

SNAG RECRUITMENT AND MORTALITY IN A BOTTOMLAND HARDWOOD FOREST FOLLOWING PARTIAL HARVESTING: SECOND-YEAR RESULTS

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Abstract—Snags are defined simply as standing dead trees. They function as an important component of wildlife habitat. Unfortunately, little information has been gathered regarding snags in bottomland forest ecosystems. We initiated a study to determine the effects of harvesting on the flora and fauna of a bottomland hardwood ecosystem adjacent the Mississippi River in Issaquena County, MS. Treatments included complete harvesting (clearcut), partial harvesting, and an unharvested control. Our objective was to determine the density, recruitment, and “mortality” of snags. We recorded 189 snags \geq 10-cm diameter at breast height (d.b.h.) during pretreatment measurements. Sugarberry (*Celtis laevigata* Willd.) and boxelder (*Acer negundo* L.) comprised 35 and 27 percent of snags, respectively. Two years following harvest, no differences were found in snag density, cumulative mortality, or recruitment between the partial harvesting and controls. However, differences were found between these two treatments and the complete harvest. Long-term data are needed before definitive statements can be made regarding management impacts on snags in bottomland hardwood ecosystems.

INTRODUCTION

The Society of American Foresters defines tree snags as standing, generally unmerchantable, dead trees from which the leaves and most of the branches have fallen (Helms 1998). For purposes of our study, we view tree snags differently, because merchantability has little to do with ecological function. Further, the above definition does not take into account trees that have recently died and retain many of their branches, including small twigs. Therefore, we define tree snags simply as standing dead trees (Cornell University N.d.).

Snags provide several key ecosystem functions. They are used by many wildlife species including birds and small mammals (Cain 1996, Connor and others 1994, Dingledine and Haufler 1983, Hamel and others 1982, Hamilton 1943, Ohmann and others 1994, Runde and Capen 1987, Sinclair and others 1977, Styskel 1983). These species use snags for nesting, foraging, perching, and roosting (Harlow and Guynn 1983, Land and others 1989, Rosenberg and others 1988, Sabin 1991); thus, including snags in forest management plans is critical to many species (Stone and others 2002, Wilson and others 2007). Snags also serve as refugia for other species including insects and fungi (Franklin and others 1981, Harmon and others 1986). In a sense, snags can be just as “alive” as living trees, serving as their own dynamic ecosystem.

Research into snag recruitment and “mortality” is limited. Previous research has focused primarily on western conifer species, including ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) and Douglas-fir (*Psuedotsuga menziesii* (Mirb.) Franco) due to their long persistence time (Franklin and others 1981, Harris 1999). Snag classification systems that define specific decay stages have been well established for these species (Franklin and others 1981). Less is known about hardwood snags (Fan and others 2003, Yamasaki and

Leak 2006), especially in southern bottomland ecosystems (Conner and others 1994). Greater rainfall and more humid conditions in the southeastern United States lead to greater decomposition rates and higher biological productivity resulting in potentially greater turnover rates for hardwood snags. Our objective was to document snag density, recruitment and mortality in the Mississippi River batture land as part of a larger study investigating changes in floral and faunal communities following complete and partial harvesting in a bottomland hardwood ecosystem (Lockhart and others 1996). Our hypotheses were (1) greater snag recruitment would occur in the partial harvest treatment in the short-term due to harvesting activities and (2) greater snag recruitment would occur in the long-term in the unharvested controls due to a greater number of available candidate trees compared to the harvested treatments.

MATERIALS AND METHODS

The study site is located on Pittman Island in Issaquena County, MS (32° 55' N, 91° 09' W) within the unprotected lands (batture) along the Mississippi River. The site is characterized by ridge and swale topography due to channel migration of the Mississippi River (Mitsch and Gosselink 1993). Soils vary but are composed primarily of Commerce silt loam (fine-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquepts), Sharkey clay (very fine, smectitic, thermic Chromic Epiaquepts), Bowdre silty clay (clayey over loamy, smectitic, thermic Fluvaquentic Hapludolls), and Robinsonville very fine sandy loam (coarse-loamy, mixed, superactive, nonacid, thermic Typic Udifluvents). Climate is characterized as humid and warm. Average high temperature is 28° C in July, and average low temperature is 6° C in January. Precipitation averages 142 cm per year with the greatest monthly average in March (15.7 cm) and the lowest monthly average in August (6.8 cm) (Information source: Rolling Fork, MS, weather station located about 25 km northeast of Pittman Island, <http://www>.

