The Power of Silviculture

Employing Thinning, Partial Cutting Systems and Other Intermediate Treatments to Increase Productivity, Forest Health and Public Support for Forestry

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Introduction

In the parlance of forestry, intermediate treatments include entries into a forest stand between the time of establishment of reproduction and up until the end-of-rotation harvest. Intermediate treatments include thinning and overstory treatments as well as understory planting, weeding and cleaning, salvage and sanitation cutting, and prescribed fire. Such treatments are applied to sustain ecosystem health and function; contain costs; improve stand quality and the proportion of large diameter, high quality stems (e.g. sawtimber); optimize yields; and shorten the period of investment return.

In large areas of the northern United States, including the Great Lakes Region, forests are actively managed for the production of wood fiber. Favored trees are typically fast-growing pioneer species, with management geared toward short rotations and even-aged stands (i.e., harvesting is often by clear-cutting). In this environment, intermediate treatments such as thinnings and partial cuttings have not been given high priority, in part because sufficient wood fiber volumes could be secured without the need for additional stand treatments between stand establishment and final harvest. Strong markets for pulpwood – used not only in manufacturing pulp and paper, but composite lumber and panels as well – have tended to minimize economic drivers for management aimed at production of sawtimber which is more likely to involve intermediate treatments.

One problem with fiber oriented, short rotation, even-aged management is that the forest mosaic over a landscape tends to be simpler than otherwise might be the case, a reality that has ecological and esthetic implications. Another problem, and one that has the greatest impact on private forest landowners who own more than half the productive forest land nationwide, is that unless that land management unit is quite large, harvests occur only once or twice in a lifetime of a forest owner. Even if rotations are as short as 40 years, harvest activity and related income skips every other generation, discouraging interest and active involvement in forest land management. Moreover, the infrequent harvests that do occur tend to be high impact events, particularly for an owner of a small forest tract in which the entire area is likely to be affected. This kind of dynamic likely affects the attitudes of forest owners, as well as overall public support for forestry.

Today, there are increasing concerns about the willingness of private forest owners to participate in the practice of forestry. As forest lands are passed on to the next generation, and in the process divided into smaller and smaller parcels, will the new owners still be willing to periodically harvest their trees? Can public support for forestry be maintained, or will opposition to forest management and harvesting activity intensify? There are also concerns about the possible impact of growing interest in forest biomass for use in energy production; is it possible to accommodate such interest while also improving forest health and vitality?

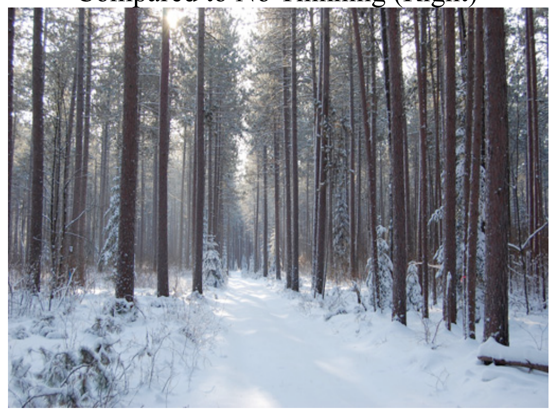
The use of intermediate treatments and modified harvest regimes, so as to provide a more even flow of forest outputs than is typical, and to develop a greater diversity of species, age classes, and structures, may be the key to increasing active engagement of forest owners in forestry, and to gaining greater public support for forestry. Such practices could also lead to greater forest productivity over the long term and increased forest use options.

This report examines the use of thinning, partial cutting systems, and other intermediate treatments in the practice of forestry. The focus herein is on forests typical of southern Canada and the northern U.S., and of Minnesota in particular. There is now a considerable body of knowledge that suggests that wider adoption of intermediate treatments could increase both forest productivity and forest health. The possibility that public interest in and support for forestry might also be enhanced provides a win-win combination that could improve the outlook for profitable production of diversified forest products, including biomass in renewable energy production.

Thinning and Partial Cutting Defined

The practice of caring for and cultivating forest trees is known as *silviculture*; silvicultural treatments are employed to control the establishment, growth, composition, health, and quality of forests and woodlands. Through the use of diverse silvicultural practices, foresters are able to influence forest conditions and provide a variety of benefits that address landowner objectives and a full range of social, economic and ecological values. Furthermore, silvicultural practices can be designed to mimic natural disturbances that are associated with a specific eco-region, forest type or species. For example, forest management in Minnesota considers the historic patterns of fire and wind disturbance as well as the influence of insects and disease, snow and ice storms, and other factors. One silvicultural method of increasing tree growth rates involves reduction of competition for available sunlight, nutrients, and water, which can be achieved through such practices as controlled spacing of trees at the time of planting or by thinning of an established stand of trees.

