

Adapting Bottomland Hardwood Forests to a Changing Climate

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ABSTRACT.—Bottomland hardwood forests will face challenges in a changing climate from altered hydrology and shifting habitat suitability for key species. Scientist-manager partnerships have been developed across the Upper Mississippi River to assess the vulnerability of bottomland hardwood forests to climate change and to develop and implement adaptation strategies using the Climate Change Response Framework developed by the Northern Institute of Applied Climate Science. Strategies include planning for more frequent and severe flooding by planting more flood-tolerant species, and planning for increases in temperature by planting species and genotypes from more southern areas. We describe two projects that are implementing these strategies: (1) A network of demonstration projects in southern Illinois and Indiana, and (2) A replicated experiment to assess alternative adaptation strategies is currently underway as part of the Adaptive Silviculture for Climate Change Network.

KEY WORDS: floodplain forests, adaptive silviculture, climate change adaptation, scientist-manager partnership

INTRODUCTION

Bottomland hardwood forests provide important ecosystem services such as nutrient cycling, flood control, wildlife habitat, and recreational opportunities. These forests are already impacted by human-induced stressors such as land conversion, fragmentation, and altered hydrology. Changes in climate may create challenges from increased precipitation, changing habitat suitability for dominant tree species, shifting flood regimes, and altered bottomland forest-dependent wildlife migration patterns. Taken together, these ecosystem types may be among the most vulnerable to climate change (Brandt et al. 2014).

We addressed these challenges by applying the Change Response Framework (hereafter referred to as Framework; Swanston et al. 2016) to two contrasting bottomland systems along the Mississippi River. The Framework is a collaborative approach to help land managers

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understand the potential effects of climate change on forest ecosystems and integrating climate change considerations into management that incorporates four main components:

- Scientist-manager partnerships
- Vulnerability assessments
- Adaptation resources
- Demonstration projects

A main focus of the Framework is the coproduction of assessments and adaptation projects involving scientists and managers at a landscape scale.

Bottomland Hardwoods in the Middle Mississippi

In the first example, Ducks Unlimited, Cypress Creek and Patoka River U.S. Fish and Wildlife Service Refuges, the USDA Forest Service's Shawnee National Forest, and the Northern Institute of Applied Climate Science applied the framework to bottomland forests in rural areas in Illinois and Indiana. In a 2015 workshop, 20 managers and scientists from the region used information in the Central Hardwoods Ecosystem Vulnerability Assessment and Synthesis (Brandt et al. 2014) to identify key impacts to the region. The following key impacts were identified through a facilitated process: (1) Increases in heavy precipitation events; (2) Increases in total runoff and peak streamflow during the winter and spring, which could lead to increases in the magnitude and frequency of flooding; (3) Increases in runoff and soil erosion; (4) Reduced habitat suitability for wet bottomland tree species at the lowest elevations in the landscape; (5) Shifts in habitat suitability of bottomland trees due to changes in temperatures; and (6) Changing migration patterns of waterfowl.

The group used the "Adaptation Workbook" (Swanston et al. 2016) to develop a joint project to address these impacts, later funded by the Wildlife Conservation Society's Climate Adaptation Fund. Strategies included diversifying the species composition and genetic stock of hardwood tree species used for reforestation efforts, such as planting pin oak and willow oak (*Quercus palustris* and *Q. phellos*), seedlings from farther south in the Mississippi Alluvial Valley, and using increased numbers of baldcypress (*Taxodium distichum*) and tupelo (*Nyssa sylvatica*). Species selection was based on modeled projections using the Climate Change Tree Atlas (Iverson et al. 2008, Prasad et al. 2014). Strategies also focused on providing more productive wintering habitat for waterfowl species that are not expected to migrate as far south, such as mallards (*Anas platyrhynchos*), American black ducks (*Anas rubripes*), gadwalls (*Mareca strepera*), and wood ducks (*Aix sponsa*). We implemented this strategy by focusing on managing for mast-producing tree species that provide a food source for these wildlife species. Implementation began in 2016 at reforestation sites at the Patoka River and Cypress Creek Refuges and at Oakwood Bottoms on the Shawnee National Forest. Sites will be monitored for species survival and changes in species richness and diversity.

Mississippi River National River and Recreation Area

In the second example, the University of Minnesota, Mississippi Park Connection, The Mississippi National River and Recreation Area (MNRRA), Colorado State University, City of St. Paul (MN) Parks and Recreation, and the Northern Institute of Applied Climate Science developed a replicated experimental design as part of the Adaptive Silviculture for Climate Change Network (Nagel et al. 2017). A workshop of about 30 representatives across multiple scientist and management organizations along the upper Mississippi River was convened in 2019. Key climate change impacts identified in this workshop were similar to those identified

in the Middle Mississippi, but had a greater emphasis on interactions with urbanization and recreation. Wildlife was still an important part of management goals, but opportunities for wildlife viewing of raptors, such as bald eagles, was emphasized over waterfowl for hunting. The participants worked collaboratively to develop three alternative adaptation treatments:

- Resistance: Maintain relatively unchanged conditions over time. For this site, the treatment will:
 - o Maintain a closed canopy condition of current species composition, focusing on trees that are characteristic of the existing forest type, such as Dutch elm disease-resistant American elm (*Ulmus americana*), silver maple (*Acer saccharinum*), and cottonwood (*Populus deltoides*).
 - o Promote or enhance native regeneration.
- Resilience: Allow some change in current conditions, but encourage an eventual return to reference conditions. For this site, the treatment will:
 - o Promote future-adapted flood and drought-tolerant species native to the upper Mississippi River. Species under consideration include swamp white oak (*Quercus bicolor*), hackberry (*Celtis occidentalis*), and sycamore (*Platanus occidentalis*).
 - o Create gaps for regeneration, using natural gaps from dying green ash (*Fraxinus pennsylvanica*), removing hazard trees, and removal of small-diameter less desirable species such as boxelder (*Acer negundo*).
- Transition: Actively facilitate change to encourage adaptive responses to changing conditions. For this site, this treatment will:
 - o Incorporate future-adapted species and genotypes from farther south along the Mississippi River (e.g., Illinois, Iowa, Missouri). Species under consideration include black tupelo (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), and pin oak (*Quercus palustris*).
 - o Create gaps with feathered edges to establish diverse microsites for planting future-adapted species.

The project, also funded by the Wildlife Conservation Society's Climate Adaptation Fund, was established at Crosby Farm Park in the city of St. Paul, MN, starting in 2019, and will be expanded to other sites along the MNRRA in 2020. The project will include three replicates of each treatment plus three replicate control treatment areas. Baseline data in 24 one-tenth acre circular plots were collected in summer 2019. Measurements include overstory composition, condition, diameter at breast height (d.b.h.; 4.5 ft above ground), height, and the composition and size of saplings and seedlings. Two 1-m² quadrats will be established within each plot to measure herbaceous composition and cover. Removals of small diameter trees and planting of saplings in each treatment will occur in winter and spring 2020. Monitoring of survival, growth, and forest health, among other measures, will be conducted over a 20-year period and treatments will be compared to control areas. Results from this study will be statistically analyzed and shared in scientific journals as well as with managers and the general public recreating in the area.

CONCLUSIONS

These two projects exemplify how scientist-manager partnerships can be effectively used at a landscape scale to address climate change impacts and co-develop adaptation strategies to meet mutually beneficial goals. Lessons learned and monitoring data collected from these projects will be helpful to other managers of floodplain forests when assessing adaptation options and developing strategies. They will also provide important information to researchers studying floodplain forests about species range limits and potential adaptation to changing climates.

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