Ecological Restoration Institute

Fact Sheet: *Carbon Cycling in Southwestern Forests: Reservoirs, Fluxes, and the Effects of Fire and Management*

October 2015

NORTHERN ARIZONA UNIVERSITY

Ecological Restoration Institute

Carbon Cycling in Southwestern Forests: Reservoirs, Fluxes, and the Effects of Fire and Management

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Introduction

Forest death from extreme drought and wildfires are reducing regional carbon reservoirs and overall forest sequestration capacity. At the same time, land use practices and development have increased the vulnerability of some forests during extreme droughts. The intent of this fact sheet is to explain the basics of the carbon cycle in southwestern forests. It also summarizes how carbon cycling patterns are most likely to change in the coming years to decades in the Southwest.

Key Points

1. **Drought and wildfire activity continues to increase in area, frequency, and severity.**

   Globally the ten hottest years on record have all occurred since 1998. The southwestern U.S. experienced a major drought in the first decade of the 21th century, which was the largest in at least 150 years. Since 2002, Arizona and New Mexico have both set new records for the largest fires in state history. As climate change progresses, the impacts of deeper droughts and longer fire seasons represent a multi-pronged threat to forest health and carbon sequestration potential.

Figure 1. *Wind driven crown fires consume surface detritus, needles and fine branches but leave heavier woody fuels intact. Above, the Las Conchas Fire incinerated more than 30,000 acres of timber in a single burning period near Cochiti Mesa, Santa Fe National Forest, in summer 2011.* Photo by T.W. Swetnam

2. **Forests sequester less carbon following a high severity wildfire or severe drought.**

   The loss of older larger trees greatly reduces the total carbon sequestration capacity of a forest. Coupled with the decomposition of woody debris, a severely burned or drought/insect killed forest can act as a net carbon emitter for many years before the balance shifts back to that of a carbon sink (Figure 1). Conifers suffering from drought can take several years to regain their growth and carbon sequestration potential relative to trees in a healthier state.

3. **A reorganization of all southwestern forest ecosystems is predicted in coming decades.**

   As ecosystems are replaced following high severity disturbances, the new systems that reestablish in a warmer climate may not resemble those that developed during the cooler and wetter 19th and 20th centuries. Existing biome locations are predicted to synchronously move north or up in elevation to maintain viability in their climate envelope (Figure 2, p. 2).

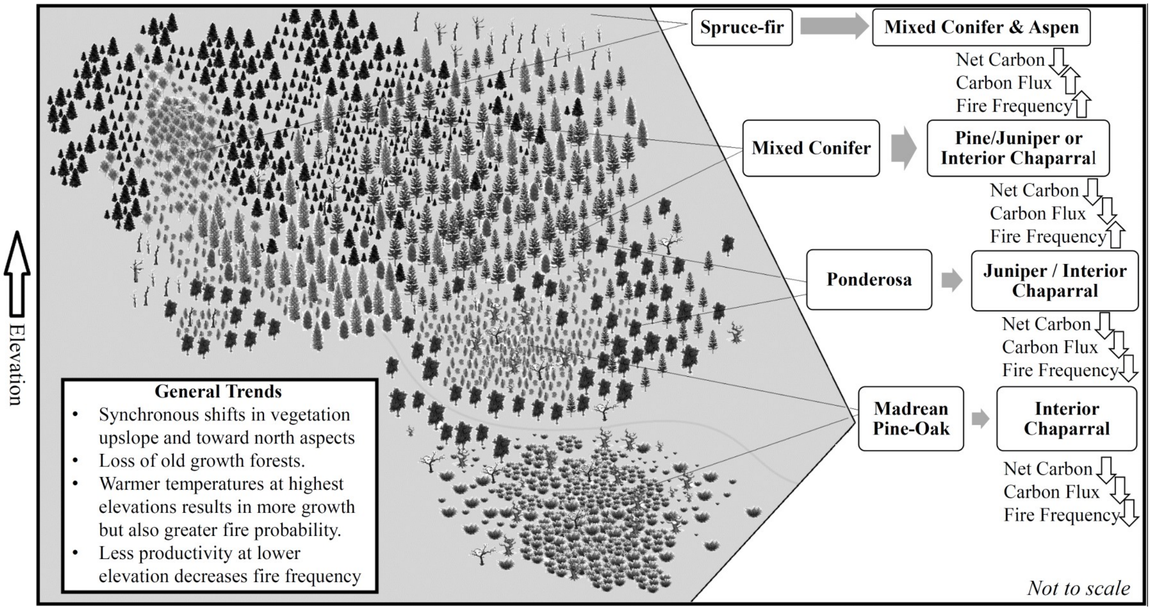

Figure 2. *Expected shifts in ecosystems by (1) vegetation type (in bold), (2) carbon reservoirs, (3) sequestration (flux) rates, and (4) fire frequency in the coming years for common southwestern forest ecosystems.*

4. **Southwestern forests will sequester less carbon because of global warming.**

   Increased temperatures make plants work harder to photosynthesize. This reduction in efficiency results in less growth, greater stress, and higher likelihood of mortality. Climate models predict an increase in temperatures, and decreased or level precipitation, for most of the Southwest in the future. This will likely result in a net decline in production across almost all southwestern forest ecosystems.

5. **Bigger and older trees do not slow their total carbon uptake over time.**

   In some cases, an individual large diameter tree can contain the majority (>50%) of the carbon in an entire forest stand. Contrary to the belief that mature forests are "senescent" or less productive, the value and importance of old growth trees should be reconsidered. A single old growth southwestern USA conifer tree can contain as much as 16 tons of carbon in aboveground biomass alone.

6. **Carbon reservoirs change size with elevation, aspect, and topographic position.**

   Carbon pools are not equally distributed across landscapes. Complex topography redistributes precipitation to lower hillslope positions and erosion results in deeper soils near valley bottoms. Lower topographic positions contain a vast majority of carbon in (1) larger and taller trees and (2) deeper soils, relative to those of ridges and hillslopes. This combination of deeper soils and access to groundwater results in trees that can hold up to ten times more carbon in valley bottoms than on steep and exposed ridges and hillslopes.

Conclusions and Management Implications

Future climate scenarios predict a potential for fast ecosystem shifts due to either high severity fire, insect attack, or extreme drought. This loss of mature forests, which developed over centuries, represents the starkest outcome for forests in the Southwest. Prioritization efforts to increase and preserve existing carbon storage generally run parallel to other traditional management objectives that involve continued access to clean water, protecting threatened and endangered species, ensuring sustainable yields for timbering, improvement of grazing forage and wildlife habitat, and reducing fire risk. Restoration toward historical conditions has the benefit of both increasing carbon storage and decreasing the probability of ecosystem collapse due to high severity wildfire or inter-tree stress for water during periods of exceptional drought and insect attack.

This Fact Sheet summarizes information from the following publication:

Swetnam, T.L. and D.A. Falk. 2015. Carbon Cycling in Southwestern Forests: Reservoirs, Fluxes, and the Effects of Fire and Management. ERI Working Paper No. 35. Flagstaff, AZ: Ecological Restoration Institute and Southwest Fire Science Consortium, Northern Arizona University. 15 p.

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NAU is an equal opportunity provider.
This research was funded by a grant from the USDA Forest Service.