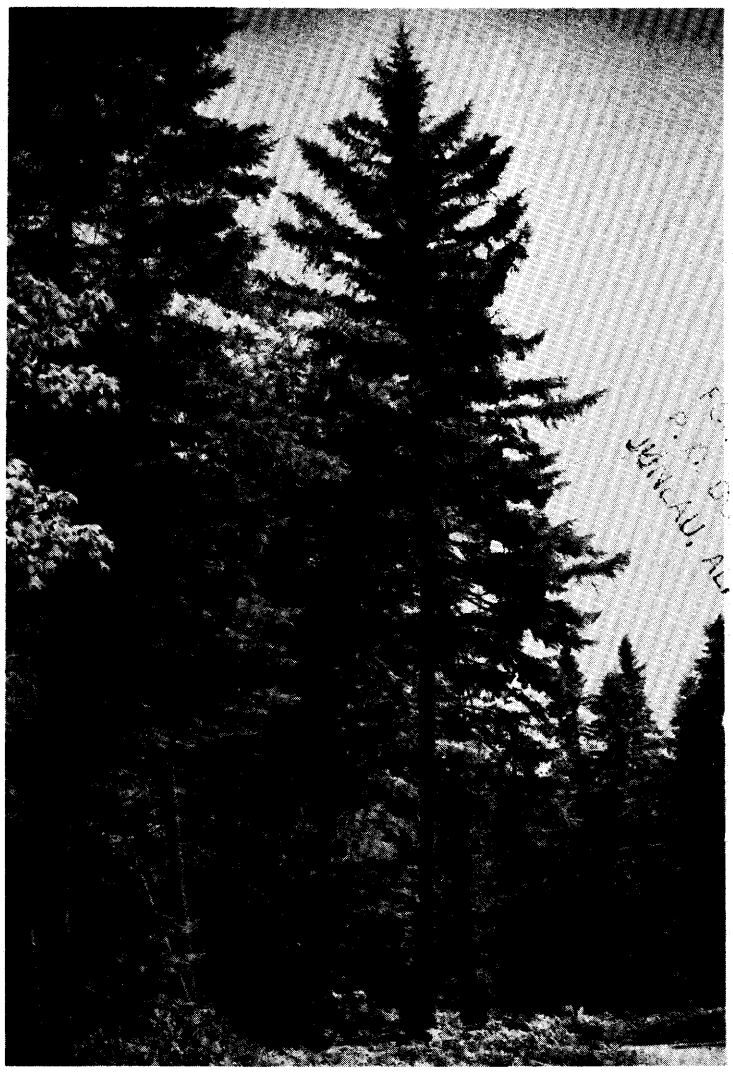
Proceedings of the SYMPOSIUM ON INTENSIVE CULTURE OF NORTHERN FOREST TYPES



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FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
NORTHEASTERN FOREST EXPERIMENT STATION
6816 MARKET STREET, UPPER DARBY, PA. 19082

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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- School of Forest Resources, University of Maine
- Maine Bureau of Forestry
- Maine Forest Products Council
- Forest Service, U.S. Department of Agriculture

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Canada: 22 July 1976, morning session.

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DISCUSSION PAPERS

Below is a list of discussion papers on important topics that were presented Tuesday evening, 20 July. These papers are not included in the proceedings, but copies may be obtained from the authors.

"Summer planting of container-grown northern hardwoods":
Raymond E. Graber, plant ecologist, USDA Forest Service, Durham, N.H.

"Planting and intensive culture of yellow birch to improve timber quality and production": Peter R. Hannah, associate professor of forestry, University of Vermont, Burlington.

"Birch management—cleaning and weeding": R. W. Nash, G. A. LaBonte, and F. H. Manning, Department of Conservation, Augusta, Maine.

"Spruce-fir silviculture and management in the northeast":
Robert M. Frank and Ken Lancaster, USDA Forest Service, Orono, Maine (slide-tape program).

"Opportunities and limitations of northern forest types in Alaska":
John Galea, Alaska Planning Team, Anchorage, Alaska, and John Zasada, Institute of Northern Forestry, Fairbanks, Alaska.

"Economic aspects of intensive management; directions of technological change currently inappropriate": Lloyd Irland, Department of Conservation, State Bureau of Forestry, Augusta, Maine.

TRANSLATING FORESTRY KNOWLEDGE INTO FORESTRY ACTION

by John R. McGuire, Chief, Forest Service, U.S. Department of Agriculture, Washington, D.C.

Abstract

The non-Federal forest lands, which comprise three-fourths of the Nation's forest lands, are the key to meeting projected future needs for all forest products and uses. At the same time, the Federal role in State and Private forestry cooperative programs is being critically questioned. Public attitudes toward Federal expenditures, and the possibility of sunset legislation, may change the nature of Forest Service cooperative programs. One possible approach would be for each State to develop a comprehensive forestry plan suited to both State and national needs, perhaps related to a national program expressed through the Resources Planning Act process, as a basis for granting Federal funds for cooperative forestry activities.

I am very pleased to have the honor of opening this symposium. It's good to be back once again in the great State of Maine and to be a part of what promises to be a very productive and interesting discussion of the culture of northern forests. We all know that here in Maine, the State that proudly claims the highest percentage of forested land in the Nation, the future economic outlook depends upon intensive culture of all lands. And, in Maine, this means private forest lands. Certainly, no State depends more on its forest lands.

The agenda for this conference promises a rather comprehensive review of the culture of northern forest types. But, to get the meeting underway this morning, I'd like to set the background in a way quite different than you might expect.

I have been increasingly concerned in recent months about the outlook for State and Private forestry in this Nation. Unprecedented challenges face us in the next few months and years regarding the non-Federal forest resource.

There are many reasons for each of us here today to be concerned about State and Private Forestry. After all, the silvicultural knowledge that has been so painfully acquired over these many years finds much of its application on the three-fourths of the Nation's forests that are privately-owned.

In addition, the Assessment of forest and rangeland resources prepared under the Resources Planning Act confirmed that small, non-industrial private forestlands are the key to meeting increased needs for wood and other forest products in the next half century.

But, how do we get this land into production? There seem to be almost as many theories on this as there are speeches during an election year.

The challenges that face State and Private Forestry today are substantial and real. For example, when the President transmitted the Resources Planning Act documents to the Congress early this year, his Statement of Policy stressed concerns over the Federal role in State and Private Forestry. Today there is unprecedented questioning of the effectiveness of, and the rationale for Federal participation in programs targeted toward non-Federal lands. There is a strong feeling that the private sector and the States can and should provide the investments in and management of these lands. There is a strong feeling that the market forces are adequate to assure sustained and adequate supplies of timber and other forest resources far into the future. Thus, the Federal role in S&PF cooperative programs is being critically questioned.

Another dimension of this new concern is the so-called Monongahela controversy. Certainly any legislation which changes the 1897 Organic Act could have far-reaching implications for private forestry. If timber flows from the National Forest System are reduced through legislative direction, and assuming that demand for timber products continues as projected, it is obvious that the vast acreage of non-industrial private land in particular will feel the brunt of increased pressure for harvest.

Let me assure you that the Forest Service considers the State and Private function a major responsibility. It is an essential part of the total mission of our agency. We are well aware that the greatest remaining challenges to forestry in this Nation are found on these lands. We know that the inter-relationships between State and Private Forestry and the National Forest System—particularly in the West--and with Research, are strong, and mutually supportive. We know that in many States--and Maine is a good example--private forest lands form a large part of the foundation of the economic and social well-being of the people. We intend to do our best to meet the emerging challenges of S&PF.

For those of you who may want to do some reading on this general subject, there are many recent analyses—for example the latest Forest Service "Timber Outlook Report" is a reasonably fresh set of statistics on forest land capability. The Resources Planning Act Assessment released in January is another. The President's Advisory Panel on Timber and the Environment put out a very comprehensive report in 1973. The National Commission on Materials Policy Report of the same year also paints a strong picture of the major significance of private forests in the United States.

We know what the challenge is. Now, how do we meet it? First, I would note that there is now, and has long been, a widespread philosophical opposition to subsidy or incentive payments to private landowners. Yet, it seems apparent--and here's where we need more analysis and data—that the typical non-industrial landowner simply will not make the investments needed in reforestation and intensive culture without some external motivation. All of us are aware of the reasons for this. But, what is lacking is a definitive analysis and projection of what would take place in the private sector without Federal or State intervention.

Some economists claim that the market place is the best arbitrator of national demands and supplies. Yet recent history has shown that market forces are not adequate to get small, non-industrial holdings into production. There has been little response to the sharp stumpage increases a few years ago and most landowners are fully aware of the fluctuations in the market price for timber—and the reality that most harvesting on their land will be done by the next generation.

I am sure this audience is well aware of what I might call the inadequate technology transfer of forestry research. We simply are not getting enough of our research findings applied on the ground. There are still many barriers that lie between the advancements of the research scientist and the practicing forest manager. Much of that linkage must come from State and Private Forestry activities such as the Cooperative Forest Management Program and from Forestry Extension programs.

There is also clearly an inadequate data base for benefit-cost determination, program evaluation, accomplishment reporting and other quantitative expressions of the effectiveness of Cooperative Forestry Programs. Until we overcome these inadequancies, we are of necessity put in the position of arguing for technical and financial assistance to State and private landowners without the necessary facts in hand.

I could elaborate for some time on the challenges facing us in State and Private Forestry as we begin this third century, but instead I would prefer to discuss some of the possible ways in which we, as a Nation, can assure that these lands are managed and protected.

Let's first take the definition or rationale for the Federal role in S&PF. Many would argue that the Federal role is and should be a catalytic role. For example, the Clarke-McNary law of 1924 established the Cooperative Fire Protection activities commonly known as CM-2. After some 52 years, the President's Office of Management and Budget argues that the program has been successful as a catalyst and should be terminated. The States have been able to establish strong capability in forest fire protection and therefore, the argument goes, there is no need to continue an outlay of some $20 million a year in payments to States. They point out that the Federal share now amounts to only about 15 percent of the total expenditures. On the other hand, the State Foresters and Congress argue that there is a continuing Federal responsibility to share the cost of protecting the Nation's private forest lands. Put simply, they conclude that it is in the national interest to have well-protected forests. The President proposes no further payments to States for this activity. The Congress, however, continues to appropriate the funds.

Another illustration, of great significance here in Maine, is the Cooperative Forest Pest Control project. As you well know, the Spruce Budworm outbreak here and in Canada is causing great and continuing concern. In recent years, the Federal Government, through the Forest Service, has contributed many

millions of dollars in repeated attempts to reduce the losses from Spruce Budworm. The State has just completed the largest aerial spraying in forestry in the United States, some 3 1/2 million acres. There are those who argue forcefully that the Federal role in pest control should be much less than a 50-50 partnership, in terms of dollars expended.

And so we are faced with the continuing need to analyze and rationalize, and establish a consensus on, exactly what the Federal role should be in protecting, developing and managing private forest lands.

Developing a rationale for Federal participation in Cooperative Forestry Programs is not something that lends itself to scientific analysis or linear programming or any other kind of hard data manipulation. Rather it is in the more difficult area of policy over what might be termed "shared responsibility" among interested parties.

To approach this question we plan to have a series of discussions with the parties concerned. For example, here in Maine later this year we plan to meet with all of the interests involved and review our strategy on Spruce Budworm control. We hope to have our Canadian friends participate in that program. This will not be a large conference, but rather a small group of the decision shapers and makers who must determine what each of the various roles should be in facing a very serious threat to Maine's forest resources. Out of that discussion, we hope to identify what the Forest Service role should be, as well as the roles of the State, private industry, and small landowners.

Another dimension of the emerging challenge to S&PF is finding much better ways of targeting the Federal contribution to Cooperative Forestry Programs. Most of the payments to States are based upon a formula distribution that attempts to provide equity among the States in receiving their share of the Federal funds made available for fire protection and technical assistance to landowners through the Cooperative Forest Management Program. In both of these long-standing programs, the formula distribution procedure is increasingly questioned. As the States increase their capability, and become dominant in the sense of far-overmatching the Federal dollars, there is less and less weight to arguments for providing Federal dollars to stimulate the program. Instead, what is needed is a targeted or directed use of Federal dollars for specific purposes, with accountability that will make possible cost-effective analysis of the Federal participation.

We are beginning to move in that direction as we work with our cooperating State Forestry agencies in revising our approaches to meet the new situation. The situation, obviously, is far different in 1976 than it was in 1924 or 1950, when these major pieces of legislation were enacted.

One illustration of the targeting approach is our so-called Sawmill Improvement Program. This activity comes under the Cooperative Forest Management Act funding and is targeted to aid mills who request assistance in improving their operations. The State Foresters and the Forest Service have been quite successful in providing this kind of technical assistance--and the results have been quite dramatic. The output of lumber from the same volume of logs going to the mill has been increased an average of about 13 percent simply by following better quality control procedures. The potential is there for even greater increases in yield. This is a good example of the effectiveness of applying some of the research knowledge that is developed at the Forest Products Laboratry and elsewhere.

The public's attitude toward Federal government expenditures is also a major element in the future role of State and Private programs. Some critics claim that we have too much government, too much bureaucracy, too many programs that are initiated but never terminated. The Office of Management and Budget has taken the stand that Federal agencies will not continue to do "business as usual." Sunset legislation may become the law. In fact, Congress and the States share this feeling to a large extent. In other words, I do not foresee that a law passed in 1976 can continue on for decades, as have the Clarke-McNary law of 1924, the Forest Pest Control Act of 1947, the CFM Act of 1950, and other major pieces of Cooperative Forestry legislation. Rather, we should think in terms of completion dates for programs, whether they are 5 years or 10 years or whatever. We should set a target to accomplish a specific objective and then conclude the program and move on to something else. The Rural Community Fire Protection Program is one illustration of Congressional direction in this regard. It provided for a 3-year pilot program and there is every indication that if the legislation is renewed it will have a very precise time limitation.

Closely tied to all of this is the need for better program evaluation. Federal legislation is increasingly requiring formal program evaluation. Both the Forestry Incentives legislation of 1973 and the Rural Community Fire Protection legislation of 1972, for instance, have this requirement. The picture emerging clearly shows increased attention to

the effectiveness of various State and Federal programs. Agencies such as the Forest Service must justify and prove the effectiveness of their activities more than ever before. And this means that we must develop an adequate basis—a factual basis--for program evaluation that is much better than we have ever had before.

There is no doubt that private lands--particularly small, non-industrial holdings—are the key to meeting the future demands for forest resources. And please remember that while this conference deals mainly with wood supplies, the demands for other forest uses are increasing just as rapidly--in some cases, more rapidly.

Those of you in the Northeast are well aware of the escalating demand for recreation, for both developed facilities and wilderness opportunities. The Allagash River is a classic example of what can happen when user demand outstrips the available resource--and the resource suffers. In other areas of the country, use of Federal rangelands is becoming highly controversial--and decisions have to be made that balance the Nation's red meat needs with the need to protect the rangeland resources. All other resources from our forestlands--water, wildlife and subsurface minerals—are also priority candidates for intensive management.

Incentives, education, and other forms of assistance are one approach to insuring adequate management and protection of private lands. But there is another approach which has become more dominant in the last few years--and this is regulation. On the Federal level, we have such laws as the Federal Water Pollution Control Act Amendments of 1972. At the same time, many States are rushing to enact their own requirements, involving everything from forest practices acts to coastal zone management. Federal and State legislation is surfacing many debates—what lands should be regulated, what level of government should do the regulating, and just as importantly, who should foot the bill?

Nor can we dismiss the international picture when we talk about meeting future needs in this country. Last year marked the first time in history that the dollar value of our timber product imports caught up with our exports.

I think these considerations--coupled with requirements for 5-year reporting periods of Forest Service accomplishments under the Resources Planning Act--logically point to some new future directions in our Cooperative Forestry programs. Let me conclude by expressing a hope about where we may find ourselves moving as we progress through the remainder of the 1970s. Basically, we are placing our hope in the idea that in each of the 50 States it will be possible to develop a comprehensive forestry plan.

One way in which this might work is through a block grant approach, very similar to the Federal revenue sharing program. It could perhaps be a 10-year plan, starting with a State resource assessment, tying into national needs as expressed through the Resources Planning Act process, and progressing to each State organization developing a forestry plan suited both to that State and to national needs. The Forest Service would then evaluate the plan, and provide a block grant to implement the plan.

Last March I wrote to each of the State Foresters, in effect challenging them to pick up this "mantle of leadership," through their resources planning process and to provide much of the State leadership necessary to bring together the various interests in forestry assessment and program development. I am happy to tell you that almost every State Forester responded positively. They are ready and willing to move forward in this direction.

I hope these comments have helped set at least a part of the stage for this symposium. I'm sure you will touch on many aspects of the need for technology transfer and for applying forestry knowledge to non-Federal lands. I believe that all forestry interests--scientists as well as practitioners--must focus their attention on this vast acreage of productive forest land that is one of the rich blessings of this Nation. It is simply not enough to know how to achieve intensive culture of northern forest types--or of any other forest type. We also need to be able to deliver that know-how and to make it effective. Transforming knowledge into action will require the coordinated efforts of all of us who are dedicated to the management and protection of this Nation's forest resources.

WOOD AS A STRATEGIC MATERIAL

by Kenneth S. Rolston, Jr., executive vice president, American Pulpwood Association, Washington, D.C.

Over the medium and long run timber can provide a major contribution to improving the balance of payments caused by the increase in oil prices. It can do so without causing severe shortages at home. This is basically the position held by most senior executives in the forest industry and I'll try to discuss briefly some of the factors necessary to fulfillment of their prognosis.

First, however, let's look at the other side.

> Let's not export our logs until we know we have enough timber for our own uses. Let's not back ourselves against the wall. Let's cut off exports and provide for our home industry. We can change later is we see we have an adequate supply.

This is a warning from a "Friends of the Earth" spokesman calling for an export ban on logs from National Forests.

In further support of the shortage advocates, Bruce Zobel of North Carolina State University in an article in American Paper Industry magazine predicted shortages of quality pine and hardwood in the South.

If our forests are to become strategic in the sense that sufficient excess production will be available for export, policy corrections will have to be made and these must be based on careful analysis of a number of controlling factors. The first is the worldwide market situation and prospects.

In recent years there has been a rapid increase in the worldwide use of wood. Population growth is one factor but other important influences are improve-

ment in the standard of living, technological changes resulting in new products, acceptance of more species as industrial raw material, and use of wood for fuel as oil prices increase. Demand in Europe and Japan is expected to show fast growth. Projections indicate European demands will double by 2000, primarily for pulp and paper products. Limited European timber supplies are expected to result in major annual deficits as high as seven billion cubic feet. Japan is already dependent on imports for over half of its requirements and this deficit situation is predicted to increase for at least several decades until her forests may be able to improve their yields.

We're familiar with predictions of U.S. demand in the year 2000; double for paper and board and substantial for lumber and plywood. In that year we'll have 55 million more people and expect a much higher standard of living.

The FAO predicts world demand to rise by 45 billion cubic feet in the 1975 to 1990 period, nearly 50 percent. Fuelwood is expected to account for 20 billion cubic feet and pulpwood for 15 billion cubic feet in that period leaving an increase of 10 billion cubic feet for sawlogs and panel products.

If we accept the premise that the markets will be there, where will the wood come from?

A recent study for the American Pulpwood Association made by Jaako Poyry, a worldwide forestry consulting firm, looked at the worldwide supply of wood along with present and future demand to the year 2000.

The firm identified Japan, Europe, the United States, China, and India as areas that will need more wood than they can supply. On the other hand, Canada, Siberia, Brazil, tropical Africa, Indonesia, and Burma are expected to have surpluses. These regions will have problems and drawbacks that will prevent actual utilization of their wood.

Brazil is planning rapid expansion of her forest

industries including expanding pulp production from one million tons in 1972 to six million tons in 1985. Brazil is expected to use most of the increase in production so the amount available for export to the deficit countries will be of marginal importance. Lack of a developed economy, lack of technical know how and other problems will continue to impede development and use of Brazilian forest for years to come.

The same problems exist in tropical Africa to an even greater degree and Asian wood is likely to be utilized primarily in that region.

Although the Soviet Union has surplus growth, most of the wood for its expansion will have to come from Siberia - an area lacking infrastructure located a tremendous distance from the final market. It is expected that Soviet domestic consumption of wood products will keep pace with the rate of production. For example, their consumption of paper per capita is only 1/10 that of the United States.

Canada has vast unutilized forest reserves and the potential for nearly doubling its allowable cut but much of its forests are economically inaccessible. Increasing distances from woods to mill as nearby forests are cut, the problem of getting sufficient labor to the woods and rapidly increasing costs will probably prevent large expansion of the Canadian industry.

It is hard to imagine the U.S. as a "deficit" area. Our supply of wood has always been more than adequate and we have had a surplus of growth over drain for many years. The rise in exports since 1950 has just about offset the increase in imports and there hasn't been much change in net trade. Net imports in 1973 were 1.6 billion cubic feet, some 12 percent of total U.S. consumption.

The prognosis reached by Jaakko Poyry is of most interest:

> The final conclusion is that, in spite of vast unutilized forest resources in differ-

ent parts of the world, it will be difficult to supply the deficit areas of the world with wood from surplus areas. Thus, the deficit regions must contribute much more than is usually assumed. Those regions generally have a well-developed infrastructure and an established industry close to the market. Therefore, the forest industry within these regions should be capable to pay a quite high wood price before it is more economical to invest in countries with less developed economy. Higher wood price means that more money can be invested in silviculture and other measures to increase forest production. The most interesting region in this regard is, without doubt, the USA, which has a potential for an increased harvest both for softwood and hardwood. The potential is big enough not only to supply the expected deficit but also to turn the US to a net exporter of forest based products.

So the real question is how to get from here to there. How can the U.S., in a few decades progress from deficit status to surplus? You will get the answers over the next several days and then be ready to go out and put them into practice in the field.

In simplified fashion the answers given to the question, at least in my mind, fall into two categories:

1. Increase productivity on all classes of forest lands
2. Improve utilization of the timber we harvest

The list of tools in our forestry toolkits aimed at increasing productivity is long and will be explored in depth during your symposium. Whether they will be used to the extent necessary to make wood a strategic material depends on policy decisions and resultant capital availability. Policy decisions with respect to public and private forests may in the future provide the motivation for allocation of capital for

forest productivity, or may move even more to withdrawals from the forest land base for other uses and non-economic restrictions on forest productivity to achieve social or environmental goals. The forestry profession has a part to play in the decision making process but in the final analysis I am not optimistic about the current chances for using economics or world trade opportunities as "hot buttons" for our legislators. We have a lot of work to do.

We have shown our ingenuity in increasing utilization of mill and forest residues and we can and will do more. Seminars and symposiums on the subject abound and there's no need for me to try to go into detail. Those of us with industry are proud to point out that with only 13% of the forest land we supply one third of the harvest. But we have not been able to develop or implement ways to similarly increase output from public and nonindustrial private ownerships.

This symposium does show that we're aware of our potential and want to get on with the job ahead. Wood can be a strategic material and forestry technique can increase productivity and improve utilization. Can we influence policy decisions so that capital will be allocated to do the job?

In closing I'd like to talk about the current situation in Sweden as an example of how a deficit situation can occur and the steps that country has taken to try to bring supply back into balance.

In 1974 Sweden was still a net exporter of unprocessed wood. Norway received 600,000 cords of roundwood and 160,000 cord equivalents of chips. The net export to Finland was 50,000 cords of roundwood. Small quantities were imported from Germany, Poland, the Soviet Union and the United Kingdom.

In 1975 the picture in Sweden changed and Sweden's forest products industry faced a shortage. Harvest was estimated to be 12% higher than growth. The report of the Swedish State Commission on National Forest Resources indicated that if the gross cut were maintained

until 1980, at a level corresponding to the industry's 1973 consumption, the harvest from Sweden's forests would thereafter have to be reduced by 20% to achieve a sustained long-term yield.

Swedish forests are among the most intensively managed in the world. Why did Sweden get into this situation? There are some reasons:

1. Up until 1973 wood prices had remained about the same for 15 years while costs had increased. As a result, the economics of Swedish forestry suffered a consistent downward trend. Inadequate reforestation resulted and timberstand improvement activities were curtailed due both to lack of funding and environmental restrictions on chemical spraying.

2. Another critical concern for Swedish forestry is an unfavorable distribution of forests by age class. Sweden has a relative shortage of forests aged 20-40 years as the result of extensive thinning operations which did not create enough young forests and slow start-up of new stands due to insect damage and overcrowding.

3. Statistical surveys on the condition of Swedish forests were overly-optimistic. The "margin of error" is unclear.

The Swedish government took action. Restrictions were made on industry expansion unless it was based on imported raw material. Investments in intensive management of state-owned lands were escalated and a new more detailed forest survey was begun.

Swedish companies began to look for a new source of wood. After looking at all possibilities throughout the world they determined that the United States would be the best source of supply from both an economic and political standpoint.

Since then, Wood Fiber Market Corporation has been formed in the United States by sawmill owners to sell chips to Sweden. Louisiana Pacific Corporation is

constructing chip export facilities at Lake Charles, LA, Weyerhaeuser has exported eight shiploads from Morehead City, NC and Georgia-Pacific is planning a deep water export facility at the Port of Savannah, GA.

There are some lessons for us in the Swedish experience. We must not wait until the limits of our forest resource are hard upon us. We must provide reasoned and effective opposition to those who would further restrict forest productivity. This nation has the potential for world leadership in forestry. We have the means and must find the ways to stimulate action.

NATIONAL AND REGIONAL NEEDS FOR INCREASING WOOD YIELDS THROUGH INTENSIVE MANAGEMENT

by Robert B. Phelps, research forester, Forest Economics and Marketing Research Staff, USDA Forest Service, Washington, D. C.

Abstract

Several recent studies show that U. S. timber markets are likely to grow rapidly in the next few decades. Part of the rising demand can be met by increasing the utilization of the timber harvested and more efficient manufacturing and construction processes. In addition, part of the increase can probably be supplied by rises in net imports, particularly at higher price levels. However, it seems clear that to meet prospective increases in demand much beyond the 1970's, it will be necessary to grow more timber in domestic forests. There are opportunities for increasing supplies from all ownerships and in all sections of the country. Through intensified management, domestic forests have the capability of producing at least twice the volume of timber they are growing today.

In recent years, spectacular increases in the price of stumpage and timber products, difficulties of many mills in obtaining wood, and concern about the future adequacy of our timber supplies has created a lot of interest in our prospective timber situation. This has resulted in a number of congressional hearings and studies. Since 1968, there have been at least 12 major studies and reports on the topic.

"The Outlook for Timber in the United States", prepared by the Forest Service (which will form the basis of most of my talk), the "Report of the President's Advisory Panel on Timber and the Environment", and "Timber: The Renewable Material", prepared for the National Commission on Materials Policy, have been widely distributed and are probably familiar to many of you. Some of you have also seen and possibly reviewed a draft of the Forest Service's assessment of all renewable resources which was required by the Forest and Rangeland Renewable Resources Planning Act of 1974.

Although there are substantive differences among the reports in content and objectives, the major conclusions about the timber

outlook are in remarkably close agreement. For example, there was agreement that the Nation's demands for timber products are likely to grow rapidly in the decades ahead. Since this is an important conclusion in analyzing our timber situation, I would like to briefly discuss its basis. I will follow this with a discussion of the possible ways of meeting the projected increases in demand.

Patterns of past consumption provide one indication of future demand. A look at recent trends shows that U. S. consumption of industrial roundwood (i.e., all timber products except fuelwood) increased from 9.9 billion cubic feet in 1950 to a peak of 13.4 billion in 1973--a rise of some 35 percent. Consumption fell in 1974 and again in 1975 as economic activity in most of the major markets declined. Particularly important were the down-swing in housing output, which in 1975 dropped to the lowest level in about 30 years, and the declines in paper and board demand. In response to these trends, consumption of industrial roundwood dropped to 10.7 billion cubic feet in 1975--about a fifth under 1973 demand. Despite the sharp decline, however, 10.7 billion cubic feet is still 5 percent above average consumption in the early 1960's. Current trends indicate that total consumption for 1976 will be somewhat larger than in 1975 and probably rise further in 1977.

Now these data on what has been happening are interesting and instructive as I noted before. However, our basic concern here is in what lies ahead. Can we expect continued growth in demand or is the current cyclical down-turn a harbinger of things to come?

Today, the future appears to be much more uncertain that it did a few years ago. The large jump in the price of fossil fuels, inflation, and the other problems that we face could materially affect economic growth and future markets for timber products. However, our historical experience suggests that we will surmount our present difficulties and that we can, with some degree of confidence, expect markets for timber to continue to expand and grow.

One of the important indicators of future demands for timber products is population. Recent trends in fertility rates indicate that population growth is likely to be below what had been generally anticipated in the 1950's and 1960's. Nonetheless, the most recent Bureau of Census projections show that if present fertility and immigration rates continue, the Nation's population will be some 265 million people in 2000, about 50 million more than we have today. I know that this is difficult to relate to timber demand. But perhaps it may help to realize that an increase of this size is about four times the current combined population of the six New England States. When you consider the

number of houses, stores, schools, factories, and other structures in this area, you can begin to appreciate what the anticipated growth in population means in the way of additional demands for timber and other materials.

In addition to this increase in numbers, the income available for people to spend is likely to continue to grow rapidly. Most recent projections, for example, indicate that per capita disposable income will more than double by the year 2000. This means, of course, that we will not only be faced with the task of meeting the additional demands of 50 million people, but the demands of 265 million people with a much higher standard of living.

On the basis of these kinds of expectations about population and economic and income growth, it seems clear that we are faced with the prospect of large increases in the demands for most timber products. The demand for paper and board, for example, is projected to roughly double by the year 2000. The demand for pulpwood is expected to show a similar rise. Projected demands for lumber and plywood also show substantial increases.

There seems to be only three practical ways of meeting the projected increases in demand. First, we can improve the efficiency with which we utilize the timber we harvest; second, we can increase the volume of net imports; and third, we can grow more timber in our domestic forests.

We have made large gains in the utilization of wood material that once presented a residual disposal problem. For example, the volume of chips--products from slabs, edgings, veneer cores, and other similar coarse material--consumed in woodpulp mills increased from 1.3 million cords in 1950 to nearly 28 million cords in 1974. Use of sawdust, shavings, and other fine material for pulp and particleboard also has been increasing.

While these gains have been impressive, there is the potential for far greater increases. In 1970, for example, more than 20 million cords of wood were left unused in the forests after logging or land clearing. This was the material left from what we call growing stock (i.e., live desirable or acceptable trees of commercial species more than 5 inches in diameter at breast height). There are much larger volumes of rough and rotten trees, dead trees, limbs, material under 4 inches in diameter, and roots available for use. As you all know, we are beginning to use this material; whole tree chippers are coming into common use in some sections of the country, and developmental work is underway aimed at making it economically feasible to utilize the taproots of some species such as the southern pine.

In addition to these kinds of residues, there was approximately 12 million cords of wood left unused in primary manufacturing plants in 1970. There were also large volumes of waste paper and other secondary manufacturing and consumer residues available for use.

A substantial part of the residues I have been talking about occur in such small volumes or in locations so remote from processing facilities that they are not now, or are they likely to be, economically usable. Nonetheless, the potential is great and this resource is likely to be drawn upon to an increasing degree in the period immediately ahead.

Some of the projected increases in the demand for lumber and plywood could be met by increasing the product output from logs through the use of thinner saws and more precise manufacturing methods and equipment. Development of stress grading systems and better product design could also extend supplies by increasing the efficiency in the use of lumber and plywood in manufacturing and construction. There is also the possibility of increasing pulp yields, although in recent decades technological advances in this direction have apparently been offset by the losses associated with the increasing production of semi-bleached and bleached pulps.

When all things are added together, it seems clear that the potential from improved utilization is large. However, even the most optimistic estimate of prospective gain is far below the projected increases in total demand.

I would now like to turn to the second possibility, increasing supplies through improving our net imports situation.

Between 1950 and 1973, imports of timber products increased from about 1.5 to 3.1 billion cubic feet. Although the volumes imported dropped somewhat in 1974 and 1975, they were still above any year prior to 1966. Softwood lumber, nearly all from Canada, accounted for over half of the growth in imports in the past 25 years and pulp and paper products, also nearly all from Canada, most of the remainder. Hardwood plywood and veneer imports, chiefly made from lauan originating in the tropical forests of insular Southeast Asia, also increased rapidly, although in 1975 they still represented less than 10 percent of total imports.

The softwood timber resources in British Columbia and the northern parts of the eastern Canadian Provinces can support a much larger harvest. A substantial increase in imports of softwood lumber, newsprint, and woodpulp from this resource is thus possible, especially at the higher prices which seem to be in prospect. Tropical hardwood forests also have the potential to supply much larger quantities of hardwood plywood and lumber.

Exports of timber products, chiefly pulp products and softwood logs, have also been rising rapidly since 1950, moving up from 0.1 billion to 1.3 billion cubic feet. Exports were also down in 1975, however, the decline was not nearly as great as for imports. Most of the growth in exports has largely reflected a combination of rapid increases in demand and inadequate timber supplies in western Europe and Japan--the major importing areas--and relatively stable prices in the United States. The latest studies of the timber outlook in the importing areas indicate that demands will continue to grow and that domestic timber supplies will fall increasingly short of domestic requirements.

In summary then, it seems that if prices remain relatively stable, increasing exports will largely offset rising imports and our net import situation may not change appreciably. At higher prices, net imports could show a significant rise, especially net imports of softwood lumber, newsprint, and woodpulp from Canada.

Although part of the projected growth in demand can be met by improved utilization and increases in net imports, the potential gains are relatively small in comparison to the projected total growth in timber product markets. Thus, if the projected growth in demand is to be met, it must come from domestic resources.

As is the case with economic growth, recent developments have tended to cloud the outlook and make our domestic timber supply prospects more uncertain. Among the things I have in mind is the increasing pressure to earmark land--and particularly the public lands--for some exclusive use such as parks and wildernesses, and increasing withdrawals for residential use, highways, reservoirs, and other similar purposes.

There has also been increasing concern about the protection and maintenance of our forest environment and about the production of recreation, wildlife, water, and other nontimber goods and services of the forests. These are legitimate concerns, but they will inevitably mean added constraints on the use of forest lands for timber production.

From an analytical standpoint, many of the changes that have been taking place are in their early stages, and unfortunately it is impossible at this time to accurately appraise their ultimate impact. In projecting timber supplies, they have been recognized and an attempt has been made to take them into account.

We have been making rather substantial progress in the way we manage our forests for both timber and other products in recent decades. In the South, for example, fire control and other forestry programs, including extension work, have improved the

timber situation to the point where timber harvests may be gradually increased as much as 60 percent over the next few decades. This increase will be largely offset, however, by expected declines in the harvesting of old-growth timber from forest industry lands in the West.

From the national standpoint, with present levels of forest management, future harvests of softwood timber cannot be increased above current levels without overcutting and reduced supplies of this preferred timber in some future period. Thus, if recent levels of timber management continue, we are faced with the prospect of large increases in the relative prices of softwood timber products as sharply rising demands are brought into balance with supplies.

In contrast, hardwood forests can support a much larger volume of harvests. Net annual growth on all growing stock trees 5 inches and larger, is some 3.5 billion cubic feet above removals. Most of this timber is on the small ownerships in the North, and is in relatively small trees of the less desirable species. However, it is suitable for use as pulpwood, and represents a major source of future wood supply for the pulp industry.

The prospective hardwood sawtimber situation is roughly similar to that of softwoods. Although the data on growth and removals indicate that sawtimber stands can support an increased level of cutting, recent increases in hardwood sawtimber stumpage prices suggest that the resource data probably overstates the volume of sawtimber that is economically accessible and available for sale. For example, much of the projected supply of hardwood sawtimber is in species and low-quality trees for which markets are currently limited. Much of the demand, on the other hand, is for species such as select white oak and red oak, sweetgum, yellow birch, hard maple, walnut, and black cherry, and for the larger sized high-quality trees. Removals have been close to or above annual growth for this preferred material in recent years.

In addition, part of the larger sized hardwood sawtimber that is suitable for the manufacture of high-quality lumber or veneer occurs as widely dispersed trees or groups of trees that may not be economically harvestable. A substantial part of the hardwood timber is also in privately owned tracts that are held primarily for recreation or other purposes that are not compatible with timber harvesting.

In summary, the data we have shows that if we continue to practice forestry much as we have in recent years, we will not be able to significantly increase our harvests of softwoods with-

out overcutting. Harvests of hardwoods can be increased, although it seems clear that it will take substantial increases in prices over the levels of the 1950's and 1960's to induce the owners of the available hardwood sawtimber to put it on the market.

Now I want to stress that this is the outlook if we do not intensify management. With better management, U. S. timber supplies, in time, could be dramatically increased. The growth attainable in fully stocked natural stands is approximately double what we are averaging today. Through the use of genetically-improved planting stock, fertilization, moisture control, and the best spacing and thinning techniques, we could go much further, but no one knows the attainable limits.

There are opportunities for intensifying management on all ownerships and in all sections of the country.

The National Forests, and particularly those in the West, have the capability of supporting much larger harvests and doing so in the near future. Through additional investments in reforestation, stand improvement, road construction, thinning, and salvage, it would be possible to increase timber harvests fairly quickly from the old growth stands which compose much of these public holdings in the West.

Growth on industry lands in all sections of the country is much below what can be achieved in fully stocked natural stands. So the forest industries also have an opportunity to increase timber supplies by intensifying management.

From the national standpoint, the biggest opportunity to increase timber growth is on the 59 percent of all commercial timberland--296 million acres--in farm and miscellaneous private ownerships. We recognize that many of these lands are held mainly for recreation, speculation, or other nontimber objectives and that management efforts for timber are limited. Average growth per acre is 36 cubic feet--considerably below reasonably attainable levels. Expanded programs of technical assistance and financial incentives to increase planting, timber stand improvement, and other management practices could, in time, result in substantial increases in the Nation's timber supply.

In closing, I would like to summarize what I have had to say as follows:

Several recent studies have shown that timber markets in the U. S. are likely to grow rapidly in the decades ahead. Although part of the increase can be met by improved utilization and increases in net imports, the potential gains are relatively

small in comparison to the total growth in timber product demands. The best opportunity for increasing supplies is through intensified management of our domestic forests. There are opportunities for intensifying management on all ownerships and all regions of the country. The Nation's forest lands have the capability under intensive management of growing at least twice the volume of timber produced today.

LET'S CALL THE WHOLE THING OFF!

by Gordon Baskerville, Department of Forest Resources, Faculty of Forestry, University of New Brunswick.

The organizers of this symposium assigned me the task of the devil's advocate. My job is to convince you that we either do not need to increase wood yield or cannot do it. Clearly they did not have much faith in my oratorical abilities because they have scheduled no less than 32 speakers to follow me, each dealing with a specific aspect of how to get on with intensive management. It is unlikely indeed that I would succeed in having the symposium cancelled as unnecessary and my title is admittedly facetious. However, I do have a deadly serious point to make. Simply stated my point is that as a profession we have been largely ineffectual (perhaps even to a degree, irresponsible) in the promotion of intensive forest management in the northern forest and that this will continue until we modify our approach. It would be most appropriate to begin here in the next two days.

To develop my point let us start with this symposium. The papers this morning are intended to rationalize the need for intensive forest management - literally to justify the real discussion which is to follow. The papers of the symposium proper are essentially of the familiar technical "how to" form. Clearly we are here to talk about getting on with the job because to us it is abundantly clear that there is a job to be done. Since we already seem to have decided we will do the job it might perhaps be useful to establish what "the job" is. I have sufficient experience in the northern forest to permit me to believe we could indeed carry out the various silvicultural manipulations we will discuss here. That is, technologically they are all feasible operations. What is not at all clear in my mind, and judging from the press and our technical journals apparently in a substantial number of other people's minds, is <u>why</u> we would do them.

Sounds heretical - not really. Do we as a group have a clear idea of the goal of intensive forest management? Of course we do - its the management of the forest, through the application of silviculture, to achieve the greatest good for the greatest number. But is that clear? Would we know when we reached that point? Is it in fact a goal at all? There are many benefits that flow from the forest - pulp and paper, lumber, aesthetics, wildlife, social, water, environmental quality and recreation just to name a few categories. If we conceive of the flow of benefits as a pipe and each of these categories as a faucett on the pipe

then it is clear that opening any faucett reduces the flow to others. Thus the goal as just stated implies optimization of all benefits. That is, a consideration of the setting of all faucetts. But do we really mean this? In this symposium only two papers deal with "other amenities" while 95% of our discussion will be concerned with the production of wood.

Obviously we cannot expect to be credible on the motherhood goal of intensive forest management. In fact, if we are honest, we have no desire to attempt to inflict our relative values of the various categories of benefits on society at large. We would prefer that society somehow make these tradeoffs and then we will manage the forest so as to produce the desired mix of benefits. How about limiting the goal of intensive forest management to obtaining the greatest possible flow of wood from the forest consistant with maintaining the flow and other amenities? Sounds better and it is directly related to our professional talents, but is it necessary? Is it realistic?

As I drove to Orono I passed through miles of forest on both sides of the border that certainly are not under intensive management by anyone's definition. A frighteningly large proportion of the recent cutover does not even appear to support a reasonable mix of useable species by current standards. There are two possible explanations for this observation. First it may be that we do not need more wood because we are not cutting the full allowable cut there is no need to manage intensively. Secondly it could be that we really do need more wood but the foresters responsible for management are incompetent. Since I am unwilling to accept the second alternative as true, I conclude that there is really no need to maximize wood yield. Intensive management means expenditure of money and manpower and we would not really expect a landowner to spend money on intensive management to produce more wood that he doesn't obviously need. In fact a manager who would spend money in such a way would not be considered responsible in our society.

Historically this line of reasoning appears to have left our profession trying to sell intensive management in a rather poor market. Also historically we have talked about 'good' or 'better' forest management, meaning intensive forest management, and have regularly implied that all silviculture is 'good'. We have used the word management so loosely as to all but destroy its meaning. The phrase intensive management implies something beyond ordinary management yet we have not been explicit as to what constututes management and what level of increased input constitutes intensive management. Further, our arguements for the implementation of intensive forest management are heavily laden with value judgements about the inherent virtues of 'good' management of the forest. One need not look far in northeastern North

America to see that these arguements have not been convincing to the landowners. You have to search dilligently to find that part of the forest that is intensively managed.

A major problem has been that rather than manage, the traditional approach in forestry has been to adjust utilization standards. When the 18 inch white pine suitable for sawlogs were gone it was more expedient to harvest smaller pine and 12 inch spruce than grow large pine by intensive management. When the large spruce are gone we utilize smaller spruce and balsam fir. With pulpwood we have seen a similar change in acceptable species and sizes. Such changes result in an instantaneous increase in useable wood and are often regarded as 'good' or 'better' management whereas the culture of a forest requires time and money which are regarded as long term investments. Perhaps the ultimate in this progression will be reached when all the tree species have been high graded out and we meet our industrial needs with something akin to Harold Young's puckerbrush paradise. We can do this without intensive management, indeed, since changing utilization standards is an immediate solution it obviates the awkward necessity of a time delay associated with management. Such an approach bears little or no relationship to the notion of planned forest management.

As a group, foresters tend not to look analytically at why there is so little 'good' management (i.e. intensive) but rather seek to promote the concept by incentive programs or policy changes. By implication we are saying that since people do not see the inherent good in silviculture and intensive management, we will pay them to do these 'good' things for themselves or make them a matter of policy. I have become cynical about such approaches. Incentives and policies as sole tools for promoting intensive management at best engender lip service and at worst result in callous tokenism. If we can only achieve intensive management by paying people from public funds or by decreeing it, and I do not underestimate the value of these, we can hardly expect a very comprehensive or vigorously pursued program. Surely if we have a valid point with respect to intensive management we can make it without buying or decreeing belief.

Experts in the field of social psychology have told me that foresters are outstanding in their free use of value judgements. This is perhaps most obvious with respect to intensive management and its associated silviculture. These are always considered as 'good'. Yet there are many with an interest in the forest who do not see or do not want our particular kind of 'good'. As a result we regularly find ourselves bogged down in endless unresolvable arguements over perceived values with all the moralistic implications this involves.

Can we, in the next two days, continously bear in mind that

intensive management and silviculture are amoral. They are simply concepts and acts that possess no inherent virtue. We do not do these things (nor advocate them) because they are 'good' or 'better', we do them because they are essential to achieve certain desirable ends. If intensive management and silviculture help us to reach our goals then they acquire goodness and of course the opposite is true. That is, intensive management and silviculture are good (or bad) only when considered in relation to our goals.

I believe there is ample evidence that our usual broad motherhood goals are inadequate to our needs. If we persist in using meaningless phrases open to many interpretations, the profession will lose its already dwindling credibility with respect to forest management. Whether we actually have control of forest management or not, we are considered to be 'the managers' of the forest and if the results of 'management' (whatever intensity) are found to be seriously lacking we - and perhaps, but not necessarily, our masters - will be publicly held to blame.

We must have explicit goals for management and we need a willingness to stand up and take a public position when our masters (political or private) accept goals but don't come through with the dollars and manpower to do the job. We have all seen acknowledgements by public and private agencies that they subscribe to good forest management. We have also all seen how most of these agencies are unwilling to dedicate the resources necessary for more than token efforst towards such laudable, but imprecise, goals. Can measurable goals be set? For a given forest an explicit goal can easily be set for yield - say 300,000 cunits per annum - rather than use the vague indeterminate notion of maximum yield. Given such a goal one can readily determine if it will be met without any management and, if not, the management steps essential to meeting the goal can also readily be determined with current technology. Most importantly, such a goal is attainable and we will know exactly when it is reached. If the dollar support for the necessary programs is not there this will also be evident and the short fall will be a finite amount rather than just 'not enough'. Note that with such an explicit goal you do not necessarily invoke all the tricks in the bag called intensive management, another general implication of which we are frequently guilty. You only need to gear up and spend dollars on the techniques essential to reaching your goal. As progress is made the goal can be raised and more sophisticated methods introduced.

As an example of goal setting let me suggest that growing more volume may not be what it is all about. In much of the forest we are discussing, we still face the problem of oversupply and the philosophy that we don't need technical management because when we run out of trees we can use puckerbrush. But

there is one major problem that can only be solved by application of some intensive methods. It may not be widespread in the Northeast, but in Atlantic Canada we have what is most simply termed a quality problem. For example in New Brunswick our harvest of hardwoods is less than one-half the allowable cut and our harvest of softwoods is just reaching the calculated allowable cut - based on volume. Perhaps more particularly in the hardwoods but also in the softwoods, we are discovering that an under-cut in terms of volume can easily be an over-cut in terms of quality. That is, we still have plenty of volume but it is made up of trees of poorer quality than we have harvested in the past. While this is not well documented we often hear industrial managers decry the faltering quality of the forest yield.

The reasons for this situation are somewhat complicated, but simply stated they relate to our past solution of management problems by lowering utilization standards and the fact that if you want a big tree of high quality you must let it grow for the time it takes to get to the desired size. We are discovering that regulation by volume does not always allow for sufficient time to reach what we consider a desirable size! There is an alternative to just waiting - we can use techniques of intensive management to get the quality we desire sooner and to concentrate the quality material spatially. In the case of New Brunswick while we cut only 47% of the allowable hardwood cut, there is an urgent (perhaps the word is desperate) need for intensive methods in part of the hardwood forest to maintain a flow of suitable quality wood. I suggest that intensive management may have greater justification today for producing quality than for producing quantity. The goals for quality can be stated explicitly in terms of amounts, sizes and quality parameters and it is therefore possible to determine readily what must be done to reach those goals.

If we want to see intensive management practiced (i.e. to have our talents used) then we should not ask that it be done simply because it is good to do so. We must extract goals from the owners and then show what must be done to meet these goals. This can be presented in the form: if you want this goal, then you must carry out this intensive management, or conversely, if you don't manage in this manner then you will not meet your goal.

The goals can be many and varied. They include quality and quantity of wood, location, and even attaining amenity values. But we must insist that the goals be made explicit so that our proposed management schemes can be properly designed and assessed.

To go back to the beginning - if we continue to try to sell intensive management as a 'good' solution to all ills (real and

imagined) I do not believe we will ever be successful. In fact the chances of being convincing in this way grow slimmer every year. On the other hand if we extract reasonable quantifiable goals from the forest owners (private and public) then we can demonstrate that a given mix of intensive management methods is essential to reach those goals - and we might find ourselves actually managing the forest. There is no doubt in my mind that we need a more intensive approach to forest management. It disturbs me that we are not getting it and that a major part of the problem is our predilection to discuss the means as if they were the ends.

As a devil's advocate this is perhaps a positive note on which to end but while I do feel strongly that silviculturists have not served their purposes well I am quite human and don't practice what I preach. I must say I would rather have talked to you about my work in spacing and early thinning in softwoods because like all of you, I want to get on with the job.

PRESENT METHODS AND TECHNOLOGY AVAILABLE FOR INTENSIVE MANAGEMENT AND EXTENT OF PRESENT USE

by Gordon F. Weetman, Associate Professor
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Abstract

While there have been major technological developments in regional agriculture and forest harvesting and in intensive forest management in the Southern pine region and the Pacific Northwest, the application and development of intensive forest management has lagged in the Northeast.

Some of the characteristics of low, medium and high yield forestry are presented and recent developments in operational and managerial technology are reviewed.

It is concluded that we do have operational "hardware" for more intensive forest management, although mechanization could be further advanced. However, we are often lacking in the decision making "software", particularly at the 'whole forest' level, in order to account for the many factors which dictate which of the management options are appropriate. The northeastern forest, particularly the hardwoods, seem best suited to medium yield management for stand quality. The need for suitable financial incentives is stressed and attention is drawn to the important human and institutional problems that must be considered.

SINCE OTHER SPEAKERS are reviewing some of the techniques used in intensive forest management in some detail, the purpose of this paper is to briefly review each of the present techniques available for use and identify those which have developed rapidly in the last ten years,and note their relevance to conditions in the Northeast. The paper will have an understandably Candian bias. The N.E. region, I assume, covers those States belonging to the Northeastern Region of the U.S. Forest Service plus the Maritime Provinces.

We live in a technological era, and while we have all noted the dramatic changes in agriculture (Schebecker 1975) which have produced the so-called "green revolution", and we have also seen dramatic changes in the development of forest harvesting techniques, there have been relatively few dramatic developments in technology in the growing and management of forest crops in the Northeast. I will not dwell on the social, economic and geographic reasons for

lack of intensive forest management in the region; suffice to say that the application of technology to the region is compounded by such problems as terrain unsuitable for mechanized equipment, low quality and non-uniform stands composed of several species, many of which have low market values, and land ownership patterns and history of land use unfavourable to investment in forest management.

The major developments in technology for intensive forest management are being developed either in the Southern pine region or in the Pacific Northwest, or are direct applications of spinoffs from the developments in agriculture. The technology presently available will be considered under two headings: Operational and Managerial. (See Table 1).

OPERATIONAL TECHNOLOGY

The region is not characterized by major investments in plantation forestry. Historically forests have often been 'high graded' for quality species stands and logs. Initial efforts of improved management have usually called for judicious partial cuts for timber stand improvement, or shelterwood cuts or modified clear cutting, all with reliance on natural regeneration. However, it is in plantation forestry where there have been dramatic technological changes. Research in forest genetics and cooperative forest tree improvement programs in the Southern United States and elsewhere have led to the massive production of genetically improved tree seed (Zobel 1976). The economic benefits of such programs can only be realized through artificial regeneration. While there is little doubt that the techniques of forestry improvement, if applied to the Northeastern tree species, would produce economically attractive changes in stand volume, quality and vigour, the application of this technology has been quite limited due to the lack of reforestation programs (Carlisle and Teich 1971, Carlisle and Ottens 1976). There has been local interest in hybrid poplar production for short rotation management (Anderson and Zsuffa 1975) and in the use of certain exotics, particularly larches (Cook 1975). While research workers continue to investigate the genetic variability and heritability of the Northeast species and conduct provenance trials and trials of exotics (Fowler 1976), at the operational level practice is limited to the usual precautions regarding seed collection zones, seed collection procedures and the identification of phenotypically superior stands for seed production. Good guides are available for the collection and handling of tree seed and mechanization of collection is developing.

There have been periodic enthusiasms for direct seeding because of its apparent low cost and ease of application. Two symposia have been held (Abbott 1964, Cayford 1974). At the operational level the track record has been grim. There have been local successes and it is used for jack and lodgepole pine in the boreal forest, but even the technology developed for chemical seed coatings

to prevent losses due to rodents are now environmentally unacceptable. Successful operational direct seeding usually calls for adequate quantities of reasonably priced seed and some very careful prescriptions regarding seed bed preparation and timing of the seeding operation, especially in relation to snowfall; these areas need further work. The operational aspects of actually spreading the seed and monitoring results are fairly well established.

In forest nursery stock production there have been major technological changes. For conventional nursery stock, the operational aspects of control of nursery bed fertility and the mass production of quality stock by mechanized techniques have all become highly developed, largely based on work done outside the region (Moon, et al 1973). The refinements in this technology have been followed by the ultimate control of growing conditions and seedling quality in container stock production in greenhouses. Forest container stock production has been the subject of another recent symposium (Tinus, Stein and Balmer 1974) and is being enthusiastically and vigorously developed. Much of the pioneering work in this area was done in Scandinavia, where it is widely used, and in certain Canadian provinces.

