# Cavity Trees, Snags, and Selection Cutting: A Northern Hardwood Case Study

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ABSTRACT

Although traditional application of the selection system includes a focus on high-value trees that may reduce cavities and snags, few studies have quantified those habitat features in managed uneven-aged stands. We examined the effects of single-tree selection cutting on cavity trees and snags in a northern hardwood stand immediately prior to the second cutting. Marking followed guidelines proposed by Arbogast, C., Jr. (1957. *Marking guides for northern hardwoods under selection system.* US For. Serv. Res. Pap. 56, Lake States Forest Experiment Station. 20 p.), with the objective of improving stand quality for timber production while maintaining a balanced diameter distribution. The stand contained seven species of cavity trees and snags; sugar maple and American beech were most common, the latter comprising 20% of snags and 26% of cavity trees despite its relatively minor (7%) contribution to stand basal area. We found that 92% of cavity trees were live, underscoring the value of living trees as sources of cavities. Precut cavity tree density (25.2 live cavity trees per hectare) was more than twice that found in other studies of selection stands, although density of snags (11.0 snags per hectare) was comparable or lower. More than 50% of sampled cavity trees were designated for removal in the second selection cut, reducing projected postcut density to 11.0 live cavity trees per hectare, a density similar to that found in other studies. Postcut density of large cavity trees (3.3 live trees >45 cm dbh per hectare) exceeded published guidelines for northern hardwoods (0.25 to 2.5 live cavity trees >45 cm dbh per hectare). We speculate that the relatively high maximum diameter (61 cm dbh) and long cutting cycle (20 years) used to define the target stand structure may have contributed to the number of cavity trees observed. Nevertheless, selection cutting as applied in this study will likely reduce cavity abundance unless retention of trees with decay is explicitly incorporated into the management strategy.

**Keywords:** uneven-aged silviculture, cavities, snags, northern hardwoods, wildlife habitat

Managing for quality sawtimber with the single-tree selection system often reduces the number of cavity trees and snags. Quality is the primary determinant of value for hardwood sawlogs, and presence of grading defects and indicators of wood decay and discoloration are considered when selecting trees to remove in selection cutting (Trimble et al. 1974). The tradition of removing the poorest trees and leaving the best does not always enhance noncommodity values, such as wildlife habitat for cavity-associated species. Trees with holes and dying crown, as well as snags, could be retained to maintain an important component of habitat.

Although a few reports describe the availability of cavity trees and snags in northern hardwood forests (Runde and Capen 1987, Welsh and Capen 1992), we found few publications about the impact of uneven-aged silviculture on those habitat features. McComb and Noble (1980) reported that a managed uneven-aged stand had a similar density of cavity trees as an unmanaged stand, but fewer snags. Goodburn and Lorimer (1998) and McGee et al. (1999) found that managed uneven-aged stands had lower densities of cavity trees and snags than old-growth stands. Fan et al. (2004) used a landscape-level simulation of cavity tree dynamics to conclude that uneven-aged stands have fewer cavity trees than unharvested stands. However, none of these previous studies provided information about pre- to postcut stand-level dynamics.

We examined the effects of single-tree selection cutting on cavity trees and snags in a northern hardwood stand. Although the study was not replicated, the treatment was the second in a rigorous application of the selection system, thus providing a well-defined management context for our findings. We believe that the results of this study will be of interest to land managers; to that end, we have compared our findings to guidelines for cavity tree management in northern hardwoods (Tubbs et al. 1987) and considered the need for modification of marking guides to ensure retention of cavity trees.

## Study Area

The study reported here was conducted in 1993 in a northern hardwood stand in central New York. The study stand had 60% of basal area (BA; trees ≥2.5 cm) in sugar maple (*Acer saccharum* Marsh.), 12% in white ash (*Fraxinus americana* L.), 8% in black cherry (*Prunus serotina* Ehrh.) and 7% in American beech (*Fagus grandifolia* Ehrh.). Other species (each <5%) included yellow birch (*Betula alleghaniensis* Britton), eastern hemlock (*Tsuga canadensis* (L.) Carr.), American basswood (*Tilia americana* L.), red maple (*Acer rubrum* L.), eastern hophornbeam (*Ostrya virginiana* (Miller) K. Koch) and striped maple (*Acer pensylvanicum* L.) (Kenefic and Nyland 2000).

