



# A framework for prioritizing conservation translocations to mimic natural ecological processes under climate change: A case study with African antelopes



Benjamin Luke Payne<sup>1</sup>, Jakob Bro-Jørgensen\*

Mammalian Behaviour & Evolution Group, Department of Evolution, Ecology & Behaviour, Institute of Integrative Biology, University of Liverpool, Leahurst Campus, Neston CH64 7TE, United Kingdom

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## ABSTRACT

Ongoing climate change is leading to significant range shifts in many taxa. Although climate-induced spatiotemporal dynamics have subtle implications for prioritization of translocation release areas, the terminology underlying current guidelines for conservation translocation remains focused on a dichotomy between 'reintroductions' within the indigenous range and 'assisted colonisations' anywhere else. We here propose a dispersal barrier-based framework for categorizing release areas according to their compatibility with natural ecological processes under climate change. Setting as a criterion that consistently suitable conditions are forecast over the timeframe considered, we define six translocation types corresponding to six translocation release zones: 'reinforcement' within the 'stable current range'; 'assisted dispersal sensu stricto' within the 'expected novel range'; 'compensatory dispersal' within the 'idealized novel range' (i.e. projected only if simulating absence of anthropogenic dispersal barriers); 'accelerated dispersal' within the 'expected connected envelope' (i.e. the spatiotemporally connected bioclimatic envelope beyond dispersal range); 'accelerated compensatory dispersal' within the 'idealized connected envelope' (i.e. unreachable connected envelope only if simulating absence of anthropogenic dispersal barriers); and 'artificial dispersal' within the 'unconnected envelope' (i.e. separated by natural physical barriers). Analysing projected range change in African antelopes by 2080, translocation across natural dispersal barriers was associated with elevated potential for interspecific competition with allopatric species and hence possible interference with ecosystem function. We argue that where translocation within the indigenous range is not an option, priority ranking of release sites would benefit from explicit consideration of dispersal barriers, favouring projected novel ranges above areas separated by distance and, especially, natural physical obstacles.

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## 1. Introduction

Translocation has been used as a conservation tool for more than a century in order to reverse species declines caused by human activities (Griffith et al., 1989; Seddon et al., 2007; Ewen et al., 2012). Although translocation is often a compelling solution for species facing a high risk of extinction in the wild, its implementation is far from straightforward: it is an intervention that by definition interferes with natural ecological and evolutionary processes, the maintenance of which is the very goal of conservation. Over the past decade, translocation has received broad interest as a means of adapting to human-induced climate change for species that are unable to track habitat changes in fragmented landscapes (Harris et al., 2006; Hunter, 2007; Seddon, 2010; Sansilvestri et

al., 2015). Still, the need remains for a systematic framework that prioritizes options for translocation according to their compatibility with natural eco-evolutionary processes in a world where climate change itself is changing what may be considered a natural process (Parmesan, 2006).

As a starting point, the International Union for Conservation of Nature (IUCN) Reintroduction Specialist Group (RSG), which was established in 1988 to promote best practice in conservation translocations, argues that translocation into indigenous areas, i.e. 'reintroduction', is generally preferable to translocation into non-indigenous areas, i.e. 'assisted colonisation' (IUCN/SSC, 2013). The justification is convincing: reintroductions can be expected to entail relatively low risks because population restoration in this case is supported by historical data on the performance of the species as a natural part of the ecosystem. However, the IUCN RSG guidelines also point out that under some conditions the non-indigenous area may in fact be more suitable for translocation than the indigenous range. Hence a wide range of potential threats faces species in the wild - including overexploitation,

\* Corresponding author.

E-mail address: [bro@liv.ac.uk](mailto:bro@liv.ac.uk) (J. Bro-Jørgensen).

<sup>1</sup> Department of Ecology, Scottish Association for Marine Science, Scottish Marine Institute, Oban, Argyll, PA37 1QA, Scotland, United Kingdom.

land use changes, civil conflict, disease transmission, invasive aliens, pollution, as well as climate change (IUCN, 2015) - and if the critical cause of a species' decline within its indigenous range has not been identified and dealt with, reintroduction is unlikely to result in a stable, self-sustaining population. Even in cases where the threat that caused local extinction is no longer present, a concern may be the subsequent emergence of new threats within the indigenous range. Moreover, future threats, such as climate change, may sometimes be more likely to affect the indigenous range than climatically suitable parts of the non-indigenous area. The IUCN RSG guidelines thus refer to assisted colonisation as the solution of choice “where protection from current or likely future threats in current range is deemed less feasible than at alternative sites” (IUCN/SSC, 2013). However, the guidelines point out that a “wide spectrum of operations” is currently covered by the term ‘assisted colonisation’ (IUCN/SSC, 2013). In this study, we view the highly heterogeneous area potentially suitable for translocation release as a continuum in terms of the degree to which translocation would mimic a likely natural change in space use under climate change.

How then can the likelihood of future distributional changes be estimated? When the climate induces habitat changes, the probability of a species colonising a given area will depend on its species-specific dispersal ability and whether barriers to dispersal are present. Dispersal barriers can be physical features of the natural world which make colonisation impossible, e.g. rivers, mountains, or intercepting hostile habitats and/or climate (Foden et al., 2008). Alternatively, the barrier can be distance in which case colonisation may be expected eventually, time being the crucial limiting factor. Also, barriers can be anthropogenic, e.g. due to wildlife incompatible human land-use or infrastructural developments, such as roads, fences or pipelines. From a conservation perspective, translocations across natural physical barriers may be considered the most artificial and therefore least desirable. More compatible with natural eco-evolutionary processes are translocations that speed up dispersal events likely to occur naturally by traversing unoccupied expanses of suitable habitat at an accelerated pace. Finally, translocations across anthropogenic barriers effectively restore natural eco-evolutionary processes by overcoming artificial obstacles to dispersal.

