STUMP SPROUTING OF NORTHERN PIN OAK ON NUTRIENT-POOR SANDY SOILS IN CENTRAL WISCONSIN

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Abstract.—Coppice with two to three reserve trees per acre is the generally accepted practice (GAP) for rotating oak stands on nutrient-poor, sandy sites (colloquially called "scrub oak sites") in Wisconsin. The future stocking of the stand is therefore dependent predominantly on stump sprouts with varying levels of contribution from advance regeneration. Two groups of sites (four cut in 1998 and four cut in 2006) were measured to examine the success of the stump sprouts. On the sites harvested in 2006, more than 85 percent of stumps had sprouted during the first year after harvest (Mujuri and Demchik 2009). By 2010, 74 percent of those sprouts were at least 6 ft tall. On the sites harvested in 1998, 90 percent of regeneration plots sampled had at least one desirable timber species with 85 percent of the plots containing at least one viable oak seedling/sapling and 41 percent of these plots containing an oak at least 10 ft tall. The average sprout height measured across all sites was 24 ft. Although there was some variability between sites, the GAP of coppice with reserve trees does seem to be effective at regenerating scrub oak sites.

INTRODUCTION

In central Wisconsin, low quality oak stands, colloquially called "scrub oak," represent one of the largest cover types. This cover type is predominantly present on nutrient-poor sites consisting of sandy soils. The most common overstory species are northern pin oak (*Quercus ellipsoidalis*) and black oak (*Q. velutina*), although the more shade-intolerant quaking aspen (*Populus tremuloides*) and moderately tolerant red maple (*Acer rubrum*) are frequently found as well. Longer-lived species such as white pine (*Pinus strobus*), bur oak (*Q. macrocarpa*), and white oak (*Q. alba*) are also common associates. Scrub oak sites have lower productivity because the soils are nutrient poor and sandy. They may have site indices (base age of 50 years) as low as 35 to 50 ft. In comparison, a more mesic site might have a site index of greater than 60 ft.

Site managers can rely on the natural accumulation of advance regeneration as well as stump sprouts on scrub oak sites for regeneration after harvest. Stump sprouting can be a very dependable form of regeneration on drier sites, where it has a greater competitive advantage due to an extensive root system (Johnson et al. 2002). A larger root mass will also have a greater carbohydrate reserve (Johnson et al. 2002), which can directly influence stump sprouting ability and success (Tredici 2001). Many abiotic and biotic factors, such as moisture stress or defoliation by pests, can affect this carbohydrate reserve (Staley 1965, Thomas et al. 2002). Both of these studies concluded that a depletion of carbohydrate reserves was the primary cause for oak decline. Oak decline has shown to similarly reduce the overall sprouting rate of arboreal species (Tredici 2001).

The typical silvicultural generally accepted practice (GAP) for scrub oak sites is a coppice cut with 2 to 3 reserve trees per acre (Wisconsin Department of Natural Resources [DNR] 2006). A coppice cut

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is an overstory removal in which the primary form of regeneration and recruitment of trees into the overstory is asexual reproduction via stump or root sprouting with varying levels of contribution from advance regeneration. Oaks have a very high stump sprouting potential (Lynch and Bassett 1987, Mujuri and Demchik 2009, Weigel and Johnson 1998, Weigel and Peng 2002) and are very well suited for this type of harvest.

A wide variety of environmental factors affects oak regeneration although the two factors that seem to be the most limiting are water and light availability (Abrams 1988, Crow 1988, Johnson et al. 2002, Lorimer et al. 1994). Biological factors such as deer prevalence and competition from other species can also present a large hurdle to the predictable regeneration of an oak stand (Buckley et al. 1998, Chadwell and Buckley 2003, Crow 1988, Lorimer et al. 1994, Russell et al. 2001, Sander et al. 1984, Steiner et al. 2007).

