

# Reframing the debate over assisted colonization

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Assisted colonization – also known as managed relocation or assisted migration – is one way of facilitating range shifts for species that are restricted in their ability to move in response to climate or other environmental changes. Over the past decade, a healthy debate has evolved in the scientific community over the costs and benefits of assisted colonization as a climate-adaptation strategy. This discussion has focused largely on the specific risks and benefits of intentionally moving species, and has led to the development of multiple frameworks and numerous recommendations for weighing and evaluating these factors. Here, we argue that this debate is, in part, misguided, and that a more productive discussion would result if the issue were reframed in light of (1) the goals of assisted colonization, (2) the realities of projected climate impacts, and (3) the use of complementary adaptation strategies, such as enhancing landscape connectivity.

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Climate change is poised to dramatically alter ecosystems and reshuffle ecological communities. The geological record reveals that, as climates changed in the distant past, some species moved great distances, retreating into pockets of suitable climate or expanding their range to fill newly forming niches. However, when we look to the future, it is clear that the projected rapidity of climate change may exceed the ability of certain species to keep pace, either by adapting to their new environments or dispersing to more climatically favorable areas (Figure 1; Thomas *et al.* 2004; Parmesan 2006). One of the many suggested conservation strategies for facilitating climate-driven range shifts is assisted colonization (also known as managed relocation or assisted migration; McLachlan *et al.* 2007; Hoegh-Guldberg *et al.* 2008; Richardson *et al.* 2009). Assisted colonization involves the intentional translocation of members of a given species to an area outside its native range, to protect it from anthropogenic threats (Seddon

2010). There are many anthropogenic threats, but here we focus on those posed by climate change.

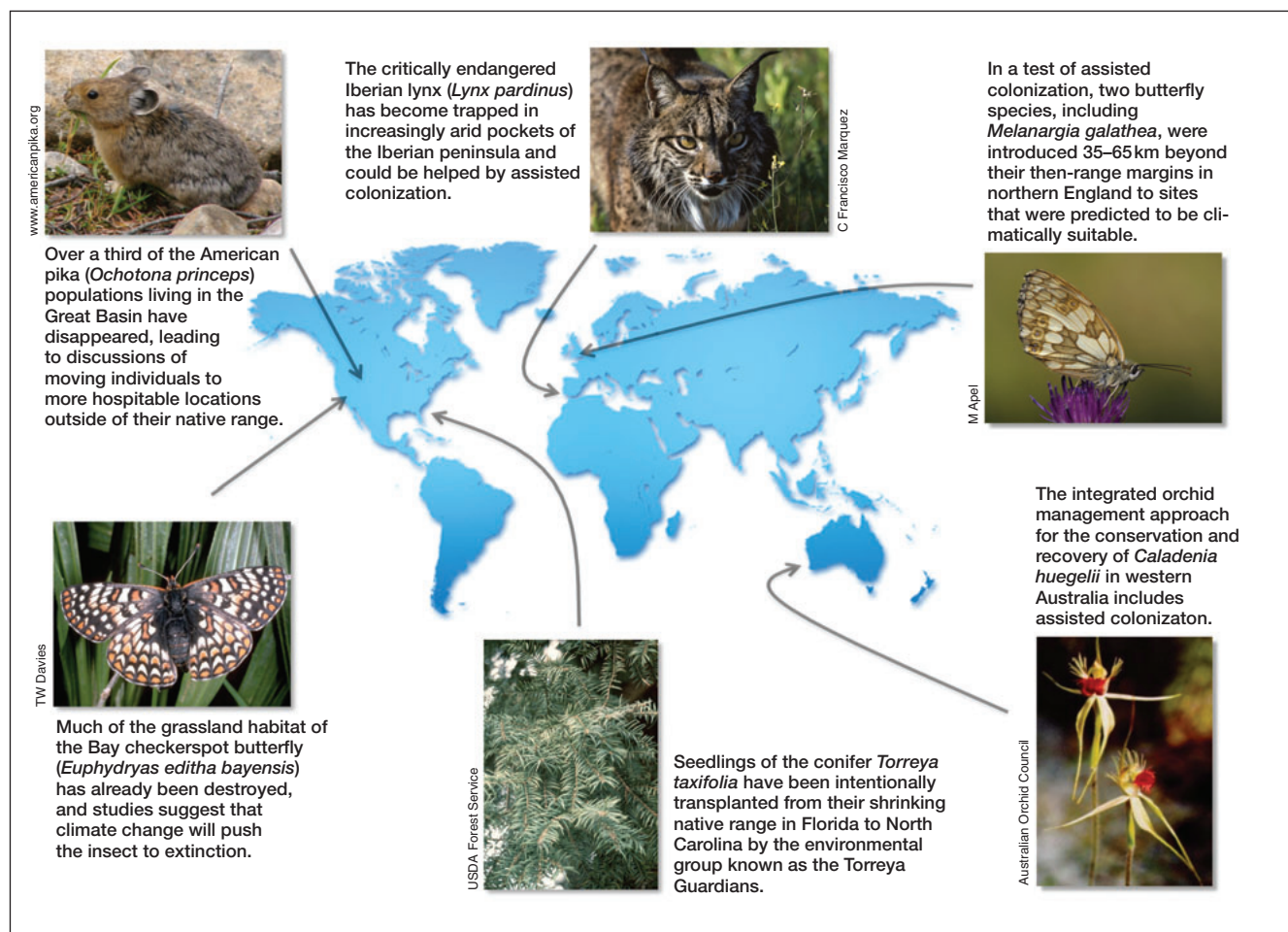
Although many hail assisted colonization as pragmatic and forward-thinking, the proposition of moving species in response to climate change has understandably raised concern and sparked a heated debate. There are those who argue that assisted colonization, when applied cautiously and judiciously, will be an essential tool for species conservation in a changing climate (Hulme 2005; Hunter 2007; McClanahan *et al.* 2008; Sax *et al.* 2009). Several frameworks have been proposed for making the ecological, socioeconomic, legal, and ethical evaluations that will inform decisions about assisted colonization (Hoegh-Guldberg *et al.* 2008; Joly and Fuller 2009; Richardson *et al.* 2009; Sandler 2010). Others suggest that it is pure hubris to assume that ecologists have the ability to determine when assisted colonizations will be successful and whether translocated species will do more harm than good (Ricciardi and Simberloff 2009; Seddon *et al.* 2009). Opponents of assisted colonization cite the devastating and unpredictable impacts of invasive species and our relatively poor understanding of the inner workings of most ecological systems, especially in a changing climate.