Following this logic, we here propose a dispersal barrier-based framework for prioritizing translocation release areas to protect natural eco-evolutionary processes under climate change. Taking as a prerequisite that conditions must remain bioclimatically suitable over the relevant timeframe (Chauvenet et al., 2013), we define six translocation types corresponding to six distinct translocation release zones that differ in the degree to which translocation would approximate a natural event (Fig. 1): (i) ‘Reinforcement’ within the ‘stable current range’; (ii) ‘Assisted dispersal sensu stricto’ within the ‘expected novel range’; (iii) ‘Compensatory dispersal’ within the ‘idealized novel range’ (i.e. the range projected only if simulating the absence of anthropogenic dispersal barriers); (iv) ‘Accelerated dispersal’ within the ‘expected connected envelope’ (i.e. the part of the bioclimatic envelope beyond dispersal range); (v) ‘Accelerated compensatory dispersal’ within the

‘idealized connected envelope’ (i.e. the unreachable, connected envelope projected only if simulating the absence of anthropogenic dispersal barriers); and (vi) ‘Artificial dispersal’ within the ‘unconnected envelope’ (i.e. the part of the bioclimatic envelope that is spatiotemporally separated from the current range by natural physical barriers).

As our empirical model, we focus on African antelopes, a group expected to be significantly affected by future climate change (Payne and Bro-Jørgensen, 2016), and of which 23% of the species are already listed as threatened on the IUCN Red List (IUCN, 2015). Translocation has a particularly strong history as a conservation tool in ungulates, from the first conservation translocation ever which targeted the American bison (*Bison bison*) in 1907 (Kleiman, 1989), through several subsequent successful reintroductions, for example of the Arabian oryx (*Oryx leucoryx*) in the 1980s (resulting in down-listing from ‘extinct in the wild’ to ‘vulnerable’; Stanley Price, 2016), to today’s efforts to restore populations of the wild-extinct scimitar-horned oryx (*Oryx dammah*) within its former range (Woodfine and Gilbert, 2016). Our study is thus intended also to address a more specific urgent challenge to conservation. To delimit translocation release zones for our empirical study system, we project spatial responses of species and their habitats to climate change using species distribution models (SDMs) with the critical timeframe set to 2080, the time horizon of the climate forecasts (IPCC, 2015).

Though we advocate for the ecological changes expected under climate change to be incorporated more firmly into translocation guidelines, we also agree that translocation initiatives should aim to retain current ecosystem structure as far as possible to avoid functional perturbation (IUCN/SSC, 2013), especially considering the uncertainty inherent in forecasting future species distributions (Synes and Osborne, 2011). A particular concern is the introduction of previously allopatric species, which can trigger unprecedented ecological processes with potentially devastating consequences; in particular, competitive exclusion can lead to both extinction of indigenous species where introduced species behave invasively (e.g. the extinction of the thylacine *Thylacinus cynocephalus* following introduction of domestic dogs *Canis lupus familiaris*; IUCN, 2015) and establishment failure of introduced populations where the indigenous species are the stronger competitors (e.g. the failure of introduced roan antelope *Hippotragus equinus* to become established in the ungulate community in Shimba Hills National Park, Kenya; Schiøtz, 1987). The risk of ecological interference in this case increases with the dietary overlap between species, which can promote unnatural interspecific competition. By contrast, interspecific competition between naturally sympatric species is an integral component of natural ecosystem function, where stable coexistence is evidenced by historical data. To assess the extent to which our classification system captures differences between translocation release zones in their similarity in community structure to current ranges, we compare zones within our empirical model system in terms of the projected occurrence of currently allopatric antelope species as well as the degree of dietary niche overlap with these.

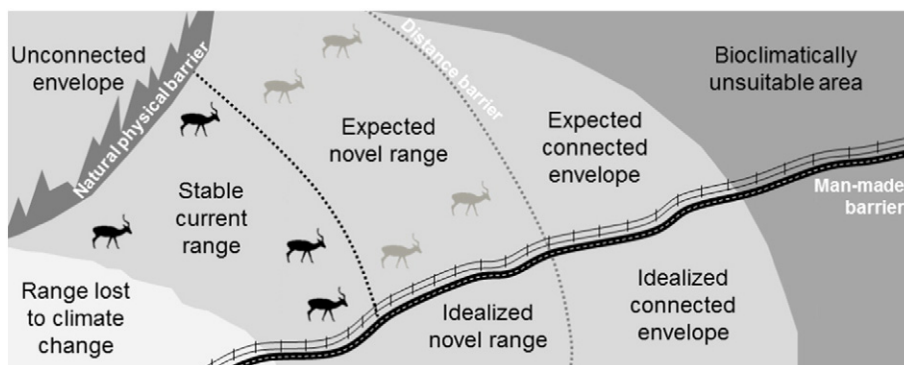


Fig. 1. Schematic representation of the translocation release zones in relation to dispersal barriers.

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