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Douglas M. Stone

John D. Elioff

Donald V. Potter

Donald B. Peterson

Robert Wagner

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Restoration of Aspen-Dominated Ecosystems in the Lake States

Douglas M. Stone[1], John D. Elioff[1], Donald V. Potter[2], Donald B. Peterson[2], and Robert Wagner[3]

Abstract*—A reserve tree method (RTM) of harvesting was installed in six 70- to 75-year-old aspen-dominated stands to determine if retaining 10 to 15 dominant aspen per acre would decrease sucker density to facilitate restoration of a conifer component. A reserve shelterwood cut was applied to three additional stands to evaluate performance of white pine planted under 50% crown cover. After the first full growing season following harvest, 96% of the RTM harvested areas were stocked; sucker density averaged 27,000 (27 k) per acre versus 38.2 k per acre on a clearcut control, 41% greater. Basal diameter of dominant suckers averaged 0.45 inch, 28% greater than the control, and mean height was 60 inches, 33% greater. The control site had 3.1 k stems per acre of associated commercial species versus 5.8 k on the RTM sites, an 87% difference. Four of the nine stands have been planted; first-year survival ranged from 75% to near 100%. The RTM shows promise for reducing sucker density, increasing their early growth, maintaining species diversity, and providing abundant regeneration of commercial species on a high proportion of the areas harvested. Early results indicate that both the RTM and shelterwood methods can facilitate restoring a component of native conifer species in these ecosystems.*

Introduction

Throughout the northern Great Lakes region, most of the forest types are far different from those of a century ago. Depending on location, the presettlement species growing on well-drained, medium to fine-textured soils of northern Minnesota, Wisconsin, and Michigan were predominantly shade-tolerant conifers including white pine (see appendix for scientific names), eastern hemlock, and northern white-cedar; and tolerant hardwoods dominated by sugar maple, red maple, yellow birch, and basswood (Albert 199; Coffman et al. 1983; Kotar et al. 1988). White spruce, balsam fir, white ash, and American elm were common associates. Without stand-replacing disturbances (primarily fires), the aspens (trembling and bigtooth) occurred as minor associates (Braun 1950).

During the late 19th century, exploitative logging, initially of conifer species, created conditions for slash-fueled wildfires that swept over large areas of the region, destroyed advanced regeneration of the former species, and resulted in "brushlands" comprised predominantly of aspen suckers and stump sprouts of associated hardwood species (Graham et al. 1963). Effective fire control beginning in the 1920s permitted these stands to develop into the present-day second-growth forests dominated by aspen.

Throughout much of the region, present-day forests have an abundance of aspen that reduce the landscape diversity associated with a more natural, conifer-dominated landscape. Resource managers are seeking silvicultural alternatives to conventional clearcutting, and ecologically sound and cost-effective means to reestablish a component of native conifer species on some of these sites. By "ecosystem restoration" we mean reestablishing a component of native conifers

[1]North Central Research Station, USDA Forest Service, Grand Rapids, MN 55744.
[2]LaCroix Ranger District, Superior National Forest, USDA Forest Service, Cook, MN.
[3]Ontonagon Ranger District, Ottawa National Forest, USDA Forest Service, Ontonagon, MI.

in these ecosystems so that stand-level species composition is somewhat closer to that prior to the logging and wildfires of a century ago. We report data on aspen regeneration the first full growing season after harvesting six stands using a reserve tree method (RTM) on the Superior National Forest in northern Minnesota, and survival of white pine planted under three reserve shelterwood stands on the Ottawa National Forest in western upper Michigan.

Ecology and Management

The aspens are shade-intolerant, rapidly growing, short-lived species that regenerate by root suckers following removal of the parent stand (Perala and Russell 1983). Suckers exhibit more rapid early height growth than seedlings or sprouts of associated species, so they typically form the dominant overstory during the early and mid-stages of stand development. On medium and fine-textured soils, pure aspen stands are rare; most include a component of more tolerant, longer lived species typical of these sites in the absence of disturbance. On most commercial forest land in the Lake States, aspen is managed for wood products or for a combination of fiber and wildlife habitat. Where wood production is a primary objective, the stands normally are harvested by a complete clearcut of all species, and the aspen is regenerated from root suckers. Presumably, the procedure can be repeated and the aspen maintained indefinitely (Perala and Russell 1983), provided the root systems are not damaged by severe soil disturbance during logging (Stone and Elioff 2000).

