CROP TREE RELEASE INCREASES GROWTH OF RED OAK SAWTIMBER IN SOUTHERN NEW ENGLAND: 12-YEAR RESULTS

Jeffrey S. Ward[1]

Abstract.—In winter 1995, five crop tree thinning plots were established in central Connecticut. Stands were mature red oak sawtimber (74-94 years old) with no history of prior management. Crop trees were upper canopy red oaks (northern red, black, and scarlet) with a potential grade 1 or 2 butt log. Growth of crop trees was monitored for the next 12 years. Diameter, cubic-foot, and board-foot growth was increased by release on three or four sides (complete release). This increase was maintained for at least 12 years. Mean diameter growth 0-3 years after cutting was slightly greater, 18 percent, for completely released trees than for unreleased trees. For the 4-6, 7-9, and 10-12 year periods after cutting, diameter growth of completely released trees was greater than for unreleased trees: 47, 41, and 42 percent, respectively. Cubic-foot and board-foot growth were greater for completely released than unreleased trees. Annual volume growth (cubic-foot) increases ranged from 50 percent for trees with diameters 10.1-11.9 inches to 29 percent for trees larger than 16.0 inches. For sawtimber oak stands where maintaining high forest cover and noncommodity attributes are important considerations, crop tree management should be considered.

INTRODUCTION

The 28 million acres of sawtimber oak-hickory forest in the Northeast and North Central states (Smith and others 2004) have become economically valuable assets. Family forest owners control the majority of forest land in the northern United States (Butler and Leatherberry 2004). Many of these holdings, especially those less than 50 acres, are managed for noncommodity amenities such as aesthetics, privacy, and wildlife (Butler and Leatherberry 2004). Nevertheless, forest ownership incurs expenses such as real estate taxes, insurance, and protection. Family forest owners may consider forest management practices, such as crop tree management, that both retain the noncommodity amenities and provide a source of income.

The current public bias against even-aged management has resulted in an increased proportion of public and private forests being managed through partial cuts over longer rotations. Partial cuttings on private lands are all too often high-grading operations under the guise of "selective" harvesting (Nyland 1992). Improperly applied partial cutting can accelerate the conversion of oak stands to mixtures of maple, birch, and other species with lower commercial and wildlife values (Abrams and Scott 1989, Ward 2005). For larger public forests and smaller private parcels where even-aged management is not possible, crop tree management could provide a viable alternative management practice that maintains forest productivity.

Previous crop tree research has largely focused on release of saplings (Della-Bianca 1975, Lamson and Smith 1978, Ward 1995) or poles (Dale and Sonderman 1984, Mitchell and others 1988, Miller 2000, Schuler 2006). There have been few studies on releasing mature (>80-yr-old) oaks, in part because of an earlier perception that mature trees in unthinned stands do not respond to thinning (Sander 1977, Hibbs and Bentley 1983, Dale and Hilt 1989). More recent reports suggest that diameter growth of sawtimber oaks can be increased by high thinning without a loss of quality. Studies in Kentucky (Miller and Stringer

[1]Department of Forestry and Horticulture, Connecticut Agricultural Experiment Station, P.O. Box 1106, New Haven, CT 06504-1106: to contact, call (203)974-8495 or email at jeffrey.ward@po.state.ct.us

2004), West Virginia (Smith and others 1989), North Carolina (Beck 1987), and Arkansas (Graney 1998) have reported that diameter growth of sawtimber oak increases following crop tree release.

OBJECTIVES

The objective of this study was to determine if crop tree management would increase diameter and volume growth of mature oak sawtimber for at least 12 years. These results will provide information for foresters considering crop tree management in sawtimber oak stands where initiating regeneration harvests is not currently feasible. Crop tree management would maintain many of the noncommodity amenities desired by forest owners and simultaneously provide a source of revenue.

