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A plea for quantitative targets in biodiversity conservation

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Ecological degradation is both ubiquitous and relentless. Human activities have left a footprint even in the most remote locations. Some species benefit from certain forms of degradation whereas many others are expected to decline to extinction under current or increasing land-use intensity (Vitousek *et al.* 1997; Norris and Pain 2002). While the optimal allocation of conservation efforts and funding at the global scale is being debated (Myers *et al.* 2000; Balmford *et al.* 2002; O'Connor *et al.* 2003; Lamoreux *et al.* 2006), target setting at the landscape scale should be viewed as equally important because, for many taxa, this is the scale over which most human activities take place and management regulations are applied. A landscape can be defined as a mosaic of habitat types whose extent reflects the perspective of target species or taxa (Wiens *et al.* 2002). However, it should be noted that this organism-centered perspective of the landscape must interact with human perception and action. Forest managers perceive the landscape as that of the "forest" or "forest management unit", which may cover hundreds of square kilometers.

The landscapes we tend to envision when considering human activities such as timber harvesting or agriculture may match those perceived by many birds and mammals, but not those over which the dynamics of most species (e.g. plants and insects) take place. With the exception of some megaprojects, most human activities tend to alter relatively small patches (e.g. a forest stand or a field). Each of these activities may not pose a serious threat to biological diversity, but their cumulative effects across the landscape

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can be severe. Hence, it is not surprising that human societies have also established more or less intricate regulations to coordinate these activities so that they do not threaten basic human needs (water supply, protection against landslides or avalanches, food production). In fact, landscapes have been "planned" for centuries either by design (e.g. royal gardens, certain settlements) or as a result of interacting social, political, and economic forces.

After millennia of overexploitation of ecological systems through agriculture, hunting, fishing, mining, and forestry, a few pioneers proposed landscape planning principles derived from an understanding of "how the land works" (e.g. Leopold 1933; McHarg 1969). Meanwhile, ecosystems around the world continue to be pushed to the limits of their resilience and often beyond. The resilience of ecosystems depends heavily on the continued presence of certain species and structures which develop or recruit very slowly, such as large-diameter trees or snags or certain lichen or invertebrate species (Bengtsson *et al.* 2003).

So far, the main strategy of conservation biologists to reduce the rate of ecological degradation has been to set aside reserves. Quantitative targets have been established through international treaties such as those of Rio (1992) and Johannesburg (2002). To guide the selection of protected area networks, sophisticated procedures are being developed to optimize certain parameters of biodiversity (Margules and Pressey 2000). Unfortunately, the range of possibilities is often limited and some reserve networks have to be intensively managed to meet conservation goals owing to resource use and development pressures in the intervening space, also known as the "matrix".

In this book, we submit that biodiversity conservation would greatly benefit from the development of quantitative targets. These targets should not only pertain to reserves, but also to the matrix (Lindenmayer and Franklin 2002), "production landscapes", or simply "managed landscapes". Site-specific, "snapshot" conservation through discrete reserves should be replaced by landscape-scale strategies embracing ecological variability in space and time (e.g. Lindenmayer and Franklin 2002; Bengtsson *et al.* 2003). Conservation objectives, and corresponding numerical targets, can be established for critical local structures such as dead and dying trees, ecological processes (e.g. fire, insect outbreaks, or flooding by beavers), or landscape elements such as grasslands or old forest. Ultimately, this approach aims to ensure that managed landscapes contribute positively to the conservation of biological diversity, whether in conjunction with or independently from nature reserves. Even arbitrary targets can be useful by

focusing conservation efforts (Margules and Pressey 2000). However, this book emphasizes empirical approaches to set targets more objectively by using the responses of certain species, structures, or ecological processes to habitat alteration.

DON'T WE SET TARGETS ALREADY?

Surprisingly few attempts have been made to set quantitative targets because this is both a difficult and risky endeavour. The scientific challenge comes from the multiplicity of relevant factors that must be addressed whereas the risk for those setting targets and the ecosystems involved comes from this very complexity. Researchers naturally tend to shy away from such risks, being trained to collect large data sets and to analyse these data very thoroughly before stating any conclusion about a system under study. In addition, few authors have focused their attention on conservation target setting at the landscape scale. The realization that "the matrix matters" and that reserves must be "functionally connected" to form networks is relatively recent (Merriam 1984; Ricketts 2001; Lindenmayer and Franklin 2002). Furthermore, the empirical knowledge required to implement this holistic vision of conservation lags far behind theoretical forays. None the less, empirically-based, quantitative targets should help focus attention toward particularly important issues and they will empower the forest manager, because one can only manage measurable parameters. In this book, we will define conservation targets as *any quantitative objective determined by using empirical data or realistic models to adjust management intensity with the purpose of maintaining forest biodiversity*.

