al.* 2007). Research in these areas remains a high priority.

Target-based conservation planning now has well-established methods for considering threats through adjustments to targets (see 1. above) (Burgman *et al.* 2001; Allison *et al.* 2003; Pressey *et al.* 2003), scheduling conservation actions to address threatened areas or features first (see 4. above) (Noss *et al.* 2002; Pressey *et al.* 2004; Stewart *et al.* 2007) and avoiding areas with non-abatable threats (Game *et al.* 2008). The approach can be adapted to favor target achievement in areas of better condition or in zones with activities compatible with conservation by varying the contribution to feature targets of areas in different forms of condition or use (Klein *et al.* 2008b).

The use of target-based methods has been demonstrated for conservation management outside reserves such as stewardship payments (Margules & Pressey 2000; Carwardine *et al.* 2008). The approach can also be used to capture benefits in addition to biodiversity, for example, socioeconomic benefits (Fernandes *et al.* 2005; Klein *et al.* 2008a) and ecosystem services (Chan *et al.* 2006; Egoh *et al.* 2007). Approaches for considering multiple actions, costs and benefits within a single target-based problem are under development (Klein *et al.* 2008b), which will allow better synthesis of complex factors (Pressey *et al.* 2007).

Past, present, and planned future research on conservation planning, including target-based approaches, addresses the dynamic interplay between conservation decisions, habitat conversion, and land market feedbacks (Armsworth *et al.* 2006; Pressey *et al.* 2007). Another important body of research is in the inclusion of stakeholder preferences and the relative suitability of areas for conservation in order to improve implementation effectiveness (Knight *et al.* 2006).

Target-based conservation planning and alternative approaches

Target-based conservation planning approaches can solve two broad types of objectives. The most common (the target constrained, or set covering problem, Camm *et al.* 1996) is to find sets of conservation areas that meet targets at a minimal cost. Less commonly, targets are used to maximize target achievement subject to some limit on opportunity or other costs (the budget constrained, or maximal covering problem, Camm *et al.* 1996). Some approaches that do not use targets also solve a maximal covering problem: to maximize the utility, or benefit, gained by spending a fixed budget, or selecting a fixed number of areas. Target-constrained, budget-constrained, and nontarget-based problems differ in the way they measure the benefit, or utility, of protecting increasing amounts of a feature (Figure 1, lines A–E).

In the most simplistic target-constrained problem, sets of areas that fail to meet all targets provide no benefit, while sets of areas that meet all targets provide maximum benefit (line A). In more realistic examples, benefit is gained incrementally until the target is reached (line B). In both cases, when a target is achieved the utility of conserving more of that conservation feature is zero. This is a simple way of helping to spread conservation effort over the range of features in the region. In reality, benefits for biodiversity accrue whenever more of a feature is conserved even after the target has been met. Continuous utility functions (Figure 1, lines C–E), usually used for budget-constrained problems, reflect this reality but come with their own limitations (Arponen *et al.* 2005).

The simplest nontarget-based approach is to use a linear utility function, meaning that utility is accrued linearly until the entire extent of the feature is conserved (Figure 1, line C). While simple to convey, linear functions tend to be inefficient at spreading conservation effort across a range of features. Curved utility functions (Figure 1, lines D–E) have the potential to represent more accurately the benefits obtained as conservation action proceeds. Defining the shape of these functions is difficult, and is often simplified by assuming the accumulation of utility follows species–area relationships, that is, a diminishing returns function (Figure 1, line D, e.g., see Davis *et al.* 2006; Wilson *et al.* 2007). In principle, any function can be used. A sigmoidal function (Figure 1, line E) might be appropriate where a substantial amount of a feature is required before much real utility is gained, for example, for the persistence of habitat-dependent species in fragmented landscapes. These curved functions encourage diversification in the protection of features by progressively switching attention to features with the largest increments of utility per unit protected (Wilson *et al.* 2007).