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msstate.edu/dept/GeoSciences/). Periodic summer droughts occur in the region. Past management activities in the forest included a partial harvest in 1979 and 1980 and infrequent light harvests before 1969. Species composition by number of trees per ha ≥ 10 cm diameter at breast height (d.b.h.) included sugarberry (*Celtis laevigata* Willd.; 62 percent), sweet pecan (*Carya illinoensis* (Wang) K. Koch; 8 percent), boxelder (*Acer negundo* L.; 8 percent), American elm (*Ulmus americana* L.; 8 percent), green ash (*Fraxinus pennsylvanica* Marsh.; 3 percent) and Nuttall oak (*Quercus nuttallii* Palmer; 2 percent).

Two harvesting (reproduction method) treatments, clearcut and selection, were implemented during the winter of 1995/1996. Each treatment and an unharvested control were located on 20-ha treatment plots and replicated three times for a 180-ha study area. In the clearcut treatment (hereafter referred to as complete harvest), all commercial stems were removed during the logging operation. A followup treatment consisted of felling all remaining stems ≥ 5 cm d.b.h. In the selection harvest (hereafter referred to a partial harvest), tree marking was done according to Anderson-Tully Company guidelines (see Lockhart and others 2005 for more information). Within the partial harvest treatment, a combination of single-tree and group selection harvests was used to remove 1/3 to 1/2 the basal area. Tree species favored for management included green ash, Nuttall oak, sweet pecan, and sugarberry.

Prior to harvest (1995), sixteen 0.1-ha circular plots were systematically established in each treatment plot (144 plots total). All snags ≥ 10 -m d.b.h. were recorded by species. Distance and azimuth from plot center were also recorded. In addition to pretreatment measurements, first and second year post-harvest measurements were conducted to determine changes in pretreatment snag condition and to document recruitment of new snags. Data were analyzed using analysis of variance (SAS, Inc. 1985). Duncan's multiple range test was used to separate treatment means if significant differences ($\alpha \leq 0.05$) were found in the analysis of variance.

RESULTS AND DISCUSSION

A total of 189 snags (mean = 13.1 snags/ha) were tallied across the study site prior to treatment application. These snags represented 14 species; sugarberry and boxelder comprised the majority at 35 and 27 percent, respectively (fig. 1). Eight percent of the snags were of unknown species due to advanced decay. The snags were evenly distributed among the designated treatments with a range of 14.0 snags/ha in the controls to 12.1 snags/ha in the complete harvest (fig. 2–1995 bars).

Following the 1996 growing season, 66 percent of the original 189 snags either perished or broken off below d.b.h. These 125 snags represented first year, post-treatment snag "mortality." A significant difference occurred in snag mortality between the complete harvest and the unharvested control ($p = 0.02$; fig. 3). Greater snag mortality was expected within the complete harvest, because all remaining stems ≥ 5 cm d.b.h. were felled in a follow-up operation. Unfortunately, two snags were not felled during this treatment resulting in only

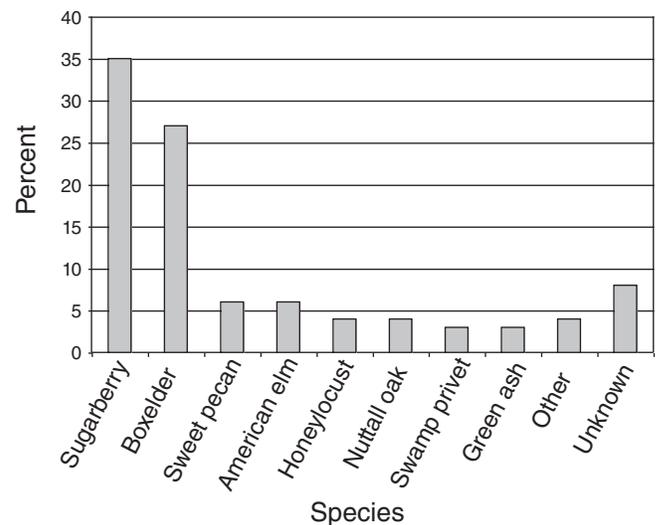


Figure 1—Pre-treatment snag percentage by species on the Pittman Island study site, Issaquena County, MS.

97 percent snag mortality. No significant difference was found between the complete and partial harvest and between the partial harvest and unharvested control due to the high variability associated with the partial harvest (fig. 3). Two-thirds of the pretreatment snags in the partial harvest were lost one year following harvesting while 1/3 of the snags were lost in the unharvested control during the same time; therefore, it is plausible that about 1/2 of the snags lost in the partial harvest can be attributed to the harvesting operation or its aftereffects (fig. 3).