STUDY AREAS

Four crop tree plots (Bear Pole, China Pole, Bear Saw, Rocky Saw) were established on Northeast Utility Forest Management Lands in cooperation with Ferrucci and Walicki, LLC, in 1995. A fifth plot (Larkin Saw) was established on private land in 1995. All plots were in mature upland oak forests (74 to 94 years old) in central Connecticut that had not been previously thinned and were scheduled for timber stand improvement. Plots were fully stocked with pre-release basal area values that averaged 88 to 113 ft^2/acre for trees with diameters greater than 4 inches. The Bear Pole and China Pole plots were near ridge tops and had low site indices of 48-50. The other plots were on benches or flats and had site indices that ranged from 55-62. For crop trees, median initial diameter was 12.6 inches (range of 6.0-26.0 inches) and median initial height was 67 feet (range of 44 to 96 feet). Sawtimber trees had a median sawlog length of 35 feet with 157 board-feet (International ¼ rule). Additional details on initial plot and tree characteristics can be found in Ward (2002).

METHODS

Sixty crop trees were selected at each plot (300 trees total). Selection criteria for crop trees were codominant or dominant crown class, at least 17 ft to first fork, and a potential grade 1 or 2 butt log. Composition of crop trees was northern red oak (*Quercus rubra*) 59 percent, black oak (*Q. velutina*) 39 percent, and scarlet oak (*Q. coccinea*) 2 percent. Trees were systematically numbered and split into two groups: trees 1-30 and trees 31-60. Treatment (crop tree release) was randomly assigned to one group on each plot. Release was completed as part of a commercial thinning operation on all plots during 1995. Most of the remaining trees that competed with selected crop trees (crowns within 3 feet of crop tree crown) were either felled or girdled. Some competing trees not removed during thinning on the China Pole plot were girdled in early summer 1996.

Crop trees were banded at 4.5 feet and numbered with red paint. Diameters were recorded to the nearest 0.04 inches each year during the dormant season. The amount of release for each crop tree was assessed in 25-percent increments 1 year after plot establishment. Total height and pulp height (4-inch top) were recorded to the nearest foot for all trees. Sawlog height (9-inch top) was recorded to the nearest foot for all trees with a diameter greater than 10.5 inches.

Trees were split into five size classes by diameter for analysis: medium poles (<10.0 inches), large poles (10.0-11.9 inches), small sawtimber (12.0-13.9 inches), medium sawtimber (14.0-15.9 inches), and large sawtimber (>16.0 inches). Cubic-foot volumes were determined using formulas from Marquis (1977). Board-foot volumes (International ¼ rule) were calculated using Scrivani (1989) with form class 78. The Scrivani algorithm was modified for sawlog length. For each size class, the effect of treatment on annual

Table 1.—Annual diameter (inches), cubic-foot volume, and board-foot volume (International ¼ rule) growth of released and control crop trees in southern New England sawtimber oak stands. Crop trees were released during 1995

d.b.h.	Released		Control				
(inches)	Mean (SE)	N	Mean (SE)	N	F-ratio	df	Prob
			-------------Annual diameter growth (1995-2006)-------------				
<10.0	0.24 (0.02)	19	0.16 (0.02)	38	23.7	1	0.000
10.0 - 11.9	0.24 (0.01)	26	0.17 (0.01)	36	27.3	1	0.000
12.0 - 13.9	0.24 (0.01)	48	0.17 (0.01)	44	40.2	1	0.000
14.0 - 15.9	0.24 (0.01)	24	0.19 (0.02)	18	7.3	1	0.011
>16.0	0.29 (0.02)	19	0.23 (0.01)	23	13.5	1	0.001
			------------Annual cubic-foot growth (1995-2006)-------------				
<10.0	0.8 (0.08)	19	0.5 (0.08)	38	22.3	1	0.000
10.0 - 11.9	1.0 (0.06)	26	0.7 (0.06)	36	28.2	1	0.000
12.0 - 13.9	1.1 (0.04)	48	0.8 (0.04)	44	25.6	1	0.000
14.0 - 15.9	1.3 (0.09)	24	1.0 (0.10)	18	5.2	1	0.029
>16.0	2.1 (0.15)	19	1.6 (0.12)	23	8.4	1	0.006
			-------------Annual board-foot growth (1995-2006)------------				
<10.0	-	-	-	-	-	-	-
10.0 - 11.9	4.5 (0.41)	14	3.3 (0.39)	17	7.0	1	0.014
12.0 - 13.9	5.5 (0.23)	48	4.3 (0.24)	44	14.5	1	0.000
14.0 - 15.9	6.7 (0.48)	24	5.4 (0.57)	18	3.6	1	0.067
>16.0	11.3 (0.88)	19	8.8 (0.70)	23	7.4	1	0.010

