Climate Change and Moving Species: Furthering the Debate on Assisted Colonization

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Introduction

With global climate change looming large in the public psyche, the recent paper by McLachlan et al. (2007) and its popular accompaniment (Fox 2007) are timely indeed. Of course some conservation biologists will not wish to think about the prospect of actively moving species that are threatened with extinction by climate change. For them this would be almost analogous to handing out placebos in the midst of an epidemic and worse yet, these placebos may have serious unintended consequences if translocated species become invasive. They will probably argue that we should focus almost exclusively on two central roles for conservation biology: (1) facilitating natural range shifts by redoubling efforts to maintain or restore large-scale connectivity (Hunter et al. 1988; Hannah et al. 2002) and (2) working with our fellow environmental professionals to avoid carbon-management solutions that will have unacceptable consequences for biodiversity (e.g., by directing biofuel production away from sites that would involve the conversion of native vegetation into fuel farms; Cook & Beyea 2000). These two roles will be very demanding, but I believe we should allocate a small portion of our attention to the issue of assisted colonization that McLachlan et al. (2007) have brought to the fore.

McLachlan et al. propose framing the debate around two considerations—perception of risk and confidence in ecological understanding—that can be construed to generate an axis or continuum from scientists who would strongly support assisted colonization to those who would oppose it. I think it is useful to advance this exercise by considering three issues that can also be construed as continua: species that are more or less acceptable to translocate, sites that are more or less acceptable for receiving translocations, and projects that are more or less acceptable because of their socioeconomic ramifications and feasibility. I have used the term *assisted colonization* in contrast to *assisted migration* used by McLachlan et al. because many animal ecologists reserve the word *migration* for the seasonal, round-trip movements of animals (Wilcove 2007) and because the real goal of translocation goes beyond assisting dispersal to assuring successful colonization, a step that will often require extended husbandry.

Candidate Species

Candidate species for assisted colonization can be characterized by three features: their probability of extinction due to climate change, their vagility, and their ecological roles. Obviously, it will be more acceptable to translocate a species that is definitely in decline because of climate change than one that is affected only mildly. Sorting out the relative importance of different threat factors is typically difficult; thus, we will often lack complete confidence that climate change is the primary threat (Thomas et al. 2004). Consequently, we might have to be vigilant against the temptation to export problems (i.e., to move an endangered species because it is inconvenient to maintain at its current location when the real issue is a threat such as contamination rather than climate change). If climate change can be pinpointed as a major problem, it probably makes sense to act before a species is in serious trouble.

All other things being equal, species that appear unlikely to disperse and colonize on their own because of limited vagility will be prime candidates for assistance. Here the issue is intergenerational movements, and in this respect a wind-dispersed plant might be more vagile than a migratory sea turtle that is highly philopatric (Hunter & Gibbs 2007). Furthermore, some species that are naturally vagile may have little opportunity to disperse because all of their nearby habitat has been lost (i.e., they are caught in a geographic bottleneck by human-induced ecosystem loss). Unfortunately, information on dispersal, especially long-distance dispersal, is limited (Clark et al. 2003).

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Species that have major ecological roles (i.e., dominants, keystones, or strong interactors [Soulé et al. 2003]) are probably riskier to move than those whose role is largely redundant with other species. For example, moving an uncommon forest herb into a new ecosystem would be less likely to effect a dramatic change than moving a dominant tree species. In addition, the most egregious examples of invasive exotics (at least as measured by extinctions) are generally animals that consume other species into oblivion. The ecological-role issue is complicated by the fact that the abundance of species, and thus the strength of their ecological role, can change dramatically over time and space (Jacobson & Dieffenbacher-Krall 1995).

Candidate Sites

Evaluating sites that might receive translocated species brings four more issues to light. First, the amount of disturbance at a potential translocation site is a significant issue. To take two extremes, many people might readily accept moving species to a mine restoration site but would absolutely balk at doing this in or near a wilderness reserve dominated by old-growth forest. Discussions will probably focus on intermediate points along the continuum (e.g., a cut-over forest that has experienced some extirpations and exotic invasions). Many ecosystems are not pristine because one or more species have been extirpated. In these cases, would it be acceptable to introduce a "climatic refugee" that might fill the role of the extirpated species? What if the role was that of an ecosystem dominant?

