INFLUENCE OF CUTTING METHODS ON 12-YEAR-OLD HARDWOOD REGENERATION IN CONNECTICUT

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Abstract—Many upland oak forests are approaching economic and biological maturity. This has led to concern over species composition following stand regeneration. A case study of hardwood regeneration was established in 1984 in central Connecticut to study the effects of cutting method on regeneration composition. The six harvest treatment plots (4-6 acres) were on medium quality sites (SI=60). Harvest treatments were: shelterwood, diameter limit, coppice with standards, commercial clearcut, silvicultural clearcut, and uncut control. Regeneration was sampled by species and height class prior to harvest, and 5 and 12 years post-harvest using 16-28 1/300 acre plots per treatment.

Preharvest inventories found fewer than 50 oaks/acre ≥ 5 feet tall, much less than the 433/ac recommended for the western branch of the Central Hardwood region. However, oak regeneration accounted for 13 percent (150 oak/acre) of codominant and dominant trees 12 years after harvest on the silvicultural clearcut plot. This strongly suggests that there should be regional standards for evaluating oak regeneration. All treatments, except diameter limit, increased regeneration density. Shelterwood, but not other partial cuts, increased the number of oaks ≥ 5 feet tall. Five years after the shelterwood cut red maple and black birch densities had also increased by 88 percent and 1500 percent, respectively. Clearly, this will increase the competition oaks experience following final harvest. Partial cutting should not be prescribed when management goals include obtaining oak regeneration in future stands.

INTRODUCTION

There are 14 million acres of mature oak forest in the Northeast, and 14 million in the North Central states (Powell and others 1993). The present forest is a mixture of land continuously forested, but repeatedly cut, and land abandoned from agriculture during the 19th or 20th centuries. Many forests were established early in the 20th century following harvests for fuelwood and charcoal production. In Connecticut, sawtimber stand area has increased from 17 percent of the 1.8 million acres of commercial forest land in 1952 to 63 percent in 1985 (Dickson and McAfee 1988). Seedling and sapling stands account for only 10 percent of forested area. The unbalanced age class and economic maturity of the forest, combined with favorable stumpage prices, have recently led to increased harvest and regeneration activity.

As many forests are approaching biological maturity, concern over forest regeneration has increased. Commercially less valuable red maple (*Acer rubrum*) and birch (*Betula lenta* and *B. alleghaniensis*) now account for half of all stems in the sapling size class in Connecticut (Dickson and McAfee 1988). The lack of adequate oak regeneration is a well-recognized problem and challenge for foresters throughout the oak-hickory region (Holt and Fischer 1979, Lorimer 1989, Loftis and McGee 1993). Nearly two-thirds of the pole and sawtimber stands in Connecticut are classified as oak-hickory (Dickson and McAfee 1988). Even-aged systems are recommended for regenerating oak forests, except on low quality sites (Roach and Gingrich 1968, Sander 1977, Hibbs and Bentley 1983, Johnson 1993). There is a consensus that oak regeneration should be present before final harvest in mature stand if the succeeding stand is to contain abundant oak. However, the minimum size and amount of oak advance regeneration (seedlings and saplings established before final overstory removal), and ability of various cutting methods to provide the regeneration, varies among studies. Prescriptions or guidelines for regenerating oak are largely derived from research in the western portion of the central hardwood forest. Their applicability to the eastern branch of the central hardwood forest, specifically southern New England, remains untested.

This research was established to provide information on hardwood regeneration in the eastern section of the central hardwood forest. The general objectives of this research are: 1) determine whether the minimum size requirements for oak regeneration developed in the Midwest are too stringent for southern New England, and 2) determine the effect of different treatments (i.e., cutting methods) on regeneration composition by species group. The specific objective of this paper was to examine how regeneration differed among treatments 12-years after cutting.

METHODS

Research plots were established in 1984 in North Madison, Connecticut to examine the effect of various cutting methods on hardwood regeneration, especially oak. Six cutting method plots (4-6 acres each) were established on medium quality sites. Cutting methods were silvicultural clearcut, commercial clearcut, coppice with standards,

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diameter limit, shelterwood, and uncut control. These results should be treated as a case study due to the lack of replication. Specific treatment guidelines were:

Silvicultural clearcut—All residual trees > 2 inches dbh were cut after sawtimber and cordwood harvests;

Commercial clearcut—All merchantable trees ≥ 11 inches dbh were harvested;

