Ecological Forestry

INTEGRATING DISTURBANCE ECOLOGY PATTERNS INTO FOREST TREATMENTS

By R. Gregory Corace III, Ph.D., and P. Charles Goebel, Ph.D.

Credit: Laurie Tansy

R. Gregory Corace III, Ph.D., is Forester and Ecologist at the Seney National Wildlife Refuge and Kirtland's Warbler Wildlife Management Area.

Credit: Ken Chamberlain

P. Charles Goebel, Ph.D., is an Associate Professor of Forest Ecosystem Restoration and Ecology in the School of Environment and Natural Resources at The Ohio State University.

Forty years ago the Kirtland's warbler (*Dendroica kirtlandii*)—a neotropical migrant that breeds in young jack pine (*Pinus banksiana*) forests—was on the brink of extinction. Concerted recovery efforts by federal and state land managers in the northern Lower Peninsula of Michigan brought the species back from the brink (Probst *et al.* 2003). However, this success has come at a cost: Recovery efforts aimed at producing breeding habitat have resulted in relatively simplified landscapes and forest stands, to the detriment of some ecosystem functions and wildlife species.

Unfortunately, this pattern of ecosystem simplification has too often been repeated by forest managers. In the zeal to accomplish highly focused population-based or commodity-based objectives, forest management has at times ignored underlying ecological principles and disturbance patterns (Holling and Meffe 1996).

Following Nature's Lead

A contrasting approach to wildlife habitat management is predicated on understanding ecology—the capabilities of land as determined by landscape position, soils, and changes in vegetation due to natural disturbances—and then managing wildlife habitat within this context. A "disturbance" is an agent of change that shapes an ecosystem over time in a dynamic manner, such as wildfires, wind events, floods, insects, and disease. Land managers, too, can be agents of disturbance simply by mechanically altering forest structure or attempting to influence the severity or magnitude of natural disturbances.

Fortunately, natural and human-caused disturbance regimes can be integrated into forest wildlife habitat management, thereby addressing the issues of land stewardship (Leopold 1949). Once known as "New Forestry" (Franklin 1989), this ecological approach to forest management bases actions on the underlying disturbance regime of a given ecosystem, recovery periods between disturbance events, and resulting vegetation patterns, which are of special interest to managers of forest wildlife habitat. Ecological forestry does *not* attempt to maximize the productivity of any single commodity, amenity, or species. Instead, it allows for multiple goals—improved wildlife habitat, carbon sequestration, soil stabilization, water filtration, and economic gain—thus enabling forest conservation and restoration across various ecosystem and ownership types (Sarr *et al.* 2004). The key is linking site conditions and natural disturbance regimes with silvicultural treatments that emulate the outcomes of natural disturbances (Seymour and Hunter 1999, Franklin *et al.* 2007). Fortunately, many texts (e.g., Frehlich 2002) outline the natural disturbance ecology patterns of various forest ecosystems, providing useful background for forest managers.

In pine-dominated landscapes of northern Michigan and elsewhere in the Upper Midwest, fire suppression or fire intervals that poorly emulate the historical range of variation have degraded the ecological integrity of many forests (Schulte *et al.* 2007). These changes have led to declines in the distribution and abundance of many fire-dependent pine-dominated ecosystems, from the openland-dominated jack pine barrens to

Credit: R. Gregory Corace III

Credit: Mike McDowell

An aerial view of the structural patterns of jack pine stands in the Kirtland's Warbler WMA reveal markedly different management strategies. The foreground shows a plantation managed intensively for Kirtland's warblers, with diamond-shaped openings created by the "opposing wave" pattern of planting jack pine seedlings after a clearcut. The area at center shows patterns resulting from a prescribed fire. Warblers (inset) breed in both of these managed areas, but the patterns in the burned stand emulate those of wildfires more closely.

the closed canopy, late successional mixed-pine stands dominated by long-lived red pine (*Pinus resinosa*) and eastern white pine (*Pinus strobus*).

