



How to Decide Whether to Move Species Threatened by Climate Change

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Abstract

Introducing species to areas outside their historical range to secure their future under climate change is a controversial strategy for preventing extinction. While the debate over the wisdom of this strategy continues, such introductions are already taking place. Previous frameworks for analysing the decision to introduce have lacked a quantifiable management objective and mathematically rigorous problem formulation. Here we develop the first rigorous quantitative framework for deciding whether or not a particular introduction should go ahead, which species to prioritize for introduction, and where and how to introduce them. It can also be used to compare introduction with alternative management actions, and to prioritise questions for future research. We apply the framework to a case study of tuatara (*Sphenodon punctatus*) in New Zealand. While simple and accessible, this framework can accommodate uncertainty in predictions and values. It provides essential support for the existing IUCN guidelines by presenting a quantitative process for better decision-making about conservation introductions.

Figures

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Introduction

Introducing individuals of a species to locations where the climate is predicted to be suitable in the future, but where the species has never occurred before, is a controversial adaptation action for combating the predicted impacts of climate change on biodiversity [1], [2], [3], [4], [5], [6], [7]. This action is a type of conservation introduction [8], and has been referred to as 'managed relocation', 'assisted migration' or 'assisted colonization' in recent debate about its implementation [3]. While discussion continues, conservation introductions motivated by climate change are already taking place [9], [10]. There are a number of critical decisions faced by those considering introductions as a potential climate adaptation strategy, and it is imperative that these decisions are aided by explicit, transparent and mathematically rigorous decision-making frameworks [11]. While such a framework has been used to determine the optimal timing of introductions motivated by climate change [12], several other key management questions remain unanswered.

The first, and most hotly debated, question is whether the benefit of introducing a species outside of its historical range in response to climate change is worth the financial costs and ecological risks [3]. Here the decision-maker must reflect not only on the potential collateral damage to the ecosystem at the introduction site, but also on the likelihood that the introduction will be successful, the benefit to the species of concern from a successful introduction, and the relative importance placed on this species by the decision-maker. Two recent studies [1], [2] develop frameworks for addressing this question, but neither do so within the tenets of decision science: both lack a quantifiable management objective and mathematically rigorous problem formulation.

As well as this key question of whether or not to go ahead with the introduction of an individual species, there are a number of related questions that need to be addressed for good decision-making. We must decide how best to implement an introduction, and where the introduction will occur. Further, these introductions incur a financial cost, and we will never have enough money to translocate every candidate species under threat, so we must consider budgetary constraints when prioritizing how and where to introduce species, and also when prioritizing among candidate species for introduction. Here we provide the first quantitative decision framework that can be used to address any, or all of, these questions. By formulating these questions in a rigorous way, we identify which predictions are necessary for making an informed decision. This framework should be applied pre-emptively, to direct future ecological research towards answering the questions most relevant to management decisions.