# Proceedings of the SYMPOSIUM ON INTENSIVE CULTURE OF NORTHERN FOREST TYPES

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# FOREWORD

THE NORTHERN FOREST TYPES constitute a vast natural resource for the United States and Canada. For instance, in the eastern United States there are more than 10 million acres of commercial forest land supporting spruce and fir types alone. The magnitude and variety of this resource is such that treating it in any detail at a 3-day meeting was impossible. Rather, the idea that germinated and developed into this symposium was to present a broad picture of the extent of our knowledge of intensive cultural techniques, the status and trends of our research in the northern forest types, and some actual experiences in managing this resource; and to explore those factors that affect our use of the intensive cultural techniques we have at hand.

There is no doubt that we face a new era in the management of northern forests. The production of wood products is no longer the primary objective of many owners, and increased pressure for the social values of our forests is being felt by all landowners. We must recognize these other forest values, which in turn dictates intensification of all aspects of forest management if we are to meet the future demands of a wood-hungry society.

The enthusiastic efforts of the symposium sponsors—the School of Forest Resources, University of Maine; the Maine Bureau of Forestry; the Maine Forest Products Council; and the U.S.D.A. Forest Service—and the individuals behind those efforts, should be commended. Special thanks are due to Great Northern Nekoosa, Inc., and Brooks B. Mills for their help in providing interesting field trips, and to the Casco Bank and Trust Co. for sponsoring the symposium brochure. Also, without the enthusiastic participation of the experts invited to present papers, and the moderators of each session, the Symposium could not have taken place.

**—BARTON M. BLUM**
Symposium Chairman

PUBLISHER'S NOTE

This report is published by the Northeastern Forest Experiment Station as a public service. The papers it contains are published as received from the authors. Any questions or comments about these papers should be directed to the authors.

# Proceedings of the SYMPOSIUM ON INTENSIVE CULTURE OF NORTHERN FOREST TYPES

*held 20-22 July 1976 at Nutting Hall, University of Maine, at Orono.*

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## SILVICULTURAL POTENTIAL FOR PRE-COMMERCIAL TREATMENT IN NORTHERN FOREST TYPES[1/]

by H. W. Hocker, Jr., Professor of Forest Resources, University of New Hampshire

Abstract

It is proposed that pre-commercial thinning of young northern hardwood, oak, white pine and spruce-fir stands be carried out using appropriate stocking guides to regulate stand density. Thinning should be carried out when stands are between 1" and 2" dbh. Pruning of eastern white pine is recommended, while pruning of spruce and yellow birch seems feasible, markets for the better grades must be present. Application of nitrogen, phosphorous, and potassium fertilizer does not appear to warrant general use at present. More research is required to determine growth response of the various species on different sites to N, P, K application. Present high cost of nitrogen fertilizers appears to be a major limiting factor to their use.

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1/ Published with the approval of the Dieector of the New Hampshire Agricultural Experiment Station as Scientific Contribution No. 829.

In the three northern New England states, there are approximately 7.8mm acres of seedling and sapling stands, about 30% of the total commercial forest acreage. (Ferguson and Kingsley, 1972; U.S.D.A., 1973; Kingsley, 1976). I present these statistics to you to point out that there is a significant potential for increased management activity, intensive silviculture if you wish, which can be carried out in existing stands. Stands which, for the most part, represent a minimal investment to date, and will not require such large capital costs as those incurred with artificial regeneration of forest stands. Nature has done the work of regeneration on these young natural stands, and if some silviculture can be applied to them, it can be expected that their value can be enhanced.

The pre-commercial silvicultural practices which will be considered here are the intermediate practices carried out in a stand before a commercial volume of timber can be removed. The practices can be designed to increase either yield or quality of a stand, or both growth and quality of individual trees, and as a result, an increase in financial return at a future date, or they will shorten the time required to produce a final crop, which also represents an increased financial return. Specifically, the practices to be considered are pre-commercial thinning, pruning, and application of fertilizer.

## Pre-Commercial Thinning

At the present time, pre-commercial thinning implies a thinning which does not result in the production of a marketable product; however, with the rate at which technological changes are taking place in harvesting and utilization systems, we may be required to revise our concept of whether there is such a practice as a pre-commercial thinning.