It now appears possible to mass produce high quality, uniform tree seedlings grown in a variety of containers such as peat pellets, Nissula rolls, styrofoam blocks, plastic bullets and biodegradable containers on a very large scale at relatively low cost to large sizes and all in a few months instead of two to four years in conventional nurseries. Such container stock production is less robust and calls again for careful site preparation and is very suited for mechanized handling and planting systems. Special high production planting machines are being developed and bullets are being 'bombed' from planes.

Site preparation for either seedbed preparation, or for planting, has developed very rapidly outside the region. It is now possible, provided a tractor can traverse the ground, to treat very large acreages at relatively low costs, using front or rear mounted equipment on the tractor, suitable for direct seeding, or for natural seeding or as suitable sites for planting operations.

The application, however, again is limited in this region to a few locations. The 30,000 plus acres of spruce plantations in northern New Brunswick were established by the Irving organization using a Letourneau tree crusher for site preparation in one such example. However, the large block of privately owned land and the gently rolling, relatively stone free soils of the area represent a rather unusual combination of favourable conditions.

Control of vegetative competition through the use of auxin herbicides such as 2,4-D and 2,4,5-T and chemicals such as atrazine and simazine and cacodylic acid are also well established techno-

nologies, which can be effective and are in cases absolutely essential, for successful stand establishment. However, enthusiasm for their use has been considerably dampened by concerns about their environmental effects. The literature in this area is enormous, but on balance it does appear that, as in agriculture, the use of such chemicals to control vegetative competition is often the only feasible way of getting the job done and that the environmental risk is acceptable, especially for the auxin herbicides (Newton 1975, Newton and Norris 1975).

Pre-commercial thinning of excessively dense young stands has received a lot of attention recently (Porterfield and Schweitzer 1975). It is widely practised outside the region and is one of the most attractive areas for investment in forest management because it controls spacing, vegetative competition and species composition and produces stands of high mean diameters on shorter rotations. It is nearly all hand labour using either power saws or special brush saws. It has resisted, and probably will continue to resist, all attempts to mechanize it (Dunfield 1974). Even the use of tree killing chemicals, such as cacodylic acid, has fallen into disfavour. The high labour content, the relative ease of application and its almost year-round application made it an attractive investment for government agencies in areas of high unemployment.

Forest fertilization is an operational technology in the South, mainly using phosphorous, and in the Pacific Northwest and Scandinavia, using nitrogen. It has attracted a lot of research, it works in the right situations. It uses expensive fertilizers and it is of doubtful economy for low quality stands, or a low value species. Whether or not nitrogen fertilization of Northeastern tree crops can match the economic returns and priorities for fertilizer use in agriculture crops is questionable. Forest fertilization is also a favourite topic for symposia, one recent in this region (Northeastern Forest Soils Conference 1973). It does appear that fertilization is the frosting on the top of the total forest management cake and without the cake there is little economic justification for the frosting. The environmental hazards involved appear to be acceptable, based on present information.

I am reluctant to blow any cobwebs off the hoary old questions surrounding the application of commercial thinnings. All over the western world, and this region is no exception, high labour costs and shortages of manual labour for hard physical work, have greatly reduced the application of the beautiful and rational thinning regimes designed to recover mortality and improve stand quality. Present trends are to grow trees at wide spacing and on short rotations and thus avoid thining (Buckman and Newton 1972). The dramatic changes in the technology of logging has in some instances led to the development of special mechanized equipment for

thinning, especially in plantations. However, outside of plantations, such machines have little application in this region, mainly because of low stand quality and excessive stand densities. Of much more pragmatic significance for the region is whether or not it is feasible for certain types of stands to carry out partial removals of the stand, which can be designated either as thinnings or partial cuts or shelterwood cuts, using rubber-tired skidders and either short wood or tree length methods. It can be done and is being done, for example, on the holdings of the Seven Islands Land Company in Maine, but does require great care on the part of the cutter and the skidder operator. This technology and this practice is very appropriate to the region and controversy exists as to whether it is possible to mechanize the operation further to remove the undesirable and unpleasant labour aspects involved, without losing the flexibility, low cost and ease of applicability.

There is also concern about the mechanization of logging. Sophisticated new machinery for tree length and whole tree harvesting, with high operating costs, limited operational flexibility, requires high quality stands. Advance growth may be destroyed, forests may be high graded and environmental problems involving physical and chemical damage to the soil may develop. Whether or not this technology favours or hinders intensive forest management is dependent upon a commitment to intensive forest management and a clear set of management objectives. In many cases this technology has invaded the forest without allowance being made in management planning, in increased investments and in adjustments in cutting schedules, allowable cuts and the application of the appropriate management technology to ensure prompt restocking. Often the response has been when in doubt scarify! It is this latter area of decision-making which leads to what I consider to be the crux of the whole affair and that is

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This has been an area of major technological change, because while historically we could handle much of the operational technology to carry out intensive management, we were not in a position to justify expenditures of money in order to make due allowance for uncertainty of yields and biological variability. The application of intensive forest management elsewhere in North America has been justifiable at the industrial level, mainly because it works biologically and it was possible to quantify the benefits. The shorter the rotation and the less biologically complex forest, the easier this job becomes. There is a new technology of forest resource decision making. A new textbook in this area which is now widely used in many North American forestry schools by Duerr et al (1975) is symptomatic of the change. Computers have made a great many changes in our lives. There is a theoretical and to a certain extent applied technology using stand

and tree growth simulation models which does permit the estimation of yields of forest stands by age, species, site class and density, with outputs in terms of tree size, volume, biomass, tree quality and age initiation of mortality (Fries 1974). Forest inventory procedures have been completely changed. Analyses of growing stock by stands, allocation of cuts, inputs from social and economic factors are now analyzable and to a reasonable degree quantifiable for whole forest systems (Navon 1971, Ware and Clutter 1971, Alston 1972, Hoyer 1975, McDonough and Park 1975, Lussier 1976). For large corporate forest holdings and for large public forests, analyses of this type now permit a rational examination of the benefits of intensive forest management. One of my favourite examples of this type of an approach in intensive forest management is that of the Swedish Cellulose Company which has stand development and silvicultural decision models, which indicate for various site classes and stand conditions those locations most appropriate for intensive management investments (Hagner and Fries 1972, Hagner 1974). The Weyerhauser corporation is very advanced in this technology, with its 'target forests' and $5,000,000 annual forest research expenditure (Mitchell and Roberge 1974).

While this technology will handle a lot of the figuring, there is still the on-the-ground problem of soil fertility and site variability. Intensive forest management calls for decision making which locates on the ground, sites most suitable for treatment and which indicates how such treatments will relate to other forest land uses, such as wildlife, recreation, watershed values, etc. The prescriptions cannot be oversimplified (Smith 1975). There have been troubles in this area, environmental troubles when forest management technologies are blindly applied, while ignoring these values. Again a system is called for. I feel we have made progress in this area. In Canada we have a biophysical land classification system which permits, through the use of appropriate inventory techniques by specialists in ranking and rating of land capability and the rational integration of land uses (Jurdant 1969). Such ecological approaches permit a rational framework into which decisions regarding intensive forest management can be incorporated. There are so called "folio" approaches to resolving some of these complex problems (Bullen 1975) and there are new inventory procedures designed to collect the appropriate information of all the resource values. Here in the U.S. my understanding of the situation is less clear. The philosophical and operational procedures are different. The decision making centres around soil mapping by the Soil Conservation Service and other agencies followed by woodland interpretations. There has been an emphasis on predictive equations to relate yield to measurable soil parameters.

Our improved understanding of growth and yield and the silvics of the species, together with our analytical capabilities in

forest economics, have given rise to a series of very useful bulletins and guides for intensive forest management. For example, the Ontario Silviculture Guides for Working Groups and the Spruce-Fir and Northern Hardwood Guides produced by the Northeast Forest Experiment Station indicate appropriate tending and harvesting procedures for different stand ages and stand conditions. Other reports indicate economic returns and methods of analyzing the results of various management practices. These bulletins are not decision making models for management but they do provide most useful information when management decisions are needed. It is now technically possible to develop a complete system for decision making in the application of intensive forest management.

APPLICATION OF TECHNOLOGY

Table 2 outlines the characteristics of low, medium and high yield forest management. While we apparently have the operational technology to conduct any of the three options, i.e.,'the hardware' to do the job; I feel that we lack the decision making 'software' to decide on which option, at which locations and at what level of intensity. Rather than follow the usual pattern of opting for low yield forestry with declining utilization standards, I feel there is a good case to be made for the middle option in the N.E. - an emphasis on stand quality rather than quantity - particularly for the hardwood species. The emphasis here is on directing the natural forces of competition and selection rather than establishing an maintaining an artificial forest crop.

Much of the work that has been done in developing high yield, intensive management systems and decision making procedures during the last few years has been done by large corporations or big government. This body of technology is essential if decisions on major investments in intensive forest management are to be made on some rational basis. Many of the areas are quite complex, require considerable capital investment and a high degree of expertise in their application. The benefits which accrue from such investments, particularly when rotations are long, are difficult to justify for smaller forest holdings. The Northeast region is characterized largely by smaller ownerships and much of this new technology for intensive forest management is thus very difficult to apply, but it has been done in other countries, as for example, Finland and Norway. Also, most of the technology is best suited to growing relatively intolerant trees in plantations. Much of it is ill-suited to tolerant trees, particularly hardwoods. Stand conversion is usually required.

It is interesting to note that in Eastern Canada much of the funding for intensive forest management, where it is practised, has come from government agencies which have been motivated by social reasons. There is a powerful argument for government subsidies, tax incentives, etc., for intensive forest management which

will give rise to improved local employment and better quality forests, which in turn will attract capital investment for forest industry. In some cases the pressure for this type of funding has come from the rural residents and not from large corporations or government planners. In my view we do have existing and workable technologists to practise intensive forest management now but their application is constrained by lack of management systems and lack of suitable financial incentives provided by government (Skok and Gregersen 1975, Weetman 1976). While we must continue to work on improving our technology and reviewing our progress in intensive management in symposia such as this one, we must not ignore the human and institutional problems and attitudes which must be changed if we are to put intensive forest management into practice.

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TABLE 1.

TECHNOLOGY FOR INTENSIVE FOREST MANAGEMENT IN NE

OPERATIONAL

- Seed Production Areas (1)
- Seed Orchards
- Seed Treatment
- Direct Seeding
- Seedbed Preparation (1) (4)
- Site Preparation (1) (3) (4)
- Conventional Nursery Stock Production (2) (3)
- Container Stock Production (1) (3) (4)
- Herbicide Control of Vegetative Competition (1) (3)
- Modified Cutting (2)
- Planting Mechanization (1) (3)
- Pre-Commercial Thinning or Spacing Control (1) (3)
- Timber Stand Improvement (1)
- Thinning (1) (3)
- Pruning (1)
- Fertilization (3) (4)
- Spraying and Cutting to Control Insects and Diseases (2) (4)

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- Ecological Surveys for Integration with Other Forest Uses and Choice of Sites, Species and Degree of Effort (1) (4)
- Improved Data Collection in Forest Inventory for Analyses of Stand Conditions and Growth Rates (1) (3) (4)
- Soil Survey and Site Index Studies for Fertility Estimates (1) (3)
- Managed Yield Tables Giving Volume Production by Species, Site, Density and Rate of Mortality or Thinning (1) (3) (4)
- Silvicultural Guides for Species Working Groups and Stand Conditions (2)
- Stand Simulation and Optimization Models Giving Production and Economic Returns from Different Management Practices and Strategies (1) (3) (4)
- Whole Forest Models Analysing Various Socio/Economic/Ecologic Inputs and Strategies (4)
- Production and Performance Models and Decision Making Tools for Choice of Operational Equipment and Methodology (2) (3)
- Studies of Effects of Changing Utilization Standards on Rotation Lengths and Usable Yield (2) (4)

(1) Used in NE on Limited Scale
(2) Used in NE on Extensive Scale
(3) Technology Well Developed and Used in Other Regions.
(4) Important Recent Developments in Technology.

TABLE 2.

CHARACTERISTICS OF INTENSIVE FOREST MANAGEMENT OPTIONS

Option	Energy & Dollar Inputs for Management	Expertise & Capital Required for Management	Application to NE	Provision of Stable Rural Employment	Technology Available?	Decision Making Tools Needed
1. High yield plantation forest - removal of original forest cover - site preparation - use of genetically improved stock - short rotations - emphasis on stand quantity & quality - mechanized operations	high	high	limited by trafficability	may be limited by expertise & mechanization required	for some species & sites	- site fertility equations - sophisticated forest inventory - managed yield tables - economic analysis of operations - a total system for management - monitoring and analysis of performance
2. Medium-yield forests - limited logging mechanization - modified cutting - seedbed preparation - natural regeneration or limited planting - precommercial thinning - longer rotations - emphasis on stand quality	medium	medium	suitable for many sites & species	good potential	for some species	- workable ecological classification - managed yield tables - inventory by stand condition - estimates of "additional" costs of operations - management system & field guides
3. Low-yield forests - lowest cost logging - often heavily mechanized - natural regeneration - stable or declining stand quality	low	low	widely applied now	limited	readily available	- inventory of commercial operable timber - a method to choose lowest cost logging operations - monitoring of stand quality & quantity

HOW APPLICABLE IS EVEN-AGED SILVICULTURE IN THE NORTHEAST?

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Abstract

The applicability of even-aged silviculture in the management of forest stands in the Northeast is examined through consideration of the forest stand, stand development, intermediate cuttings, and regeneration methods. It is concluded that even-aged silviculture is quite applicable in the management of forest stands in the Northeast.

Experience has taught me that rational discussions of silvicultural practices require mutual understanding of standard terminology. I have had on occasion the frustrating experience of continuing a somewhat heated discussion regarding a particular silvicultural practice with a colleague only to realize eventually that we were in complete agreement but were using different terminologies. To avoid such an occurrence here, I shall give particular attention when warranted to terminology in answering the question, "How applicable is even-aged silviculture, i.e. the growing of timber crops in even-aged stands, in the Northeast?" Furthermore I have organized my answer in what seems to me to be a logical approach by considering the forest stand, stand development, intermediate cuttings, and regeneration methods.

FOREST STAND

The forest stand is defined as being "a community of trees possessing sufficient uniformity as regards composition, constitution, age, spatial arrangement and/or condition to be distinguishable from adjacent communities so forming a silvicultural or management entity" (Society of American Foresters 1971). I should like to emphasize (1) that a forest is composed of forest stands, each occupying a specific area on the

landscape and reflecting the sum total of the time period and environmental conditions under which it has developed, (2) that forest stands, having developed under different time periods and/or environments, differ recognizably one from the other in one or more attributes and (3) that forest stands, because they differ one from the other, may require different silvicultural treatments to attain given objectives of management and therefore, form the basic units of silviculture. Professional foresters examine forest tracts, write silvicultural prescriptions, and impose silvicultural treatments stand by stand.

Forest stands are classified depending on their constitution, i.e. the representation and distribution of age and/or size classes, as being either even-aged or uneven-aged. Even-aged stands are composed of trees having no or relatively small differences in age. By convention, the maximum age differences admissible is generally 10 to 20 years, however, with rotations of greater than 100 years, differences up to 30 percent of the rotation may be admissible. Uneven-aged stands are composed of intermingling trees that differ in age more than is admissible for the stand to be classified as an even aged-stand.

Forest stands that originate following the destruction and/or removal of forest vegetation, whether by natural causes or man's activities, usually do so quite rapidly and are almost always even-aged. Forest fires, hurricanes, floods, insect and disease epidemics, timber harvesting, and the abandonment of crop and pasture lands have provided and continue to provide excellent opportunities for even-aged stands to become established. As pointed out by Smith (1972), foresters have repeatedly found the establishment of even-aged stands following major catastrophes to be a most common phenomenon.

Forest stands are also classified on the basis of composition, i.e. the representation of species in a stand expressed quantitatively as percent by number, basal area, or volume. Stands in which 80 percent of the trees forming the main crown canopy are of a single species are classified as pure stands. Stands failing to qualify as pure stands are classified as mixed stands. Pure stands are less common than mixed stands because sites favorable for the natural establishment and growth of only one tree species occur infrequently in nature (Baker 1950).

Since no two species have exactly the same pattern of height growth with respect to time, the main crown canopies of many even-aged mixed stands tend to become stratified vertically into more or less distinct layers (Smith 1972). In such stands, the crowns of the faster growing, more intolerant species occupy the uppermost layer of the crown canopy; the crowns of the slower growing, most tolerant species, the lowermost layer; and the crowns of species intermediate in growth and tolerance, if present, the middle layer. Stands of this type may appear to be uneven-aged but upon close examination are usually found to be even-aged. Mixed even-aged stands growing on good sites are usually quite productive and may provide the forest practitioner with a variety of management options, however, they are probably managed most effectively as even-aged stands.

STAND DEVELOPMENT

Nondormant viable seed of all tree species germinate and produce established seedlings only on well-aerated, moist seedbeds under favorable temperatures and sufficient light. Consequently, natural seedbeds tend to be either very favorable or very unfavorable for germination and seedling establishment. Unfavorable seedbeds fail to become stocked with even a single seedling while favorable seedbeds become stocked with an excessive number of seedlings. Thus, even-aged stands and small even-aged groups of trees in uneven-aged stands begin life too densely stocked for individual seedling to grow for long entirely free of competition.

As a young stand begins to attain full occupancy of the site competition among trees for water, light, and nutrients intensifies both above and below ground, branches near the ground begin to die, and the trees begin to differentiate into crown classes in accordance with their relative ability to grow in height. The stronger, most vigorous individuals forge upward to occupy dominant and codominant positions in the crown canopy. The weaker, less vigorous individuals fall behind to occupy initially intermediate and later overtopped positions in the crown canopy where they are destined eventually to die. As the stand grows into the pole stage, competition becomes increasingly more intense, crown classes become more distinct, losses of trees due to suppression and death reaches a maximum, and natural pruning produces progressively longer branch-free boles and shorter crown lengths. By the time the stand has attained its maximum height for the site, competition has reduced

the crown size of most trees below that required for them to remain vigorous and the stand begins a long period of slow growth followed by a period of deterioration. Thinnings begun early in the life of the stand and repeated as needed would have increased the yield of merchantable wood, maintained the vigor of the crop trees, and lengthened the productive life of the stand.

INTERMEDIATE CUTTINGS

An intermediate cutting is any cutting made in a forest stand between the time of its formation and the first regeneration cutting. Intermediate cuttings are conducted in immature forest stands with the two principal objectives of (1) enhancing the value of existing stands by controlling the composition, density, and growth through all stages of stand development and (2) increasing the total yield of stands by utilizing all of the merchantable wood produced during the life of the stand. Intermediate cuttings differ from regeneration cuttings in that no effort is made to secure regeneration and the creation of permanent openings in the crown canopy is carefully avoided.

Eight different kinds of intermediate cuttings, each designed to accomplish a particular purpose, are recognized as follows: (1) weeding (2) cleaning (3) liberation cuttings (4) thinning (5) improvement cutting (6) salvage cuttings (7) sanitation cutting and (8) pruning (Smith 1962). Weedings, cleanings, and liberation cuttings are conducted in stands not past the sapling stage of development to release desirable growing stock from the competition of herbaceous and woody vegetation. Improvement cuttings are made to improve the composition and quality of mixed stands past the sapling stage of development by removing trees of undesirable species, form and quality from the main canopy. Thinnings, made primarily to control the density and growth of stands, are conducted periodically as needed throughout all stages of stand development. Salvage cuttings to utilize merchantable wood in trees killed or injured by injurious agencies and sanitation cuttings to prevent the spread of insects or diseases are conducted as required throughout the life of the stand. Selected crop trees of species that produce lumber commanding a premium when free of knots may pruned to improve the quality and value of wood produced.

The judicious application of intermediate cuttings provides the best means of increasing the yield and quality of merchantable wood produced by a forest stand. Intermediate cuttings are as applicable in the management of uneven-aged stands as they are in the management of even-aged stands. However, the need for an intermediate cutting is more easily recognized and intermediate cuttings are more economically applied in even-aged stands than in uneven-aged stands.

REGENERATION METHODS

A regeneration method is the procedure by which a mature forest stand is harvested and replaced with a young stand. A regeneration method includes not only the removal of the mature stand in such manner as to create, in so far as it is feasible, environmental conditions conducive to germination and seedling establishment but also any cultural treatments of the seedbed that might be required to ensure rapid replacement of the old stand by an adequately-stocked young stand of desirable tree species. Various methods of establishing even-aged forest stands from seed have found application, however, any given method can usually be classified under one of three standard regeneration methods each of which denotes distinctly different principles (Smith 1962). The three standard regeneration methods of establishing even-aged forest stands from seed are the clearcutting method, seed-tree method, and shelterwood method as defined below.

Clearcutting Method

In the clearcutting method, all trees on an area to be regenerated are removed in one cutting with regeneration of desirable tree species being subsequently obtained either naturally from seed disseminated over the cutting area from adjacent forest stands and/or from trees removed in the harvesting operation or artificially by either planting tree seedlings or sowing seed on the cutting area.

Natural regeneration of a clear-cut area is usually either wholly or impart dependent upon seed disseminated naturally by wind subsequent to the removal of the mature timber, therefore, no portion of the clearcut area should be more distant from seed-bearing trees of the species to be regenerated than the distance to which the seed can be disseminated in sufficient quantities to produce adequately-stocked stands.

Seed-Tree Method

In the seed-tree method, all trees on an area to be regenerated are removed in one cutting save for a small number of seed-bearing trees, usually from one to ten trees per acre, retained either singly or in small groups to provide seed for the subsequent natural regeneration of the area. Following the establishment of adequate regeneration, the seed-bearing trees may be removed in a second cutting or left indefinitely. Since under the seed-tree method of regeneration, a seed source is retained on the cutting area, the size of the cutting area is not limited as it is under the clearcutting method.

Shelterwood Method

The shelterwood method involves the removal of all trees from the area to be regenerated in a series of cuttings extending over a period of years equal usually to no more than one-quarter and often not more than one-tenth of the rotation with the establishment of natural regeneration of desirable tree species being obtained under the partial shelter of the parent stand. Regeneration of a previously untreated mature stand by the shelterwood method may require three different kinds of cuttings namely, preparatory cuttings, seed cutting, and removal cuttings as defined below.

Preparatory cuttings. Preparatory cuttings are cuttings made to prepare dense mature forest stands, under which regeneration of desirable tree species has failed to become established for regeneration by (1) removing defective trees and trees of undesirable species (2) improving the vigor, seed production, and wind firmness of desirable tree species and (3) increasing the rate of decomposition of thick humus layers that tend to preclude the establishment of natural regeneration.

Seed cutting. The seed cutting is a cutting made in a mature forest stand to create permanent openings of sufficient size in the crown canopy to permit heat, light, and moisture to penetrate to the forest floor in amounts required for germination and seedling establishment of desirable tree species. To be most effective the seed cutting should be made during a year when the desirable tree species bear seed in abundance.

Removal cuttings. Removal cuttings are cuttings made to remove the remainder of the mature stand. Removal cuttings are commenced as soon as regeneration

has become established over a sizable portion of the cutting area and are continued periodically as required to prevent the mature stand from unduly retarding the growth of established regeneration. The last removal cutting (final cutting) is made when all portions of the cutting area have been regenerated satisfactorily.

Regeneration of an under-stocked mature stand under which an abundance of advance regeneration of desirable species has become established may require only one removal cutting to complete the regeneration process. Such a cutting may be classified erroneously as a clearcutting but, in as much as the regeneration has become established under the protection of an overstory, is properly classified as being the final removal cutting of the shelterwood method.

The three methods of regenerating even-aged forest stands differ one from the other in respect to the number of cuttings required to harvest the mature stand and the arrangement of the cuttings on the ground. The arrangement of the cuttings on the ground determines not only the quantity of seed available for dissemination over the cutting area but also the environmental conditions under which seeds germinate and seedlings become established. Thus, the applicability of a particular regeneration method is determined largely by the silvical characteristics of the species to be regenerated. Tree species intolerant of shade can usually be regenerated most effectively by either the clearcutting method or the seed-tree method. Tolerant tree species can usually be regenerated most effectively by the shelterwood method.

Application in the Northeast

The northeastern spruce-fir, northeastern northern hardwood, eastern white pine, Allegheny hardwood, and Appalachian mixed hardwood types occupying an estimated 11, 15, 7, 12 million acres and a substantial but undetermined acreage respectively in the Northeast have persisted through 200 years of exploitation (U.S. Department of Agriculture, 1973). Although other factors have undoubtedly played a significant role, the persistence of these forest types, in spite of the many and various types of treatment to which they have been subjected, can, I believe, be attributed primarly to the relative shade tolerance of the component species. Furthermore, I believe the regenerative response of the forest types over time and the results of research to date indicate strongly that they can be regnerated in even-aged stands by the

shelterwood method or some modification of this method as effectively as they can by any other natural regeneration method (U.S. Department of Agriculture, 1973)

SUMMARY

In summary, I would emphasize the following:

1. Acceptance of the forest stand as being the basic unit of silviculture and dutiful observance of stand boundaries place a definite limitation upon the size of the area available for particular silvicultural treatment at any given time.

2. The forest stands with which foresters have to deal tend usually to be more even-aged than uneven-aged in constitution and more mixed than pure in composition.

3. Consideration of the way even-aged stands develop accentuates the need for intermediate cuttings applied periodically to favor the growth of crop trees and to utilize all merchantable wood produced by the stand.

4. The need for intermediate cuttings are more easily recognized and intermediate cuttings can usually be conducted more economically in even-aged stands than in uneven-aged stands.

5. When properly applied the clearcutting, seed tree and shelterwood methods of regeneration produce even-aged forest stands. Intolerant tree species are regenerated most effectively by either the clearcutting method or the seed-tree method and tolerant tree species, by the shelterwood method.

6. The major forest types in the Northeast can probably be regenerated by the shelterwood method or some modification of this method as effectively as they can by any other natural regeneration method.

7. Even-aged silviculture is quite applicable in the management of forest stands in the Northeast.

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HOW APPLICABLE IS UNEVEN-AGE MANAGEMENT IN NORTHERN FOREST TYPES?

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Abstract

For the proper application and practice of uneven-age management, one must consider residual stocking, maximum tree-size objective, and diameter distribution. All three components are described, and it is shown how they fit into a practical package for application in a timber tract.

THE DECISION to practice uneven-age management in northern forest types is usually based on a combination of factors. Although some of the factors are concerned with silvical or ecological requirements of the species or species groups being managed, there often are other overriding considerations.

But first, what is uneven-age management? What are some of the major components of the system?

There are several definitions and descriptions in forestry literature, and I am sure each of us has our own pet way of describing uneven-age management.

An all-inclusive definition of uneven-age management was presented recently at a workshop sponsored by the U.S. Forest Service (1975). I believe it is a good one. Essentially, uneven-age management is the manipulation of a forest for continuous tall-tree cover and the orderly growth and development of desirable trees, through a range of diameter classes, to provide sustained even-flow yields.

It is implemented through the selection system: single-tree selection for mostly tolerant species, or a combination of single-tree and group selection to increase the proportion of intermediate and intolerant species (Berry 1963; Leak and Filip 1975; Roach 1974). Each operation is not only a harvest of merchantable products, but also an improvement cutting and release

job to promote the growth of the retained trees and to maintain or enhance stand structure and composition. Managed uneven-age forests are composed of intermingled trees or groups of trees that differ markedly in age (U. S. Forest Service 1973), but no separate age classes are recognized in regulating the yield (Meyer and others 1962).

For the proper application and practice of uneven-age management, at least three basic components must be taken into consideration: residual stocking, maximum-tree-size objective, and diameter distribution based on a q-factor guideline.

The real challenge to foresters is to understand how all three are linked together, and how they affect growth and quality, allowable harvest, operating cycle, timber-stand-improvement requirements, and the entire economic situation.

RESIDUAL STOCKING

Residual stocking is the volume or basal area to be retained after each cyclic harvest for further growth and development. Available data show that total stand growth varies only slightly over a moderately wide range of stocking levels. Cutting mature stands back to about 50 or 60 percent of full stocking is generally adequate for the northern forest types (Frank and Bjorkbom 1973; Leak and Filip 1975; Tubbs 1968). For example, a residual stocking of about 70 to 80 square feet per acre in trees 6 inches dbh and larger is recommended for northern hardwoods in New England.

MAXIMUM TREE SIZE

The largest tree to be retained after each timber harvest under uneven-age management in northern forest types ranges between 16 and 24 inches dbh. Much depends on site quality, the growth capability of the species involved, the accepted rate of return, and the owner's objectives for the tract.

DIAMETER DISTRIBUTION

The third component that is important in uneven-age management is diameter distribution; that is, retaining an adequate number of trees per acre after each harvesting operation. A prescribed residual diameter distribution, of course, determines the residual basal area and volume.

The general procedure for establishing a diameter distribution is to apply a q-factor guideline, usually referred to as q. The q simply refers to the average quotient or ratio between numbers of trees in successively smaller diameter classes. An ideal structure based on the same q-factor throughout all diameter classes is represented graphically by a smooth reverse-J-shaped curve. Q-factors ranging from 1.3 to 1.7 for 2-inch dbh classes have been recommended as goals in uneven-age management (fig. 1). The lower the q, the higher the number and proportion of large trees in the stand. Old-growth stands tend to have a lower q than second-growth stands.

PUTTING IT ALL TOGETHER

Now that we know something about the three essential components characterizing uneven-age management, how do we link them together into a practical package? And, probably of greater interest and concern to you: How is this package applied on the ground?

Many timber managers undoubtedly have been and still are reluctant to accept all this formality behind uneven-age management. They probably have good reasons for this, and I believe the major one is the apparent difficulty in trying to mark the timber tract to a rigid residual diameter distribution. I admit that trying to control the marking to some specified numbers of trees per acre (or basal area) by 2-inch dbh classes is not easy. Actually, it would be impractical, if not impossible, to maintain the perfect diameter distribution indicated by a smooth reverse-J-shaped curve. Really, it is not necessary to be that exact. The structure represented by the curve is only a guide. But you should not stray too far from it so as to be assured an even-flow of products, especially the large-size sawtimber.

Undoubtedly, most of the stands in northern forest types have an imbalanced diameter distribution; that is, there are excesses in some diameter classes and deficiencies in others--although graphically resembling the typical reverse-J-shaped form. Also, the average q is probably somewhere between 1.7 and 2.0--somewhat high--and merchantable trees larger than 20 inches dbh are not too prevalent.

Many uneven-age management recommendations suggest diameter distribution or stocking goals based on a

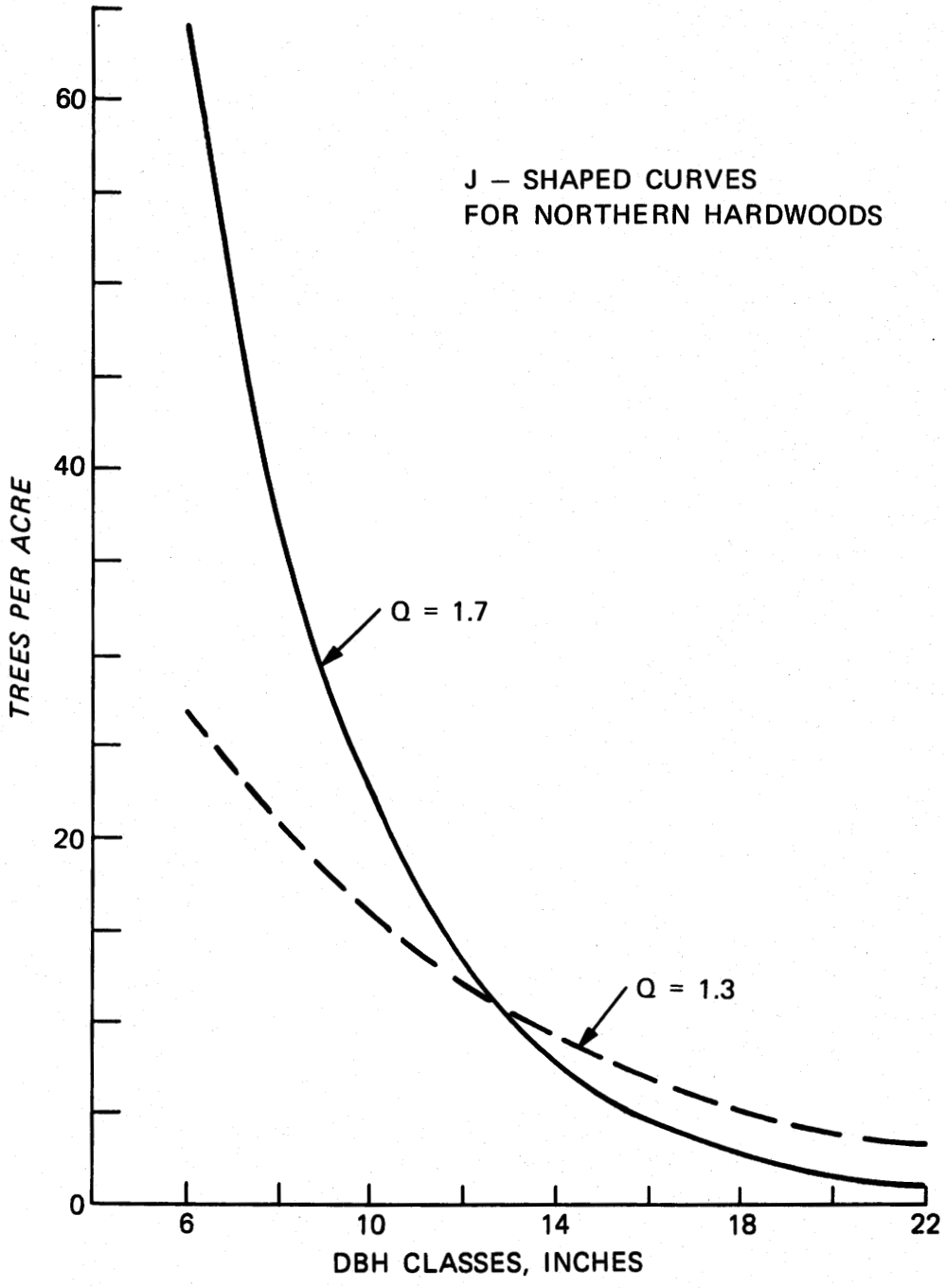

Figure 1.--J-shaped curves for northern hardwoods.

a constant q ratio of 1.3. This probably is too low for most stands, if the major objective is timber production. A q of 1.5 or a little higher would be a more realistic long-term goal. Some stands may require several improvement or conditioning operations before the long-term goal is achieved. In the improvement or conditioning operations, it may be more economical to regulate initial yields by a set of components that blend more closely with existing stand conditions.

For example, for second-growth northern hardwoods in New England, which usually have a high q, we recommend an initial structural guide based on a q of 1.7 or 1.8, about 70 square feet per acre, and a maximum diameter class of 18 or 20 inches (Leak and Filip 1975). If we attempted to use a management package based on a q of 1.3 or 1.4 and 80 square feet per acre, and a 22- or 24-inch maximum tree size as an immediate goal, we would run into application problems. Trees in the large sizes would be lacking, and a heavy treatment in the small sizes would be required--which may not be economically justified. However, these latter components could probably be applied immediately in many old-growth northern hardwood stands.

After a timber cruise is made, q can be calculated for the stand by using the least-squares method proposed by Leak (1963). Armed with the information on q, as well as the desired stocking goal and maximum tree size, a forester can readily compute a stand-structure guide for the tract (table 1). From this computed information, an allowable harvest by diameter classes can be determined.

A more practical procedure, especially in small woodlands, is to use a diagnostic tally sheet containing a stand-structure guide based on a predetermined value of q (table 2). After the timber cruise is made, a forester can visually compare the structure of the stand with structures based on different q values; then he can select the one that compares most favorably. The next step is to prepare a prescription for treating the stand.

When marking the timber, it is often more practical--especially on large units of 100 acres or more--to guide the allowable harvest tally by grouping the trees in broader diameter classes than 2 inches. Three or four diameter groups can be used in the field if necessary, corresponding to poletimber--6, 8, and 10 inches; small sawtimber--12 and 14 inches; medium saw-

Table 1.--Calculation of a stand-structure guide for uneven-age management

1. List the dbh classes to be used. As a trial run, start with one tree in the largest diameter class. Keep multiplying by the selected q to get the number of trees in each smaller diameter class.

2. Calculate the basal area of each dbh class and determine the total basal area.[1/] This total basal area will not agree with the desired residual basal area stocking. Therefore, determine the ratio between the desired residual basal area and the calculated basal area.[2/] Multiply this ratio or correction factor by the numbers of trees and basal area in each diameter class. This correction gives the desired stand-structure guide.

Dbh class	Trial run (q = 1.7)		Desired structure (q = 1.7)	
	Trees per acre	BA per acre	Trees per acre	BA per acre
	No.	Sq. ft.	No.	Sq. ft.
6	40.8	8.0	63.5	12.5
8	24.0	8.4	37.3	13.1
10	14.1	7.7	21.9	12.0
12	8.3	6.5	12.9	10.0
14	4.9	5.2	7.6	8.1
16	2.9	4.0	4.5	6.2
18	1.7	3.0	2.6	4.7
20	1.0	2.2	1.6	3.4
Total	97.7	45.0	151.9	70.0

[1/] BA per dbh class = $0.00545D^2$.

[2/] Ratio or correction factor = $\frac{70}{45}$ = 1.556.

TABLE 2.--DIAGNOSTIC TALLY SHEET FOR UNEVEN-AGE MANAGEMENT

Cumulative Tally - Number of Trees Per Acre (B.A. Factor 10)

DBH	Number of Trees														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6	51	102	153	204	255	306	357	407	458	509	560	611	662	713	764
8	29	57	86	115	143	172	201	229	258	287	315	344	372	401	430
10	18	37	55	73	92	110	128	147	165	183	202	220	233	257	275
12	13	25	38	51	64	76	89	102	115	127	140	153	165	173	191
14	9	19	28	37	47	56	65	75	84	94	103	112			
16	7	14	21	29	36	43	50	57	64	72	79	86	Basal Area		
18	6	11	17	23	28	34	40	45	51	57	62	6	Per Acre (sq.ft.)		
20	5	9	14	18	23	27	32	37	41				Merchantable		
22	4	8	11	15	19	23	27	30	34						
24	3	6	10	13	16	19	22	25	29	Tally Legend		#Prism Points	Cull		
26	3	5	8	11	14	16	19	22	24	/					
28	2	5	7	9	12	14	16	19	21	0					
30	2	4	6	8	10	12	14	16	18	X		Total B.A. ____ sq.ft.			
Total												Total #trees ____			

Total Number of Trees Per Acre - Add the last figure used in each block and divide by the number of point samples tallied.

B.A. per acre - Add the total number of entries by class (first row), multiply by 10, and divide by the number of point samples tallied.

STAND DIAGNOSIS

DBH Class	Present Stand		Q = 1.7 Goal per acre		Surplus (Deficit)		Marking per acre	
	Trees per acre	Basal Area per acre	Trees	Basal Area	Trees per acre	Basal Area per acre	Trees	B. A.
	No.	Sq. ft.	No.	Sq. ft.	No.	Sq. ft.	No.	Sq.ft.
6			63	13				
8			37	13				
10			22	12				
	Sub-total		122	38				
12			13	10				
14			8	8				
	Sub-total		21	18				
16			5	6				
18			3	5				
	Sub-total		8	11				
20+			1	3				
	Sub-total		1	3				
Total			152	70				

(Tally sheet suggested by Ken Lancaster), USDA, Forest Service)

timber--16 and 18 inches; and large sawtimber--20 inches plus.

DISCUSSION

I believe a general misunderstanding of how uneven-age management works has caused much reluctance by many foresters and timberland owners to accept the system or to apply it completely. You either cut too much, or not enough, or the wrong trees; that has been the usual response. But as I described the details of the system to you, it can be made to work with flexibility to fit many stand conditions. Also, we now have tree-value conversion standards for several hardwood species, even to the point of making on-the-ground projections of each tree's development, based on each tree's own unique characteristics (DeBald and Mendel 1976; Mendel and others 1976).

Some foresters believe that it is difficult to harvest marked timber, as required by the system over a range of diameter classes, without injuring or damaging much of the residual growing stock. This is true to a degree. Regardless of whether track-type or wheeled skidders are used, some tree injury will occur. The injury need not necessarily exceed acceptable limits for timber production.

In a logging-damage study in northern hardwoods in New York State, logging injured about 30 percent of the residual trees; and major injury was done to about 20 percent (Nyland and Gabriel 1971). In our uneven-age management studies at the Bartlett Experimental Forest, logging injuries have been within these percentage ranges or usually lower. Of course, if felling and skidding operations are not planned properly, injury could be much higher, which would have a serious impact upon future tree quality. We must remember that logging injury can also occur in timber tracts under even-age management, particularly during commercial thinnings. Some care must be exercised under both systems.

Others say that uneven-age management can be applied only on small timberland ownerships--up to 200 or 300 acres. However, there are many portions of larger ownerships where uneven-age management would also be applicable. Areas with fragile soils, or with steep topography, or those areas that have high esthetic appeal, should probably be under uneven-age

management. There are other areas covered by northern forest types that should also be considered for uneven-age management, especially where public use is increasing or multiple-use management is important. Where such areas must be partially cut to maintain high-forest conditions, they could be managed for sustained yield under uneven-age management, using the three basic components for stand manipulation that I have outlined.

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EVEN-AGED INTENSIVE MANAGEMENT
TWO CASE HISTORIES

by Harold M. Klaiber, Forestry Manager, Northeast Operations, Scott Paper Company, Winslow, Maine.

INTRODUCTION

In 1967 Scott Paper Company merged with the S. D. Warren Company and S. D. Warren became a division of Scott. In 1969 the S. D. Warren timberlands in the Bingham, Maine area were transferred from the Warren Division to the Northeast Operations of Scott. Included in this transfer were approximately 700 acres of tree plantations which had been established in the 1920's and early 1930's. A wide variety of both native and exotic species were planted. These included Douglas-fir, Norway spruce, European larch, Austrian pine, red and white spruce, and red and white pine.

As case histories to illustrate the practice of even-aged intensive silviculture, I have selected one plantation consisting of native red pine and white spruce in alternating rows, and one plantation of exotic Norway spruce as a pure stand.

TUSCON PLANTATION

The red pine (Pinus resinosa Ait.) and white spruce (Picea glauca Voss) plantation is located in Bingham, Maine and is commonly called the Tuscon plantation. The plantation contains 31 acres, of which 14 acres are alternating rows of red pine and white spruce. The planting site was an old field that had not been mowed and weedy vegetation occupied the site. Planting was done in the fall of 1930 at a cost of $10.40 per acre.

Initial spacing was 6 feet x 6 feet.

The white spruce planting stock was 3-1, and the red pine stock was 2-1.

In 1948 and 1949 the red pine was pruned. The stand was also thinned on an individual stem selection basis. The records do not indicate how much volume was removed, but report a profit of $31 per acre over and above the actual thinning cost, so some merchantable volume must have been removed in the thinning.

In 1971 increment borings on the red pine which had almost completely over-topped the white spruce showed that the red pine grew at a maximum of 5 rings per inch, but by 1971 had slowed to 10 rings per inch.

Also in 1971, measurements on 3 sample plots showed the following:

Species	Volume in Cords/Acre	Basal Area per Acre
Red pine	54.2 Cds.	186 sq. ft.
White spruce	7.3 Cds.	31 sq. ft.
Combined	61.5 Cds.	217 sq. ft.

In the 41 years since planting, merchantable volume growth averaged 1.5 cords per acre per year. This figure does not include the volume removed in the 1948-49 thinning because no record of the actual volume removed is available.

BRAZIER PLANTATION

The Norway spruce (Picea abies (L.) Karst.) plantation that I selected for the second case history is located in Brighton, Maine and is commonly known locally as the Brazier plantation. The total plantation is 27 acres, of which 10 acres are pure Norway spruce. The planting site was an old field with heavy grass cover. Planting was done in the spring of 1921.

Initial spacing was 6 feet x 6 feet.

The planting stock was 2-1.

In 1928 at plantation age 7 years, the Norway spruce were released from alder and grey birch competition which are typical volunteer species on old fields in this location.

In 1941 at plantation age 20 and again in 1948 at plantation age 28, individual crop trees were pruned.

In 1955 at age 34, the plantation contained a volume of 30 cords per acre. A thinning removed every 6th row of trees completely and removed individual stems on a marked tree basis in the 5 residual rows. Approximately 20% of the total merchantable volume was removed leaving a residual volume of 24 cords per acre for the entire 10 acres.

The year following this thinning, in 1956, a permanent 1/4 acre sample plot was established. The results of 20 years of measurements on this plot are shown in Table 1, covering the period from July 2, 1956 to June 30, 1976.

Table 1. BRAZIER PLANTATION - NORWAY SPRUCE

Date	Cords/ Acre	Basal Area (Sq.Ft.)	Avg. DBH (in.)	Avg. Height (ft.)
7/2/56	31.3	133	8.95	46
11/59	36.8	162	9.85	50
12/3/65	43.3	184	11.30	58
6/16/70	52.7	211	12.00	69
11/17/71	55.5	225	12.20	71
9/26/73[a].	44.9	175	10.30	71
6/30/76	48.5	187	10.40	71

a. After thinning.

In 1971 the plantation averaged 55.5 cords per acre with an average DBH of 12.2 inches. In early 1972 additional thinning was done with individual trees removed on a marked tree basis. Removal in this thinning averaged 10 cords per acre.

Based on the 1976 remeasurement of the permanent plot, the present stand volume is 48 cords per acre. The two thinnings have removed 15 cords per acre making a total net merchantable growth of 63 cords per acre for the 54 years since planting. This averages 1.2 cords per acre per

year for the 54 years.

During the 16 year period between thinnings (1956 to 1971) the net merchantable growth was 24.3 cords per acre or an average of 1.5 cords per acre per year for each of the 16 years.

EVEN-AGED GROWTH POTENTIAL

In both case histories cited, the intensive management consisted only of:

1. Species selection
2. Control of initial spacing
3. Early release from volunteer hardwoods
4. Thinning at infrequent intervals

One can only speculate what the growth potential of even-aged stands would be if initial planting stock were selected for superior growth capabilities, if the stand were fertilized perhaps 2 or 3 times during the rotation, and thinning was done at more frequent intervals. I believe these two case histories demonstrate that with some modest increases in the intensity of our management it is extremely likely that a minimum growth of 1.5 cords per acre per year over the entire rotation could be attained on considerable acreage in Maine.

SILVICULTURAL SYSTEMS - UNEVEN-AGED MANAGEMENT

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Uneven-aged Management, to me, indicates some form of partial cutting, perhaps selective cutting or diameter limit control in the harvesting cut, which, in most cases, removes the larger diameter, more mature trees and leaves a residual stand composed of healthy, fast-growing, well-spaced second growth timber, with a good number of trees in the 6" - 12" diameter class.

My whole forestry background has been largely oriented towards some form of partial cutting, having been brought up in a logging family that believed strongly in this method of handling timberland. In fact, my own experience, gained from over 40 years of working with and observing the forests of Maine, has done nothing to shake my original belief that some form of selective or partial cutting is best suited for a high percentage of Maine forest land and, most particularly, for the spruce-fir type. Natural regeneration and good stocking is no problem here and nature needs only a little help to improve growth rates markedly.

I can think of only two future changes that could greatly alter my thoughts along these lines. One would be the development of some fast-growing softwood species or "super tree" that could be, hopefully, planted cheaply and would grow several times faster than natural regeneration. The other break-through would be some method wherein pulp mills could utilize bark-on softwood chips that would permit commercial and profitable thinnings of softwood thickets that normally occur after clear-cutting procedures.

When thinking of partial cutting, there comes quickly to mind several distinctive benefits to the landowner:

1. Better and more continuous growth rate (no raspberry stage).

2. Less exposure to a disastrous fire.

3. Better conservation of both soil and water.

4. Better control of desirable species mix in the residual stand and the natural regeneration that follows harvesting.

5. The control of species mix helps to reduce susceptibility to future insect epidemics; i.e., spruce budworm.

6. Improved wildlife habitat (for the public).

7. Higher return per acre because of increased stumpage values from sawlog quality, larger diameter trees.

8. Maintaining a constantly high resale value of the land, due to the ever-presence of a residual merchantable stand.

9. More frequent and continuing stumpage returns, with the escalation of stumpage value staying closer to the ever-increasing expenses of supervision and logging.

I did not mention in the above listed advantages the subject of aesthetics, but, surely, this is uppermost in the minds of some, and cannot be wholly discounted.

It is my strong belief, in view of rapidly rising cost of supervision and land taxes, that a forest landowner in Maine can no longer afford clear-cutting, in most instances. In this land of long, cold winters, the landowner cannot lose a single growing season. It is true that the landowner may gain in lower logging costs at the time of cut, but the continuing annual expenses of administration, protection, and taxes will

will surely eat up the money saved in logging expense before he can return to cut again on the same parcel.

It is apparent that it is becoming increasingly difficult to perform selective cutting in large commercial operations. It is also true that most mechanical logging systems on the market today do not lend themselves well to a system of partial cutting. It is my belief, however, that just around the corner, in Maine, there will be a need for more intensive forestry and, with this approach, the demand for machines oriented toward partial cutting will manifest itself. Heretofore, in Maine, wood supply has not been a problem and the demand has been for a machine to (1) replace labor, and (2) to log more cheaply, although it is sad to contemplate that this has not been achieved. It is obvious that the timberland base is going to remain about the same in this State and, somehow, more intensive forestry must be practiced if the growth rate is going to meet the demand.

Twenty years ago this spring, in 1956, International Paper Co. commenced the first large-scale marked wood operations in Maine. I think it will make more sense to you if I confine my remarks to spruce-fir management in northern Maine and I would like to use Twp. 16 Range 9 as an example of what one might expect as a result after some 50 years of partial cutting. I chose this town particularly because the cutting history of this land is typical of many land ownerships in northern Maine. T 16 R 9 is located fairly close to the confluence of the Allagash and St. John Rivers, with the township draining northerly into the St. John and easterly into Fish River. Company ownership in this town commenced by purchasing 1/4 interest in common and undivided in 1917. Over the years, the Company has acquired additional interest in this town until the present ownership is 65/72 I-P and 7/72 Pingree Heirs. This is a full size township comprising 23,340 acres, with almost exactly 80% of the land area in either mixedwood or softwood type. Although there are small volumes of white spruce and black spruce in the softwood mix, the major species, by far, consist of red spruce and balsam fir. In our Maine lingo, Foresters would refer to T 16 R 9 as a "good growing town", meaning a good site,

well drained, and definitely better growth than experienced on some other towns.

I think I should start the story on this town with a Company cruise in 1927 as made by John Marsh under the direction of Charles King. This cruise was made immediately after sawlog operations were completed, with most timber being cut to a stump diameter of about 12". This 1927 cruise found a residual stand of 144,000 cords, or 6.2 cords per acre. Some comments in this 1927 cruise report may be of interest to you.

The cruiser referred to two small sawmills that had been operating on the town during the 1920's and both of these mills had machinery for making shingles as well as lumber. He also commented that the sawlogs were hauled to the mills by log haulers and that the town had been cut hard (in his opinion) during the last 15 years.

I believe the significant thing here is that there was a residual stand left of some 6.2 cords of spruce-fir per acre, with 56% of the softwood volume in trees 10" d.b.h. and larger.

For the next 20 years, through the depression era, there was very little cutting of any kind taking place on this ownership and the next inventory figures available on this town were developed from a joint cruise by Great Northern Paper Co. and International Paper Co. in 1946. This cruise indicated a total stand of 213,000 cords, with an average stand per acre of 8.88 cords of spruce-fir. A few comments made in this cruise report might also be of interest.

I note that the cruiser is still making observations in 1946 about a road system that needs corduroying. He also mentioned extensive damage to white and yellow birch by the bronze birch borer. He also stated that in spite of heavy logging prior to 1929, "there is a good stand of spruce-fir on this town, due no doubt, to the fact that at the time of operating, the smaller diameter trees were not considered merchantable". The cruiser found no evidence of epidemic infestation of insects; so apparently this town missed the earlier spruce budworm epidemic.

Shortly after this cruise and in 1949, we commenced extensive operations on this town, with 179,000 cords being removed during the next 12 cutting seasons through 1960. All of these operations were on some type of a partial cutting basis, with the period 1949 through 1955 on diameter limit controls, and with the period 1956 through 1960, for the most part, marked wood on an individual tree selection basis. Since 1960, little cutting took place on the town until the spring of 1975 when nearly 5,000 cords were salvaged as a result of the spruce budworm epidemic. The total volume removed from the town, 1947 through 1975, and before the 1975 cruise, was 185,000 cords.

This township was re-cruised again last year (1975) which is some 15 years after large-scale operations ceased. The 1975 cruise revealed a total stand of 226,000 cords of spruce-fir, with 51% of the volume in sawlog quality trees 10" d.b.h. and larger. I might mention that the 1975 cruise indicated a stand of 11 cords per acre in the softwood plus mixedwood types and 13.6 cords per acre in the softwood type only which comprised almost exactly 50% of the total forested area. Of this volume above 10" d.b.h., 55% is spruce and 45% is fir.