diameter, cubic-foot, and board-foot growth was determined using a two-factor ANOVA (plot, treatment). Tukey's HSD test was used to test differences of tree growth among release levels. Differences were judged significant at $p < 0.05$.

RESULTS AND DISCUSSION

Diameter Growth after Release

Crop tree release increased diameter growth of oaks in all diameter classes examined (Table 1). Growth increases for the 12-year period ranged from 52 to 26 percent for trees with diameters less than 10.0 inches and 14.0-15.9 inches, respectively. During the 12-year period, diameter growth of completely released crop trees was 0.24 inches/year, compared with 0.17 inches/year for unreleased trees, a difference of nearly 0.07 inches/year. In other words, 13 years after treatment, completely released trees will gain an extra inch in diameter relative to unreleased trees. This growth is similar to the growth responses observed for 54-year-old red oaks in West Virginia (Lamson and others 1990), 61-year-old red oaks in Arkansas (Graney 1998), 75- to 80-year-old red oaks in West Virginia (Smith and others 1989, Smith and Miller 1991), and 70- to 75-year-old white oaks in Kentucky (Miller and Stringer 2004).

An earlier assessment of this study noted that there was a delay in growth response of previously unmanaged oaks to crop tree release (Ward 2002). Relative to unreleased controls, crop tree release increased diameter growth of sawtimber oaks by less than 20 percent for the first years after treatment (Fig. 1). Other studies have also reported a delayed growth response for sawtimber red oaks (Graney 1998,

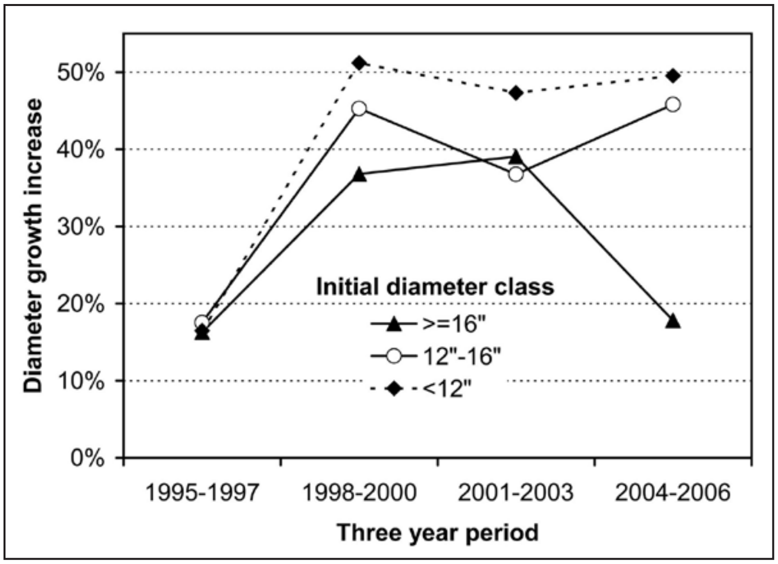

Figure 1.—Diameter growth (percent) of released (two or more sides) relative to control (not released) oak trees by initial diameter class for the first 12 years after treatment in southern New England.

Meadows 1998). However, diameter growth of 85-year-old oaks increased immediately after release in North Carolina (Beck 1987).