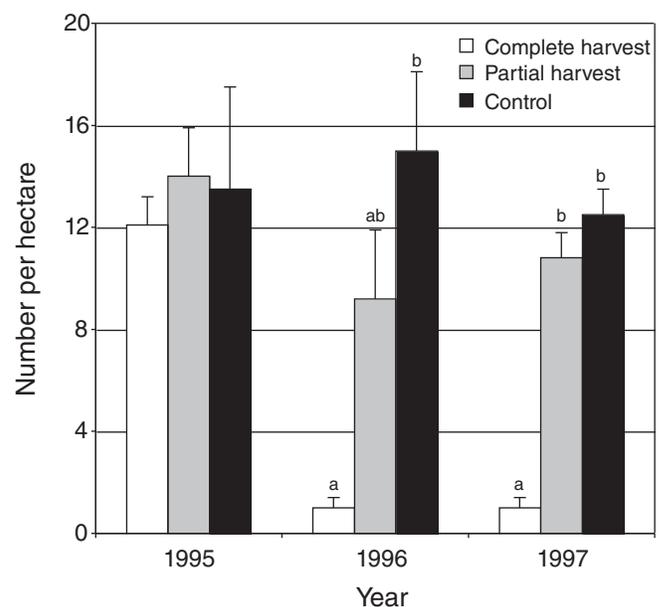


Figure 2—Number of snags per hectare by year and treatment on the Pittman Island study site, Issaquena County, MS. Bars with different letters within a year are significantly different at $p \leq 0.05$.

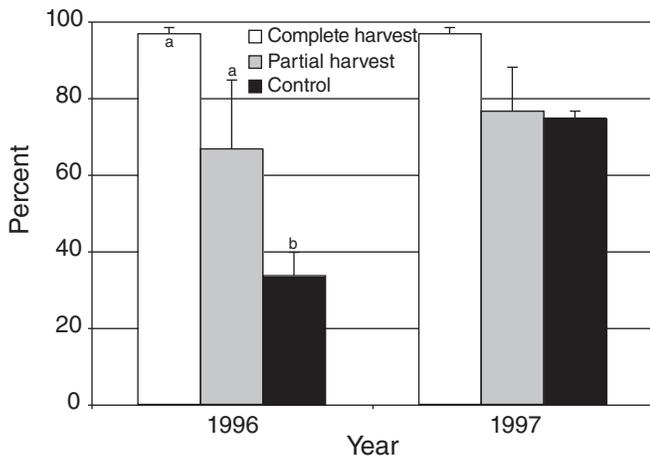


Figure 3—Cumulative mortality of pre-treatment snags by year and treatment on the Pittman Island study site, Issaquena County, MS. Bars with different letters within a year are significantly different at $p \leq 0.05$.

Recruitment of new snags during the 1996 growing season ranged from 0.6 to 6.5/ha for the complete harvest and unharvested control, respectively (fig. 4). Three snags were recruited in the complete harvest. Two snags were boxelder stems that were 20 and 24 cm d.b.h. The third snag was a 62 cm sugarberry that was only about two meters tall, because the main stem broke off during harvest operations. These stems were also missed during the follow-up treatment. Greater recruitment of snags occurred in the partial harvest and unharvested control compared to the complete harvest ($p = 0.01$) due to greater availability of candidate trees (fig. 4). No difference was found in snag recruitment between the partial harvest and unharvested control in 1996; therefore, the average number of snags ≥ 10 cm d.b.h. recruited across the two treatments was 5.7/ha. Recruitment and mortality of snags during the 1996 growing season resulted in a 34 percent net decrease in the number of snags in the partial harvest and an 11 percent net increase in the unharvested control (fig. 2). These two treatments contained more snags than the complete harvest (fig. 2; $p = 0.05$).

An additional 30 pretreatment snags were lost within treatment areas following the 1997 growing season. The two snags in the complete harvest were still present, while snag mortality increased 10 percent in the partial harvest and 41 percent in the unharvested control (fig. 3). No difference existed across treatments in cumulative snag mortality ($p = 0.14$), again owing to greater variability in the partial harvest (fig. 3). Greater variability (larger standard error bar) in snag mortality in the partial harvest probably was a function of harvest activities. Harvesting, either by direct contact with the equipment or dropping tree crowns into snags, would increase the likelihood of individual snags being lost between treatment replications. Spring time floods in both 1996 and 1997 also may have contributed to snag mortality, i.e., flood water and debris may have toppled weak snags. Less obstruction from remaining trees in the partial harvest may have resulted in greater water velocity and increased debris