Although drastically different in terms of structure and composition, these forest ecosystems share similar sandy soils, a reliance on fire, successional states, and many species of wildlife. However, differences in the severity and the return interval of disturbances (the latter often a result of management objectives) can yield contrasting forest conditions. More frequent and/or more significant disturbances (e.g., stand replacing fires or clearcuts) yield different vegetation patterns and habitats for different wildlife species compared to infrequent surface fires or partial harvests.

Cautionary Tale of Warblers

The challenge of managing forests altered by changes in the natural disturbance regime is particularly acute in Michigan, where the endangered Kirtland's warbler breeds. This species evolved to breed within a habitat influenced by wildfire. Fire opens jack pine cones for seed dispersal and prepares the soil surface for the seeds to germinate. Years of fire suppression and other changes in land use have led to a loss in appropriate habitat and a dramatic population decline of Kirtland's warblers: In 1971, only 201 singing males were counted in Michigan (Probst *et al.* 2005).

Although prescribed or managed wildfire would yield the most "natural" breeding habitat for the birds, changes in land use make broad-scale application of fire untenable in Michigan's northern Lower Peninsula, where most of the birds breed. Consequently, most warbler habitat management involves clear-cutting mature jack pine, then trenching and densely planting these sites with jack pine seedlings in an "opposing wave" pattern (see photo). Akin to the way natural wildfire would move across the landscape and produce large patches of burned-over land, these plantations are managed as multiple-square-mile patches with a rotation age that approximates natural return intervals for stand-replacing fire events (Frehlich 2002). This type of jack pine plantation management has resulted in an unprecedented nine-year run in which the global population of singing male warblers exceeds the established recovery objectives of 1,000 singing males. In 2009, nearly 1,800 singing male warblers were counted in Michigan alone. Breeding birds are also now found in neighboring Wisconsin and Ontario (see photo on page 38).

Research has shown a downside to this single-species approach, however. By placing such an emphasis on habitat variables important for Kirtland's warblers and not emulating patterns of natural disturbance, management has produced monotypic plantations with drastically simplified structure compared to stands generated by wildfire. Indeed, the typical biological legacies of fire-produced stands—such as residual live trees, dead standing trees or snags, and downed coarse woody debris—are nonexistent or significantly reduced (Spaulding and Rothstein 2009). Such homogenized conditions do not bode well for many ecological processes (LeDuc and Rothstein 2007).

Fortunately, because Kirtland's warbler population recovery objectives have been met for the past nine years, a more ecological approach to the species' habitat management may now be possible. We suggest that the focus of future management should be to emulate patterns of wildfire. In doing so, the judicious application of prescribed fire should be used, especially in landscapes with large contiguous blocks of public land (Wilson *et al.* 2009). It is also important to note that plantations do not necessarily restore habitat, but instead provide a surrogate condition for breeding birds. Plantations are therefore not a 'silver-bullet' for the management of jack pine forest ecosystem types.

Credit: R. Gregory Corace III

With its bark mechanically stripped off in a process called girdling, this pine will die and create a snag–a potential future home for woodpeckers and other wildlife in the Kirtland's Warbler WMA. Such techniques help vary the structure in monotypic jack pine plantations, mimicking historic disturbance patterns and enhancing species diversity.

That said, plantation management for Kirtland's warbler habitat will still be necessary, and in this vein we suggest that future habitat management take the following approaches:

- Consider the dynamic nature of jack pine forests and manage for the range of successional states and associated structure of jack pine ecosystems. Of these, perhaps the most imperiled is the openland-dominated jack pine barrens (Houseman and Anderson 2002).
- Set aside large-scale (hundreds of acres) openings for the rotation age (estimated time of harvest) of the nearby plantations, with both managed as a shifting mosaic of barrens and plantations across the landscape. Doing so would help restore pre-Euro-American landscape structure that has been degraded by changes in land use. Such management would also benefit many openland wildlife species, such as upland sandpiper (*Bartramia longicauda*) and sharp-tailed grouse (*Tympanuchus phasianellus*) (Corace *et al.* in press, a).