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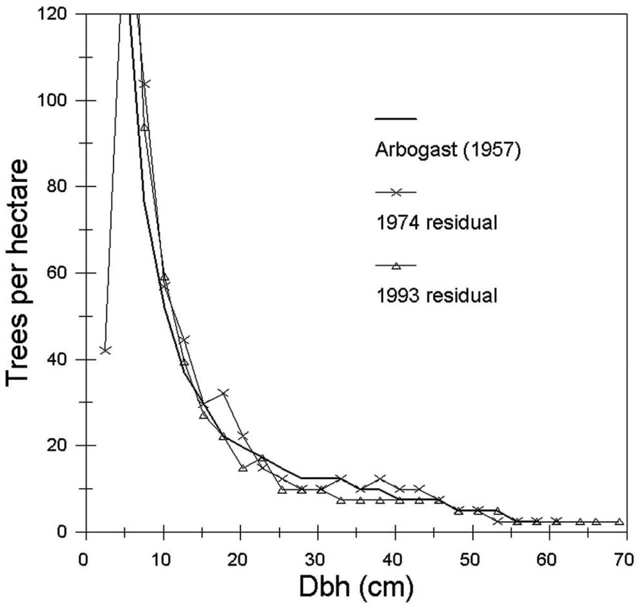

**Figure 1. Diameter distribution of the Cuyler Hill selection stand in 1974 and 1993, compared with the Arbogast (1957) distribution.**

The study site lies toward the center of the Cuyler Hill State Forest, a 2,238-ha area of northern hardwoods with interspersed conifer plantations. The hilly upland country has pronounced ridges and valleys characteristic of the northern end of the Allegheny plateau. Adjacent private lands along the ridge have predominantly hardwood forest cover, with interspersed open fields. Nearby valleys are characterized by pastures, hay fields, and scattered forest. Soils in the study area range from well to somewhat poorly drained channery and medium-textured loams and silt loams and are a combination of the Lordstown, Mardin, and Vlusia series derived from siltstone, sandstone, and embedded shales (Nyland et al. 1976).

The 12-ha research stand had been unmanaged prior to 1974 but received unspecified types of partial cutting until about 1930. It was treated with single-tree selection cuttings in 1974 and 1993; chainsaws and rubber-tired tractors were used for felling and skidding tree-length logs in both harvests. Residual structure after both treatments closely resembled the diameter distribution proposed by Eyre and Zillgitt (1953) and presented as a management guide by Arbogast (1957) (Figure 1). This structure represents a balanced distribution of trees by size class, with a target residual maximum dbh of 61 cm. Marking for both treatments was conducted by R. Nyland, with the objective of removing the poorest growing stock while maintaining a uniform spatial distribution of trees and an interspersion of size classes. No special provisions were made to retain cavity trees or snags. Stand quality for timber production has improved, and upgrading of the growing stock should be essentially finished after the next harvest. Basal area was reduced from 25.9 to 16.5 $m^2$ ha in 1974 and from 26.4 to 18.8 $m^2$ ha in 1993.

## Methods

Cavity trees and snags were inventoried by observation from the ground without binoculars on 45, 8.0-m radius plots located at alternate points on a 30.5-m systematic grid. Sampling was done in July of 1993, prior to the second selection cutting. Cavity trees ≥10 cm dbh and snags (dead standing trees or tree boles) ≥10 cm dbh and ≥1.8 m tall were recorded (Thomas et al. 1979, Bayer 1987, Kruse 1990). Cavity trees were defined as trees with a nest cavity, den, or hollow that might shelter a hole-nesting species (Healy et al. 1989). We did not differentiate between inactive and active cavities or between bird-excavated and natural (wound-origin) cavities. We recorded dbh and species for all cavity trees and snags and estimated cavity height and size of the entrance hole using ranges. Postcut numbers and diameters of cavity trees were projected from the precut tally of trees marked for harvest. Means and standard errors are presented to facilitate interpretation of our findings.

