LONG-TERM EFFECTS OF CLEARCUTTING ON TREE SPECIES COMPOSITION IN AN OAK-HICKORY FOREST

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Abstract—In 1973, a silvicultural clearcut, with and without a post-harvest herbicide treatment, was performed on an upland oak-hickory forest in southern Illinois. Prior to harvest, permanent plots were established, and a survey was conducted to determine stand structure and composition. In 2003, a post-harvest survey was performed using the permanent plots. Relative density and relative basal area were calculated for all oaks and dominant mesic species. Differences in stand structure were compared between the pre-harvest and post-harvest stand. Overall, disturbance-dependent species such as oak appeared to be decreasing while mesic species were increasing.

INTRODUCTION

Currently in the central United States, upland hardwood stands are a mixture of species that reflect site conditions and past treatments (Steinbeck and Kuers 1996). Following harvest treatments, it has been observed that the oak component on certain sites has not been regenerating successfully. These regeneration failures have led to the decrease of oak dominance, the loss of one species of oak, or virtually a total loss of the oak component in a stand (McGee and Loftis 1993). Foresters need a thorough understanding of how different types of harvesting methods affect species regeneration and stand composition.

Changes in disturbance regimes over the past several decades is believed to play an integral part in species composition shifts in hardwood forests of this region. Suppression of disturbances such as fire negatively impact the growth of disturbance-dependent species (Fralish 1997). Light fires favor oak regeneration by killing fire-intolerant species, promoting growth of sprouts, and reducing overstory density (Larsen and Johnson 1998). Without these disturbances shade tolerant species such as sugar maple (*Acer saccharum* Marsh.) and American beech (*Fagus grandifolia* Ehrh.) have encroached upon historically oak-dominated sites. Within the Shawnee National Forest, managers are faced with the dilemma of maintaining an oak-hickory cover type in an environment where creating necessary disturbance regimes on public lands has become difficult. The general objective of the study was to assess the shift in stand composition 30 years following a clearcut and herbicide treatment.

METHODS

The research site was located on the Shawnee National Forest at Atwood Ridge, Union County, IL. This region of southwestern Illinois is on the easternmost extension of the Ozark Province and is characterized by steep, hilly topography (Thornbury 1965).

In 1973, a silvicultural clearcut was performed on 24 ha with maintenance of the present cover type of mixed oak-hickory as the management objective. After harvest, to increase the amount of light reaching the forest floor, undesirable residual trees >10 cm d.b.h. were treated with 2,4,5-T and 2,4-D herbicides using a tree injector. Economically-desirable trees, such as oak, were felled and not treated with herbicide so they would resprout (Weaver and Robertson 1981). Prior to harvest, 52 permanent plots, 0.04-ha in size, were established and inventoried for species composition and tree diameter. In the summer of 2003, the plots were again surveyed.

RESULTS AND DISCUSSION

Changes in overstory relative density occurred between the pre-harvest and 30-year post-harvest stand. In 1973, white oak (*Quercus alba* L.) was the most numerous species in the overstory with a relative density of 18 percent (fig. 1). Thirty-years later, the most numerous species present was yellow-poplar (*Liriodendron tulipifera* L.), which comprised 288 stems/ha (table 1). When there are seed sources present, yellow-poplar can be expected to comprise most of the reproduction after a clearcut (Merz and Boyce 1958). Rapid growth enables it to quickly capture growing space and outcompete a cohort of species (Beck and Hooper 1986, Loftis and others 2004).

The status of the oak component had changed dramatically from pre-harvest to post-harvest conditions. In 1973, oak species dominated the basal area in the stand (fig. 2). Thirty-years later, chestnut oak (*Quercus prinus* L.) is the only oak to have maintained its relative basal area. Shifts in oak density have also occurred. These changes include a decrease in the amount of white oak and black oak (*Quercus velutina* Lam.). However, both chestnut oak and northern red oak (*Quercus rubra* L.) have increased in stem density.