Stocking, site, age are factors which determine growth of individual trees in a stand. Age and site for a given stand can be fixed and the effect of stocking on growth can be determined. It is primarily diameter increment which is involved. Chisman and Schumacher (1940) showed that stocking of individual stands can be evaluated by a function where $S = b_1 N + b_2 d + \Sigma b_3 \Sigma d^2$ (where N is number stems per acre and d is dbh of individual trees). Trimble (1969) found also that this stand relationship best defined growth of individual trees within a stand when compared to several individual tree measurements. Earlier, Buell (1945) used the relationship to define growth in un-evenaged stands of oak and mixed oak-pine.

Gingrich (1967) using the Chisman-Schumacher relationship and data from Schnur (1937) developed a stocking guide for evenaged mixed oak. Gingrich showed that a single stocking guide could be utilized for a variety of sites and ages; that trees on the better sites enter different stages of growth earlier than did trees on the poorer sites, and as a result, it was position within the stocking guide which separated stands on the better sites from stands on poorer sites and, therefore, it is not necessary to have different guides for different sites. Further, tree diameter reflects the age factor and as a result, a single stocking guide will serve for stands of different ages.

To establish stocking levels, it is necessary to set the upper or full stocking 'A' level and a lower or minimum stocking, 'B' level. If sufficient space for only dominant and some codominant trees is accepted as B level stocking, this level can be used to define the lower limit of stocking of stands to be accepted for management (Figure 1). 'A' level is set by values from fully stocked stands, which are obtained from normal stand tables. The result of this process is the production of a stocking guide which can be used to measure the stocking level of any stand whose species composition matches that of the species for which the guide was developed.

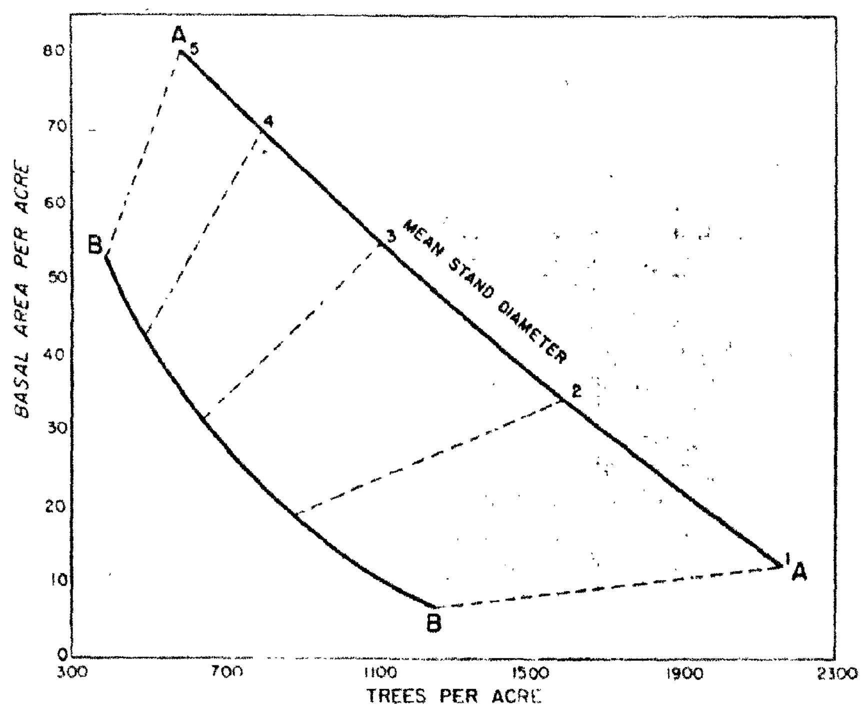



Figure 1.--Stocking guide for even-aged sapling stands of paper birch. From: Solomon, D. L. and W. B. Leak, 1969.

Before a decision can be made whether to treat a stand requires that an estimate of stocking be made. It is important to know, for example, what proportion of a stand is made up of desired stems of desired species, and whether this component of a stand is adequate to utilize the site if the remaining stand, or a part of the remaining stand, is removed. A stocking guide is the primary tool for determining stocking level of a stand. In addition to the oak stocking guide, stocking guides have been developed for paper birch (Marquis, Solomon, and Bjorkbom, 1969); for northern hardwood (Leak, Solomon and Filip, 1969); for spruce-fir (Frank and Bjorkbom, 1973); for white pine (Philbrook, 1971). These guides provide a means for making a decision of which stands to treat in a thinning and which stands require more drastic treatment such as conversion. Note needs to be made of the fact that the minimum mean stand diameter, MSD, for the guide for oak is 3"dbh, spruce-fir 5", and white pine 5".