**Table 1. Mean number of live cavity trees per hectare ± standard error, summarized by dbh class before and after the 1993 cut.**

| | Diameter class (dbh) | | | |
|---|---|---|---|---|
| | <30.0 cm | 30.0–44.95 cm | 45.0–60.0 cm | >60.0 cm |
| Precut | 7.7 ± 2.7 | 6.6 ± 2.5 | 9.9 ± 3.0 | 1.1 ± 1.1 |
| Postcut | 5.5 ± 2.3 | 2.2 ± 1.5 | 3.3 ± 1.8 | 0 |

**Table 2. Mean dbh ± standard error, dbh range, and proportion of live cavity trees by species before and after the 1993 cut.**

| | Mean dbh (cm) | dbh range (cm) | Percentage of all live cavity trees (%) |
|---|---|---|---|
| Precut ($n$ = 23) | | | |
| Sugar maple ($n$ = 12) | 41.1 ± 3.6 | 22.0–55.8 | 52 |
| Yellow birch ($n$ = 1) | 38.4 | NA | 4 |
| American beech ($n$ = 6) | 33.2 ± 6.61 | 12.5–53.4 | 26 |
| White ash ($n$ = 2) | 42.1 ± 13.6 | 22.8–61.4 | 9 |
| American basswood ($n$ = 2) | 39.4 ± 4.5 | 33.1–45.8 | 9 |
| Postcut ($n$ = 10) | | | |
| Sugar maple ($n$ = 7) | 38.9 ± 3.6 | 22.4–53.1 | 70 |
| Yellow birch ($n$ = 0) | NA | NA | 0 |
| American beech ($n$ = 1) | 12.5 | NA | 10 |
| White ash ($n$ = 1) | 22.8 | NA | 10 |
| American basswood ($n$ = 1) | 45.8 | NA | 10 |

NA, not applicable.

## Results and Discussion

### Cavity Trees

Prior to the 1993 cut, live cavity trees ($n$ = 23) occurred at a mean density of 25.2 ± 4.5 per hectare, with a mean of 1.0 ± 0.04 cavities per cavity tree. This was approximately twice that documented by McComb and Noble (1980) in mixedwood selection stands (13.1 cavity trees per hectare, 3 years postcut) and by Goodburn and Lorimer (1998) in northern hardwood selection stands (12.5 cavity trees per hectare, lapse times since cutting not specified). Mean dbh of live cavity trees (39.0 ± 2.0 cm; range, 12.5 to 61.4 cm) was similar to those reported by McComb and Noble (1980) (38.1 cm dbh) and Goodburn and Lorimer (1998) (44.8 cm dbh). The distribution by diameter class is shown in Table 1. Cavities were unevenly distributed among five tree species (Table 2). Although sugar maple accounted for about half of observed cavity trees, this species' proportional contribution to stand BA was high (60%). American beech, on the other hand, constituted <10% of stand BA but >25% of cavity trees; this is likely due in part to the prevalence of beech bark disease (a *Cryptococcus fagisuga–Nectria* complex) in the study area. This is consistent with Fan et al. (2003), who classified American beech as highly susceptible to cavity formation.

Frequencies by cavity size and height class are shown in Table 3. The upper range of opening sizes exceeds that found in northern

**Table 3. Pre- and postcut distribution of cavities by height class and size of the entrance hole, 1993.**

| | Precut ($n$ = 24) | Postcut ($n$ = 11) |
|---|---|---|
| Size class | | |
| Smaller than 8.0 cm | 6 (25%) | 5 (45%) |
| Between 8.0 and 15.0 cm | 7 (29%) | 1 (9%) |
| Larger than 15.0 cm | 5 (21%) | 3 (27%) |
| Size not measured | 6 (25%) | 2 (18%) |
| Height class | | |
| Below 1.5 m | 13 (54%) | 8 (73%) |
| Between 1.5 and 5.0 m | 2 (8%) | 1 (9%) |
| Between 5.0 and 12.0 m | 9 (38%) | 2 (18%) |
| Above 12.0 m | 0 (0%) | 0 (0%) |

The percentage of cavities in each size class is listed in parentheses.

**Table 4. Mean dbh ± standard error, dbh range, and proportion of snags by species before and after the 1993 cut.**

| | Mean dbh (cm) | dbh range (cm) | Percentage of all snags (%) |
|---|---|---|---|
| Precut ($n$ = 10) | | | |
| Sugar maple ($n$ = 5) | 14.8 ± 2.1 | 10.7–20.4 | 50 |
| American beech ($n$ = 2) | 35.6 ± 11.7 | 19.1–52.0 | 20 |
| Black cherry ($n$ = 2) | 15.6 ± 1.5 | 13.5–17.7 | 20 |
| Eastern hophornbeam ($n$ = 1) | 10.0 | NA | 10 |
| Postcut ($n$ = 7) | | | |
| Sugar maple ($n$ = 4) | 15.8 ± 2.3 | 11.0–20.4 | 57 |
| American beech ($n$ = 1) | 19.1 | NA | 14 |
| Black cherry ($n$ = 1) | 13.5 | NA | 14 |
| Eastern hophornbeam ($n$ = 1) | 10.0 | NA | 14 |

NA, not applicable.

hardwood selection stands of the Lake States, where all were <10 cm (Goodburn and Lorimer 1998). This difference may reflect smaller maximum dbh associated with the stand diameter distributions in that study (specified only as >45 cm dbh), compared with the 61 cm maximum dbh in the Cuyler Hill stand.