The Problem

Clearcutting at frequent (40- to 50-year) intervals to maintain single species stands in an early successional state counters several of the objectives of ecosystem management (e.g., Irland 1994) by interrupting natural processes and “resetting the successional clock” (Mladnoff and Pastor 1993). Many stakeholders object to clearcutting and to single species management because of visual quality and aesthetic values. Extensive loss of the conifer component from much of the forest area of the Lake States region has caused concerns about ecosystem structure and function and the diversity and quality of wildlife habitat (Green 1995; Mladenoff and Pastor 1993). Ruark (1990) proposed a reserve shelterwood system to convert 30- to 35-year-old, even-aged aspen stands to two-aged stands, and to allocate limited site resources (sunlight, nutrients, water, and growing space) to fewer stems per unit area. The method had not been tested or validated, but offers several potential advantages at different spatial scales (Stone and Strand 1997).

A major objective of ecosystem management is maintenance or enhancement of species diversity (Kaufmann et al. 1994). Many resource managers are seeking ways to reestablish a component of native conifer species. Establishing these species on suitable sites would be a first step toward increasing stand-level species diversity. Moreover, total yields of mixed-species stands may well exceed those of aspen alone (Man and Lieffers 1999; Navratil et al. 1994; Perala 1977). Natural regeneration of most conifers on these sites usually is limited by lack of available seed sources. Development of planted seedlings frequently is hampered by competition from dense stands of aspen suckers, beaked hazel, mountain maple, and herbaceous species.

Approaches to Solution

As an alternative to conventional clearcutting, and to facilitate reestablishing a component of native conifer species on the Mighty Duck timber sale, the LaCroix District on the Superior National Forest decided to take an "adaptive management" approach and try a reserve tree method (RTM) to reduce the density of aspen suckers and to increase survival and growth of planted conifers. Similarly, the Ontonagon District on the Ottawa National Forest utilized a reserve shelterwood approach to protect advance regeneration of white spruce (Navratil et al. 1994), and underplanted white pine on three sites where it formerly was a major component of stands on clay soils. On both forests, the aspen was 65 to 75 years old, mature or overmature, and the stands were losing net volume from mortality due to stem decay. The residual aspen overstory will not be salvaged on either forest. Both forests contain inclusions of poorly drained soils occupied by black ash, red maple, and associated moist-site species; these were delineated on the ground during sale preparation and excluded from the sales.

Methods

LaCroix District

In each stand, 7 to 15 dominant or codominant aspen stems per acre were selected at a uniform spacing of 50 to 80 feet and marked with paint spots at the stump and at 6 to 8 feet. Prior to harvest, we established transects at 1.5 chain intervals across each stand, marked sample points every 1.0 chain along each line, measured the basal area of all living trees >4 inches d.b.h. with a 10-factor prism, and recorded all saplings and shrubs >6 inches high on a circular 5 m^2 (54 ft^2) plot at each sample point. Stand 9 included an intermittent drainage that served to separate the RTM portion from a control portion that received a silvicultural (complete) clearcut. Stands 1 and 7 were harvested during the summer (July 1997 and August 1998) and the other four during the winter. During September, after the first full growing season following harvest, we recorded the d.b.h and height of each reserve tree within 1.0 chain west or south of the transect lines. On each 5 m^2 regeneration plot, we recorded the number of stems of all commercial species >6 inches high, the basal diameter at 6 inches, and height of the dominant aspen sucker on each. Each regeneration plot was considered stocked if it included one (800 per acre) or more stems of aspen or other commercial species. The data were summarized and means calculated for each site.