Much of the recent scientific debate over whether assisted colonization is a practical conservation strategy has focused on the details of the decision process, rather than on the larger issues. We are not suggesting that carefully arguing the details is trivial or unimportant, but that there are bigger issues that might help advance the dialogue by better framing the debate. More specifically, we call attention to the potential difficulties of focusing discussion on the consequences of action versus inaction, the degree to which society wishes to engineer future ecosystems, and the alternative approach of restoring or enhancing landscape connectivity. Although we do not provide solutions to these broader issues – in part because

## In a nutshell:

- Given that climate change will likely reorganize natural communities and drastically alter ecosystems, it will often be extremely difficult to assess the potential risks of assisted colonization to the systems into which a species is to be moved
- How society feels about assisted colonization will depend largely on human and ecological values and the degree to which we, as a society, want to try to shape or even create future ecosystems
- Although increasing landscape connectivity to promote range shifts poses many of the same risks as assisted colonization, the former strategy has not attracted the same level of debate

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**Figure 1.** Examples of species that could benefit from assisted colonization to address the adverse effects of climate change.

they cannot all be tackled by scientists, but rather will need to be addressed by society – we feel that by highlighting these challenges, it may be possible to advance the discussion and identify the scientific questions that will lead to sound and useful practices and policies involving assisted colonization.

### ■ Weighing the consequences of action versus inaction

At the heart of the debate is whether the consequences of action (moving a species) outweigh the consequences of inaction (not moving the species). Those opposed to assisted colonization argue that the risks imposed on the receiving ecosystem are greater than any gains to be made by moving a species (Ricciardi and Simberloff 2009), whereas proponents argue that those risks are overblown and that the risk of extinction of the target species will, in many instances, outweigh the potential risks to the receiving ecosystem (Sax *et al.* 2009; Schlaepfer *et al.* 2009).

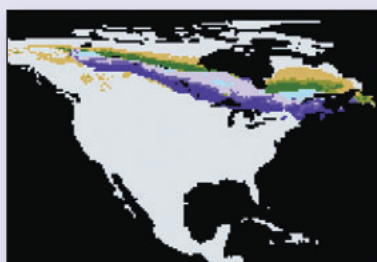
Considering these risks and benefits can be quite difficult (Minteer and Collins 2010). For example, how does one weigh the 70% chance of extinction of the target species against the 50% chance that the species will substantially alter the community into which it is intro-

duced, and the 5% chance that one or more species in this community will be driven locally extinct? One could argue that global extinction trumps local extinction, but one could also make the case that losing a single species is less detrimental than potentially altering ecosystem function in other systems.

