REPORT

Ecological Restoration in the Face of Global Climate Change: Obstacles and Initiatives

by Brian Lavendel

Global climate change: Is the ecological restoration community ready?

> In the case of major changes in global climate, "we may have to depend upon the lessons and techniques of ecological restoration ecology to save many species—and even whole communities."
>
> –Robert L. Peters II (*Restoration & Management Notes*, Winter 1985)

In 1985 Rob Peters predicted that ecological restoration would be a leading strategy for saving species doomed by global climate change. In the nearly two decades since then, the evidence of global warming has become more definitive, while the role of ecological restorationists in a climatically different world remains a topic rarely discussed, much less put into practice. Was Peters simply wrong? Is there really anything restorationists can do to alleviate or plan for the effects of global warming?

My survey of restorationists' responses to global climate change indicates that, while many obstacles remain, theorists and practitioners in the field are gradually beginning to consider the role of ecological restoration in adapting to global climate change.

A Globally Warmer World

Evidence for a globally warmer world continues to increase both in scope and credibility, and the effects of such warming appear daunting. According to a report on biodiversity from the United Nations' Intergovernmental Panel on Climate Change (IPCC), "Changes in climate exert additional pressure and have already begun to affect biodiversity....The risk of extinction will increase for many species that are already vulnerable."

Even those species that survive a warmer climate will be affected. Writing in the journal *Nature* (January 2, 2003), biologist Camille Parmesan and economist Gary Yohe presented a suite of analyses which indicated that the "climatic fingerprint" is pervasive and that climate change is "an important driving force on natural systems." Yohe and Parmesan, both members of the IPCC, undertook the meta-study to improve the level of confidence needed to draw conclusions about the causal connection between global warming and biological changes. Their meta-analyses showed that while many species of plants and animals remained stable in terms of their phenology, distribution, and abundance, many others experienced dramatic changes. For example, in one case study of the phenology of 385 mixed plants over 46 years, 279 species showed trends toward advanced spring events, 46 species showed trends toward delayed spring events, and 60 species remained stable. Citing the results from a number of similar studies, the

Ecological Restoration, Vol. 21, No. 3, 2003 ISSN 1522-4740 E-ISSN 1543-4079
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authors found similar correlations between climate change and biotic events. "Shifts in phenologies that have occurred are overwhelmingly (87 percent) in the direction expected from climate change."

Implications of Global Climate Change for Ecological Restoration

Assuming the data about climate change are correct, what does it portend for the practice of ecological restoration? Can ecological science and conservation address the effects of global climate change on species and ecosystems? What role, if any, should restoration play in adapting to or mitigating such change? I recently put these questions to a wide variety of academics and practitioners in the restoration field. Their responses indicate that, despite significant obstacles, restorationists can and are taking actions to address global climate change.

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Ecologists John McCarty of the University of Nebraska at Omaha and Joy Zedler of the University of Wisconsin-Madison have studied the role of ecological restoration in response to global climate change. In a recent article about ecological restoration and its potential to reduce the negative impacts of global change, McCarty and Zedler concede that restoration techniques cannot prevent negative impacts on ecosystems caused by global climate change (*Encyclopedia of Global Environmental Change* 2002). "However," the authors submit, "global change can and should be considered when designing restoration projects." They suggest that "Restoration and related land-management projects offer potential tools for mitigating some of the effects of global change on ecosystems."

Indeed, restoration may be the discipline best positioned for responding to global climate change. "Restoration ecology is going to play a big role in helping those species and communities disturbed by changes in climate adapt to new and changing conditions," McCarty told me in a telephone interview. But all observers agree that there are serious—although not insurmountable—roadblocks to our ability to respond to current and future global climate change.

Obstacles to Action in Response to Global Climate Change

Several obstacles, including a lack of data or information and the uncertainty related to variations in local climate change, are keeping practitioners from taking action to address the consequences of global climate change.