- Enhance biological legacies in plantations. Patches of live trees, especially larger-diameter red pine that would likely survive many wildfires, should be retained, and more patches of snags and coarse woody debris, the biological legacies of wildfire, should be created (Corace *et al.* in press, b). Girdling trees using the mechanized logging equipment commonly employed in warbler management is one cost-effective option.

Restoring Mixed-Pine Forests

On the opposite side of the dynamic pine ecosystem are the late successional, mixed-pine forests dominated by long-lived red and eastern white pine. Although turn-of-the-century events degraded many sites that were formerly mixed-pine, numerous opportunities exist to restore this forest ecosystem type, even without a clear flagship wildlife species. Fortunately, where most restoration potential exists (especially in Michigan's Upper Peninsula) the landscape has many features making it conducive to a more holistic approach to forest management. Large swaths of public land make the use of prescribed fire easier, and because the plant community is relatively representative of the past, natural seed sources are readily available. Consequently, restoration of mixed-pine forests need not be driven by the need of any one species, but by broad-based ecosystem goals predicated on disturbance regimes.

Credit: R. Gregory Corace III

A history of extensive logging led to monotypic jack pine groves like this one in Michigan's Seney National Wildlife Refuge, where a rotting stump of white pine hints at the potential for restoration. When managed for a mix of white, red, and jack pines, area forests can sustain greater diversity of mammals and bird communities.

In any restoration attempt, baseline information on disturbance patterns and forest composition and structure provide useful benchmarks. For mixed-pine restoration in the Upper Peninsula, this information exists in the virgin red and white pine stands of the 25,150-acre Seney Wilderness Area of Seney National Wildlife Refuge. Research from these areas shows that large (12,000 to 25,000 acres), low-severity surface fires with a return interval of 50 to 60 years characterized the pre-Euro-American landscape, and that past management actions over the last 100 years have altered these fire regimes (Drobyshev *et al.* 2008a). In addition, past logging activities and the use of prescribed fire outside the historical range of variation resulted in shifts in successional trajectories, with jack pine displacing red and eastern white pine (Drobyshev *et al.* 2008b).

With these findings as a framework for restoration, managers have moved forward with silvicultural treatments to help restore mixed-pine forests to more natural development trajectories. Because altered fire regimes have modified the successional progression of these forests and increased fuel loads (including dominance of jack pine), low-severity prescribed fire treatments are nearly impossible. Managers therefore oversee commercial timber harvests in most stands to clear the way for effective fire management.

Furthermore, unlike in jack pine forests, the historic fire regimes of mixed-pine forests were not typically stand-replacing events, so the type and amount of residual structure important for biodiversity and wildlife (such as snags and coarse woody debris) must be managed differently. Instead of using clearcuts to produce conditions of stand-replacing wildfire, partial harvests can promote natural regeneration of red and eastern white pine and increase the radial growth of residual trees. During these harvests, management actions are also creating larger snags to mimic patterns in benchmark stands. Such actions should bode well for many wildlife species, including crossbills (*Loxia* spp.) and black-backed woodpeckers (*Picoides arcticus*).

Prescribed fire or wildfire may be the best tools for restoring the structure and function of fire-dependent ecosystems, but efforts need to be made to better educate the public to this fact, citing research that provides guidance. To this end, we are trying to reach both professionals and the public by working to establish a Fire Consortium for the Upper Midwest, funded by the federal government's Joint Fire Science Program. The Consortium hopes to work with groups and individuals responsible for managing and restoring fire-dependent forest ecosystems including policymakers, federal and state agencies, forest managers, and interested citizens and NGOs.

To provide wildlife habitat, maintain biodiversity, and meet multiple ownership objectives, contemporary forest management should incorporate ecological principles that are based on landscape position, soils, natural disturbance regimes, and resulting patterns in composition and structure. Doing so will create forest ecosystems that are more resilient to natural and anthropogenic stressors in a quickly changing world. ■

This article reflects the views of the authors and not necessarily those of the U.S. Fish and Wildlife Service.

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