Overall, regenerating oak on scrub oak sites seems to have a much higher degree of predictability. On these dry, nutrient-poor sites, oaks have a competitive advantage due to their moderate shade tolerance (Larsen and Johnson 1998) and good drought tolerance. Oaks can tolerate drought because of the large tap root that establishes early in the life of the seedling (Johnson et al. 2002). This tap root allows oaks to avoid the moisture stress experienced by other less adapted species (Chadwell and Buckley 2003). Another competitive advantage of this genus is that many species are vigorous stump-sprouters, even at maturity (Johnson et al. 2002).

Seed production and establishment is highly variable within oak and is subject to high levels of seed predation. For example, in a bumper crop year as much as 90 percent of the acorns may be rendered unviable by predation from mammals, insects, or other pests (Johnson et al. 2002). Stump sprouting allows for rapid growth with a high probability that the site will return to a largely oak-dominated overstory (Sander et al. 1984). Extensive studies have been conducted in Michigan (Lynch and Bassett 1987), Indiana (Weigel and Johnson 1998, Weigel and Peng 2002), and Wisconsin (Mujuri and Demchik 2009). These studies agree that even though sprouting decreases with age, coppicing dry sites is a viable regeneration method for the retention of oaks.

Mujuri and Demchik (2009) studied the stump sprouting success of northern pin oak in central Wisconsin on scrub oak sites. Initial data for our study were derived from their study. Mujuri and Demchik (2009) collected data in summer 2007 examining the percentage of stumps (in 1-inch diameter classes) that had sprouted the first season after harvest. Like Weigel and Johnson (1998) and Weigel and Peng (2002), they found a direct negative correlation between stump diameter and percentage of stumps sprouted. Mujuri and Demchik (2009) found that for stumps less than 4 inches in diameter the sprouting rate was almost 100 percent. The sprouting percentage decreased significantly as stump diameter increased, but for stumps greater than 18 inches in diameter the rate was still 71.4 percent.

For this study, data collection occurred during summer 2010, which provided a glimpse of stump sprout growth and success through time. For the purpose of this study, success was defined as having the dominant sprout reaching at least 6 ft tall, which was assumed to be beyond the height of heavy deer browsing of the terminal buds.

STUDY AREAS

Four sites previously studied for stump sprouting frequency of northern pin oak (Mujuri and Demchik 2009) were selected to provide the initial sprouting success data for this study. Two sites were in the Meadow Valley State Wildlife Area (average deer density of 27 deer per square mile the first 4 years after harvest) in Monroe County, and two sites were in the Sandhill State Wildlife Area (16 to 25 deer per square mile, 2007 to 2009). Both wildlife areas are managed by the Wisconsin DNR. These sites were harvested during winter 2006 to 2007 and were sampled in summer 2007 to assess the frequency of northern pin oak stump sprouting in relation to stump diameter and again in summer 2010 to assess the height growth of stump sprouts. Both sites are primarily northern pin, black, and white oak, with several scattered red (*Pinus resinosa*) and white pine per acre.

Both Meadow Valley and Sandhill State Wildlife Areas are characterized by dry, sandy soils formed on level sand plains. The dominant habitat types are *Pinus strobus*/*Euphorbia corollata* and *Pinus*/*Vaccinium-Gaultheria* (Kotar and Burger 1996). These two habitat types are very similar with the only difference being that the latter one often has a slightly higher water table and may be slightly less nutrient deficient.

Four additional sites, harvested in 1998, were selected in cooperation with the DNR (average deer density of 39 deer per square mile the first 5 years after harvest). These sites were not classified by habitat type but qualified as scrub oak sites on nutrient-poor, sandy soils. All four sites were located on privately owned land in Waushara County and ranged from 5 to 18 acres in size. Harvesting was done in winter according to standard Wisconsin DNR GAP for scrub oak, which is a coppice with two to three reserve trees per acre (Arend and Scholz 1969). These sites serve to add a temporal context to this study and examine the efficacy of regenerating oak using the harvesting system typical on scrub oak sites.

