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Setting conservation targets for sandy beach ecosystems

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ABSTRACT

Representative and adequate reserve networks are key to conserving biodiversity. This begs the question, how much of which features need to be placed in protected areas? Setting specifically-derived conservation targets for most ecosystems is common practice; however, this has never been done for sandy beaches. The aims of this paper, therefore, are to propose a methodology for setting conservation targets for sandy beach ecosystems; and to pilot the proposed method using data describing biodiversity patterns and processes from microtidal beaches in South Africa. First, a classification scheme of valued features of beaches is constructed, including: biodiversity features; unique features; and important processes. Second, methodologies for setting targets for each feature under different data-availability scenarios are described. From this framework, targets are set for features characteristic of microtidal beaches in South Africa, as follows. 1) Targets for dune vegetation types were adopted from a previous assessment, and ranged 19–100%. 2) Targets for beach morphodynamic types (habitats) were set using species–area relationships (SARs). These SARs were derived from species richness data from 142 sampling events around the South African coast (extrapolated to total theoretical species richness estimates using previously-established species–accumulation curve relationships), plotted against the area of the beach (calculated from Google Earth imagery). The species-accumulation factor (z) was 0.22, suggesting a baseline habitat target of 27% is required to protect 75% of the species. This baseline target was modified by heuristic principles, based on habitat rarity and threat status, with final values ranging 27–40%. 3) Species targets were fixed at 20%, modified using heuristic principles based on endemism, threat status, and whether or not beaches play an important role in the species' life history, with targets ranging 20–100%. 4) Targets for processes and 5) important assemblages were set at 50%, following other studies. 6) Finally, a target for an outstanding feature (the Alexandria dunefield) was set at 80% because of its national, international and ecological importance. The greatest shortfall in the current target-setting process is in the lack of empirical models describing the key beach processes, from which robust ecological thresholds can be derived. As for many other studies, our results illustrate that the conservation target of 10% for coastal and marine systems proposed by the Convention on Biological Diversity is too low to conserve sandy beaches and their biota.

1. Introduction

A rich biodiversity, in all its forms, is fundamental to the life and functioning of the biosphere. It provides the basis for ecological processes, ecosystem resilience (including resistance, recovery and reversibility), and thus the sustainability of ecosystem-service delivery on which human livelihoods depend (e.g., Duarte, 2000; Millennium Ecosystem Assessment, 2005; Balvanera et al., 2006; Díaz et al., 2006; Worm et al., 2006; Palumbi et al., 2009; Turner et al., 2012; and many others). It therefore seems paradoxical that our understanding of this critical role that biodiversity plays has unfolded only relatively recently. In the interim, escalating human population size has driven large-scale habitat transformation for food production, housing and associated infrastructure, with unsustainable exploitation of natural resources to support these activities (Vitousek et al., 1997; Millennium Ecosystem Assessment, 2005; Pimentel et al., 2010). The resulting impacts to natural systems have contributed to a substantial loss of biodiversity (e.g.,

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Perfecto et al., 1997; Gaston et al., 2003; Waycott et al., 2009), and carry considerable inertia. We recognise now that conserving biodiversity and protecting ecosystems and the ecological processes driving their functioning is more than just a moral obligation: our quality of life and existence in the long term depends on it (Millennium Ecosystem Assessment, 2005; Díaz et al., 2006; Barnosky et al., 2012; Cardinale et al., 2012).

The challenging questions that follow, then, are: how do we conserve biodiversity; how much of what should we protect; where; and how do we measure the achievement or even success of conservation efforts? As a starting point to addressing these questions, organisations, countries and intergovernmental agencies have taken the approach of establishing visions and/or goals for biodiversity conservation (Margules and Pressey, 2000), which could be for species representation (Rodrigues et al., 2004), species persistence (Cowling et al., 1999; Nicholson et al., 2006), and/or ecosystem function (the latter including ecosystem service provision because it implies maintained ecological processes; e.g., Kremen et al., 2004; Chan et al., 2006; Klein et al., 2009). Under these goals are several targets (quantitative or abstract; time bound or not), where their achievement would, in turn, meet the conservation goal (Tear et al., 2005). While the sentiment expressed in abstract targets is good, perhaps even imperative, it is hard to measure progress towards their achievement. Ideally, the purpose of setting conservation targets should be to ensure that there is an amount of a feature in a protected state that exceeds a critical ecological threshold, in order to prevent its complete demise and expiration (Huggett, 2005; Rondinini and Chiozza, 2010). For example, the critical threshold for a certain species could be calculated on the basis of its minimum abundance or extent of distribution (Kerley et al., 2003; Rhodes et al., 2005; Traill et al., 2010). Ultimately, quantitative targets (preferably time bound) must comprise the fundamental core of targets required to achieve the overarching conservation goal; abstract targets should be seen as being ancillary to the core, serving as complementary targets rather than being paramount to achieving the conservation goal.