Although we detected no cavities above 12 m in height, dense vertically stratified foliage may have obscured cavities in the upper canopy. This problem was reported by DeGraaf and Shigo (1985) and by Gysel (1961), who found no cavities during summer sampling but more than 5 cavities per hectare with winter surveys of the same site using binoculars and tree climbers.

### Snags

The 1993 precut stand had 11.0 ± 3.8 snags >1.8 m tall per hectare ($n$ = 10, Kenefic and Nyland 2000), similar to the density that McComb and Noble (1980) found in mixedwood selection stands (14.8 snags >1.8 m tall per hectare). This density is less than one-third of that found in northern hardwood selection stands of the Lake States (38 snags >1.5 m tall per hectare) (Goodburn and Lorimer 1998) and the Adirondacks of New York (43 snags >1.0 m tall) (McGee et al. 1999). It is not known to what extent the smaller height thresholds used for sampling in those studies are responsible for the differences in observed snag density. Mean snag dbh in the present study was 18.6 ± 3.9 cm, compared with the 26.8 cm reported by Goodburn and Lorimer (1998). Both mean dbh and range in snag diameter differed by species (Table 4), and American beech again accounted for a high proportion of observations relative to its overall abundance in the stand. This is likely due to beech bark disease (see Houston 1994 for information about this complex); the killing front passed through the study area more than a decade before sampling and resulted in the deterioration and mortality of many American beech trees.

Only 8% of sampled cavity trees were dead (i.e., snags), and there appears to be a relationship between snag species and the presence of cavities, suggesting that cavity formation in snags and/or the death of cavity trees are not independent of tree species. In our stand, all snags with cavities were beech, and every beech snag sampled had at least one cavity.

### Impact of Cutting

The precut tally of marked trees revealed that 52% of sampled cavity trees were designated for removal during the 1993 treatment. The projected postcut density of cavity trees was 11.0 ± 3.2 per hectare, with a mean dbh of 34.6 ± 1.9 cm (range, 12.5 to 53.1; Table 2). Residual stand cavity density and size were comparable to findings of earlier studies in selection stands (McComb and Noble 1980, Goodburn and Lorimer 1998). The removal of cavity trees, i.e., trees with holes in the main stem, suggests an improvement in quality and value yield potential of the Cuyler Hill stand that is consistent with traditional timber management objectives.

The stand was marked for harvest 4 years prior to the 1993 logging. Our sample was made just weeks before the cut and included marked snags, even though no dead trees had previously been designated for cutting. These included beech that apparently succumbed to the beech bark disease during the 4-year period prior to sampling. These findings are consistent with marking guidelines for timber management goals, which give priority to removal of potential mortality trees. The projected postcut distribution of snags by species was not substantially changed (Table 4). Snag density (7.7 ± 2.7 per hectare) and mean snag dbh (15.1 ± 1.8 cm; range, 10.0 to 20.4 cm) were also not greatly different from precut averages.

## Management Implications

After two selection system cuttings in a previously unmanaged uneven-aged northern hardwood stand, the number of large live cavity trees per hectare (3.3 trees >45 cm dbh, Table 1) compared favorably with guidelines from Tubbs et al. (1987), although no special provisions had been made to retain cavity trees. Tubbs et al. (1987) recommended a per hectare density of 0.25 to 2.5 live cavity trees larger than 45 cm dbh to meet the needs of large-bodied, cavity-dwelling wildlife. Likely, constraints on cutting intensity for the selection system treatment per the Arbogast (1957) guidelines and the decision to retain large trees led to the retention of many cavity trees. Leak (1985) noted that cavities are common in sugar maple ≥56 cm dbh and beech ≥41 cm dbh; maximum dbh in our stand was 61 cm. Even so, if management continues to focus on growing high quality trees for their timber values, subsequent treatments may reduce cavity tree abundance below the suggested threshold levels. In addition, it should be noted that presence of cavities does not necessarily equate to use by wildlife. Healy et al. (1989) reported that only 68% of cavities in unthinned sawtimber oak (*Quercus* species) stands were being used by wildlife, whereas Sandstrom (1992) found that only approximately 7% of cavities in managed and unmanaged forests in Sweden were occupied. Additional research on cavity use is needed to confirm the adequacy of habitat in the present study.