A second major consideration is the geographic isolation of a site. Moving species into a well-connected site that has experienced major changes in species composition as species have shifted their ranges in response to natural climate change would be far more acceptable than using a site that has long been an island (in the largest sense of the word, e.g., an isolated mountain or lake). Importantly, and often easier to measure, an isolated site will be more likely to harbor a unique biota such as endemic species and genetically differentiated populations. Conversely, because it would be wise to treat initial translocations as experiments, an ideal first site might be one that was well connected historically, but is currently surrounded by human-dominated landscapes that might be a barrier if the translocated species had unacceptable effects.

Third, the acceptability of a site will be influenced by any paleobiological evidence (scarce for most taxa) that the site occurs within a species' long-term geographic range (Willis & Birks 2006). It is noteworthy that the worst examples of invasive exotic species usually involve movements well outside a species' long-term geographic range, such as transoceanic introductions to Australia, and that paleoecology data indicate massive reshuffling of community composition within continents. Of course, if we start thinking about how species were distributed more than 10,000 years ago, it could lead to radical proposals such as replacing North America's extinct large mammals with their African analogues (Donlan et al. 2005). Looking to the past for guidance is also of limited value because future climates may have no past analogues (Williams et al. 2007).

Fourth, the literature surrounding both invasion of ecosystems by exotic species and the relationship between stability and diversity (Hooper et al. 2005) suggests that, all other things being equal, a species-rich ecosystem may be less likely to be disrupted by a translocation than a species-poor ecosystem. (I use weak language here because this is still a controversial topic.)

Feasibility

Evaluating species and sites is clearly within the purview of biologists, but there is a third set of issues—cost, technology, and humaneness—that will require attention from both biologists and social scientists.

The cost of translocations will vary enormously depending on the biology of the target species. Perhaps as important is the issue of who should bear these costs. Having a species-focused group such as the Torreya Guardians (www.torreyaguardians.org) dedicate their money and time to a translocation may be more acceptable to the conservation community than if a government agency or broad-based environmental group, such as The Nature Conservancy, does so. In the latter case many will argue that efforts would be better allocated to conserving whole ecosystems and their connectivity. On the other hand, organizations with a broader mandate might evaluate assisted colonization in a more balanced and accountable way.

The technology for moving species is far from perfect; thus, the likelihood of success varies considerably (Fischer & Lindenmayer 2000). If we have the practical know-how for moving a particular species safely (e.g., with minimal risk of disease transmission) and with a high probability of establishing a new population, then the project will be more acceptable. Finally, moving organisms can be quite intrusive for the individual creatures involved, and the public may find it much more acceptable to do this for plant propagules than for highly sentient animals.

Other Considerations

McLachlan et al. provide a thoughtful overview of the biological research questions raised by the prospect of assisted colonization, but they do not explicitly address socialscience research. For example, will people living in or near the current range of a local endemic oppose having individuals removed from the local population, and, conversely, will people living near the translocation site resist the introduction of an "exotic" species even if it is a "climatic refugee."

The long list of issues that are amenable to research may suggest that we need to complete a vast research program before assisted colonization can begin. Nevertheless, we are unlikely to have adequate time and money for truly comprehensive research and when popular species appear to be going over the edge action will be demanded. One approach may be to accelerate research that addresses the issues indirectly. To take two examples, research on the ecology of invasive exotics and on the translocation of species to fill gaps in their recent geographic ranges (Seddon et al. 2007) can help create a foundation of knowledge for assisted colonization.

The role of ex situ conservation in assisted colonization merits some attention. Moving species into the artificial ecosystems of zoos, gardens, and aquaria would certainly be less risky and it may be the only option for species living near the geographic end of climate gradients (notably polar and alpine species). Furthermore, ex situ conservation often uses funds that are not otherwise available for conservation (e.g., gate receipts and city tax dollars) and may be far less expensive for plants than for the carnivores, great apes, and other large animals that are often in the limelight. On the other hand, if the ultimate goal is free-living populations, the dismal track record of restoring species that have become extinct in the wild clearly makes this an option of last resort.

Conclusions

Deciding whether or not a particular assisted-colonization project should be undertaken is patently a complex problem. The many issues outlined here cannot be easily reduced to a multifactorial score card to judge acceptability, and no doubt other issues will arise in future discussions. As we go forward, I expect that some projects will be judged acceptable but many more will be rejected as too risky and expensive. Sound science as outlined by McLachlan et al. (2007) may reduce the risks and costs of these projects, but we seem destined for a period that will exercise our ability to advance conservation in the midst of uncertainty and disagreements over the best course of action. We should, at the least, be able to agree on how to frame the discussion, and as McLachlan et al. emphasize, the discussion needs to begin soon.

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