Using several sources, a compilation of densities was determined for stands with MSD below those given in the stocking guides for northeastern species (Table 1). Number of trees per acre in young stands is an adequate expression of stocking since basal area does not differ a great deal among stands having large

Table 1. Number of acceptable stems per acre required to meet a 5"MSD 'B' line stocking level.

| MSD | Paper Birch | Northern Hardwoods All Comm. Species | Northern Hardwoods Intolerant & Intermediate | Spruce and Fir | Oak | White Pine |
|---|---|---|---|---|---|---|
| 1 | 1250 | 2050 | 1430 | 1660 | 1780 | 1354 |
| 2 | 890 | 1390 | 1040 | 1340 | 1154 | 986 |
| 3 | 650 | 890 | 730 | 1075 | 780 | 750 |
| 4 | 490 | 580 | 540 | 850 | 525 | 596 |

differences in number of stems. Note in Figure 1, that for paper birch, a 1" MSD stand with 2000 stems per acre has a basal area of 11 $f^2$; while a stand with 1250 stems per acre has a basal area of 7 $f^2$/acre - a difference of only 4 $f^2$.

As valuable as the stocking guides are, they do not indicate whether a stand after thinning will respond sufficiently to carry the cost of treatment, or how long it will be before another thinning can be made. For this, it is necessary to be able to estimate stand growth with and without treatment, more exactly it is necessary to be able to estimate value increase as a result of treatment.

Murray, Russell, and Barrett (1975) have developed a computer program to estimate stand growth for several species groups utilizing stocking guides and growth equations for each species group. This program, called "MIXUP", estimates growth of white pine, spruce-fir, oak, northern hardwood. The program projects growth of a stand through the stocking guide for each species using stand position before thinning with respect to a fully-stocked condition to estimate mortality. Growth of a stand is established using a stand mortality predictor to determine number of trees and basal area increment with and without thinning.

If a stand is to be thinned, its growth and final condition can be estimated, assuming that the thinned stand has the same growth pattern as an unthinned stand of the same characteristics, and the final volume compared to the volume estimate for the stand if it is not thinned. Marsh and Burgers (1973) conclude that this method for predicting growth of thinned stands is sound; however, the time interval between thinnings should not be carried beyond five years for species in South Africa.

There are two major limitations in this approach to simulation. One is the accuracy of the estimated mortality. To be able to predict volume at some future time requires that mortality of trees of different sizes in the stand be estimated. "MIXUP" can estimate total number of trees which die, between periods, but not mortality on each size class. There is a need to improve the ability to estimate mortality so that future stand structure can be estimated more accurately. It is important to estimate the number of trees which survive in the different diameter classes to be able to estimate stand volume accurately. It is toward this end that research is being directed. Dale (1972) has developed a program for mixed upland oak.

A second limitation in this "MIXUP" simulator is that it will not permit estimates of growth for stands less than 5" MSD. As a result, the program does not meet the need for stands which require pre-commercial treatment.

If stand structure can be set early in the life of a new stand, say in the late seedling-early sampling stage, then the chance of increasing production is increased over that of stands in which treatment is delayed until pole stage or later. Gingrich (1971) showed that young oak stands when thinned at age 10 years, had greater production than stands thinned at 30 years or older or were left unthinned. By shaping structure of young natural stands, it is possible to duplicate some of the early rapid growth which occurs in plantations. Young trees when released are able to expand into the space available and fill out their crowns and extend their roots into the area formerly occupied by competing growth. Young trees have the capacity to make rapid growth and because they have not been suppressed, are able to take immediate advantage of the additional growing space. Quality of growth should be better because the young trees have not been suppressed too long under the domination of less desirable but more vigorous stems.

Dale (1972) suggests that in young oak stands stocking level be reduced to about the 60% level (near the 'B' level) as soon as possible, and that because of differences in stand structure, it is not necessary to adhere specifically to the 60% level, that it may be entirely suitable to reduce stand basal area of young oak by 10-20$f^2$. Gingrich (1971a) indicated that at age 20, unthinned oak stands would have a basal area/acre of 55-70$f^2$, and thinned stands would have 35-46$f^2$/ac. The conclusion that volume production is better with early or heavy thinning agrees with the conclusion of Johann and Dollanschutz (1974) for Norway spruce.