This study found no evidence that the growth of released crop trees, relative to control trees, had slowed 12 years after release, except for trees with initial diameters greater than 16 inches (Fig. 1). Diameter growth of released crop trees was greater than for unreleased trees during the subsequent three 3-year periods for trees smaller than 16 inches. Released trees grew 47 percent more than unreleased trees 4 to 6 years after release, 41 percent more 7 to 9 years after release, and 42 percent more 10 to 12 years after release. Extended periods (>10 years) of increased growth for sawtimber-sized oaks after release have been reported elsewhere (Sonderman 1984, Beck 1987, Graney 1998, Perkey and Onken 2000).

Degree of Release

Discounting growth during the first 3 years after release, when there was a minimal growth response (Fig. 1), the increase in diameter growth was directly related to the amount of release for trees released on two or more sides (Fig. 2). Diameter growth of trees released on one side was not significantly different from that of unreleased trees ($p > 0.99$). Releasing trees on two sides increased diameter growth during the

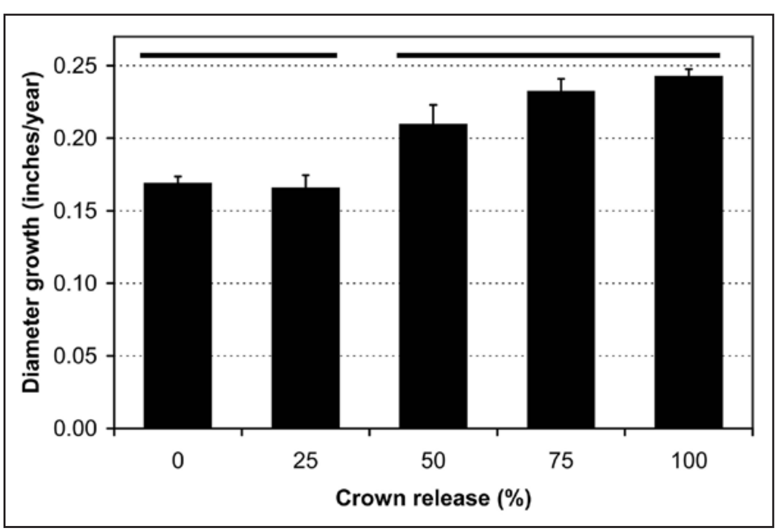

Figure 2.—Annual diameter growth (standard error) by amount of crown release in a sawtimber oak crop tree study in southern New England. Growth is for the period 4-12 years after initial treatment. Release levels linked by horizontal lines above bars were not found significantly different using Tukey's HSD test ($p < 0.05$).

fourth through sixth years after release by 25 percent relative to unreleased trees. Releasing trees on three sides increased diameter growth by another 15 percent, whereas complete release increased growth by an additional 16 percent.

Early studies reported diameter growth was not significantly increased by releasing only one side (Lamson and others 1990). Releasing red oaks on two or more sides did increase diameter growth relative to unreleased trees in other studies (Lamson and others 1990, Graney 1998, Perkey and Onken 2000). Similarly, release on two or more sides was required before there was an increase in diameter of black cherry (Smith and others 1994).

As noted in the earlier report (Ward 2002), only minimal growth response occurred when less than two sides were released (Lamson and others 1990, Smith and others 1994; Fig. 2). This may explain, in part, earlier recommendations not to thin mature sawtimber stands (Sander 1977, Hibbs and Bentley 1983, Dale and Hilt 1989). Most prior thinning studies in sawtimber stands were area-wide, low thinnings. Low thinning, with its emphasis on removing smaller trees, would not release residual sawtimber trees sufficiently (two or more sides) to initiate a positive growth response.

Volume Growth

It is important that any management alternative not sacrifice potential economic returns on forests that are actively managed for timber. For most diameter classes, cubic-foot and board-foot volume growth of completely released crop trees was higher than for unreleased trees (Table 1). For example, crop tree release increased volume growth of trees with diameters greater than 16 inches by 29 percent (Fig. 3).