Now, bear in mind that this present stand of timber on T 16 R 9, comprising 13.6 cords per acre in the softwood type, is now ready to cut again, even though 185,000 cords of softwood were removed from this town between 1949 and 1975. A comparison of the 1927 cruise with the 1975 cruise indicates that land classified as softwood had increased from 38% of the area to 49.8% of the forested area. It is true that some of this difference could be caused by a variation in cruising techniques, but it is obvious that the partial cutting procedures had at least maintained, and probably increased substantially, the acreage in softwood type.

There are many ways of expressing growth and growth rates on forest land. However, a factual examination of the growth data on this town between 1946 and 1975, based on actual cords removed and cords now standing in 1975, indicates a growth rate of .353 cords of spruce-fir per acre per year on the mixedwood plus softwood types together (18,327 acres).

Of course, if the rate of growth could be identified separately on just the softwood type, it would be considerably more than the .353 cords per acre aforementioned.

I would like to have you bear in mind that the results on this town were obtained with no added expense of site preparation, planting, or the incumbent costs associated with artificial regeneration. The only extra costs involved here were some 22¢ to 30¢ per cord for tree marking spent on approximately one-half of the volume that was removed. The cutting operations were on a large-scale, commercial basis, with the cutters all paid on piecework. The operations were nearly 100% horse yarded. During the cutting operations, we were blessed here with a Woods Superintendent who had an intense desire to see the land handled well, two cooperative woods contractors, and two thoroughly experienced Scaler-Inspectors. Pulpwood from this town is expensive, at a long freight rate, and our new mill at Jay had not yet been built at the time of these operations. In fact, at that time, we were hard pressed to market the allowable cut. However, it is my belief that if conditions had permitted the expenditure of a few dollars more per acre to further improve and control the harvesting, we could have increased the growth rate per acre on the residual stand even more than has been experienced.

Time has permitted me only to sketch briefly the history on this one township in northern Maine, which is surely not the worst land owned by International Paper. I believe you can agree, from the facts presented, that with only a little care exercised in the harvesting, you can "have your cake and eat it too" in the spruce-fir type of northern Maine.

NATURAL REGENERATION - SMALL OWNERSHIPS FROM CONCEPT TO PRACTICE

by Arthur G. Dodge, Jr., North Country Resources Conservation and Development Area Forester, New Hampshire Cooperative Extension Service, Conway, N. H.

Abstract

Established concepts of successful natural regeneration are not necessarily practiced on small ownerships of ten to 500 acres. Unevenage management will be the primary management system on small ownerships and natural regeneration is the most practical method of providing for continuous forest production. We can obtain satisfactory natural regeneration by good planning and proper supervision of the on site application of necessary techniques.

Small Ownerships

American Forest Institute tells us that individuals own 59 percent of the commercial forest land in this country. This is a significant portion of our forest and small ownerships fall within this category. For the purposes of this paper, I will be discussing ownerships of 10 to 500 acres in size (4.05 - 202.40 hectares). In the three southern New England states plus New Hampshire and Vermont, the USFS Northeast Forest Experiment Station estimates that there are some 348,000 private landowners. Of this group, approximately 150,000 (43 percent) own more than ten acres but less that 500. In New Hampshire, the average privately owned woodlot is about 47 acres and I believe the average within the northern forest types that we're discussing probably will not be much larger than that, but for today, let us consider ownerships up to 500 acres.

There are several premises upon which I base this paper. They are:

A. These owners will continue to depend on natural regeneration to reproduce trees on their woodlots.

B. With the exception of a few pure stands of white pine and spruce-fir, management on these areas will be primarily unevenaged. Well over half of New Hampshire's commercial forest is in mixed hardwood-softwood types or hardwood types. I am assuming that this is pretty much

the case for the rest of the area that concerns us. Unevenage management seems more practical on small ownerships containing these types. Another reason that I believe unevenaged management will prevail is that even though the reconstituted wood industry has grown at approximately 15 percent annually over the past few years, the price for fiber alone will not be attractive to this owner. Mr. Charles W. Bingham of Weyerhaeuser Company expressed this idea very well when he spoke to the Sixth American Forest Congress at Washington, DC in October 1975. He stated that "The industry is also a direct user of its own raw materials, to a large degree. Through its manufacturing facilities, it can obtain efficiencies and values that the owner of a 40-acre woodlot cannot achieve." According to Nick Engalichev, our Extension Utilization and Marketing Specialist at Durham, wood in the solid form is going to get more value recognition. To quote him, "Good hardwoods are going to be worth the price of gold." He tells me that on today's wholesale market, a thousand board feet of the top grades of northeastern oak sells in the 500 dollar range.

The other factor that requires us to think in terms of unevenaged management is, this landowner usually wants to use his or her land for several purposes. Timber production is not necessarily the main aim in life and the owner is unwilling to have large areas clearcut at any one time. A large area in this owner's mind may be two or three acres. Ten acres could be "complete devastation".

I would also like to point out that my statements regarding natural regeneration are based on some application of other people's research, and personal observation of small ownership forest management in the New England area since 1957.

Natural Regeneration Concept

Before we talk about natural regeneration practices on the small ownership, we should consider several related ideas or concepts. First, assuming that a preferred species seed source exists in the area, there will nearly always be some natural regeneration. This regeneration really has no expense attached to it. You might say it's pretty much a gift of nature. Secondly, the sixth edition of "The Practice of Silviculture" by Hawley and Smith states "Most of the answers to problems of securing natural regeneration are to be found in existing forests". In my experience I have found this to be very true. The third concept is that a tremendous amount of written information on this subject exists. The Northeast Forest Experiment Station

publications, various university bulletins, textbooks, and Forest Service handbooks are all available and should be included in your personal, company or institutional libraries.

Practice

In practice I have found several things of interest and very apparent on the small ownerships that I have observed:

A. The desirable natural regeneration has occurred pretty much by chance and is usually associated with a silvicultural activity. In most cases, this has been an unsupervised harvesting operation.

B. Much of the regeneration is not where we want it. It's found primarily in or adjacent to logging roads or yards that will have to be relocated in the future if we decide to produce timber from this regeneration. If the young trees are not growing under the previous situation, they will be found in close proximity with or, what I term, within easy suppression distance of unwanted species.

C. In the case of intolerant and intermediate species you may, at first glance, get the impression that natural regeneration has not provided enough desirable specie stems per acre.

Even though these are the conditions that usually exist in practice, I see no reason why we cannot provide plentiful natural regeneration of the species we choose. In my opinion this is the only way to go when dealing with small ownerships. Stand establishment by direct seeding is a more expensive alternative. At this point in time, it appears that conventional planting is just too expensive. Good planning, layout, and particularly supervision, are the criteria for successful natural regeneration. We must keep in mind such things as seed source, timing, amount of shade or sunlight necessary, site factors, plus forest protection and be sure that the proper techniques are accomplished on site.

The biggest problem is getting to the landowners and convincing them that intensive culture is needed. I remind you that in two recent forest landowner studies the USFS Northeast Forest Experiment Station indicates that no more than five percent of small ownerships receive professional advice during harvest operations. I understand this includes selection or intermediate cuttings. I've long been of the opinion that our profession has not been in the driver's seat, particularly when it comes to the management of small forest ownerships. National

commercial forest production statistics bear this out. We foresters have to go on the offensive, convince these landowners that we know how to make their lands more productive, and that there is not just one step but many steps in maintaining this renewable resource. Establishing a forest by natural regeneration is the least expensive and most practical first step in the cycle.

PUBLIC LANDS - FROM CONCEPT TO PRACTICE

by: John J. Vrablec, District Ranger, Evans Notch Ranger District, White Mountain National Forest, Bethel, Maine

Abstract

Intensive timber management can and is practiced on National Forest lands in the Northeast. There are, however many constraints and limitations which are placed upon the public lands manager. The key issue here is that the National Forests are PUBLIC lands which must be managed for the public.

INTRODUCTION

So far today we have heard much about what is available or ideally desireable in the science of intensive forest management of Northern Forest Types. I have been asked to comment as to how these concepts are practiced on public lands in a sort of case history. My approach will be simply to relate in a very non-technical manner the experiences of a public land manager on one of our National Forests.

BACKGROUND

Many of you are aware of the many laws and regulations under which the National Forests are managed. I will name only a few of the key ones which do have and will probably continue to have direct impact upon the practice of intensive culture of <u>any</u> forest types. They are:

1. The Organic Administration Act of 1897 - provided for management, protection and use of the Forest preserves.
2. The Multiple Use - Sustained Yield Act of 1960
3. The Wilderness Act of 1964
4. The National Environmental Policy Act of 1969
5. The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA)

There is also new Legislation pending which many of you are aware of. Such bills as Senate Bill 3091 (Humphrey Bill) and its companion bill H.R. 12503 + 13832, Senate Bill 2926 (Randolph Bill) and its companion bill H.R. 11894 and Senate Bill 2851 are some of the bills, which would have an impact on how, if any, forest management will be practiced on National Forest lands.

The White Mountain National Forest made a management plan modification in 1968, which changed the system of timber management from uneven - aged to even - aged. This was based on results of research conducted at the Bartlett Experiment Forest over a 30-year period which indicated that even-aged management of northern hardwoods and associated species was a desireable system. Thus, the present timber management and therefore any intensive culture of Northern Forest Types on the WMNF is based on this even-aged system.

PRACTICE

The general objective of timber management on the WMNF will be to grow and harvest timber crops to the best public advantage in accordance with the previously mentioned laws and regulations. A timber management plan provides guidance for the development of the timber resource.

Some Specific Objectives Are:

1. Development of even distribution of age classes by the end of $1\frac{1}{2}$ rotations.
2. Increase the proportion of desireable species (yellow birch, paper birch, white ash, sugar maple and red spruce) through proper cutting methods and timber stand improvement work.
3. Market the full potential yield consistant with Multiple Use requirements.
4. Maintain a healthy, vigorous forest.

To achieve the stated objectives, coordination of all the land and social resources of the National Forest are needed. This coordination is achieved best through the Land Use Planning practices and policies which are carried out on the WMNF as well as throughout the Forest Service. Here on the WMNF, we have completed the "Guide for Managing the National Forest in New England" in 1973 and the "Forest Plan - WMNF" in 1974. These planning documents provide the guide and policies for all coordination requirements between timber management activities and other resources. The third step in this planning effort, the individual Unit Plans provide even more specifically the necessary coordination as it applies to individual areas on the Forest.

I will not go into great detail as to the specifics of the management guides for the various timber types on the WMNF since that would entail a detailed description of the Timber Management plan itself. Some over-all guides and comments are as follows:

1. The Spruce-fir type which comprises 11% of the commercial forest land on the National Forest, is managed in accordance with "A Silvicultural Guide for Spruce-Fir in the Northeast" USDA report NE-6. Rotation age will be 90 years

for red spruce. Balsam fir should be removed as part of an intermediate cut before age 70. Regeneration can be either shelter wood or final harvest.

2. The Spruce-hardwood type which comprises 24% of the CFL on the National Forest has a rotation age of 110 years. Regeneration cutting will be by the shelterwood method. Balsam fir should be removed during intermediate cuts (thinnings) prior to age 70.
3. The Maple - Beech - Birch type, which makes up the majority of the CFL (58%) will be managed using "A Silvicultural Guide for Northern Hardwoods in The Northeast" USDA Research Paper NE - 143. The rotation age will be 120 years. Regeneration cutting will generally be by Final Harvest (patch, strip or stand) and seed tree methods.
4. The Paper Birch type, although a small component (7%) of the CFL, is economically important. The management guide used is "A Silvicultural Guide for Paper Birch in the Northeast" USDA Research Paper NE - 130. Rotation age will be 70 years. Regeneration will be by final harvest and seed tree cutting methods where more than 50% of the future stand will be paper birch.

These guidelines are just a few of the many that the professional forester has to guide him in the scientific application of forest management on the WMNF. There are many more, quite specific as to area (acreage) control, potential yield, allowable cut, etc. All of these speak to the professional forester and to his scientific management. But what about the human side of the coin or the fact that the National Forests are public lands?

CONFLICTS/OPPORTUNITIES

Again, as you probably are all aware of, National Forest management must be responsive to the myriad of laws, national interests, public demands for the various uses of the National Forest, and a land use ethic which at times defies purely scientific or technological knowledge.

Since converting to the even-aged system on the WMNF in 1968, we <u>also</u> have had to cope with the many multiple-use conflicts and opportunities which have risen. For instance, during the period of 1971 to 1975, we had harvested 528 acres of softwood stands and 8654 acres of hardwood stands through intermediate cutting practices, and 543 acres of softwood stands and 6173 acres of hardwood stands through regeneration cuttings. And even though we had some rough moments, we <u>do</u> continue to be able to practice the types of harvesting methods which have come under fire in other parts of the country.

Because of its location, the WMNF is one of the most highly used National Forests in the country. Recreation use and management permeates every facet of our operations. We have many user publics, ranging from the ultra-preservation minded to the exploiter, the sightseer to the logger, the hunter to the bird watcher.

AVOIDING THE CONFLICT

How do we deal with all these conflicts and opportunities? I wouched very briefly upon our Land Use Planning process and won't go into any details because I believe there will be another speaker dealing with the subject. I do believe however, that we have dealt with these issues in at least two parallel means which have contributed to our staying out of court, so far. These have been through our Information and Education processes (keeping the public well informed) and through our own policies of public involvement in our decision making processes.

To expand a little on these, we have made every attempt at informing the general public, the pressure groups, and the individual of every facet of our management practices. No longer can any one of us assume that the public is disinterested or ignorant of what we are attempting to do. We therefore concentrate, through the educational process, on having a knowledgeable public work with us in resolving the issues and conflicts.

This leads us into our second most valuable tool, Public Involvement. To state it very briefly and non-scientifically, we ask the public how they would like to see us manage their lands. Of course we don't do this blindly. We attempt to present the public with all of the facts, scientific knowledge, technical data, etc. that we have gathered. This is done by the professional on the ground. He also uses his scientific knowledge and training to recommend what he believes in the best course of action. This then is sent out to the various publics with the request that they study it and give us their input. We stress very strongly that they not only tell us what they do or don't like, but more important, that they provide us with their rationale for their recommendations. By analyzing the inputs from the public and combining it with our analysis, we have been able to come up with decisions for forest management which at least to date has worked fairly well.

Over the years we have developed a sensitivity to some of the conflicts which impact forest management practices on public lands. We have for instance limited our individual clearcutting Units to 40 acres and in some places even down to 10 acres. We recognized that aesthetics played a major role in how the majority of the public viewed our management practices. These same practices have been modified by our wildlife considerations.

I could go on and on about the various considerations interwoven into our land management. It should be clear that the key word or issue here is that we deal with "Public" lands, in which the public has a vested interest and in which the public is apparently demanding its say.

ARTIFICIAL REGENERATION; APPLICABILITY, OPTIONS AND RESEARCH NEEDS

by

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Abstract

In this overview of the status of reforestation in the northeastern United States, the applicability of natural regeneration is compared to planting and direct seeding. Foresters are urged to conduct careful planning of reforestation and to use harvesting as a silvicultural tool. Landowners are cautioned against the use of clearcutting unless they are prepared to use artificial regeneration measures. Research in the economics of reforestation options is recommended and the importance of forest genetics research to the regeneration phase of intensive forest management is emphasized.

One of the major decisions to be made in the sustained yield management of any plant crop is how to first establish it and then how to replace it after harvesting. Most so-called "cultivated plants" require much human assistance, not only in their establishment, but in subsequent survival, maintenance of genetic identity and continuance in usefulness to mankind. Only a few species of cultivated plants provide the world population with the bulk of its food. They have little resemblance to their wild ancestors and are biological monuments to man's long-term efforts in selection, introduction, breeding and intensive management.

Conversely, tree species yielding most of our world's wood products are essentially "wild plants" and persist as a residua of man's exploitation. The northern forest types of concern to this symposium contain no exceptions. They consist almost entirely of indigenous species which have attracted little attention to improve or even preserve their existing genotypes and they have not been intensively managed except experimentally or on a small scale.

NATURAL REGENERATION

Although the records show that nearly two million acres have been planted to trees in New England and New York, most of this has been done on abandoned farmland and forest landowners in the Northeast have concerned themselves but little with artificial regeneration as an alternative available to them in re-establishing forest types following logging. Trees eventually replace trees and most resulting species have been marketable. Thus we have relied upon the resilience of the land to return to us, through succession, a new crop for an old one. Nature, in serving its purpose, has generally satisfied ours for we have not been sensitive to setting standards of composition and stocking which were very demanding of either of us.

Although natural regeneration, when unplanned and unaided, is highly erratic and unreliable as to timing, species, density and distribution, regionwise it has provided a surplus of wood and only following forest catastrophies has our confidence in it been badly shaken. Therefore, it is understandable why people have not pressed for a departure from the traditional dependence upon wild seeds, sprouts and suckers to renew a wild crop.

These are generalities, and are not meant to imply that management of all our woodlands are without purpose, planning or provision for replacement. To the contrary, much progress has been made during our professional lifetimes in promoting those forest practices which at least tend to preserve the status quo of most of our northern forest types. Improved forest protection, more and better access roads, conservative cutting practices, professional custodianship, free consulting services to small landowners and productive research are among the achievements which have helped to move us from the purely exploitative operations of the past toward a more intensive form of socially-oriented forest management. But our achievements have been too few and we should consider our progress with professional discontent, especially from the silvicultural viewpoint. A critical analysis of the status of our regional silviculture would pointedly indicate courses of action and choices of options not necessarily new nor novel but more publicly popular and more privately profitable than those now being followed. No analysis should be necessary to convince us that we should abandon our

dependence upon unaided natural regeneration before we are forced into doing so by legislation, as has been the case in several western states.

Choosing the proper silvicultural method of natural regeneration and applying it as intensively as needed should probably be the first reforestation option of many landowners. With most of our major species, ecological knowledge and silvicultural experience are adequate to the task. In those instances where they are not, research to correct such deficiencies should be conducted. However, if man-aided natural regeneration is to satisfactorily serve our purposes, we must adopt a new philosophy toward silviculture and harvesting. They cannot be treated as separate activities as they generally are today. Continuance of the practice of permitting "logging" to primarily serve as a means of removing forest products to keep paper mills and lumber producing plants in operation should not be condoned. Logging must become a management technique and a silvicultural tool or the harvesting will continue only as managed exploitation; and forest re-establishment will be little influenced by silvicultural options of natural regeneration methods. Artificial regeneration will then be mandatory to replace preferred species at proper densities without undue delay.

Natural regeneration methods have the reputation of being less expensive than planting or seeding but they are never free and may not be the cheapest. If we use them, then we should not only carefully evaluate their successes but also compute their costs in order to make proper choices between them and to compare their application with other alternatives. Examples of such comparisons with species of other regions have appeared in recent literature. McDonald (1976) has discussed costs associated with the seed-tree method in regenerating ponderosa pine (Pinus ponderosa) in California. He challenges the belief that this method, which is especially appealing to small landowners, is necessarily cheaper than planting because of such factors as: (1) direct costs resulting from the inhibiting effects of the seed trees; (2) negative effect of advance growth on seedling survival; (3) decrease in stocking and density of regeneration caused by seed tree removal; and (4) increase in logging costs.

Loblolly pine (Pinus taeda) the most intensively planted species in North America, is also successfully regenerated by the seed-tree and shelterwood methods. The decision, therefore, as to the proper method to use is an economic one and Sundry and Lowry (1975) have presented some interesting case studies relating to this decision-making. Important factors influencing the cost of the two natural methods and not tree planting were those associated with: (1) delay in regeneration; (2) tree marking; (3) seed tree (opportunity costs); and (4) pre-commercial thinnings. Costs attributed to delayed regeneration were particularly important to the choice of method, even at relatively low interest rates.

These references are cited to emphasize that the use of any reforestation method should represent a compromise between biological success and economic feasibility. Regardless of the method used, whether natural or artificial, its costs should be determined and compared against other methods and against the probability of incurring a greater cost in the future if no regeneration is planned.

ARTIFICIAL REGENERATION

Planting of Nursery Stock:

The Northeast played a leading role in the early history of reforestation in the United States. The Massachusetts State Nursery at Amherst, established in 1907 (operations terminated in 1970), was one of the first American sources of forest planting stock. Also the state nurseries in New York were once among the nation's leaders in seedling production and innovative techniques of nursery culture.

Low land values, large acreages of abandoned farmland, cheap labor and substantial subsidies helped create a custom, sustain a cause and develop a culture for which there now seems to be little regional demand. The Soil Bank Program of the 1950's stimulated planting but there have been no subsequent instances of motivating circumstances, except for Christmas tree propagation, sufficiently adequate to offset the lack of easy planting sites (those not needing site preparation), increased land values, expensive seedlings and high planting costs. Consequently, the average annual acreage planted in New England and New York has been only about 6,000 and 13,000 respectively, for the past decade and

has not increased significantly during the last five years (Table 1). Thus, planting of bare-rooted stock has been largely confined to restocking old fields and pasturelands and is a low-priority option of forest landowners. It is rarely used as an alternative to natural regeneration in revegetating cutover woodlands and its contribution to intensive forest management in the region is inconsequential. It is interesting to note that this situation exists even when three of our prominent northern species (Pinus strobus, P. resinosa, Picea glauca) and two European ones which thrive here (P. sylvestris and Picea abies) constitute five of the top ten species planted in eastern United States.

Table 1. --Acreage of Forest Planting in New England and New York, 1966-1975 (U.S. Forest Service 1961-75)

State	Acres Planted 1966-75	Avg. Annual Acreage Planted (rounded) 1966-75	1971-75
Connecticut	16,302	1,630	1,950
Maine	20,439	2,040	2,030
Massachusetts	6,302	630	440
New Hampshire	8,657	870	1,030
Rhode Island	2,767	280	290
Vermont	7,133	710	670
	61,600	6,160	6,410
New York	128,262	12,800	13,780

Direct Seeding:

There is also a noteworthy record of this region's involvement in direct seeding. Extensive sowing of pitch pine seed on Cape Cod during the mid-1800's was undoubtedly the first operational direct seeding in this country. Research in contemporary seeding has been conducted by several investigators, beginning in the late 1950's, and in 1964 knowledge gained to that date was presented at a symposium on Direct Seeding in the Northeast. Since then, workshops have been conducted, seeding machines developed and papers published on additional research.

Thus, it has been demonstrated here and elsewhere that direct seeding of some northern species can be successful and could be included among our options of regeneration methods. However, in a recent state-of-the-art paper (Abbott, 1973) it was pointed out that direct seeding was of no practical importance to forestry in northeastern U. S. because it wasn't being used. Only 1162 acres were seeded from 1961-71, a period during which 2.5 million acres of direct seeding accounted for 14% of the land area reforested in the U. S. (Table 2). The regional situation remains unchanged, for less than 100 acres have been sown each year since then.

Table 2. --Contribution of Direct Seeding to Reforestation in the U. S., 1961-1975 (U. S. Forest Service, 1961-75)

Year	Total acres (M) reforested	Number acres (M) direct-seeded	Percent of area reforested by direct seeding
1975	1,930.4	131.5	6.8
1974	1,603.5	166.7	10.4
1973	1,749.7	200.8	11.5
1972	1,680.2	224.5	13.3
1971	1,692.9	242.9	14.3
1970	1,599.8	263.5	16.4
1969	1,457.5	224.6	15.4
1968	1,468.6	218.0	14.8
1967	1,407.7	182.0	12.9
1966	1,319.8	178.8	13.5
1965	1,325.0	188.8	14.2
1964	1,353.6	184.0	13.5
1963	1,362.7	221.5	16.2
1962	1,402.1	210.9	15.0
1961	1,796.2	181.4	10.1
	23,149.7	3,019.9	13.2

Although several factors have contributed to a national decline in the area seeded (Table 2), direct seeding continues to be very important in several states. There are those who believe that it has not

been given a fair chance to prove its worth, even in the South, where it has worked well. The major reason why it is not used more by southern foresters has been recently attributed to their reluctance to recommend it. They don't use it because they lack knowledge and experience of how to do so. They object to its use chiefly because they feel it is too technical (Kerr, 1975).

The disadvantages of seeding are well-known, but they are sufficiently over-shadowed by its advantages to earn it a place among our reforestation options in the Northeast. It is the fastest, cheapest, and least labor-intensive of our artificial regeneration practices. It seems unreasonable not to give it an opportunity to serve us simply because we don't know how to use it properly, are unwilling to gain experience with it, or consider it too technical.

Although it is especially adaptable to small woodlots, the principal use of direct seeding in the South and West has been on large, contiguous areas and it is especially applicable to reseeding newly harvested lands as a supplement to or substitute for natural regeneration. It would appear, therefore, that direct seeding has the potential to become very useful to us if we were more receptive to it.

Planting of Container-grown Seedlings:

The third and newest mode of artificial regeneration available today consists of planting small seedlings grown in individual containers in a greenhouse. Given several names in the past under the general title of Container Planting, it is perhaps most precise to refer to this method as "planting of container-grown seedlings" since these trees may be set out in the field either in their containers or without them.

Largely ignored by foresters in the U. S. until after several years of operational use in Canada, planting of container-grown stock has become popular in the Pacific Northwest where it is estimated that over 90% of such stock is being grown. Production has increased from less than a million plants in 1970 to nearly 50 million or 20% of that region's planting stock in 1976 (Ter Bush, 1975).

A North American Containerized Tree Seedling Symposium was held in 1974. Its proceedings and other forestry literature contain many reports on this subject, and an excellent article in the Journal of Forestry (Stein et al.1975) presented an outlook for using this method and described the state of its art.

There are numerous reasons why planting container-grown seedlings is attractive, even though it is likely to be the most costly. Southern foresters are interested in it primarily for the purpose of extending their planting season. Some tree species are difficult to raise in nurseries and are more easily grown in containers in the greenhouse. There is hope for better survival and growth over bare-root stock and greater production and planting efficiency are promised.

It seems more than coincidental, however, that in the region where container seedling production has thrived, forest management is being intensified and increases in reforestation are motivated, at least in part, by laws requiring it. Also, foresters in Washington and Oregon, the two leading states in total acres of direct seeding, have been forced, involuntarily, to curtail this practice because of restrictions on the use of chemical seed protectants and pre-baiting poisons used to reduce small-mammal populations.

Greenhouse facilities permit the growing of seedlings on more flexible schedules, can be constructed quickly and economically and require only about 5% as much area as do conventional tree nurseries. These are important features where good nursery sites are scarce and new planting programs are planned. These features can make the container seedling method particularly appealing to industrial foresters of the Northeast whose companies are interested in intensifying their forest management. Two such companies in Maine have recently become involved in container seedling propagation.

RECOMMENDATIONS

Natural Regeneration:

The biggest step forward, regeneration-wise, toward more intensive forest management in the Northeast would be to take the necessary action to assure

that no harvesting is conducted without sound plans for obtaining prompt replacement with a well-stocked crop of commercial species. If landowners do not volunteer this action or are not soon educated to do so, they will eventually be legislated into it. In this respect, the long-range good of society must take precedence over the short-range objectives of property owners. If foresters fail to adopt this philosophy toward our forest resources, then they will generate new restrictions on their options of operations and they will bring about the relinquishment of land-use leadership to others more willing to do so.

With the exception of clearcutting of large areas, methods of natural regeneration, if properly applied, should result in satisfactory crop replacement when mature stands of preferred species are timely cut. However, pre-harvest cuttings, site preparation work and even supplemental seeding may be needed to insure prompt establishment of the new stand.

Although the clearcutting method may not only give acceptable, but also the best results of all our options when applied on small areas of proper configuration, we should be cautious in its use. Criticism and punitive action by the public against this method, whether justified or not, can eclipse the benefits gained from it and eventually delete it from our directory of options or place even more inhibiting restraints upon our management practices. Geographical location, personal preference, nor professional dogma cannot for long isolate us from the opinions of an increasingly critical public. Clearcut harvesting, as distinct from the clearcutting method of regeneration should not be allowed and we could enhance our professional image, create more forestry jobs and promote intensive forest management if we were the initiators of regulations to prevent it.

Future Role of Artificial Regeneration:

Therefore, what is the future role here of artificial regeneration? Will it become an integral part of intensive management of northern forest types?

We probably will continue for more than a decade to use it only sparingly throughout the region, except for such crops as Christmas trees and the unique

involvement by a few of the more progressive industrial landowners. This situation will continue as long as: (1) no legal obligations force a change; (2) primary wood processors continue to enjoy a large land base from which to harvest wild crops; (3) there is a surplus of available wood; (4) no forest catastrophies occur; and (5) landowners, particularly forest industry, are not presented with some special circumstance of monetary motivation to intensify their management. The last three of these criteria are particularly vulnerable to change, at least in some areas and with certain species and types.

A need for doubling the nation's wood production in 20 years has been predicted and if this transpires, then the scarcity of supply and escalation of prices of preferred species will force cultural changes.

As a professor of forest protection, I must make a pitch for those practices which are the only reasonable cure for correcting such excessive losses of forest crops as those caused by windstorms, wildfires and epidemics of insects. The first two are always a threat, the third is a reality and all are interrelated. It took forty years to reforest the Tillamook Burn in Oregon, even with the aid of artificial regeneration. We certainly cannot tolerate such a reforestation timetable of any comparable catastrophe in the Northeast, and we should be prepared to plant or direct seed if we have one. The spruce budworm epidemic and the fire hazard of its aftermath are ecological phenomena sufficient by themselves to force us into readiness and willingness to use artificial regeneration or else to forsake any plans for intelligent intensive management.

Money motivates management. Therefore, benefits to the landowners from artificial regeneration should exceed the costs and until they do, there will be little enthusiasm for it. Changes could be made in the Forestry Incentives Program to encourage more intensive reforestation on small woodlots, such as cost-sharing for site preparation and acceptance of direct seeding as a substitute for planting. Cost accounting procedures by large landowners who process their own wood may undergo changes when their balance sheets between harvesting and regeneration show a growth-drain ratio which necessitate increased reforestation to support their wood demands.

Research Needs:

Research needs in artificial regeneration should be considered within the total context of intensive management. What is needed most is new knowledge which will help forest landowners make a profit growing trees under the many sociological, economic, and biological constraints with which they must contend.

A culturally sound and economically attractive method of reforestation may have limited utility if it is flawed by a factor which makes it unacceptable to society. We have recently been shown some classic examples in this regard, such as the curtailment of direct seeding by regulations restricting the use of chemical rodenticides and seed protectants. Also, tree planting following clearcutting of large areas, though profitably appealing and professionally preferred, has offended the public and produced its own problems. Other, less notable, cases could be cited but these should suffice to accentuate the need for a new forest research perspective -- a perspective which includes people as well as practices. We must learn how to make what we do in the management of forests seem right to others, which points to the need for "communications research."

When several methods of regeneration have proven culturally successful and the decision as to which to use is an economic one, then information on costs, both cash and compounded, must be made available on all options and their supplemental or supporting activities. Because of the dearth of such information on regenerating our northern species, research in the economics of reforestation is recommended.

If we measured what we know against what we do not know of the ecology of our northern forest types and species, the results should shock us from any complacency with our existing efforts in biological research. The opportunities and needs for such research are many but I will name only one subject-matter area -- forest genetics -- for the silviculture of intensive management must be based upon genetic principles. The intensive selection and breeding of trees require artificial regeneration, which in turn is dependent upon the application of genetics to provide it with high quality seed (or other propagules) from good genotypes. Hence, research in

forest genetics must receive top priority and should be planned and supported on a Cooperative basis as it has been in the South.

CONCLUSION

I have presented this overview of our reforestation situation, not to be critical or condemnatory of it, but to place it in perspective. For I sincerely believe that unless the regeneration phase of forestry is given proper consideration, the management of our northern forest types cannot become truly intensive.

Foresters must eventually emulate those achievements of their agricultural counterparts who have developed a successful culture of "cultivated food plants." Fiber from the forests of the Northeast will perhaps some day make its mark in the millenium of mankind when the species from which it comes, though still resembling their wild ancestors, can be called "biological monuments" to man's efforts to tame them through intensive management.

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LARGE SCALE SOFTWOOD PLANTING OPERATIONS IN NEW BRUNSWICK

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Abstract

New Brunswick is presently planting 20,000 ac. per year and expects to be planting nearly 60,000 ac. per year by 1979. Total productive forest area is 15,000,000 acres. The program is directly related to projected industrial demand and other forest uses. Plantations are established by scarification and planting of paper pot containers and bare root stock.

Introduction

This presentation will depict the softwood planting program being implemented in the Province of New Brunswick, Canada. I will outline briefly, past and present efforts, future plans, reasons for the program, techniques involved and lastly provide some observation of results and problems.

The Province comprises some 15,000,000 acres of productive forest land. Of this approximately 7,000,000 acres is Provincial Government controlled and the remainder freehold. My remarks will be slanted to Government activity although softwood planting is relatively similar on all lands.

Considering the Provincial situation, planting on an operational basis has been taking place since the early 1960's and has increased from 5,000 acres per year to 15,000 acres in 1975. This year approximately 20,000 acres will be planted and by 1979 (only 3 years) nearly 60,000 acres, representing approximately 1/3 of the annual cutover. Planted acres are expected to level off at this date or be reduced by thinning and seeding.

Why a Softwood Planting Program

This is the first question the administrators of any province, state or private agency must ask themselves before embarking on a program costing millions of dollars annually. In New Brunswick it is simply a matter of supply and demand. The forest industry is essential to the Province and the Government has committed itself to a program of development and proper management. The demand for wood has been calculated and projected; the potential of the Province to meet the demand has been assessed and projected. A necessary third step has been the adjustment of demand to conform with potential supply by controlling industrial activity through mutual cooperation and regulations - the net result being a clear indication of large scale planting effort required along with other silvicultural treatments. This calculation and projection is not an easy exercise and I will not go into the numerous considerations including economic feasibility, natural regeneration, natural growth rates, plantation growth rates, annual allowable cut determination, other forest uses, industrial expansion, land tenure, politics, social impacts, etc. But, it should be re-emphasized that this is the necessary first approach to any planting or reforestation program and it must be "sold" to all those concerned or at least a substantial majority. New Brunswick is plagued with the spruce budworm and this calculated effect on the forest has also been very influential in dictating the planting program.

Planting Techniques

Softwood planting stock for government controlled land consists at present of 50% bare root and 50% greenhouse grown paper pot containers. This will change to 70% containers and 30% bare root when the 30,000,000 seedling goal (30,000 acres) is reached in 1979.

Other than the fact that they are an acceptable type of planting stock, there are basically two reasons for a high proportion of containers (1) encouragement of a more stable labour force (planters) by producing stock which can provide employment throughout the season rather than large bare root operations in the spring and fall (summer planting of bare root represents a survival problem in New Brunswick); (2) to

provide short term flexibility with respect to varying species and quantity requirements of forest managers and possible nursery crop failures. Container stock can be produced in 4-5 months whereas bare root is restricted to production schedules of 2-4 years.

All planting stock is now produced in a central nursery and delivered to District Forest Managers. By 1979 satellite nurseries are planned for several regions. Custom made truck boxes are used for transportation. Costs of growing nursery stock (excluding capital investment) are in the vicinity of $35/M for both container and bare root. However, it is felt that container stock can be significantly reduced through improving nursery expertise and large volume material purchases.

Species composition is now 45% black spruce, 40% jack pine and 15% miscellaneous. These two species are resistant to spruce budworm and are native species currently believed to be best suited to a broad range of New Brunswick sites. However, experience and study indicate a different proportion because of growth-site response. In other words these species may not provide the volume at rotation age required to meet demand projections. By 1979 the proportion should be less than 40% black spruce, jack pine approximately 25% and the remainder white spruce, red pine and larch.

Obtaining sufficient quantities of seed is not a simple accomplishment in the Province and necessitates intensive planning and expenditure of reforestation dollars. A new and modern seed extraction plant and storage facilities are under construction this summer. Also a tree improvement program was initiated in 1974 and we are planning for ever improving sources of quality seed.

Actual planting sites are selected by District Forest Managers who base their selection on regeneration surveys after cutover, projections of annual allowable cut and professional opinion as to site-species productivity. It is recognized that these professional opinions are often less than satisfactory and study of site-species productivity has commenced to devise a systematic and feasible technique for measuring the most important parameters involved.

Most planting is carried out on scarified areas. The different types of scarification equipment are as

follows in descending order of use.

- Barrell scarifier
- Finnish plow
- Marden roller
- Crusher
- Bracke
- Root rake
- Disc trencher
- Prescribed burning
- Full tree logging

Costs vary from $16-$60 per acre (including capital purchase) depending on site and equipment efficiency. An attempt is being made to reduce the variety of equipment to those few preparing a suitable site at least cost.

Planting is nearly all by hand labour with payment on a pieces rate basis. Planting costs range from $20-$40 per acre.

The first large scale operational use of herbicides will be attempted this year on some 4,000 acres of plantation.

Summary

To conclude a softwood planting program such as New Brunswick is embarking on is not the oversimplified procedure I have perhaps presented. Ideas, techniques, problems and even objectives change and represent a continuing challenge to foresters. For example New Brunswick is now facing the problem of under utilization of its hardwood resource. This wood supply will and is influencing demand-supply projections for softwood. Further, uncut hardwood within clear-cuts is a serious hindrance to scarification treatment and reduces the available sites for plantation establishment.

Cost per acre of planting is too high but can be reduced by standardizing one or two systems of growing stock and perhaps only two or three systems of scarification.

Finally, accurate site identification and scientific assessment of plantation survival and development have been recognized as essential components of a successful and feasible planting program.

HARDWOOD PLANTING IN SOUTHERN ONTARIO

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ABSTRACT

Successful hardwood afforestation is possible provided the following conditions can be met: (1) a deep, moist but well-drained soil; (2) intensive site preparation, preferably plowing and disking of the total plantation area; (3) careful planting of healthy, sturdy planting stock; (4) effective weed control for at least the first two and preferably three years after planting; and (5) control of rabbits and mice.

INTRODUCTION

Most hardwood species can be planted successfully provided the proper conditions are met. However, many hardwood species are very exacting in their climatic and site requirements and require intensive cultivation during the early years after planting. Therefore, successful hardwood establishment is generally more difficult and certainly more expensive than planting of coniferous trees.

In the past, hardwood plantations have often failed because foresters and tree planters had insufficient knowledge of the site requirements of the various species, and planting techniques developed for planting conifers have proved to be unsuitable for hardwood planting.

Although our knowledge of the factors affecting hardwood establishment and growth is still rather limited, sufficient information is available now to recommend hardwood planting if the following conditions are met.

SELECTION OF THE PLANTING SITE

The most important factor in establishing hardwood plantations is the selection of a suitable planting site (von Althen 1964). For satisfactory establishment and growth, hardwood species demand a deep, fertile, moist but well-drained soil, and

even land that may produce fair farm crops is not always suited to good hardwood growth. In southern Ontario, good hardwood sites will usually be found along creeks and streams, on lower slopes and in depressions where topsoil has accumulated, in abandoned orchards or gardens, and in agricultural fields where the A and B horizons are at least 18 in. (45.72 cm) deep (von Althen 1972). Hardwoods will never produce high-quality timber when planted on dry, exposed slopes and ridges, or in areas where the topsoil is shallow and the subsoil consists of heavy compacted clay.

Since sites for afforestation are generally available only because the land is unsuitable for agriculture, it would be unrealistic to envision the establishment of large hardwood plantations. At the same time, most available afforestation sites contain some small areas that are capable of growning high-quality hardwood timber. These are the sites on which hardwoods should be planted.

SITE PREPARATION AND WEED CONTROL

The second most important factor in successful hardwood plantation establishment and early growth of seedlings is the control of herbaceous competition. Since the effectiveness of weed control during the first few years after planting depends largely on the intensity of site preparation, the most intensively prepared sites will generally require the least post-planting weed control. If Princep[1] is used in post-planting weed control, site preparation is especially important for the successful establishment of those hardwood species that are highly susceptible to Princep damage at dosages necessary for the effective control of deep-rooted perennial weeds. For example, to control goldenrod (Solidago spp.), wild aster (Aster spp.) and other deep-rooted weeds effectively, applications of 4-8 lb per acre (4.8-8.96 kg/ha) of active Princep are required. However, cottonwood (Populus deltoides Bartr.) and white ash (Fraxinus americana L.) seedlings may be damaged by applications of more than 3 lb of active Princep per acre (3.36 kg/ha). Therefore, if the deep-rooted perennial weeds are not eliminated before the trees are planted it is very difficult, if not impossible, to control them after planting. However, once the perennial weeds have been eliminated by site preparation, an annual application of 3 lb per acre (3.36 kg/ha) of active Princep will generally prevent re-establishment or at least keep weed competition to an acceptable level (von Althen 1976).

Site preparation may take the form of plowing and disking or chemical eradication of the competing vegetation. The choice of method will depend on the condition of the soil, topography and accessibility, density and composition of the existing cover, and

last but not least, on the cost of the various methods under consideration. Under no circumstances, however, should the success of a plantation be sacrificed for an initial saving in the cost of site preparation and weed control.

Plowing and disking of the total plantation area is the best method of site preparation developed to date because it offers advantages not obtainable by any other method: it destroys all weeds, including the deep-rooted perennial species; it stimulates microbial activity; it loosens the soil and improves aeration and water infiltration; and it incorporates plant material into the soil, thereby improving the nutrient status and organic content of the soil.

Where plowing and disking of the total plantation are not feasible or desirable because the soil may be subject to erosion or the planting site may be partially treed, strips at least 6 ft (182.88 cm) in width may be plowed and disked, rototilled, or sprayed with herbicides, and the trees planted along the middle of these strips. However, site preparation in strips generally is less effective in promoting tree growth than is complete mechanical site preparation. The latter should, therefore, be used wherever possible.

Post-planting weed control for the first two or three years after planting is an absolute necessity for successful hardwood afforestation. Manual and mechanical methods of weed control have proven very successful but the frequency of operations required for effective control makes these methods rather expensive. Herbicides offer more economical control, but many hardwood species are highly susceptible to damage by the dosages necessary for effective control. Although many herbicides are currently available and new chemicals are marketed every year, Princep remains one of the most useful and reliable herbicides in hardwood afforestation.

Each tree species has its own herbicide tolerance. This tolerance is modified by the texture and moisture of the planting soil, seedling age, length of establishment, and time and method of application. To provide the best possible weed control without causing seedling damage, all dosages must therefore be carefully metered. A preliminary guide to the application of Princep in hardwood plantations is listed in Table 1.

Quackgrass (Agropyron repens [L] Beauv.) is one of the most competitive weeds and its elimination by mechanical means generally requires several years of intensive cultivation. Recently Rohm and Haas have marketed the herbicide "Kerb" which effectively kills all grasses including quackgrass. Kerb is very selective in its action. If applied properly it will kill grasses but will not kill or harm either trees or broad-leaved weeds. It may

Table 1. Preliminary guide to applying active Princep in hardwood plantations established on fully cultivated, former agricultural land

Species	Soil texture	Maximum allowable application of active Princep[a]	
		Shortly after planting (lb/acre)[b]	In the spring of the 2nd and 3rd years (lb/acre)[b]
Black walnut	loam	6	4
(*Juglans nigra* L.)	clay-loam	8	4
Butternut	loam	6	4
(*Juglans cinerea* L.)	clay-loam	6	4
Silver maple	loam	4	3
(*Acer saccharinum* L.)	clay-loam	5	3
	clay	6	3
Black-locust	loam	4	3
(*Robinia pseudoacacia* L.)	clay-loam	5	3
	clay	6	3
White ash	loam	3	3
(*Fraxinus americana* L.)	clay-loam	3	3
	clay	3	3
Basswood	sand	4	3
(*Tilia americana* L.)	loam	4	3
	clay-loam	5	3
Red oak	sand	5	3
(*Quercus rubra* L.)	loam	6	3
Black cherry	sand	3	3
(*Prunus serotina* Ehrh.)	loam	3	3
Sugar maple	sand	2	2
(*Acer saccharum* Marsh.)	loam	2	2

[a] Commercial grade of Princep (simazine) is available at 50 and 80 percent active chemical.

[b] 1 lb/acre = 1.12 kg/ha.

Note: 1 lb active Princep = 2 lb Princep 50W.
1 lb active Princep = 1.25 lb Princep 80W.

therefore be broadcast over the trees, like Princep, without shielding the trees or directing the spray away from them. In our experiments 1.5–2.0 lb/acre (1.68–2.24 kg/ha) of active Kerb, applied in November, killed 95% of all grasses during the winter. As a site preparation treatment, Kerb should be broadcast over the total area in late October or early November. Treated areas may include both plowed and disked land containing quackgrass rhizomes which will sprout again, and grassy fields or pastures which have not been plowed.

PLANTING STOCK

The success of any plantation will also depend on the quality and suitability of the planting stock. Good planting stock should be sturdy and have a well-branched root system (Limstrom 1963). In a study of the quality of hardwood planting stock, seedling size was much more important than seedling age (von Althen 1969). Not only did the largest trees of either 1+0 or 2+0 seedlings always grow faster than the smaller trees, but the 1+0 seedlings with large root-collar diameters generally survived and grew better than 2+0 seedlings of equal size. Table 2 lists recommendations for planting stock grades for the most commonly planted hardwood species in Ontario. Tree planters have often

Table 2. Recommended planting stock grades for hardwoods planted in Ontario

Species	Length of stem		Root-collar diameter	
	Minimum (in.)[a]	Preferred (in.)[a]	Minimum (in.)[a]	Preferred (in.)[a]
Silver maple	8	12	0.20	0.25
Basswood	8	12	0.20	0.25
Red oak	8	12	0.20	0.25
White ash	8	12	0.20	0.25
Black walnut	8	12	0.25	0.35

[a] 1 in. = 2.54 cm.

expressed a preference for large transplant stock, believing that planting large trees would eliminate the need for site preparation and weed control. Although this probably is true for individual,

large trees, those 3-4 ft (91.44-121.92 cm) high and up to five years old grew very poorly when planted in a weed-infested soil without prior site preparation or without subsequent weed control (von Althen 1974). Since transplant stock is very expensive to produce, transport and plant, and since growth of seedlings on unprepared sites is generally inferior to that of seedlings planted in plowed and disked soils treated with herbicides, it is much more economical to spend the available money on site preparation and weed control than on producing large transplant stock.

PLANTING METHODS

Small hardwood seedlings may be planted either with a planting machine or by hand using the wedge method, while large trees with spreading root systems are most efficiently planted in holes made with a posthole auger. Care must always be taken that the trees are planted at normal depth and that the soil is well packed around the roots. All trees should be planted in an upright position since leaning hardwood seedlings often develop a new vertical shoot from the root collar, necessitating the removal of the original stem by pruning and thereby losing valuable height increment (Erdmann 1966).

DIRECT SEEDING

Establishing hardwoods by direct seeding has been investigated as an alternative method to planting of nursery-grown stock. Advantages of direct seeding over planting are reduced planting costs and elimination of planting injury. The greatest disadvantage is the uncertainty of satisfactory establishment. Hardwood species with relatively small seeds such as ash and birch were generally found to be unsuitable for direct seeding and only the oaks and black walnut showed any promise of success (Winch 1937, Scholz 1964, Bjorkbom 1969). Until more successful seeding methods are developed, planting nursery-grown seedlings guarantees better plantation establishment than does direct seeding.

FERTILIZATION

Since low fertility is one of the characteristics of land withdrawn from agriculture, fertilization appears to offer possibilities of improving tree growth on nutrient-deficient sites. Although Mitchell and Chandler (1939) showed that growth of hardwood stands could be improved significantly by nitrogen fertilization, the growth response of hardwood seedlings to fertilization at time of planting has often been disappointing (Cummings 1941, McComb 1949, Burke and Williams 1973, Geyer 1974). The failure of fertilization at time of planting to improve seedling growth significantly was probably the result of one or more of

the following conditions: (1) the planting soils contained a sufficient supply of available nutrients to satisfy the nutrient requirements of the newly planted seedlings; (2) the applied fertilizer either did not reach the roots or was not taken up by the seedlings; (3) the dosages of fertilizer applied were too small to produce measurable growth responses; (4) soil physical conditions, e.g., poor drainage, were limiting growth; and (5) a deficiency in nutrients other than those applied was more limiting to seedling growth than was the deficiency in the applied nutrients.

Until more information is available, fertilization at the time of planting is inadvisable because it may do more harm than good by increasing weed competition and adding to the pollution of rivers and lakes. Fertilization is also expensive and money spent on fertilizer applications at the time of planting could be put to better use by intensifying site preparation and weed control treatments which have proven beneficial to hardwood plantation establishment and seedling growth.

RODENT CONTROL

Tree girdling by mice and browsing by rabbits can cause heavy damage in hardwood plantations (von Althen 1971). The most common method of mouse control has been the broadcast application of poisoned grain. However, this method generally provides only short-term relief. Recently, Radvanyi (1974) developed a mouse poison feeder station which provides longer lasting control. Control of rabbit browsing may be obtained by painting repellents on the trees. However, these methods are rather expensive for the degree of protection they afford. The best protection against rodent damage is the elimination of weeds; this deprives the animals of shelter and food and makes the plantation a hostile environment for rodent survival and reproduction. Also, weed control generally increases seedling growth, and fast-growing trees are less vulnerable to rodent damage because they soon outgrow the danger.

SUMMARY

The requirements for successful hardwood plantation establishment are:

1. a deep, moist but well-drained planting soil
2. plowing and disking the total area
3. healthy, sturdy planting stock
4. careful planting
5. effective weed control for the first two or three years after planting
6. rodent control where necessary

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FOOTNOTE

[1] Identification of commercial products is for information only, and does not constitute endorsement by the Great Lakes Forest Research Centre.

DIRECT SEEDING IN NORTHERN FOREST TYPES

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Abstract

Two direct-seeding experiments were established to determine the effect of time of seeding (spring 1962 versus fall 1962), type of seedbed (prepared versus unprepared), and species (red pine (Pinus resinosa Ait.) versus white spruce (Picea glauca (Moench) Voss)) upon the success attained in the reforestation of a pine-barren site and a recently burned-over forest site in eastern Maine. A split-split-plot experiment with 0.75-acre treatment plots was replicated three times on each site. Seedbeds on the pine barren were prepared by disking with a Rome disk harrow and seedbeds on the burn, by scarifying with a bulldozer. Treatment plots were broadcast sown by hand at a seeding rate of 50,000 viable seed per acre. All treatments on the pine barren except those established on unprepared seedbeds, all of which were failures, resulted in the establishment of moderately-stocked to over-stocked stands five years after seeding. All treatments on the burn produced adequately stocked stands initially, however, by the fifth growing season competing vegetation had reduced the average milacre stocking percent of most treatments to less than 50 percent.

Publication of guidelines for direct seeding loblolly pine (Pinus taeda L.) by Mann and Derr (1959, longleaf pine (Pinus palustris Mill.) by Derr and Mann (1961), and a paper on the direct seeding of conifers presented at the Winter Meeting of the New England Section of the Society of American Foresters in March 1961 by Abbott (1961) resulted in stimulating anew an interest in direct seeding among forest land managers in Maine. Sufficient interest was generated for the Maine Agricultural Experiment Station, Bureau of Forestry, Bureau of Sport Fisheries and Wildlife, St. Regis Paper Company, Standard Packaging Corporation, and Georgia-Pacific Corporation to collaborate in the establishment of two experiments in the spring of 1962

to study the applicability of direct seeding in northern forest types. The experiments were established specifically to determine the respective effects of time of seeding (spring 1962 versus fall 1962), type of seedbed (prepared versus unprepared), and tree species (red pine (Pinus resinosa Ait.) versus white spruce (Picea glauca (Moench) Voss)) upon the success attained in the reforestation of a pine-barren site and a recently burned-over forest site. Early results of both experiments have been reported by Griffin, DeCoster, and Collom(1965 and Collom(1965). This paper summarizes the results of the experiment on the pine-barren site through the 1967 growing season and the results of the experiment located on the burned-over forest site through the 1966 growing season.

LOCATION AND DESCRIPTION OF EXPERIMENTAL AREAS

The experiment on the pine barren was located in the northeast corner of Township 30 M.D., Washington County, Maine. The soil, a well- to excessively-drained Colton sandy loam supported a dense stand of vegetation composed principally of lowbush blueberry (Vaccinium angustifolium Ait.), lambkill (Kalmia angustifolia L.), wintergreen (Gaultheria procumbens L.), sweet fern (Comptonia peregrina (L.) Coult.), and reindeer moss (Cladonia rangiferina (L.) Web.)

The experiment on the burned-over area was located near the southeast side of Duck Lake in Township 4 N.D., Hancock County, Maine. The soil was a well-drained Hermon very stony loam. Previous to a wildfire in the summer of 1960, the area supported a forest stand composed principally of eastern hemlock (Tsuga canadensis (L.) Carr.) red spruce (Picea rubens Sarg.) and balsam fir (Abies balsamea (L.) Mill.). Trees of merchantable size were being harvested when the fire occurred. The fire, covering approximately sixty acres, burned to the mineral soil. Vegetation was still quite sparse in the spring of 1962. Many of the fire-killed trees had been blown down and others were in the process of falling. Sarsaparilla, (Aralia hispida Vent.), bracken fern (Pteridium aquilinum var. latiusculum (Desv.) Underw.), raspberry (Rubus idaeus var. aculeatissimus Regel and Tiling), fireweed Epilobium angustifolium L.) and numerous grasses began to appear on the burn in the summer of 1962. Tree species consisted principally of quaking aspen (Populus tremuloides Michx.), bigtooth aspen (Populus grandidentata Michx.), pin cherry (Prunus pensylvanica L. f.), paper birch (Betula papyrifera Marsh.) and

yellow birch (Betula alleghaniensis Britton). Sprout clumps of American beech (Fagus grandifolia Ehrh. and red maple (Acer rubrum L.) occurred sporadically.