Comparing such disparate impacts presupposes that it is even possible to assess the risks in the first place. Thus, a secondary question is whether it will be possible to evaluate these two sets of risks with enough certainty to make an informed decision. Although tools and data are available for measuring these risks (Panel 1), it will be difficult to assess both the threat of extinction and the likelihood of impacts to receiving ecosystems. One fundamental tool for assessing the risk of extinction of a given species is population viability assessment (PVA; Soulé 1987; Burgman *et al.* 1993). The challenge will be to develop appropriate climate-impact assessments and to incorporate them into PVAs and other risk-assessment methods. Such impact assessments might include forecasting rates of climate-induced habitat loss or predicting the effects of climate change on physiology, prey availability, or the impacts of a new predator.

Estimating the potential impacts of assisted colonization on the receiving ecosystem is even more problem-

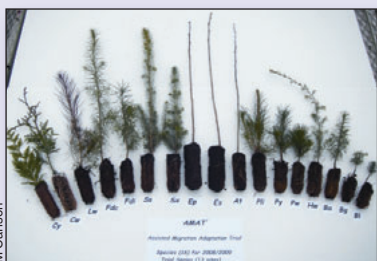
### Panel 1. Tools for informing assisted colonization decisions



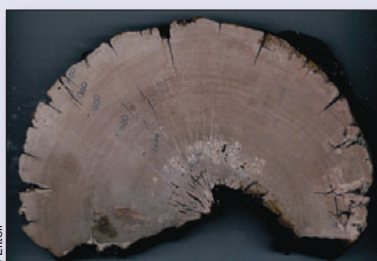
**Forecasts of potential climate impacts.** Bioclimatic models projecting changes in biomes, species' distributions, population dynamics, or ecosystem function can provide information to help inform decisions about assisted colonization. The map on the left depicts a projected shift in the range of the bay-breasted warbler, *Dendroica castanea*, over the next 100 years. The map shows the level of agreement across projections based on 10 simulated future climates. Blue areas depict where the range may be stable; green to yellow areas depict potential range expansion; purple areas depict potential range contractions; and darker colors indicate greater agreement across the 10 simulated climates.



**Knowledge from previous reintroductions.** Many of the lessons learned from both successful and unsuccessful reintroductions can be used to inform assisted colonization. The globally endangered freshwater pearl mussel, *Margaritifera margaritifera*, is under serious threat of extinction throughout its geographical range and only a few remnant populations are recruiting to adulthood. Several European institutions are developing protocols and hatcheries to culture and rear young mussels from population remnants, with the intention of reintroducing these juveniles into rivers.



**Experiments.** Well-designed experiments can provide important insights into how a given species or genotype will respond to translocations, how changes in climate will affect populations and communities, and how receiving ecosystems will respond to transplants. The seedlings in the image to the left are part of the Assisted Migration Adaptation Trial project initiated by the British Columbia Ministry of Forests, Mines and Lands (Marris 2009). The project involves experiments with 16 different tree species to explore how trees grow when planted in both southern and northern locations, simulating the effects of an assisted colonization and the effects of warming, respectively.



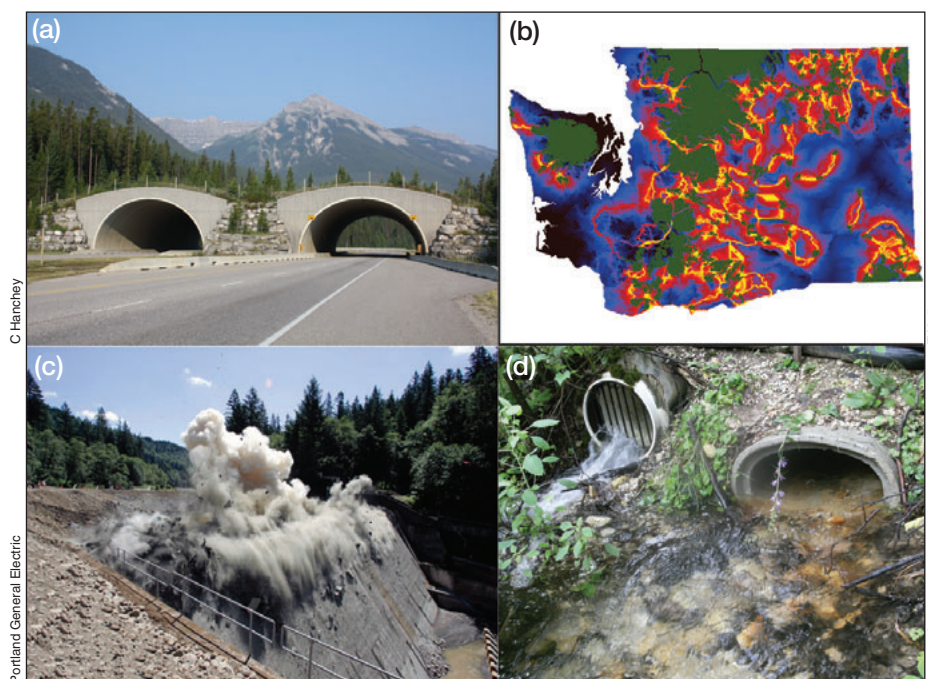
**Historical records, paleoecological data, and genetic analyses.** Historical distribution records and paleoecological data derived from pollen in sediment cores, tree rings, and fossils can provide an idea of how species responded to climatic changes in the past. Likewise, genetic analyses can reveal how species ranges changed as climates changed in the past (eg McLachlan *et al.* 2005).

