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Snag Longevity and Decay Class Development in a Recent Jack Pine Clearcut in Michigan

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ABSTRACT

To better understand the factors that influence the longevity and decay class development of natural and girdled snags in jack pine (*Pinus banksiana* Lamb.) plantations managed for Kirtland's warbler (*Dendroica kirtlandii* Baird) breeding habitat in the northern Lower Peninsula of Michigan, we followed the fate of 335 jack pine and oak (*Quercus* spp.) snags. After 2.5 years, 41% of snags snapped or uprooted, with most snapping or uprooting occurring within the first year. Jack pine snags experienced higher rates of snapping or uprooting than oak or all snags combined, regardless of whether natural or girdled. Girdling by itself or as an interaction term had no significant effect on snapping or uprooting for either jack pine or oak, but both diameter ($P = 0.03$) and height ($P = 0.01$) influenced snapping and uprooting in oak. Thirty months after treatment, the percentage of snags among decay classes differed between species of snag and snag types (natural-girdled), with snag height inversely related to snag decay class development. These results suggest that snag development will occur rapidly in recently clearcut jack pine stands and that higher densities of snags may need to be retained if management goals are to emulate more natural conditions.

Keywords: ecological forestry, forest wildlife habitat, jack pine, Kirtland's warbler, snags

In many regions of northern Lake States, changes in land-use practices and altered fire regimes have produced pine (*Pinus* spp.)-dominated forests that are structurally simplified relative to stands that developed following wildfire (Schulte et al. 2007, Drobyshev et al. 2008). Biological legacies such as residual live trees, dead standing trees (snags), and downed coarse woody debris (CWD) are either absent or are found in low abundance (Spaulding 2008). In some instances, the homogenization of pine-dominated stands is exacerbated by single-species habitat management that prioritizes actions on the basis of highly specific species needs and not necessarily on emulating structural patterns that result from natural disturbances. Such is the case in the northern Lower Peninsula of Michigan, where forest managers with the US Forest Service, the Michigan Department of Natural Resources, and the US Fish and Wildlife Service intensively manage approximately 52,600 ha with the primary goal of producing young (5–23-year-old) jack pine (*Pinus banksiana* Lamb.) plantations as breeding habitat for the Kirtland's warbler (*Dendroica kirtlandii* Baird).

The Kirtland's warbler is an endangered, neotropical migratory bird that evolved to breed in young, dense stands of jack pine produced by wildfire (Hutto et al. 2008). However, the loss of large-scale, stand-replacing wildfire across the regional landscape has led to the need for intensive habitat management to produce the desired breeding conditions (Probst 1986, 1988). Contemporary habitat management now involves clearcutting mature (>40 year) jack pine and then trenching and planting these sites with 2-year jack pine seedlings in an "opposing wave" pattern whereby the pattern of densely (>2,500 stems ha^{-1}) planted seedlings changes in a scheduled way and produces small openings in the plantation in which birds forage (Probst 1986, 1988, Huber et al. 2001).

Although intensive jack pine plantation management as described above has led to an increased population of warblers and has aided in breeding range expansion into the Upper Peninsula of Michigan, Wisconsin, and Ontario (Probst et al. 2003), plantation management has also had the unintended consequence of producing conditions that poorly emulate the structure and function of wildfire-generated jack pine stands. These plantations are often characterized by altered ecosystem patterns (Houseman and Anderson 2002) and processes (LeDuc and Rothstein 2007), in part because of the lack of biological legacies. In particular, because snags are not a breeding requirement for Kirtland's warbler, the abundance of snags in many of these plantations differs dramatically from wildfire-generated stands. According to Spaulding (2008), the abundance of snags in jack pine stands regenerated by wildfire differed by stand age (younger stands averaged 252 snags ha^{-1}, and older stands had up to 700 snags ha^{-1}) but were consistently much greater than in plantations.

Fortunately, snags can be a focus of management, and past studies have investigated the importance of snag management elsewhere (Franklin et al. 1987, Hutto 2006) and have described management techniques for enhancing snag abundance (Bull and Partridge 1986). Consideration of snags is even mentioned in the most recent multiagency guidelines for Kirtland's warbler habitat management: "All dead trees should be left in the sale area. An overall objective of

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This article uses metric units; the applicable conversion factors are: centimeters (cm): 1 cm = 0.39 in.; kilometers (km): 1 km = 0.6 mi; hectares (ha): 1 ha = 2.47 ac.