PROCEDURE

Experimental Design

A split-split-plot experiment was replicated three times on each experimental area. Each major block was divided into two 3-acre main plots; each main plot, into two 1.5-acre subplots; and each subplot, into two 0.75-acre minor plots. Within a major block, times of seeding were assigned at random to the main plots; types of seedbed, to the subplots; and tree species, to the minor plots.

While the respective treatments were applied as uniformly as possible over the entire acreage of each minor plot, measurements of results were confined to a 0.5-acre area in the center of the minor plot. Thus, each treatment was surrounded by a 0.25-chain buffer strip.

Preparation of Seedbeds

Seedbeds on the pine barren were prepared with a Rome disk harrow pulled by a D-7 Caterpillar. The plots were disked twice. The second disking accomplished an almost complete break-up of the thick root mass turned up by the first disking. Plots sown in the spring were disked in May and those sown in the fall, in September.

Seedbeds on the Duck Lake Burn were prepared by working a bulldozer through the plots in a zigzag pattern by alternately locking the tracks. The partial turning of the bulldozer chewed up much of the debris and exposed some mineral soil. However, large boulders and down timber precluded the attainment of a uniformly prepared seedbed similar to that obtained with the Rome disk harrow on the pine barren. Plots seeded in the spring were prepared in June 1962 and those seeded in the fall, in September 1962.

Treatment of Seed

Seed from red pine and white spruce seed lots collected in the Lake States was used in both spring and fall seedings. Germination percents of the red pine

and white spruce seed sown in the spring were 78 percent and 70 percent and of those sown in the fall, 85 percent and 51 percent respectively.

The seeds were coated for protection against losses to mammals and birds with 50 percent wettable endrin powder (2 percent to weight of seed), 75 percent wettable Arasan powder (1 percent to weight of seed), Dow Latex 512-R (1 part latex to 9 parts water) and enough aluminum paint flakes to cover the seed uniformly.

Seeding of Minor Plots

Within each minor plot, twenty square milacre observational plots were established at one-half chain intervals. While the observational milacres on the pine barren could be located systematically, some of those on the Duck Lake Burn had to be located irregularly to avoid heavy accumulations of debris.

Within each observational milacre, twenty seed spots were located systematically and marked with wooden dowels. The seed spots were seeded by dropping five seeds around each dowel. Thus, the seeding rate on the observational milacres in terms of viable seed per milacre was the same as the germination percent of the seed sown as given above.

The remaining 730 milacres in each minor plot was broadcast sown at the rate of 50 viable seeds per milacre. To obtain an even distribution of seed, the minor plots were divided into four strips of equal size and each strip was broadcast sown by hand with one-fourth of the total amount of seed sown on the plot. On the pine barren, spring-sown plots were sown May 30-June 5, and fall-sown plots, October 1-2. On the Duck Lake Burn spring-sown plots were sown June 12-14, and the fall-sown plots, October 10-13.

Small Mammal Populations

Small mammal census plots were established on an undisturbed site in each experimental area in May 1962. The census plot on the pine barren measured 100 by 125 feet and the one on the Duck Lake Burn, 125 by 175 feet. Sherman live traps were stationed at the intersections of a 25 by 25-foot grid system. Population censuses were conducted during the spring and fall of 1962, 1963, and 1964 (Ladd 1965).

No animals were trapped on either the census plot or additional spot-check trapping sites located on the pine barren. The absence of small mammals on the pine barren was attributed to a lack of suitable cover.

The small mammal population on the Duck Lake Burn increased as the density of the herbaceous vegetation increased. The censuses indicated a population per census plot of one deer mouse (Peromyscus maniculatus) in May 1962, three red-backed voles (Clethrionomys gapperi) in October 1962, no animals in June 1963, sixteen deer mice plus four red-backed voles in October 1963, and thirteen deer mice in August 1964 (Ladd 1965).

Weather

Since both experimental areas were within a twenty-mile radius of the Fire Danger Weather Station maintained by the Bureau of Forestry at Beddington, Maine, the weather was probably quite similar to that recorded at the Station. The weather during the 1962 and 1963 growing seasons was noticeably different in two respects. Rainfall in May 1963 (6.44 inches) totaled 4.74 inches more than that in May 1962 (1.70 inches). The average air temperature in July 1963 ($69^{\circ}F$) averaged eight degrees higher than that in July 1962 ($61^{\circ}F$). Thus, the weather was probably more favorable for prompt germination and early establishment of seedlings in 1963 than in 1962.

Inventories

Inventories were made of germination, seedling survival, and seedling mortality on the observational milacres of both experiments in the spring and fall of 1962, 1963, and 1964 (Collom 1965). The final inventory of the observational milacres on the pine barren was made in late July 1967 when the spring-sown and fall-sown plots were in their sixth and fifth growing season respectively. The final inventory of the observational milacres on the Duck Lake Burn was made in late August 1966 when the spring-sown and fall-sown plots were in their fifth and fourth growing season respectively. Concurrently with the last inventory of the observational milacres, inventories were made of an additional 100 circular milacre plots (hereinafter referred to as inventorial milacres) located systematically in each of the 0.5-acre minor plots. When an inventorial milacre overlapped an observational milacre, the location of the inventorial milacre center was moved eight feet

from the boundary of the observational milacre.

RESULTS

Pine Barren

Germination on spring-sown prepared seedbeds began prior to June 29, 1962 and on fall-sown prepared seedbeds prior to May 26, 1963. In both years, germination on unprepared seedbeds was not evident until after germination on prepared seedbeds was well underway.

By the fall of 1964, seedling mortality expressed as a percentage of stocking ranged from a low of 36 percent for red pine on prepared seedbeds to a high of 82 percent for white spruce on unprepared seedbeds. Twenty-four percent of the total seedling mortality on prepared seedbeds and 29 percent of the total seedling mortality on unprepared seedbeds were attributed to unknown causes. Seventy-three percent of the total seedling mortality on prepared seedbeds was attributed to frost heave (54 percent), drought (12 percent), and heat injury (7 percent). Seventy percent of the total seedling mortality on unprepared seedbeds was attributed to drought (47 percent), insects (18 percent) and heat injury (5 percent). In September 1964, red pine tree percentages, i.e. the number of live seedlings present for each 100 viable seeds sown, averaged 5.3 on unprepared seedbeds and 24.6 on prepared seedbeds. White spruce tree percentages averaged 1.9 on unprepared seedbeds and 12.7 on prepared seedbeds (Collom 1965).

The average number of seedlings per observational milacre and percent of observational milacres stocked with a minimum of one, two, five, and ten seedlings respectively in August 1963, September 1964, and July 1967 are recorded for each treatment on the pine barren in Table 1. Analysis of variance of the 1967 data found the effect of type of seedbed and the effect of species to be highly significant. Although more seedlings usually resulted from fall-sown seed than from spring-sown seed, the effect of time of seeding proved to be nonsignificant.

The inability of white spruce to become established on an undisturbed pine-barren seedbed and the relative poor vigor of the white spruce seedlings that managed to become established on prepared seedbeds were readily apparent in August 1963. Nevertheless, in July 1967 -

Table 1. - Average number of seedlings per observational milacre and percent of observational milacres stocked with a minimum of one, two, five and ten seedlings respectively for each treatment on the pine barren in August 1963, September 1964, and July 1967.

Time of observation and stocking level	Seeded spring 1962				Seeded fall 1962			
	Prepared seedbed		Unprepared seedbed		Prepared seedbed		Unprepared seedbed	
	P[a]	S[b]	P	S	P	S	P	S
	Number[c]							
Oct. 1962	13.4	7.1	6.3	1.5	-	-	-	-
Aug. 1963	20.3	6.6	5.5	0.7	36.2	23.5	5.1	1.6
Sept. 1964	16.0	3.3	4.8	0.6	24.5	10.5	3.8	1.5
July 1967	11.4	1.8	2.5	0.1	16.2	7.5	1.5	0.2
	Percent[d]							
Aug. 1963								
One seedling	100	95	92	40	100	98	90	58
Two seedlings	100	88	85	20	100	98	83	32
Five seedlings	98	65	47	27	100	97	58	15
Ten seedlings	93	30	15	0	97	83	30	2
Sept. 1964								
One seedling	100	87	90	33	100	95	85	50
Two seedlings	100	72	75	13	100	90	78	33
Five seedlings	100	25	38	0	98	73	37	7
Ten seedlings	87	5	13	0	93	48	5	0
July 1967								
One seedling	100	68	72	7	95	85	55	12
Two seedlings	98	48	53	0	95	72	37	3
Five seedlings	83	12	15	0	92	45	7	0
Ten seedlings	58	0	3	0	75	18	0	0

[a]Red pine.
[b]White spruce.
[c]Average of sixty observational milacres (twenty milacres in each of three replications) per treatment.
[d]Percent of the sixty observational milacres stocked with the specified minimum number of seedlings.

the sixth and fifth growing season for the spring-sown and fall-sown plots respectively - the number of white spruce seedlings on the spring-sown and fall-sown prepared seedbeds combined averaged 4.7 seedlings per observational milacre with 77 percent and 60 percent of the milacres being stocked with a minimum of one seedling and two seedlings respectively.

In July 1967, the number of red pine seedlings on the spring-sown and fall-sown unprepared seedbeds combined averaged 2.0 seedlings per observational milacre with 64 percent and 45 percent of the milacres being stocked with a minimum of one seedling and two seedlings respectively. In contrast, the number of red pine seedlings on the combined spring-sown and fall-sown prepared seedbeds averaged 13.8 seedlings per observational milacre with 88 percent and 67 percent of the milacres being stocked with a minimum of five and ten seedlings respectively.

Regardless of species, the growth in height of seedlings on prepared seedbeds was greater than that of seedlings on unprepared seedbeds. In October 1964, the average maximum height (based on measurements of the tallest seedling on each observational milacre) of seedlings on prepared seedbeds (0.18 feet) was significantly greater than that of seedlings on unprepared seedbeds (0.11 feet) and the average maximum height of red pine seedlings was significantly greater than that of spruce seedlings (Collom 1965). In July 1967, the average maximum heights of red pine seedlings on prepared and unprepared seedbeds were 1.36 feet and 0.28 feet respectively. At that time the average maximum heights of white spruce seedlings on prepared and unprepared seedbeds were 0.66 feet and 0.35 feet respectively. By June 1976, red pine on the prepared seedbeds had reached a maximum height of around 15 feet while most of the white spruce on prepared seedbeds and most of the red pine on unprepared seedbeds were still less than 5 feet tall.

The average number of seedlings per inventorial milacre and percent of inventorial milacres stocked with a minimum of one, two, five, and ten seedlings respectively in July 1967 are recorded for each treatment on the pine barren in Table 2. While the effects of both type of seedbed and species were highly significant, the effect of time of seeding was nonsignificant.

Table 2. - Average number of seedlings per inventorial milacre stocked with a minimum of one, two, five and ten seedlings respectively for each treatment on the pine barren in July 1967.

	Seeded spring 1962				Seeded fall 1962			
	Prepared seedbed		Unprepared seedbed		Prepared seedbed		Unprepared seedbed	
Stocking level	P[a]	S[b]	P	S	P	S	P	S
	Number[c]							
	9.81	1.60	1.01	0.04	11.30	4.58	0.14	0.04
	Percent[d]							
One seedling	85	50	32	3	81	61	5	3
Two seedlings	78	32	17	0	77	50	2	1
Five seedlings	59	7	6	0	59	28	1	0
Ten seedlings	24	2	2	0	39	13	0	0

[a]Red pine.
[b]White spruce.
[c]Average of 300 inventorial milacres (100 milacres in each of three replications) per treatment.
[d]Percent of the 300 inventorial milacres stocked with the specified minimum number of seedlings.

The number of red pine seedlings on spring-sown and fall-sown unprepared seedbeds combined averaged only 0.5 seedlings per inventorial milacre with only 19 percent and 10 percent of the milacres being stocked at the one- and two-seedling level respectively. On spring-sown and fall-sown prepared seedbeds, the number of red pine seedlings averaged 10.6 seedlings per inventorial milacre with 83 percent and 78 percent of the milacres being stocked at the one- and two-seedling level respectively.

Duck Lake Burn

On the Duck Lake Burn, germination on prepared and unprepared seedbeds began apparently at about the same time. The spring-sown seed began germination soon after June 29, 1962 and the fall-sown seed sometime prior to May 26, 1962.

By the fall of 1964, seedling mortality expressed as a percentage of stocking ranged from a low of 28 percent for red pine on both prepared and unprepared seedbeds respectively to a high of 53 percent for white spruce on prepared seedbeds. Thirty-one percent of the total seedling mortality on prepared seedbeds and 46 percent of the total seedling mortality on unprepared seedbeds were attributed to unknown causes. Fifty-four percent of the total seedling mortality on prepared seedbeds was attributed to drought (22 percent), frost heave (20 percent) and heat injury (12 percent). Forty-two percent of the total seedling mortality on unprepared seedbeds was attributed to drought (27 percent), heat injury (11 percent) and frost heave (4 percent). In September 1964, red pine tree percentages averaged 13.6 on unprepared seedbeds and 24.8 on prepared seedbeds. White spruce tree percentages averaged 11.8 on unprepared seedbeds and 12.7 on prepared seedbeds (Collom 1965).

The average number of seedlings per observational milacre and percent of observational milacres stocked with a minimum of one, two, five, and ten seedlings respectively in September 1963, September 1964, and August 1966 are given for each treatment on the Duck Lake Burn in Table 3. Analysis of variance of the 1966 data showed the effect of type of seedbed to be significant and the effect of species to be highly significant. The effect of time of seeding was not significant.

In August 1966, - the fifth and fourth growing season for the spring-sown and fall-sown plots respectively - the number of white spruce seedlings on spring-sown and fall-sown unprepared seedbeds combined averaged 3.1 seedlings per observational milacre with 63 percent and 55 percent of the milacres being stocked with a minimum of one seedling and two seedlings respectively. In contrast, the number of white spruce seedlings on spring-sown and fall-sown prepared seedbeds combined averaged 3.9 seedlings per observational milacre with 83 percent and 63 percent of the milacres being stocked with a minimum of one seedling and two seedlings respectively.

Table 3. - Average number of seedlings per observational milacre and percent of observational milacres stocked with a minimum of one, two, five, and ten seedlings respectively for each treatment on the Duck Lake Burn in September 1963, September 1964, and August 1966.

Time of observation and stocking level	Seeded spring 1962				Seeded fall 1962			
	Prepared seedbed		Unprepared seedbed		Prepared seedbed		Unprepared seedbed	
	P[a]	S[b]	P	S	P	S	P	S
	Number[c]							
Oct. 1962	17.8	3.7	19.1	6.9	-	-	-	-
Sept. 1963	16.2	4.1	15.0	5.8	33.5	14.3	10.4	8.9
Sept. 1964	13.8	3.2	12.0	4.9	27.1	10.6	9.6	8.4
Aug. 1966	10.1	2.0	4.9	2.7	14.1	5.8	2.7	3.5
	Percent[d]							
Sept. 1963								
One seedling	98	88	98	82	97	100	95	87
Two seedlings	98	73	98	70	97	98	80	83
Five seedlings	88	32	88	47	97	83	57	62
Ten seedlings	70	12	73	23	95	62	40	40
Sept. 1964								
One seedling	97	75	92	75	95	97	87	85
Two seedlings	97	65	92	58	95	90	73	77
Five seedlings	87	20	78	42	95	72	50	60
Ten seedlings	58	12	57	23	88	42	40	38
Aug. 1966								
One seedling	98	75	82	63	100	90	60	63
Two seedlings	95	53	68	52	100	73	55	58
Five seedlings	80	5	40	25	88	48	23	28
Ten seedlings	38	0	15	5	60	17	5	7

[a]Red pine.
[b]White spruce.
[c]Average of sixty observational milacres (twenty milacres in each of three replications) per treatment.
[d]Percent of the sixty observational milacres stocked with the specified minimum number of seedlings.

In August 1966, the number of red pine seedlings on spring-sown and fall-sown unprepared seedbeds combined averaged 3.8 seedlings per observational milacre with 71 percent and 62 percent of the milacres being stocked with a minimum of one seedling and two seedlings respectively. In contrast, the number of red pine seedlings on spring-sown and fall-sown prepared seedbeds combined averaged 12.1 seedlings per observational milacre with 98 percent and 67 percent of the milacres being stocked with a minimum of two and five seedlings respectively.

The average number of seedlings per inventorial milacre and percent of inventorial milacres stocked with a minimum of one, two, five and ten seedlings respectively in August 1966 are recorded for each treatment on the Duck Lake Burn in Table 4. Analysis of variance indicated the effect of type of seedbed to be significant. The effects of time of seeding and species were nonsignificant.

The number of white spruce seedlings on spring-sown and fall-sown unprepared seedbeds combined averaged 1.25 seedlings per inventorial milacre with 37 percent and 22 percent of the milacres being stocked at the one- and two-seedling level respectively. On spring-sown and fall-sown prepared seedbeds combined, the number of white spruce seedlings averaged 1.71 seedlings per inventorial milacre with 41 percent and 27 percent of the milacres being stocked at the one- and two-seedling level respectively.

The number of red pine seedlings on spring-sown and fall-sown unprepared seedbeds combined averaged 1.54 seedlings per inventorial milacre with 35 percent and 27 percent of the milacres being stocked at the one- and two-seedling level respectively. On spring-sown and fall-sown prepared seedbeds combined, the number of red pine seedlings averaged 3.43 seedlings per inventorial milacre with 59 percent and 44 percent of the milacres being stocked at the one- and two-seedling level respectively.

Table 4. - Average number of seedlings per inventorial milacre and percent of inventorial milacres stocked with a minimum of one, two, five, and ten seedlings respectively for each treatment on the Duck Lake Burn in August 1966.

	Seeded spring 1962				Seeded fall 1962			
	Prepared seedbed		Unprepared seedbed		Prepared seedbed		Unprepared seedbed	
Stocking level	P[a]	S[b]	P	S	P	S	P	S
				Number[c]				
	3.89	1.27	2.05	1.51	2.96	2.14	1.03	0.99
				Percent[d]				
One seedling	63	40	43	41	54	41	27	32
Two seedlings	53	25	33	25	45	28	20	19
Five seedlings	29	7	16	9	22	15	5	4
Ten seedlings	15	3	5	3	8	7	2	1

[a]Red pine.
[b]White spruce.
[c]Average of 300 inventorial milacres (100 milacres in each of three replications) per treatment.
[d]Percent of the 300 inventorial milacres stocked with the specified minimum number of seedlings.

DISCUSSION

The experiments were established in the spring and fall of the same year because of circumstances rather than by choice. Seeding in the fall and in the spring of the following year, inasmuch as the germination of both seedings would have then occurred under the same environmental conditions, would have provided a more valid test of the effect of season of sowing. Nevertheless, the results of both experiments indicate strongly that the season of sowing has little, if any, effect upon the success attained in the reforestation of pine-barren sites and recently burned-over forest sites. On sites where excessive losses of seed to small mammals and birds might occur, which apparently was not the case on the areas direct seeded in this study, fall seeding of untreated seed would be quite likely to

result in failure. Fall seeding exposes seed to depredation by destructive agencies for longer periods of time than spring seeding. On the other hand, fall seeding not only eliminates the need to stratify seed prior to sowing but also ensures that seed will be in place on the site and ready to germinate as soon as conditions are favorable, thereby providing the resultant seedlings with the full length of the growing season in which to become firmly established. In practice, spring seeding may be accomplished too late, as happened in this study, to enable seedlings to make full use of the first growing season.

Pine barrens reforest so slow naturally that the process is almost imperceptible yet broadcast sowing white spruce and red pine seeds on disked seedbeds in the spring and fall at rates of 50,000 viable seeds per acre resulted in the establishment of moderately- to well-stocked stands of white spruce and over-stocked stands of red pine in the fifth and sixth growing season for spring-and fall-sown plots respectively. Red pine has the inherent ability to become established and to grow reasonably well on disked seedbeds. A surprising number of red pine seedlings was able to become established on unprepared seedbeds. On the other hand, white spruce, being much less drought resistant than red pine, failed to become established on unprepared seedbeds and white spruce seedlings on prepared seedbeds grew much more slowly in height than red pine seedlings on comparable seedbeds. Thus, white spruce cannot be recommended as being a species suitable for use in the reforestation of pine barrens.

The striking success obtained with red pine indicates strongly that pine barrens can probably be reforested successfully by broadcast sowing red pine seed at rates less than 50,000 viable seed per acre on seedbeds prepared less thoroughly than the seedbeds were in this study.

On the Duck Lake Burn, the average number of seedlings per milacre was significantly greater on prepared seedbeds than on unprepared seedbeds, however, the difference was not as great as that on the pine barren. Furthermore,both prepared and unprepared seedbeds were apparently suitable for the germination and establishment of both species for all treatment plots were adequately stocked with seedlings at the end of the third and second growing season for the spring-and fall-sown plots respectively. However, by the fifth growing sea-

son, severe competition of overtopping hardwood growth had reduced the seedling milacre stocking percents on the broadcast sown portions of all treatment plots, except the red pine on prepared seedbed plots, to below 50 percent. An adequate stocking of established seedlings could probably have been maintained on all treatment plots had the seedlings been released promptly by either cutting or deadening the overtopping vegetation with a herbicide. Such cultural treatments will usually be required to maintain an adequate stocking of a direct-seeded species on sites favorable to the natural establishment of other faster growing species.

Successful techniques for direct seeding the southern pines were developed only after many years of study involving experimentation followed by numerous field trials. The results of this study give no reason to doubt that an effort in the Northeast similar to that in the South would result in the development of reliable techniques for direct seeding the northern conifers.

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INTERMEDIATE CULTURAL PRACTICES

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Bureau of Conservation, Augusta, Maine.

What are these interesting sounding things? Are they theory, are they pie in the sky, fantasies of desk foresters - or are they the real McCoy - something the landowner needs if he is going to make his woodlands pay a return on his investment. To list briefly, shall we say they are pre-commercial treatments, marginal commercial treatments, commercial thinnings, pruning for improved quality and perhaps a few more that we all generally recognize.

Frankly, I have been fascinated by them since my grammar school years when I transplanted wild strawberries from a field and set them out in a weeded garden and saw them triple or more in size with this simple procedure; when I cut back scrub oak over-topping white pine reproduction and saw these trees easily surge upward above the poor quality hardwoods and the non-released pines die; when I planted a gravel bank on a north slope that had been barren of vegetation for years with hemlock I dug out of the woods and saw it become a vigorous young stand with a humus layer in a few short years.

And when I went to forestry school and found in the silviculture books the discussions of these principles, I felt as happy as Columbus when he didn't fall off the edge when he sailed westward.

That forestry school was many years ago and the time devoted to intermediate cultural practices was brief, and the field exercises or examples for us neophyte foresters to see, were practically non-existent, and I have a feeling they are in today's schools also. Researchers were a rare breed (and maybe still are) and they had not proliferated to the degree they have now where everything under the sun is being probed and researched and a good job done on it - but the universal complaint now as then - and justifiably so, <u>how do we get this research read and put into practice by the forester - it just is not being done</u>.

Let me digress just a moment. Foresters are, and try to be, all things to all people. Let me see if I can cover all angles briefly. There is need for bulk fiber and a need for quality wood. I believe they are not only compatible, but that foresters and industry must believe this and practice it. There is the pucker-brush forestry of Harold Young which will have a place in providing the bulk fiber the world needs. I have no problem believing the foresters, the engineers and the chemists will solve all the intermediate problems it now may have. As an example, when I first came to work in Maine, S. D. Warren Company took no oak for their paper making. Then they took 10% oak well scattered throughout the load; then 30% well mixed throughout the load, in other words, not entire tiers, and then suddenly you could bring in all the oak you wanted, truckloads and woodlots full of oak. At another period, S. D. Warren took green white pine, but the Brown Company wanted their pine seasoned a year before delivery. As I raced between their paper making plants trying to figure this one out, I began to realize the limitless potential of our forests and our chemists.

But there was also the human element that contributed to the problem - and some of you here may be old enough to remember when pulpwood contracts specifically read "the entire tree and the entire woodlot will be cut into pulpwood. Any trees, or portions of trees, diverted to other products or markets will be cause for cancellation." And "integrated logging" was a dirty word that Bob Dinneen thought up while sitting at his forestry desk.

Some of you may read the Forbes magazine, a financial publication - and all of you know the International Paper Company, the largest paper company in the world. While I have heard they had things going on the past year or so, changes, etc., that are interesting, the June 16, 1976 (1) issue discusses these and other things in more detail. Their new president, Stanford Smith says, "We're in the land resource business" and continues on citing what he says is an industry truism "You get your highest value from using trees as poles, the next highest from lumber, then plywood. Paper is last. Only the residuals are ground into pulp for paper."

Stanford Smith is about my age - not a forester - and became president of I. P. in January 1974 and he is saying <u>now</u> all these nice well known things that I, and

many other foresters, were saying years ago, and he's President... and I. P. never even offered me a job scaling pulpwood - Ah, Kismet, thine name is fate.

My point to the above digression is that if we as foresters, we as land managers, continue to ignore the needs of our woodlands for intermediate cultural practices, then we are basically in the bulk fiber production business - the residuals - if you wish, that I. P. President Smith says is last in the line of profit making. And hence the last in the line of profitableness for the small woodland owner who is the provider of a vast amount of our stumpage and is one of our largest landowners. He has to be kept financially viable or else you are going to deal with an ever increasing number of total preservationists.

And the only way he will remain not only financially viable, but interested in continuing in the forest landowning business, is by making it possible for him to grow high quality timber, and intermediate cultural practices are the key to doing this successfully.

And Bob Dinneen, past and present non-entity, and Stanford Smith, now President of the International Paper Company, the largest paper maker in the world, both say this applies to all landowners, big and small.

You have all seen hundreds and thousands of acres cut and left to grow and we may acknowledge they have bulk fiber - but how many have quality wood growing? A few years ago the Forest Management Division of the Maine Forest Service visited the Bartlett Experimental Forest in New Hampshire and saw an excellent hardwood site covered with pin cherry and white birch 35 feet tall and 2-3 inches in d.b.h. The pin cherry was the dominant species and the white birch was hanging on. We discussed why this had not been weeded, a pre-commercial treatment, and were told that pin cherry being a pioneer species would die out soon and the white birch would take over. I may agree with this, but what of the 15-20 years and money lost by prolonging the time of harvest because the white birch has been held back all this time? On a more personal note, I bought a piece of land in 1948 that had an area that had been blown down by the 1938 hurricane. My reconnaissance showed that the area had an excellent stocking of vigorous white pine along with miscellaneous hardwoods including poplar, pin cherry, grey birch and white birch. I felt that the area was not pressing as

as far as working on it immediately compared to other areas. Unfortunately, a constant need for money continued this line of reasoning, as I only very occasionally looked the area over again..... And one day I looked it over and found that less than 5% had white pine and the rest miscellaneous hardwoods, most of low value. It is obvious now that I had my priorities wrong, as at the time very little work would have been necessary to bring the white pine through.

If a person such as myself who is a firm believer in the need for intermediate cultural practices lets himself be diverted so easily, what about all the foresters and forest land managers - and their bosses - who may not really be sold on these practices, and have many pressing problems needing - they believe - immediate attention. You are right - intermediate cultural practices take a far back seat.

On a more optimistic note, I had a 10 acre old field stand of white pine approximately 25-30 years of age in need of thinning and pruning. This I thought had real priority and in 1955 it was thinned for pulpwood and a stumpage return of $1.50 per cord was received. I then personally pruned 100+ trees per acre to 17 feet. (No wonder I never got to the weeding job mentioned above.) In 1975 a power line had to go through it so we made a study of the results from the pruning, sawing pruned trees and adjacent unpruned trees at a local sawmill. (2) These trees were marked, measured, etc., before the power line clearing commenced. The results were as follows:

Lumber Grade Recovery From Pruned Logs		Lumber Grade Recovery From Unpruned Logs	
Selects	17.3%	Selects	1.5%
#1 and 2C	41.4%	#1 and 2C	7.8%
#3 C	31.7%	#3 C	49.9%
#4 C	9.6%	#4 C	40.5%
#5 C	0.0%	#5 C	0.3%
	100.0%		100.0%

Or to put it in other words, 58.7% of the lumber produced from pruned logs was Grade 2 C or better, while only 9.3% of the lumber from unpruned logs was in Grade 2 C or better.

My money pruning investment at the time was 20¢ a tree, or $3.83 per MBF for the pruned log sample. According to the figures, the actual value achieved was equivalent to an interest rate of 17.68%. Carrying it further, the study showed it would have been possible at the time to invest 77¢ per tree and still show an earning rate of 10%, or invest $1.61 per tree and show an earning rate of 6%.

Following me will be Harold Hocker of the University of New Hampshire and Bob Frank of the U.S. Forest Service at Orono to talk on the Research Potential that Silviculture holds, and Ted Tryon of Sewall Company and Oscar Selin of the Georgia-Pacific Corporation to discuss their field experiences. I am sure they will have other examples to offer you from their work in the field.

In 1968 I wrote a Paper on Research Needs for the Cooperative Management Program of the U.S. Forest Service giving my views on this subject. As a farewell gasp - gesture - as I left the lucrative field of forestry last February, I xeroxed it again and sent copies to the U.S. Forest Service with a mild note saying I hoped someone would try reading it.

I was most happy to have an excellent reply (my only one) from Bill Leak, Silviculturist for the USFS at Durham, N. H. who said some things I think are timely and important. (He also says that some of the things I said in 1968 were not complimentary.)

One of his points is that putting together guidelines that are practical and specific enough to be used by practicing foresters is difficult. And I agree with him.

Another major problem is economics. He says many researchers are not heavily oriented in this direction - and I agree - but add that, unfortunately, neither are most field foresters. (Can a cord of wood or a thousand board feet of logs be cut and transported at a profit? That's first grade arithmetic... Can you do a pre-commercial thinning, carry it out at 1.op^{n} for yourself or your company and make a profit? Man, that's forest economics.) Are we knowledgeable in this so all of us, from the bottom to the top of the forestry ladder can use it easily, correctly and saleswise for our companies so they will invest in a forest management program? So they invest in title searches,

boundary line work, roads, equipment..... but forest management work? That is a good question.

Another major problem is products. Fortunately, here in New England, and particularly in Maine, we are blessed with many diversified markets and products that possibly even Stanford Smith, IP's president, may not know about from the listing he made. But what I recommend in Maine, may not be valid in Vermont. - However, that is true only at the moment I said it. Given any number of changes - market demands, better roads, better trucks, knowledge of markets and a good salesman-forester - and my statement will not be valid tomorrow. But are we as foresters keeping up with these important points or are we bound to our traditional market places? Another question to ask...do we need quality products, produced by intermediate cultural practices, to be able to afford longer trucking distances? I am sure all of you have heard of raw products being trucked phenomenal distances that a few years ago would have been thought impossible. (Not to mention some years ago shipping Dutch Elm infected logs from Holland to middle America for further manufacture as well as spreading the disease.) Along this line, a few years ago, Blynn Merrill a former Service Forester with the Maine Forest Service resigned to go to work in New Hampshire for a private company. He sold forest products to markets in Maine, trucking tremendous distances, that few in New Hampshire had ever even tried to tap before, and did it successfully.

I believe one of our major needs - and many people are in agreement on this - is to get our forest research and forest economics into practice by our field foresters. I believe this will only be accomplished - if and when there is a persistent, dogged effort by forest supervisors to upgrade and train their foresters through continual educational and training programs. In these programs, the forestry schools and the Society of American Foresters through its sections and chapters, must be involved and lend their time, expertise and facilities.

But most important, this education and training must have the complete support of top company and public management personnel, aiding, pushing and abetting their foresters. It is only by such encouragement that foresters will be successful in bringing their profession to its rightful place that we all believe it should hold.

It will not be easy - it will not be an 8 to 5 job as some new, and possibly some old, foresters believe. But forestry has never been an easy profession.

I believe we have the ability, I believe we have the will, and I believe the country has the need for us to achieve this high professional status to supply it with the goods and services that will be needed in the years ahead.

And I also believe that Intermediate Cultural Practices are important keys to our being able to do this.

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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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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 $S = b_1N + b_2 d + \Sigma b_3 \Sigma d^2$ (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.

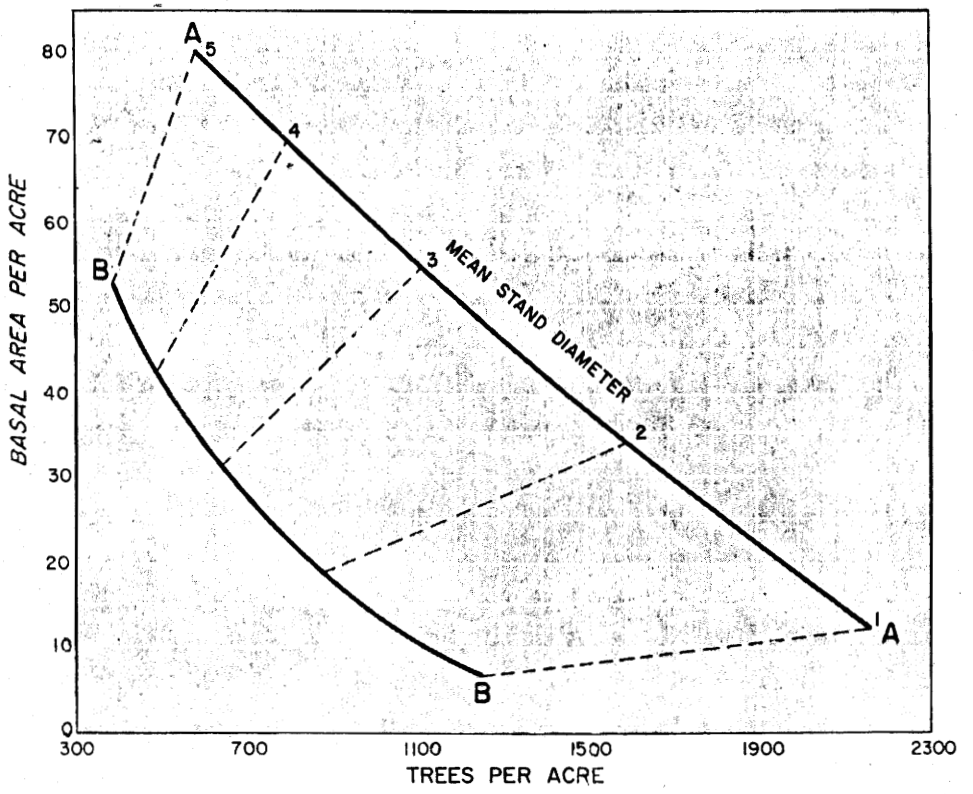


Figure 1.--Stocking guide for even-aged sapling stands of paper birch. From: Solomon, D. L. and W. B. Leak, 1969.

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 pre-

dict 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 10-20f^2. Gingrich (1971a) indicated that at age 20, unthinned oak stands would have a basal area/acre of 55-70f^2, and thinned stands would have 35-46f^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 85f^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.

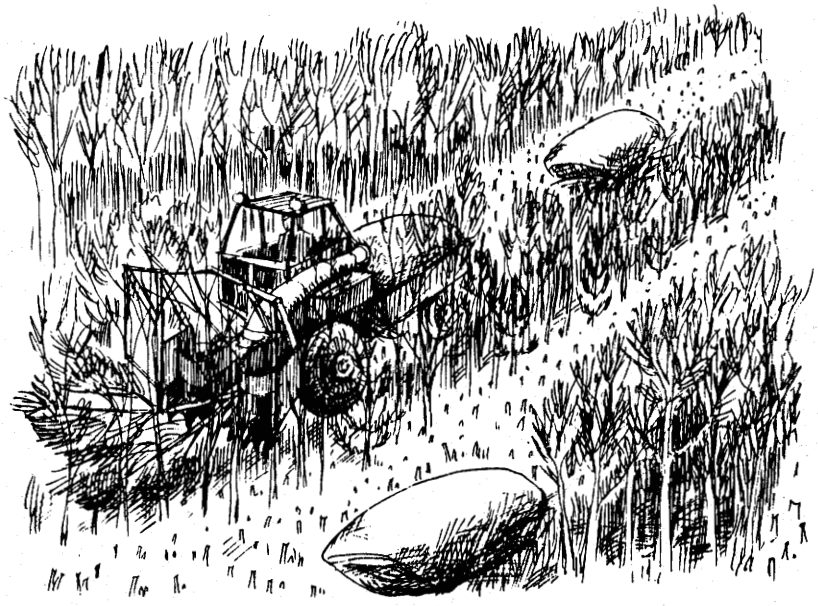
The Pallari Busharvester (Hakkila and Mäkela, 1975) which is being developed in Finland may make it possible to utilize rather than destroy the material when mechanical thinning young stands (Figure 2). Even though the yield per acre from an early harvest may not be self sufficient in cost, a partial 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 1363f^3 in 20 years (PAI = 68f^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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FIELD EXPERIENCE SILVICULTURAL CLEANING PROJECT IN YOUNG SPRUCE AND FIR STANDS IN CENTRAL NOVA SCOTIA

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Abstract

Silvicultural cleaning production varied from .15 to .34 acres per man day using light weight chain saws in young Spruce and Fir stands in Central Nova Scotia.

Direct labor and saw costs, in cleaning young softwood stands in Nova Scotia, can be expected to range generally from $55.00 to $90.00 per acre, depending on crew experience, stand density, and equipment used.

Many of you are aware that the James W. Sewall Company, in 1970, opened an affiliated Canadian office in Truro, Nova Scotia, and in 1974 purchased, renovated, and moved into a former military building in the new Debert Air Industrial Park in Debert, Nova Scotia, being on land of the former Canadian Forces army camp, commonly referred to as Camp Debert. We are now located about ten miles West of Truro.

You may possibly be asking yourselves how we became involved in a project of this nature. As you can appreciate, operating and expanding a new based forestry and surveying consulting business offers headaches relative to maintaining experienced and reliable staff through periods, where business volume fluctuates considerably from one month to the next. In an attempt to keep trained cruisers and instrument men on our payroll during slack times, we reached an agreement with the Nova Scotia Department of Lands and Forests, in which we contracted to silviculturally treat approximately 50 acres of young Spruce and Fir thickets by 'cleaning', referred to as "spacing" by some. This agreement contained no stringent time constraints, allowing us to work on the project while not engaged in our normal consulting work, and most importantly enabled us to keep our experienced men for when we needed them for cruising

and surveying.

Leading into a more in-depth discussion on our field experience, I feel it appropriate to take the time to give you a little background regarding silviculture programs in the Province, which will serve as a partial explanation for the high-cost, long term investments having been and presently being invested in softwood land in Nova Scotia.

In 1965 and 1966 the Nova Scotia Department of Lands and Forests initiated a stand improvement program, and since that time have silviculturally treated roughly 50,000 acres of which some 10,000 acres have been "cleaned" or "spaced". In 1975 they "cleaned" 767 acres and have projected completing the same on 1000 in 1976.

In 1958, the Nova Scotia Pulp Company, now called Nova Scotia Forest Industries, with a pulp and newsprint mill in Point Tupper, Nova Scotia, entered an agreement with the Province of Nova Scotia and agreed to build a pulp mill in Eastern Nova Scotia, sell as much of their product on the local market as possible, and prepare within five years of the start of the mill a forest management plan for the lands from which they were to receive their wood. In return the Province gave them cutting rights on all Crown Lands in the seven Eastern counties of Nova Scotia.

N.S.F.I.'s forest management plan is called "Silviculture" and is directed toward producing harvestable pulpwood volumes in treated stands within 45 years as opposed to 60 years in untreated stands. This program is largely funded through an agreement with the Province by which Nova Scotia Forest Industries pays the Province $2.75 per cord of softwood cut from the lands, of which $1.75 is channeled into a silviculture fund and is spent on the silvicultural improvement of the lands.

Since 1971, Nova Scotia Forest Industries have silviculturally treated an estimated 30,000 acres of leased Crown Land of which about 9,000$\pm$ acres have been "cleaned". They plan on "cleaning" about 3,500 acres this year.

Also; a federal-provincial agreement under the Agricultural and Rural Development Act (ARDA III) has terminated this past March (1976) and a similar agreement, now being negotiated, hopefully will be in effect in the near future. The new program is to be called the General Development Agreement (GDA) and supposedly is to offer private land forestry assistance similar to the previous (ARDA III) program. Presently, while only an interim situation, there is no forestry assistance to private land

owners in Nova Scotia other than windfall recovery assistance.

To give you an appreciation of the availability of government monies I want to comment briefly on the mentioned (ARDA III) program. I realize I'm getting away from the subject of interest but we must recognize and realize the role these government assistance programs have played in not only silviculture but other areas of forest management as well.

Anyone owning forest land in Nova Scotia under the past (ARDA III) program, could apply for government financial assistance in the following areas of forestry. In addition to this financial assistance, the landowner is provided professional and technical forestry guidance from the Provincial staff.

I. Woodland Road Construction:

Offered assistance up to 60% of bulldozing and grading costs to a maximum of $900.00 per mile. Assistance of $1.75 per cubic yard of gravel to a maximum of 800 cubic yards per mile. Maximum assistance would be $3,300.00 per mile.

II. Boundary Lines:

Offered assistance at a rate of 60% of the survey costs up to a maximum of $300.00 per mile of boundary line cut and surveyed.

III. Silviculture:

a.	Site preparation - Up to $25.00 per acre	
b.	Forest planting	
	Open root stock	Up to $30.00/M trees
	Container stock	Up to $20.00/M trees
c.	Acquisition of planting stock	
	Open root stock	
	Nursery	Up to $40.00/M trees
	Wildings	Up to $40.00/M trees
	Container stock	Up to $20.00/M trees
d.	Cleaning	
	Long term	$50.00/acre
	Short term	$40.00/acre
e.	Thinning	Up to $30.00/acre
f.	Pruning	Up to $15.00/acre

Many private land owners recognized full advantage of the road and boundary assistance but response to the

silviculture assistance was less than originally hoped for.

At this point I should clear up one point regarding forestry terminology and explain that in Nova Scotia the term "cleanings" is used to describe "weedings" as well. Many treated areas, according to definition, are comprised of "cleanings" and or "weedings". For the benefit of those of us who studied Silviculture decades ago, Smith defines a "cleaning" as: "A cutting made in a stand, not past the sapling stage, in order to free the best trees from undesirable individuals of the same age, which overtop them or are likely to do so". He defines "weeding" as: "A term that denotes the removal of all plants competing with the crop species, regardless of whether their crowns are above, beside, or below those of the desirable trees". While we have used the term "cleaning", we recognize that the area we treated was for the most part "weeded". Michaud, with the Nova Scotia Department of Lands and Forest states: "The cleaning operation is one in which the stem number per acre of a desired species, generally of young stands (i.e. six to 12 feet high, 15 to 20 years old) is reduced to a number more closely approaching that of a mature stand".

Some advantages to "cleaning" and basic concepts we've all been exposed to over the years are:

a. Shorter rotations through increased growth rates by concentrating growth potential on fewer stems per unit area.

b. Reduced harvesting costs through production of larger future crop trees of more uniform size.

c. Species composition regulation.

d. Longer growing season effect through exposing young stands to sunlight penetration.

e. Promotion of well formed crowns and root systems.

Many softwood stands in Nova Scotia, between 12 and 20 years of age support between 10,000 and 50,000 stems per acre. Opinions are that at this age, stand density should not exceed 1000 stems per acre. Studies in Nova Scotia, New Brunswick, and New Foundland indicate that by opening dense stands from 10-20 years old to a spacing of seven to eight feet (700-900 trees/acre) will reduce rotations by as much as one third. Nova Scotia Department of Lands and Forests personnel suggest that a good site with a stand at age 15 and spaced to 700 trees per acre may average a cord per acre per year over the length of the rotation, which may

be in the order of 45 years.

Our project called for the "cleaning" of some 50 acres of Spruce and Balsam Fir saplings from an estimated 10,000 to 20,000 stems per acre to an approximate 8-foot x 8-foot spacing or about 680 stems per acre. Seventy-five percent of the stems were Balsam Fir, 24% Red Spruce, and 1% Hardwoods. Heights varied from 4 to 14 feet with average height of eight feet. We spaced, changing the stand composition to as heavy a component of Spruce as possible, achieving a residual stand of approximately 60%-70% Spruce.

(The technical aspects of the basic "cleaning" operation will be presented in a slide presentation in a few minutes.)

We started with a crew of six cutters and a general foreman, the foreman reporting to our forester in charge. The foreman's responsibilities were to lay out and assign segmented working areas to each cutter, to keep records regarding each cutter's weekly production, and to maintain quality control.

In laying out these working compartments, he used a device called a "topo-chain", (See picture) which lays down a fine string, simultaneously giving a reading of the distance laid off. This device enabled the foreman to lay out and measure the working areas unassisted. His records simply consisted of a general map illustrating the location and acreage of each compartment plus a weekly listing of completed acres per cutter. The foreman inspected the works daily and periodically with Lands and Forests personnel, carried out a detailed quality control inspection. During this inspection they measured 1/50th acre plots as a check on residual spacing.

Cutters worked in only the areas assigned, thus keeping out of each others' way, yet being close enough to render assistance should someone get hurt. Fortunately we experienced no bad accidents other than one or two slight nicks with the saws. I might add that operating the type of light weight chain saw that we did, or any other type chain saw for that matter, can be very dangerous in these softwood thickets. Our men were outfitted with safety pants, boots, gloves, safety glasses, ear protection, and hard hats. Also kept on hand were first aid supplies and fire fighting gear. Not so dangerous are the more expensive brush saws, which cost over twice the price of a light weight chain saw but by some are considered more productive for this work. Nova Scotia Forest Industries claims excellent success with the Swedish brush saws called "Husqvarna". (See picture)

All spacing was left to the discretion of the cutters, followed by the previously mentioned inspections by the foreman. They did an excellent job of maintaining a residual stand of the desired number of stems per acre and likewise the overall quality of their work was outstanding. Their instructions were to cut all trees low and below the live green portions of the crowns, thus discouraging the development of new trees from lateral shoots. They were additionally required to fell medium sized hardwoods, large dead stubs and to girdle the larger hardwoods.

Extreme summer heat, flies, hornets and mostly the inexperience of our crew, resulted in a much lower than expected level of production. Their production was .15 acres per man day. We previously, through discussions with Lands and Forests personnel, anticipated a man could "clean" about .40 acres per day. In all fairness, our crew's production included an orientation process. After allowing adequate time and giving the crew the full benefit of the doubt, we realized we were in trouble at this rate of production and subsequently curtailed the project until such time as we could come up with a solution yielding production hopefully of the magnitude of .40 acres per man day.

We were paying the men $70.00 per acre while Lands and Forests, at that time, were paying their crews on a prorated price, proportional to stocking per working area. That is, they paid $70.00 per acre for the most densely stocked areas and considerably less for lesser stocked stands. We paid $70.00 per acre across the board, as a partial recognition of our crews' inexperience.

Because of our unusual working arrangement, we were required by law, to make up the difference if the cutter's piece rate amounted to less than minimum wage. I'm not suggesting that these men were lazy but perhaps that they were smart enough to realize their inexperience and desire would not allow them to earn much over the minimum wage, regardless of their expended effort. In any event, we were temporarily out of the "cleaning business", and our "cleaning" project was 'in the red'.

Our forester in charge, seeking advice, spent an interesting afternoon with Oscar Selin, whose advice was for us to investigate the possibility of using Marden Choppers or similar equipment, for creating regularly spaced, cleared corridors throughout the area, and hand clearing between these corridors. We located the equipment but were denied permission to use by Lands and Forests, until they had evaluated the systems' effectiveness. Their main concern, being the percentage of trees in and on the edge of the

corridor that would not be totally killed, thus regaining stature and competing with residual crop trees. This corridor concept makes real sense to us and I believe warrants further investigation in Spruce and Fir thicket spacing.

We additionally investigated the possibility of recovering part of our costs by marketing Christmas trees from the area; this to be integrated with the normal "cleaning" process. We were again denied this option as this was in contradiction with Lands and Forests policy regarding Christmas tree production on Crown Land. Admittedly, in dense softwood thickets many trees are unacceptable as Christmas trees, but many of the interspersed, less densely stocked areas will yield Christmas trees of some standard.

Shortly thereafter, we were approached by four woodsmen, who had just come off powerline right of way clearing, needed work, and were willing to give this a try. After looking the area over, they figured they could earn sufficient money. To avoid the previous situation we were in, we subcontracted the remaining acreage at $90.00 per acre. This crew averaged .34 acres per man day on a completed 15 acres. However, because they were discontent with the work and our supervision and transportation costs still held us over the break-even point, both parties agreed to end the project.

Those of you who ever asked a nurseryman the cost of raising 1,000 seedlings found that comparing his figure to another nurseryman's was like comparing apples to oranges. Not that they're not good figures, but it seems each nursery figures this a little differently. I'm sure the same situation prevails when you go to find out what it costs to "clean" an acre.

In our situation, we got down to where our supervision, transportation, and direct labor was costing us about $142.00 per acre. We were realizing a mark-up on our supervision costs only. Our direct labor cost at this level was $90.00 per acre.

The Department of Lands and Forests cleaned 767 acres last year for $86.93 per acre. This includes a foreman, without the time of the supervising forester being included.

Most impressive are Nova Scotia Forest Industries' figures. They averaged .75 acres per man day on 1,000 acres, with chain saws, and .96 acres per man day on 1,500 acres, with the brush saws. They are projecting their direct labor and saw costs to be in the order of $55.00 per acre for this year. This does not include a field foreman or salaried supervision and planning.

As a closing comment, the number of stems per acre dictates, to a large degree, production rates and should be ascertained by several classes. Good sites that have not been densely stocked by natural regeneration, warrant consideration when selecting areas in which to practice "cleaning".

This talk is supposed to be on our "field experience" and an "experience" it was. What we lost in dollars we charged to "experience".

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INDICATIONS OF SILVICULTURAL POTENTIAL FROM LONG-TERM EXPERIMENTS IN SPRUCE-FIR TYPES

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Abstract

Data collected since the 1950s from commercial treatments on more than 400 acres in the Penobscot Experimental Forest in Maine indicate a high mortality rate of 520 percent of net growth in the woodland preserve where timber is not harvested, a low mortality rate of 16 percent of net growth under the selection system. As the intensity of silvicultural treatment increased, periodic net annual growth increased from 10 cubic feet per acre (0.7 m^3/ha) in the woodland preserve to 56 cubic feet per acre (3.9 m^3/ha) under the selection system.

THE KEY to more productive forests is stand-improvement to replace untended and undertended stands with cultured stands containing fast-growing high-quality trees of favored species. Few are the acres that cannot be improved by ridding them of excessive trees, poor-risk trees, low-quality trees, or trees of inferior species. A rigid scheduling of intermediate cultural operations, preferably in conjunction with periodic thinnings or harvests, will accomplish this and enable the land to produce yields at capacity.

COMMERCIAL VERSUS PRECOMMERCIAL TREATMENTS

Simply stated, a cultural treatment that over time transfers at a profit the growth from undesirable trees to trees that will be removed either as crop trees or in subsequent thinnings is logically a commercial treatment. In this respect intensive culture in stands of trees is not unlike agronomy applied to other crops.

Dunfield (1974) stated that "precommercial thinning may be defined as a silvicultural method to eliminate a certain percentage of trees from a forest stand in order to increase the growing space and growth of the residual trees. The trees destroyed are usually of no commercial value, although collectively they

contain a substantial volume of wood fiber."

Berg (1970) defined this in a more profound economic sense. He stated that, regardless of whether or not a thinning operation pays for itself in part or all, it must be considered a precommercial operation unless an immediate economic profit is returned. Worthington and Staebler (1961) were less restrictive. They maintained that, if an operation pays for itself, profit not withstanding, it is a commercial treatment.

Fully realizing that the terms precommercial treatment, noncommercial treatment, and commercial treatment are rapidly becoming archaic because of the more complete utilization of forest biomass, I shall make perhaps one of the last attempts to define the latter--commercial treatment, the subject under discussion. I define this intermediate cultural practice as follows:

> An operation involving the removal from a forest stand of trees primarily of merchantable size and of marketable species in a quantity sufficient to at least equal the cost of the operation and having one or more of the following purposes:

- To reduce stand density in order to increase the growing space and growth of residual trees and new regeneration.
- To reduce trees in diameter classes with excessive numbers of trees.
- To reduce the number of poor-risk trees.
- To reduce the number of trees of low species priority.

The treatment may also include the removal of both nonmerchantable-size trees and merchantable-size trees nonmarketable because of quantity, quality, or species. I have chosen to exclude from my definition pruning, the application of fertilizer, and land-drainage techniques.

CONSTRAINTS AND SILVICULTURAL CONSIDERATIONS

The minimum amount of marketable material necessary for an economic or profitable operation depends

on many variables. It probably ranges between 250 cubic feet per acre and 750 cubic feet per acre (17.5 m^3/ha and 52.5 m^3/ha) in spruce-fir types. Among the important variables are species, quality, product, logging conditions including spatial distribution of trees to be harvested, skidding distance, and proximity to mill.

