THE ADAPTIVE SILVICULTURE FOR CLIMATE CHANGE PROJECT: A SCIENTIST–MANAGER PARTNERSHIP

Linda Nagel, Courtney Peterson, Jim Guldin, Chris Swanston, Maria Janowiak, Brian Palik, Steve Jack, and Seth Bigelow

Extended abstract—Forest managers in the United States face many challenges to sustaining critical ecosystems, including observed and projected climatic changes that require implementation of climate-adaptive strategies. However, there is a lack of on-the-ground forest adaptation research to help managers determine what adaptation measures or tactics might be effective in preparing local forest ecosystems to deal with climate change, which can create challenges in translating these concepts into operational silvicultural prescriptions specific for individual forest types that vary in structure, composition, and function (Kemp and others 2015). The Adaptive Silviculture for Climate Change (ASCC) project responds to these barriers by providing a multi-region network of replicated operational-scale research sites testing ecosystem-specific climate change adaptation treatments across a gradient of adaptive approaches. Here we describe the ASCC project along with two of the research sites and provide ideas for how these concepts might apply to oak forests.

The ASCC project utilizes a decision-making framework (Swanston and others 2016) and manager–scientist partnerships to co-design locally relevant treatments and research questions. The study is designed to test broad, conceptual adaptation concepts appropriate to the management of public and private lands (Joyce and others 2009, sensu Millar and others 2007). The adaptation options occupy a continuum of management goals related to desired levels of change:

1) resistance—maintaining relatively unchanged conditions over time;
2) resilience—allowing some change in current conditions but encouraging an eventual return to reference conditions; and
3) transition—actively facilitating change to encourage adaptive responses.

A consistent study design (e.g., size and replication of treatments, monitoring approach, etc.) has been implemented across distinct ecosystem types, allowing scientists and managers to leverage a shared approach to further reveal trends and measure the efficacy of adaptive management strategies across the ASCC network (Janowiak and others 2014, Nagel and others 2017, Swanston and others 2016).

There are currently five sites that make up the National ASCC Network:

1) the Cutfoot Experimental Forest site on the Chippewa National Forest in Minnesota;
2) the Flathead National Forest/Coram Experimental Forest site in northwest Montana;
3) the Joseph W. Jones Ecological Research Center site on the southeastern coastal plain in Georgia;
4) the San Juan National Forest site in southwest Colorado; and
5) Dartmouth's Second College Grant site in New Hampshire.

At each site, we used an interactive workshop process where local managers and scientists determined management objectives to meet desired future conditions (DFCs) and developed an array of silvicultural treatments that correspond to each of the adaptation options of resistance, resilience, and transition.

The Cutfoot Experimental Forest was the first ASCC site to be developed. Scientists and managers assessed the current condition of the red pine-dominated forest (overly dense, history of fire exclusion) and examined ecosystem vulnerability information, including Tree Atlas and LANDIS II projections (Handler and others 2014), as well as expert opinions to inform the development of adaptation strategies. Based on the DFCs for the site, the

Author information: Linda Nagel, Department Head and Professor, Forest and Rangeland Stewardship Department, Colorado State University, Fort Collins, CO 80523; Courtney Peterson, Research Associate, Forest and Rangeland Stewardship Department, Colorado State University, Fort Collins, CO 80523; Jim Guldin, Station Silviculturist, Southern Research Station, USDA Forest Service, Hot Springs, AR 71902; Chris Swanston, Research Ecologist, Northern Research Station, USDA Forest Service, Houghton, MI 49931; Maria Janowiak, Biological Scientist, Northern Research Station, USDA Forest Service, Houghton, MI 49931; Brian Palik, Ecologist, Northern Research Station, USDA Forest Service, Grand Rapids, MN 55744; Steve Jack, Conservation Ecologist, Joseph W. Jones Ecological Research Center, Newton, GA 39870; and Seth Bigelow, Assistant Scientist, Joseph W. Jones Ecological Research Center, Newton, GA 39870.

Citation for proceedings: Clark, Stacy L.; Schweitzer, Callie J., eds. 2019. Oak symposium: sustaining oak forests in the 21st century through science-based management. e-Gen. Tech. Rep. SRS-237. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 192 p.

resistance strategy for the Cutfoot ASCC site includes maintaining red pine (*Pinus resinosa* Ait.) dominance and increasing soil moisture availability through density management. The resilience strategy includes maintaining red pine dominance while also increasing the presence of future-adapted native species over time. Finally, the site's transition strategy is aimed at actively facilitating change including increasing future-adapted native and novel species to gradually become more abundant than red pine.