We submit that research-based conservation targets represent the most efficient way to incorporate conservation values or priorities into the socio-economic agenda of a region or country. Establishing targets helps (1) to focus the attention of all stakeholders (e.g. environmentalists, land owners, land managers, regional or national politicians, conservation biologists) and, when an agreement has been reached, (2) to coordinate the efforts of these various parties. Setting targets also represents a good approach to link basic research to public needs without stifling the curiosity driving it. To be stimulated and efficient, researchers must explore new issues or phenomena; there is no shortage of unexplored areas in the world of conservation target setting! Finally, conservation targets provide useful checkpoints for feedback into adaptive management programs (see Chapter 17, this volume). Conservation planners and ecosystem managers increasingly realize that they cannot "get it right the first time". Targets must evolve along with

the global environment. Hence, human activities must be planned by using scientifically rigorous yet flexible approaches. Quantitative targets can thus be implemented in an attempt to keep land use within certain bounds, and they can be adjusted when necessary in ecosystems where we still have the luxury of making mistakes.

When it is based on shaky scientific procedures or "expert advice", target setting can also lead to a massive waste of time and energy or, more dramatically, to the disengagement of stakeholders. Thus, it is critical that scientific standards be established and gradually refined to ensure that the targets set are robust to scrutiny and, thus, easily defensible. This book aims to provide guidance to those who want to contribute to the establishment of a scientific foundation for conservation target setting.

TYPES OF CONSERVATION TARGET

Biodiversity conservation targets can take a variety of forms, depending on the species or functional group, or the space and time scales considered. None the less, we can divide ecological parameters for which we could set targets into four broad categories: (1) local habitat features associated with the presence or abundance of individual species or guilds; (2) landscape structure; (3) demographic parameters; and (4) ecosystem processes.

Critical habitat features

This category pertains to structures that are critical to certain life-history requirements of a species or set of species. Because some of these structures may be relatively rare in the environment, targets may have to be established specifically for them. Suitable sites for reproduction or shelter are an obvious example. Several species nest or roost in tree cavities or "hollows" (e.g. Whitford and Williams 2002; Martin *et al.* 2004). Suitable trees or snags may be relatively rare, especially when the primary excavator or secondary users have a large body size. Trees or logs of a certain type and size may also play a critical role as substrates for certain species of lichen and moss (Berg *et al.* 2002). Large mammals such as canids or bears have fairly specific requirements for denning sites (Fernandez and Palomares 2000). Resources may also be very patchily distributed in the case of insects whose larvae feed on a single species of plant (Hanski and Singer 2001; Hanski and Heino 2003; Paivinen *et al.* 2003). Finally, some species have very specific requirements when selecting mating sites. Well-known cases are species congregating in lekking or rutting sites, such as certain grouse species and

ungulates, respectively (Helle *et al.* 1994; Apollonio *et al.* 1998; Hanowski *et al.* 2000).

Landscape structure

Even when a given site provides suitable habitat for a species, its presence or abundance may still be significantly influenced by the proportion of habitat in the surroundings (Mazerolle and Villard 1999; Cushman and McGarigal 2004). This may simply reflect the probability of immigration into the site (Venier and Fahrig 1996) or the fact that the species requires several slightly different habitat types depending on its life-stage, climatic conditions, etc. For example, the probability that larvae of the Bay checkerspot butterfly (*Euphydryas editha bayensis*) will reach the adult stage may vary considerably between different slopes of the same mountain range according to the climatic conditions that year. In wet years, larvae will be more likely to reach the adult stage on warmer, south-facing slopes whereas in dry years, north-facing slopes will provide better conditions (Ehrlich and Murphy 1987). In landscapes where forest, pastures, and cropfields are interspersed, the reproductive success of forest birds may vary greatly as a function of the particular crops or the spatial extent of pastures and their use by potential nest predators (Andrén 1992) or brood parasites (Robinson *et al.* 1995).

Landscape structure designates the particular extent and arrangement of resource patches beyond the scale of a species' home range. Maintaining connectivity among resource patches is an important challenge in managed forest landscapes. For a plant, the concept is equally relevant, because landscape context may influence the seed rain, the availability of pollinators, the intensity of grazing, parasitism, competition, etc. (Jacquemyn *et* al. 2001; Verheyen *et al.* 2003).

Population parameters

Managers of protected areas have often used quantitative targets to guide their interventions when developing conservation strategies for species at risk. Such targets may pertain to the minimum number of individuals required in a population to reduce the loss of genetic variability (Frankel and Soulé 1981) or extinction (Marshall and Edwards-Jones 1998). Procedures to set recovery targets for threatened species are discussed at length by Armstrong and Wittmer (Chapter 13, this volume). Population-viability analysis (PVA) is often used to estimate the extinction risk associated with various scenarios or conservation strategies (Beissinger and McCullough 2002). PVA can in turn be used to define targets for population size or

various demographic parameters, e.g. maintaining fecundity above a certain limit.