A commercial treatment in a developing even-age stand begins as soon as the treatment is financially self-sustaining. Both in even-age stands and in uneven-age stands, the interval between operations is such that wood losses due to mortality are minimized. This is best accomplished with relatively short periods of time between stand entries. Operating intervals of 10 to 15 years are well suited for this objective.

The amount of growing stock removed during a commercial treatment should not exceed 50 percent, and it can be as low as 10 percent on sites where the danger of excessive wind damage is apparent (Frank and Bjorkbom 1973). A second constraint on the amount of growing stock to remove involves stands not adequately stocked. These stands should be replenished promptly by adding to the growing stock an amount equivalent to a portion of each periodic increment until an acceptable stocking level is reached.

COMMERCIAL TREATMENTS IN SPRUCE-FIR TYPES --SOME EARLY EXPERIMENTAL RESULTS

Extremely varied site and stand conditions in spruce-fir types, coupled with existing market conditions, strongly suggest that silvicultural practices are never uniformly applicable (Westveld 1930). Or, there is not a "best" silvicultural system for all lands all of the time.

History and Scope

An example of various silvicultural systems and management methods applied to formerly unmanaged stands is available. Work was initiated during the 1950s and trends are developing after less than 20 years of treatment. Treatments include three intensities of the selection system, two intensities of the shelterwood system, two intensities of the diameter-limit method, one example of unregulated harvesting by the commercial clearcutting method, and a woodland preserve where harvesting is not allowed. All treat-

ments with the exception of the woodland preserve are replicated twice. Treatment descriptions are outlined in the Appendix.

Data are reported according to availability. For instance, no data are being reported for the two-stage shelterwood treatment because the final harvest in one replication occurred less than 2 years ago. Original regeneration data were not recorded for any treatment, and second-measurement data are not yet available for the diameter-limit treatments.

The Study Area

Data are being collected in the Penobscot Experimental Forest, just 2 miles southeast of Orono, on more than 400 acres (162 ha) of spruce-fir types. Before being placed under management, these stands supported substantial amounts of hemlock and associated hardwoods. Some stands still do. The reason for these admixtures is that the Forest is located in the transition belt between the transition/hardwoods white pine/hemlock and the spruce-fir/northern hardwoods forest types as described by Westveld et al. (1956).

Sites within the study vary from areas of impeded drainage where red spruce (Picea rubens Sarg.), white spruce (P. glauca (Moench) Voss) and balsam fir (Abies balsamea (L.) Mill.) predominate, with northern white cedar (Thuja occidentalis L.) and red maple (Acer rubrum L.) as associates. On moderately well-drained locations, eastern hemlock (Tsuga canadensis (L.) Carr.) is a strong contender for site occupancy, along with occasional paper birch (Betula papyrifera Marsh.), eastern white pine (Pinus strobus L.), and red maple. A scattering of several other species is also present.

Commercial treatments being applied vary in intensity. Volumes removed in separate operations range between 300 and 1,250 cubic feet per acre (21.0 m^3/ha and 87.5 m^3/ha).

Except for the earliest timber-stand-improvement operations, the removal of undesirable nonmerchantable trees has been an integral part of each periodic harvest. The selection, three-stage shelterwood, and flexible diameter-limit treatments receive varying degrees of timber-stand-improvement: the 5-year and the 10-year interval selection treatments are the most intensive. In the latter two treatments, the TSI

effort is extended to include trees down to the 1-inch diameter class. The fixed-diameter-limit and unregulated harvesting treatments receive no timber-stand-improvement work. And, in the woodland preserve, no cutting or harvesting of any kind is allowed.

Growth Response and Mortality

Net annual growth of natural softwood stands that have had a minimum of past silvicultural treatment is reported by Safford (1968) to be just under 51 cubic feet per acre (3.6 m^3/ha).

With less than 20 years of intensive culture, our selection treatments average 56 cubic feet per acre (3.9 m^3/ha) per year and range from 51 to 59 cubic feet per acre (3.6 m^3/ha to 4.1 m^3/ha).

There is virtually no difference between the two diameter-limit treatments where net annual growth averages 53 cubic feet per acre (3.7 m^3/ha).

A pronounced reduction in growth is noted for the unregulated harvesting treatment when compared with both the selection and diameter-limit treatments. In this treatment, commercial clearcutting left the stand with only 58 square feet per acre (13.3 m^3/ha) of basal area in merchantable-size trees. As stocking becomes reestablished, growth increases and averages 36 cubic feet per acre (2.5 m^3/ha) per year for the treatment period. Growth during the initial measurement period was only 29 cubic feet per acre (2.0 m^3/ha) per year; during the most recent measurement period, 43 cubic feet per acre (3.0 m^3/ha) per year.

Periodic net annual growth is only 10 cubic feet per acre (0.7 m^3/ha) in the woodland preserve area. With no timber harvesting by man, natural mortality is averaging 52 cubic feet per acre (3.6 m^3/ha) per year. Expressed as a percentage of net growth, mortality is 520 percent in this treatment compared to 42 percent or 15 cubic feet per acre (1.0 m^3/ha) per year in the unregulated harvest treatment.

Annual mortality ranged from 10 cubic feet per acre to 13 cubic feet per acre (0.7 m^3/ha to 0.9 m^3/ha) in the diameter-limit treatments. This is 22 percent of net growth.

Corresponding figures for the more intensive selection-system treatments range from 6 cubic feet

per acre to 13 cubic feet per acre (0.4 to 0.9 m^3/ha) or 16 percent of net growth.

These results are similar to the results reported by Snow (1938). He reported that over a 29-year period average annual mortality for an unthinned stand was 49 cubic feet per acre (3.4 m^3/ha). In a thinned stand losses averaged 11 cubic feet per acre (0.8 m^3/ha).

Stand Quality

The reduction in number of cull trees in a stand is a major goal in intensive forest management operations. And the more frequent a stand entry is made, the more rapid and enduring is the reduction.

Intervals of 20 years and longer allow for the continual development of undesirable growing stock. Short intervals--about 10 years--are most efficient in eliminating cull trees and other poor-risk trees that are likely to develop into cull trees (fig. 1).

Cull trees have been practically eliminated from stands being managed under intensive selection silviculture. Cull-tree volume is only 0.2 percent in the 5-year-interval treatment where four combined harvests and timber-stand-improvement operations have already been made. The 10-year-interval treatment shows a corresponding reduction in cull trees to 2.4 percent of total volume after two combined operations.

The only obvious increases in cull-tree representation occurred in the two treatments not subject to stand improvement work--the fixed-diameter-limit and unregulated harvesting treatments.

The reduction in cull-tree representation in the woodland preserve is attributed to the high mortality rate.

Species Composition Changes

An attempt to alter species composition is best described by the cliché, "It is easier said than done!" The only exception is artificial regeneration. Even with this method, invasion of the planting site by formerly undesirable species or by successional species usually requires cultural measures to insure the ultimate dominance of the planted stock.

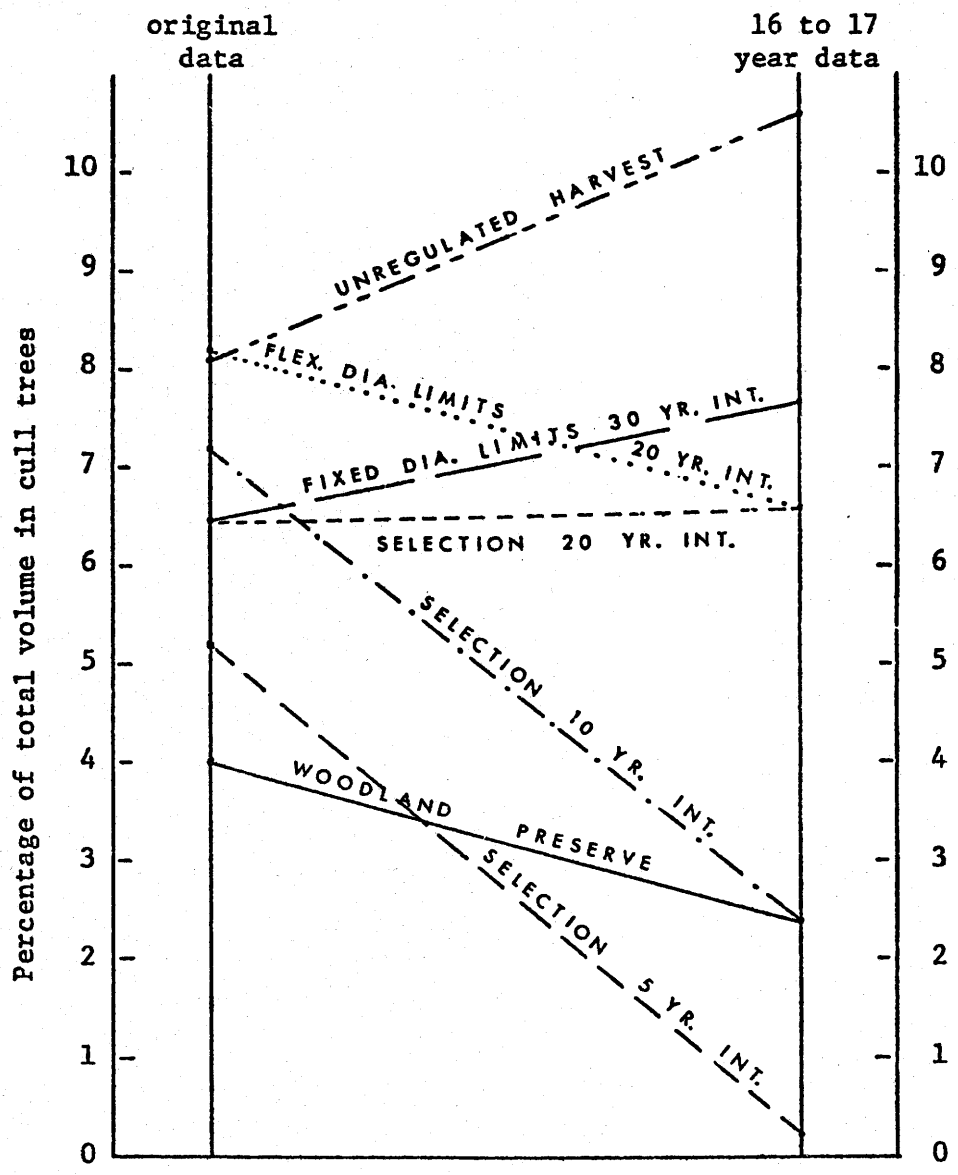

Figure 1.--Changes in stand quality by treatment, all species combined.

When natural regeneration methods are relied upon, compositional changes take place more rapidly under even-age management than under uneven-age management. An example is the shelterwood system.

Composition changes in regeneration.--All treatments show increases in numbers of balsam fir seedlings except for the selection-system treatment managed on a 5-year operating interval, where there is a slight decrease (fig. 2). The reason for this is not clear, although the frequency of stand entry with resultant logging damage may be a factor.

Fir seedlings currently range in number from fewer than 3,000 per acre (7,400/ha) in two of the three selection treatments to just over 12,000 per acre (29,600/ha) in the woodland preserve. Continuous dense overstory cover in the woodland preserve, gradually tempered here and there by mortality, plus an almost complete lack of site disturbance, has maintained site conditions suitable for fir germination and establishment but less hospitable to most other species.

Initial counts of spruce were all below 1,000 seedlings per acre (2,500/ha). However, the shelterwood-system treatment, where spruce was favored during the regeneration period, registered a 24-fold increase in spruce seedlings--from 100 to 2,400 per acre (250/ha to 5,900/ha). All other treatments registered gains, but the magnitude of the increases is much less.

The responds to the various treatments by hemlock seedlings is not unlike the response noted for spruce, particularly red spruce. This is because the environmental conditions necessary for their establishment, shade, and adequate moisture are very similar (Fowells 1965).

The reaction of the intolerant species to treatment is more predictable. Hardwoods and white pine show dramatic gains in the shelterwood treatment. In the unregulated harvesting treatment, the initial increases of these same species (original data not available) apparently peaked before regeneration counts were made. Therefore, a decline is noted between the 9th-year measurement and the 19th-year measurement. The selection treatments all show a slight decline in the numbers of intolerant species.

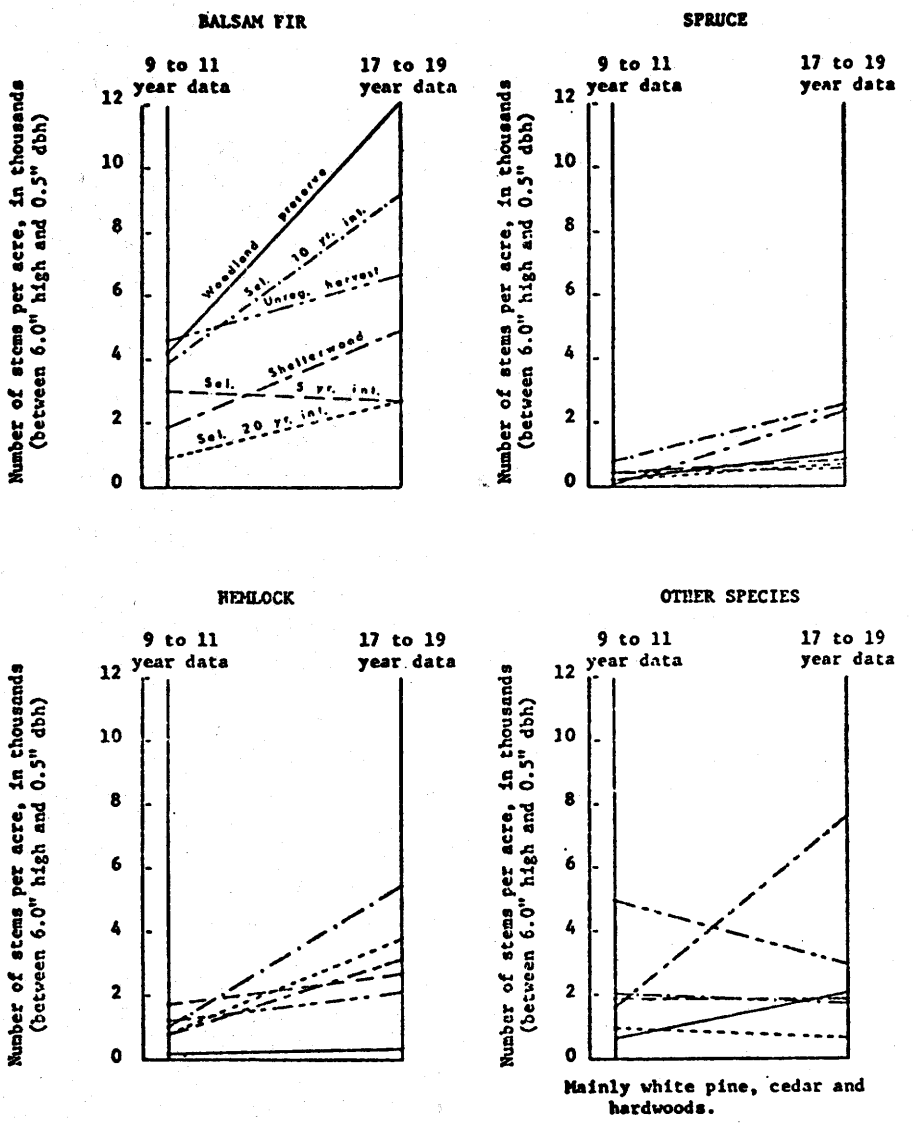

Figure 2.--Changes in regeneration, by treatment.

Ratio of balsam fir seedlings to spruce seedlings.--The slow-growing shallow root systems of spruce seedlings often are not able to reach available moisture and compete with the faster-growing balsam fir unless: (1) the organic layers of the soil profile are reduced in thickness; (2) rainfall can better penetrate the overstory following an operation; or (3) rainfall during the crucial growing season is frequent and plentiful.

Disturbance in a spruce-fir stand caused by timber harvesting usually results in a reduction of the ratio of fir seedlings to spruce seedlings. The reduction in the depth of the organic layers by scarification and the greater penetration of rainfall because of tree removals trigger a relatively greater response in establishment of spruce than in establishment of balsam fir. In the absence of logging, natural mortality can also create conditions that improve the moisture regime in the forest floor.

Immediately before the final removal of predominately spruce overstory trees in stands resulting from the shelterwood treatment, the fir-to-spruce ratio was 2:1. Eight years previously it had been 14:1. Unquestionably, this shelterwood operation was successful because a major goal was to increase spruce representation.

Since original data are not available we can only speculate about the ratio before treatment. The woodland preserve is perhaps indicative, however. The initial measurement resulted in the tabulation of a ratio of 28 fir to 1 spruce for this treatment. Currently it is 12 fir to 1 spruce. Originally, before excessive mortality, the ratio was perhaps significantly greater than 28:1.

All selection treatments display a reduction in the fir-to-spruce ratio--from about 5 to 7 fir for each spruce to a ratio of 4:1.

Composition changes in merchantable-size trees.--Changes in species representation after 16 to 17 years of observations is at best only trend-setting. And, variations based on volume in original compositional representations were pronounced (fig. 3).

The stands in the study area originally were about 85 percent softwood by volume:

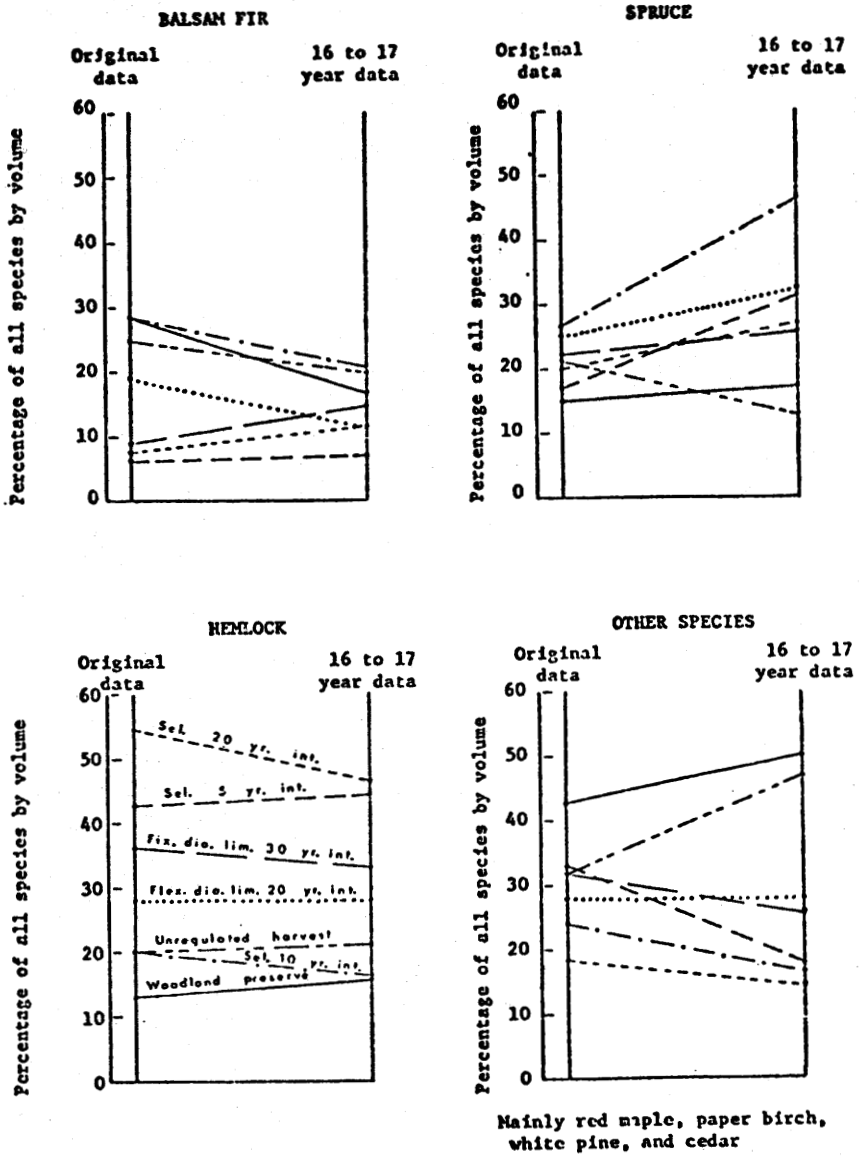

Figure 3.--Changes in species composition, by treatment.

	Percent
Spruce	22
Balsam fir	18
Hemlock	30
Cedar and White pine	15
Hardwoods	15

In general, because of risk and poor quality, balsam fir is being reduced by silvicultural treatment. Conversely, spruce representation in stands under the most intensive treatments appears to be increasing. Hemlock, with widely varied original representations, shows little change. Other species, but primarily the poor quality red maple and other hardwoods, are changing in relation to the intensity of management. Hardwoods tend to increase with little or no management and decrease in relation to other more desirable species as cultural practices intensify.

The Selection System and Diameter Distribution

The normal or classic uneven-age forest is comprised of trees of several or all ages in which no age class can be recognized. Trees of all sizes are interspersed as individuals or in small groups. Regeneration may be found either in small openings or under dense overstory trees. But in order to be assured of sustained periodic yields from an uneven-age forest, it is essential that a balanced or near-balanced diameter structure be maintained. The characteristic of gradually decreasing number of trees in successively larger diameter classes is necessary.

Plotting number of trees by diameter classes on semilogarithmic paper is one way of determining whether or not an uneven-age forest has a balanced diameter distribution. The closer the plot resembles a straight line, the better balanced is the diameter distribution.

The original diameter distributions of the three selection treatments were not similar (fig. 4). The major difference was in the number of saplings in the 5-year-interval treatment. The stands receiving this treatment originally supported about one-half the number of saplings compared to the 10- and 20-year intervals. In fact, the original diameter distribution was considered balanced. However, the continual removal of poor-risk trees and other unwanted trees in the initial four harvest-TSI operations resulted in

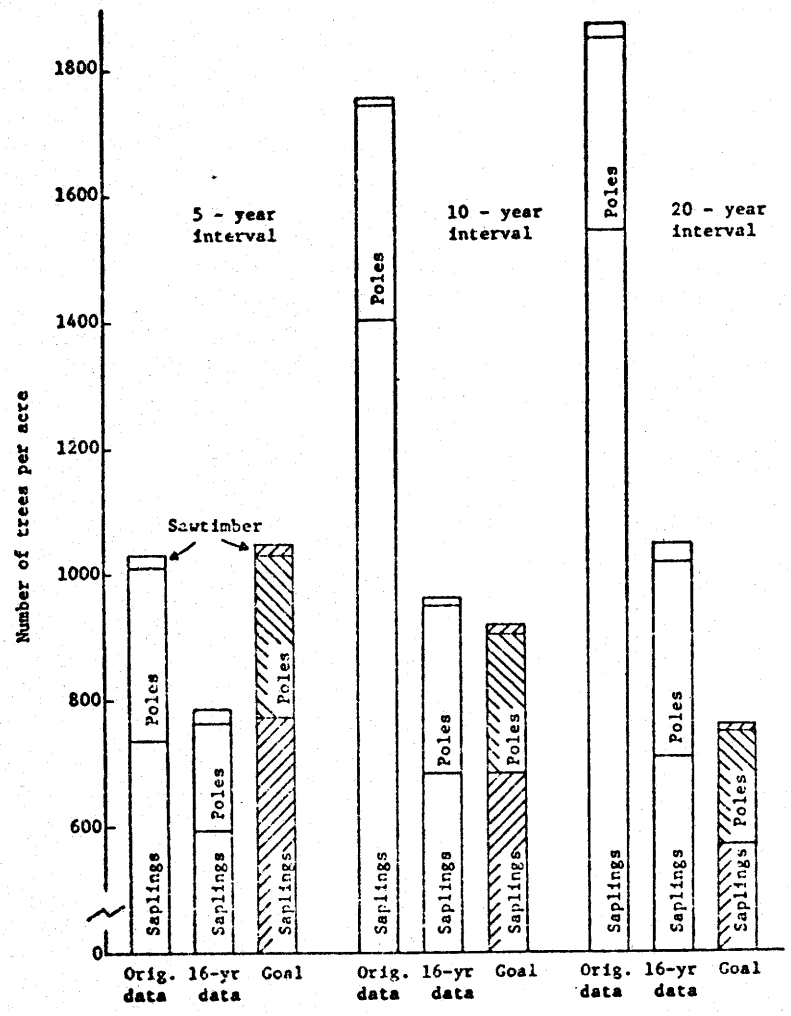

Figure 4.--Diameter-class distribution for selection-system treatments, by operating interval.

less-than-desirable stocking. Until stand density a again approaches the goal, only additional poor-risk trees will be removed in subsequent operations.

The 10-year-interval treatment area is balanced after two entries. The next combined harvest-TSI operation at 20 years will concentrate on the removal of poor-risk trees as well as excess trees in any diameter class. It is reasonable to assume that the current balanced state will be maintained.

The second stand entry for the 20-year-interval treatment at 20 years is expected to result in a reasonable state of balance.

All selection treatments displayed a reduction in the fir-to-spruce ratio between about the 10th year after treatment and the 20th year after treatment--from about 5 to 7 fir for each spruce to a ratio of 4:1.

During the same period, the ratio of fir to spruce changed slightly in the unregulated harvesting treatment--from 12 fir for each spruce to 11 fir for each spruce. In this treatment spruce is not favored; indeed, most spruce were removed during the commercial clearcutting. This reduction in spruce seed-source trees has perhaps negatively influenced the fir-to-spruce ratio.

IN CLOSING ....

Much can be done to improve the condition of spruce-fir stands. For long-term investment, the employment of commercial treatments utilizing silvicultural systems and skillful methods of harvesting are no more costly than no system at all and ill-timed harvests that fail to take into consideration the needs of the stand.

Indications of silvicultural potential from long-term experiments suggests that it is possible to increase growth, improve stand quality, change species composition, and control diameter distribution.

Immediate results from formerly mismanaged and undermanaged stands cannot be expected. But the continual application of approved commercial treatments designed to aid stands to produce near their capacity, will eventually mean larger profits to the landowner.

The measures suggested in this paper are considered sound and practical. I believe they can be undertaken at a profit.

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APPENDIX I

Cultural treatments and goals for various silvicultural systems and methods are as follows:

I. Species preference, where applicable, in order of desirability:

Red spruce/black spruce, white spruce, balsam fir, pine, paper birch, hemlock, cedar, other species.

II. Tentative optimum stand structures and goals for the selection system:

A. Species composition, in percent basal area--Spruce, 35-55 percent; balsam fir, 15-25 percent; white pine, 5-10 percent; paper birch, 5-10 percent; hemlock, 15-25 percent; cedar, 5-10 percent; other species, 5-10 percent.

B. Stand density, basal area per acre, at beginning of an operating interval for trees 0.5 inches (1.27 cm) dbh and larger:

1. 5-year operating interval--115 ft^2 (26.4 m^2/ha).

2. 10-year operating interval--100 ft^2 (23.0 m^2/ha).

3. 20-year operating interval--80 ft^2 (18.4 m^2/ha).

C. Diameter-class distribution:

1. Maximum size tree at end of an operating interval is 20 inches (50.8 cm) dbh.

2. Quotient ("q") between adjacent classes is 1.4.

D. Harvest limitations:

1. Initial harvest--up to 35 percent of gross volume for both the 5-year and 10-year operating intervals; up to 45 percent of gross volume for the 20-year interval.

2. Subsequent harvests--50 percent to 100 percent of net periodic growth for both the 5-year and 10-year operating intervals; 75 percent to 100 percent of net periodic growth for the 20-year operating interval.

E. Timber stand improvements:

1. Remove all cull, wolf, and other unwanted trees to 0.5 inches (1.27 cm) dbh and prune up to 75 spruce and pine per acre (185/ha) for both the 5-year and 10-year operating intervals; to 4.5 inches (11.4 cm) dbh and prune up to 50 spruce and pine per acre (124/ha) for the 20-year operating interval.

III. Objectives and constraints of the three-stage shelterwood system:

A. First harvest--remove overmature, defective, and slow-growing trees; remove less desirable species; create conditions favorable for the establishment of regeneration; increase growth rate of residuals. Limit removal to 50 percent of gross volume.

B. Second harvest--made about 10 years after first to further improve growing stock; increase growth of regeneration; and continue to establish new regeneration. Limit removal to two-thirds of gross volume.

C. Third and final harvest--made about 5-10 years after second harvest to remove all trees down to 2.5 inches (6.4 cm) dbh when stocking of regeneration is at least 85 percent and the area supports 1,000 or more trees per acre (2,500/ha) 2 feet (0.6 in) or over in height.

D. Stand improvement work--includes the deadening of culls and trees interfering with potential spruce seed trees.

IV. Diameter-limit management constraints and guides:

A. Flexible diameter basis:

1. Diameter limits, in inches (centimeters)

Species	First Harvest		Second Harvest	
	(in)	(cm)	(in)	(cm)
Balsam fir	6.5	(16.5)	6.5	(16.5)
Spruce	9.5	(24.1)	14.5	(36.8)
Hemlock	9.5	(24.1)	12.5	(31.8)

Pine	10.5	(26.7)	14.5	(36.8)
Larch	--	--	12.5	(31.8)
Cedar	--	--	7.5	(19.0)
Paper birch	7.5	(19.0)	9.5	(24.1)
Other hardwoods	6.5	(16.5)	5.5	(14.0)

2. Stand-improvement work limited to leaving some trees above limits for seed source and wind protection and removing some trees below limits to prevent their complete loss.

3. The operating interval is 20 years and the volume removed in subsequent harvests is limited to periodic net growth.

B. Fixed diameter basis:

1. Diameter limits, in inches (centimeters)

Species	All harvests	
	(in)	(cm)
Balsam fir	All merchantable	
Spruce	9.5	(24.1)
Hemlock	9.5	(24.1)
Pine	10.5	(26.7)
Larch	All merchantable	
Cedar	7.5	(19.0)
Other hardwoods	7.5	(19.0)

2. Stand-improvement work is not scheduled.

3. Subsequent harvests are made when stand is operable for the same volume as originally removed.

V. Unregulated harvesting by the commercial clear-cutting method--a brief description:

Most merchantable trees on operable areas are removed in a single harvest. No stand-improvement work is done. Small patches of merchantable trees considered inoperable are left to grow. The next harvest is made when it is operable for the same volume as originally removed.

APPENDIX II

Before treatment, parameter averages for the entire 400-acre study area were as follows:

Basal area--146 square feet per acre (34 m^2/ha).
Volume--2,075 cubic feet per acre (145 m^3/ha).
Number of trees less than 4.5 in. dbh--1,090 per acre (2,700/ha).
Number of trees 4.5 in. dbh and larger--360 per acre (890/ha).

Percentage species representation--

Species	Parameter		
	Volume[1]	Basal area[2]	No. trees[2]
Spruce	22	17	8
Balsam fir	18	24	56
Hemlock	30	28	11
Other	30	31	25

[1] Trees 4.5 inches dbh and larger.

[2] Trees 0.5 inches dbh and larger.

FIELD EXPERIENCES IN PRE-COMMERCIAL THINNING, PLANTING AND CONTAINER GROWING OF NORTHERN SOFTWOODS

by L. Oscar Selin, Chief Forester, Georgia-Pacific Corporation, Woodland Division, Woodland, Maine.

Abstract

In preparation for intensive logging mechanization and for the subsequent silvicultural treatments of clear-cut areas the Woodland Division of Georgia-Pacific Corporation started a pre-commercial thinning trials in young softwood and mixed wood stands during the spring and early summer of 1970. Pre-commercial thinnings were intended to be a backbone of a large scale silvicultural system which relied upon natural regeneration of clearcut areas and early thinning of subsequent pre-merchantable stands. It was hoped that through this cycle of treatments the average diameter growth occurring on individual stems could be more than doubled in comparision to natural stands. It was also automatically assumed that the treatments would make considerable shorter rotations possible.

Only a few years later when the techniques of growing viable seedlings in containers had been fully tested and proven, it came obvious that even further reductions in length of rotations were possible for a private landowner who was willing to risk a modest investment on productive greenhouse facilities. As a result of these observations the Woodland Division of this corporation initiated in the spring of 1974 a comprehensive program on intensive silvicl1tural practices which consisted of raising container-type planting stock in large numbers and hand planting it on clearcut sites which in turn had been prepared for planting by heavy mechanized crushing and rolling equipment. It is expected that pulpwood rotations of twenty-five to thirty years and sawlog rotations of forty-five years are possible within the scope of this approach.

PRECOMMERCIAL THINNING OF SOFTWOODS

During the summer of 1970, a twenty year old burn which had naturally regenerated to a mixed stand of spruce, fir and low-grade hardwoods was released of hardwood overstory and the remaining softwoods were spaced out. The entire work was carried out by a six-man crew using lightweight power saws. The total acreage thinned amounted to seventy-one acres and a total of one hundred twenty nine mandays were required to complete the project. A rate of productivity of 2,500 trees or 0.55 acres per manday was achieved. The original stand density was six thousand stems per acre and it was reduced to one thousand four hundred stems per acre when the hardwood overstory was removed and the softwoods spaced out. This was somewhat higher than desired but a fear of wind and snow damage prevented from removing any greater number of stems. The basal area of the stands prior to thinning was sixty-four square feet per acre and fifty-one square feet were removed leaving only a basal area of thirteen square feet per acre for residual stand. The average DBH after the thinning had taken place was 1.35 inches.

The major problem in this type of silvicultural work is the great number of stems to be handled. While the work is in progress, the stems which have been cut occasionally pile up to the waist height and thereby limit the movement and efficiency of workers. Some idea of the size of this problem is given by making reference to the total number of stems involved in this particular operation. We estimated that a total number of 322,500 stems in sizes of 0.5 inches DBH and larger were removed in the course of this seventy one acre operation. Another fifty thousand could have been easily removed if we did not have to worry about snow and wind damage. In order to minimize this problem with numbers we have opened corridors with mechanized crushers in all of our later precommercial thinning projects and thereby reduced the stems to be manually handled by half. So far approximately one thousand acres have been handled in this fashion.

The responses to thinning have been measured only on comparative terms to the average annual diameter growth of our natural spruce-fir stands. Observations extending over several decades have confirmed an average annual growth rate of 0.10 inches per year on med-

ium sites. Against this level of growth our permanently established plots in the thinned area indicate, at the end of the first five years, an average growth rate of 0.25 inches per year. If this rate of growth can be maintained over the next fifteen years, a harvestable crop of pulpwood with an average DBH of 6.25 inches had been raised in forty years. This in comparison to sixty to seventy years required to raise a crop of trees of a similar size in natural stands.

GROWING SEEDLINGS IN STYROBLOCK CONTAINERS

This system of handling and growing seedlings was introduced to Georgia-Pacific Corporation's operations by its Forestry Research Manager, Philip F. Hahn in Eugene, Oregon. He has further refined it to such a degree that it is presently known under his name as a Quarterblock System. The core of this system is a polystyrene moldable quarterblock container. It has proven to be the most superior among the several types of containers. It supports an outstanding seedling development at the nursery and also lends itself well for a high degree of mechanization at the nursery and in the field.

This container is produced in a quarterblock form in two different sizes. The smaller one, #2, is five inches wide, fourteen inches long and 4.5 inches high. It has forty eight cavities, each cavity being one inch in diameter and slightly tapered towards the bottom. The large type, #8, quarterblock container is five inches wide, fourteen inches long and six inches high. It has twenty cavities, each 1.5 inches in diameter and also tapered towards the bottom. One cavity in #2 container holds 2.5 cubic inches of soil and produces a smaller tree than is possible in #8 which contains eight cubic inches of soil. Each container has its place. The smaller container is used in routine operations and the larger one in special areas where higher costs for larger seedlings can be justified. Cleaned and disinfected blocks are reusable several times which saves material and cost. Since the cost of the containers is largest single expense item in container operation, considerable savings can be effected by recycling the blocks.

In the filling of containers a light weight mixture of peat and vermiculite is used. The soil loading and

seeding operation is mechanized and the last step in loading is the covering of seed with layer of grit. When the whole operation is fully automated over three hundred thousand container cavities can be loaded and seeded in eight hours.

Since the container cavities hold only small amounts of soil, frequent irrigation and fertilization are needed. This is done normally two or three times a week during the active growing season. In all cases before the seedlings are ready to go to the field they must be hardened. This is generally done with a combination of measures which include the exposing of the seedlings to systematic moisture stresses, the shortening of the photo period and the manipulation of the nutrient diet.

The type of houses used to shelter the growing seedlings by Georgis-Pacific Corporation in the Northeast are of a double layer polyethylene and steel frame construction. They are equipped with a heating and ventilation system which is controlled by thermostats. Two crops per year are raised and artificial lighting is used to accelerate growth. These types of houses give excellent shelter against the extremes of the weather in the Northeast and they also support an excellent seedling growth for a relatively low cost while staying close to natural growing conditions.

PLANTING

The fully grown and hardened seedlings are shipped to the planting site in their original quarterblock containers. They can be boxed for longer trips but they can be also conveniently transported as they are in slightly modified pick-up trucks. At the planting site the quarterblocks are placed in the backpack carriers which handle up to nine quarterblocks or approximately 430 seedlings and have a total loaded weight of twenty seven pounds. Each tree planter carries his own supply of seedlings while he plants the trees.

The carrier is so designed that a double lock system operated by the tree planter moves one quarterblock into the bottom compartment. This quarterblock could be then removed and placed in a belt holder where the seedlings are in easy reach to the planter. After punching a hole of the same shape as a rootplug into the ground, he can extract the seedling from the belt

holder and place it into the hole. As soon as the supply of seedlings is depleted from the quarterblock in the belt holder, the empty quarterblock is placed into the carrier through the top to return it for another use while it is replaced with a fully stocked quarterblock.

The planting rate with quarterblock containers is very good. It is generally twice as high as the bareroot planting rate under similar conditions. Planting rates of 1,500 seedlings per manday have been easily reached in the Northeast operations of this corporation and it is expected that a rate of 2,000 seedlings per manday will be reached in the near future.

PLANTING SITE PREPARATION

All the sites to be planted are prepared prior to planting, and two types of equipment are presently used. In New Brunswick operations of this corporation the so-called shark finned barrels with anchor chains are pulled by Caterpillar D-8 Tractor and in Maine a single drum-type Marden B10 brush cutter is being drawn by model 668 Clark rubber-tired skidder.

This work needs to be done in order to make the sites accessible to tree planters and to break up the heavier layers of humus. It also leads to elimination of great numbers of competive shrubs, seedlings and trees. No scalping and only very light scarification effect is being sought. No sedimentation of adjoining waters as a result of this work has been observed nor expected in the future.

HOW DO STYROBLOCK SEEDLINGS PERFORM

The West Coast Divisions of Georgia-Pacific Corporation have been engaged in large scale containerized seedling production since 1971. The annual growing capacity of the present facilities is about fifteen million seedlings, and all these nurseries use the quarterblocksystem developed by Philip Hahn. We are also raising 1.5 million seedlings annually by this same method in the nurseries located in Maine and New Brunswick, Canada.

Comparison tests to bare-root seedlings in all of West Coast locations have shown that the containerized seedlings nearly always out-produce bare-root stock in survival and growth rate. The survival difference is often substantial. A ten to twenty per cent higher survival rate is quite common. On harsh dry sites as high as forty per cent survival differences have been observed.

In the Northeast operations the experience with the styroblock container stock is limited more or less to one growing season but it shows that the styroblock seedlings can be planted throught the summer with excellent results and they do survive well even under the harshest conditions.

STATUS OF FERTILIZATION AND NUTRITION RESEARCH IN NORTHERN FOREST TYPES

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Abstract

Forest fertilization is a useful tool that, when combined with other silvicultural practices, results in increased forest growth. Many experiments have demonstrated that both hardwoods and conifers of the northern forest respond to the addition of one or more nutrients. Examples of pitfalls and successes are given. Present status of research and future research needs are discussed.

GREATER DRAIN on the northern forest is expected in the not-distant future. Obviously more raw material will have to be grown and harvested at shorter rotations and on less land.

Liming and fertilization are useful tools which, when combined with other ameliorative site treatments and silvicultural practices, result in increased forest growth.

In this paper I present a digest of available information and summarize the status of research in progress on forest fertilization in northern forest types, with emphasis on the work being done in New England and the Maritime Provinces of Canada.

This paper does not contain all details and does not pretend to be complete. The area is large, the forest conditions are diverse, and the research activities are complex. Attempt is made to point out the examples of pitfalls as well as successes in forest-fertilization efforts in northern forests.

AVAILABLE GUIDELINES

At the outset, something has to be said about the knowledge available worldwide. During the last quarter century, intensive research activities in forestry and

forestry-related disciplines such as soil science, tree physiology, and biochemistry have formed a basis for forest tree nutrition as an area of study in many schools and experiment stations in Europe, Canada, and the United States. Thus there is a considerable body of literature on both basic and applied aspects of forest fertilization, published worldwide.

Knowledge accumulated in recent years made possible four symposia, three international and one regional in scope, plus a workshop held recently in Canada. Two international symposia were held in 1967, one at the University of Florida; the second, organized by the International Potash Institute, was held in Finland. The third symposium, sponsored by FAO/IUFRO, was held in Paris, France, in 1973.

In recent years forest fertilization received considerable attention in northern forest types. The current knowledge on activities taking place in the northeastern United States and Eastern Canada were discussed at the symposium held in Warrensburg, N. Y. (Northeastern Forest Experiment Station 1973); at the Fourth North American Forest Soil Conference held in Quebec, Canada (Armson et al. 1975); and at the recently held workshop in Ontario (Environment Canada 1974).

In addition to the most recent research findings, the participants presented a digest of existing literature. If it were not for these proceedings, the researcher would be forever looking to article sources or collecting scattered papers of diverse research published in many journals and languages.

EFFECTS OF WHOLE-TREE HARVESTING

The changes in the management practices from uneven-age to even-age silviculture is a common occurrence. In certain instances this involves complete stand removal. Previously unusable species, sizes, and qualities are now marketable. Significant acreage of spruce-fir forest is being salvaged to minimize the losses caused by spruce budworm.

Changes of this kind, which result in more biomass removed from the forest, are causing concern about depletion of soil nutrients and possible site degradation. We are very short of detailed information on this subject for New England conditions, but some valuable data are available from other regions, and an attempt to obtain additional information is in progress.

The effects of wood harvesting on the nutrient status of spruce-pulpwood stands in Quebec were discussed by Weetman and Webber (1972). They concluded that "it is unlikely that the full tree logging will result in any reduction in growth, due to nutrients removed, during the second rotation of trees. However, there is a possibility full-tree harvesting on sites of marginal fertility and low in organic matter may eventually require an addition of Ca, K, and N."

Recently, changes in nutrient status were assessed on spruce-fir sites harvested by strip-clearcutting in which slash was left in place, removed, or burned. Eight years after harvest, the clearcut areas showed an increase in both pH and percent base saturation, but concentrations of N and P were comparable to those found in the residual forest. There was no evidence of site degradation from strip-clearcutting (Czapowskyj et al. 1976).

Young and Guinn (1966), and Young and Carpenter (1967), in the context of complete-tree utilization concept, provided data on chemical elements in the wood, bark, and leaves of the major species of different ages. The data provide a basis for calculating nutrient budget and estimating nutrient losses due to timber harvesting in Maine.

NUTRIENT AVAILABILITY AND DEFICIENCY

Forest fertilization is a supplement of essential nutrient elements that are lacking in a soil or are not available in adequate quantities for optimum tree growth. Thus a knowledge of soil fertility, the establishing of tree needs, and the identification of deficient elements are essential to a meaningful fertlization program.

Nutrient deficiencies have been observed in coniferous plantations established nearly 50 years ago on abandoned agricultural land in the State of New York (Heiberg and Leaf 1960). Diagnostic techniques of determining soil-nutrient deficiences--mainly K--were studied; and the responses to fertilization were documented (Heiberg and White 1949 and 1951). The pioneer work by Mitchell and Chandler (1939) clearly identified lack of available N as a critical factor in the growth of many hardwood species on many sites in the United States Northeast.

Foliar analysis seems to provide a valuable tool for diagnosing nutrient deficiencies and relationships in tree-growth parameters. However, it does not tell enough about the soil fertility.

Valuable information on foliar nutrient contents for major species growing in Maine was provided by Young and Guinn (1966). Swan (1966 and 1971) provided basic information for evaulating the results of foliar analysis and suggested critical levels of deficiency, sufficiency, and luxury consumption for major Canadian species.

Schomaker (1973a) studied foliar nutrient concentrations of fertilized mature red spruce (Picea rubens Sarg.) in Maine and compared his data with those reported by Young and Guinn, and with the critical levels suggested by Swan. From these comparisons, Schomaker concluded that the foliar N levels of red spruce stands growing in Maine were within the deficiency range, whereas P, K, Ca, and Mg were sufficient for good growth; and some of them were even approaching the luxury-consumption levels.

Assuming that Swan's critical values could be extrapolated to New England conditions and to all age classes, one might expect a marked response by red spruce to N applications. However in assigning the critical values based on foliar analysis alone for any element and for any of the species, extreme care must be taken. Time and method of sampling are of great importance. Nutrient levels in the foliage vary with the season. In red spruce, for example, nutrient levels vary among different soils and locations within the same soil series (Safford and Young 1968), as well as with the location of the foliage in the crown (Young et al. 1967), and with the foliage age (Safford 1970).

Hoyle and Mader (1964) reported that different growth parameters related differently to tree nutrition. Height growth correlated better with Ca levels, and basal-area growth with K; and the volume growth was related to available soil moisture.

RESPONSE TO FERTILIZATION

Northern Hardwoods

In their summary paper on fertilizing eastern hardwood species, Auchmoody and Filip (1973) emphasized

the following points:

1. Some hardwood species have potential for greater response to improved fertility.

2. N is the primary growth-limiting element on many sites, but response to P and other elements can be expected on some sites when used with N.

3. Response to N is rapid and easily observed in sums of tree growth and foliage color and size, but duration of response is not yet known.

Since the Auchmoody-Filip paper, some additional studies have been reported.

Bjorkbom (1973) tested the effects of N, P, and K on the growth of paper birch (Betula papyrifera Marsh.) in sand culture and found that seedling growth improved with increasing supply of N. Three to 4 percent N in the foliage seems to be adequate for seedling growth. There was no response to P and K applications. But response by yellow birch (Betula alleghaniensis Britton) to P had been demonstrated in a pot-culture experiment with a Vermont soil (Hannah 1973). This confirms earlier work by Hoyle (1965, 1969, 1970, 1971) in New Hampshire.

Field trials of lime plus N-P-K to a 90-year-old stand resulted in increased biomass of fine absorbing roots throughout a podzol soil profile (Safford 1974). Nutrient content of these roots was elevated above those of the control, providing a source of enrichment to the deeper soil horizons as a result of surface application of fertilizers. Diameter growth of these mature trees was also substantially increased: sugar maple (Acer saccharum Marsh.) 158 percent greater than control, paper birch 69 percent, yellow birch 51 percent and beech (Fagus grandifolia Ehrh.) 20 percent (Safford 1973b).

An application of N-P-K fertilizer plus lime to the soil after clearcutting and site scarification increased biomass after 4 years by 300 percent over the control. Unfortunately pin cherry (Prunus pensylvanica) responded so strongly that the growth of birch and other desired species was hindered (Safford and Filip 1974). On another site that was heavily scarified and deep-limed, planted yellow and paper birch responded dramatically to control of competition and N-P-K

fertilizer. Fertilized and released yellow birch were 20 percent taller and 120 percent greater in basal area; paper birch were 50 percent taller and over 400 percent greater in basal area than the control or trees released only (Hoyle 1975).

Not all hardwood plantations have shown positive response to fertilizers. In southern Ontario, von Althen (1973) reported little or no response to added nutrients by hardwood seedlings. This lack of response is probably due to having fertile planting sites and good site preparation. Von Althen (1973) concluded that "if hardwood planting is restricted to good planting sites with deep, moist, but well-drained soils, there is little need for fertilization... However...hardwoods are often planted on sites that do not meet the foregoing criteria. Fertilization may be necessary on these marginal sites."

Stone and Christenson (1974) reported no diameter-growth response to N, P, or K treatments in factorial combinations in a pole stand of sugar maple in Michigan. Release increased growth over controls by about 80 percent. Foliar N of controls was close to satisfactory levels (2 percent) given by Mitchell and Chandler (1939) and Mader et al. (1969). Concentration of nutrients in foliage of released trees decreased despite the growth response. Stone and Christenson attributed this decrease to a dilution effect and suggest that some site factor other than nutrition might be limiting growth in this Michigan stand (Stone and Christenson 1975).

A combination thinning-and-fertilizer study with 25-year-old paper birch in Maine also showed greatest growth response to thinning, 100 percent over controls; but fertilizer treatments stimulated growth by an additional 30 percent. Foliage nutrient levels in released-only trees increased over controls; and each element--N, P, K, and Ca·Mg (in lime)--whenever added, increased nutrient levels above that of released-only trees (Safford, L.O.: unpublished data on file at U.S. Forest Service Forestry Sciences Laboratory, Durham, N.H.).

These conflicting results point to a need for caution when extrapolating data from one location or species to another. They also suggest that standardized research methods and analysis would benefit evaluation of results of fertilizer studies.

Conifers

Forest fertilization activities in coniferous forests of the eastern United States have been summarized by Safford (1973a), and in eastern Canada by Krause (1973). However, the most relevant facts will also be repeated briefly in this section.

Long- and short-term studies have been conducted in the Adirondack mountains in New York State. The summary of results have been given by Heiberg et al. (1959 and 1964) and Leaf et al. (1970 and 1975). Information has been used to improve productivity of soil deficient in K through application of potash to red pine (Pinus resinosa Ait.) plantations.

I do full justice to the researchers of SUNY for their manifold contributions to red pine and potash fertilization relationships in this brief review. Those interested in specifics are referred to the more detailed accounts: (Fornes et al. 1970; Kawana et al. 1969; Madgwick et al. 1970; White 1954 and 1956; Wittwer et al. 1975).

Information on white pine (Pinus strobus L.) is limited. Studies conducted in Pack Forest, New York, showed a response of a young plantation on a coarse sandy glacial outwash soil to the addition of logging slash, K, and complete fertilizer. The responses were immediate and lasting. No response to N was observed (Heiberg and Leaf 1960). The growth response of white pine plantations on coarse-textured droughty soil in Maine to N (urea), K, and N-P-K, were studied by Stratton and others (1968). The response in terms of basal-area growth were similar to those obtained on the Pack Forest. The stand responded to K and N-P-K application, but not to N alone. On the other hand, Schomaker (1973a) reported that the 10-year radial growth of a medium-aged white pine stand in southern Maine correlated positively to foliar N and negatively to P. Correlations between foliar K and diameter growth were weak.

Spruce-Fir

An extensive research program is under way in the northeastern United States and eastern Canada. Forest industries in Maine in cooperation with the School of Forest Resources, University of Maine, are currently conducting a series of field studies.

Experimental plots in nearly-mature spruce-fir stands were fertilized with 10-10-10, equivalent to 150 pounds per acre (168 kg/ha), each of N, K_2O, and P_2O_5 singly and in combination, and urea equivalent to 150 pounds per acre of elemental N. The preliminary results indicated that, after three growing seasons, only one stand responded significantly in basal-area growth. Increased growth was due to N-P-K treatments and due to N alone in urea form (Schomaker et al. 1973). The follow-up remeasurements will yield additional information in respect to response duration and the explanation as to why two other stands did not respond.

Our Northeastern Forest Experiment Station Unit in Orono, in cooperation with Georgia-Pacific, has recently established a study to determine how a young stand with pioneer northern hardwoods in the overstory, and a spruce-fir understory, will respond to thinning plus lime and fertilizer treatments. The question asked is if the hardwoods will respond so that a merchantable product can be harvested at a shortened rotation and if the spruce-fir in the understory will benefit from lime, N, and P fertilization.

In another study, the effects of site preparation, lime, and N-P-K, fertilizer treatments and control of competition on growth of black and white spruce (Picea mariana [Mill.] B.S.P. and Picea glauca [Moench] Voss) planted on a chip-harvester clearcut are presently being tested.

In the early 1960s an extensive research program had been initiated in the Maritime Provinces and in Quebec. Numerous tests and long-term studies had been established by the Pulp and Paper Institute of Canada, Canadian Forestry Service, provincial governments, and universities. It was soon recognized that N was deficient in the vast areas of northern coniferous boreal forests (Weetman 1962) and that northern coniferous forests will respond to N applications.

Available reports (Weetman 1968, 1971, 1975; Weetman et al. 1974) revealed strong responses of black spruce to N fertilization. The responses were manifested in height, diameter, and volume growth.

Stand thinning and fertilization relationships were demonstrated. a 65-year-old stand was thinned by 25 and 50 percent and fertilized with urea at the rates of 100 and 400 pounds per acre (112 and 448 kg/ha).

The stand responded to the N treatment after 1 year and to thinning only after 7 years. The basal-area growth was not increased by 25-percent thinning, but was increased by 50-percent thinning; however, it always was increased by the addition of N. The 10-year growth increases over control were: 130 to 290 ft^3 (9.1 to 20.3 m^3) for 100 pounds (112 kg) N and 238 to 297 ft^3 (16.6 to 20.8 m^3) for 400 pounds (448 kg) of N per acre (hectare).