Because several assumptions were made in estimating board-foot volume growth, estimates of volume change probably underestimated the true magnitude of the increases in economic value. First, it was assumed that sawlog height did not change. Second, no premium in price given for larger diameter logs (i.e., higher prices paid for higher grades were not factored into increased value). No increase in value was given to larger diameter trees because of regional and temporal vagrancies given for higher log grades.

There is little published information on volume growth of individual trees following crop tree release. However, thinning studies indicate that diameter growth of residual trees is maintained for at least 10 years (Sonderman 1984, Stringer and others 1988, Graney 1998). Stand volume growth was higher on thinned than control plots in West Virginia (Smith and Miller 1987). Initial gains in stand volume growth following complete release are maintained for at least 14-17 years (Ward 2005). After 32 years, black and scarlet oak volumes were higher on thinned than control plots (Dwyer and Lowell 1988).

CONCLUSIONS

This study found complete release of sawtimber red oak crop trees resulted in significant and sustained increases in diameter and volume growth (Table 1, Fig. 1). The combination of the positive growth response of crop trees and the aesthetic appeal of the residual stand (pers. obs.), suggests that crop tree management may be a potential introduction to forest management for forest owners who are hesitant to initiate harvesting, or for those for whom high forest cover and noncommodity attributes are primary considerations. The results indicate that the upper age limit at which red oaks respond to high thinning is at least 90 years and initiation of regeneration treatments can be delayed in some regions. Therefore, crop tree management could also be used on larger tracts where development of stands with a balanced age structure would require that the regeneration cuts in some stands be delayed past economic maturity.