Ecological processes

Ecologists and land managers now realize the critical importance of certain processes in maintaining the integrity of ecosystems. Natural processes such as fire (Perera *et al.* 2004) and flooding (Naiman and Décamps 1997) may play critical roles in the persistence of certain species or species assemblages. Effects of fire on stand and landscape dynamics have been widely documented. Fire creates optimal conditions for many species associated with dead wood (Hoyt and Hannon 2002; Nappi *et al.* 2003) and its effects on soil and understory vegetation may be critical to the maintenance of long-term forest productivity (Nilsson and Wardle 2005). Managing these processes undoubtedly represents one of the key challenges facing both land stewards and conservation planners.

OBJECTIVES OF THIS BOOK

This book aims to (1) review past attempts and approaches used to set quantitative conservation targets; (2) present empirical approaches that are being used in various forest regions of the world to develop targets; and (3) summarize key statistical and practical issues associated with target setting. Ultimately, we aim to provide a conceptual framework for all the individuals involved in the management of forest lands and interested in developing conservation targets for their own forest region. Although we recognize that tradeoffs are required between ecological principles and socio-economic considerations when implementing conservation targets, the book will focus on the ecological dimension of conservation planning and forest management. The reasons for this are outlined in detail in Chapter 3, this volume.

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2

Setting conservation targets: past and present approaches

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INTRODUCTION

Biodiversity is a term now commonly used in the political arena. However, it has a fairly strict definition that is widely recognized in ecology. In essence, biodiversity refers to genes, species, and ecosystems as levels of organization, and it includes ecosystem structure and function (Noss 1990). These different aspects of biodiversity must also be the starting point for setting conservation goals for forest landscapes. However, when applied to forest management, biodiversity objectives must be broken down into measurable targets based on clear and, preferably, functional links to the overall goals.

Around the world, relatively pristine forest ecosystems have been preserved through the foresight of a few individuals, have been restored at great cost, or they simply persisted by default owing to slow economic development. In regions that are still undeveloped (e.g. portions of the boreal forest or the Amazon basin), targets may be set as proactive measures to limit impacts of foreseeable economic development (see also Chapter 4, this volume). In regions where conservation planning has maintained an intermediate level of ecological integrity, targets must still be set to protect sensitive species or critical ecological processes (see Chapters 8, 9, and 10, this volume). Finally, conservation targets may also represent useful tools to monitor the success of ecological restoration (see Chapter 11, this volume) in regions where major habitat loss and conversion have taken place.

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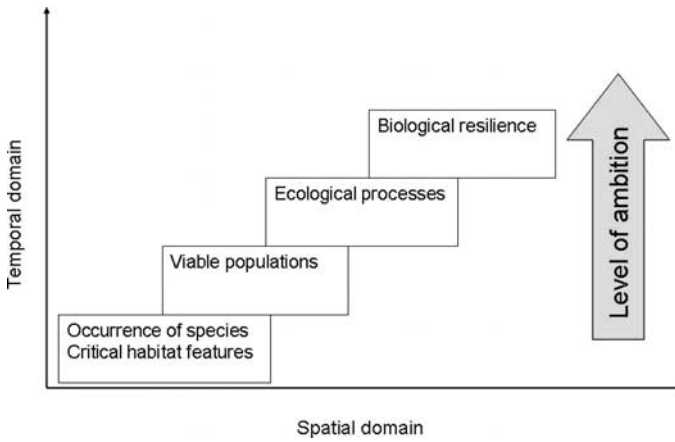

Figure 2.1. Target setting is needed for conservation goals representing different levels of conservation ambition, relating to increasing temporal and spatial domains (based on Angelstam *et al.* 2004).

Any specific target is relevant to a temporal and spatial domain. In addition, it may relate to different levels of conservation ambition. In this respect, at least four levels can be distinguished (Fig. 2.1): (i) occurrence of individual species, community types, or critical habitat features; (ii) viability of populations; (iii) maintenance of ecosystem processes; and (iv) biological resilience. Here, resilience refers to the ability of an ecosystem to withstand external disturbances (e.g. climate change). For each of the four levels, quantitative targets can be set. In this chapter, we will limit the discussion to the first three levels.

To set conservation targets, researchers and land managers have mainly relied on expert opinion, empirically derived rules of thumb, complex ecological models, or a combination thereof. Each approach has strengths and weaknesses, as illustrated by the chapters in this book. In spite of its relative cost-efficiency, expert opinion appears to have limited value compared to purely objective, empirically based modeling (Seoane *et al.* 2005, but see Martin *et al.* 2005). Empirically based rules of thumb may also be misleading and their application should be accompanied by active adaptive management (see Chapter 17, this volume). Finally, more complex ecological models (e.g. population viability analysis, Akçakaya 2004) may represent powerful tools but (a) they are relatively costly, (b) they are highly sensitive to the quality of the data upon which they are based, and (c) their outcome may vary according to the modeling frame selected. Burgman *et al.* (2005)