From Restoration to Resilience Ecology

Donald A. Falk

Rapid climate change is destabilizing ecological communities, reminding us that our world has rarely been truly in stasis. The central sustainability challenge of our time thus aligns with core scientific uncertainties regarding the non-equilibrial behavior of ecological systems. Anthropogenic climate change modulates natural variability in Earth's climate system; ecological responses may be rapid, or may lag climate by decades or longer. For example, tree-scale mortality may increase during extended droughts, while the reorganization of ecological communities, requiring dispersal, recruitment, and assembly processes, can take decades to centuries. Correlative approaches such as bioclimatic envelope modeling provide a null hypothesis for species range shifts, but these must be informed by more process-based demographic and community models. Species and population responses can be partitioned into resistance, recovery, and reorganization, which are emergent properties of finer-scale demographic processes. The future of restoration ecology must be viewed against this background of non-equilibrial ecosystems, for three primary reasons. First, global change alters what is possible; modeling and empirical studies predict changes in species distributions in response to changing climate, likely expressed at multi-annual to decadal time scales. Thus, a return to 20th century or earlier distributions may not be biologically feasible. Second, many keystone ecosystem processes, including hydrological and biogeochemical cycles, are becoming so extensively altered that they exert a distinct influence on ecosystem response and recovery. Finally, the role of altered disturbance regimes in many ecosystems is becoming a primary accelerator of ecological change: severe large-scale disturbances can reorganize ecosystems rapidly, accomplishing in weeks to years changes that would require decades to centuries by climate forcing alone. Combinations of climate change, altered ecosystem processes, and disturbance regimes are already triggering abrupt ecosystem transitions into novel configurations which can be resilient in their new state, resisting return to pre-disturbance conditions and creating new metastable alternative states. Under these conditions, a resilience ecology framework represents a natural evolution of restoration ecology, better suited to emerging global challenges. Restoration ecology must embrace change, not only resist it, in order to help ecosystems remain viable and adaptable in the coming period.