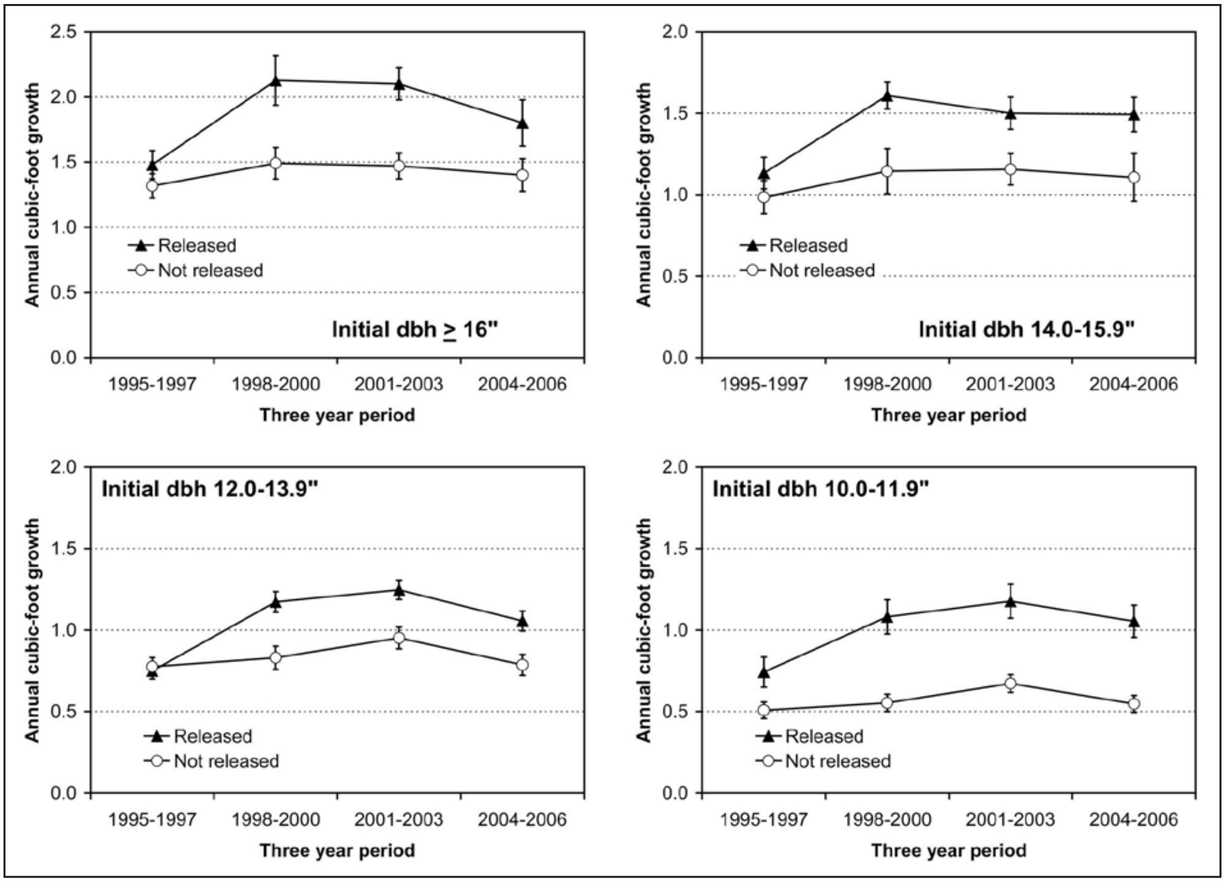

Figure 3.—Cubic-foot volume growth of released (two or more sides) relative to control (not released) oak trees by initial diameter class and 3-year intervals for the 12 years after treatment in southern New England.

ACKNOWLEDGMENTS

A special thanks to Northeast Utilities, Ferrucci and Walicki, LLC, and Dr. Charles Larkin, who donated the land, materials, and personnel that made this research possible. J.P. Barsky assisted with the data collection and plot maintenance. This research was partly funded by McIntire-Stennis Project CONH-554.

LITERATURE CITED

Abrams, M.D.; Scott, M.L. 1989. **Disturbance-mediated accelerated succession in two Michigan forest types**. Forest Science. 35: 42-49.

Beck, D.E. 1987. **Management options for southern Appalachian hardwoods: the two-aged stand.** In: Phillips, Douglas R., comp. Proceedings of the Fourth biennial southern silvicultural research conference; 1996 Nov. 4-6; Atlanta, GA. Gen. Tech. Rep. SE-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 451-454.

Butler, B.J.; Leatherberry, E.C. 2004. **America's family forest owners.** Journal of Forestry. 102(7): 4-9.

Dale, M.E.; Hilt, D.E. 1989. **Estimating oak growth and yield.** In: Clark, F.B.; Hutchinson, J.G., eds. Central Hardwood notes. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station: 5.03-1-5.03-6

Dale, M.E.; Sonderman, D.L. 1984. **Effect of thinning on growth and potential quality of young white oak crop trees.** Res. Pap. NE-539. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiement Station. 12 p.

Della-Bianca, L. 1975. **An intensive cleaning of mixed hardwood saplings - 10-year results from the southern Appalachians.** Journal of Forestry. 73: 25-28.

Dwyer, J.P.; Lowell, K.E. 1988. **Long-term effects of thinning and pruning on the quality, quantity, and value of oak lumber.** Northern Journal of Applied Forestry. 5: 258-260.

Graney, D.L. 1998. **Ten-year growth response of red and white oak crop trees to intensity of crown release.** In: Waldrop, T. A., ed. Proceedings of the ninth biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-20. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 163-168.

Hibbs, D.E.; Bentley, W.R. 1983. **A management guide for oak in New England.** Storrs, CT: Connecticut Cooperative Extension Service. 12 p.

Lamson, N.I.; Smith, H.C. 1978. **Response to crop-tree release: sugar maple, red oak, black cherry, and yellow-poplar saplings in a 9-year-old stand.** Res. Pap. NE-394. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Experiment Station. 8 p.

Lamson, N.I.; Smith, H.C.; Perkey, A.W.; Brock, S.M. 1990. **Crown release increases growth of crop trees.** Res. Pap. NE-635. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Experiment Station 8 p.

Marquis, D.A. 1977. **Volume tables for Allegheny hardwoods.** U.S. Department of Agriculture, Forest Service. (unpublished progress report). In NED-1.