Preliminary results from fertilization data obtained in New Brunswick (Krause 1973) are encouraging. Krause stated "that N shortage is commonly limiting growth in pole-size and maturing conifer stands and that substantial growth increases can be obtained with addition of fertilizer N. Under certain site conditions, tree growth may also be improved by the addition of K and P".

The growth response of a 35-year-old white spruce plantation due to K treatments was reported from Quebec. Applications of 84 lbs/acre (94 kg/ha) K alone or in combination with 102 lbs/acre (114 kg/ha) N produced during a period of 10 years 4.0 and 3.8 cunits (11.3 and 10.8 m^3) respectively of extra wood (Gagnon et al. 1976). Response was due to K only. On the other hand, Timmer (1976) reports that in Nova Scotia neither young balsam fir (Abies balsamea (L.) Mill.) fertilized with 400 lbs/acre (448 kg/ha) of urea N, or semimature white spruce stands fertilized with 100 and 200 pounds of urea N per acre (112 and 224 kg/ha), resulted in increased basal-area increment 5 years after fertilization.

A recent unpublished report on a Canadian Interprovincial Forest Fertilization Program (Weetman et al. 1976) provides an analysis of 5-year growth responses of major coniferous species in eastern Canada. It was evident that the responses of the spruce-fir stands to N fertilization were significant, but maximum gains were obtained from combined high N and P or high N and K, or high N and PK treatments. The effects of P and K were less important. White spruce stands in New Brunswick that were also affected by spruce budworm either did not respond to fertilizer treatments, or the results were inconclusive.

The growth responses of jack pine (Pinus banksiana Lamb.) to fertilization were observed in a few instances in Canada. The young stands growing in well-drained soils were fertilized with N (urea) and super-

phosphate. The treatments increased the needle weight of the foliage, but not height growth (Calvert and Armson 1975). The authors concluded that fertilization of young jack pine growing under conditions as in the study is not necessary.

In another study a 40-year-old stand responded to N fertilization, and the ammonium nitrate was found to be superior to the urea form of N. The growth responses were associated with increased needle weights and increased foliar N concentration (Weetman and Algar 1974).

FOREST FERTILIZATION IN PRACTICE

In Maine, a spruce-fir forest was limed and fertilized at several locations with the objective of demonstrating increased growth due to fertilization. One such demonstration area was established at the Penobscot Experiment Station in 1970. Lime was applied at the rate of 2 tons per acre (4.5 metric tons/ha), and fertilizer, N-P-K 15-15-15, at the rate of 120 pounds per acre (134 kg/ha). Fertilizer was applied on both limed and unlimed plots. Band dendrometers were installed and periodic observations have been made. At the present time the data are being analyzed.

Maine forest industries are conducting some fertilization experiments on their own.

Scott Paper Company has fertilized in 1967 about 300 acres (121 hectares) of mature and regenerated spruce-fir stands. Ammonium nitrate at rates of 100, 150, and 200 pounds of N per acre (112, 168, and 224 kg/ha) was applied. Preliminary data showed that overall the stands responded positively to fertilization. Balsam fir responded better than spruce. However there was no consistency as to the rates of fertilizer applied. In certain instances the volume growth of spruce actually decreased.

Great Northern Paper Company fertilized experimentally clearcut areas and second growth spruce-fir stands in 1968. On the clearcut areas 0.75 tons/acre (1.68 metric tons/ha) of lime and 600 pounds per acre (673 kg/ha) of 10-10-10 N-P-K was applied. Seven years later the area was heavily overgrown with raspberries with a few stems of softwood or hardwoods remaining. In mature spruce-fir stands urea or N-P-K (10-10-10) was applied at the rates 100, 150, and 200 pounds per acre (112, 168, 224 kg/ha) of each element. Seven years later responses were observed as increased height

growth and dbh, but there was no certainty that the fertilized plots showed superior growth or that the control plots exhibited marginal growth.

The Dead River Company has fertilized over 300 acres (121 hectares) of mature and second growth stands of spruce-fir, hemlock (Tsuga canadensis (L.) Carr.), mixed softwood and hardwood stands. The rates varied from 50 to 150 pounds of N urea per acre (56 to 168 kg/ha). Preliminary measurements indicate trends of increased growth. Another study involves ground application of NP and some minor elements in various combinations.

The Oxford Paper Company is also experimenting with lime and N-P-K fertilization. Data are being collected and evaluation will be made.

Georgia-Pacific has fertilized small plots of Norway spruce (Picea abies (L.) Karst.) and Japanese larch (Larix leptolepis) plantations. Ammonium nitrate at the rate of 400 pounds per acre (448 kg/ha) was applied in 1971. Preliminary observations indicate an increase in height growth. The company is also experimenting with applications of lime. In 1975 lime at a rate of 2 tons per acre (4.5 metric tons/ha), was experimentally applied to about 60 acres (24 hectares) of pioneer northern hardwoods and softwood stands.

ONGOING RESEARCH

To assess the course of ongoing forest-fertilization research in northern forests, a questionnaire was mailed to the researchers engaged in this in the New England States and the Maritime Provinces. From the response to the questionnaire, it is estimated that at present there are approximately 70 studies about equally divided between the northeastern United States and eastern Canada. The species studied and their frequencies are given in table 1.

Conifers are the prime subject of investigation in Canada, whereas the hardwoods get most attention in New England. The objectives of the studies in descending order are: tree growth increase, stand establishment, and seed and sap production.

Table 1.--Frequency of ongoing fertilization research in northern forest

Species	Northeastern U.S.	Eastern Canada	Total
	CONIFERS		
1. Red spruce	4	8	12
2. Black spruce	1	9	10
3. White spruce	3	7	10
4. Balsam fir	3	7	10
5. Jack pine	-	5	5
6. Red pine	2	-	2
7. Eastern hemlock	1	-	1
Total	12	36	48
	HARDWOODS		
1. Sugar maple	9	3	12
2. Yellow birch	4	-	4
3. Paper birch	3	-	3
4. Red maple	3	-	3
5. White ash	3	-	3
6. Black cherry	3	-	3
7. American beech	2	-	2
8. Pin cherry	1	-	1
9. Hybrid poplar	1	-	1
Total	29	3	32

The application of N in the form of urea and ammonium nitrate at rates from 50 to 400 pounds per acre (56 to 448 kg/ha) of elemental N are used. The application of P in the form of superphosphates range from 25 to 200 pounds per acre (28 to 224 kg/ha) of elemental P. K is used less frequently, and lime the least.

A few studies included micronutrients. In one instance the effects of the municipal sewage sludge are being investigated. There are no indications of use of legumes.

COMMENTS

After discussing the established facts of soil nutrient deficiencies, citing examples of responses obtained from fertilization, and summarizing the research in progress, I have to say something about future research needs.

- The importance of forest health cannot be overrated. Thus research is needed on the health of fertilized forests, including population dynamics of insects and the changes occurring in pathogenic organisms.

- There is an increased awareness of disposal of municipal sewage sludge and farm manure. The possibilities of disposing of it on the forest warrants consideration.

- Site preparation and fertilization of extremely marginal forest areas, including the mechanical drainage of swamps and bogs, should be studied and evaluated.

- Introduction of nitrogen-fixing legumes and microorganisms, as an alternative for mineral fertilizer applications, would reduce the cost and energy needed in processing and applying fertilizers. This subject deserves adequate attention.

- Possibilities of using the coated slow-releasing fertilizers should be explored.

- Improved techniques of soil and foliar analyses and the calibration of results for estimating site productivity and fertilizer needs are desired.

- Future research on soil productivity, natural fertility, or stand responses to ameliorants and fertilizers should be correlated with a kind of soil series or soil association.

If the physiologically healthy forest is to be grown, cultured, protected, and harvested, the land manager has to be aware of the potentials offered by intensive silviculture, including fertilization for a

given site and conditions. At present information is still inadequate. Research is needed to produce answers.

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SITE CLASSIFICATION FOR NORTHERN FOREST SPECIES

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Abstract

Summarizes the extensive literature for northern forest species covering site index curves, site index species comparisons, growth intercepts, soil-site studies, plant indicators, physiographic site classifications, and soil survey studies. The advantages and disadvantages of each are discussed, and suggestions are made for future research using each of these methods. Suggests a complementary framework that coordinates site quality, yield, and forest land classification. Discusses how this complementary framework can help in practicing more intensive timber management.

THE QUANTITY AND QUALITY of timber yield closely depends upon forest site quality. Accordingly, one of the first steps for intensively managing forest land is to determine the site quality of land for various trees so that the most productive and valuable tree can be selected for each parcel of land. Armed with site and yield information, a forest manager can estimate future wood supplies, and thus can make realistic decisions about future costs and benefits of intensive forest management, land acquisition, and industrial investments.

Estimating site quality for forest land has been a primary concern of American foresters since the early days of our profession. An extensive volume of literature has accumulated regarding methods for estimating site quality in the United States (Carmean 1975). Likewise Canadian foresters have long been concerned with site quality estimation and with methods of forest land classification and mapping (Rennie 1962, Rowe 1962, 1971, Burger 1972).

I have three goals for this paper. First, I will give an inventory of the American and Canadian site quality research already accomplished for northern forest species. Second, I will try to show how these accomplishments can be joined into a complementary framework for site quality estimation, yield prediction, and forest land classification. And third, I hope to show how this complimentary framework can guide us in making decisions about where, what, and how intensively we should manage timberlands in the future.

INVENTORY OF SITE QUALITY RESEARCH

Site Index Curves

Site index based on height growth is the most widely accepted method for estimating site quality in the United States (Carmean 1975). Height and age measurements from free-growing, uninjured, dominant, or dominant and codominant trees are used with a family of height-age (site index) curves to estimate total tree height at a specified index age. For most northern species 50 years is the index age. The site index method is accurate and simple to use when (1) suitable trees are available for measuring site index, and (2) when accurate site index curves are available.

Many site index curves have been constructed for northern forest species, but most of these curves are for conifers (table 1) and relatively few are for valued hardwood species (table 2) such as yellow-birch, black cherry, and white ash. Most of the site index curves now in use are older, "harmonized" curves that accompanied regionwide normal yield tables. These harmonized curves are not based on actual tree height growth studies, but on dominant and codominant tree height and age measured from growth and yield plots scattered throughout a particular forest region. An average height-age curve is calculated and this curve is used to construct a family of proportional site index curves all having the same shape or pattern of height growth. Thus harmonized curves are based on the assumption that the pattern of tree height growth is the same for all site classes, localities, and soil conditions included in a regional yield study. We now know that this assumption is not valid and that height growth patterns may vary greatly (are polymorphic) for many species that grow on contrasting sites, or that have a wide geographic distribution (Carmean 1970, 1975).

For intensive timber management we need site index curves that are more accurate than harmonized curves. Stem analysis is the method most favored for developing more accurate site curves, and we need such curves for all important northern forest species. Because height growth patterns may vary from area to area we may have to construct separate site curves to fit certain localities, or certain soils and climates. For example, stem analysis data (Hegar and Lowry 1971) indicate that Plonski's (1960) harmonized curves are applicable to black spruce (see Appendix list of common and scientific names) in Ontario and Quebec. However, black spruce in the maritime climate of eastern Canada has much different height growth patterns than in continental areas (Page and van Nostrand 1971), thus separate curves may be needed for the maritime areas. In contrast, northern hardwoods in the White Mountains of New Hampshire (Solomon 1968) have height-growth patterns similar to hardwoods in Vermont's Green Mountains (Curtis and Post 1962a), thus the site curves prepared for Vermont northern hardwoods should be usable in New Hampshire.

Table 1.--SITE INDEX CURVES FOR NORTHERN CONIFER FOREST SPECIES

Species	Area	Reference
Jack, red, and white pines	Lake States	Brown and Gevorkiantz (1934)
Jack pine	Lake States	Sterrett (1920), Wackerman et al. (1929), Eyre and LeBarron (1944), Gevorkiantz (1956a)
Jack pine	Saskatchewan	Kabzems and Kirby (1956), Jameson (1963)
Jack, red, white pines; black spruce	N. Ontario	Plonski (1960), Payandeh (1974a)
Red pine	N. Minnesota	Eyre and Zehngraff (1948)
Red pine	Lake States	Gevorkiantz (1957e)
Red pine	Central New England	Reed (1926)
Red pine	Connecticut	Bull (1931)
Red pine	Northeast and Lake States	Spurr (1956)
Red pine	Quebec	Phu (1974)
Red pine	Ontario	Stiell and Berry (1973b)
Red pine	Pennsylvania	Kinsley and Bartoo (1967)
Red pine	Illinois	Gilmore (1967)
Red and white pines	S.E. Ohio and S. Indiana	Gaiser and Merz (1953)
Red and white pines	S.E. Ontario	Ardenne (1950)
Red and white pines	Quebec and Ontario	McCormack (1956), Horton and Bedell (1960)
Red, white, and Scotch pines	Vermont	Hannah (1971)
White pine	N. England and Mid-Atlantic States	Frothingham (1914)
White pine	New England	Leak et al. (1970)
White pine	New Hampshire	Husch (1954)
White pine	New Hampshire	Barrett and Goldsmith (1973)
White pine	Wisconsin	Gevorkiantz and Zon (1930)
White pine	Lake States	Gevorkiantz (1957d)
White pine	S. Appalachians	Barrett (1934), Vimmerstedt (1959, 1962), Doolittle and Vimmerstedt (1960), Beck (1971b, 1971c)
White pine	Illinois	Gilmore (1968)
Spruces and balsam fir	Northeast	Meyer (1929)
Spruces and balsam fir	Maine	Mount and Gore (1952)
Spruces and balsam fir	Newfoundland	Van Nostrand (1964), Page (1968)
Spruces and balsam fir	Quebec	Linteau (1955)
Spruces and balsam fir	Ontario	Payandeh (1974b)
Spruces and balsam fir	Saskatchewan	Payandeh (1974c)
Spruces and balsam fir	N. Michigan	Bowman (1941)
White and black spruces	Central and E. Canada	Heger (1968, 1969, 1971) Heger and Lowry (1971) Page and Van Nostrand (1971)
White spruce	Ontario	Stiell and Berry (1967, 1973a)
White spruce	Saskatchewan	Kabzems (1971)
White spruce	Lake States	Gevorkiantz (1957c), Ek (1976)
Red spruce	Maine	McLintock and Bickford (1957)
Black spruce	Minnesota	Fox and Kruse (1939), LeBarron (1948)
Black spruce	Lake States	Gevorkiantz (1957b)
Black spruce	Alberta	Horton and Lees (1961)
Black spruce	Saskatchewan	Kabzems (1953)
Black spruce	Manitoba and Saskatchewan	Jameson (1964)
Black spruce	Ontario and Quebec	Bedell et al. (1955), MacLean and Bedell (1955)
Balsam fir	Lake States	Gevorkiantz (1956c)
Jack, red, and white pines; white and black spruces; balsam fir; tamarack; white-cedar	Lake States	Lundgren and Dolid (1970)
White-cedar	Lake States	Gevorkiantz (1957a)
Tamarack	Lake States	Gevorkiantz (1957f)
Hemlock	New York, Michigan, S. Appalachians	Monserud and Ek (1976)

Table 2.--Site index curves for northern hardwood forest species

Species	Area	Reference
Sugar maple, yellow birch, white ash, paper birch	Vermont, New Hampshire	Curtis and Post (1962a), Solomon (1968)
Sugar maple, white ash	Vermont	Farrington and Howard (1958)
Sugar maple	Vermont	Hawes and Chandler (1914)
Sugar maple	New York	Farnsworth and Leaf (1963)
Sugar maple	N. Lower Michigan	Shetron (1972b)
Red maple	Connecticut and Massachusetts	Hampf (1965)
Beech	Northeast	Hampf (1965)
Sugar maple, yellow birch, beech, elm, basswood	Lake States	Monserud and Ek (1976)
Black cherry	New York	Hampf (1965)
Black cherry	N.W. Pennsylvania	Ward et al. (1965)
Paper birch	N. Wisconsin	Cooley (1958, 1962)
Q. Aspen and paper birch	Lake States	Lundgren and Dolid (1970)
Aspens	Lake States	Kittredge and Gevorkiantz (1929), Brown and Gevorkiantz (1934), Gevorkiantz (1956b)
Aspens	Lower Michigan	Graham et al. (1963), Zahner and Crawford (1965)
Aspens	N. Cent. Minnesota	Schlaegel (1971)
Aspens	Saskatchewan	Kirby et al. (1957)
Aspens	Alberta	Horton and Lees (1961)
Aspens	Newfoundland	Page (1972)
Aspen, paper birch, tolerent hardwoods	N. Ontario	Plonski (1960), Payandeh (1974a)
Q. aspen, paper birch	Alaska	Gregory and Haack (1965)
Quaking aspen	Rocky Mountains	Jones (1966, 1967), Jones and Trujillo (1975)

Site Index Comparisons Between Species

More intensive timber management requires the ability to select the most desirable tree species for each parcel of land. Should we, for example, choose from among several species of pine, or should we manage aspen on short rotations? On other areas should we consider favoring certain hardwood species for veneer and high value saw log production? Stands rarely have measurable trees of all species for which we need site index comparisons. But even when a stand does not contain the tree species for which site index estimates are desired, we can still estimate site index using the tree species actually present. Species comparison graphs can be used to convert site index of the species present to site index of the desired species. Unfortunately, only six site index comparison studies are available for northern forest species (table 3).

Table 3.--Site index comparisons for northern forest species

Species	Area	Reference
White pine; eastern hardwoods; shortleaf, pitch, and Virginia pines	S. Appalachian Mts.	Doolittle (1958)
White pine and red maple	N. Connecticut, W. Massachusetts, E. New York	Foster (1959)
Northern hardwoods	Vermont	Curtis and Post (1962b)
Northern conifers and hardwoods	N. Minnesota	Carmean and Vasilevsky (1971)
Red, jack, and white pine	Upper Michigan	Shetron (1975)
Red pine and quaking aspen	N. Minnesota	Alban[a/]

[a/] Alban, D. H. 1976. U. S. Forest Service, North Cent. For. Exp. Stn. (unpublished manuscript).

Site index comparison graphs are most useful in areas having great ranges in soil and site, and where the forest manager has the problem of selecting the most desirable tree from among many alternative species. However, when selecting the most desirable tree species we should keep in mind that site index comparisons are merely that--comparisons of tree height at index age--and they are only the necessary first step in choosing the most desirable species for a particular site. We should also consider tree height growth before and after index age. And we should also compare both volume and value of wood produced in addition to comparing site index.

Growth Intercept

The growth intercept method uses a period of early height growth rather than long-term height growth as an index of site quality. The method was developed for conifers having distinct internodes marking annual height growth; usually the total length of the first 5 internodes above breast height is used an an index of site. Several growth intercept studies have been published for red and white pine (table 4). This method is particularly useful for areas where trees are too young for the usual 50-year site index curves. However, the method has the disadvantage of basing site quality estimation only on early height growth, and this may not be a very good indication of height growth in later years.

We need additional growth intercept studies for red and white pines in areas where existing studies may not apply. Futhermore, the method also might be applicable to jack pine, spruce, and larch, or even to hardwoods such as ash and maple. Internodes are not as distinct on these species, nevertheless, internodes still can be observed when trees are relatively young.

Table 4.--Growth intercept studies for estimating site quality of red and white pines

Species	Area	Reference
Red pine	New York	Ferree et al. (1958), Richards et al. (1962)
Red pine	Michigan and S. Ontario	Day et al. (1960), Schallau and Miller (1966), Gunter (1968)
Red pine	Wisconsin	Wilde (1964, 1965)
Red pine	N. Minnesota	Alban (1972a)
White pine	S. Appalachian Mts.	Beck (1971a)

Soil-Site Evaluation

The soil-site method has received more emphasis in the United States than other methods of indirectly estimating site quality (Carmean 1975), and many studies have been published for northern forest species in the United States and Canada (tables 5 and 6). This method is particularly useful for areas that vary greatly in soil and site, and where forest stands are usually not suited for direct measurements of site index, for example in unevenaged, poorly stocked, too young, or heavily cut stands.

The soil-site method relates soil, topography, and climate in a forest area to site index. Studies are made using many plots representing the range of site quality, soil, topography, and climate found within the area. Site index is estimated from the trees on each plot, and then multiple regression methods are used to relate site index to the associated soil, topographic, and climatic features. The resulting multiple regression equations are used to calculate tables and graphs for estimating site index in the field. Field foresters can easily measure the needed features which may include surface soil depth, texture, stone content, aspect, slope position, and slope steepness. The features found to be important in soil-site studies may differ depending on tree species, soil, topography, and climate of the area. So results are valid only for the particular study area, and for the soil and topographic conditions sampled within the study area. Except for the listed studies (tables 5 and 6) large gaps exist in our knowledge about soil-site relations of many northern forest species.

Plant Indicators

Understory vegetation has long been used for classifying forest site quality in northern Europe using methods first developed by Cajander (1926) in Finland. The method received considerable support in the early days of American forestry, and in Canada an active

program of site classification developed following a visit by Ilvessalo (1929). Most plant indicator research for northern forest species has been done by Canadians (table 7) and several articles review its philosophy and methodology (Holman 1929, Kabzems 1951, Linteau 1953, Long 1953, Rowe 1956, Jurdant 1969, Jurdant et al. 1975, Burger 1972).

Table 5.--Soil-site studies for northern conifer forest species

Species	Area	Reference
Red pine	Connecticut	Haig (1929), Hicock et al. (1931)
Red pine	New York	Stone et al. (1954, 1958, 1962), Richards et al. (1962), Richards and Stone (1964), Dement and Stone (1968)
Red pine	Massachusetts	Mader and Owen (1961), Mader (1968)
Red pine	Lower Michigan	Van Eck and Whiteside (1958, 1963), Hannah (1969)
Red pine	S.E. Minnesota	Scott and Duncan (1958)
Red pine	N. Minnesota	Alban (1972b, 1974)[a/]
Red pine	Quebec	Popovich (1975)
Red and jack pines	Lower Michigan	Hannah and Zahner (1970)
Red, jack, white pines; white and Norway spruce	Wisconsin	Wilde et al. (1951, 1964a, b, c, d, 1965), Wilde, Maeglin and Tanzer (1966), Wilde, Paul and Mikola (1951), Wilde, Tanzer and Trautmann (1963), Wilde (1970)
Red and white pines	S.E. Ohio, S. Indiana	Gaiser and Merz (1953)
Jack pine	N. Minnesota	Pawluk and Arneman (1961), Frissell and Hansen (1963)
Jack pine	N. Ontario	Chrosciewicz (1963)
White pine	Maine	Czapowskyj and Struchtemeyer (1958), Stratton and Struchtemeyer (1958)
White pine	S.E. New Hampshire	Husch and Lyford (1956)
White pine	New Hampshire	Barrett and Goldsmith (1973)
White pine	Massachusetts	Mount (1976)
White pine, spruces	Maine	Young et al. (1950), Young (1954), Mader et al. (1952)
White, red, Scotch pines	Vermont	Hannah (1971)
Northern conifers and hwds.	N. Minnesota	Bakuzis et al. (1962)
Northern conifers and hwds.	Quebec and Ontario	Bedell and MacLean (1952), MacLean and Bedell (1955)
Northern conifers and hwds.	Manitoba	Halliday (1935)
Black spruce	N. Minnesota	Heinselman (1963), Watt and Heinselman (1965)
Black spruce	Newfoundland to W. Ontario	Lowry (1964, 1970, 1975)
White spruce	Cent. Alberta	Duffy (1965)
Red and white spruce	Maine	Hoar and Young (1965)
Japanese and European larches	S. New York	Aird and Stone (1955)

[a/] Also Alban, D. H. 1976. U.S. Forest Serv., North Cent. Forest Exp. Stn., (unpublished manuscript).

Table 6.--Soil-site studies for northern hardwood forest species

Species	Area	Reference
Sugar maple	Vermont	Post (1968), Post and Curtis (1970)
Sugar maple	N. Michigan	Westveld (1933)
Sugar maple	Pennsylvania	Nuss and Borden (1968)
White ash	N.W. Pennsylvania	Lewis and Ward (1967)
Black cherry	N.W. Pennsylvania	Davis and Ward (1966)
Yellow and paper birches	New England and Lake States	Post et al. (1969)
Paper birch	N. Wisconsin	Cooley (1962)
Quaking aspen	Minnesota and Wisconsin	Kittredge (1938), Stoeckeler (1948, 1960), Fralish and Loucks (1967)
Quaking aspen	N. Minnesota	Meyer (1956), Voigt et al. (1957) Strothmann (1960)
Quaking aspen	Cent. Wisconsin	Wilde and Pronin (1949, 1950)
Bigtooth aspen	Lower Michigan	Graham and Harrison (1955), Hannah and Zahner (1970)

In Canada plant indicators are mainly used to describe natural "ground vegetation types." As part of a broad land classification system, these types include forests believed to have similar trends in productivity, regeneration, and succession. For this reason these vegetation types might be managed using similar silvicultural practices. This system is useful for stratifying variable forest areas, but in most cases there is little factual evidence about how closely these vegetation types describe forest site quality.

The plant indicator method has been widely used in undisturbed northern coniferous forests because they usually have relatively few understory plant species, and plant communities are usually distinct and easily recognized. But our more southerly forests have often been repeatedly disturbed, and the numerous understory species usually occur as a continuum rather than discrete communities. Nevertheless, plant indicators can supplement other methods of site estimation and forest land classification, despite the complexities and shortcomings of the method.

Physiographic Site Classification

Forest land classification programs in Canada have been in progress for many years (Lacate 1966, Burger 1972) and were initially based on the understory vegetation methods of Cajander. Following World War II, aerial photographs became an important tool in "forest site" mapping (Losee 1942a, 1942b, Hills 1950, Burger 1957, Jurdant 1964b). As a result landforms have become prominent in forest land classification because they are easily identified on aerial photos. The most widely used method of physiographic site classification was developed in Ontario (Hills 1952,

1953, 1954, 1958, 1960, 1961, Hills and Pierpoint 1960, Pierpoint 1962, Brown 1953, Farrar 1960). Using this method Ontario was subdivided hierarchically into site regions, landscapes, land types, and sites. Variations of this method also have been used in other Canadian provinces where northern forest species occur (Wilde, Voigt, and Pierce 1959, Bedell and MacLean 1952, Bedell, Brown, and MacLean 1953, Bedell, MacLean, and Brown 1955, MacLean and Bedell 1955, Duffy 1965, Duffy and Nemeth 1967, Knight and Duffy 1967, Loucks 1962).

Table 7.--Plant indicator studies for estimating site quality of northern forest species

Species	Area	Reference
Jack pine	Saskatchewan	Kabzems and Kirby (1956)
Jack and red pine	Manitoba	Ritchie (1961)
Jack pine and black spruce	Manitoba	Mueller-Dombois (1964, 1965)
White pine	New Hampshire	Hazard (1937), Stanley (1938)
White pine	Wisconsin	Gevorkiantz and Zon (1930)
White pine	Great Lakes and St. Lawrence Valley	Horton and Brown (1960)
Spruce-fir	Adirondack Mts of New York	Heimburger (1934)
Spruce-fir, Northern hwds.	Adirondack Mts, Vermont, N. Hampshire, W. Maine	Westweld (1951, 1952, 1953, 1954)
Spruce-fir, Northern hwds.	Lake Edward, Quebec	Sisam (1938a), Heimburger (1941), Ray (1941, 1956)
Spruce-fir, pines, hwds.	Lake States	Anon. (1930)
Spruce-fir, pines, hwds.	Quebec, Ontario, Saskatchewan	Losee (1942a, 1942b)
Spruce-fir, pines, hwds.	Manitoba, Saskatchewan	Rowe (1956)
Spruce-fir	Newfoundland	Damman (1964), Page (1970a, 1970b)
Spruce-fir	Quebec	Linteau (1940, 1953, 1955), Bellefeville (1932), Lafond (1958, 1960, 1964)
Black spruce	N. Minnesota	Heinselman (1963)
Black spruce	Newfoundland to W. Ontario	Vallée and Lowry (1970, 1972)
White spruce plantations	Quebec	Gagnon and MacArthur (1959)
N. hwds. and oaks	Connecticut	Hicock et al. (1931)
N. hwds.	Upper Michigan	Wilde and Scholz (1934)
Quaking and bigtooth aspens	Petawawa, Ontario	Sisam (1938b)
Quaking aspen	Minnesota, Wisconsin	Kittredge (1938)
Quaking and bigtooth aspens, jack pine	Michigan	Hellum and Zahner (1966)

In boreal forest portions of Quebec attempts were made to relate physiographic methods to the Braun-Blanquet plant sociological methods (Jurdant 1964a, 1964b, 1969, Jurdant and Roberge 1965, Jurdant et al. 1975); similar methods have been proposed for the northern Rocky Mountains (Layser 1974). In floristically richer portions of southern Quebec the Zürich-Montpellier sociological methods were combined with physiographic site classification methods (Lemieux 1963). Physiographic site classifications also were included with the nationwide Canada Land Inventory for the agricultural portions of Canada (McCormack 1966, 1967, 1968, Lowe et al. 1972). A "Land Systems Inventory" based on physiographic features also has been proposed for the western United States (Wertz and Arnold 1975).

Hills considers his physiographic method a "total site" classification, and defines site as "an integrated complex of climate, relief, geological material, soil profile, ground water, and communities of plants, animals, and man". Thus, his methods are "holistic" (Burger 1972), paralleling the "ecosystem" viewpoint (Rowe 1953, Rowe et al. 1960). This broad ecological viewpoint differs from the specific site quality viewpoint in which quantitative values of site index and yield are used for classifying forest land productivity.

The physiographic site methods for forest landscape classification provide a good framework for stratifying large inaccessible forest regions into broad subdivisions based on general features of climate, landform, soil and vegetation. However, in most cases relatively little quantitative data is given regarding site quality for forest trees or for the range of site quality that is included within each physiographic subdivision. The physiographic system involves much subjective judgement and intuition, and considerable research is needed to provide the needed site quality information.

Soil Surveys

Soil surveys of agricultural land in the United States have been made for more than 75 years, but only in recent decades have forested lands been surveyed using modern methods of the National Cooperative Soil Survey. Soil survey reports often contain tables listing site index averages for soil mapping units, or for various "Woodland Suitability Groups". Several soil-site and other publications list site index averages for northern forests species using soil survey classification units (table 8).

How reliable are soil survey mapping units for estimating forest site quality? Unfortunately, in many areas most of the mapping units have similar site indexes, even though site index may vary widely within each soil mapping unit. Probably much of the site variation within soil units is due to certain soil and

topographic features that are important for tree growth, but that are not well described in soil unit definitions. For example, surface soil depth, subsoil texture, aspect, slope position, and slope steepness are features often closely related to site quality, but these features may vary widely within definitions for certain soil mapping units. If such important site quality features are not well defined or are not included in soil unit definitions, then excessive site variation within the soil unit can be expected.

Table 8.--Site index of northern forest species in relation to soil survey classification units

Species	Area	Reference
Red pine	Connecticut	Hicock et al. (1931)
Red pine	Massachusetts	Mader (1968)
Red pine	New York	Richards and Stone (1964), Dement and Stone (1968)
Red pine	Lower Michigan	Van Eck and Whiteside (1958, 1963)
Jack pine	N. Cent. Minnesota	Pawluk and Arneman (1961)
Jack and white pines, aspen, northern hwds., oak	Lake States	Roe (n.d., 1935)
Jack, red, white pines; quaking aspen	N. Wisconsin	Stevens and Wertz (1971)
Jack, red, white pines	Upper Michigan	Shetron (1975)
Jack pine, red oak, sugar maple, bigtooth aspen	Upper Michigan	Shetron (1969, 1972a)
Northern hwds. and conifers	E. New York	Diebold (1935)
Northern hwds.	Vermont	Post and Curtis (1970)
Sugar maple	Vermont	Farrington and Howard (1958)
Sugar maple	New York	Farnsworth and Leaf (1963)
Sugar maple	N. Michigan	Westveld (1933)
Quaking aspen	Minnesota and Wisconsin	Kittredge (1938), Stoeckeler (1960)

Classification systems for soil surveys are flexible and provide an excellent framework for the addition of soil phases or other soil and topographic subdivisions needed for more accurately defining site quality--if the requisite soil-site information is available. This information can be provided by soil-site studies that pinpoint the various soil and topographic features closely related to tree growth, and that also express the magnitude of site change associated with each important site features. Some soil-site studies are already available for northern forest species (tables 5 and 6), but for many localities we lack this necessary information.

COMPLEMENTARY FRAMEWORK FOR SITE, YIELD, AND FOREST LAND CLASSIFICATION

The sheer volume of literature for the many methods of site quality estimation, yield prediction, and forest land classification may at first glance seem confusing, and in some cases, even contradictory. But this confusion is more apparent than real because these fields are in many ways complementary rather than contradictory. All have a common goal--to determine and classify the productivity of land for tree growth. Accordingly, in the future we should not remain separated in mensurational, soil, and ecological lines, but instead we should try to coordinate the various methods for estimating site quality, predicting timber yields, and classifying forestlands (fig 1).

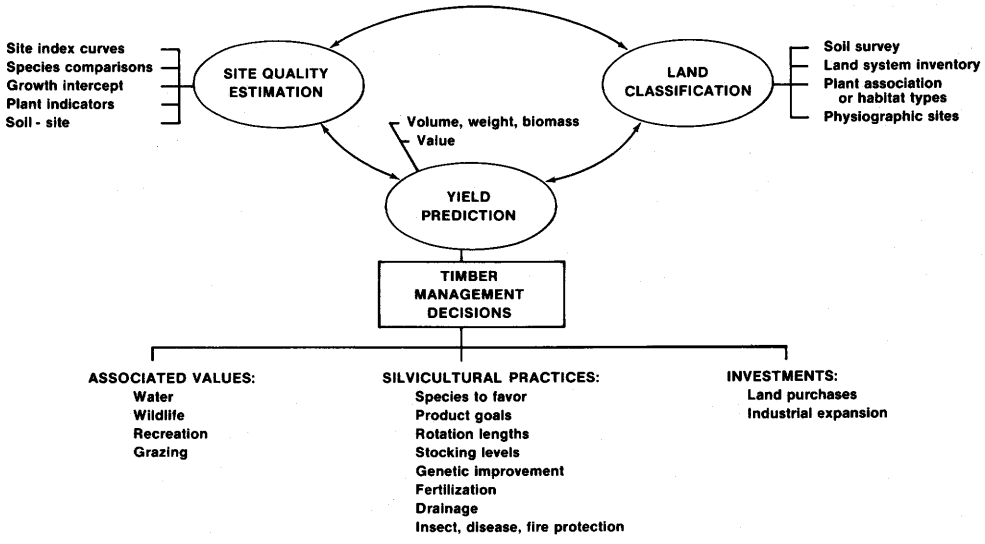

Figure 1.--Decisions about intensive timber management depend upon a complimentary framework of site quality estimation, yield prediction, and forest land classification.

All of us are dealing with separate parts of the overall problem of determining forest land productivity, and regardless of where we begin we eventually will arrive at each of the other important parts. Those concerned with local estimation of site quality will eventually strive to classify site for the entire area, and they also will need to convert site index estimates into yield estimates. Those concerned with yield prediction eventually will need means for determining both local site quality and yield, as well as site and yield estimates for the entire area. And those

concerned with forest land classification will eventually need both site and yield estimates for their classification units. Each of these three major areas--site quality estimation, yield prediction, and forest land classification--have major contributions to make because intensive timber management of the future will hardly be possible without a closer coordination of all disciplines.

How can we coordinate these three major fields? First of all we should recognize that we already have considerable scattered information about site quality, yield, and forest land classification (tables 1 to 8). For any specific area we should gather this information and then determine how much is accurate, applicable, and useful. If information is lacking, is not applicable, or is too general for intensive timber management, we should make the appropriate studies to get this needed information.

Site Quality Estimation

Our goal should be to estimate site quality for all portions of a forest area regardless of the character and condition of existing forest cover. Site index can be directly measured in the few areas having suitable trees. For other areas we might be able to extend site estimates using species comparison graphs or growth intercepts. And plant indicator and soil-site methods can be used for the remaining areas where no suitable trees can be found for direct site index measurements.

Yield Predictions

Site index estimations for local stands, or for the entire forest area, are only estimates of tree height at the 50-year index age. Site index is a qualitative index of relative forest land productivity, and merely ranking areas on the basis of height at index age is not enough. We also must be able to convert site index estimates into quantitative values for timber growth and yield. This can be done if adequate yield tables are available for the many tree species, stocking levels, and sites found in northern forest areas. However, before these yield tables can be applied we must have means for estimating site quality for each local stand as well as for the entire forest area. Accordingly, both site estimation and yield prediction methods should be viewed as complementary fields both of which are needed to attain our overall goal of predicting productivity for forest lands.

Forest Land Classification

Each of the various methods of estimating site quality and yield are still only point estimations regardless if we use trees, understory vegetation, or soil-site features. Still to be resolved

is the problem of abstracting point observations into a site and yield classification for the entire landscape. Such site classifications can be made for the entire area if detailed forest land surveys are available that use mapping units known to be closely related to site quality and yield.

Unfortunately forest land surveys are usually made using "basic" soil, physiographic, or vegetal mapping units defined by soil scientists or ecologists. After the survey is completed, attempts might then be made to interpret the survey in terms of the site quality and timber yield associated with each mapping unit. At this time it may be discovered that site quality and yield vary so much within mapping units that only very broad and general conclusions are possible. But more accurate and usable mapping units could have been achieved if, prior to the survey, factual soil-site information had been used to define mapping units that included the specific soil, topographic, and climatic features known to be closely associated with forest site quality. This requires coordinated research efforts to acquire factual soil-site information prior to the survey rather than after the survey has been finished. And such coordinated research requires the knowledge and skill of mensurationists, soil scientists, ecologists, and foresters as well as cartographers capable of using aerial photographs and other remote sensing techniques.

USING SITE, YIELD, AND FOREST LAND CLASSIFICATION FOR INTENSIVE TIMBER MANAGEMENT

How can the inventory of site information (tables 1-8) and the complimentary framework (fig. 1) help us practice more intensive timber management?

One of the first steps is to map and stratify the landscape into categories of management intensity. Usually the superior sites will be managed most intensively, less productive sites will be managed less intensively, and the poorest sites will receive little or no management, or perhaps will be designated for other land uses.

Next, decisions must be made about what silvicultural practices are appropriate for each site shown on our landscape classification. We know that thinning, fertilization, drainage, and other silvicultural practices can be very effective for certain species and sites. However, we often are not certain about the specific sites and soils where these practices should be applied or, further, how intensively these practices should be applied on each site. Because growth responses differ on different sites we must have growth and yield information for all sites so that estimates can be made of the increased growth achieved by applying each silvicultural practice. And knowing growth responses from

silvicultural practices on each site we then can estimate costs and benefits associated with the various practices employed in intensive forest management.

Likewise, decisions about land acquisition and industrial investments also require specific knowledge about site quality and about timber growth and yield. Such knowledge enables a manager to weigh the costs of these investments against the anticipated additional growth, yield, and income to be derived from the intensively managed forest. A further consideration is that compromises and restrictions on timber management might be needed because of other associated values (water, wildlife, recreation, grazing) and such compromises may decrease timber yields. Accordingly, we need specific knowledge about site and yield so that we can estimate the amount of these growth reductions, and hence the economic costs, resulting from such compromises.

In addition to timber values, forest land also has values for water, wildlife, recreation, and grazing. Managing land for these values requires much the same information as for timber--soil, topographic, and climatic data. Accordingly, for each of these associated values we could reason, as we have done for timber (fig. 1), that a coordinated approach is needed for local site estimation, yield prediction, and land classification. In many cases we may find that land features associated with timber site quality and yield may also be important in determining yields for these other associated values. If so, forest land classification for timber might be integrated with land classification for these other values resulting in a multiple use forest land classification.

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Appendix: Common and scientific names of tree species (Little 1953)

Common name	Scientific name
Balsam fir	Abies balsamea (L.) Mill.
Red maple	Acer rubrum L.
Sugar maple	Acer saccharum Marsh.
Yellow birch	Betula alleghaniensis Britton
Paper birch	Betula papyrifera Marsh.
American beech	Fagus grandifolia Ehrh.
White ash	Fraxinus americana L.
European larch	Larix decidua Mill.
Tamarack	Larix laricina (Du Roi) K. Koch
Japanese larch	Larix leptolepis Murr.
Norway spruce	Picea abies (L.) Karst.
White spruce	Picea glauca (Moench) Voss
Black spruce	Picea mariana (Mill.) B.S.P.
Jack pine	Pinus banksiana Lamb.
Shortleaf pine	Pinus echinata Mill.
Red pine	Pinus resinosa Ait.
Pitch pine	Pinus rigida Mill.
Eastern white pine	Pinus strobus L.
Scotch pine	Pinus sylvestris L.
Virginia pine	Pinus virginiana Mill.
Bigtooth aspen	Populus grandidentata Michx.
Quaking aspen	Populus tremuloides Michx.
Black cherry	Prunus serotina Ehrh.
Northern red oak	Quercus rubra L.
Northern white-cedar	Thuja occidentalis L.
American basswood	Tilia americana L.
Eastern hemlock	Tsuga canadensis (L.) Carr.

NUTRIENTS : A MAJOR CONSIDERATION IN INTENSIVE FOREST MANAGEMENT

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Abstract

Estimates of nutrient losses are compared for a stem-only harvest versus a whole-tree harvest of a clearcut northern hardwood stand. Combined nutrient losses due to increased leaching and removal of vegetation after stem-only harvesting are estimated to be 334 kg/ha for calcium and 265 kg/ha for nitrogen. For a whole-tree harvest, combined losses are estimated at 537 kg/ha for calcium and 486 kg/ha for nitrogen. Replenishment of available calcium and nitrogen could be a problem, depending upon the rate of soil mineralization and natural replacement.

THE NUTRIENT CAPITAL of the forest ecosystem is a main concern in intensive management. In some cases the concern is that nutrients are lacking and additions are needed to promote additional growth and more rapid growth. In other cases concern is about the nutrients lost from a site through physical removal by harvesting and by basic changes in the nutrient cycle after harvesting.

Conceptual models for fluxes of major nutrients in forest ecosystems are now commonplace. In some cases these models are detailed; J. Melillo at Yale University (personal communication) defines 25 different compartments and numerous interrelated pathways for nitrogen flow into, within, and out of a northern hardwood forest. Less commonplace are quantitative values for the many compartments of forest nutrient cycles.

There are obvious reasons why we need quantification of the nutrient cycle. Intensive management can mean shorter rotations and more complete utilization and thus a greater drain of nutrients in harvested products. We need to know what this means in relation to overall nutrient capital and productivity of the managed site.

Harvesting the forest can also increase nutrient losses by leaching. The magnitude and importance of leaching losses will be greater for the more complete and more frequent harvests likely to accompany intensive management. Nutrients lost through leaching represent a drain on nutrient capital as well as a source for increasing the nutrient concentrations of streams and groundwater. With implementation of the Federal Water Pollution Control Act Amendments of 1972, nutrient leaching from silvicultural activities has gained recognition as a potential source of water pollution, furthering the need for quantifying leaching losses.

Information about nutrient leaching and removal by harvesting is limited. To my knowledge, only four studies have been made in the eastern United States and eastern Canada on the problem of nutrient removal in harvested trees (Jorgensen et al. 1975; White 1974; Boyle et al. 1973; Weetman and Webber 1972). More information is available about leaching of nutrients to streams (Corbett et al. 1975; Hornbeck et al. 1975a, 1975b; Aubertin and Patric 1974; Pierce et al. 1972, 1970; Verry 1972; Johnson and Swank 1973; and Stone 1973). But the research on nutrient leaching is still at a stage where it is generating more questions than answers.

In this paper I will apply information from the above and other studies to demonstrate some potential impacts of forest harvesting on nutrients and the nutrient cycle. This demonstration requires considerable extrapolation of various types of data, but serves to show the extent of our knowledge about relationships between intensive management and nutrients in northern types.

METHODS

For this demonstration I will consider two nutrients, calcium and nitrogen. Both are important ecologically in forest ecosystems, and both may undergo increased leaching after forest harvesting.

For a forest type I have chosen northern hardwoods (beech, birch, and maple mixture) because of the available information and data, and because large areas of the Northeast are covered by this type. Species composition and size classes are taken from a

90-year-old stand at the Bartlett Experimental Forest in central New Hampshire. On this area of 2.5 hectares, all trees over 2.5 cm dbh were measured (data provided by S. M. Filip, Northeastern Forest Experiment Station, Durham, N. H.).

To estimate nutrient removal by various intensities of forest harvesting, both biomass values and nutrient content of plant tissues are needed for individual components of the forest stand. Biomass values were obtained by using a dimensional analysis of a northern hardwood stand at the Hubbard Brook Experimental Forest in central New Hampshire (Whittaker et al. 1974). Diameter at breast height is used as an independent variable in a series of linear regression equations. The equations provide estimates of biomass for stem wood, stem bark, branch wood, and current leaves and twigs by individual species.

Nutrient content of these components was determined by using chemical analyses of plant tissues made at Hubbard Brook by Likens and Bormann (1970). These analyses provide nitrogen and calcium values as a percentage of biomass. Weight of nutrients in each component is estimated simply by multiplying biomass by the percentage of calcium or nitrogen.

RESULTS

Using data from the northern hardwood stand at Bartlett Experimental Forest and applying the equations from Whittaker et al. (1970), I found that total biomass in trees >2.5 cm dbh is 203 metric tons/ha (table 1). Of this total, stem wood comprises 64 percent, stem bark 7 percent, branches 27 percent, and current leaves and twigs 2 percent. By species, 34 percent of the biomass is maple, 32 percent birch, and 24 percent beech. White ash, red spruce, and eastern hemlock make up the remaining 10 percent.

Multiplying biomass by the nutrient contents of individual components of biomass (Likens and Bormann 1970), I find that total calcium and nitrogen in trees >2.5 cm dbh is 547 kg/ha and 483 kg/ha, respectively (table 2). For calcium, 229 kg/ha or 42 percent of the total in trees is bound in branches and 193 kg/ha or 35 percent of total is bound in stem bark. Stem wood contains 99 kg/ha or 18 percent, and current twigs and leaves contain only 25 kg/ha or 5 percent of the total. By species, 36 percent of the calcium total in trees

Table 1.--Dry weight of biomass, in metric tons per hectare

Species	Stem wood	Stem bark	Branches	Current leaves and twigs	Total	
	------Metric tons per hectare-------					Pct.
Beech	31.82	2.18	13.19	1.08	48.27	24
Yellow birch	26.76	3.24	14.36	.80	45.16	22
Paper birch	11.25	1.29	6.79	.31	19.64	10
Sugar maple	2.41	.31	.59	.08	3.39	2
Red maple	43.80	5.33	13.85	1.13	64.11	32
White ash	3.10	.20	1.37	.07	4.74	2
Red spruce	.45	.07	.12	.01	.65	0
Eastern hemlock	11.46	1.42	3.66	.14	16.68	8
Total	131.05	14.04	53.93	3.62	202.64	
Percent	64	7	27	2	--	--

is in maples, 30 percent in birches, and 26 percent in beech.

For nitrogen, 195 kg/ha or 40 percent of the total is in branches and 81 kg/ha or 17 percent is in stem bark (table 2). Stem wood contains 126 kg/ha or 26 percent and leaves and twigs contain 80 kg/ha or 17 percent of the nitrogen total. By species, 38 percent of the nitrogen total in trees is in birches, 32 percent in maples, and 24 percent in beech.

Only minor portions of biomass and nutrients are in trees that might be considered too small to harvest. For the Bartlett stand, trees less than 10 cm dbh contain only 3 percent of the total biomass, 2 percent of the total calcium in vegetation, and about 3 percent of the total nitrogen in vegetation.

DISCUSSION

The above data can be used to compare nutrient removal for differing harvests. An illustration is clearcutting to harvest stems only versus clearcutting for whole-tree harvest. For the Bartlett stand,

Table 2.--Calcium and nitrogen in biomass

Species	Stem wood	Stem bark	Branches	Current leaves and twigs	Total	
	kg per hectare					Pct.
			CALCIUM			
Beech	19.2	55.2	62.0	6.4	142.8	26
Yellow birch	16.5	31.1	60.3	7.1	115.0	21
Paper birch	7.0	12.4	28.5	2.8	50.7	9
Sugar maple	2.5	4.4	2.6	0.5	10.0	2
Red maple	45.0	75.2	59.6	7.2	187.0	34
White ash	1.9	5.0	6.5	0.4	13.8	3
Red spruce	0.3	0.5	0.3	0.1	1.2	0
Eastern hemlock	6.9	9.6	9.2	0.4	26.1	5
Total	99.3	193.4	229.0	24.9	546.6	
Percent	18	35	42	5	--	--
			NITROGEN			
Beech	35.1	16.4	39.6	22.7	113.8	24
Yellow birch	24.7	19.4	63.2	21.0	128.3	26
Paper birch	10.4	7.8	29.9	8.1	56.2	12
Sugar maple	2.4	1.7	2.2	1.8	8.1	2
Red maple	42.9	29.3	51.3	23.7	147.2	30
White ash	3.4	1.5	4.1	1.5	10.5	2
Red spruce	0.3	0.2	0.1	0.1	0.7	0
Eastern hemlock	6.3	5.0	5.0	1.6	17.9	4
Total	125.5	81.3	195.4	80.5	482.7	
Percent	26	17	40	17	--	--

combined stem wood and bark contain a total of 293 kg/ha of calcium and 207 kg/ha of nitrogen (table 2). All components, including stems, branches, leaves, and twigs, contain 547 kg/ha of calcium and 483 kg/ha of nitrogen. Thus a whole-tree harvest has potential for removing about 1.9 times as much calcium and about 2.3 times as much nitrogen as a stem-only harvest.

For any harvest, some residual materials and their incorporated nutrients will be left on the site. For the comparison of the two clearcuttings mentioned above, both harvests were assumed to be about 80 percent efficient--or that 20 percent of the harvestable materials were left on the site. Thus for the Bartlett stand, harvesting stems only would remove an estimated 234 kg/ha of calcium and 165 kg/ha of nitrogen (table 3). A whole-tree harvest is estimated to remove about 437 kg/ha of calcium and 386 kg/ha of nitrogen.

Nutrient losses also occur as a result of increased leaching in the several years immediately after harvest. From several studies in central New Hampshire (Pierce et al. 1970; Hornbeck et al. 1975a and 1975b), I have estimated leaching losses from the Bartlett stand to be increased about 100 kg/ha for both calcium and nitrogen (table 3). Thus combined losses

Table 3.--Soil nutrient capital and losses due to clearcuttings in which 80 percent of product is removed

Nutrient losses and reserves	Calcium	Nitrogen
	-------kg per hectare---------	
Losses due to:		
Stem-only harvest	234	165
Whole-tree harvest	437	386
Leaching losses	100	100
Total losses:		
Stem-only harvest	334	265
Whole-tree harvest	537	486
Soil reserves:		
Bound	6,000-20,000	6,000-8,000
Available	500-1,000	25-250

from a stem-only harvest are 334 kg/ha for calcium and 265 kg/ha for nitrogen. For a whole-tree harvest, combined losses are estimated at 537 kg/ha for calcium and 486 kg/ha for nitrogen.

One means of evaluating the losses is to compare them with nutrient content of the forest soil (table 3). For soils similar to those at Bartlett, total bound calcium is estimated between 6,000 and 20,000 kg/ha, and available calcium is estimated between 500 and 1,000 kg/ha. Corresponding estimates for nitrogen are 6,000 to 8,000 kg/ha bound and 25 to 250 kg/ha available. When compared with the total reserves in the soil, the calcium and nitrogen losses from either stem-only or whole-tree harvests are relatively small. However, in the case of nitrogen, of which the soil reserves are smaller, combined losses from stem-only harvesting may represent 3.3 to 4.5 percent of the bound nitrogen in the soil, and losses from whole-tree harvesting may represent 6.1 to 8.1 percent.

The above evaluations are in terms of total nutrient reserves in the soil. Important concerns also include how much of the losses come from the pool of nutrients readily available for plant use, and how fast such losses are replenished. Most of the increased losses to leaching probably come from the available pool. This could mean that as much as 20 percent of the available calcium and much of the available nitrogen could be lost to leaching (table 3).

Replenishment of the available pool could be a problem for both calcium and nitrogen. Although there were large calcium reserves bound in rocks and soils, the conversion to available calcium is slow (Johnson et al. 1968). In previous studies, Boyle et al. (1973) and Weetman and Webber (1972) both projected the depletion of calcium as being potentially the first adverse consequence of whole-tree harvesting. In the case of nitrogen, there is little, if any, input from rock-weathering; so most available nitrogen must come from soil mineralization. Both nitrogen and calcium are supplied to the available pool through precipitation, but the amounts are relatively small. At Hubbard Brook, the annual additions in precipitation average 2.2 kg/ha for calcium and 6.5 kg/ha for nitrogen.

Replenishment of nutrients may become a more significant problem if rotation age is reduced. Most northern forest types are currently on 50- to 100-year or longer rotations, thus providing a good opportunity for natural replacement of nutrients. Intensive management and improved utilization could shorten rotations to 30 years or less. The possibility of shorter rotations further emphasizes the need for

information about rates and methods by which nutrients are made available for plant use, both before and after harvesting.