In addition to decreases in the oak-hickory component, increases in the mesic species component present in the 30-year post-harvest stand have been observed. All mesic species maintained or surpassed their pre-harvest absolute and relative densities and relative basal areas. The number of stems/ha of the mesic species also greatly increased compared to pre-harvest amounts. Several studies in uncut or partially cut forests have reported mesic species encroaching upon historically oak-dominated sites in Illinois due to low intensity or complete lack of disturbance (Fralish 1997, Fralish and others 1991, Groninger and others 2002, Ruffner and Groninger 2004, Zaczek and others 2002). This encroachment

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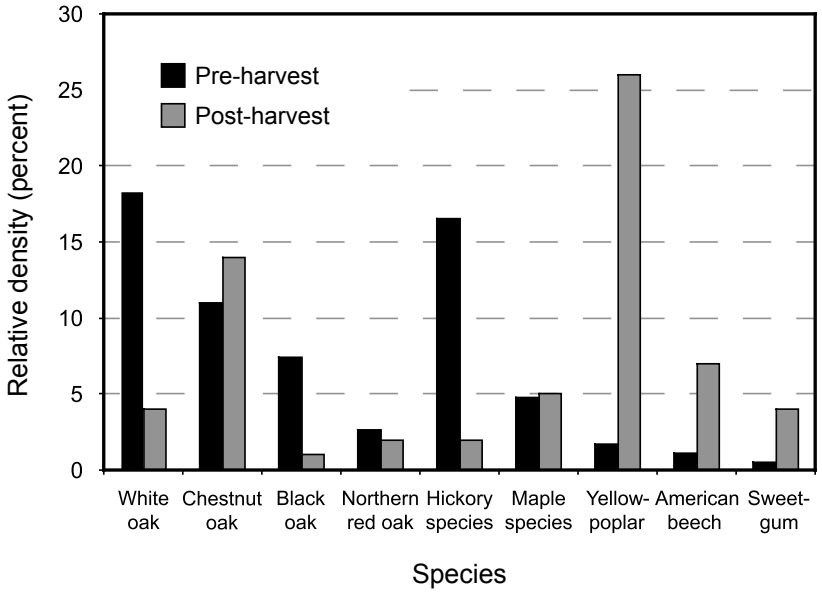

Figure 1—Relative density: pre-harvest stand versus 30-year post-harvest stand.

Table 1—Number of stems per hectare in the pre-harvest and 30-year post-harvest stand

Species	Pre-harvest	Post-harvest
White oak	82	43
Hickory spp.	74	20
Chestnut oak	49	161
Black oak	33	12
Maple spp.	22	59
Northern red oak	12	17
Yellow-poplar	8	288
American beech	5	78
Sweetgum	2	50

of mesic species has been attributed to the lack of fire as a disturbance in the ecosystem.

CONCLUSIONS

Chestnut oak was the only oak to maintain its pre-harvest density and basal area. The oak-hickory component that was present prior to harvest has diminished greatly. Mesic species present in the overstory have increased from pre-harvest conditions. This influx of mesic species will most likely continue with the absence of disturbance or management of the site. Cutting or herbicide injection of unwanted mesic species in the overstory followed by a prescribed burn would remove a large amount of seed sources as well as control established mesic stems in the understory.