The Joseph W. Jones Ecological Research Center, a fire-maintained, pine-dominated site with a competitive component of oak and other hardwoods, is located on the southeastern coastal plain in Georgia. The site hosts a diverse range of ecological communities, including open-canopy longleaf pine (*Pinus palustris* Mill.) and mixed pine-hardwood forests that have a highly diverse herbaceous groundcover of global ecological significance. Based on climate change projections and DFCs for the site, the team created a resistance strategy that enhances the dominance of longleaf pine and optimizes fire behavior by eliminating oaks and off-site pines. The resilience strategy maintains response diversity by retaining drought-tolerant oaks, removing the water-profligate mesic oaks, and lightly thinning longleaf pine. The transition strategy aims to diminish vulnerability to drought by reducing longleaf pine basal area by 40 percent, eliminating all but the most highly drought-adapted oaks in the overstory, creating a multi-aged, multi-cohort structure by planting drought-tolerant, fire facilitating oaks (i.e., turkey oak, *Quercus laevis* Walter), and planting warm season C_4 grasses to help carry fire in the grass-dominated understory. All treatments are scheduled to receive prescribed burning every two years.

Future climate change has the potential to significantly impact disturbance dynamics and species response of oak forests. Historical and dendrochronological records indicate a strong relationship between drought years and oak decline (Dwyer and others 1995, Jenkins and Pallardy 1995). As droughts are projected to increase in duration and aerial extent (Mishra and others 2010), oak decline could become an even larger problem for species in the red oak group across the Missouri Ozarks, especially for older trees on marginal sites. Oak decline could be exacerbated by other stressors: insect defoliation may increase with rising temperatures, and red oak species may already be stressed due to a decline in habitat suitability as projected by tree species models. As these species decline, new opportunities could open up for other species that are better adapted to projected climate, such as pine and white oak species (Brandt and others 2014). Utilizing ecosystem vulnerability information will be key to promoting resilient ecosystems into the future, with the ASCC study potentially informing climate-adaptive management decisions.

As we move into a future where it is easy to become overwhelmed by the uncertainty and the high potential for loss and change, it is imperative that scientists and managers work together to create innovative solutions and new alternatives for adaptive management. The interactive process of the ASCC study allows the network to directly address numerous barriers natural resource managers face when it comes to developing adaptive management strategies for climate change, which can in turn be applied more broadly and be replicated by others working to sustain a variety of ecosystem types into the future.

LITERATURE CITED

Brandt, L.; He, H.; Iverson, L. [and others]. 2014. Central hardwoods ecosystem vulnerability assessment and synthesis: A report from the central hardwoods climate change response framework project. Gen. Tech. Rep. NRS-124. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northern Research Station. 254 p.

Dwyer, J.P.; Cutter, B.E.; Wetteroff, J.J. 1995. A dendrochronological study of black and scarlet oak decline in the Missouri Ozarks. Forest Ecology and Management. 75(1-3): 69-75.

Handler, S.; Duveneck, M.J.; Iverson, L. [and others]. 2014. Minnesota forest ecosystem vulnerability assessment and synthesis: A report from the northwoods climate change response framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northern Research Station. 228 p.

Janowiak, M.K.; Swanston, C.W.; Nagel, L.M. [and others]. 2014. A practical approach for translating climate change adaptation principles into forest management actions. Journal of Forestry. 112(5): 424-433. http://dx.doi.org/10.5849/jof.13-094. [Date accessed: June 7, 2018].

Jenkins, M.A.; Pallardy, S.G. 1995. The influence of drought on red oak group species growth and mortality in the Missouri Ozarks. Canadian Journal of Forest Research. 25(7): 1119-1127.

Joyce, L.A.; Blate, G.M.; McNulty, S.G. [and others]. 2009. Managing for multiple resources under climate change: National forests. Environmental Management. 44(6): 1022-1032.

Kemp, K.B.; Blades, J.J.; Klos, P.Z. [and others]. 2015. Managing for climate change on Federal lands of the Western United States: Perceived usefulness of climate science, effectiveness of adaptation strategies, and barriers to implementation. Ecology and Society. 20(2): 17.

Millar, C.I.; Stephenson, N.L.; Stephen, S.L. 2007. Climate change and forests of the future: Managing in the face of uncertainty. Ecological Applications. 17(8): 2145-2151.

Mishra, V.; Cherkauer, K.A.; Shukla, S. 2010. Assessment of drought due to historic climate variability and projected future climate change in the Midwestern United States. Journal of Hydrometeorology. 11(1): 46-68.

Nagel, L.M.; Palik, B.J.; Battaglia, M.A. [and others]. 2017. Adaptive silviculture for climate change: A national experiment in manager-scientist partnerships to apply an adaptation framework. Journal of Forestry. 115(3): 167-178.

Swanston, C.W.; Janowiak, M.K.; Brandt, L.A. [and others]. 2016. Forest adaptation resources: Climate change tools and approaches for land managers. 2d ed. Gen. Tech. Rep. NRS-87-2. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northern Research Station. 161 p. www.nrs.fs.fed.us/pubs/52760. [Date accessed: June 7, 2018].