"I don't think most practitioners and land managers have enough understanding of what is happening with climate change to consider how it might affect what they are doing," offers Buddy Huffaker, director of the Aldo Leopold Foundation. Huffaker sees a "significant disconnect between academia, which is responsible for determining the rate of climate change, and practitioners, who may be trying to mitigate any potential impact."

Thomas Lovejoy, former chief biodiversity advisor to the World Bank and co-editor of the forthcoming *Climate Change and Biodiversity* (Yale University 2004), agrees with Huffaker and fears that this lack of communication may hinder a timely response to impending climate change. He calls for scientists to step forth with information that applies climate change data to on-the-ground applications. "The likelihood of overcoming these obstacles is dependent to a significant degree on the willingness of the professional scientific community to engage on the issue." "Our role," he says, "is to get in front of the public the fact that biology is going to be affected by climate change."

Other observers like Jay R. Malcolm, an assistant professor at the University of Toronto and co-author of the World Wildlife Fund report, *Global Warming and Terrestrial Biodiversity Decline*, concur. According to Malcolm, "There is an obvious role for leadership in outlining potential threats and looking for strategies to help. To do nothing is problematic." Malcolm believes that scientists may have to overcome a deep-seated reluctance to be perceived as advocates. "It looks like we're headed for significant species loss if we don't do something about it, so action is called for. You have to join the battle."

The other significant issue is the question of scientific uncertainty related to local climate-change scenarios. According to many observers, such uncertainty makes it problematic to take direct actions to mitigate the harmful effects of future climate change. For example, researchers Cynthia Rosenzweig and William D. Solecki, who are assessing the potential for climate change in metropolitan New York City, note that the "scientific uncertainty regarding regional manifestations of climate change makes local responses difficult. Currently, institutional decision makers are not sure how, when, and where climate change-related impacts might emerge in the region."

Upmanu Lall, a senior researcher at the International Research Institute for Climate Prediction, considers most of the work that relates climate change to detailed impacts as too speculative to be useful for management purposes: "The detailed changes in space or time in atmospheric or oceanic circulation or rainfall are far from credible."

Raymond Najjar, an associate professor at Pennsylvania State's Earth System Science Center, agrees that the working models are not sufficiently fine-tuned. Najjar, who studies the effects of anthropogenic activity on Chesapeake Bay and its watershed, notes, "One of the problems with incorporating predicted flow changes into planning, for example, is that such changes are highly uncertain. Even the direction of change is not well known."

Even if science gains a higher degree of confidence in local climate-change scenarios, multiple confounding variables still must be factored in. "Recent developments in forecasting have improved confidence in quantitative predictions of global warming and a rise in sea level," says Wim Kimmerer, a senior researcher at San Francisco State University's Romberg Tiburon Center. But, Kimmerer adds, it is next to impossible to scale these changes down to the local level in light of "high uncertainty of regional responses to global effects, influence of local anthropogenic effects, and opposing effects of likely mechanisms." According to Kimmerer, changes in local precipitation represent a huge challenge.

The long-term nature of a science-based response to climate change is more likely to be reactive than proactive, because as McCarty and Zedler point out, "We will need reliable predictions of when, where, and how environmental conditions will change." This suggests that specific geographic areas—such as coastal areas where sea-level rise can be anticipated—will be among the first areas where restorative actions will take place. Meanwhile, other areas where the effects of climate change are less predictable will take longer and will likely be implemented after the fact.

Measures to Overcome Obstacles

Is uncertainty reason enough to defer responding to rising sea levels or planning for other climatic changes? Lovejoy insists it is not. "Most of us make decisions involving uncertainties on a daily basis, and there is no reason we shouldn't be doing that for biodiversity and the environment," he argues. Agreeing with McCarty and Zedler, Lovejoy points out that land managers and conservation planners can incorporate measures into conservation and restoration projects that

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would be effective independent of the local specifics of temperature or precipitation changes. In particular, Lovejoy would like to see efforts put into restoring connective corridors within the landscape. "If we wait around until we know, it's going to be that much harder to acquire land or restore it," he says.