Figure 1
A Thinned Stand of Norway Pine (Left) as Compared to No Thinning (Right)



Source: University of Minnesota, Department of Forest Resources

Thinning (Left-hand side of Figure 1) involves removal of a portion of the trees on a site to reduce forest stand density, with the goal of increased growth rates, enhanced forest health, and reduced potential mortality. Thinning can also be used to diversify structure and composition of a forest. For example, heavy thinning can increase the growth of the ground and shrub layer with potential wildlife food and cover benefits. There are many possible approaches to thinning. For example, in some cases, trees that might eventually be expected to die due to natural competition are harvested and utilized; this thinning approach is sometimes described as "capturing mortality." Other thinning approaches include high-thinning and crown thinning where the objective is to remove dominant or co-dominant trees and increase growing space for the highest quality "crop trees". Thinning is classed as *pre-commercial* if there is no market for material removed, or *commercial* if the products can be profitably marketed.

In Minnesota, harvesting of shade-intolerant species[1] is typically done by clearcutting – the complete removal of trees from a given site (Figure 2). The average size of a clear-cut harvest in Minnesota is about 17 acres. Clearcutting is employed when young trees need an abundance of sunlight in order to successfully compete with grasses and other plants in early stages of life. The size and width of the opening that results from the cutting will influence the species that dominate the new forest and the wildlife habitat it provides. For example, openings that are more than two tree heights in width will generally have core areas that are largely unaffected by the surrounding forest in terms of moisture and temperate conditions.[2]

Figure 2
Harvest by Clearcutting

Source: USDA-Forest Service, North Central Research Station, Forest Management Guide (http://www.ncrs.fs.fed.us/fmg/nfmg/fm101/silv/index.htm)

[1] Trees that cannot thrive in the shade of other trees.
[2] For example, if the adjacent or surrounding stand has trees that are generally 50 feet in height, an opening less than 100 feet wide will continue to be significantly affected by the shading and mitigating influence of the adjacent forests. However, if the opening is 200 feet wide, then it will include a core area that is largely unaffected and provides conditions that are distinct from those in the adjacent forests.

In other words, openings of this size (more than two tree heights in width) can provide habitats and forest conditions that are distinct from surrounding forests. Therefore, clearcutting is an effective way to accomplish at least two possible goals: 1) regenerate a shade-intolerant species, and 2) create a forest type that is different from surrounding forests and thereby introduce diverse structure and habitats. On the other hand, and for these very same reasons, clearcutting can also be characterized as "fragmenting" the forest as it creates a new forest opening that is unlike adjacent stands and habitats. The full accounting for whether clearcutting results in a net ecological benefit for a given site depends upon the landscape conditions, landowner objectives, and the impacts of forest management including economic and social considerations. The debate over the pros and cons of clearcutting as a silvicultural method has included the fact that it is a management technique that often generates negative public opinions. The social reaction to clearcutting is an important consideration for foresters, especially those managing public lands.

Potential alternatives to clearcutting include partial cutting systems such as shelterwood harvesting and group tree selection (Figure 3). In a shelterwood system, partial harvesting allows new, mid-tolerant to fully shade-tolerant trees to grow up under an overstory of maturing trees. The new trees can result from seeding, sprouting or planting. Mature overstory trees are typically removed once the new stems are well established, usually five to ten years after the initial shelterwood establishment. In a group tree selection system the idea is to create scattered openings in the forest in which species having a range of shade tolerance can become established. A stand managed using a shelterwood system is pictured in Figure 4. Partial cutting can also include the leaving of legacy patches, reserve trees or reserve areas, and other retention targets that address specific objectives for biodiversity, wildlife, stand structure or other forest values.

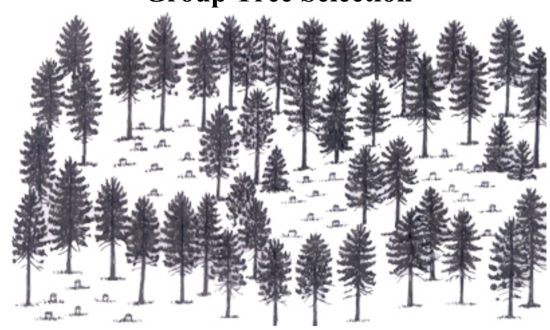
Thinning and Partial Cutting - Research Findings

The potential use of intermediate silvicultural treatments depends in part on the species and type of forest being managed. Considerable research related to thinning and partial cutting treatments for some of Minnesota's major forest cover-types, including aspen,

Figure 3
Partial Cutting Systems Employed in Forest Management

Shelterwood

Group Tree Selection



Source: USDA-Forest Service, North Central Research Station, Forest Management Guide
(http://www.ncrs.fs.fed.us/fmg/nfmg/fm101/silv/index.htm)

Figure 4
A White Spruce Stand in Ontario Following a Shelterwood Harvest

Source: Ministry of Natural Resources, Ontario, Canada
http://www.mnr.gov.on.ca/images/199162.jpg

spruce, red pine and hardwoods, has either been completed or is underway, and a summary of representative studies are presented below. One of the apparent gaps in research and management information related to intermediate treatments is a full understanding of how to effectively apply these treatments to diverse stands and with mixed species management. Like many forestry practices, intermediate treatment strategies have largely been researched in relationship to single species attributes and responses. Mixed species management may require additional research and a greater understanding of ecological processes.