Meadows, J.S. 1998. **Growth and epicormic branching of residual trees following deferment cutting in red oak-sweetgum stands.** In: Waldrop, T. A., ed. Proceedings of the ninth biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-20. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 148-153.

Miller, G.W. 2000. **Effect of crown growing space on the development of young hardwood crop trees.** Northern Journal of Applied Forestry. 17: 25-35.

Miller, G.W.; Stringer, J.K. 2004. **Effect of crown release on tree grade and dbh growth of white oak sawtimber in eastern Kentucky.** In: Yaussy, D.A.; Hix, D.M.; Long, R.P.; Goebel, P.C., eds. Proceedings. 14th central hardwood forest conference; 2004 March 16-19; Wooster, OH. Gen. Tech. Rep. NE-316. Newtown Square, PA: U.S. Department of Agriculture. Forest Service. Northeastern Research Station: 37-44. [CD-ROM].

Mitchell, R.J.; Dwyer, J.P.; Musbach, R.A.; Garrett, H.E.; Cox, G.S.; Kurtz, W.B. 1988. **Crop tree release of a scarlet-black oak stand.** Northern Journal of Applied Forestry. 5: 96-99.

Nyland, R.D. 1992. **Exploitation and greed in eastern hardwood forests.** Journal of Forestry. 90(1): 33-37.

Perkey, A.W. and A. Onken. 2000. **A decade at a crop tree demonstration area.** U.S. Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry, Forest Management Update 20: 1-13.

Sander, I.L. 1977. **Manager's handbook for oaks in the north central states.** Gen. Tech. Rep. NC-37. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 35 p.

Schuler, T.M. 2006. **Crop tree release improves competitiveness of northern red oak growing in association with black cherry.** Northern Journal of Applied Forestry. 23(2): 77-82.

Scrivani, J.A. 1989. **An algorithm for generating "exact" Girard form class volume table values.** Northern Journal of Applied Forestry. 6: 140-142.

Smith, H.C.; Lamson, N.I.; Miller, G.W. 1989. **An esthetic alternative to clearcutting?** Journal of Forestry. 87(3): 14-18.

Smith, H.C.; Miller, G.W.; Lamson, N.I. 1994. **Crop-tree release thinning in 65-year-old commercial cherry-maple stands (5-year results).** Res. Pap. NE-694. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 11 p.

Smith, H.C.; Miller, G.W. 1987. **Managing Appalachian hardwood stands using four regeneration practices--34-year results.** Northern Journal of Applied Forestry. 4: 180-185.

Smith, H.C.; Miller G.W. 1991. **Releasing 75- to 80-year-old Appalachian sawtimber trees: 5-year d.b.h. response.** In: McCormick, L.H.; Gottschalk, K.W., eds. Proceedings, 8th central hardwood forest conference; 1991 March 4-6; University Park, PA : Gen. Tech. Rep. NE-148. Radnor, PA: U. S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 403-413.

Smith, W.B.; P.D. Miles; J.S. Vissage; Pugh, S.A. 2004. **Forest resources of the United States, 2002.** Gen. Tech. Rep. NC-241. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 137 p.

Sonderman, D.L. 1984. **Quality response of even-aged 80-year-old white oak trees after thinning.** Res. Pap. NE-543. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Stringer, J.W.; Miller, G.W.; Wittwer, R.F. 1988. **Applying a crop-tree release in small-sawtimber white oak stands.** Research Paper NE-620. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

Ward, J.S. 1995. **Intensity of precommercial crop tree release increases diameter and crown growth in upland hardwoods.** In: Gottschalk, K.W.; Fosbroke, S.L.C., eds. Proceedings, 10th central hardwood forest conference; 1995 March 5-8; Morgantown, WV. Gen. Tech. Rep. NE-197. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 388-398.

Ward, J.S. 2002. **Crop tree release increases growth of mature red oak sawtimber.** Northern Journal of Applied Forestry. 19(4): 149-154.

Ward, J.S. 2005. **Influence of cutting method on stand growth in sawtimber oak stands.** Northern Journal of Applied Forestry. 22(1): 59-67.