Coppice with standards—Approximately 55 "crop trees" per acre were selected from among desirable poles and sawtimber. All other trees ≥ 5 inches dbh were harvested. At 10 to 15-yr intervals 5 crop trees per acre will be harvested and 5 new crop trees will be selected;

Diameter limit—the diameter limit was 16 inches for desirable species (oaks, ash, sugar maple) and 14 inches dbh for other species and low quality desirable species;

Shelterwood—stands were marked to remove 50 percent of basal area and 50 percent of upper canopy (dominant and codominant trees) by removing undesirable species and favoring retention of oak; and

Control—No cutting

The coppice with standards treatment was the first step of converting a relatively, even-aged stand into a multi-aged stand. Therefore, we selected crop tree by diameter classes rather than by age. With time we hope to convert this stand to a traditional coppice with standards stand. The coppice with standards is designed to favor selected crop trees for the production of high value timber or veneer logs while periodically removing all other merchantable material at regular intervals. This system, originally developed in Europe to provide fuel and waddle for tenant farmers and timber for estate owners, may be useful for small accessible tracts were a market for fuelwood exists. About 40-50 standards, potential crop trees, are selected on each acre from existing pole and sawtimber. Preference is given to desirable species, single stems, and excellent form. Eight to ten new standards are selected 10-20 year intervals. Then one fifth of crop trees are harvested along with all other stems larger than 5 inches dbh. Harvesting intervals are flexible to accommodate market conditions and growth.

Poles (4.5-10.5 inches dbh) and sawtimber (> 10.5 inches dbh) were inventoried prior to harvest using 4-7 prism plots (10 factor) per treatment. Prism point centers were randomly placed and then permanently marked using treated stakes. The following data were recorded for all trees ≥ 4.5 inches dbh: species, diameter, and crown class. For this paper, regeneration is defined as stems < 4.5 inches dbh. Regeneration was sampled prior to harvest, and 5 and 12 years post-harvest using 4 1/300 acre plots per each prism point, each 33 ft from the prism plot center in a cardinal direction (16-28 plots/treatment). Regeneration plot centers were also permanently located using treated stakes. For each inventory the following data were recorded for all stems: species, height (<1 ft, 1-1.9 ft, … 8-8.9 ft, ≥ 9 ft), and crown class. All regeneration, including 1-year-old seedlings, was tallied.

To simplify analysis and discussion, the 26 species found on the plots were collapsed into 5 species groups: Oak—*Quercus alba, Quercus coccinea, Quercus prinus, Quercus rubra, Quercus velutina*; Maple—*Acer rubrum, Acer saccharum*; Birch—*Betula alleghaniensis, Betula lenta*; Other—*Carya cordiformis, Carya glabra, Carya tomentosa, Fagus grandifolia, Fraxinus americana, Juglans cinerea, Liriodendron tulipifera, Nyssa sylvatica, Prunus serotina, Sassafras albidum*; and Minor—*Amelanchier arborea, Betula populifolia, Carpinus caroliniana, Castanea dentata, Cornus florida, Juniperus virginiana, Ostrya virginiana*.

RESULTS AND DISCUSSION

Prior to harvest, seedling density (< 5 feet tall) was high on all treatments, 15-29,000/acre (Table 1). Maple and oak were found on nearly every regeneration sample plot, 99 and 96 percent respectively. Birch was found on only 58 percent of the 1/300 acre plots. Maple dominated the seedling size class with an average of nearly 10,000/acre. Oak seedlings were quite numerous, 4,700/acre. Although oak seedling densities were high, there were few oak saplings (≥ 5 feet tall, Table 2). Only 25 of the 144 plots (17 percent) had an oak sapling. This is far below the 60 percent stocking recommended by Sander (1977). It should be noted our estimate of stocking was optimistic because

Table 1—Density (stems/acre) of seedlings (< 5 feet tall) prior to harvest by cutting method and species group in North Madison, CT

	Oak	Maple	Birch	Other	Minor	Total
Silvicultural clearcut	4489	9707	1093	3139	1693	20121
Shelterwood	2368	16404	2604	6000	1757	29132
Diameter limit	3814	13939	868	3171	1232	23025
Commercial clearcut	6840	7920	1185	1200	1245	18390
Coppice with standards	6638	3694	844	3319	300	14794
Uncut	4100	6663	4963	4325	675	20725
Mean	4700	9721	1926	3526	1150	21031

Table 2—Density (stems/acre) of saplings (≥ 5 feet tall) prior to harvest by cutting method and species group in North Madison, CT

	Oak	Maple	Birch	Other	Minor	Total
Silvicultural clearcut	11	311	129	107	418	975
Shelterwood	0	107	43	32	171	354
Diameter limit	11	300	11	129	214	664
Commercial clearcut	105	180	165	30	195	675
Coppice with standards	113	131	150	19	94	506
Uncut	13	250	163	113	225	763

we used a larger sampling plot (1/300 acre) than indicated by Sander (1/735 acre) and we assumed that 100 percent of pole and sawtimber oaks would resprout.