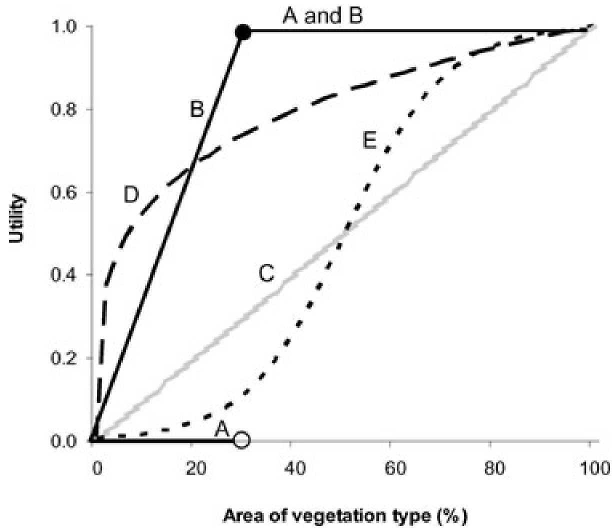

Figure 1 Target-based and alternative utility functions for a single vegetation type. The utility indicates the benefit of protecting increasing amounts of a single vegetation type. (In real-world applications the utility of conserving each of many features, including species and ecosystem services, would be represented by separate functions). In simple binary target-based approaches, utility is zero until the entire target—in this case 30% of the extent of the vegetation type—is reached (A). Alternatively, utility is gained incrementally until the target is reached (B). In both cases, (A and B) no utility is gained beyond the target amount. In contrast, continuous utility functions are never "satiated": there is always some additional utility from each incremental area protected. They can be linear (C), where utility accrues in equal increments until the entire vegetation type is conserved. Alternatively, they can follow diminishing returns (D) or sigmoidal (E) curves. In these cases, the largest increments of utility are gained where curves are steepest in a positive direction. When curves flatten, efforts are switched to protecting different features for which larger utility can be gained from the same investments.

Approaches that apply these alternative utility functions have no advantages over target-based conservation planning in dealing with data paucity and complex information. Continuous utility functions for conservation features might be more realistic biologically than target-based utility functions, but targets have some practical advantages for both planners and policymakers. They are simple to convey, politically tractable, and allow whole portfolios of potential conservation areas to be identified. Continuous functions encourage incremental conservation but fail to provide a clear goal—many conservation planners need to know when their short-term goals have been achieved.

There are of course many other proposed alternatives to target-based conservation planning. As a general rule, approaches should solve some kind of quantifiable objective (something that is being maximized or minimized). Nonquantitative approaches are sometimes proposed as alternatives to target-based conservation planning, for example, the guiding principles laid out in Woinarski *et al.* (2007):

1. *The natural environments must be valued recognizing their national and international significance.*
2. *The ecological integrity of the processes that support life must be maintained.*
3. *The population viability of all native species must be protected.*
4. *Thresholds defined by the limits to ecological integrity... must be used to assess and guide development options.*
5. *The contributions of all property holders and managers are needed to maintain the North's natural values.*

Not many conservation scientists would disagree with these principles; but alone they are not enough to decide where, when, and how to manage for conservation. Principles, qualitative goals, and other expert information are important for shaping more specific, quantitative objectives (such as targets) that are essential to make conservation management operational, repeatable, and transparent (Cowling *et al.* 2003b; Fernandes *et al.* 2005; Knight *et al.* 2006). The complementary nature of principles and targets extends to the need for regular review of targets to ensure that they remain accurate and quantitative interpretations of principles as information on biodiversity and our ecological understanding improves (Pressey *et al.* 2003; Smith *et al.* 2006).

Conclusions

Our review suggests that many existing perceived limitations of target-based conservation planning have arisen largely due to poor communication. A key source of confusion has been the misconceived association of targets with the right to clear and destroy the untargeted proportion of biodiversity, coupled with a lack of acknowledgment that the protection of biodiversity both inside and outside reserves will require a suite of planning, legal, and policy tools. Further, while many published examples focus on academic aspects of the approach, best-practice, target-based conservation planning is flexible, guided by socioecological context, expert input, and stakeholder engagement, and should be used to guide decision making by experts, rather than over-ride good judgment (Cowling *et al.* 2003b). Targets are transparent, simple to convey, and allow conservation progress to be measured, but in some cases alternative approaches to targets will be useful—we expect that less abrupt utility functions will also become popular in the future for their more realistic measurement of utility (Moilanen *et al.* 2007).

We suggest that better communication among science, policy, and practice is essential to guide both development and implementation of target-based conservation planning. The ability of contemporary target-based conservation planning approaches to address sophisticated problems is broadly unknown, and its potential is hindered by the misconceptions we discuss. We hope that this article clears up the confusion around target-based conservation planning and sets the stage for further discussion and innovation.

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