Requiring quantitative targets reiterates the question of: how much of what do we need to conserve? In terms of how much to conserve, there are currently two approaches, relating to the two types of quantitative conservation targets. Fixed targets are generally policy driven, like those codified in international agreements, or national legislation or policy, and are completely detached from case-specific data. Flexible targets, on the other hand, are data driven and, ideally, should relate specifically to empirically-derived ecological thresholds. Because flexible targets are scientifically determined, transparent and defensible, they are certainly the preferred approach. In comparison, fixed targets have been criticised by the scientific community, largely because they have no ecological substantiation (Soulé and Sanjayan, 1998; Agardy et al., 2003), and are generally too low to adequately conserve biodiversity (Soulé and Sanjayan, 1998; Pressey et al., 2003; Solomon et al., 2003; Desmet and Cowling, 2004; Svancara et al., 2005; Metcalfe et al., 2012). Nevertheless, fixed targets can serve as a good starting point in the reserve design process, and they can facilitate faster proclamation of protected areas, first because the process is not delayed for data collection and analysis, and second, because the targets themselves can be easily communicated to governments, making support for reserve implementation more likely (Porter et al., 2011).

In terms of what to conserve, both fixed and flexible targets can be applied to a variety of biodiversity features, including: genetic diversity or subpopulations (Neel and Cummings, 2003; see also; von der Heyden, 2009; May et al., 2011); species and communities (Turpie et al., 2000; Kerley et al., 2003; Pressey et al., 2003; Drummond et al., 2009); habitats and ecosystems (Airamé et al., 2003; Leslie et al., 2003; Lombard et al., 2003; Pressey et al., 2003; Metcalfe et al., 2012); fixed and flexible/dynamic processes (Lombard et al., 2007; Lagabrielle et al., 2009; Grantham et al., 2011); and ecosystem services (Chan et al., 2006). Naturally, the features included (and methods used to derive their targets) will depend on the data available, the conservation goal, and the objectives of the specific conservation plan (Rondinini and Chiozza, 2010). Generally, targets can be set for individual species (considered as fine-scale targets), for higher-order surrogates of biodiversity or ecological processes, such as habitat types (considered as coarse-scale targets), or in a complementary combination of fine- and coarse-scale targets.

While the practice of setting conservation targets is common, it has not been formally considered in the context of sandy shores. It is imperative that the sandy beach scientific community engage with this topic, because beaches are threatened ecosystems (Brown and McLachlan, 2002; Schlacher et al., 2006, 2007; Defeo et al., 2009) and require proactive conservation. The vision for sandy beach conservation is to have an adequate, representative network of beaches and dunes maintained in a near-pristine state, supporting fully diverse, functional ecosystems, and sustainable low-impact human uses (Schlacher et al., 2013). The conservation goal, very broadly, is thus to achieve ecosystem persistence. Selecting appropriate conservation targets is a pivotal step towards achieving this goal, and ultimately, in achieving our vision for sandy beaches. It was agreed during the VIth International Sandy Beach Symposium 2012 Workshop IV: Conservation Targets for Sandy Beaches that: we are in a position to set conservation targets for sandy beaches; that targets should be set for species, habitats and processes; species–area relationships and heuristic principles were the most suitable methods; and that different beach types should not be treated equally. In this paper, we formalise these decisions into a target-setting framework, and propose the first suite of conservation targets for sandy beach ecosystems. Specifically, a classification scheme of valued features of beaches is constructed, and methodologies for setting targets for each feature under different data-availability scenarios are described. Finally, targets are proposed for beach biodiversity features and processes, using data from microtidal sandy shores in South Africa as an example.

2. Material and methods

2.1. Target-setting premise

The premise underlying the approach adopted here is that persistence can be achieved by ensuring sufficient representation of biodiversity features and of the processes or associated features that maintain them in protected areas. Accordingly, we propose that targets should be set hierarchically: first for habitats and species as a proportion of their respective distributions, and second for an amount of the processes and features required to maintain the proportion of habitat or species distributions calculated in the first step, as appropriate (Fig. 1). Recalling that quantitative targets are strongly preferred over qualitative targets, and recognising that data availability will likely constrain the type of analyses that can be undertaken, the framework we present includes methods and recommendations for setting quantitative targets for scenarios where data are available (e.g., species–area curves) and unavailable (e.g., fixed targets).

In supplement to this framework, a categorical list of the important biodiversity features comprising sandy beach ecosystems, and warranting conservation (and thus conservation targets), was tabulated. The list drew (in part) from group-discussion notes compiled during the VIth International Sandy Beach Symposium 2012 Workshop I: Valued Features of Sandy Beaches (Table 1). This