Aspen

In North America, aspen is typically harvested by clearcutting because it is a shade-intolerant species. After cutting, the harvest site is allowed to regenerate naturally via root suckers (e.g., young trees resprout from the roots of the trees that were harvested). An aspen stand that has been harvested by the clearcutting method will begin to re-sprout almost immediately following harvest, with the development of 20,000 to over 50,000 new stems per acre within one year on an average to good site. Allowed to grow without intervention, self-thinning will occur in such a stand in response to natural competition, with the result that 200-300 stems remain at the end of a 60 to 70 year period, the general life-span of a typical aspen forest. A pattern of harvest, natural regeneration through root-sprouting, stand development and self thinning, maturation, and re-harvest at age 40 to 55 is a typical rotation[3] in Minnesota aspen. Seldom are silvicultural treatments applied in mid-rotation for the purpose of improving stand vigor or tree quality due to the cost of such treatments and the perceived difficulties of operating in aspen stands.

A renewed interest in early or pre-commercial thinning of aspen has occurred in recent years in response to a predicted aspen timber shortage in the Lake States due to an imbalance in the age structure.[4] In young aspen stands where sucker and sprout densities are high, precommercial thinning has been used to shorten the length of pulpwood rotations, promote the diameter growth of residual stems, and favor superior clones (Graham 1963), Perala 1977, Jones et al. 1990).

Steneker (1974) concluded that thinning of aspen to increase fiber production is not economical, a finding that has been confirmed by a number of others. Thus, it can be argued that mid-rotation silvicultural treatments should not be promoted for Minnesota aspen because harvest volumes are used almost exclusively as a source of fiber for papermaking or hardboard production, or flakes for production of OSB. On the other hand, it is likely the case that aspen is used largely as a source of fiber precisely because of the way that aspen is (or isn't) managed.

A considerable body of research, much of it dating back to the 1960s and 1970s, indicates that aspen responds well to thinning, and that a positive response to thinning can be realized at stand ages ranging from less than ten to over 30 years. Findings suggest that one or more thinnings during the life of an aspen stand can increase both the volume of output overall and at final harvest, and the value of products obtained at the end of a rotation. Domke et al. (2007) provided examples of such research, citing several studies begun in the mid-1960s which pointed to thinning early (when a stand is young), light (e.g., removing less than 50% of the basal area[5]), and often (e.g., re-entries to thin every 5-15 years) to improve overall rotation yields and product mix.

Research begun even earlier, but reported in the 1970s, also indicated significant benefits of aspen thinning when markets were available for saw- and veneer-logs. Bella (1975), for example, reported that crowding in aspen stands may reduce by half the diameter increment (e.g., growth rate) of dominant and co-dominant trees at an age as early as 5 years, and suggested that thinning, even at an age of 5 years, may be effective for improving

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[3] A rotation is defined as the number of years required to establish and grow trees to a specified size, product, or condition of maturity. For example, a rotation for a given species may range from as short as 20 years for pulpwood to more than 60 years for sawtimber.
[4] Management activities between 30 and 50 years ago largely excluded the harvesting of aspen and therefore little aspen was regenerated during this time and the age class "gap" or imbalance resulted.
[5] Basal area is a measure of a forests' density in terms of the total area of tree trunks on a square foot per acre basis.

diameter increment in similar stands. Steneker (1974) also found positive effects of thinning in aspen. He reported results of thinning trials in 11, 14, and 23 year old aspen stands in Manitoba that had begun in the late 1940s. Through follow-up field studies in 1971 he found that individual tree growth was markedly increased by thinning, noting that the diameter increment of all tree sizes was positively impacted in all stands studied, and that cubic volume production of material of 8-inch (20 cm.) diameter and larger was markedly increased (+45%).

Because aspen is a relatively short-lived species, some investigators have questioned how late (e.g., at what age) thinning can be conducted and still yield both a positive thinning response and economic return. Schlaegel and Ringold (1971) for instance, reported that aspen did not respond to thinning at age 37, as measured over a 10-year period following thinning. In contrast, Hubbard (1972) conducted thinning trials in well-stocked and highly productive (site index 85-90[6]) aspen stands 31 and 34 years old, with harvest by clear-cutting done 16 years following thinning. At the harvest ages of age 47 and 50 years it was found that net diameter growth in the partial cut areas had exceeded that in the control by 1.45 inches. Thinning increased the veneer value per acre (after 15½ growing seasons) by $197.90/acre, a 53.5% increase. Based on study findings, management of an aspen stand with a pre-commercial thinning, followed by a commercial thinning at mid-rotation, and a final harvest at age 50 showed an average diameter of 14.03 inches in a thinned stand as compared to 9.5 inches in an un-thinned stand. Perala, who appears to have conducted more thinning investigations than any other researcher in the region, reported the results of extensive aspen thinning trials in 1978. A thinning strategy identified as optimal involved thinning at age 10 to 550 stems per acre, followed by a single repeat thinning to 200 stems per acre at age 30. It was reported that while a single thinning increased merchantable pulpwood volume, a two-thinning strategy as described above resulted in greater volume increases in larger trees, with increases at age 60 on the order of 35-77 percent.

It appears, therefore, that thinning of aspen can lead to significant yield increases over the relatively short rotation age of an aspen stand. Yield increases over a rotation are most notably in the form of larger diameter trees.

