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From Forest Nursery Notes, Winter 2010

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A role for assisted evolution in designing native plant materials for domesticated landscapes

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Developers of native plant propagation materials for wildland restoration may emphasize naturally occurring genetic patterns or, in contrast, the material's empirical performance in comparative field trials. We contend that both approaches have value and need not be mutually exclusive. Anthropogenic influences have pushed many ecosystems across ecological thresholds, to less desirable states, so that actively managing for "domesticated nature" – nature as modified, either intentionally or inadvertently, by humans – is more realistic and more likely to succeed than recreating the original ecosystem. Furthermore, when domesticated nature is the most reasonable objective, empirical performance, together with geographical origin, are plausible criteria for choosing restoration plant material. For altered ecosystems, we suggest that evolution should be assisted by the inclusion of plants that (1) reflect general historical evolutionary patterns, (2) are particularly suited to the modified environment, (3) are able to adapt to contemporary selection pressures, and (4) contribute to the restoration of ecosystem structure and function.

Front Ecol Environ 2009; 7(10): 541–547, doi:10.1890/080028 (published online 21 Apr 2009)

As a matter of policy, scientists and land managers sometimes emphasize protection and sustainability of lands that have been only minimally altered by anthropogenic influences. The goal with these less altered ecosystems is to maintain endemic genotypes. On the other hand, many ecosystems have been drastically altered (ie domesticated), leaving very few truly wild places on Earth (Kareiva *et al.* 2007). Previous generations of conservationists have written off lands impacted by humans as "lost causes", yet the discipline of restoration ecology has emerged, with the goal of restoring ecosystem processes to such lands (MacMahon 1997).

Many scientists believe that these domesticated systems must be managed at some point (Gallagher and Carpenter 1997). Hobbs *et al.* (2006) suggest managing highly modified systems for utilitarian purposes when a

return to their previous state is not feasible. Kareiva *et al.* (2007) challenge scientists to manage these landscapes by balancing tradeoffs between ecosystem services. Ultimately, to be successful, management objectives must be based on pragmatism (Hobbs *et al.* 2006) and sound scientific principles (Gallagher and Carpenter 1997).

Here, we consider issues surrounding the development and choice of plant propagation materials for restoring domesticated ecosystems. First, as an example of a domesticated landscape, we describe the modification of western North America's sagebrush steppe by an invasive plant–wildfire cycle. Next, we make the argument for plants that restore evolutionary and ecological processes under such dramatic circumstances. Finally, we contend that human-assisted evolution offers the best hope for repairing ecosystem structure and function when landscapes have become domesticated. We use the term "ecological restoration" in the broad sense – that is, "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed", as defined by the Society for Ecological Restoration International Science and Policy Working Group (SER 2004).

In a nutshell:

- Indigenous genetic material may no longer be adapted in modified ecosystems that have crossed ecological thresholds
- Genetically manipulated plant materials developed to overcome common biotic and abiotic stresses are useful for restoring ecosystem structure, function, and biodiversity in modified ecosystems
- Considering both empirical performance and geographic origin is important when fashioning plant materials to assist evolution along a desirable trajectory

■ A controversial topic: options for restoration plant materials

Two paradigms have long vied for the allegiance of scientists who develop plant materials for restoration. The "evolutionary" paradigm seeks to restore putative natural patterns of genetic variation, in order to generate an evolutionary trajectory as similar as possible to that which prevailed before the advent of any anthropogenic distur-

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