METHODS

Field Methods

Parallel transects were run across the longest axis of each site harvested in 2006. Any northern pin oak stump falling within 5 ft of the transect was measured for diameter, height of dominant sprout (measured in 1-ft height classes), and average percent browse of all sprouts by four levels (0-25% , 26-50%, 51-75%, and 76-100%). On each site 100 stumps were recorded along these transects. Height was measured using a graduated height pole constructed from polyvinyl chloride and marked in 1-ft increments.

More extensive sampling was conducted on the 12-year-old sites to assess regeneration from stump sprouts as well as advance regeneration. Preharvest data were provided by the DNR for seedling regeneration. In summer 2010 parallel transects were run across the longest axis of each site to measure 25 stumps, twenty 0.0014-acre regeneration plots (located every 66 ft along the transect), and all trees within 5 ft of the transect greater than 2 inches in diameter at breast height. These data were intended to be pilot data, but after preliminary data analysis the sites were determined to be relatively homogenous and variation was low enough that more sampling was not required.

Data Analysis

Descriptive statistics were conducted to determine the rate of success in reaching a height of at least 6 ft. These tests were performed in Microsoft Office Excel™ (Microsoft, Redmond, WA). Regression was also performed to determine if the height of the dominant sprout could be estimated using the outside bark diameter of the stump. The regression analysis was conducted using Minitab® 15.1.1 (Minitab, Inc., State College, PA) statistical software. Correlation between level of deer browsing and height of the dominant sprout was also analyzed.

The 12-year-old sites were analyzed to see if they meet the requirements for adequate stocking based on DNR standards (Wisconsin DNR 2006). According to these standards, at least 59 percent of the plots surveyed must be stocked with a viable seedling/sapling of a desired species. For the purposes of this study the following species were deemed desirable: any oak or maple, green (*Fraxinus pensylvanica*) or white ash (*F. americana*), and white or red pine. If this condition was not satisfied, the stump sprouts were then examined to determine if they would fill the gap that was left by inadequate advance regeneration from seed and seedling sprouts.

RESULTS

All sites were measured during summer 2010. On the sites harvested in 2006, 74.5 percent of the sprouts were at least 6 ft; the average height of the dominant sprout across all sites was 7.8 ft. The average stump diameter was 8.3 inches (Table 1). The percentage of stump sprouts in each browse category was highly variable within and across all sites (Table 2). With the alpha level set at 0.05, there was a significant correlation ($p > 0.001$) between stump diameter and height of the dominant sprout ($r = 0.299$). There was also a significant correlation ($p = 0.019$) between deer browsing and height of the dominant sprout.

On the sites harvested in 1998, 88.8 percent of plots were stocked with a desirable species; 85 percent of these plots were stocked with at least one viable oak seedling/sapling. Of those stocked with oak, 41 percent were stocked with an oak greater than 10 ft tall. The average height of stump sprouts measured was 24 ft (Table 3).

Stump Sprouting

Stump sprouts are a very effective tool for regenerating oak on nutrient-poor, sandy sites. They have the ability to quickly regenerate a site. In only four growing seasons roughly 75 percent of stump sprouts on these sites were able to achieve a height greater than the effective deer browse line. The data from the sites harvested in 1998 also demonstrate the rapid growth rates of these stump sprouts as they were able to achieve an average height of 24 ft in only 12 growing seasons. This height is beyond the predicted height based on site index curves assuming a base age of 50 and a site index between 40 and 50 ft, which is typical on these dry nutrient-poor sites (Carmean 1972).

A positive correlation was seen between the outside bark diameter of the stump and the height of the dominant sprout. The greater root mass of a larger stump would be able to gather more water and nutrients than a smaller stump and would also contain a greater store of carbohydrates. Although the r^2 was significant ($p > 0.001$), it was too low to allow for accurate prediction of sprout height from stump diameter. There are simply too many other variables that can affect height growth. If more

Table 1.—Average values of percentage of sprouts >6 inches, dominant sprout height, and stump outside bark diameter by site, Meadow Valley (MV) and Sandhill (SH) State Wildlife Areas

Site*	Sprouts >6 inches (%)	Avg. Sprout Ht. (ft)	Avg. Stump OB Diameter (in)
MV 826	80	9	9.8
MV 855	78	7	9.2
SH 105	66	8	5.9
SH 112	74	7	8.2
Average	75	8	8.3

*Site names used are Wisconsin DNR stand designations.