But this may not be easy because, as Rosenzweig and Solecki point out, short-term concerns tend to dominate management actions. "Policy responses to climate change are hampered by the generally reactive nature of management organizations. Institutional action is often directed at immediate and obvious problems; issues that might emerge fully only after several decades are perceived as less pressing." To overcome this institutional inertia, they call for improved communication, education, and outreach to inform decision makers and the general public.

Some practitioners are reluctant to take potential climate-change scenarios into account because the scale of most restoration projects is smaller than the landscape-scale at which climate change is currently modeled. The Aldo Leopold Foundation's Huffaker says that the issue of scale will be an important factor in determining appropriate climate-change strategies. He would like to see more research specifically into how small-scale ecological restoration activities can respond to climate change.

Researchers indeed agree that relatively small restoration and conservation areas may have an important role to play in protecting species and ecosystems by providing refugia for sedentary species and sources of propagules and colonists for future expansion. Such refugia may be key in preserving genetic diversity, say ecologists.

Case Studies

Despite the significant obstacles, a growing contingent of restorationists and others are pushing the envelope by incorporating climate-change scenarios into their planning and implementation. These practitioners and researchers acknowledge the unlikelihood of forecasting with precision the local effects of climate change, but insist that there are significant steps that can mitigate potential negative impacts. Moreover, they argue that to ignore or discount the potential for climate change impacts on any given project is to invite potential ecosystem disruption and degradation as climate change takes place.

Coping with Rising Sea Levels

The Albemarle-Pamlico Estuary, extending along the coast of North Carolina, is a huge complex of shallow sounds, rivers, and wetlands. With a total water area that exceeds 2,900 square miles (7,540 square kilometers), it is the second largest estuarine system in the United States. Here, Sam Pearsall, science director for The Nature Conservancy in North Carolina, is planning for sea-level rise—which is already underway—of about 2 inches (5 cm) every ten years.

Pearsall is seeking not only to preserve the integrity of existing natural areas but, in anticipation of predicted sea level rise, to protect places that will enable species and their surrounding systems to migrate inland and upstream. Pearsall reports that The Nature Conservancy is negotiating with public and private land holders in the region to develop coordinated plans to accommodate the sea-level rise as well as upland habitat needs. The plans cover a wide range of options, from having the conservancy finance the planting of select species, such as saltwater-tolerant bald cypress (*Taxodium distichium*), to buying lands outright.

Providing Refugia and Migration Corridors

How will species adapt to climate change? For mobile species, one obvious way is by moving with the shifting climate. However, ecosystem fragmentation resulting from widespread agricultural and other development will pose a significant barrier to this type of ecosystem adaptation, according to Ray Malcolm of the University of Toronto. “Current habitat fragmentation patterns and human barriers may prevent range shifts,” he explains. “Thus, reduction of fragmentation rates is a critical climate mitigation strategy and increases in connectivity are a high priority.”

McCarty and Zedler note that while “small patches of habitat provide refugia for sedentary species and sources of propagules and colonists for future natural expansion,” larger areas will have more potential to serve as buffers against climate change. They write, “Large size restoration projects, like large preserves, can sustain more species and more genotypes. They can also support more effective exotic-species control programs, as they are more likely to have smaller perimeter/interior ratios, thus reducing chances for reinvasion. Finally, they would have the space needed to include well-planned translocation experiments.”

Where large sites are not available, conservationists are pushing for large, contiguous areas and connectors as key to designing conservation areas for adaptability to climate change. “In order to conserve an ecoregion, you have to conserve nodes where the biodiversity is concentrated or left, you have to conserve networks of corridors and connective areas, and you have to conserve a fair amount of buffer land so that your core areas are not completely inundated by edge effects,” explains The Nature Conservancy’s Pearsall.

One means by which ecologists are making accommodations for climate change is by incorporating north-south corridors and topographic heterogeneity to facilitate species migration and adaptation as climatic conditions change.

Species that can’t move fast enough or are less mobile may be in danger, up to and including extinction, predicts Ian Burton, lead author of the United Nations Environmental Program’s Adaptation to Climate Change report. “In some instances, migration may be impossible, as in island ecosystems or high mountain ecosystems, where the limits of migration are set by the height of the mountains.”