Ontonagon District

The shelterwood stands were marked to remove the poor quality aspen and mature white spruce and balsam-fir, leaving about 50% crown cover of predominantly healthy aspen to provide high shade. The stands were commercially harvested using cut-to-length equipment. After logging, the sites were prepared by manually cutting the understory shrubs (predominantly hazel) to reduce root competition and low shade. During May, 1998, they were planted with 3-0 bare root, rust-resistant white pine seedlings at about 9 x 9 ft spacing (500 per acre). They will be manually released once or twice during the first 10 years. Breakup of the residual overstory will provide a final release.

Results and Discussion

LaCroix District

The density of reserve trees ranged from 7.3 to 15.3 per acre and averaged 11.6 per acre on the six sites (table 1). Site 1 was the first stand marked and fell below the desired 10 to 15 trees per acre. As the markers gained experience, their judgement of spacing distance improved and density on the other five sites was close to the objective. Except for the first stand, the reserved basal area was consistently between 10.5 and 12.2 ft^2 per acre, indicating that markers can produce uniform results with relatively little training and experience. Except for site 11, the d.b.h and height data indicate better-than-average site quality. However, the first-year regeneration data (table 2) suggest that this stand may have been younger than the others.

After the first full growing season following harvest, sucker density ranged from 18.3 k per acre to 33.4 k per acre and averaged 27.0 k per acre on the six RTM sites (table 2). Interestingly, the highest density occurred on a summer-logged site (1), and the lowest on a winter-logged site (13). However, the relatively low sucker density on site 13 most likely is because 40% of the initial basal area consisted of associated species, predominantly paper birch and red maple. Thus, in these areas there would be few, if any, aspen roots present to produce suckers.

During the public comment period on the environmental assessment of the timber sale, there were concerns that the RTM might severely reduce sucker density and growth. These data indicate clearly that this is not a problem.

Table 1—Characteristics of reserve trees on the Mighty Duck sale.

Site	Number	D.b.h.	Height	BA	Density
		inches	*feet*	*square feet per acre*	*number per acre*
1[a]	100	15.0	88	9.4	7.3
7[a]	150	11.5	66	12.2	15.0
9	108	13.5	80	10.7	10.0
11	150	10.6	56	10.5	15.3
13	129	12.2	67	11.8	12.8
17	171	15.2	93	12.2	9.3
Mean	135	13.0	75	11.1	11.6

[a]Summer logged.

Table 2—First-year regeneration on the Mighty Duck sale.

Site	Number plots	Aspen Diameter	Aspen Height	Aspen Density	ACS[a] density	Total density	Percent stocked
		- - - - *inches* - - - -		- - - - - - - *k per acre* - - - - - - -			
1[b]	138	—[c]	59	33.4	5.0	38.4	99.3
7[b]	101	0.38	46	21.8	5.5	27.3	90.1
9	109	0.40	49	31.4	5.0	36.4	95.4
11	98	0.56	76	29.7	7.5	37.2	99.0
13	102	0.37	50	18.3	7.4	25.7	95.1
17	187	0.58	80	27.4	4.4	31.8	95.7
Mean	122	0.45	60	27.0	5.8	32.8	95.8
Cont.	43	0.35	45	38.2	3.1	41.3	97.7

[a]Associated commercial species.
[b]Summer logged.
[c]Not measured.

Graham et al. (1963) considered a sucker density of 6 k per acre as minimum stocking and 12 k well-distributed suckers per acre as optimal; using these criteria, all six of the sites are more than fully stocked. A mean basal diameter of 0.45 inch and height of 60 inches is excellent first-year growth. Moreover, the greater diameter and height of suckers on the RTM sites suggest that carbohydrate and/or nutrient reserves in the parent root systems are indeed channeled to fewer suckers, thereby increasing their early growth as postulated by Ruark (1990). Site 1 was logged during August 1997, and planted with container-grown white pine in May 1998; first-year survival was near 100%.

An objective of ecosystem management is conservation or enhancement of species diversity (Kaufmann et al. 1994). Dense stands of aspen suckers and their rapid early height growth place the seedlings and sprouts of associated species at a competitive disadvantage. The nearly twofold difference in density of associated species on the RTM sites (table 2) suggests that reserving a portion of the overstory contributes, either directly or indirectly, e.g., less machine traffic, to maintaining stand-level species diversity. While this is a limited sample size, we have noted similar trends in other studies (unpublished data on file).