Heavy early thinnings repeated at frequent intervals can result in stands which mature earlier than stands which are kept at moderate stocking levels. Burton and Shoulders (1974) report that a loblolly pine stand which was first heavily thinned at age 9 to 100 trees/acre followed by two more thinnings at age 19, leaving 76 trees/acre, and age 24, leaving 64 trees/acre produced, at age 27, a volume of 11.9Mbf/ac. with a MSD of 14-15 inches; compared to a stand which was thinned every 3 years to 85$f^2$/ac. which produced 5300 bf/ac. with a MSD of 10 inches. Mann and Lohrey (1974) state that southern pine stands with 5000 or more stems per acre should be mechanically thinned at age 3 years so that there are between 500 and 750 stems per acre. Such a density will not reduce yield and treatment can be carried out at a minimum cost. Wiley and Murray (1974) after a study of pre-commercial thinning in Douglas fir found that the increase in merchantable volume in that species is sufficient to warrant adoption of early thinning as a standard practice on Weyerhaeuser lands.

Not all of the reports of early treatment indicate that the efforts are long lasting or necessarily favorable. Della-Bianca (1975) reported that a release carried out in a 11 year old mixed hardwood stand showed after 10 years that there was a 46% increase in diameter and 38% increase in basal area of released trees, but that there was no significant difference in production for cleaned over uncleaned stands. This brings out the importance in the need to consider the volume units which are used to measure production. If board foot production is the criteria for measuring production, then early thinning to get trees to a 9 inch dbh as soon as possible may show satisfactory results. If cubic foot production is used to measure growth, stand volume differences, due to tree size may not be so large with the result that stands in which partial release is carried out will not be shown to be disadvantaged from released stands.

Thinning Methods

Early release can be accomplished either mechanically or on an individual tree basis at a cost of $25-40 per acre. At the present time, it would appear that stands on better sites should be treated first; that if early release is to be effective on a cost basis, site index of northern hardwood should be greater than 60 feet; eastern white pine 65 feet; oak 70 feet; spruce-fir 46-50 feet. McCauley and Worley (1969) and Webster and Meadows (1971) indicate a need to consider site quality when considering intermediate operations in paper birch and oak stands; on the better oak sites (70-90 ft.), they estimate a rate of return of 7-8% for pre-commercial thinning in oak stands.

Method of treatment will vary with ownership. On private non-industrial land the tendency is for treatment to be applied to individual trees either by chemical or mechanical girdling, or by felling. Various estimates of cost have been made (for example, Ashley, 1975). ACP and FIP per acre rates average around $40/ac. It can be expected that axe girdling with herbicide treatment will require 6-12 man-hours per acre (average 9 hours) - about 1 acre/man day.

On large industrial ownerships and on public lands, treatment may be done with a bulldozer, a drumchopper, or a "thinning machine."

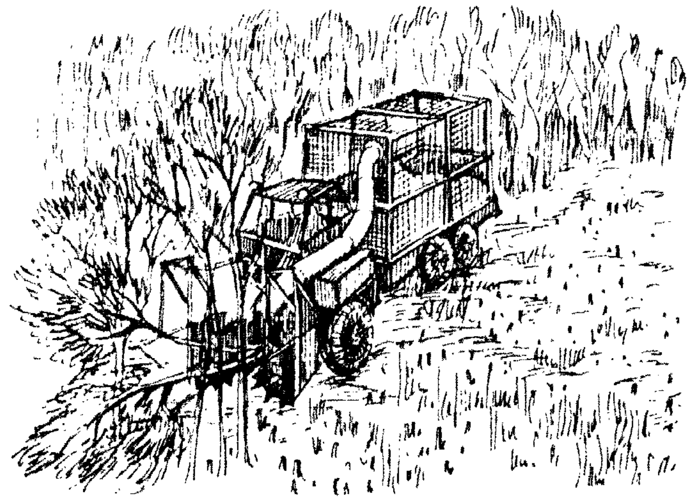
Current practice is to mash down, to chop, to cut strips (Wilton, 1971) or to cut and chip trees at intervals in the stand leaving intervening intact strips. In jack pine, 7 foot chopped strips with 7 foot intervening strips resulted in a 40-50% increase in growth of trees adjoining the strips when there were 12M stems/acre, but there was no improved response in a stand where there were 24M stems/acre (Bella, 1974). In very dense young stands, it is apparently necessary to release trees within the intact strip when mechanical thinning is carried out.

The Pallari Busharvester (Hakkila and Mákela, 1975) which is being developed in Finland may make it possible to utilize rather than destroy the material when mechanical thinning young stands (Figure 2). Even though the yield per acre from an early harvest may not be self sufficient in cost, a partial return might be sufficient to reduce the present cost of bulldozing which is around $25/acre.

