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Letters

Assisted colonization: evaluating contrasting management actions (and values) in the face of uncertainty

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In their recent Opinion article in *Trends in Ecology & Evolution*, Ricciardi and Simberloff [1] argue that assisted colonization is not an appropriate management option because the impacts of introduced species are too difficult to predict, and can have harmful consequences for recipient ecosystems, including the extinction of native species. Invoking the precautionary principle, the authors argue that alternative conservation tactics must be pursued, even for species faced with extinction in their native range. We concur with the authors that there are risks associated with introducing species outside of their current range. However, we disagree for three reasons that these risks are so great that assisted colonization should not be considered among possible management options.

First, the probability of translocated organisms causing significant damage to native species might be overstated. Indeed, the sources on which the authors base their analyses (<http://www.issg.org> and Ref. [2]) report impacts on native species that are sometimes based on anecdotal or correlative evidence, a common challenge when evaluating the impact of non-native species [3,4]. For example, the extinction of a Puerto Rican bullfinch subspecies from St. Kitts (*Loxigilla portoricensis grandis*) is attributed in the authors' data set to the introduced green monkey (*Cercopithecus aethiops*) [2] even though the monkeys were uncommon within the bird's range, the two species had coexisted for more than 200 years and the demise of the local Puerto Rican bullfinch population coincided with two catastrophic hurricanes [5]. Furthermore, for each species with multiple introductions, the authors scored only the most extreme impact, rather than an average one (Figure 1 caption in Ref. [1]). Reports of extreme examples are important because they describe worst-case scenarios, but these should also be accompanied by modal outcomes, which are more likely to occur.

Second, there is a need to weigh the risks of assisted colonization versus the risk of extinction using more traditional conservation practices. Data provided by the authors (Figure 1 in Ref. [1]) suggest that 85% of intra-continental mammalian translocations resulted in no detectable effect in recipient ecosystems. Translocations within a species' former range were not included in the authors' analyses (A. Ricciardi, pers. commun.), and might have even lower probabilities of adverse effects. We suspect that if a species were under imminent threat of extinction, could not migrate to suitable habitat, was unlikely to cause ecological harm and benefited from broad public support, few would argue against assisted colonization.

Third, risk assessments need to be evaluated and debated in a framework that recognizes that different stakeholders might place a premium on different outcomes. Even among conservation biologists, there appear to be divergent value systems that influence conservation targets and management tactics. Ricciardi and Simberloff appear to place a premium on protecting species in their native habitat, whereas proponents of assisted colonization are willing to translocate species to prevent their extinction even though in some cases this could result in adverse effects [6].

There is a need for a framework that integrates both biological information and socioeconomic data, and allows for debates regarding more subjective values surrounding species conservation. Hoegh-Guldberg *et al.* [6] proposed a relatively simple framework based on three categories: the need of a taxon (how imperiled is it?), technical feasibility (can it be translocated?) and suitability (do biological, social and economic benefits outweigh costs?). More comprehensive (K.B.S. *et al.*, unpublished) and alternative [7] frameworks are being proposed to help stakeholders evaluate the numerous, complex questions embedded within each of these three categories.

Proponents and opponents of assisted colonization share a concern for biodiversity and, as the impacts of climate

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change become increasingly apparent, more managers are likely to seek guidance from scientists as to when assisted colonization might be an appropriate tool to use. Humans have historically moved organisms for a variety of purposes, and at least two species have already been moved under the aegis of assisted colonization [7,8]. Thus, we believe that an attempt to prohibit intentional translocations of species for conservation purpose is excessively restrictive and unrealistic. A better approach is to debate the relative (and subjective) merit of all possible courses of action given current information under an agreed-upon framework.

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Letters

Managed relocation: a nuanced evaluation is needed

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Managed relocation (aka ‘assisted colonization’ and ‘assisted migration’ [1,2]) aims to save species from the effects of climate change by purposefully transporting them to areas where they have not previously occurred, but where they are expected to survive as temperatures increase. In a recent Opinion article in *TREE* [3], Ricciardi and Simberloff suggest that ‘assisted colonization is tantamount to ecological roulette and should probably be rejected as a sound conservation strategy by the precautionary principle.’ We disagree for three primary reasons.

First, the precautionary principle is not a stand-alone reason to rule out managed relocation. It states that ‘Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.’[†] In the context of managed relocation, ‘precaution’ cuts both ways, as a motivation to avoid relocations that might cause unwanted harm and as a motivation to act before a species is driven extinct by climate change.

Second, we know more about the impacts of species invasions than Ricciardi and Simberloff suggest, particularly with respect to species extinction. For instance, extinctions facilitated by exotic species occur primarily on islands (>90%) as opposed to continents [4]. Also, extinctions are generally caused by predation as opposed to competition; there are no documented cases to our knowledge where competition from exotic species has been the sole causal factor for the extinction of any native species [4]. Indeed, over the past few hundred years, thousands of exotic plant species have been introduced

to islands around the world, but few native plant species have become extinct as a result [5]. Given sufficient time, competition from plant species might eventually cause extinctions, but this has not yet occurred. Collectively, these findings suggest that relocated plant species are unlikely to cause extinctions, at least over the next few hundred years, and especially not within continents. Other findings (e.g. Ref. [6]) exist that can help inform the risks of relocating species, both with respect to species extinctions and ecosystem functioning.

Third, because extinctions are permanent and irreversible, using managed relocation to reduce extinctions at the cost of changing the composition and functioning of ecosystems is a tradeoff that some managers might be willing to make. This will be particularly true if most changes that result from relocations are small, and if those that are large are not necessarily detrimental. In considering these tradeoffs it is important to recognize that ‘most invasions appear to have only minor impacts’ [3] and that these impacts are not necessarily detrimental. Indeed, many exotic species provide important ecosystem services; for example, invasive aquatic plants can maintain water quality and provide habitat for native species [7].

Ultimately, the risk of species extinctions from climate change is too large to summarily discount managed relocation without first carefully evaluating its benefits and dangers in a nuanced way. Beginning this process now will better position us to make informed decisions in the years ahead, as threats of climate-mediated species extinctions become more common.

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* The findings and conclusions in this article are those of the author and do not necessarily represent the views of the US Fish and Wildlife Service.

[†] Rio Declaration Anon. (1992)