As a footnote to studies showing volume increases in conjunction with thinning, several investigators have addressed the issue of mortality of remaining stems following a thinning treatment. One of the more recent such investigations (Gilmore et al. 2006) found that thinning did not increase mortality of leave trees, but did increase the amount of light reaching the forest floor, resulting, in turn, in greater herb and shrub biomass in the year immediately following thinning. These results suggest non-timber benefits beyond volume yield, including benefits to wildlife and greater species and structural diversity in a thinned stand. In addition to growing interest in the potential for aspen thinning, an increasing number of land managers are also promoting variations of partial cutting systems as an alternative aspen management strategy.

Research uniformly shows that retention of a partial canopy in an aspen harvest will markedly reduce natural regeneration through root suckering. Perala (1977) indicated that 2.4-3.6 m^2/ha (10.5-15.7 ft^2/ac) of residual overstory would reduce sucker growth by 35-40 percent. The 40 percent number is found frequently in research findings. Examples include the 1995 study (Peterson and Peterson) which found that a residual canopy in aspen that reduces sunlight on the harvested site by 50 percent can reduce suckering density tenfold; it was reported that as little as 1-1.5 m^2/ha (4.4-6.6 ft^2/ac) basal area of residuals may slow sucker production by 40 percent. Stone et al. (2000) also found about a 40 percent reduction in the amount of resprouting when an aspen overstory was maintained following harvest. However, while a partial canopy reduces sprouting, the sprouting that does develop is often sufficient to provide adequate site restocking and may be of larger diameter and greater height. For instance, Doucet (1989) cited examples of adequate stocking with residual basal areas as high as 14 m^2/ha. (61 ft^2/acre).

[6] Site Index is a measure of forest site quality and potential productivity and is derived from the height (in feet) of the dominant trees at a specific age (usually 25 or 50 years, depending on rotation length).

What is considered to be adequate for successful regeneration of harvested aspen sites had been earlier defined by Graham et al. (1963) as a minimum number of about 15,000 sprouts/hectare (6,100/acre) with 30,000 sprouts/hectare (12,000/acre) identified as optimal. Regional field experience indicates that as few as 3,000-4,000 sprouts/acre may be adequate to ensure that aspen remains a canopy component of the regenerated stand. The Stone et al. study cited earlier, that found a marked reduction in the number of sprouts when an overstory was maintained following harvest, also found that the sucker sprouts that did develop were, on average, 28% larger in diameter, and 33% taller. They noted that the “reserve tree method” shows promise for reducing sprouting 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 also indicated that both the reserve tree and shelterwood methods can facilitate restoration of a component of native conifer species in aspen dominated ecosystems.

Despite acknowledged decline in the number of sprouts when harvesting leaves behind a residual canopy, there is nonetheless interest in the possibility of using partial cutting systems in conjunction with aspen management. David et al. (2001) suggested leaving individual trees or patches of trees un-harvested where enhancing biodiversity is an objective; this meshes with the findings of Kenefic and Nyland (2000) who concluded that diversity of habitat characteristics provides a non-commodity incentive to practice the selection system in some form. Other arguments in favor of more complex management of aspen that moves away from development of even-aged stands include Harvey et al. (2002), Hannam (2005), and Domke et al. (2007). Also, Wedeles et al. (1995) proposed practicing more complex management in buffer areas along lakes, streams, and wildlife or transportation corridors, but also pointed out that management strategies become much more complicated with alternative systems than with clear-cutting. Other research indicates that harvesting costs will be greater in these more complicated systems.

Domke et al., who reviewed considerable research dealing with non-traditional harvest systems, summarized their findings as follows: “In order to address changing forest management interests, forest managers must mix traditional silvicultural techniques with contemporary approaches (e.g. early and commercial thinning, variable density thinning, retention patches in clearcuts, and clear cutting with residuals) to manage for a non-timber objective or multiple objectives.” They noted, however, that short and long-term losses in yield with the adoption of complex management practices have not been carefully examined.

One caution, as expressed by Maini (1972), is that any partial cutting in aspen must not fall victim to the temptation to take the best stems and leave the rest. He noted that this practice will prevent suckering of the roots of the trees harvested, and these roots will decay within 3-4 years after cutting if they do not produce sucker sprouts. He emphasized that partial cutting *must not* be concentrated on removing the superior growth and low defect stems if a partial cutting method is to be used.

White and Black Spruce

White Spruce

Whereas white spruce is typically harvested by clearcutting, several studies suggest that white spruce can be successfully regenerated in a shelterwood system (Man and Lieffers 1998). One 27-year study of shelterwood harvesting (Wurtz and Zasada 2001) found successful regeneration (with and without scarification[7]) with about 100 leave trees per hectare (40 leave trees per acre). There is some evidence that mixtures of aspen and white spruce are more productive than single species stands (Man and Lieffers, 1999). There are especially advantages for spruce in such mixtures (DeLong 1997). A number of studies have also suggested benefits from releasing white spruce stands by harvesting the aspen component. Yang (1989) found greatest benefits when

[7] Scarification is the removal of the top litter layer on the soil so that the mineral soil seedbed is exposed and the site can then support successful regeneration.

spruce was released at 15-40 years of age, while Yang and Bella (1994) recommended releasing at age 65, but this conclusion was based on the assumption of no market for young, small diameter aspen.