There are options that may reduce the loss of nutrients due to harvesting. An example for whole-tree harvesting: avoid removing leaves, either by harvesting in the dormant season or by felling trees well in advance of skidding so that senescence and leaf fall occur on site. Such an action for the Bartlett stand could reduce calcium removal by 25 kg/ha and nitrogen by 80 kg/ha (table 2). Configuration of the harvest can also affect nutrient losses. After a Hubbard Brook watershed was clearcut progressively in strips, nutrient losses to leaching were one-third to one-half less than those from nearby watersheds that were cut in large blocks (Hornbeck et al. 1975b).

In addition to the gross nutrient losses discussed above, forest harvesting can have other more subtle impacts on the nutrient cycle. For example, the removal of hydrogen ions by exchange in the forest canopy (Eaton et al. 1973) may lessen the impact of acidic precipitation that occurs in the Northeast (Likens and Bormann 1974). The important chemical changes that occur as precipitation passes through the canopy raise the question of what may happen when the forest canopy is removed. In an earlier study at Hubbard Brook, in which a previously forested watershed was devegetated for a 3-year period, the stream water pH decreased from 5.1 to 4.3 (Likens et al. 1970). This change represents about a fivefold increase in hydrogen-ion content of stream water. There were many complex changes in the chemical composition of the stream as a result of devegetation. However, the absence of hydrogen-ion exchange in the canopy may have contributed to the increased acidity of stream water after vegetation was eliminated.

As another example, recent studies at Hubbard Brook indicate that nitrogen is fixed in northern hardwood stands at an estimated rate of 1 to 11 kg/ha/yr (personal communication, Joann Roskoski, Yale University). Practically all the fixation occurs in rotting wood, especially in material greater than 2 cm diameter. More intensive harvesting may leave less of this material on the site and eliminate much of the substrate for future nitrogen fixation.

Both the gross and subtle impacts on nutrients must be considered in attempts to harvest greater quantities of wood from northern forest types. Cooperation is needed between the manager and the researcher in quantifying the changes in nutrient cycles and in implementing practices that will conserve nutrients on the site.

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STATUS OF GROWTH AND YIELD INFORMATION FOR NORTHERN FOREST TYPES

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Abstract

Existing regional growth-and-yield information for most of the northern forest types is summarized by species. Present research is concentrated on growth-simulation models, constructed by either aggregating available information or through individual tree growth studies. A uniformity of more refined measurements is needed so that future growth models can be tried for other species and forest types.

MOST FOREST-MANAGEMENT decisions include some form of growth information, because cultural treatments on different sites cause growth responses to vary. Growth data are not only some of the most sought after information, but also are some of the most difficult to obtain. In order to report on the status of growth and yield information in northern forest types, it is necessary to realize that different forest types are comprised of many species within that type and that each species grows at a different rate. Each species has its own growth rate in height and diameter; and these rates depend directly upon site, moisture, and competition.

DESIRED GROWTH AND YIELD INFORMATION

The information desired most frequently would be used to predict the long-term influence of site, stand density, and silvicultural systems on the growth and yield of different stands in terms of product objectives. The long-term growth and yield predictions are desired for managed and unmanaged stands growing on different sites for varying periods of time.

Yield information is also needed for different silvicultural treatments used for different management objectives. In addition to different growing conditions, one needs knowledge of yields by product

classes, including various portions of whole trees. Thus for growth and yield information to be meaningful, different aspects of tree growth--from fiber production to high quality sawlogs--must be considered. These products should be described within a framework of growing conditions and time requirements needed to achieve the desired product or measurement classes.

AVAILABLE GROWTH AND YIELD INFORMATION

Classical growth information has been developed for diameter and volume growth measured at 4.5 feet above ground, or volume growth of the whole bole by age classes.

The growth information available is primarily stand growth over an average set of conditions, usually for a relatively short period of time. This seems logical because it is impossible to collect data from various aged stands, with different silvicultural treatments, growing on different sites.

Existing yield tables are of two types. Normal tables, based on unmanaged stands at maximum or full stocking, show yields attained at various stand ages. The other type is empirical tables, which are constructed over the life of the stand, representing average stocking that may have varied greatly at different periods.

Normal tables are poor indicators of attainable product yields from thinned stands, while empirical tables do not give accurate estimates for long-term conditions unless stands are grown under the same conditions as those on which the tables were based. Yield information available gives harvest volume by age class and frequently by site index or class.

The major northern forest types recognized by the Society of American Foresters (1954) are: aspen-birch-pin cherry; white pine; swamp conifers; spruce-fir; and northern hardwoods. As a means of reviewing existing literature, I will discuss the growth and yield information for each of these forest types. This review of growth and yield information is not complete, and it is not intended to include all available sources of information. My purpose is to try to report the most recent or the most significant literature dealing with growth and yield in the northern forest types.

Within the aspen-birch-pin cherry type, almost pure stands of individual species occur. Therefore I will review existing growth and yield information by each species. For birch in New England, early information is available from Dana (1909) for natural uneven-age stands. Height, diameter, and volume growth are given by age and regeneration classification. Yield is given by age and quality class.

Diameter growth data for young managed birch crop trees with different degrees of thinning are presented by Solomon and Leak (1969). Merchantable volume yields are also given for even-age stands of various mean diameters and the number of years to reach that mean stand diameter by site index for managed and unmanaged stands. Normal yield tables for birch stands in the Midwest were reported by Plonski (1956); these tables give yield by site class, age, height, diameter, number of trees, and basal area. The same information for well-stocked aspen stands is presented in a similar manner. Information about aspen stands in the Midwest is given by Schlaegel (1972). He presents net periodic annual basal-area growth by age and stand density. Also, yield information is presented by age, site index, thinning regime, and stand density.

For white pine in New England, we have yield information for well-stocked stands (Frothingham 1914), and for old-field plantations for different locations by age and site index. The most recent yield information is given by Leak and others (1970) for white pine in New England related to age, site, and stocking. Although this and other yield information are available for white pine, extensive stand-growth information does not seem to be available. What growth information is available in the literature is for specific areas and is not presented by alternative management criteria.

For natural stands of red pine in the Lake States, extensive growth information by age, site index, and stand density are available (Buckman 1962). His tables present basal area, net growth, cubic feet, cordwood, and board-foot growth by site index, age, and stand density. Yield information is also presented, by site index, age, and stand density for various residual thinning densities.

Yield information for jack pine in the Lake States, along with cordwood growth and basal-area growth after thinning, is available by site and age (Eyre and

LeBarron 1944). Gevorkiantz (1947) published yield information with growth rates by size class and conversions for less-than-normal stocking. Later, normal yield tables for jack pine in northern Ontario were developed by Plonski (1956). Therefore, tables by site and age are available for a wide range of stand densities and varying silvicultural treatments.

Since the Lake States have stands of predominately black spruce with a low mixture of other spruce species, black spruce will be discussed separately. The growth and yield of black spruce in the Lake States is available for managed stands by age, site, and basal-area density (Perala 1971). From these data, equations have been developed for estimating growth and yield for both cubic feet and cords. Also, normal yield tables are presented by site and age (Plonski 1956). Diameter growth by stocking and size class, and basal-area growth for various residual stand densities of the swamp conifers, are also available (Skilling 1959).

In addition to black spruce information, stand volume growth, and yields by age, site, and competition indices are available for balsam fir (Gevorkiantz and Olsen 1950). Growth and yield information for spruce and fir stands in the Northeast started in 1917 with Murphy's (1917) work on old-growth and old-field red spruce. This work included diameter growth by size and stand type for different locations throughout the Northeast. It also contained basal-area growth by age and quality class.

In the Northeast, both normal yield tables by Meyer (1929) and empirical yield tables by Westveld (1953) are available for spruce-fir stands. The normal tables are by age and site index for different species. The empirical tables are given by age, using a density and stand-composition index.

Average cubic-foot stand growth rates for spruce-fir stands have been presented for New England (Safford 1968). The averages are presented by density, height, and type of stand mixture. Yield information is presented by Merrill and Hawley (1924) for hemlock stands in southern New England. Cubic-foot and board-foot measures, and current annual and mean annual increments, are given by age and quality class. A more recent publication by Baskerville (1965) has given production of balsam fir stands in New Brunswick in both cubic feet and weight for different tree components for

varying number of stems per acre.

Growth information for northern hardwoods began with diameter, height, and volume growth for stands in the Lake States and yield information for the Northeast (Hawes and Chandler 1914; Frothingham 1915). Both the growth and yield information is for fully-stocked stands by age and site differentiation.

Later additional normal yield information was presented by Spaeth (1920) and Gevorkiantz and Duerr (1937). These provide yields by age and site classifications for both the Lake States and New England northern hardwoods.

Yields for managed stands in New England have been combined and presented by Leak, Solomon, and Filip (1969). Their tables make use of existing information, both published and unpublished, for northern hardwood stands and present the number of years required to reach a specified yield by site index. Growth information for stands under different forms of management is given by Erdmann and Oberg (1973). Also Solomon [in press] has compiled stand growth responses for northern hardwoods in New England, by size class for different densities in uneven-age stands.

It becomes apparent from the partial listing of existing growth and yield information that much work has been done. Hence arises the question of "Why do we need more?" Why not just revise or adjust existing information?

FUTURE GROWTH AND YIELD INFORMATION

The general comparison of the desired growth and yield information with the actual published information indicates the intensive need for data, especially for managed stands. Since no two stands are alike, the need arises for the forest manager to have separate growth and yield information for stands of different species composition growing under different levels of stocking.

Stand information is usually based on average growth and yields over a large area. A broad average usually ignores many of the differences between individual stands. Thus one of the functions a land manager has is to determine how close his stands are to the reported average conditions.

Therefore, to estimate future growth rates and yields accurately and make meaningful forest-management decisions, the land manager needs information about the response of his stands to a variety of environmental and physiological conditions. He needs single tree information rather than broad averages for specific local cases. The use of individual tree responses to develop an average for a whole stand should provide an equally reliable base for future growth estimates.

There have been two basic approaches toward fulfilling the need for determining forest growth and yield under different silvicultural systems on different sites. Both approaches employ simulation models of actual responses. One method is to use stand growth and yield data for different conditions and combine them into a stand model. The second method is to take specific data, usually individual tree growth, and develop stand responses.

As you can see from existing information, stand results are not reported on a similar basis, which makes the first method of comparison or combining difficult. Also, species combinations for mixed stands are most difficult to deal with.

Various stand growth and yield simulators have recently been developed for the northern forest types. Moser (1974) has developed a system of equations for forest stands of sugar maple in the Lake States. Solomon (1974) presented a simulation model for different silvicultural treatments of even-age northern hardwoods in New England.

The method of modeling that uses individual tree data allows significantly more flexibility; however, it requires more time to develop, and extensive field calibration. Many different individual tree models are available (Arney 1971; Beck 1974; Lin 1974; and Mitchell 1969). Simulation models have been developed for the northern forest types relying on different expressions of competition and growth. Hegyi (1974), for example, has developed a model for managing jack pine. Likewise Ek and Monserud (1974) have provided a model that deals with mixed species in even- and uneven-age stands.

Ongoing growth and yield research within the northern forest types is attempting to use individual-tree information together with stands to construct models.

Another urgent need is for the forester to measure products in more specific units. If we are to intensify our tree growth we need to know the responses of different tree components and how to measure this response. For example, volume, as measured by cords, is unsatisfactory for branches or leaves (Young 1973). Therefore we should bring the forestry world to a more common and precise basis, such as cubic meters, cunits, or weight. We need to be able to communicate as well as understand.

SUMMARY

For the land manager to manage his forests intensively, he needs growth and yield information for different species in mixed, even-age, and uneven-age stands on different sites with varying degrees of density and stocking. These stands need to have different combinations of these conditions both for managed and unmanaged stands.

Available growth and yield information deals with normal stands and some segments of managed stands. There is not only a need to develop growth responses for trees growing under different environmental conditions: there is also a need for collecting data and reporting results on a more common and conforming measurement basis. Therefore, the development of simulation growth models, as is being done, seems the most logical path to follow in an attempt to bridge existing gaps.

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THE STATUS OF TREE IMPROVEMENT PROGRAMS FOR NORTHERN TREE SPECIES

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Abstract

Forest tree improvement research and application in the Northeast is reviewed in the perspective of past development and future needs. Control over provenance selection can provide the best quality seed for today's reforestation programs. Future supplies of seed must come from seed orchards if forest land owners are to attain the maximum production per unit area as industrial reforestation efforts in the region increase.

When one considers the intensive culture of forests with any type of planting program, it is logical to include a tree improvement program to assure that you are planting seedlings of superior genetic quality. The very active and intensive tree improvement programs in the southeastern and western United States have focused worldwide attention on the tremendous gains that are possible through forest tree breeding (Zobel 1974). Foresters from the northern states visiting these areas are invariably impressed with the modern seed extraction facilities, expansive nurseries and greenhouse complexes, vast acreages of seed orchards, and the thousands of acres of fast growing plantations. In this paper, I would like to place in perspective for northern species the tree improvement activities to date and what I envision the prospects to be for the future. Most of my comments will be directed to the Northeastern states in general and Maine in particular.

As evidenced in the southeastern and western states, the development of tree improvement programs requires economic justification for their implementation. Forest industries and forest managers have responded to and accepted change only when they have found it economically advantageous. Several innovations in harvesting techniques in the Northeast such as tree-length logging and complete tree chipping have

extended the fiber supply. These methods, however, became acceptable only when the lack of labor made it physically impossible to harvest a sufficient quantity of wood or the economics of wood production dictated a change. The same might be said of tree improvement in the Northeast: the acceptance of planting genetically improved seedlings by industrial and other foresters will result only when it becomes economically attractive or necessary, or because a potential shortage of raw materials requires a new approach to forest management.

PAST HISTORY OF TREE IMPROVEMENT IN THE NORTHEAST

The development of tree improvement in the Northeast is well documented in the "Proceedings of the Northeastern Tree Improvement Conferences", which have been held annually since 1953 (Garrett 1972). Notable among these accomplishments is that the first large-scale breeding project in the world devoted exclusively to the genetic improvement of forest trees was begun in 1924 by the Oxford Paper Company of Rumford, Maine in cooperation with the New York Botanical Garden (Schreiner 1975). The objective of this project was to produce rapid-growing poplar (Populus) hybrids for pulpwood reforestation. Today these hybrids have been planted extensively around the world. They have not, however, been planted to any large extent by the local industries for which they were developed.

Special mention should also be given to the early efforts made to breed American Chestnut (Castanea dentata (Marsh.) Borkh.) resistant to the chestnut blight fungus (Endothia parasitica) (Jaynes 1969). This effort was begun in 1929 by Dr. A. H. Graves of the Brooklyn Botanic Garden and has been continued to date by the Connecticut Agricultural Experiment Station.

With the exception of the two previously mentioned examples, most of the early tree improvement work in the Northeast was concerned with species introduction and provenance testing. Emphasis was placed on european and asiatic conifers adapted to plantation culture. These early tests quickly pointed out the significant contribution genetics makes to growth rate, seedling survival, form, wood properties, etc.

CURRENT RESEARCH PROGRAMS

Programs in tree improvement research are currently being carried out in all of the Northeastern and Lake States as well as the Canadian provinces. The work is being conducted by universities, federal governments, state agencies and private industries. The areas of investigation for purposes of discussion can be categorized as follows: (1) exotic species introduction and provenance testing; (2) individual tree selection and progeny testing; (3) hybridization; and (4) vegetative propagation.

Exotic species introduction and provenance testing. The northeastern region of the United States including the Lake States and southeastern Canada are very fortunate to have climates similar to several northern hemispheric regions of the world that contain valuable forest tree species. This condition permits us to successfully plant several of these species and in many instances obtain growth rates superior to our indigenous species. Today proper species selection and specific provenance recommendations can be made with a high degree of assurance for success. Besides the early provenance tests, several recent large-scale intensive provenance tests of indigenous species have been assembled and are currently being field tested in both the United States and Canada. For the most part, these recent tests are being conducted on species that show a large amount of genetic variation (e.g. jack pine (Pinus banksiana Lamb.)) or species that have gained in importance in recent years (e.g. black spruce (Picea mariana (Mill.) B.S.P.) and white birch (Betula papyrifera Marsh.)).

Both the earlier and more recent tests have shown dramatic differences for such traits as: (1) growth rate in white spruce (Picea glauca (Moench) Voss), eastern white pine (Pinus strobus L.), Norway spruce (Picea abies (L.) Karst) and Scotch pine (Pinus sylvestris L.); (2) form and foliage color in Scotch pine; (3) disease resistance in jack pine; and, (4) frost resistance in Douglas fir (Pseudotsuga menziesii (Mirb.) Franco) (Nienstaedt and Teich 1972, Wright 1970, Baldwin et al. 1973, Wright and Bull 1963, King and Nienstaedt 1965, Hattmer and Konig 1975). The general area where most information is still lacking is with hardwood species, however, this void is rapidly being filled as hardwoods are destined to become more important in this region.

Individual tree selection and progeny testing. The tree improvement programs in the southern and western states have for the most part been based on individual tree selection and progeny testing. The primary reason for this is that at the inception of the tree improvement programs in those regions in the 1950's, there already existed extensive planting programs and the immediate need was to obtain the maximum amount of genetic gain in the shortest possible time span. The approach taken was to establish clonal seed orchards from highly selected trees. This need, to obtain immediate genetic gain, did not exist to the same degree for most northern species as planting programs were comparatively small. Thus, individual tree selection was not given much emphasis. During the last fifteen years, however, this field of research has expanded rapidly and selection programs have been made or are currently in progress for many of the commercially important species. Population parameters and heritability estimates are rapidly being gathered for the commercially important traits such as growth rate, specific gravity, etc. (Morgenstern et al. 1975).

Hybridization. Inter-specific hybridization in the pines, spruces, poplars, and larches have produced several combinations that hold considerable promise for increased growth (Fowler and Yeatman 1973). Perhaps the hybrid in the Northeast that has received the most attention besides hybrid poplar is the Larix decidua x leptolepis combination. Trees from this cross have made astounding growth on well-drained sites throughout the region. Both seed and seedlings are available periodically from the state of New York.

Vegetative propagation. Methods of vegetative propagation by grafts and cuttings have been developed for the important northern species. Much research, however, should still be conducted on the grafting and rooting of spruce species. Especially critical is the propagation of trees that have been attacked by the spruce budworm (Choristoneura fumiferana (Clemens)). In recent years much progress has also been attained in the methods of cell and tissue culture as a means of vegetative propagation (Brown 1976).

ANALYSIS OF THE APPLICATION OF RESULTS

The ultimate objective of all tree improvement programs is to control seed quality. Ideally all seeds sown in nurseries or greenhouses should reflect some

degree of genetic control. This objective has been attained by several organizations, however, it is still lacking in others. The practice of buying cones and seed on the open market still exists. The greatest degree of control has been attained in the Lake States, Canadian provinces and the state of New York. In these areas: (1) seed zones have been established to regulate the flow of seed across ecological zones; (2) seed production areas have been established for many species to ensure a continuing supply of seed from designated areas and environments; (3) seed orchards have been established. The 1974 Directory of Forest Tree Seed Orchards in the U. S. lists 434 acres of seed orchards for all species for the geographic region from Connecticut to Minnesota. This number is quite small when compared to the fact that Florida alone has 1606 acres of seed orchards.

FUTURE PROSPECTS

The amount of acreage planted each year in the northern region has steadily decreased since it reached its maximum in the early 1960's. These plantings for the most part were federally subsidized by the Federal Soil Bank Program and established on abandoned farm fields.

I believe the Northeast will see a dramatic expansion of applied tree improvement and planting programs in the near future. This development, especially in the state of Maine, will be spearheaded by forest industries. The need will be brought about by the growing demand for fiber and the realization by industry and state governments that cutover forest lands must be fully stocked with suitable species at a desirable spacing as soon after cutting as possible so that optimum growth can be attained. The need now for the region is one of "applied technology". A sufficient background of information from researchers in the United States, Canada and the Scandinavian countries on containerized growing, accelerated growth, site preparation and genetic principles exists to mount a truly active tree improvement program.

In Maine alone there are approximately 17.2 million acres of commercial forest land. Traditionally the State has been in the very favorable position of having an annual cut well below the growth. However, long-range forecasts by the U. S. Forest Service predict that by the year 2000 we shall have twice the

demand for pulpwood than we now produce (Ferguson and Kingsley 1972). As implied earlier, improved utilization can augment and extend timber supplies, but the major long-term reliance must rest entirely on increased productivity of all available commercial forest land. This increased productivity can be attained by sound investment in the land and those trees growing on the land.

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STATUS OF HERBICIDE TECHNOLOGY FOR CONTROL OF TREE SPECIES AND TO REDUCE SHRUB AND GRASS COMPETITION

by Maxwell L. McCormack, Jr., Professor of Forestry, Department of Forestry, University of Vermont, Burlington, Vt.

Abstract

The values of herbicides as silvicultural tools are summarized. Treatments are discussed with reference to chemicals and methods of application as they pertain to control of grass and herbaceous weeds, understory vegetation, and overstory vegetation.

An herbicide is a chemical used to reduce or eliminate the detrimental effects of undesirable plants. The potentials for effective use of herbicides in the culture of northern forest types are much greater than current practices indicate. Herbicides are an effective, low cost, easy to apply means for reducing management costs and impact from forest pests while improving growth rates, wildlife habitat, watershed quality, and other objectives of forest management. Though herbicides play an important role in nursery practices, the concern of this report is the production of forest products. Competition from adjacent plants, as undesirable species or stems in an overstocked stand, is a major deterrent to growth and pest resistance of desirable trees. However, uses of herbicides go beyond removal of plant competition and can be grouped into several major categories.

1. Site preparation and preplant treatments
2. Control of species composition
3. Reduction of stocking levels
4. Direct reduction of competition from undesirable plants
5. Establishment of openings for such purposes as wildlife management and scenic vistas

6. Improving access through maintenance of roads and right-of-ways

7. Marking of treatment areas

8. Protection by removing host plant material

9. Protection through firebreak maintenance, and others as management needs require

Alternatives to herbicides such as mulching, cultivation, mowing, and other forms of mechanical treatment are more costly. Often they cause physical injury to desirable tree stems and their root systems. Increased erosion and pollution often result. Abrupt changes in forest environments and consequences of quantities of slash dropped directly to the forest floor from mechanical treatments, as opposed to gradual opening and crop tree conditioning accomplished through herbicide techniques, are factors worth careful consideration.

Herbicides offer many solutions to silvicultural problems. Consideration should be given to the original cause of the undesirable plant material such as harvesting methods, species preferences, residual cull trees, and pest impacts as well as management objectives based on ecological principles rather than a simple policy of eradication of the unwanted. Herbicide techniques appropriate for use today may be inappropriate for tomorrow. Continuous advances in application technology and development of new chemicals make new treatments available. Environmental conservation interests, legal restrictions, applicator licensing requirements, and possible reduced availability because of labeling regulations and costs can make established treatments unavailable. Any treatments used must comply with existing regulations and applicators should consult with their appropriate regional pesticide coordinators. Specific data are available from such references as the Herbicide Handbook of the Weed Science Society of America.

A detailed account of all materials and techniques is beyond the scope of this report. Periodically, practical summaries of basic practices have been prepared (Stamm, 1964; Lindmark, 1965; Shipman and Farrand, (no date); and others). Proceedings of

the Northeastern Weed Control Conference are a source of information on recent developments and additional summary information from other regions is useful (Oregon State University, 1967; Gratkowski, 1975).

Because of the large number of possible treatments, the status of herbicide technology will be generally grouped according to some common field situations.

CONTROL OF GRASS AND HERBACEOUS WEEDS

Intensive cultural practices involved in the production of Christmas trees have provided much information and experience in control of herbaceous weeds (Ahrens, Flanagan, and McCormack, 1969). Paraquat (1, 1'-dimethyl-4, 4'-bipyridinium salts) has been useful for preplant preparation at rates of 1 to 2 pounds active ingredient per acre treated (lbs. ai/a). Rapid killing back of above ground plant material provides for easier planting and subsequent weed control. Health hazards associated with paraquat make special safety equipment essential and can be cause for using substitutes. Glyphosate (N-phosphonomethyl glycine) is a new material that shows great promise for killing weeds prior to planting. It is a postemergence, relatively non-selective, non-residual material which will control a large number of narrow and broadleaf perennial and annual weeds, trees, and brush. It has the additional advantage of exhibiting active translocation from vegetative plant parts to underground roots or rhizomes. It is best applied at early flowering to maturity.

Residual control of herbaceous weeds is best achieved with simazine (2-chloro-4, 6-bis(ethylamino)-s-triazine) applied as a spray of wettable powder in water. Simazine has good residual action and should be applied early in the spring for best results. Response from late season applications can be accelerated through the use of wetting agents which also help to keep spray equipment clean and functioning. Simazine works well with our native conifers with balsam fir (Abies balsamea (L.) Mill.) tolerating highest rates, followed by the pines (Pinus L. spp.) and then spruces (Picea A. Dietr. spp.).

Action of simazine can be accelerated and improved by combining its application with that of

fertilizer. In turn, simazine also provides nutritional benefits by improving the nitrogen regime and the habitat for mycorrhizal fungi. This latter relationship has been observed with balsam fir, Fraser fir (Abies fraseri (Pursh.) Poir.), white spruce (Picea glauca (Moench) Voss) and species in other areas (Uhlig, 1966). Simazine treatments to balsam fir result in increased survival and improved plant tissue production. In some studies this herbicide alone has resulted in better growth than combinations of fertilizer plus simazine. Planted balsam firs with weed control, primarily with simazine, as the only cultural treatment have grown to heights exceeding seven feet in five growing seasons after planting (Unpublished data, University of Vermont). Wildlife management implications and browse problems result from apparent preferences by browsing white-tailed deer (Odocoileus virgincanus borealis Miller) for simazine-treated balsam fir which have been related to resultant increases in crude protein (Morgan and McCormack, 1973).

Atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino-s-triazine) which is similar to simazine, but more soluble, is also effective and can be used in combination with simazine for faster action and reduced rates of application. Care must be taken not to allow atrazine to contact soft, new growth on conifers or some defoliation can result. Generally, rates of 2 to 10 lbs. ai/a are effective depending on site and operating conditions.

Though most experience with these triazine herbicides has been with conifers, increased survival and growth has been achieved in plantings of black walnut (Juglans nigra L.), red oak (Quercus rubra L.), white ash (Fraxinus americana L.), and yellow-poplar (Liriodendron tulipifera L.) (Erdmann, 1967). Recent field observations in Vermont indicate that sugar maple (Acer saccharum Marsh.) will seed in and grow well in maintained simazine bands.

CONTROL OF UNDERSTORY VEGETATION

Undesirable understory vegetation must be approached with special care to avoid injury to desirable overstory trees. This can be accomplished by careful application of herbicides with hydraulic sprayers or mist blowers in hardwood and softwood stands. Best approaches are with translocatable

foliage applications. It is recommended that basal spraying be avoided since it requires larger volumes of chemical and oil carriers which are undesirable from the viewpoint of environmental and aesthetic concerns.

Best results are obtained with 2,4,5-T (2,4,5-trichlorophenoxyacetic acid). Other phenoxys are also used successfully as separate applications or in combinations. Silvex (2-(2,4,5-trichlorophenoxy) propionic acid) is effective as well as treatments including 2,4-D (2,4-dichlorophenoxyacetic acid). Glyphosate shows promise, but requires more study. Krenite (ammonium ethyl carbamoylphosphonate) may also have some application in the future, but must be applied late in the season. Initial responses to foliar sprays of Krenite simulate normal autumn loss of foliage which has some advantages where recently treated areas might be viewed by the public. Attempts at using amitrole (3-amino-1,2,4 triazole) can result in some root uptake which is potentially injurious to small overstory trees.

The "workhorse" of this category of treatments is 2,4,5-T which is effective in rates of 1 to 3 lbs. ai/a. Mist blowers give most efficient coverage using water as a carrier. Several adjuvants are now available to improve wetting, penetration, translocation, and weatherability. The disadvantages of oil in the carrier can now be avoided. To accomplish thorough kill, it is important to achieve good intake for translocation of the herbicide; quick burning of foliage which is dramatically impressive often precludes this desirable objective.

In addition to beneficial uses of adjuvants, other modifications in technique show promise. For example, difficult to control red maple (Acer rubrum L.) has exhibited increased susceptibility to 2,4,5-T when phosphorus applications are combined with treatment (Brady, 1970). Also, changes in timing of application are possible. Some brush species are susceptible to spring herbicide treatments while conifers are still resistant. Screening tests in the Pacific northwest with genera present in the northeast (Alnus, Rubus, Acer, and Corylus) have been encouraging (Stewart, 1974).

Heavy invasions of Rubus often occupy openings in northeastern forests. Present studies in northern Maine and Vermont indicate that herbicide treatments

show hope of suppressing the undesirable vegetation to the benefit of spruce and fir. To date silvex looks good at rates of 2 to 3 lbs ai/a and shows good control of all strata of Rubus, even when there is a closed upper canopy of leaves. Good results have also been obtained with 2,4,5-T glyphosate. Krenite exhibits potential, but will require more study. In cases where residual trees or larger plants are present it is important to take measures so they do not interfere with reaching target plants with herbicide applications.

CONTROL OF OVERSTORY VEGETATION

Treatment of overstory plants, or stands of brush species where no trees are present, can be accomplished through foliar applications. Aerial applications can be very efficient. Spraying of 2,4,5-T controls hardwood growth sufficiently to allow establishment of conifers. Isolated trees which are larger than the target canopy can result in shielding so that separate preparation or followup treatments might be desirable. In cases where fresh stumps and girdled trees result in quantities of sprouts that are not desired for wildlife management purposes, herbicide treatments can be utilized to reduce impact from sprouting. Treatment of fresh cut stumps very soon after cutting is desirable. These applications are a good example of where colored dyes are a definite aid in efficient execution of treatment.

Aerial sprays using several phenoxys in Vermont have shown that all treatments including 2,4,5-T gave some level of control (Newton and Smith, 1971). Application of low rates of 2,4,5-T from fixed wing aircraft on relatively small areas, 17 to 54 acres, has been effective in reducing hardwood competition in softwood stands (Butler, Hudson, and Flanagan, 1963).

Where broadleaved brush poses a threat to conifers another material which has been effective is picloram (4-amino-3,5,6-trichloropicolinic acid). When combined with 2,4-D or 2,4,5-T in foliar applications, picloram provided better brush control than either of the phenoxys alone (Perala, 1974).

Hard to kill species and individual large stems may need special attention where foliar sprays are used. Where combination treatments or removal of selected large stems are the basis of timber stand improvement operations, injector or frill-plus-chemical

applications can be very effective. In effect, a frill plus herbicide is a continuous series of injections around the circumference of a stem. Injection by long-handled tree injector at the root collar or hypo-hatchet at a convenient working height has the advantages of being neat and efficient, and placing the chemical in an individual selected stem as a metered dose. Present techniques involve use of undiluted herbicide in rates of 0.5 to 1.5 ml per injection with spacing of injections regulating dosage. The phenoxys are used. Their effectiveness is increased, especially on red maple, by adding picloram. Very good results are obtained with the organic arsenicals. Depending on season of treatment, summer months appear to give best results, cacodylic acid works best to control beech (Fagus grandifolia Ehrh.). Monosodium methane arsenate provides control of red maple, sugar maple, striped maple (Acer pensylvanicum L.), white birch (Betula papyrifera Marsh.), aspen (Populus L. spp.), hophornbeam (Ostrya virginiana (Mill.) K. Koch), white ash, and conifers which is equal to, or better than, cacodylic acid (Newton and Smith, 1971). Materials and dosages vary with species and season. Several existing reports provide practical guidelines (Little and Fenton, 1964; Filip, 1965; Peevy, 1972; and others).

SUMMARY

Numerous opportunities exist to use herbicide treatments for intensive culture of northern forest types. Each situation must be evaluated for its specific requirements so an ecologically sound treatment can be directed at realistic, undesirable target vegetation while exposure of non-target organisms is minimized. All must be done within legal restrictions. It should be remembered that complete kill of undesirables is often not necessary and a significant positive response of the desirable trees is the objective and proof of beneficial treatment.

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COMPATABILITY OF INTENSIVE TIMBER CULTURE WITH RECREATION, WATER AND WILDLIFE MANAGEMENT

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Abstract

Two principles of ecology can be applied to make management for recreation, water, and wildlife habitat compatible with timber management. They are diversity within plant communities (i.e. timber types) and interspersion of these diverse communities in place and time. Intensive cultural operations can be the tool to create the right mixture of diversity and interspersion to serve the priority needs of the landowner. This requires imaginative planning and the recognition of key-value areas. Areas where recreation, water, and wildlife assume the key position are relatively small compared with timber. Usually, timber operations can be carried out on at least eighty percent of the land with only slight modification to accomodate other resource values. Forest management based on such a multiple-resource approach overcomes small losses in timber income with large gains in public acceptance.

Reliable information links timber with recreation, timber with water, and timber with wildlife, but I can find no investigation that considers all of these at one time. My assignment is to lay the groundwork for pulling these four values together into one management package for the forest landowner. Recreation, water, and wildlife have different meanings to different people, so I will begin by defining what they mean in this paper.

DEFINITIONS

Recreation

Forest recreationists can be separated into three broad groups (Fletcher 1975). At one extreme are the relatively few but vocal solitude seekers who require large undisturbed, inaccessible back-country. At the other extreme is a larger group of socializers who derive their pleasure from resorts, fancy campgrounds, and other places where man-made facilities dominate the landscape. Although it is important to satisfy the needs of both these groups,

I am assuming that public agencies will provide for the solitude seekers, and private capital will take care of the socializers. Seldom does either group see timber cultural operations in action.

This paper is concerned only with that vast in-between group of moderates who may enjoy some solitude and socializing in small doses but derive their greatest satisfaction from a casual type of recreation in a more natural forest environment. These are dispersed recreationists who use the woods for such activities as pleasure driving, hiking, bicycling, picnicking, hunting, fishing, birding, nature study, photographing, horse back riding, and casual camping.

Most of these activities require some access for vehicles, along with small woods roads and trails for walking into remote areas of the forest. The quality of the experience is based mostly on visual impressions of the forest setting. Eighty-seven percent of man's perception is based on sight (USDA, 1973), and aesthetically pleasing landscapes relate directly to high quality experiences. In other words, recreation in this paper means forest aesthetics.

Water

Our main concern is the effect of manipulating forest vegetation on the quantity and quality of water appearing in the forest in the form of wetlands (marshes, shallow-water areas, swamps and bogs), springs and seeps, streams, lakes, and reservoirs. Wetlands attract recreationists and scientists because of their special ecological values, and they provide habitats for unique forms of plant and animal life rarely found elsewhere in the forest.

Many springs and seeps have these same values, and they supply drinking water for both humans and wildlife. The fishery values of streams, lakes, and reservoirs attract anglers. Treatment of riparian vegetation is especially critical, but any cultural operations which affect underground and surface flows to these water areas are also important.

Wildlife

Wildlife includes primarily birds, fish, and mammals, although lesser forms are considered if they have special scientific or public-interest value. Game and nongame species are considered equally, unless the landowner indicates otherwise. The goal is to insure healthy populations of as many species as possible. The system to achieve this is referred to as "management for species richness" (Evans 1974). It allows special attention to the habitats of unusual interest such as eagle nesting sites, locally unique plants and animals, songbird habitat along nature trails, and deer yards.

CONCEPTS

Ecologists and wildlife managers use two guiding principles or concepts: diversity and interspersion. I believe both of these can be used, in different combinations, to set priorities and procedures for coordinating recreation, water, and wildlife management into a single forest management plan. Cultural operations carried out by timber managers should be a major tool for achieving coordinated action. There will be a few exceptions where relatively small special-interest or sensitive areas need prescriptions by a biologist, hydrologist, landscape architect, or some other nontimber specialist to give full recognition to the various resources.

Diversity

Diversity is the amount of variation that exists in plant and animal communities. It is synonymous with variety. Some examples are:

(a) Successional stages within the same timber type, such as bare ground, early invaders (herbs and shrubs) and stands dominating by seedlings, saplings, poles, and sawtimber; i.e. certain species prefer young stands while others may be found only in old growth.

(b) Border between two broad timber types such as northern hardwoods and spruce-fir.

(c) Nontimber areas like grassy fields, bogs, log landings, water areas, fire lanes, and facility right-of-ways.

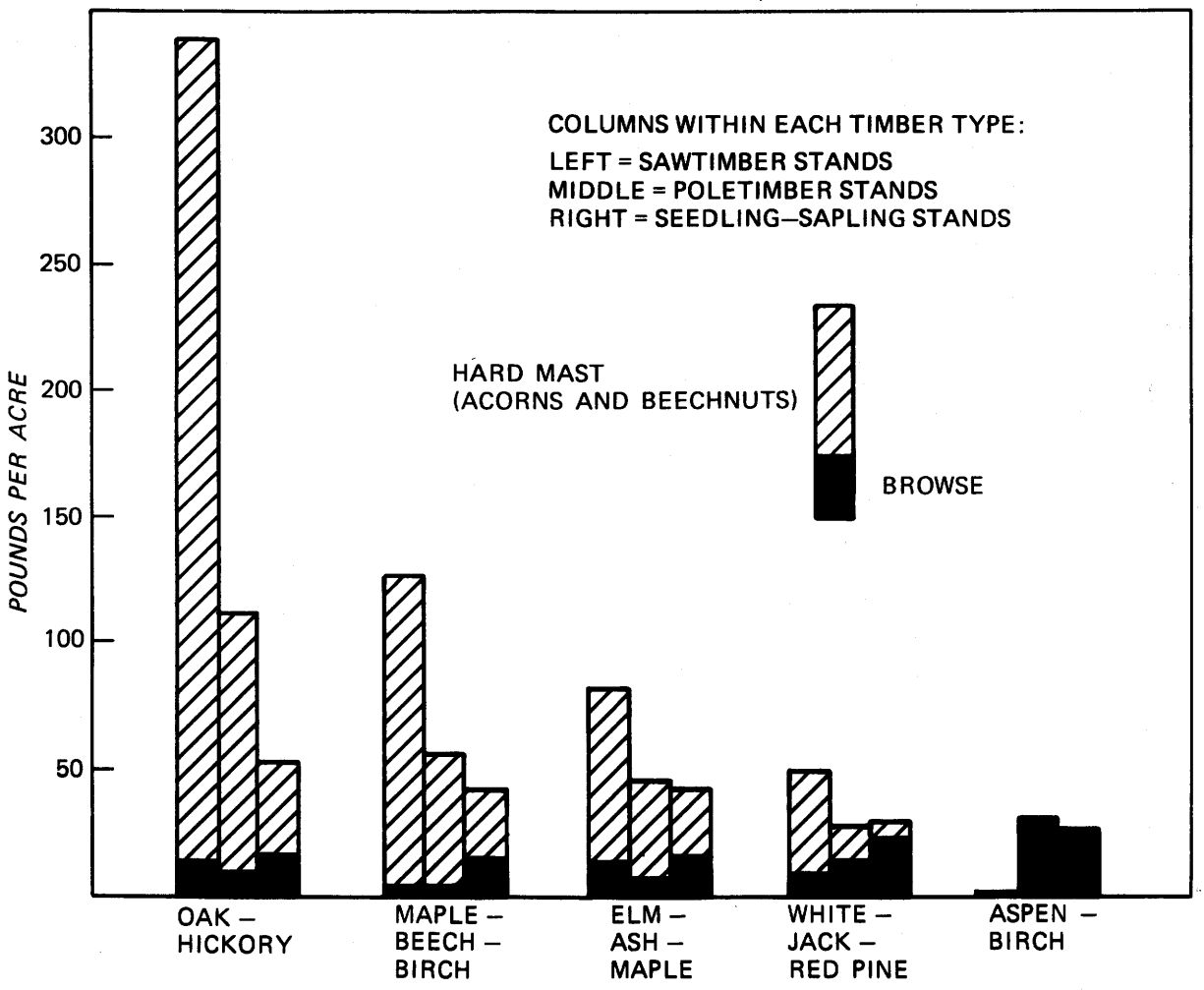
(d) Isolated stands of trees which are not typical of the surrounding timber type such as a beech-birch-maple stand within a spruce-fir type, or an aspen-birch stand in a northern hardwood type.

(e) Large conifer plantations broken up by unplanted strips.

Diversity occurs where different plant communities or successional stages within them come together. Wildlifers call this edge. The forest edge habitat usually contains many of the plant and animal species of each of the adjoining communities plus those characteristic of (and sometimes restricted to) the edge habitat itself. For example, both the diversity of bird species and the density of some are greater in the edge than in either community flanking it (Odum, 1959).

An example of the need for diversity is shown in Figure 1. Information comes from Barnes (1976) who used

Figure 1. Relative importance of winter deer foods by timber type and stand size class in the seven southern counties of New Hampshire.



Forest Service survey plots to evaluate the amount of woody browse and hard mast (acorns and beechnuts) available to deer during the winter. He gives results according to three age classes in each of five forest types found in the seven southern counties of New Hampshire. Mast and browse are staple winter deer foods.

To have both mast and browse requires a combination of timber types and age classes. For instance, a sawtimber stand in the maple-beech-birch type is a relative high producer of mast but a very low producer of browse. A pole or seedling-sapling stand of aspen-birch, on the other hand, is a very high producer of browse but provides no mast at all. This means that if a young stand of aspen-birch adjoins a maple-beech-birch sawtimber stand, there would be ample supplies of both browse and mast. Diversity, in this case, results in improved winter deer range.

Another example of how diversity works in favor of wildlife comes from an Ontario study of breeding birds in relation to three broad timber types (MacDonald 1965).

Timber Type	Bird Species Represented	Pairs per 10 Acres
Northern Hardwood with Mixed Pine	18	36
Semi-Open Pine	6	15
Pine Plantations	1	1

Interspersion

Interspersion is the degree to which different plant communities or successional stages -- in other words, diverse habitats -- are randomly mixed within the mobility range of wildlife and recreationists, or within a watershed.

We can use clearcutting on a 200-acre woodlot to illustrate. If there were one 25-acre clearcut in the middle of the lot, there would be localized diversity but poor interspersion because this diverse condition is not repeated elsewhere. On the other hand, if there were five 5-acre clearcuts scattered over the lot, one in each 40-acre block, there would be good interspersion.

We know that diversity combined with interspersion is extremely important in managing wildlife habitat because they combine to create a good assortment of places, called niches, where various species can find suitable habitat to feed, hide, rest, sleep, play, and breed within their home range. Diversity and interspersion are also important considerations in forest aesthetics and watershed management.

Forest Aesthetics

Those in the environmental planning profession use three basic concepts -- variety, harmony, and contrast -- and the three are interrelated (USDA 1965). On the subject of variety, which is the same as diversity, this source states:

> "Variety produces that changing quality of the landscape that captures and holds one's interest. A continuing diversity or change leads one to anticipate something different and delightful around the next bend in the trail or beyond the next ridge. In planning for variety one should ask, "How will people use or view this?" Is it both functional and interesting, or is it too much like that which has gone before? Variety is truly the spice of life, but it must not be allowed to run wild. It must be balanced with just the right amount of repetition to prevent chaos and confusion."

There is no question that timber cultural operations can be planned to create that "right amount of repetition."

Water Management

Normally, water yield increases directly with the amount of basal area removed. Consequently, even-aged management has a greater effect on the magnitude of water yield than uneven-aged management (Curtis and Ripley 1975). Light thinnings rarely affect streamflow, but clearcutting on a northeast deciduous forest can increase annual water yield the first year by 4 to 12 inches. These increases decline each year after cutting, and in 10 to 15 years water yields return to pretreatment levels (Lull and Reinhart 1967).

It follows that to maintain a high sustained water yield, new areas must be cut periodically as earlier cuts mature. These cuts create diversity and interspersion. They can be planned in space and time to enhance aesthetics and wildlife habitat.

EXAMPLES

Now we will look at some examples of how aesthetics, water, and wildlife can be coordinated for their mutual advantage as cultural and other operations are carried out as a part of timber management work. Selected practices are shown in Table 1. Several of the recreation (aesthetics) examples are taken from Noyes (1968). Some modifications benefit all three resources simultaneously. These are list-

Table 1. Examples of how recreation, water, and wildlife values can be enhanced by modification of certain timber management operations.

		Recreation (aesthetics)	Water (yield)	Wildlife (habitat)
1.	Plantation Establishment	Create variety by planting evergreens in pure deciduous stands, and vice versa.	Favor deciduous over evergreen trees. Thin plantations frequently to break up canopy.	Leave unplanted travel lanes every 600 feet. Thin frequently to favor ground vegetation.
2.	Weeding	Favor trees with aesthetically pleasing crown, bark, foliage, and flower colors. Leave trees not commonplace to location.	No measurable effects	Favor trees and shrubs with high food or cover values: i.e. mountain ash, crab apple, and small hemlocks.
3.	Pruning	Concentrate work along trails and wood roads for easier access and greater safety. Maintain some naturalness by not overpruning (i.e. 100 crop trees per acre).	Slight increase in water reaching forest floor.	Leave live unpruned patches along roads and trails used for birding. Pile branches for wildlife cover.
4.	Improvement Cutting	Create vistas or views of unique features by heavy cutting. Avoid deadening trees in places frequently seen by people.	Cut heavier than usual and frequently as possible. Favor retention of deciduous over evergreen trees.	Leave productive mast-producing and den trees. Release patches of small evergreens for cover.

Table 1. (cont.)

		Recreation (aesthetics)	Water (yield)	Wildlife (habitat)
5.	Cutting for Uneven Aged Management	Use especially along roads, trails, water bodies, and recreation areas. Retain trees and shrubs of high aesthetic appeal. Log in dormant season to reduce residue mass. Lop tops.	Use single tree selection and cut lightly in buffer strips to prevent silting.	Favor group selection over single tree to put more "brush in the sun". Favor retention of best mast and den trees.
6.	Cutting for Even Aged Management	Create undulating edges when regenerating, with small tongues of standing trees extending into cut area. Blend cuts into terrain. Scatter debris and keep it low.	Do not cut on steep slopes, erosive soils, or wet areas. Supervise operation closely to prevent damage to stream channels and other sensitive areas.	Shape large regeneration areas so short axis stays within average of 500 to 800 feet. Scatter cuts over management unit. Four 20-acre cuts better than one 80-acre.
7.	Log Roads	Plan location for use after sale by recreationists for vehicle or foot access to high-interest spots. Leave roadside trees and shrubs with high aesthetic appeal.	Avoid locating roads in wet or poorly drained areas. Seed steep slopes with grass or clover to prevent erosion. If stream must be crossed, build bridge or use culverts.	"Daylight" some stretches to create early - succession vegetation along edges. Seed roadbed with clover. Gate certain remote areas for hunters, birders, or others who want a back-country experience.

ed under the resource believed to be benefitted most. For example, daylighting and seeding log roads improves aesthetics, water yield, and wildlife habitat, but it is listed under wildlife as the most enhanced resource.

All the modifications shown in Table 1 result in increased diversity of one kind or another. Good interspersion results when these practices are scattered over the management unit. Modification of timber operations is the most practical way to achieve diversity and interspersion on the ground.

APPLICATION

The management program for the Quabbin Reservoir lands in Central Massachusetts illustrates how many of the principles, practices, and modifications discussed here can be applied. Highlights of this program are given in an article titled CURRENT MANAGEMENT PRACTICES ON METROPOLITAN BOSTON'S MUNICIPAL WATERSHEDS, by Bruce A. Spenser. It appears in Municipal Watershed Management Symposium Proceedings, 1975, available from the Northeastern Forest Experiment Station at Upper Darby, Pa. It is a good reference. Here are a few highlights:

Management zones are delineated, and specific management policy developed for each zone. Six zones are recognized, occupying the following percentages of the 75,000-acre management area.

	Area Use	Percent
1.	Watershed Management	83.0
2.	Aesthetics	6.0
3.	Protection	6.0
4.	Administration	0.5
5.	Wildlife	3.5
6.	Recreation	1.0

Each zone requires specific silvicultural practices. The silvicultural goals are to maintain and improve the health and quality of the forest; salvage defective, mature and dead trees; and prepare sites for the regeneration of native species. Spenser states:

> "In the past 10 years, watershed-management operations treated 10,000 acres of forest, and should have yielded an additional 3.3 billion gallons of water, valued at $200,000, plus 33 million

board feet of stumpage valued at $658,000. This decade (1970-1980) we will treat 12,000 acres and produce similar yields but of greater value. This increased water yield seems like a small contribution, but it is more economical and of higher quality than other additional sources of water."

Here is a Municipal District Commission in business primarily to produce quantity and quality water for human consumption. Significantly it accomplishes its goal with a very active timber improvement and harvesting program. At the same time it is responsive to aesthetic, recreation, and wildlife priorities -- good evidence of multi-resource compatibility. Application of the principles of diversity and interspersion, I believe, can help create and maintain this compatibility.

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PLANNING PITFALLS

by James H. Freeman, Director, Programming and Land Use Planning, USDA Forest Service, Eastern Region, Milwaukee, Wisconsin,
Symposium of Intensive Culture of Hardwoods, University of Maine, Orono, Maine, July 22, 1976.

The subject this morning is planning and the problems peculiar to planning for management on public lands. As I am sure you know, we could devote entire seminars to problems encountered in planning. However, within the scope of the program today, we have the opportunity to touch briefly on some of the more important highlights of planning with the focus on major factors that influence the usefulness and continued viability of our plans.

When we consider long and short range planning involving forest resources, it is well to remember the hierarchy of plans that has evolved over the years. With the development of the assessment and subsequent program required by the Resources Planning Act, the Forest Service has seen the top planning level of our hierarchy of resource land management plans come of age. The hierarchy of plans can be illustrated in this fashion with the R.P.A. program being represented at the national level. (Table a)

1. Note the mix of management plans and budget, and programming activities.
2. The downward flow of direction and,
3. The provision for feedback.

Why is this hierarchy important to us?

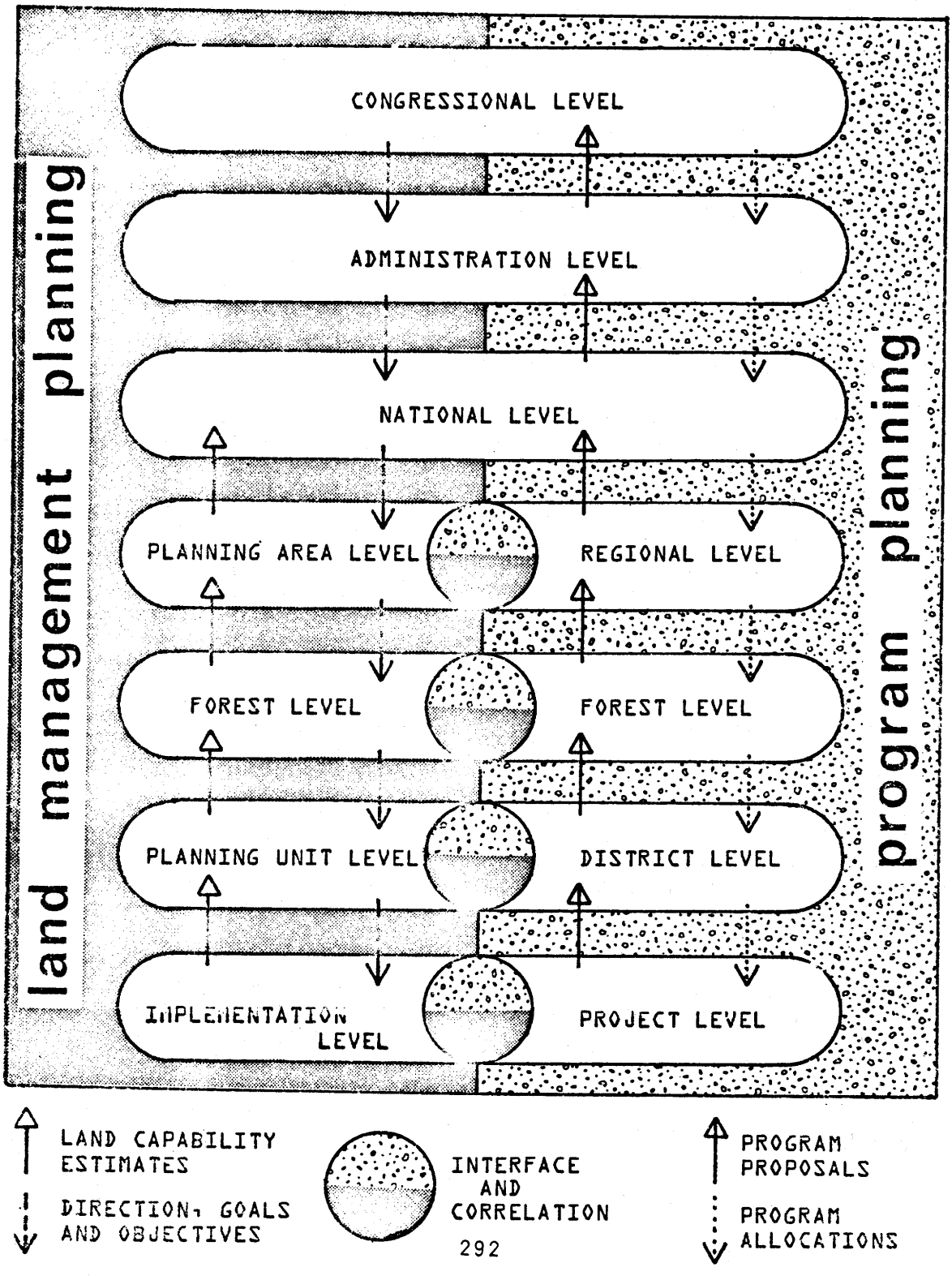
For one thing, it helps to inject a sense of structure and organization into the overall planning process. That structure, keyed as it is to organization level reinforces our ability to build a set of dependent plans that are responsive to both direction and objectives set from higher authority, and to knowledge of local concerns and land capabilities developed at ground level.