atic. Not only is it notoriously difficult to predict which species will be invasive and how those species will affect a given system (Parker *et al.* 1999; Ricciardi and Cohen 2007), but such estimates will also have to be made for ecosystems that are likely to be transformed by the changing climate, even without the introduction of the target species (Williams and Jackson 2007; Rahel and Olden 2008). For example, under a moderate to high greenhouse-gas emissions scenario, vertebrate faunas in any given part of the Western Hemisphere are, on average, projected to experience a 35% turnover by the end of the 21st century – and many areas are projected to experience over 90% turnover (Lawler *et al.* 2009). Thus, potential receiving communities will be “moving targets”. One might be able to conduct experiments to assess the effects of the target species on some of the species in the receiving community, but given the rate of

projected climate change, the results may tell us little about the potential interactions with that community in 50 (or even fewer) years.

In light of the difficulty in weighing the consequences of action versus inaction, we conclude that focusing the debate on this issue is counterproductive. In fact, we would argue that, given the magnitude of change that is likely to occur in many receiving ecosystems, there is little use in worrying about the effects of introducing one particular species. This is not to say that we should abandon efforts to assess potential impacts to the receiving ecosystems. However, it does suggest that we consider the amount of change forecast for that ecosystem before conducting detailed experiments on a system that may not exist in the future. Several forecasts of potential changes in communities and systems have been made for different taxa in different parts of the world, and new perspectives





**Figure 2.** Increasing connectivity is one of the most often cited climate-change adaptation strategies for plants and animals (Heller and Zavaleta 2009). Connectivity in terrestrial systems can be enhanced with (a) wildlife crossing structures, such as this overpass in Banff National Park in Alberta, Canada; (b) connectivity plans for prioritizing conservation actions, like this set of potential corridors (shown in red and yellow) in the state of Washington; (c) dam and diversion removal (eg the decommissioning of the Marmot Dam on the Sandy River, Oregon); and (d) modified fish-passage structures, such as engineered fish-friendly culverts (eg the culvert on the right, compared with the original, less fish-friendly culvert on the left).

on restoration and conservation strategies are emerging (Choi 2004; Hobbs *et al.* 2006). These approaches may help determine which systems are likely to be more or less volatile and therefore where impact assessments might be more or less useful.

### ■ Engineering future ecological systems

Range-shift projections suggest potential extinction rates of 15–37% by 2050 (Thomas *et al.* 2004), and the complete reshuffling of flora (Thuiller *et al.* 2005) and fauna (Araújo *et al.* 2006; Lawler *et al.* 2009) in some places. The paleoecological record indicates that systems can change dramatically with changes in climate and can result in no-analog communities and novel ecosystems (Brubaker 1989). Future forecasts also predict no-analog climates and communities (climates and communities unlike any that exist today; Williams and Jackson 2007; Stralberg *et al.* 2009). These changes will have profound effects on the functioning of ecosystems and the provision of ecosystem services. As a result, we as a society will need to determine the desired state of these ecosystems, how we want them to function, and how we want to benefit from them (Jackson and Hobbs 2009). Do people want an ecosystem that maximizes particular services (eg water availability, carbon sequestration, aesthetics, timber production), protects as many species as possible, or preserves particular

species? Alternatively, policy makers and natural resource managers can avoid answering these questions and let the chips fall where they may, allowing species to rearrange themselves into new assemblages of their own accord. The degree to which people want to play a role in shaping the development of these new and altered systems will, in large part, determine how society feels about assisted colonization and its implementation as a conservation strategy. Scientists can clearly inform this discussion, but it is one that will need to be taken up by society and decision makers before policies on assisted colonization are developed. We would therefore argue that the debate over assisted colonization should be broadened to include an audience that extends well beyond the scientific community.