Frank and Bjorkbom (1973) recommend initial thinning at 25-30 years in white spruce-fir stands, followed by periodic thinnings at 10-20 year intervals. They noted that growth responses to thinning in white spruce are quite significant. They strongly advocated the use of shelterwood or patch harvesting methods, citing continuous forest cover, inexpensive regeneration, lower fire hazard, more stable wildlife populations, and better aesthetics than when clearcutting is used.

Ball and Walker (1997) provided a different argument for a shift in harvesting practices. They examined regeneration in 100-year-old mixed white spruce-aspen stands that had been partially cut and then reassessed 37 to 39 years later. They concluded that current practices are causing a shift toward hardwoods and noted that changes in current practices are needed to ensure continuation of a softwood component in stands. A promising prescription identified by these researchers to support softwood regeneration was a treatment that included the removal of all hardwoods and 75% of softwoods, leaving 4.4 m^2/ha (19 ft^2/ac) of white spruce seed trees, and using patch scarification around pockets of advance growth. MacDonald (2000) indicated that a basal area reduction of 40% in harvesting produced silviculturally adequate and economically acceptable results; he noted that this level of removals inhibits the development of understory hardwood trees and shrubs, maintains conifer advance growth, minimizes windthrow losses, and generates the kind of microclimate needed for regeneration. These observations were later echoed by Hall (2001) who observed that white spruce regenerates most successfully in the shade of larger hardwood trees, so using the mixed-wood stand as a kind of natural nursery for the highly valuable white spruce makes economic sense.

A very recent study (D'Amato 2008) examined productivity and growth dynamics of young aspen-white spruce stands in Minnesota, with results in this case generally pointing to advantages of mixed stand management. Total standing biomass and overall productivity rates in mixed aspen-white spruce stands were found to be significantly greater than pure white spruce stands over a 26-year period, but about the same as in pure aspen stands. One asterisk to the positive findings is that although there were no initial differences (up to year 7) in height growth between white spruce grown in pure stands and with aspen, by year 26, white spruce planted in pure stands was significantly taller than those in mixed stands.

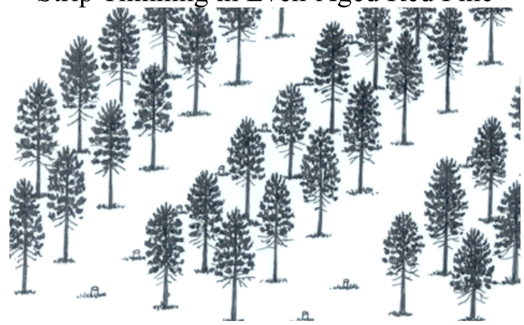
Black Spruce

As described by Viereck and Johnston (2001), black spruce is tolerant of shade but is less tolerant than balsam fir and northern white cedar, two common competitors. While reporting that seedling survival and growth are much better in the open, they note that seedlings develop in as little as 10 percent of full light intensity. They found that the maximum overstory basal area that can be tolerated without serious loss of seedling vigor is in the range of 9-11 m^2/ha (40-50 ft^2/ac). A modification of block clearcutting in black spruce – strip clearcutting – has been investigated by a number of researchers. Typical of published reports is that of Jeglum and Kennington (1993) which indicates that strip clearcutting in black spruce provides acceptable to desirable levels of stocking in a high proportion of the cut strips. Jeglum (1990) indicated that strip clearcutting in black spruce is biologically feasible and because the regeneration comes from the black spruce seed sources that are retained after harvest, it is considerably cheaper than clearcutting and replanting.

Red (Norway) Pine

As described in the U.S. Forest Service North Central Red Pine Management Guide, there are a number of thinning methods which can be used over the life of a red pine stand. One method described in even-aged, planted stands (typical of red pine throughout Minnesota) involves mechanical thinning of rows or strips of trees at fixed spacing intervals throughout a stand (Figure 5) for the purpose of reducing crowding and improving growth.

Figure 5
Strip Thinning in Even-Aged Red Pine



Source: USFS
(http://www.ncrs.fs.fed.us/fmg/rp/silv/established/p2_thinning.html)

Strip thinning is later followed by removal of intermediate and co-dominant high risk undesirable species, and trees of poor quality and low vigor trees, in order to concentrate subsequent growth on the large, high quality trees in the upper crown classes. The openings created by the strips are kept wide enough to provide greater room for the remaining trees to develop, while being narrow enough so that regeneration of young trees is not likely within the strips.[8]

A key benefit of thinning is that individual trees are allowed to grow larger in the course of a stand rotation, thereby increasing the relative rate of stand growth. The Forest Service notes that thinning serves to capture volume otherwise lost to mortality, often resulting in an increase in total wood volume removed over the life of a stand when a thinning program is implemented.