## Pruning

If it can be shown that pruning increases grade recovery of lumber in a specific time, then pruning will probably pay off. Hocker (1973) using lumber grade recovery for different tree grades of eastern white pine, showed that it appears quite possible to earn a high rate of return from pruning. The rate of return for a $0.65 pruning cost per tree ranged from 9-14% depending upon estimate of value increase and length of time required for trees to reach the desired 14" dbh.

McCoy (1976) in a more thorough study of pruning eastern white pine, showed that trees having the butt log (12 ft.) which graded II or III had the best potential for retuning relatively high rates of return; that the rate of return begins to decline for investment periods beyond 30 years for Grade III trees and age 40 for Grade II trees (Table 2). It would appear that pruning to a height above 12 feet results in a reduction in rate of return if the grade of the second 12 foot log is the same as



a. Felling and chipping in clear-cutting of small-sized hardwood. Recovery of chips into the container of the bush-harvester.

b. Felling and chipping in corridor thinning of a young pine plantation.

Figure 2. Illustration of the Pallari Busharvester (from Hakkila and Mäkela, 1975)

Table 2.--Best combination for pruning white pine trees based on tree grade, pruning height, and investment period (taken from McCoy, 1976).

| Years from pruning | Grade 12' butt log | ROR pruning 0-9 | Grades 2'd 12' log | ROR pruning 0-13' | Grade 2'nd 12' log | ROR pruning 0-17' |
|---|---|---|---|---|---|---|
| | | % | | | | |
| 20 year | III | 9.16 | III | 8.62 | III | 7.78 |
| 30 | II | 7.94 | II | 6.99 | II | 6.62 |
| | | | III | 8.43 | III | 7.78 |
| 40 | II | 8.28 | II | 8.00 | II | 7.74 |
| | | | III | 8.37 | III | 7.77 |
| 50 | II | 7.78 | II | 7.54 | II | 6.93 |
| | | | III | 7.76 | III | 7.25 |
| 60 | II | 7.20 | II | 7.02 | II | 6.52 |
| | | | III | 7.14 | III | 6.70 |

the grade of the first log; e.g. Grade II - Grade II. If the grade of the second 12 foot log is lower than the first 12 foot log, i.e. Grade II - Grade III, then the rate of return from pruning increases for trees pruned to 13 or 17 feet. The study showed that at no time does rate of return for Grade I 12 foot butt logs compare with pruning Grade II or Grade III trees. Apparently, it does not pay to prune Grade I trees unless the alternate rate of return is 6% or less. The study assumed a $50 per day cost of pruning and an assumed diameter growth of 0.3 inches for pruned trees.

It would appear that satisfactory rates of return could be obtained for yellow birch if there is a good price difference between lumber grades. Whether it pays to prune spruce, I cannot say. This would depend on the value difference for the different grades. Berry (1964) did find that it required twice as much time to prune white spruce (9 minutes to 17 feet) as it did to prune white pine to the same height; however, he did indicate that where a market differential existed for pruned spruce, that pruning did seem feasible.

The results of the white pine analyses do show that it is important for trees once pruned to maintain a rapid diameter growth rate. At least 0.3 inch annual diameter increase is required; if diameter growth is less, rate of return is less.

Fertilization

Here the picture is blurred. Reports of significantly increased tree growth in other regions after application of nitrogen and/or phosphorus are accepted. When we look at results for local studies, the growth responses are not always encouraging. Hendrickson (1976) showed that average annual volume growth of white pine treated with 400 lbs./ac. of N; 50 lb./ac. of P; 100 lbs./ac. of K was 10% over 5 years compared to 7% for control. There was much variation in the data and the increase in growth was significant only at the 5% level. Safford and Filip (1974) reported that fertilizing 4 years after clearcutting a northern hardwood stand stimulated growth of pin cherry so much that growth of the more valuable stems in the stand was suppressed. Van Althen (1973) recommended that fertilizer not be used at the time of regeneration in northern hardwoods. A southern report (N. C. State, 1976) indicated that there was no response of naturally reproduced hardwood stands to N. and P. applications.