15–25 dead trees per acre (37–62 ha^{-1}) is desirable. In those cases where fewer than 10 standing dead trees per acre (25 ha^{-1}) are present, live trees greater than 6 inches (15 cm) dbh may be used to recruit snags" (Huber et al. 2001, p. 15). However, as far as we are aware, no studies have examined the longevity of snags left in jack pine clearcuts or the efficacy of mechanical treatments to produce snags by girdling trees with commonly used logging equipment in Michigan. Although several studies have examined snag dynamics in older wildfire-generated jack pine stands in Canada (Brais et al. 2005, Metsaranta et al. 2008), most snag research has been completed in the western part of the United States. These studies have either focused on natural snags within the context of postfire salvage logging or investigated snag management techniques on western species of pine (Bull and Partridge 1986, Shea et al. 2002, Hutto 2006). However, autoecological differences among pine species and geographic variation in the disturbance regimes that maintain pine-dominated forest ecosystems and produce snags warrant more regionally appropriate snag management studies.

To foster a more ecological and multispecies approach to jack pine plantation management of Kirtland's warbler breeding habitat in Michigan, we conducted a retrospective analysis of 335 natural and girdled snags in a recent jack pine clearcut. Specific research questions were as follows: (1) What is the longevity of natural and girdled snags of different tree species 2.5 years after silvicultural treatment (clearcut)? (2) How does decay class development compare between snag species in the two snag types (natural and girdled)? (3) What physical snag characteristics are related to observed patterns in the above?

Figure 1. Northern Lower Peninsula of Michigan counties (shaded) with Kirtland's Warbler Wildlife Management Area tracts (scattered blocks). The actual study site was in northwest Clare County.

Study Area

This study was conducted on the US Fish and Wildlife Service Kirtland's Warbler Wildlife Management Area (WMA). The WMA comprises 125 tracts in eight counties of the northern Lower Peninsula of Michigan and covers 2,705 ha. The majority (94%) of the WMA stands are in the Highplains Landtype Association, with sand-dominated soil types well suited for the growth of jack pine and the production of Kirtland's warbler habitat (US Fish and Wildlife Service 2009). The WMA is also characterized by a relatively severe climate. The growing season ranges from 70 to 130 days, with frequent spring freezes. Mean annual precipitation is relatively uniform across the area (71–81 cm) (Albert 1995). In terms of soil and forest types, the specific study parcel (located in the northwest corner of Clare County, Michigan) was representative of the WMA overall (Figure 1).

Methods

As part of the typical initial treatment to produce Kirtland's warbler habitat, 35 ha of mature (>40 year old), monotypic, even-age jack pine were clearcut during September and October 2006. Approximately 95% of the basal area/volume was removed from the site during harvest. After harvest, the remaining 5% was composed of snags and scattered residual live trees (mostly red pine [*Pinus resinosa* Sol.]). To create snags, one logger was assigned to use a Ponsse harvester to girdle live trees (Figure 2). All girdled live trees were >18 cm dbh, the approximate mean dbh of the jack pine-dominated stand before harvest. Individuals of all overstory tree species were girdled: jack pine, red pine, white pine (*Pinus strobus* L.), black cherry (*Prunus serotina* Ehrh.), and oak (*Quercus* spp.).

Between September and December 2007 (on average, 12 months after treatment) a total of 335 snags (those that developed through natural processes prior to harvesting and those that were produced by girdling during the harvest) were inventoried. A total of 165 were natural snags (86 jack pine, 78 oak, and 1 black cherry), and 170 were girdled snags (85 jack pine, 75 oak, 9 red pine, and 1 white pine). For each snag, we recorded (1) snag species, (2) snag size (dbh), (3) snag height, (4) snag decay class (Holloway et al. 2007, Table 1), and (5) direction of fall, if snag had reached decay class 5 (DC5; i.e., uprooted or snapped to <6 m in height). During four subsequent visits in April 2008 (approximately 17 months after treatment), July 2008 (approximately 20 months after treatment), October to November 2008 (approximately 24 months after treatment), and April 2009 (approximately 30 months, or 2.5 years, after treatment), each snag was reinventoried to determine longevity (i.e., time to DC5). Because this plantation and others of the WMA are managed primarily for the benefit of wildlife species and the fact that standing snags (especially larger snags) are an important structural variable in habitat selection of many associated bird species (Corace et al., in press) our main interest was in the longevity of snags (natural and girdled) in the stand. In addition, we also investigated differences in decay class development between natural and girdled snags and between tree species comprising both snag types.

We used chi-square tests to test for differences in the cumulative percentage of snags (between snag types of the same species) that experienced DC5 within each of five sampling periods over 2.5 years. We used analysis of variance to test whether differences existed between the average initial snag size (dbh) and height of those snags that developed to DC5 and those that did not. We used binary logistic regression to determine how the additions of an indicator variable (girdled, yes/no) and interaction terms (dbh_girdle and height_girdle) influenced a binary categorical response variable (DC5 yes/no) after 2.5 years. We used linear regression to examine