Dickmann and Koelling (1997) recommend several thinnings during a rotation in managing for red pine poles, referring to regular income opportunities for landowners at 10-15 year intervals. Longer thinning intervals are recommended by the U.S. Forest Service (2009) based on economics. The kind of income stream that can be realized from red pine management that incorporates two thinnings over an 80-year rotation is shown in Table 1; values given show why earlier and more frequent thinning is not recommended from an economic point of view.

Table 1
Summary of income stream from Managed Red Pine Stand Utilizing Periodic Thinning Strategy

Site Index 75												
Age (Yrs)	**Treatment**	**Stand Height** (ft)	**Avg DBH** (in)	**Stems** (/ac)	**Basal Area** (sqft/ac)	**CuFt** (/ac)	**Cords** (/ac)	**BdFt** (/ac)	**Harvest Value** ($)	**Timber Value** (% dif)	**NPV** ($)	**Soil Exp. Value** ($)
20		30.0	5.9	436.0	82.8	1013.8	9.7	0.1	401		256	271
25		38.4	6.9	433.1	113.0	1585.3	17.6	1.4	501	21.6	140	81
30	Commercial Thin	46.4	7.7	430.8	140.2	2450.3	28.6	4.9	1092	14.0	24	141
35		54.1	8.5	270.7	106.4	2067.0	24.7	5.9	1860	10.7	172	311
40		61.3	9.5	269.4	132.0	2998.0	36.6	11.3	2827	7.6	300	442
50	Commercial Thin	74.3	10.9	267.5	173.7	4968.5	61.5	22.5	4947	4.7	424	532
60		85.5	13.3	156.1	151.5	4865.2	60.9	24.8	7871	4.2	487	563
70		95.0	14.6	155.3	181.5	6644.8	83.4	34.9	11327	3.4	473	522
80	Final Harvest	103.0	15.6	154.8	204.1	8232.4	103.5	43.9	15545	3.1	425	455

Adapted from: U.S. Forest Service, North Carolina Region (http://www.ncrs.fs.fed.us/fmg/rp/mgt/table1.html)

[8] Thinning in strips can be contrasted with "shelterwood cuts", which involve removing trees on the harvest area in a series of two or more cuttings with the expressed goal of creating space for new trees and successful regeneration; or "strip clearcutting", which also has a goal of creating regeneration in the openings. In contrast, thinning is intended to favor the growth and development of the existing trees on the site without an expressed goal of regeneration.

Support for red pine thinning, especially in planted stands, is well established. Recent research, however, points to advantages of partial cutting systems in red pine management. Palik and Zasada (2003), for example, propose management strategies that generate stand structures and compositions that better mimic the complexity associated with natural disturbance, including stands with mixed-species, diverse age clasess, and spatial variations. Recommended strategies include 1) overstory retention (retaining trees in the dominant size class) and 2) variable retention that considers dispersed as well as large aggregates that favor species with different degrees of shade and understory tolerance. Variable retention also offers the potential for understory shrub development, wildlife habitat, and other benefits to be retained or enhanced following harvest.

<u>Hardwoods</u>

Mixed Species

Clearcutting, shelterwood and group selection methods are also used to manage hardwood forests. Shelterwood treatments have been found to produce better seedling regeneration than clearcutting in northern hardwood stands, but clearcutting has been shown to result in better growth rates and subsequent high stand volumes (University of New Hampshire). The conclusion of a 26-year study (Ray et al.1999) was that a shelterwood approach could be used successfully to regenerate northern hardwood species, provided that certain other control treatments were also done at the time of logging. In the study, sites were thinned to 35-65% canopy cover on the first cut; at the same time, understory regeneration of competing species (e.g., beech) was treated with herbicides and damage from deer browsing was controlled by hunting. The results showed establishment of new growth after harvest within five years and canopy closure within ten years.

Whether clearcutting or a shelterwood approach is used in hardwood management will greatly affect the composition of the regnerating forest. Clearcutting will favor shade-intolerant species (e.g., aspen, white birch) while a shelterwood with a residual crown of 30 to 50% will favor mid-tolerant species (e.g., yellow birch and red maple), and a shelterwood with a residual crown of 80% will favor shade-tolerate tree species (e.g., sugar maple).

In addition to clearcutting and shelterwood management, hardwood forests can also be managed using what is referred to as an “uneven-aged” approach. Whereas clearcutting and shelterwood treatments result in a new forest that includes trees of essentially one age class (i.e., even-aged management), an uneven-aged management strategy may utilize frequent (e.g., annual) harvests to create many different age classes within a stand. Studies in the northern hardwoods region suggest that management that results in regenerating about 1% of the canopy per year may approximate the natural canopy turnover associated with historic disturbance regimes (Seymour et al. 2002). This rate of turnover would translate to an average maximum tree age within a managed stand of about 105 years (the potential range is 70 to 140 years). There continues to be debate over the feasibility and merit of a greater focus on uneven aged management in northern hardwoods, especially given the dominance of even-aged methods in forest management over the past several decades. Some recent work suggests promise in stepwise approaches to conversion from even-aged to uneven-aged management and development of multiple age classes (e.g, 3 or 4 age classes in a stand) as a compromise to development of a fully uneven-aged condition (Nyland 2003). Research scientists note that managers working with existing mixed-species maple-hardwood stands must understand that having a range of tree diameters does not ensure that there are several age classes.