Table 2.—Stump sprouts (%) found in each browse category by individual site, Meadow Valley (MV) and Sandhill (SH) State Wildlife Areas

	Site			
Browse Category	MV826	MV855	SH105	SH112
0 - 25 %	23	72	12	74
25 - 50 %	49	22	37	23
50 - 75 %	18	5	38	3
75 - 100 %	10	1	13	0

*Site names used are Wisconsin DNR stand designations

Table 3. —Plots stocked with desirable species, plots stocked with oak, and plots with oak >10 ft (average percentages), and average stump sprout height, Waushara County sites

Site	Plots stocked with desirable species (%)	Plots stocked with oak (%)	Plots with oak >10 ft (%)	Average stump sprout height (ft)
1	95	90	75	25
2	90	95	50	20
3	70	55	10	26
4	100	100	30	24
Average	89	85	41	24

variables were to be entered into the equation, such as soils (moisture and texture), light availability, stresses, pests, or competing vegetation, an equation could possibly be developed to predict the growth of the dominant sprout more accurately.

Seedling Regeneration

Stump sprouts may provide for quick restocking of oak, but they are not the only contributor. Even on scrub oak sites, seedling regeneration can be a vital addition to the reliable stump sprout regeneration. On the sites harvested in 1998 extensive seed-origin regeneration was present. Black, northern pin, and white oak seedlings were prevalent across all sites. Whereas black and northern pin oaks tend to be relatively shorter-lived species, white oak can have a much longer life span. Much of the seed origin regeneration was white oak (present in 70 percent of plots), which gives further hope for the future of these stands.

Figure 1.—Six-year-old northern pin oak stump sprout in central Wisconsin.

Deer Browsing

One of the main concerns of many foresters for the future of oak is the effect that deer can have on regeneration.[2] A significant positive correlation (r = 0.132) between deer browsing and dominant sprout height was observed, implying one of two possibilities. Either deer will preferentially browse more successful sprout clusters as they are more nutrient rich, or the browsing that occurs reduces the competition, allowing the dominant sprout to be more successful. Although deer browsing may be a factor in the success of oak regeneration on scrub oak sites in general, for all of the sites used in this study it appears that sufficient oak stump sprouts (combined with other desirable components of regeneration) were produced to adequately regenerate the stands and the majority of stump sprouts were able to grow above the deer browse line.

The amount of browse observed was highly variable both across an individual site and between all four study sites as a whole. The form of a stump sprout may actually serve as a competitive advantage against deer browsing. The sheer volume of sprouts that typically occur (Fig. 1) would make it very difficult for a stump sprout to have all of its shoots browsed as some will naturally be protected by the surrounding shoots. Browsing was not examined for advance regeneration from seed, but as an average of 85 percent of plots were stocked with oak after 12 years it does not seem to be significantly detrimental, at least on scrub oak sites.

[2]Wisconsin Department of Natural Resources. 2006. Natural oak regeneration in Wisconsin survey. Unpublished survey.

Management Implications

In any management situation, sites should always be evaluated on an individual basis. If oak decline is present, different management actions may be required. A guide for managing oaks in Michigan recommended a sanitation harvest, salvage harvest, or letting the stand sit to allow a more natural progression, depending upon current conditions (Michigan DNR 2000). The main source of variation found in this study was site history. When the four sites harvested in 1998 were examined, one site appeared quite different from the others. Three of the sites had extensive seed-origin oak regeneration, whereas the seed-origin regeneration in the fourth was largely black cherry (*Prunus serotina* Ehrh.). This difference could be the result of previous agricultural use of the site. Despite this variation, even this site was successfully regenerated with economically desirable tree species based on the combination of oak stump sprouts and seedlings of a range of commercial species. The GAP called for on these nutrient-poor, sandy sites is an appropriate method for achieving full site regeneration.

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