Although spatial distribution was not quantified, cavity trees and snags were found on 49% and 17% of sampled plots, respectively. There was no apparent clustering of cavities in the precut stand; no plot with cavity trees was more than two sample points away from another plot with cavity trees (based on 8.0-m radius plots on a

30.5-m sample grid). Snags, however, were found only on plots adjacent to skid trails, suggesting a link to past logging damage. Interestingly, marking for commodity objectives resulted in the removal of >90% of the cavity trees in the eastern half of the stand but none in the western half. A high incidence of logging damage in the eastern half of the stand during the earlier cut (personal observation) may explain this apparent inconsistency in marking. Regardless of the mechanism, the clustered postcut distribution of cavity trees may limit their potential for utilization by territorial species (Evans and Conner 1979). Previous studies of cavity trees in selection stands (McComb and Noble 1980, Goodburn and Lorimer 1998, McGee et al. 1999) did not address spatial distribution, and this topic warrants additional study. In the interim, our observations suggest that management should address both the density and spatial distribution of cavity trees.

Snags have traditionally been viewed as an important source of cavities, and snag management has been considered an effective means of enhancing habitat for cavity nesters (Conner 1978, Evans and Conner 1979, Thomas et al. 1979, Mannan et al. 1980, Miller and Miller 1980, Scott et al. 1980, Franklin et al. 1981, Sandstrom 1992). We found that only 8% of cavity trees in the Cuyler Hill stand were snags. This finding is similar to that of Goodburn and Lorimer (1998), who reported that only 15% of cavity trees in northern hardwood selection stands were snags. This has implications regarding the feasibility of substituting snag management for cavity management in uneven-aged northern hardwoods. Since 92% of cavity trees in the Cuyler Hill stand were live, and few observed snags had cavities, managing for snags alone would not ensure adequate availability of cavities. Instead, our findings highlight the importance of the recommendations by Healy et al. (1989), who note that providing dead trees is a separate issue from retaining live cavity trees; they recommend the retention of live, vigorous cavity trees as a means for maintaining the habitat for cavity-nesting species over an extended period.

Tree species also must be considered. In our uneven-aged northern hardwood stand, the only snags with cavities were beech. This is likely a function of the beech bark disease, which causes extensive decay and predisposes trees to mortality in the sawtimber classes (Filip 1978, Houston and O'Brien 1983). Savage (1990) noted the presence of *Nectria* in the study area, and that influenced the choice of trees to remove (personal observation). In most cases, cutting would reduce the number of new snag beech that could serve the needs of snag-associated hole-nesting species. On the other hand, keeping infected trees would diminish stand-level quality and growth and allow the natural propagation of trees with susceptible genotypes.

## Conclusion

Our findings from the Cuyler Hill stand led us to conclude that uneven-aged northern hardwood stands under the selection system may have the requisite number of cavity trees to sustain many cavity-associated wildlife species. The focus on growing high-value trees that is traditionally associated with selection management will likely reduce cavity abundance, unless managers incorporate cavity tree retention as a deliberate part of their marking strategy.

The density of cavity trees documented in this study exceeds (20 years following the first cut) or equals (immediately following the second cut) that found in other studies of selection stands (McComb and Noble 1980, Goodburn and Lorimer 1998). Data on cavity utilization were not collected in the current study, and we recognize that the presence of cavities and snags does not necessarily equate to use by wildlife. Additional research is needed to clarify relationships between wildlife use and the type, size, and spatial distribution of cavity trees. Nevertheless, the recommendation of Tubbs et al. (1987) of 0.25 to 2.5 large (>45 cm dbh) live cavity trees per hectare was exceeded in the Cuyler Hill stand.

Although we did not find that commodity-oriented marking reduced the habitat for cavity-nesting species below threshold levels, it should be noted that the study stand has a relatively long cutting cycle, balanced diameter distribution, and large maximum diameter. Although we suspect that these factors contributed to the amount of cavity formation and retention, additional research is needed to determine the impacts of repeated cutting and of alternative structural goals.

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