Each of these stands was commercially harvested using conventional logging equipment, i.e., mechanical fellers and grapple skidders. Except for the second summer-logged site (7), >95% of the regeneration plots were stocked with one or more stems of aspen and/or other commercial species (table 2). In related studies designed to monitor harvesting effects on site disturbance and regeneration, 10 to 20% (or more) of most sites are occupied by roads, skid trails, landings, or other heavily disturbed areas that remain nonstocked for several years following harvest (Stone and Elioff 2000). A significant difference between the contract for the Mighty Duck sale and other typical national forest timber sales was the inclusion of a clause specifying a $75 penalty for damage to each reserve tree. The damage clause was highly effective; except for an occasional broken live limb, we noted little logging damage to reserve trees. Operator awareness is critical to protecting advance regeneration (Navratil et al. 1994). Enhanced operator awareness also may have contributed to the relatively low amount of rutting and other severe site disturbance, and in turn, to the high proportion of the areas stocked with commercial species. Use of reserve tree, or other contract modifications, to increase operator awareness of site disturbance and silvicultural objectives merits serious consideration.

Ontonagon District

Shortwood harvesting of the shelterwood stands on the Ontonagon District provided lower sale volumes and required manual removal of the understory, but produced an overstory that probably will be more favorable for establishment and growth of the planted conifers. There has been no significant windthrow or stem breakage on any of the three sites. Despite an exceptionally dry summer, first-year survival of planted seedlings ranged from 75 to 88%.

Summary and Management Implications

Reserving 7 to 15 dominant aspen per acre in six commercially harvested stands resulted in: (1) little logging damage to the reserve trees; (2) regeneration of aspen and associated commercial species on 96% of the area; (3) first-year sucker density of 27.0 k per acre on the RTM sites versus 38.2 k per acre on the clearcut control; (4) mean sucker diameter of 0.45 inch and height of 60 inches;

and (5) 5.8 k stems per acre of associated commercial species versus 3.1 k on the control site. Of the four stands that have been planted, first-year survival ranged from 75 to near 100%. The RTM shows promise for reducing sucker density, increasing their early growth, maintaining species diversity, and providing abundant regeneration of commercial species on a high proportion of the areas harvested. These early results indicate that both the RTM and reserve shelterwood methods can provide stand conditions that are favorable for restoring a component of native conifer species in these ecosystems.

Application

From a landscape perspective, two-storied stands comprised of a mixture of species are aesthetically more appealing to many people than are clearcuts and single-species management. Maintaining partial stocking of the site can be less disruptive to normal hydrologic and nutrient cycling processes; this can be a critical factor on some sites. Two-storied, mixed-species stands provide structural diversity that benefits some wildlife species. The portion of the timber volume retained will reduce the sale volume per unit area, so the Allowable Sale Quantity can be distributed over a larger area. This will accelerate development of a more balanced age class distribution and reduce the eminent breakup of overmature stands. From a silvicultural and forest health viewpoint, this is especially important to those districts that are losing net volume from mortality due to stem decay.

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Appendix: Common and Scientific Names of Trees and Shrubs

Common name	Scientific name
Balsam fir	*Abies balsamea* (L.) Mill.
Red maple	*Acer rubrum* L.
Sugar maple	*Acer saccharum* Marsh.
Yellow birch	*Betula alleghaniensis* Britt.
Paper birch	*Betula papyrifera* Marsh.
White ash	*Fraxinus americana* L.
Black ash	*Fraxinus nigra* Marsh.
White spruce	*Picea glauca* (Moench) Voss
Eastern white pine	*Pinus strobus* L.
Bigtooth aspen	*Populus grandidentata* Michx.
Trembling aspen	*Populus tremuloides* Michx.
Northern white-cedar	*Thuja occidentalis* L.
Basswood	*Tilia americana* L.
Eastern hemlock	*Tsuga canadensis* (L.) Carr.
American elm	*Ulmus americana* L.
Mountain maple	*Acer spicatum* Lam.
Beaked hazel	*Corylus cornuta* Marsh.