An important source of hardwood management information for the Great Lakes region is the research of the Argonne Experimental Forest in Wisconsin.[9] The many decades of research at the forest includes pioneering of uneven-aged management under the Arbogast system. The Argonne system is well developed and widely practiced in Wisconsin and upper Michigan, with recent emphasis on including gaps of various sizes to ensure that mid-tolerant species are represented in the forest, and in part to prevent sugar maple from completely dominating species composition.

[9] http://www.nrs.fs.fed.us/ef/locations/wi/argonne/

Red Oak

Recent experience in the Lake States indicates that commercial thinning of middle-aged red oak stands can provide an income stream, improve tree quality, and increase growth rates on better quality sites. These thinnings may be carried out in red oak from 45 to more than 90 years of age and should be carried out with crop tree release in mind.

Early thinning of red oak is not recommended due to the high probability of lowering the bole quality (increased branching), and thinning should be delayed until oaks have reached high canopy positions. In addition, red oak tends to have a shorter life span on lower quality sites (< 55 site index) and thinning may not be practical or economical on these sites.

Research of oak management on intermediate-quality sites in Lower Michigan found that oak shelterwoods harvested to retain 25% canopy cover contained significantly more oak seedlings (measured 10 years after treatment) than other treatments (Hartman et al. 2005). The study also found that oak regeneration was more successful in the understory of pine stands as compared to oak stands, where red maple is often dominant in the understory. While oak regeneration was found to be typically less dense under a pine understory, it also had less competition and therefore more room to grow. This research raises the possibility that there may be opportunities to shift toward management focused on regeneration of oak beneath pine stands.

A consideration in determining the need for intermediate treatments for oak stands includes whether the stand origin is from seedlings or from resprouting (e.g., stump sprouts). Stands originating from sprouts are likely to require early (e.g., before age 12) intermediate cuttings to select for quality sprouts and to improve spacing. On the other hand, stands resulting from seedlings may not require treatment for several decades. In central New England, where the main competitors with oak may include red maple and birch, recommendations for oak management include delaying the first thinning to stand until about 45 years after stand establishment. Oak has been found to effectively out compete red maple and birch within the first several decades of stand development in this region. In stands in New England where the oak is competing with yellow-poplar, sugar maple or beech (e.g., where young oak is being overtopped), earlier crop tree release may be needed for oak to be retained as a dominant species. In any event, after age 45, thinnings may be conducted every 12-18 years to manage stand densities, capture mortality and release crop trees. As rotation age is reached, shelterwood cuts may be used to encourage regeneration. The recommended rotation given current markets and technologies is from 80 to 120 years or when diameters are about 21 to 25 inches.

Stands regenerated from stump sprouts present a particular challenge in subsequent stand management. Early thinning of oak can negatively impact height growth and increase branching which impacts timber values; therefore, thinning of young stands (study of 7-year old trees) should be done conservatively with canopy gaps no more than 5 feet wide on three or four sides of selected crop trees. Thinning of northern red oak stump sprouts in Wisconsin has been show to benefit stem growth and quality when clumps of sprouts are thinned to one stem before they reach 3 inches in diameter (e.g., age 12 to 15). Given the cost of such treatments, recommendations include thinning only on sites with a 65 or greater site index.

There is today a considerable body of research of oak management, and numerous sources of information for land managers. One of these, the Minnesota Landowner's Guide (Baughmann and Jacobs 1992), provides guidelines for oak harvest, regeneration, and intermediate stand treatments aimed at improving quality of dominant stems. Such information consistently indicates a need for intermediate stand treatments to maximize stand quality and landowner income and to achieve other management objectives.

Other Intermediate Treatments

Thinning and partial cutting systems encompass a diverse range of treatments that can be used to enhance forest values. In addition to these kinds of silvicultural treatments, a number of additional approaches to forest management can be employed depending upon landowner management objectives and operational feasibility.

Understory Planting

When the landowner or manager has a management objective of enhancing species diversity, understory planting is sometimes effective. This approach may be necessary if a natural seed source for a desired species is not adequately available. One example of an understory planting approach would be the under planting of conifer species in an aspen stand to support the transition to a conifer cover-type. To support this objective, a land manager may thin or partially harvest an aspen stand to create growing space for the trees to be planted. After the conifer trees (e.g., white spruce or white pine) are established in the understory, the landowner can complete the removal of the overstory trees with a final harvest treatment. The landowner may also allow the remaining overstory trees to simply mature and die naturally without any further harvesting if there is a significant risk of damaging the understory trees that have been planted, or if retaining the mature overstory will help meet wildlife, aesthetic, coarse woody debris or other goals.

Habitat Enhancements

Intermediate treatments such as the use of prescribed fire or application of herbicides, or selective tree removal or girdling can be used to meet wildlife habitat enhancement objectives. For example, fire or herbicide treatments may be used to create more open habitats, to control invasive exotic species or to remove species that have lower wildlife value. Tree girdling involves cutting a ring around and through the bark of the tree so that the tree dies, but the stem is still left standing for use as a snag and future cavity nesting site for wildlife. The creation of snags through girdling must be done with care so that the hazards to the public and future forest operations are managed.

