

PUBLIC LANDS AND ECOSYSTEMS: MANAGEMENT CHALLENGES AND OPPORTUNITIES FACED BY THE U.S. FOREST SERVICE (Adaptation to Climate Change in the Desert Southwest: Impacts and Opportunities)

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The US Forest Service manages 155 national forests and 20 national grasslands covering approximately 192 million acres, including over 34 million acres in the Southwest (NM, AZ, NV, UT). Each forest is managed for the most appropriate combination of multiple goods and services, including timber and wood products, water supply, air quality, biodiversity and endangered species, recreation, and most recently, carbon sequestration and storage. The primary challenge for the Forest Service is to optimize the ecosystem services in each location while maintaining the resilience of these forest ecosystems as the climate that sustains them changes.

In the desert southwest, these national forests are distributed primarily on isolated mountain ranges. At lower elevations, woodlands dominated by oaks, pinyon pine and junipers give way to ponderosa pine forests. These dry woodlands and forests are well adapted to surviving the direct effects of the droughts that are increasingly characteristic of the southwest. Although both ecosystems are also adapted to frequent surface fires, they are particularly vulnerable to the more intense wildfires and insect infestations that current drought and fire suppression activities have induced. At higher elevations, ponderosa pine is replaced by Douglas fir and by true fir and spruce species which the cooler and more moist conditions permit to grow more densely. Wildfire is less frequent in these forests under normal circumstances, but after multiple years of drought, they become vulnerable to intense stand-replacing fires that require many years to regrow.

Recently, the indirect impacts of global climate change on forests has acted through increasing wildfire and insect infestations to provide the most obvious management challenges faced by the Forest Service. In contrast, future decades are expected to be increasingly dominated by the direct effects of increasing warmth and evaporation (if not also decreased precipitation) on southwestern forest ecosystems. As the climate to which vegetation is adapted becomes gradually more foreign, tree species and varieties will become increasingly maladapted and unproductive. Certainly, sources of seeds of tree species that are more warmth and drought adapted will be present on lower slopes of many mountain ranges. These seeds will need only the strong updrafts of a summer thunderstorm to sail higher on the mountainsides where they can germinate and establish as trees more suitable for future climates there. Yet, there is only so far up each mountain range that species can immigrate before running out of land. In addition, each mountain range contains a limited set of species and genetic variation, both of which will be needed at other isolated ranges in the future, but in many cases will be too far away to undergo transport there by winds or birds.

Set against these environmental changes, topographic constraints, and biotic responses, National Forest System management in the Southwest is increasingly focusing on increasing forest resilience for the short term and increasing the genetic variation of planted species and varieties for the long term. For example, by thinning stands now to decrease tree densities while maintaining woodland or forest structure, management actions can increase forest resilience to drought – fewer trees remain to share same amount of soil water and nutrients. Intense wildfires and insect infestations are also

moderated as fuels are reduced as is the density of leaf material needed to support dense insect populations.

Thinning of forests presents obvious commercial opportunities for CO₂ mitigation in terms of transfer of live and dead carbon into long-lived pools represented by building materials (e.g., lumber, various composite wood materials) and as substitutes for fossil fuels (e.g., burning wood for heat and energy; making cellulosic ethanol for fuel; etc.). The immediate importance for these tasks cannot be overstated; reducing standing forest densities, harvesting dead and dying trees, and removing small diameter woody biomass from forests increases forest resilience, and increases the rate of carbon cycling through forests. Forests in the U.S. currently absorb approximately 10% of the emissions from burning fossil fuels, and cellulosic biofuels alone are thought to be capable of replacing one-third of fossil fuels used in the U.S., without displacing crops from agricultural land. At the same time the trees and forests that remain increase their leaf areas and take up more CO₂ annually.

Later in this century, as the mitigation boost from removals stabilizes, warming will become most important, and assisted migration of species will be required, as genetic stocks on many mountain ranges become too sparse to support healthy forests. The management activities needed to facilitate natural seeding by exotic trees that are warmth and drought adapted, several decades in the future, must begin soon. The ability of established trees to survive far beyond the geographic range limits that keep their seeds from germinating and establishing is obvious from the healthy ornamental trees that originated much further south now growing in our parks and yards. Yet, the choice is not obvious of which species to plant, in part because the climate conditions of those future forests remain uncertain – will they be dryer and hotter in all seasons? Will either winters or summers become wetter or dryer? A management solution in the face of these uncertainties is to hedge by planting a diverse set of varieties and species, expecting not all will be successful, and to frequently reexamine both the health of the plantings and the assumptions behind their selection.

This adaptive management of forests will become much more necessary than it has been in the past, and the Forest Service is moving toward implementing it much more than it did in the past. Combined with risk assessment and risk management approaches that use statistical estimates and measures of uncertainty, adaptive management can provide effective management of long-lived trees and forests under a constantly changing future.