### ■ The greater issue of landscape connectivity

The issue of enhancing connectivity between fragmented landscapes has been noticeably absent from

the debate over assisted colonization. Although many have voiced concerns about assisted colonization, little objection has been made to the far more numerous calls for increasing the connectivity of the landscape as a climate-change adaptation strategy (Heller and Zavaleta 2009). With respect to addressing climate change, increasing connectivity and assisted colonization have the same basic goal – to move species, or to help them move, to suitable climates. Building highway overpasses, designing corridors, removing water diversions, and managing landscapes in ways that promote permeability all have the potential to allow species to move into ecosystems that lie outside their historical ranges (Figure 2; Manning *et al.* 2009). Yet there have been few objections to making landscapes more permeable, despite the fact that this may ultimately promote the spread of invasive species (Pascual *et al.* 2009; Jackson and Pringle 2010; Olden *et al.* 2011). If facilitating movement by enhancing habitat connectivity is acceptable, why is assisted colonization objectionable? Is it the level of intervention that conservation biologists object to, or is it the potential effects of intervention?

Arguably, there is a moral difference between reconnecting anthropogenically fragmented landscapes and moving species outside of their historical ranges. The former can be seen as an act of restoring the natural order of things and the latter as disrupting it, regardless

**Table 1. Comparative limitations and challenges of assisted colonization and increasing habitat connectivity**

<i>Limitations and challenges</i>	<i>Assisted colonization</i>	<i>Increasing habitat connectivity</i>
Scope	Will be limited to a relatively small number of species	Has the potential to facilitate range shifts for a greater number of species, but will fail to facilitate range shifts for dispersal-limited species
Control over which, where, and when species are moved	More control	Less control
Ecological impacts	Has the potential to damage the receiving ecosystem	Has the potential to damage multiple receiving ecosystems
Financial cost	May be less expensive than increasing connectivity for a single species, but cost ultimately depends on the level of evaluation and precautionary measures that are taken	Will generally be more costly to purchase land or easements or to provide incentives to land owners, but has the potential to facilitate the movement of multiple species
Public support	Less resistance from land owners	More resistance from land owners
Policy	New policies will be needed	Can often be implemented through existing (or by modifying) current policies

of the fact that the outcome of both actions may be the same. Although the level of intervention is clearly different, some of the key impacts of the interventions are likely to be similar. As mentioned previously, much of the debate over assisted colonization has focused on the potential impacts to receiving ecosystems. If enhancing connectivity were to have the desired outcome, there would be no difference in the potential risk to a receiving system from the two adaptation strategies. This begs the question of whether the arguments against “assisted colonization” should be brought to bear on the adaptation strategy of increasing connectivity.

Increasing connectivity and assisted colonization can be seen as complementary approaches, two tools that conservation planners and natural resource managers could have at their disposal. Each tool has its limitations and challenges (Table 1). For example, developing new policies to successfully implement and regulate assisted colonizations may be more difficult than creating additional policies to enhance landscape connectivity. Similarly, public support for these two strategies will likely differ, particularly across various sectors of society. Land owners, for instance, will probably be more opposed to increasing connectivity, particularly if it involves regulating land or water use.

Of course, managers may not necessarily be choosing between these two approaches for a given species. There will clearly be cases where only one option is available. Assisted colonization may be the only option for those species with very limited dispersal abilities. For these species, increasing connectivity will do little to facilitate their tracking of suitable climates. It can also be applied when increasing connectivity would have detrimental effects, such as facilitating the movement of diseases or introduced predators.

## ■ Conclusions

Perhaps the most important issue that needs to be addressed in the debate over assisted colonization is the degree to which we want to try to shape future ecological systems. One potential response to climate change is to interfere little with ecological systems as climate changes, letting new communities and ecosystems sort themselves out. At the other end of the spectrum of possible responses is the engineering of communities and ecosystems – perhaps using species not native to the region – with the goal of maximizing ecological functioning and benefits to humanity (Mitsch and Jorgensen 2004; Seddon 2010). Given that the answer to this basic question depends on societal values and not scientific evidence, the debate will need to move from the pages of scientific journals and into the public and policy arenas (Richardson *et al.* 2009; Minter and Collins 2010). That is not to say that we, as scientists, cannot and should not play a major role in shaping the debate. However, without framing the discussion in the context of this larger question and without seriously considering the sheer magnitude of projected future climate impacts, the debate will remain purely academic.

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