Five years after harvest, distinct differences had developed among the cutting methods (Table 3). Overall sapling (≥ 5 feet tall) and oak sapling density was higher on treatments that removed pole sized material, i.e., shelterwood and silvicultural clearcut. Oak sapling density increased on both the shelterwood and silvicultural clearcut plots, but decreased on the diameter limit, commercial clearcut, and coppice with standards plots. There was a much greater concurrent increase in maple and minor species density on the silvicultural clearcut and birch and minor species on the shelterwood plot. Sapling density had actually decreased on the other plots.

A clearer picture had emerged 12 years after cutting (Table 4). Oak sapling density remained high on the silvicultural clearcut plot after canopy closure. Although oak only accounted for 13 percent of upper canopy stems (Table 5), the 150 oaks/acre in the codominant and dominant crown class should be more than adequate to meet management goals. The mystery is where did the other upper canopy oaks come from? Only 2 of the 7 plots with an oak in the upper canopy at age 12 had had an oak at least 5 feet tall prior to the harvest. Three of the other 5 plots did have an oak 2-5 ft tall. On the remaining 2 plots, all oak regeneration was less than one foot tall prior to harvest.

Table 3—Density (stems/acre) of saplings (≥ 5 feet tall) 5 years after harvest by cutting method and species group in North Madison, CT

	Oak	Maple	Birch	Other	Minor	Total
Silvicultural clearcut	257	1296	171	300	1050	3075
Shelterwood	96	236	589	43	600	1564
Diameter limit	21	214	0	107	225	568
Commercial clearcut	90	105	105	30	255	585
Coppice with standards	19	75	113	0	19	225
Uncut	13	263	163	75	163	675

Table 4—Density (stems/acre) of saplings (≥ 5 feet tall) 12 years after harvest by cutting method and species group in North Madison, CT

	Oak	Maple	Birch	Other	Minor	Total
Silvicultural clearcut	889	804	450	900	1468	4511
Shelterwood	86	268	1511	107	696	2668
Diameter limit	21	257	461	129	268	1136
Commercial clearcut	105	60	195	60	285	705
Coppice with standards	19	19	56	0	19	113
Uncut	0	188	150	38	288	663

Table 5—Density (stems/acre) 12 years after a silvicultural clearcut by crown class and species group in North Madison, CT

	Oak	Maple	Birch	Other	Minor	Total
Dominant/codominant	150	332	107	193	386	1168
Intermediate	171	161	75	107	343	857
Suppressed (≥ 5 ft tall)	568	311	268	600	739	2486
Suppressed (1-4 ft tall)	461	54	96	793	193	1596
Suppressed (< 1 ft tall)	1018	568	32	1500	2057	5175

Thus, it appears that minimum size standards to obtain oak in the upper canopy at crown closure in the Northeast may be smaller than for the central (Sander 1977) and southeastern states (Loftis 1990).

The initial gain in oak sapling density on the shelterwood plot was not lost, but was being overwhelmed by a three-fold increase in birch sapling density through 12 years after cutting (Table 4). Shelterwood success has been spotty in other studies (Sander and Graney 1993), especially where deer herds are large (Smith 1993). Recommendations for regenerating oak involve two or three shelterwood cuts extended over a 10-30 year period (Hibbs and Bentley 1983, Martin and Hix 1988, Loftis 1993). Small diameter maple and birch readily sprout after cutting and respond well to release (Ward and Stephens 1993, 1996). Therefore, it is likely that shelterwood cuts extended over a long period will increase the proportion of birch and maple in the next stand.

This case study provides strong evidence that a new standard should be developed for evaluating oak regeneration in the Northeast. Furthermore, when increasing oak regeneration is part of the management objectives, partial cutting from above (cutting the largest trees) is counter-productive. Care should also be taken to not delay overstory removal with partial cutting from below. Assuming the relative competitive status is correlated with height; a long interval between the initial cut and the final harvest increases the competitive status of maple and birch relative to oak.

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