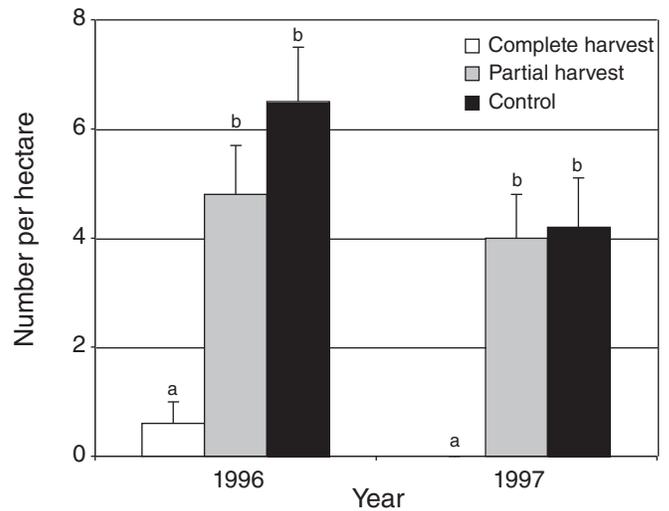


Figure 4—Number of snags recruited per hectare by year and treatment on the Pittman Island study site, Issaquena County, MS. Bars with different letters within a year are significantly different at $p \leq 0.05$.

flow, further increasing treatment variability. Concurrently, smaller-d.b.h. snags in the unharvested control would be more susceptible to mortality during flooding events.

No recruitment of new snags occurred in the complete harvest following the 1997 growing season, because no candidate stems remained from the follow-up chainsaw felling treatment (fig. 4). Greater recruitment of snags again occurred in the partial harvest and unharvested control compared to the complete harvest ($p = 0.04$), but no difference existed between the former 2 treatments (fig. 4); therefore, the average number of snags ≥ 10 cm-d.b.h. recruited across these 2 treatments was 4.1/ha. Mortality of 1996 snags (first year, post-treatment new snags) was 27 and 26 percent for the partial harvest and unharvested control, respectively (data not shown). The three 1996 snags in the complete harvest were still standing following the 1997 growing season. Mortality and recruitment of snags following the 1997 growing season resulted in a 17 percent increase in the number of snags/ha in the partial harvest while snags in the unharvested control decreased by 17 percent (fig. 2).

Our review of the total number of snags by treatment (instead of treatment replication means) showed a net loss of five snags in the controls or one snag/ha/year. Therefore, two-year snag retention, or the initial number of snags plus new snags less those snags that perished, was 92 percent. Likewise, a net loss of 14 snags occurred in the partial harvest, or 2.9 snags/ha per year. Two-year snag retention was 79 percent. Based on these results, we reject our first hypothesis that greater snag recruitment would occur in the partial harvest in the short term. No differences were found between snag recruitment in the partial harvest and unharvested controls (fig. 4), although both treatments obviously recruited more snags than the complete harvest. The second hypothesis, that greater snag recruitment would occur in the long term in the unharvested control, could not be answered due to the short term (two-year) results reported in this study.

Snag dynamics are a function of species composition, stand structure, age, and stage of stand development. Disturbance also influences the rate of snag recruitment and mortality (van Lear 1996). Previous work with hardwood snags indicates that snag abundance declines in managed forests compared to unmanaged forests (Graves and others 2000, Harlow and Guynn 1983, McComb and Noble 1980). We did not find this to be the case in the present study based on short-term results comparing partial harvesting to controls. No differences were found in snag density (fig. 2), cumulative mortality (fig. 3), or recruitment (fig. 4) during the two-year study period following partial harvesting, compared to unharvested controls. We conclude that longer-term results are needed to determine if snag abundance declines in managed forests compared to unmanaged forests in bottomland hardwood ecosystems.

Snags are increasingly recognized as an important component of forest management plans. Wilson and others (2007), in a report about enhancing wildlife habitat in the Lower Mississippi Alluvial Valley, state that desired stand conditions for bottomland hardwood forests would include 15 snags/ha \geq 25-cm d.b.h. A stand structure that contained < 10 snags was considered the target to trigger management actions to increase the number of snags. Results from our study were slightly below the desired stand structure, but within the range of 10 to 15 snag/ha – given that our minimum snag d.b.h. was 10 cm.

Practices to increase the number of snags in managed forests include designating snags or potential snags during tree marking operations, such as trees with noticeable decline (crown dieback, disease, streaks indicating lightning strikes, and suppressed trees that may not respond to release) (Harlow and Guynn 1983). Other practices could include injecting individual trees with herbicides (Hurst and Bourland 1996) or have harvesting equipment damage trees explicitly marked for the objective of creating den trees and future snags (Personal communication. Kenny Ribbeck. 2007. Biologist Program Manager, Louisiana Department of Wildlife and Fisheries, P.O. Box 98000, Baton Rouge, LA 70898-9000). More research is needed to quantify snag dynamics in bottomland hardwood ecosystems, including densities by species and size classes, longevity, and recruitment. Eventually, a snag classification system (by species), similar to the one developed for northern hardwood species in Wisconsin (Runde and Capen 1987), will aid wildlife habitat management efforts.

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