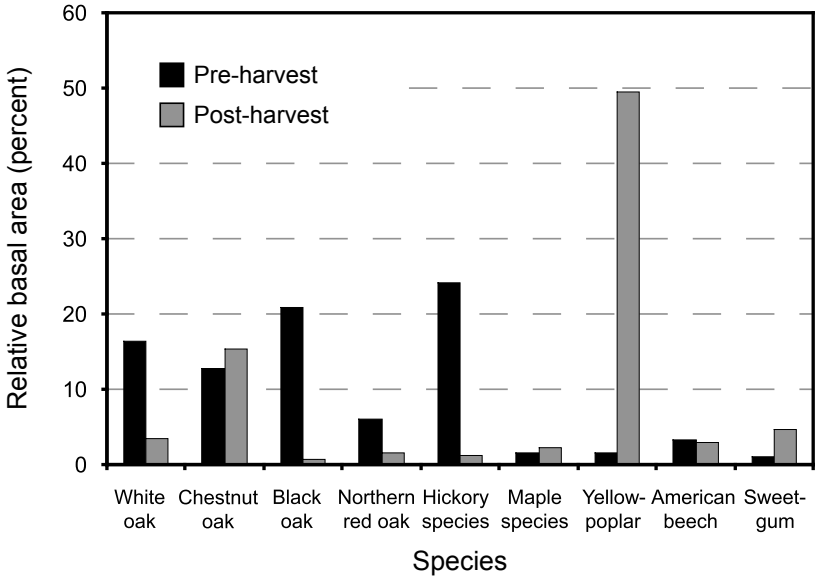

Figure 2—Relative basal area: pre-harvest stand versus 30-year post-harvest stand.

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LITERATURE CITED

Beck D.E.; Hooper, R.M. 1986. Development of a southern Appalachian hardwood stand after clearcutting. Southern Journal of Applied Forestry. 10: 168-172.

Fralish, J.S. 1997. Community succession, diversity, and disturbance in the central hardwood forest. Conservation in highly fragmented landscapes. New York, NY: Chapman and Hall: 234-266.

Fralish, J.S.; Crooks, F.B.; Chambers, J.L.; Harty, F.M. 1991. Comparison of presettlement, second-growth and old-growth forest on six site types in the Illinois Shawnee Hills. American Midland Naturalist. 125: 294-309.

Groninger, J.W.; Ozier, T.B.; Ruffner, C.M. 2002. Stand compositional dynamics in a mature Illinois Ozarks forest: implications for management. In: Van Sambeek, J.W.; Dawson, J.O.; Ponder, F., Jr. [and others], eds. Proceedings, 13th central hardwood forest conference. Gen. Tech. Rep. NC-234. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station: 296-302.

Larsen, D.R.; Johnson, P.S. 1998. Linking the ecology of natural oak regeneration to silviculture. Forest Ecology and Management. 106: 1-7.

Loftis, D.L.; McNab, W.H.; Berg, E.C.; Oprean, T.M. 2004. Lessons learned in 84-year-old plots at Looking-Glass Rock, North Carolina. RMRS-P-34. Fort Collins, CO: U.S. Department of Agriculture, Forest Service Proceedings: 235-241.

McGee, C.E.; Loftis, D.L. 1993. Oak regeneration: a summary. In: Loftis, D.; McGee, C.E., eds. Oak regeneration: serious problems, practical recommendations. Symposium proceedings. Gen. Tech. Rep. SE-84. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 316-319.

Merz, R.W.; Boyce, S.G. 1958. Reproduction of upland hardwoods in southeastern Ohio. Tech. Paper 155. Columbus, OH: U.S. Department of Agriculture. Forest Service, Central States Forest Experiment Station. 24 p.

Ruffner, C.M.; Groninger, J.W. 2004. Oak ecosystem restoration and maintenance in southern Illinois. In: Spetich, M.A., ed. Upland oak ecology symposium: history, current conditions, and sustainability. Gen. Tech. Rep. SRS-73. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 177-181.

Steinbeck, K.; Kuers, K. 1996. Development of pine-hardwood mixtures following clearcutting on two upland sites in the Georgia Piedmont: 10 year results. Southern Journal of Applied Forestry. 20(4): 203-208.

Thornbury, W.D. 1965. Regional geomorphology of the United States. New York: John Wiley and Sons, Inc. 609 p.

Weaver, G.T.; Robertson, P.A. 1981. Regrowth of *Quercus prinus* and associated tree species following regeneration harvesting in the Ozark Hills of Illinois. Bulletin of the Torrey Botanical Club. 108: 166-179.

Zaczek, J.J.; Groninger, J.W.; Van Sambeek, J.W. 2002. Stand dynamics in an old-growth hardwood forest in southern Illinois, U.S.A. Natural Areas Journal. 22: 211-219.