But there are steps that can be taken to minimize this risk. “The adaptation of natural, unmanaged ecosystems does not have to be left entirely to chance. It is possible to adopt policies and practices that assist species in adapting, for example, by designating and protecting migratory corridors,” says Burton.

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Amalie Couvillion, a senior conservation planner for The Nature Conservancy’s Arctic Coast Ecoregion in Alaska and the Yukon, is examining potential climate scenarios, landscape-scale refugia, and the vulnerability of conservation targets to climate change. Figuring potential climate change into their conservation scenario has led her to look northward to “some areas in northern Alaska that we haven’t looked at previously because they have features that might make them suitable as refugia for species we are looking to preserve.”

Emergence of New Ecological Communities

Clearly, even as restorationists build resilience and adaptability into local and regional ecosystems, there is still the question of how species may shift as global warming becomes more advanced. One particular area of concern is what effects climate change will have on invading species. In North Carolina, for example, plant species that have in the past been restricted to regions to the south can be expected to advance northward. “I do expect to see a number of species, such as sable palmetto, arriving,” predicts Pearsall.

We do not know how individual populations, species, or ecosystems will respond to climate change because of differences in competitive abilities, migration rates, responses to disturbance, and more. Thus, new combinations of species will arise. Malcolm and his colleagues describe some of the possible consequences for species and ecosystems as follows:

1. Many species may be able to disperse fast enough to keep up with projected climate change, provided they can move through unfragmented and relatively undisturbed natural ecosystems.
2. Depending on the rate of climate change, other niche parameters may not change at the same rate, resulting in novel habitat combinations that species have not experienced before.
3. Changes in the relative timing of seasonal events during the yearly cycle may have strong negative impacts for many species, especially migratory ones.
4. Invasion of alien species into natural ecosystems is likely to be exacerbated by climate change.

5. Disturbance and dieback will probably increase as longer-lived organisms, such as trees, are farther from their optimal environmental envelopes and subject to increasing pressure from land-use change.
6. Increased disturbance will lead to more ecosystems in early successional states, resulting in a generally "weedier," structurally simpler biosphere with fewer systems in a more ecologically complex, old-growth state.
7. Markedly different effects of climate change on species composition will occur within individual landscapes because of local effects of soil, land use, and topographic variation.
8. Reductions in the area of "cold-adapted" ecosystems, such as arctic and alpine ecosystems, are expected, with negative results for arctic and alpine species.

Unquestionably, all of these considerations will require further study—now, and as climatic conditions change in the future. But in the interim, restorationists should continue to pursue efforts aimed at protecting and building up rare populations to aid in their eventual dispersion, says Malcolm. He echoes the call for increased connectivity, remarking that restorationists can help species adapt and migrate by identifying critical corridors and sites for increased habitat connectivity.

This broad and varied range of considerations raises the question of whether, in light of global climate change, we will need to reconsider the traditional view of ecological restoration, that is, of restoring an ecosystem to its past conditions. Joy Zedler points out that we need to broaden the definition of ecological restoration to account for a wide range of variables, including our knowledge, available tools, and altered habitats. She argues that the purist definition of ecological restoration is becoming increasingly "impractical." "There is almost no place where we can put things back exactly the way they used to be. Ecological restoration needs to take into account the fact that habitats change," she told me in a phone interview.

Conclusion

The climate change researchers, restoration ecologists, and ecological restorationists I contacted for this article were clear about the significant amount of work ahead in confronting the uncertainties inherent in global climate change. At the same time, a small but growing group of pioneering restorationists is gearing up to take on the challenge of designing and implementing restoration projects with global climate change as a key consideration.

As research is more fully communicated to land managers and practitioners, and as the ecological community—and the social, political, and economic communities—grapples with the uncertainty inherent in a consideration of global climate change and its looming consequences, practitioners may, as Rob Peters predicted, find ecological restoration at the forefront in crafting an ecologically based response to global climate change.

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