Leaf (1970) summarized the results of their studies with potassium on conifers growing on a Hinckley soil in New York. Red and white pine and red and white spruce showed responses to applications of K, while Scots pine did not show a response. The response of red pine was best at 110 to 165 Kg/h (98-147 lbs./ac.). A response to K was reported for pine growing on wind blown soils in Europe (Bruning and Krolikowski, 1973). Stratton, Safford and Struchtemeyer (1960) note that white pine responded to K 100 lbs./ac. on a droughty site.

Gagnon, Conway and Swan (1976) state that for white spruce additions of other elements as well as nitrogen seemed to produce little added response in closed stands. They did find that addition of potassium as potassium sulphate at rates of 100 to 200 lbs./ac. resulted in an increased wood value in 1975 of $18.00 for a $2.36 cost (an ROR of approximately 16%). They indicate the 1975 nitrogen costs have reached a level where it is not feasible to consider using urea fertilizer.

Weetman (1975) reported that black spruce responded to both thinning and fertilizer application. Best response was to 50% reduction in basal area and application of 400 lb./ac. N (29.7$f^3$/ac./yr.) but this was not different from 100 lb./ac. of N (29.0$f^3$/ac./yr.). This would compare to an increase in growth rate of 50$f^3$/ac./yr. for white pine receiving 400 lb./ac. N (Hendrickson, 1976).

Weetman et al (1974) reported on a number of studies involving black and red spruce and jack pine where growth increased 7-24 $f^3$/ac. for black spruce, and 20-22 $f^3$/ac. for jack pine after application of 100 to 400 lb. N/ac. Best response for black spruce again as the 50% thinning and application of 400 lb. N/ac. where growth response of 37.8 $f^3$/ac./yr. was noted.

Although the responses to N fertilizer appear significant, growth increases reported to date do not appear to warrant a great amount of enthusiasm when they are considered in a cost/unit growth context. For example, if the response of white pine to an application of 400 lb./ac. of N. is considered, fertilizer would cost \$78.80/ac. (spring 1976 cost of N as $NH_4NO_3$ = \$0.187/lb.) for the N. Over a 20-year period at a 6% ROR, this cost would increase to \$239.89. If stumpage is worth \$0.176/cu. ft., a growth response of 1363$f^3$ in 20 years (PAI = 68$f^3$) would be required to return the cost of fertilizer alone. Using the estimate of Cromm (1974) for determining delivery and application costs, and adding these costs to the cost of N reduces the ROR to 4.4% over 20 years, assuming growth increase is sustained for the 20-year period.

It is quite important when applying fertilizer that growth increase be placed on the larger trees in the stand (Moller, 1971); that none be wasted on small unmerchantable trees or on understory vegetation. Therefore, stands to receive fertilizer should be ones where there is an adequate stocking of commercially valuable trees.

Although site quality has not been directly related to fertilizer application in the Northeast, Handley and Pienaar (1972) note that growth response of Douglas fir to N application increased with increase in site index and with application of N up to 300 lb./ac. Perhaps the lack of a relationship to site quality and N application in the Northeast is the result of site quality not having been measured directly in each study. A site quality growth response can be implied on excessively drained soils (low site) where responses to K are recorded. Responses to N have been recorded on the well-drained to somewhat poorly-drained (med. to good) sites. Pritchett and Gooding (1974) indicate that established stands of slash pine on poor to somewhat poorly-drained soils may need applications of N and P, or N-P-K; on moderately well-drained soils stands may require application of N; on excessively-drained soils stands may require N only.

Summary

It is important when contemplating any intermediate silvicultural treatment that consideration be given to stocking and to site quality. Stocking guides are available for most of our commercial tree species. Value increase per unit of production should be the criteria used to measure response to treatment. Before a treatment can be considered for operational use, unit cost of treatment should result in a marginal return sufficient to pay the cost of treatment. It would seem that when research results are reported, response would be best measured as periodic annual increment, in cubic foot/acre/year. By doing this, it is possible to make estimates of marginal value increase.

Pre-commercial thinnings should be made as early as possible after stand establishment, probably when stand MSD is between 1" and 2". Thinnings seem feasible where stand composition can be altered so that the more valuable species are favored on the better sites, and where stocking levels for young stands exceed that required to meet the 'B' line level at 5" MSD. Pruning can be considered for white pine, white spruce and yellow birch where there is a premium for clear wood.

More research is required to determine where fertilizer application has a place in the Northeastern forest. We also need to improve computer simulation programs to permit more precise estimates of growth and estimates of returns for intermediate practices, primarily from different thinning methods. Eventually, computer programs should be developed to take into account pruning, fertilization, and use of genetically improved trees.

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