Weeding and Cleaning

Weeding and cleaning are pre-commercial treatments that can influence the development of a young forest stand. Weeding generally refers to the removal of shrubs, grasses and other vegetation that may be suppressing the young trees. Cleaning refers to removing less desirable species or individual trees in favor of the more desirable one, and may include selecting for stems that are straighter, taller, or more evenly spaced. Weeding and cleaning treatments can be cost intensive and difficult to justify when managing for lower valued products; however, similar to returns on early thinning treatments, investments in early weeding and cleaning practices can provide meaningful benefit on high productivity sites or where higher value products are being managed.

Salvage and Sanitation Cutting

There are times when rather than being proactive, land managers must be reactive to changes in forest conditions that are beyond their control. In cases of insect or disease outbreaks or damage due to wildfire, winds, ice or other weather events, a land manger may need to consider salvage or sanitation cuttings. Salvage and sanitation operations include recovery of dead, dying or damaged wood while it is still merchantable. When these operations are not conducted there may be increased risk of catastrophic wildlife fire resulting from the fuel loading, spread of insects or disease from the infested materials, reduced water quality due to increased runoff and nutrient loading, or a loss of economic returns for the landowners. Arguably, natural disturbance and the resulting changes in forest conditions can provide benefits for wildlife habitat, nutrient cycling and biodiversity, but properly conducted intervention can have positive impacts on these values while also enhancing human safety and other social values.

Watershed Management

In various parts of the country, there are innovative examples of forest management and the use of intermediate treatments to protect and enhance municipal water supplies. Such management is designed to address concerns about water quality (sediment loading, contaminants) as well as water quantity (rates of discharge, timing). Such watershed programs include the use of riparian forest buffers in sensitive areas, adoption of strategies for retaining and/or expanding the amount of forest area in a watershed, and monitoring of forest conditions in the watershed to ensure that the level of natural or human-caused disturbance is within acceptable limits. For example, in areas that may be prone to infrequent but high intensity wind events, such as the Quabbin Reservoir Watershed that serves the greater Boston area of Massachusetts, land management plans are oriented toward maintaining a diversified forest that includes areas of young, resilient trees. The desired outcome is that when a disturbance occurs the impact will tend to be less catastrophic than if trees are all large or of few species, and important proportions of the watershed will be able to withstand or rapidly recover (Massachusetts Department of Conservation and Recreation 2005).

Seeking Greater Use of Intermediate Treatments

Benefits

Intermediate treatments, including thinning, partial cutting and other practices, help landowners and managers meet diverse objectives. Through these varied techniques and strategies, objectives for forest productivity and potentials for increased revenues as well as interests in wildlife, water quality, human enjoyment, recreation and safety can be addressed and balanced. Diverse practices and treatments result in diversified management and diversified benefits.

Barriers to Greater Use and Overcoming Them

There are several potential and recognized barriers to the expanded use of intermediate treatments, In 2008, participants in the Blandin Foundation's *Seeing the Forest AND the Trees* study tour conducted an informal survey of land managers in Minnesota to identify use of intermediate treatments in forest management and barriers to expanded use of such treatments. Nearly all of the respondents were found to be conducting at least some intermediate treatments and use of such treatments was an established part of their management strategies. At the same time, however, for most of the organizations, less than 10 percent (or at most 25 percent) of their treatments were intermediate. The top impediment to conducting intermediate treatments is reported to be inadequate funding and staff resources (e.g., manpower) and a lack of knowledge or limited understanding of the science and technology related to intermediate treatments. Land managers responding to the survey also expressed concerns about a lack of markets for products resulting from intermediate treatments, a lack of equipment and operators that can conduct intermediate treatments, and limitations posed by an existing planning process that focuses on mature stands and final harvest regeneration.

Some suggestions for overcoming existing barriers included:

- Contractor and logger training, including workshops and tours of intermediate treatment practices in the field;
- Development of a market for woody biomass and improved mill utilization of materials;
- Finding ways to generate sufficient revenues through timber sales to support additional staff for intermediate treatments;
- Additional research and silvicultural studies to demonstrate the viability of intermediate treatments within a broader range of cover types; and,
- Policy and statewide leadership providing clear direction to do more intermediate treatments related to achieving multiple objectives.

Bottom Line

The use of intermediate treatments and modified harvest regimes could be the key to expanding the engagement of forest landowners in active management, and increasing public support for forestry while also increasing forest productivity, improving the outlook for profitable production of diversified forest products, and supporting the responsible use of forest biomass for energy production.

One of the apparent gaps in research and management information related to intermediate treatments is a full understanding of how to effectively apply these treatments to diverse stands and with mixed species management. Mixed species management using intermediate treatments may require additional research and expanded understanding of ecological processes. Barriers to increased adoption have also been identified to include staff resources, training needs and service provider capacity.

There is now a considerable body of knowledge that suggests that wider adoption of intermediate treatments could increase both forest productivity and forest health. The possibility that public interest in and support for forestry might also be enhanced through greater complexity in forest management provides a win-win combination.

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