It also serves another very important purpose. It visually illustrates to us the intended interdependency of the land management planning, the programming of activities, and the actual funding of projects.

So, now we can begin to relate to a basic question that I believe must be answered in the minds of the people engaged in a planning job. To be at all successful, a planner or planning

TABLE a

FOREST SERVICE PLANNING RELATIONSHIPS



team must understand why a planning activity is necessary or desirable. This seems basic but it is surprising how often people can lose sight of their basic purpose as they become emeshed in the process of developing a plan.

So, why do we plan? In the National Forest System, we plan in order to achieve selected (directed) objectives in the most effective, efficient manner available. A fairly simple statement. However, in practice the question becomes more complex; and we replace the original question with several that are more difficult to answer.

What are the objective(s) we wish to achieve? How will we measure effectiveness? What yardstick will we use to measure efficiency" How will we know when we have satisfied our objectives? What time factors are involved?

You may feel these are all rather basic questions with obvious and mutally understood answers. However, failure to deliberately address each of these areas and to reach mutual understanding on the answers between members of a planning team is a common pitfall in many troublesome planning efforts.

When it comes to objectives, it is necessary to distinguish between what I call "planning" objectives and the final output related results or management objectives that are the end product of the plan directed actions. For example, planning objectives are fulfilled for the most part through the process of developing the plan. They may include such things as, "provide an opportunity for local and county officials to participate in the planning process, or to involve specialists in the fields of anthropology, forest economics, and landscape architecture in the analysis of alternative courses of action."

On the other hand, management objectives relate to the primary results desired and are usually achieved as a result of carrying out actions prescribed by the plan. Examples of such objectives include: provide for an annual timber harvest level between X cunits and Y cunits by 1990, provide dispersed recreation opportunities for 900-1100 PAOT by 1985, maintain wildlife habitat diversity at current levels and so on. These objectives, quantified and dated, become planning guides and later are the yardsticks against which the ultimate success of planning and execution is measured.

So far so good, except that about now someone usually says, "just a minute." "You haven't described any planning activities yet and already you have established your output targets." "You've come to the bottom line before you start." "Where did those management objectives come from?" If you have already decided what you are going to do, there really is no use playing all these planning games!"

There is a parable that is aprepo here that says, "Any road is a good road if you don't care where you're going," and by the same token, any plan is fine if you don't care what the results are. Without objectives, there is very little to use to determine whether a plan and its alternatives is even heading in the right direction. So I look for those management objectives and I find them as assigned targets contained in plans prepared at a superior level. Failing that, as is occasionally the case, objectives must be developed from an analysis of such things as: historical use patterns, predictions of future demands, timber survey reports, and population and economic growth predictions.

Objectives developed from such analysis must always be agreed to by the line officers responsible for making final decisions and approving the plan before proceeding.

There is a reward for this effort, for now that objectives are established and agreed to, the planning serves several purposes among which are to: test the capabilities of the area you are considering to provide the desired mix of output benefits, and to develop a number of alternative strategies for delivering the desired results.

A common problem area is a failure to do an adequate job of preplanning. An important product of preplanning is a PERT chart or general bluepoint for carrying out the planning process. A number of different display charts can be developed, but it is important to build these planning progress and schedule charts on a large enough scale to put on the wall and mark up on a daily or weekly basis. That way, important dates are least likely to be missed and jobs will generally proceed in the desired sequence.

During this preplanning phase, the individual who will ultimately be responsible for making the decisions has several critical duties.

One of these duties is to determine, to the extent possible, the major factors that will influence or have a bearing on the decisions that are anticipated. He may identify aesthetics, benefit/cost, soil movement, or other factors that his experience has lead him to regard as critical to decisionmaking in his area. This identification of decision influencing factors is by no means final at this stage, but it will help him identify the makeup of skills needed on the initial planning team. It is also useful in identifying the data needed during planning. This helps to offset a tendancy of some planning teams to get mired down in purposeless inventory and data collection.

Usually, the preplanning phase also will include an intensive training session for all members of the planning team. This training serves an essential function in addition to providing

information on the expected planning process. That essential is the first step in the team-building process, which molds the individuals assigned to the planning job into a fully functioning group.

In the "preplanning phase" it is also time to begin the public involvement connected with the planning process. This in itself is a broad enough subject for a separate symposium so I'm going to simply say that the public involvement actions developed for any particular planning activity must be carefully designed to elicit full participation from the publics involved and must avoid meaningless meetings or requests for inputs for which there is no planned use. The key is early involvement in the process coupled with realistic use of the opinions and comments received. There is no use asking for comments or opinions on matters that cannot be adjusted as a result of the public comment and these items are often well identified as basic assumption or management direction.

Data collection seems to be a common stumbling block for many planning teams. The tendancy of many planners has been to try to collect much more information than is needed or really used in the decisions.

In some instances, of course, the collection of data is aimed at covering every conceivable, even remotely related, question. All this data is nice to have and may even be useful at some future time. However, quite often extra data collected on the basis that it may be useful sometime only confuses the issues when it comes to making decisions for the short time. I'm not advocating a careless disregard for the full range and variety of resources and factors that bear on any resource decision. I am saying there is a great need to make deliberate decisions early in and during the planning process, on what data is really needed to make the alternative selections, and on how that data will be used. Not only can this save time and prevent confusion, but there are some real cost factors involved in collecting, storing, and maintaining data.

A common rebuttal to deliberate limitations on data collection is to refer to possible challenges that may be forthcoming from some of the publics. Here our public involvement can serve as a very useful and sensitive sounding board. Continually during the process, the sensitivities and concerns of a wide variety of interests can be sifted and weighed to help determine the final decision criteria and the data needed for support. We have a number of tools to help us do this, and Here I refer you to the work of Dr. John Mendee and Roger Clark of the Pacific Northwest Forest and Range Experiment Station, and George Stankey from the Intermountain Station in developing the CODINVOLVE system for analyzing public comments. Their system isn't complicated but it is certainly useful in helping to organize and keep track of comments from all kinds of sources.

It must be understood that I am not suggesting that we can respond effectively to all challenges and questions through intensive public involvement efforts. What we can and do accomplish is to develop heightened sensitivities to peoples' concerns and values as they related to specific issues. This heightened sensitivity may help make our final action as responsive as possible to peoples' current needs as we can make them. And that's what we in both the public and private sector are working for.

The analysis of the data leading to decisions can employ many techniques ranging from computer assisted techniques to simple graphic comparisons. A key is to keep it simple and with a highly visable or traceable thread of logic.

Although the need to keep the analysis as uncomplicated as possible to provide for maximum understandability is great, there are several items that commonly need improvement.

One is economic considerations. It is imperative that we indicate, in our planning and analysis, the benefit/cost ratio we anticipate from our proposals. We must be able to identify the long term return on the investment we are recommending, and we should also be able to compare alternative courses of action in terms of long range returns and costs.

Another item for analysis that is often a problem is the determination of the effect of proposed or considered actions on archaeologic, cultural or historic features. Here the problem often lies with whether or not the issue has even been addressed. If no historic features are effected by any of our proposals, we must so indicate in our environmental analysis reports or statements and documenting evidence must be cited. Failure to address this issue has resulted in unnecessary delay and frustration. The key to dealing with the cultural, historic, or archaeologic resource is to address the issue squarely. Conduct whatever level of field reconassiance or survey is needed. Verify the presence or absence of cultural resources. Then deal positively with the subject according to Federal law and requlation.

The final point I would share with you today has to do with the need to provide easily traceable and visable evidence of the rationale used in making decisions. Many people, both from within the Forest Service and from other walks of life, are interested in decisions of public officials. Often all that is sought is to be able to easily trace through an open and understandable train of logic to a decision point. This doesn't guarantee agreement, but it may help build trust in the process followed. This may, in turn, lighten the case load of requests for administrative review and build credibility in our decisionmaking.

In covering this potpourri of problem points in public land management planning, I have not attempted to prescribe a cure all for all public planning efforts. Hopefully, some additionaly attention to some of the points I have touched on briefly will help smooth some of the wrinkles out of your planning efforts.

PLANNING FOR & IMPLEMENTING INTENSIVE CULTURAL
LONG & SHORT RANGE PLANNING

by Lester W. Hazelton, Director-Timberlands, Planning & Development, Great Northern Paper, Millinocket, Maine.

Abstract

Great Northern Paper, a major industrial forest owner in Maine (2,000,000 acres), began a program for more intensive silviculture in 1972. The first step has been a major woodlands reorganization into five geographical districts with forest management and procurement responsibilities delegated to these districts. This has been accompanied by a re-inventory of timberlands and development of a new computer-processed resource and information system (WIPS). Current and future major emphasis will be placed on improved administrative procedures for the very close coordination of wood procurement, logging and forest management functions to insure the realization of the maximum growth and quality potential of Great Northern's timberlands.

Introduction-background

Great Northern Paper, a division of Great Northern Nekoosa Corporation, is a major forest products manufacturer and forest owner in Maine with approximately 2,200,000 acres of total ownership. Initial purchases were for approximately 350,000 acres in 1900 with subsequent purchases taking place through to the early 1950's. Since that time, land sales, exchanges, and State park establishments have reduced total ownership, but Great Northern still retains nearly 2,000,000 acres of forestland. Our principal use and demand on this forest has been for the spruce (Picea (L.)) and fir (Abies (L.)) timber found in its softwood types.

The initial working or forest management plan for Great Northern's timberlands was developed by the U. S. Forest Service's forerunner, the old U. S. Bureau of Forestry, in 1904. It is interesting to note that the Bureau of Forestry's (Mr. M. C. Hodge, Jr.[1]) initial recommendation for operating these timberlands (365,000 acres) included minimum diameter limits on spruce of 12", on fir of 8", a projected cutting cycle of 53 years, and a cut regulation of 6,338 acres annually, with annual harvest volumes of 13,437,000 fbm. Although Great Northern has revised its forest management plans periodically over the past 70 years the initial thinking and silvicultural concepts which went into this original plan are still alive, still valid, and still form the basis for the recommendations made today by our present staff

of foresters.

Great Northern's most recent plan revisions and developments for more intensive silviculture began in 1972 with a basic reorganization of the woodlands department into five geographical districts. This change was made concurrent with a major re-inventory of our total timberlands and the decision to develop an improved resource information system.

Our present and future emphasis for improved forest management will be on the actual administration of the forest and improved harvest operations to insure that Great Northern achieves the full potential in growth and economic returns from its timberlands. Thus the following brief case study of a planning effort by one large corporate owner will consider - I The Organization, - II The Information System and - III The Administration for that Forest Resource.

I ORGANIZATION

In 1972 Great Northern's demand for total softwood reached nearly 1,000,000 cords annually. This total demand on the forest resource had been carefully assessed during the 1960's and the supply was considered adequate to support it. However, in projecting for long range future supply on a state/national basis, including recent regional expansions in wood consumption, Great Northern made a considered decision to improve its own posture in relationship to the total forest resource. The first step was a basic reorganization of its Woodlands Department and in the functioning of its procurement-forest management responsibilities. A considered objective was to delegate and incorporate forest management responsibility more closely to the forest, to the stump itself, and to the people directly in charge of forest harvest and management operations.

Great Northern's total wood draw area includes nearly 40% of the State's total forest area, (6,000,000 acres) and a million acres or so of forest land in New Brunswick and Quebec. This area, influenced considerably by Great Northern's own land ownership pattern, was divided into five principal procurement-management districts. These districts range in size from 1,000,000 acres to 2,000,000 acres with GNP forest ownership in the districts ranging from a minimum of 100,000 ± acres in our Penobscot District to over 1,000,000 acres in our West Branch District.

The districts themselves for forest management purposes will be further divided into management units, consisting of several townships, with each township divided into individual planning units. The planning unit itself is a refinement of the old

standard forest compartment and is designed to be the basis for all information and forest planning.

The major personnel and responsibility changes in our new district system have been the increase in forestry staff within each district and the direct delegation of nearly all forest management activity and responsibility to the district superintendent.

Previous to 1972, Great Northern had a loosely structured Purchased Wood and Operated Wood procurement districting with total forest land management responsibility centered at the Woodlands Department headquarters (Division of Forest Engineering).

For a large industrial forest owner and consumer of the forest, who is as concerned with the economics of the harvest as with forest growth, this close integration of responsibility for the success of the total system is critical. We have been pleased with many features since inaugurating this new districting (more innovative thinking by field forestry personnel) but we still have much to do to fulfill original organization objectives.

II RESOURCES INFORMATION SYSTEM

As Great Northern considered its position in regard to silvicultural decisions, softwood supply and also expansion into other products, it became apparent that an improved resource information system was a necessity. Great Northern's last complete inventory of its forest lands had been performed in 1953. Since that time inventories had been kept current through systematic measurements of growth plots and, of course, harvest deletions. The existing inventory records for softwoods were considered accurate, and in fact have been so confirmed by the recent re-inventory conducted by the James W. Sewall Company (completed in 1976). However the hardwood volumes and other miscellaneous species had not been as well addressed. These considerations, plus the need to develop a total computer-processed forest data base on which to develop supply-demand projections, silvicultural and land-use programs, prompted a management decision for a complete and new inventory of the forest. This re-inventory was finished last month.

The new forest inventory will become part of, will be controlled by, will be manipulated, and drawn upon by a newly installed forest resource information system (GNP-WIPS - Woodlands Information & Planning System[2]). This system, of course, is computer processed. The principal design work and installation of this new system has been the prime responsibility of Mr. L. O. House, a recent staff addition to Great Northern's Woodlands

Department.

Briefly summarized, the WIPS system will furnish us with the following:

1. Effective and rapidly developed long and short range harvest options for basic planning units, management blocks, districts and for the total woodlands' operation.

2. Effective and rapid update of information for the total forest resource and the total land area (Land Use Planning).

3. Rapid evaluation of varied silvicultural systems, their effect on the total forest and on district forestry management.

The WIPS system as presently structured consists of the following subsystems:

- A data base - the informational heart of the system.

- A master file - for each basic planning unit (2,000 to 4,000 acres), an informational filing system on microfiche for district and staff day-to-day use.

- Pre-operation evaluation - stand and operational cruising for product volumes and silvicultural information.

- Inventory updating - growth and inventory plots randomly located.

- Growth and yield simulation - prediction of future stands.

- Capital investment evaluation

- Short range planning

- Long range planning

Although the development of this total information system is far from complete we have already begun to reap some of the benefits from it. Cruises this past spring for example have been rapidly computed (within 1 or 2 wks. after completion) with a wealth of necessary stand information available for district

foresters to make more accurate silvicultural and operational recommendations.

Because of the size and complexity of this natural forest we are dealing with in Northern Maine, it is almost mandatory that we develop all available and pertinent information prior to making silvicultural or operating decisions. We believe this system under development will provide that information.

III ADMINISTRATION OF OPERATIONS

A viable forest management organization to structure the forest, the operations and its people is one important phase; vital and pertinent forest stand information is certainly another; but the actual operation itself - the planning, harvest, transport, and conversion of products, road construction, fire protection and forest practices - is the pay-off and the culmination of the process.

There are many planning and operating areas which we consider important and critical to intensive silvicultural development.

Some of those most important to Great Northern are:

(1) - Research

(2) - Road construction

(3) - Logging systems

(4) - Silvicultural criteria

(1) Research: The principal and first new position created in order to accelerate our development of intensive silviculture was that of Research Forester. The objectives of this position are in the field of applied research, to test and implement improved silvicultural techniques in our softwood types. Our emphasis to date has been in the area of regeneration. We have a pilot greenhouse and planting program underway.

(2) Road construction: The very wording "intensive culture" implies travel access to, and on the land in order to apply silvicultural practices. In 1904 the U. S. Bureau of Forestry recommended a 53 year cutting cycle for Great Northern; by 1955 P. K. Patterson, then Superintendent of the Division of Forest Engineering for Great Northern Paper, recommended a 30 year cutting cycle for the ensuing 10 year period. In 1976 we are realistically planning on 20-30 year cutting cycles where possible and feasible under the selection system. By 1986, certainly with the virtual completion of road systems onto GNP townships, we should

be able to consider 15 and 20 year cutting cycles in nearly all areas where we are applying a selection system or uneven-aged management.

Intensive silviculture on large forest ownerships depends on a well designed and economical transport system.

(3) Logging systems: So closely is logging and harvest technology wedded economically, and dependent on the tree and the land that we may assume they act and interact as one total and integrated system. To consider silviculture apart from the techniques, the machines and the men who work the forest, who actually conduct the harvest, is to deny this integration and to forfeit its benefits.

The forest which Great Northern harvested in 1945-1955 was in large measure influenced and created by the men and logging technology of the early 1900's. The forest stands which we are harvesting today were created for us by the men and machines of the 1940's and 1950's; and we also are creating anew, the forest for the loggers and forest managers of the 1990's and 2000's.

Great Northern, in its own logging development, (T. A. Wildman, Logging Engineer) is actively engaged in seeking out and testing those machines and systems which have the flexibility and capability of many and varied silvicultural applications - clear-cutting, thinning, timber-stand improvement, site preparation and planting. The wheeled skidder itself of course is a remarkable forest machine which has been specifically developed over the past 15 years by foresters, loggers and logging engineers - the economic benefits for forest industry have been substantial.

(4) Silvicultural criteria for Intensive Management: The criteria for tree harvest on an extensive basis in our spruce-fir types has been varied over the 75 year period. We have noted the original forestry cutting recommendation by the Bureau of Forestry as 12" on spruce and 6" on fir. This criteria was not followed - in the heavy budworm salvage years and afterward into the 1930's, stocking on GNP lands was so reduced that operations were conducted in stands containing only 4-5 cords per acre of spruce and fir. In 1955, however, GNP set overall diameter limits of 8" on spruce and 6" on fir for its cutting policy. In 1963, long range cutting programs (5 year) were outlined using a 10" minimum diameter class (DBH) on spruce and 6" on fir to backup ongoing marked selection cuts in spruce-fir stands. These criteria since 1955 have been generally followed in stands where application was feasible.

Great Northern, in its current program to intensify forest management on its forest lands, will establish cutting standards

and criteria on a stand basis, with the overall responsibility for setting standards and controlling silvicultural practices delegated to district forestry staffs.

Specific criteria

(a) Stocking: We have accepted the basic guidelines and goals for spruce-fir stands as developed by the Maine Chapter of the S.A.F. in their recent publication "Forest Practices, Goals and Standards", issued in December 1973.

(b) Cutting cycles: On those areas and stands where a selection system (uneven-aged managment) is deemed feasible we are recommending a 20 year cutting cycle. Our previous projected cutting cycles for 1955-1975 had been based on 30 years. In this instance, of course, stand condition and road systems have been a principal determinant.

(c) Spruce budworm salvage: In our efforts to respond to the damages and losses due to the spruce budworm we have also had to set some basic criteria. In selection cuts we will harvest fir to a 6" minimum diameter. In stands to be clear-cut for salvage/pre-salvage operations, a minimum volume/basal area of fir of 30% has been chosen as an initial guide.

All spruce-fir stands, of course, are assessed and rated on a priority basis for current and prospective budworm damage. Operating plans are based on this assessment.

The above silvicultural criteria are an indication and example of our overall approach to a more intensive management system. We find ourselves in the midst of this planning process and a great deal remains to be done.

Conclusion: Great Northern is developing and intensifying its forest management by a careful step-by-step approach, based on assignment of forestry responsibility directly to the forest practitioner, by building a good resource information system, and developing administrative procedures which more closely integrate the total forest activity cycle of regeneration, growth, and harvest.

In closing I should like to respond briefly and directly to Mr. Hodge (in absentia) from the U. S. Bureau of Forestry. His final recommendation and dictum to Great Northern Paper in his report of 1904 was as follows:

FORESTER

"It is recommended that the Company employ a forester perma-

nently, whose duties shall be: To decide what areas should be cut; to supervise the marking of trees; to inspect and criticize logging contracts; to supervise the protection of the tract - - - -"

To Mr. Hodge: Great Northern Paper has hired a forester - several of them, in fact, whose duties are substantially as you have recommended. We hope to achieve, in time, a forest management program as well conceived as the original working plan which you developed for us in 1904.

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[1]M. C. Hodge Jr., "Working Plan for Penobscot Timberlands-GNP Co.", 1904.

[2]Kwen M. Du and L. O. House, "Woodlands Information and Planning System," Systems Analysis and Forest Resource Management, ed. J. Meadows, et al, (Bethesda, Maryland: Society of American Foresters, 1976), pp 427-32.

SMALL WOODLAND OWNERSHIP MANAGEMENT

by Albert J. Childs, SRA, RPF, President, Eastern Forest and Land Management Company, a Division of Eastern Appraisal Company, Portland, Maine

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Small woodlot ownerships are a commodity on the real estate market which have cycled through a supply and demand curve on a somewhat irregular basis. In order to have some understanding of what it is we are talking about, it is necessary to define what a small woodlot is, and where it may be found. In size these parcels can range from ten acres to fifteen acres on up to fifteen hundred acres to two thousand acres. Geographic locations encompass the entire Northeast. Most of our our larger communities encompass a few forest production parcels within their municipal boundaries, and these are the properties that we see being developed yearly for commercial and residential purposes. The outlying urban and rural areas of the organized communities have their land base created almost entirely by these tracts. The magnitude of this forested area is startlingly apparent when you fly over the Northeast and see the relatively small amount of land intensively developed as opposed to woodland acres.

If we have all of this forest land on the face of the earth, then who owns it and what are they doing with it? At this point we enter into the real problems and address the challenge to the managing forester. Land ownership patterns have been changing since Columbus made a right turn at the Azores and landed on our shore. From that time forward the scribes, lending merchants, lawyers, and real estate brokers have done a tremendous job in complicating the management of our small woodland parcels. In recent years probably no faction has had more influence on the existing ownership pattern than real estate brokers and entrepreneurs, with considerable help from environmental groups along with the declining stock and bond market.

The real estate brokers and entrepreneurs have tracts of land in all sizes for a variety of reasons. While most statistical surveys use a so called average buyer or average real estate owner, I have yet to see or truly identify with that individual. In our business

the average land owner does not exist and each property owner is an individual in his own right with individual motivations and opinions. A forester who thinks otherwise may be headed for a real public relations problem, to say nothing of managerial and legal problems. Some consistent characteristics of small woodland owners do appear quite frequently such as: 1) principal employment is of the skilled or professional field, 2) woodland properties are acquired primarily for investment either on a short term or long term basis, 3) initial acquisition is generally made during a period of time when the owner's personal financial situation is optimistic, 4) typically there is no comparative investment analysis made by the buyer with other forms of investment prior to acquisition. Again, it should be pointed out that these are only characteristics frequently seen or discussed with small woodlot owners and are not a statistical conclusion, but rather an observation.

With all of this as background we can now discuss management philosophy and goals. A basic philosophy for the management forester must come primarily from the owner's attitude and reasons for ownership and ultimate objectives to be accomplished through land management. The most frequently discussed objectives of ownership include conservation, generation of periodic income, or capital gains to be derived through real estate appreciation and ultimate sale of the property in gross. An individual who owns property for conservation purposes offers an opportunity to manage a parcel of land on a relatively long term basis, with the least probability of disruption through sale of the property. The second form of ownership objective, namely the generation of an income stream, is probably one of the most tenuous because the income that can be derived from a small woodlot is going to be periodic at best. In most cases it will not offset actual cash carrying charges if the property was acquired at current fair market value with a debt service requirement and return on equity desired. This is not to say that a small woodlot parcel cannot be managed on a profitable basis when long term appreciation and capital gains are considered, but rather that foresters managing lands owned primarily for their income generation potential should be cautious in their goal setting procedures and not extend them out over a long period of time.

Quite frequently owners who are looking to an income from the land for repayment of debt or purchase monies may find themselves in a position where sale of the property is necessary due to a change in their own

personal finances. This can be caused by a change in other financial circles that has nothing to do with the land on which the forester is working. The third category of land ownership is the objective of a capital gain to be received by the owner at some future date when the land is sold in gross. This form of ownership objective offers some variables to the general management scheme. The forester must be aware of changing land uses in order to orient his harvesting and management practices toward a form of use that will increase the overall property value as required by the owner. Again, we must be prepared to recognize that management of lands held for this purpose could quite reasonably be of relatively short duration and that probably a conversion of use is anticipated at some future date.

After considering the various objectives of the land owner a forester must then examine his property for development of the management policy and method of achieving the basic goals. Properties owned for conservation purposes lend themselves to the standard silvicultural practices where TSI (Timber Stand Improvement) or harvesting of merchantable timber is indicated. Here in the Northeast it is extremely difficult to justify TSI on all but the highest quality species and stands if the economics and financial requirements are considered on an investment basis. A managing forester must have a working knowledge of cost accounting to include calculation of debt service on the land, return to equity investment, and the incremental additional charges for interest on invested capital for supplemental improvements. TSI is a capital improvement to the land and should be treated as such for capital gain accounting purposes as well as the need to know what your actual costs are to produce a given volume of work.

In cases where a capital gains objective is the purpose for ownership, the forester must be aware of short range costs deferral methods. His management plan must be geared to abstract from the land the maximum goods or services on a short run basis without deminishing the owners potential for profit at some future date. This form of planning requires a rather extensive knowledge of general land uses in the immediate area of your management property and should include a general knowledge of regional and national affairs affecting the real estate market.

It is wise to be prepared for the unexpected, and hence a "bust" program should be devised for each such parcel

in the event that the owner becomes financially shaky. This event may require immediate working capital derived through the sale of the managed property. In order to be prepared for such an event, and to properly prepare a medium to long range management plan, it is necessary that the forester be familiar with marketing strategy for both products and the land itself. Real estate, which is the item a forester is managing, is not classically known as a liquid asset. In other words, you cannot predict with any degree of certainty the exact length of time it will take to sell a particular parcel of land at its market value. It is even difficult to predict how long it will take to sell a parcel of land at liquidation prices. In order that a forester be relatively familiar with time segments required for marketing, a constant vigil must be kept on the activity of the general real estate market and who is dealing in it.

Another relatively recent problem which confronts the managing forester is the changing environmental and zoning codes initiated by all levels of federal and state government. These codes not only affect the way and procedures by which the land can be managed, but also has a decided effect on the economics of forest land ownership. In recent years we have seen productive timber land removed from the productivity classifications without any reimbursement to the land owner, merely on the basis of environmental safeguards. This form of zoning and loss of revenue production property may, at some future date, be pronounced an environmental taking similar to the eminent domain proceedings commonly used throughout the land. However, today we must live with, and manage, the small woodlots under an ever-increasing restrictive public policy. An awareness of land law and environmental law is an absolute must for the professional forester in order to advise his client on the affect of such law, and to explain why his income producing base has diminished. With the unquestioned fact that real estate taxes, carrying costs, and demand for forest land for other purposes is on the rise will unquestionably make the managing forester's job more challenging and more profitable to himself. Small woodland management is merely the implementation of what is commonly called the Six "P" rule, i.e., "Prior Planning Prevents Piss Poor Performance."

EFFECTS OF TAXATION ON THE PLANNING AND IMPLEMENTATION OF INTENSIVE TIMBER MANAGEMENT

by David B. Field, Associate Research Professor, School of Forest Resources, University of Maine, Orono

Abstract

Taxes on forest properties and on income from timber disposal impose one of the most significant kinds of cost burden faced by owners of interests in forest lands. Local property taxes impose annual charges regardless of the level of management, and may even be increased by intensive practices. Federal and state income taxes are usually second in impact only to property taxes. Federal transfer and state death taxes can seriously endanger the continuity of management programs from one generation to another. Taxpayers can significantly reduce the impacts of these taxes by an awareness of the advantages and pitfalls in each as they apply to timber management.

DESPITE THE FACT that many economic analyses of timber management options omit tax considerations as being "too complex" or "too variable", an oversight or error of judgement in this area can have a far greater impact on the profitability of a venture than will an error in many of the elements of analysis on which a great deal of effort is usually expended. Timber owners judging the desirability of intensifying management practices may fail to take adequate account of probable tax impacts and may fail to recognize readily avoidable pitfalls or available tax advantages. This paper offers a synthesis of the rules and effects of the major taxes faced by forest land managers, of both large and small ownerships, with respect to decision-making on matters of intensive timber culture.

TAX LAW FUNDAMENTALS

Taxes imposed on forest landowners include: 1) income taxes, 2) general property taxes, 3) transfer taxes, and 4) sales, excise, and other special levies.

Special taxes can be substantial, as those paying Maine's spruce budworm charges of 28¢-56¢ per acre would be quick to agree. However, with the possible exception of that complex and still-evolving scheme, special taxes tend to be rather stable and show little change in impact under different management decisions. The remainder of this paper concentrates on the other three types.

Federal Income Taxes

One of the most important tax burdens faced by a forest landowner in the United States is the Federal income tax. Individual taxpayers face a levy (1975) of from 14% to 70% of their adjusted gross income. Corporations pay 20% of the first $25,000 of taxable ordinary income plus surtaxes that increase the rate on the next $25,000 to 22% and on amounts over $50,000 to 48%. (These rates resulted from the Tax Reduction Act of 1975. Unless that law is extended, corporate rates will revert in 1976 to the former levels of 22% of the first $25,000 plus a surtax of 26% of income in excess of $25,000.)

The Federal income tax is levied on net income, that is, on the proceeds of an investment or business venture less the costs of earning those proceeds. The basic idea is that you should not be taxed for income that simply replaces costs of earning that income. Deductible costs include annual outlays for the "ordinary and necessary" expenses of carrying on a trade or business, gradual recovery of investments in long-lived assets, and expenditures for the carrying charges, such as taxes and interest, of holding a business property. Individuals, moreover, may deduct from their ordinary income, from all sources, ordinary and necessary expenses for the production or collection of income, or for the management, conservation, or maintenance of property held for the production of income, even though no formal trade or business is involved.

The ways in which the costs of forest ownership and management may be recovered, for tax purposes, are outlined in Figure 1. Three kinds of expenditure may be involved: 1) capital expenditure, 2) revenue expenditure (expense), and 3) carrying charge. Capital expenditures are costs of acquisition of long-lived property or property rights, or permanent improvements that increase the value or extend the life of property already owned.

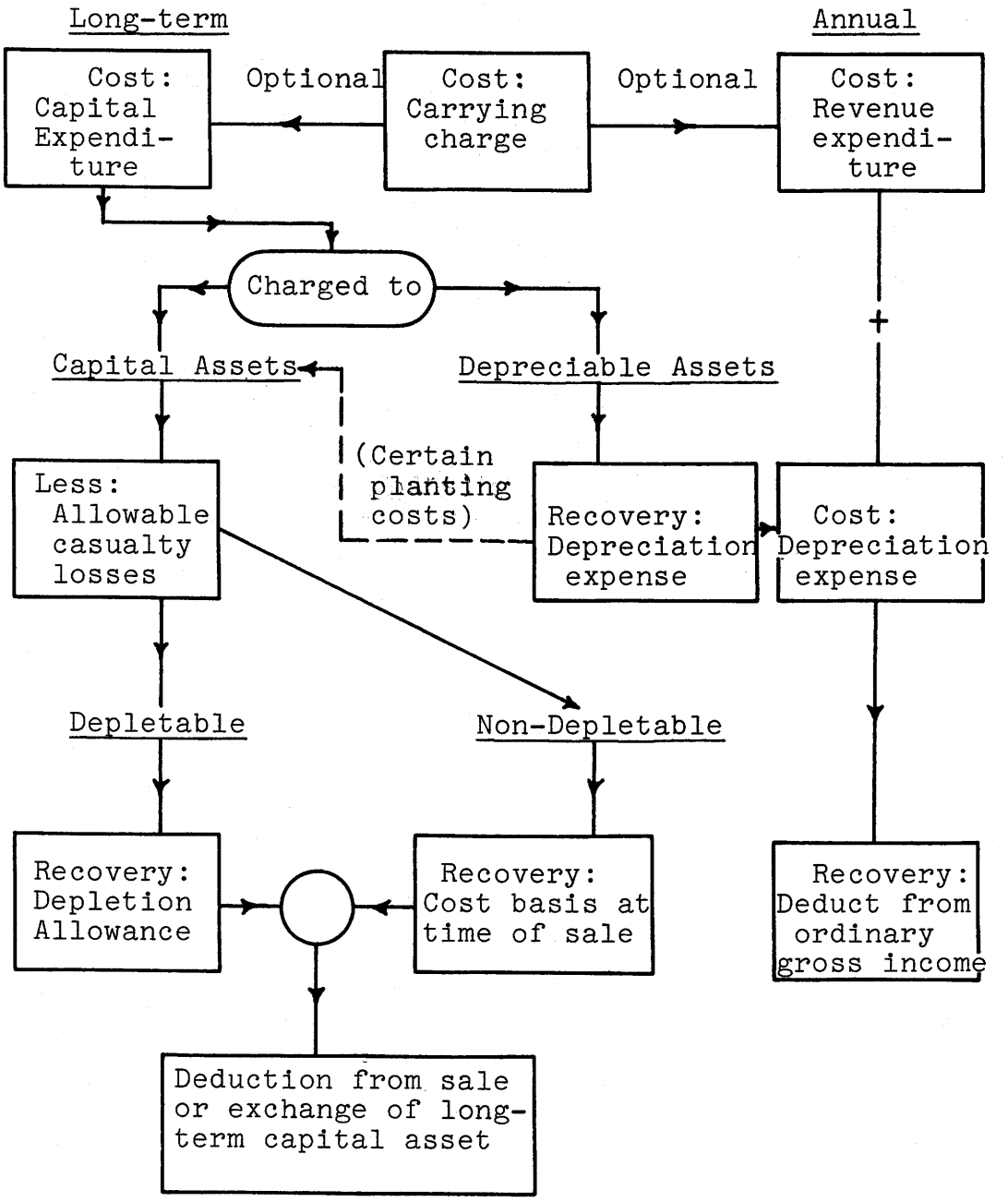

Figure 1. Recovery, as Federal income tax deductions, of the costs of forest ownership and management.

Such assets are classified under tax law as either depreciable or capital. Depreciable assets are defined under Section 167 of the Internal Revenue Service (I.R.S.) 1954 Code as property with a limited and determinable useful life of more than one year which must be used in your trade or business or be held for the production of income. Investments in such property are recovered through a gradual writing off of their cost against ordinary income as the assets wear out or become obsolete. (The term "amortization" is commonly used to refer to the depreciation of intangible assets such as management plans and maps.)

Capital assets are defined by exclusion in Section 1221 of the 1954 Code as any property held by a taxpayer (not necessarily a business property) except: 1) stock in trade or other inventoriable property, 2) property held by the taxpayer primarily for sale to customers in the ordinary course of his trade or business, 3) Section 167 depreciable property used in the taxpayer's trade or business, or real property so used, and 4) accounts or notes receivable acquired in the ordinary course of a trade or business. Investments in capital assets can be recovered only when the assets are disposed of. Costs of "wasting" capital assets, typified by natural resources such as timber and minerals, are recovered by deducting, from disposal proceeds, a pro rata allocation (termed "depletion") of that cost to the units removed from the property, as allowed by Section 611 of the 1954 Code.

Federal income tax law includes three major tax reduction incentives designed to encourage investments in long-lived assets, on the assumption that such investments are beneficial to the health of the national economy. None of these provisions were created to encourage forestry specifically--they apply to all business and other income-producing ventures--but their influence is of great importance to the timber owner. I will discuss, in turn, accelerated depreciation, the investment credit, and the preferential treatment of income from the disposal of capital assets.

Accelerated depreciation. Straight-line depreciation is the regular deduction, from ordinary taxable income, of an equal portion of the cost of a depreciable asset (less any estimated salvage value) over the expected life of that asset. To encourage reinvestment, Federal law allows taxpayers to accelerate the deprecia-

tion write-off by as much as twice the normal rate. Moreover, certain kinds of personal property qualify for a first year deduction of 20% of cost in addition to regular depreciation.

Investment credit. An income tax credit can be a far more significant incentive measure than an expenditure deduction. The latter simply reduces taxable income, hence lowers tax payments only by a multiple of your tax rate. A credit, on the other hand, is a direct deduction from the tax liability itself. The investment credit is applicable to depreciable property with an estimated useful life of three years or more and to "qualifying progress expenditures". Property covered by the credit includes, in part, tangible personal property used as an integral part of manufacturing, production, or extraction activities. Qualifying progress expenditures are amounts actually paid for the construction of these kinds of property if such property has a normal construction period of at least two years and an estimated useful life of at least seven years. The investment credit allows a deduction from your tax bill of 10% of the cost of a qualified investment in covered property for the year in which that property is placed in service, or for 20% of the full amount of qualified progress expenditures made in that year. A qualified investment is one-third of the cost of new or used property with an estimated life of three to five years, two-thirds of the cost of new or used property with an estimated life of five to seven years, and the full cost of property with a useful life of seven or more years. (The full value of used property claimed cannot exceed $100,000.)

Capital gains. Gains or losses from the sale or exchange of capital assets are granted special treatment for tax purposes. This incentive takes the form of a special exclusion for individual taxpayers and a preferential rate for corporations. A capital gain is the excess over the adjusted basis (usually book value) of the amount realized from the disposal of a capital asset. Such a gain is either long-term or short-term, depending on whether the asset has been held for longer than a required holding period (currently six months). If an individual taxpayer's net long-term capital gain exceeds his net short-term capital loss, he may claim as a tax deduction 50% of the difference. This exclusion applies regardless of tax bracket. Thus, the effective tax rate on an individual's net long-term capital gains

is only half that of his ordinary rate.

An individual is entitled to calculate his tax liability in two alternate ways, and to pay according to the approach which yields the smallest tax. By the first method, no tax at all is paid on 50% of the long-term capital gain and ordinary tax rates apply to the balance. In the alternate computation, a taxpayer whose net long-term capital gains do not exceed $50,000 may take the 50% capital gains deduction, compute a partial tax on the residual taxable income, then add 50% of the capital gains deduction to the result, for a maximum effective tax rate of 25%. Taxpayer's with net long-term capital gains of greater than $50,000 may use an alternate computation which, in effect, taxes the first $50,000 at 25% and the balance of the gain at higher rates (maximum of 35%).

The tax rate on net corporate long-term capital gains is a flat 30%. Corporations may also calculate their tax liability in two ways and pay the lesser of the two. The regular tax is found simply by applying the regular rate to total taxable income. The alternate tax is calculated in two steps: 1) Apply the regular tax rate to total taxable income, less the excess of net long-term capital gain over short-term capital loss. 2) Apply the capital gains rate to the long-term capital gain. The alternate tax is the sum of these two. Whether a corporation benefits from the preferential capital gains rate depends on its tax bracket and the relative amounts of its capital gains and net ordinary income.

Clearly, Federal income tax law offers some powerful incentives for long-term capital investments. But, there are two considerations which moderate the beneficial effects. First, current tax law levies a surtax on both individuals and corporations for "tax preference items" in excess of $30,000, less certain deductions. These items include amounts claimed for accelerated depreciation in excess of allowable straight-line deductions, and capital gains allowances. Secondly, deductions for capital expenditures may be used to offset capital gains income only, and may not be charged against ordinary income. Thus, they reduce tax liabilities at capital gains rates rather than the usually higher ordinary rates. This is a key point to keep in mind in the discussion of the effects of Federal income taxes on forest management, presented later.

State Income Taxes

State income tax laws vary so greatly that I will comment only on Maine's law, by way of example. Corporations are taxed 5% of the first $25,000 of Federal taxable income apportioned to Maine (adjusted for Federal tax allowances specific to Maine) and 7% on the excess over $25,000. Individuals, estates, and trusts will pay (for 1976) at rates of 1% to 8% on Federal adjusted gross income (adjusted further for differences between Maine and Federal allowances). An income-splitting provision for married taxpayers filling jointly reduces the effective rate substantially. The rates will go up in 1977.

Property Taxes

Property tax laws vary so much from state to state as to make a comprehensive summary beyond the scope of this paper. From the viewpoint of effects on intensive timber management, the most important types of property tax laws are the conventional ad valorem taxes on land and timber together, yield taxes, productivity taxes, current use laws, and the myriad of special rebates, exemptions, and other direct subsidies which have been tried from time to time to achieve specific forestry objectives.

Transfer Taxes

The Federal government taxes both gifts and bequests. Nearly all of the states impose both an estate tax and an inheritance tax. The Federal transfer taxes are really neither taxes on property nor on a beneficiary or donee's right to receive property. They are excise taxes on the rights to transmit property at death and by gift (Anonymous, 1963).

Federal estate tax. The estate tax is levied on the value of all property, to the extent of the decedent's interest at the time of his death, less certain deductions and exemptions (U.S.D.T., I.R.S., 1971) The gross estate includes all property which passes through the estate, property over which the decedent retained certain rights until his death, and transfers "in contemplation of death". The taxable estate is the gross estate, adjusted for expenses of and claims against the estate, and

reduced by a marital deduction (the lesser of 50% of the adjusted gross estate and the value of all interests passing to the surviving spouse that qualify under I.R.S. rules), a deduction for charitable bequests, and a specific exemption of $60,000. The gross estate tax is calculated on the amount of the taxable estate at a rate varying from 3% (for up to $5000) to 77% (for taxable estates over $10,000,000). The tax actually paid is the gross estate tax less: certain credits for state death taxes, Federal gift taxes on property subsequently included in the decedent's estate, and Federal estate taxes on property bequeathed to the decedent within certain time limits of his death.

Federal gift tax. The Federal gift tax is a levy (upon the donor) imposed upon the value of property or property rights transferred by gift. The tax applies to the total value of the gifts, less: an exclusion of $3,000 of gifts made to any one person during any calendar year, a specific exemption, and a marital deduction. A lifetime exemption of $30,000 is allowed and may be spread over time as the donor sees fit. The marital deduction, in effect, allows a maximum annual gift of $3,000 to a spouse in addition to the $3,000 exclusion. Spouses may pool their allowable deductions in donating to a third party. The tax actually paid is calculated on the taxable gifts at a rate varying from 2.25% (for up to $5,000) to 57.75% (for taxable gifts over $10,000,000).

State death taxes. Most states impose both an inheritance tax (levied on the beneficiaries rather than the estate) and an estate tax. The latter is usually designed simply to obtain for the state the benefit of the credit allowed under Federal estate tax law for state death taxes paid. Maine's inheritance tax, applicable to much the same transfers and kinds of property as the Federal estate tax, recognizes several classes of inheritors, based on closeness of relationship to the decedent. For closest relations, the tax rate varies from 5% on taxable inheritances of less than $25,000 up to 10% on inheritances of $250,000 or more, with exemptions of $50,000 for spouses and a total of $25,000 in the case of natural or adoptive parents and natural or adopted children and grandchildren.

INTENSIVE MANAGEMENT OPTIONS

What do we mean by "intensive timber management"? Obviously, the term can cover a wide range of practices and levels of treatment, but we might reasonably view its scope as including any effort over and above the periodic extraction of timber grown with no deliberate management at all. I will outline the possibilities under five categories: 1) the resource base, 2) stand establishment, 3) stand management, 4) forest management, and 5) indirect influences, with emphasis on topics especially influenced by taxation.

The Resource Base

Management decision associated with land, the forest resource base, may be listed in four categories: 1) land acquisition, 2) land inventory, 3) land development, and 4) land disposal.

From the viewpoint of social welfare, public benefits can result from any acquisition, in fee or in partial right, of bare or poorly-stocked forest land, by an individual or organization determined to actively manage that land for timber. Such activities represent intensification of management of forest lands in general.

Acquisition of stocked forest land, or rights to that land and timber, may also represent an intensification of the level of management on such land. This country's many years of experience with and study of "the small woodland problem" suggest that an aggregation of fragmented parcels into larger management units may offer one of the more promising opportunities for significantly improving the management of those lands. A few successful cooperative associations of landowners themselves exist, but the greatest promise may lie in the leasing of lands from small landowners to block them up into more effective management units under the control of long-lived legal entities with a vested interest in productive timber management.

The device of acquiring partial, rather than full legal interest in land and/or timber may serve the cause of intensive management regardless of the nature of the landowner. The lower capital investment requirements of such arrangements can make affordable practices that would not be possible in cases of fee acquisition.

Information about the resource base is a fundamental prelude to any kind of intensive management. Planimetric surveys, topographic surveys, soils surveys and site mappings of varying intensities may be involved in the land inventory portion of the management program.

A third area of interest associated with the forest land base is land development. Intensive management of timber stands requires access and support facilities. Extending and improving road networks affords access for cultural work and more careful harvesting. Although rare in the Northeast, intensive management in the Lake States and Scandinavia has included land drainage activities.

Finally, a persistent problem of both large and small non-corporate woodland management is that of maintaining continuity from generation to generation. Poor estate planning can force liquidation of family interests in a given land parcel, or premature harvest of timber on that parcel. A carefully-planned forest may be forfeited to pay death taxes that could have been avoided.

Stand Establishment

Management decisions associated with forest regeneration may also be listed in four categories: 1) species selection, 2) genetic tree improvement, 3) site preparation, and 4) methods of sowing, planting or natural regeneration.

The opportunities for intensifying timber management in the area of stand regeneration are many. So far as taxation is concerned, the question of fundamental importance is whether regeneration is artificial, natural, or a combination of these (e.g., site preparation with natural seeding).

Stand Management

Timber stand management options may be listed in three categories: 1) cultural activities, 2) silvicultural systems, and 3) rotation age decisions.

Cultural activities (weeding, thinning, pruning, fertilizing), along with artificial regeneration, are the paths along which most land-owners embark upon intensive timber management.

Silvicultural systems blend consideration of site capability, species choice, regeneration method, product goals, and harvesting economics into prescriptions for individual stand management. Attainable rotation ages can be strongly influenced by intensive management. Taxes are reflected in desirable rotation limits.

Forest Management

Management decisions associated with forests or groups of forest properties may be summarized in four categories: 1) forest inventory and analysis, 2) forest protection, 3) harvest planning and management, 4) timber disposal.

Along with land inventory, a forest manager needs a comprehensive forest inventory system. Information from these inventories may be studied through conventional methods, and by simulation and optimization analyses based on stand and forest models, to develop management plans for individual stands or types, forests, and entire ownerships. Forest protection, through fire prevention and suppression, and insect and disease control, can vary over a wide range of intensity. Harvesting planning must consider long-range impacts on production possibilities, utilization intensities, and salvage of dead or damaged timber. Timber disposal, by use of roundwood in the landowner's own mill, sale of stumpage, sale of logs, or transfer by gift or inheritance, involves taxation effects that can greatly influence the profitability of that disposal.

Indirect Influences

I stopped the management option list at the forest level in order to focus on matters of primary concern to this symposium. However, neither the individual nor the corporation can afford to analyze the impacts of taxes on forest management decisions in a vacuum. The small woodland owner should constantly be aware of the interactions of these decisions and such matters as his other sources of income, his other business activities, and his estate. Ideally, integrated forest products firms should consider interactions within their whole corporate system. For example, land and timber acquisition decisions should not ignore other wood-source options, nor should an optimum rotation question

be studied independently of the timing of mill wood needs. In practice, intelligent judgement seeks the point where the benefits of decision option analysis outweigh the costs.

You should also keep in mind that the effects of taxation on landowners directly are certainly not the only way in which taxes influence management intensity. All costs of harvesting and processing roundwood through to the consumer can influence timber management options throughtheir impact on residual stumpage values. Any knowledge of tax law which allows a reduction of these costs can be beneficial to timber management.

Public forest management, also, can be influenced by tax law in at least three ways: 1) pressure for higher payments to local towns in place of property taxes, 2) Federal capital gains treatment of revenues from National Forest stumpage sales, and 3) the effects of yield taxes on the behavior of loggers harvesting public stumpage.

EFFECTS OF TAXATION ON INTENSIVE TIMBER MANAGEMENT

Let us now see how the various taxes affect the comparative economics of the intensive management options just listed.

Effects of Income Taxes in General

All income taxes, Federal, state, or local, will affect rotation decisions variably, according to the tax bracket and other financial circumstances of the taxpayer. They may shorten or lengthen the rotation, depending on these conditions. Capital gains tax provisions tend to lengthen optimum economic rotations (by comparison with ordinary income taxes) under all circumstances. These effects result from the fundamental criterion underlying the economic rotation decision: So far as mill wood needs or cash flow requirements allow, it makes sense to hold a stand of timber so long as one more year's earnings on growth and/or value appreciation exceed one more year's costs of holding and managing that timber. Income taxes, by reducing net earnings, cause this point in time to be reached earlier than would otherwise be the case. But, preferential capital gains taxation allows a longer rotation than do ordinary income tax rates.

Effects of the Federal Income Tax

My outline of Federal income tax law should have made it clear that it is to the landowner's advantage to try to ensure capital gains treatment of as much of his income as possible, and to try to make as much of his expenditures as possible qualify for deduction against ordinary income.

Keys to the first of these two goals lie in Sections 1221, 1231, and 621 of the 1954 Code. Because Section 1221 excludes from the definition of capital assets any "property held primarily for sale to customers in the ordinary course of his trade or business", disposal of timber for a lump sum price by a dealer in timber properties results in an ordinary gain or loss. But, timber held for investment and not as a business property is a capital asset and qualifies for capital gains treatment. Moreover, Section 1231 states that if the gains on disposal (by sale, exchange, or involuntary conversion such as destruction or theft) of property that is used in a trade or business exceed the losses from such disposals, then both the gains and the losses shall be treated as capital gains and losses regardless of Section 1221. If the losses exceed the gains, both are treated as ordinary. Section 1231 further specifies that timber to which Section 631 applies is defined as property used in the trade or business for the purposes of Section 1231 treatment.

Section 631 (which affords capital gains treatment to timber only through the reference from Section 1231) defines gains and losses under certain kinds of timber disposal. Section 631(a) specifies that one who has owned or held a contract right to cut timber for a period of more than six months before the beginning of the year in which it is cut, and who cuts the timber for sale or for use in his own business, may <u>elect</u> to treat the cutting as a sale or exchange of standing timber. The gain on this fictitious sale is the difference between the cost basis of the standing timber in the taxpayer's hands and the fair market value of that timber as of the first day of the taxable year in which it is cut. Section 631(b) specifies that, in the case of a disposal with a retained economic interest of timber held for more than six months, the difference between the proceeds from that disposal and the

adjusted depletion basis shall be considered as though it were a gain or loss on the sale of the timber. The key to retention of an economic interest is that the income on the sale must depend on the severance of the timber and the payment must be on the basis of the amount actually cut.

The conclusion to be drawn from these sections of the Code is that net timber disposal proceeds--the basic aim of and source of funding for intensive management--can be markedly affected by the nature of the sale arrangements and management activities. Several details are worth further consideration.

Intensive harvesting. Consider intensifying management through increased tree utilization. If you plan to sell tops, limbs, stumps, and/or roots, do so at the same time as the rest of the tree is sold. 631(b) applies only to the disposal of standing timber. 631(a) applies only to the whole tree standing. Sales of residual material after the fact will be treated as ordinary, not capital in nature.

Leases. Lease arrangements must be handled carefully for tax purposes. The lessor should try to retain an economic interest in the timber, in order to qualify for capital gains treatment under Section 631(b). The lessee, on the other hand, should try to obtain a sufficient legal interest in the timber to qualify for the use of Section 631(a) and sufficient interest in the whole property to be able to expense, rather than capitalize, management costs. Generally speaking, it is not possible for both parties to satisfy these interests simultaneously, so the tax effects of a lease agreement can be an important issue in the bargaining process.

Litigation over leasing and other long-term cutting arrangements was summed up, from the lessor's viewpoint, in Revenue Ruling 62-81 and the basic court findings of the Dyal Case in 1965 (Fendig, 1966): 1) A taxpayer is not entitled to capital gains treatment under Section 631 for fixed annual payments to be paid regardless of cutting. 2) A taxpayer is entitled to capital gains treatment for timber sold on a scale basis according to the amount actually cut. 3) Regardless of whether an economic interest is retained, a taxpayer is entitled to claim capital gains treatment to the extent of the fair

market value of the timber on the land at the time the leasing agreement is made. This third circumstance is the only one for which the courts have ruled that the lessor may claim a 631(b) sale even though the lessee is allowed an ordinary expense deduction for the rental fee. In effect, the "sale" (by virtue of the lease) of the initial timber stand is treated separately from the long-term management and harvesting of subsequent growth. Then, the lessee is entitled to ordinary deductions for rental fees and management costs only, in the opinion of Landis (1966), if: 1) he has a possessory interest in the land, not just annual cutting rights; 2)there is a clear limitation of cutting rights to annual growth, or some other device which separates payment for timber on the land at the outset from later annual payments; and 3) the payments must be made regardless of whether the timber is actually cut or even available for cut.

Deductible expenses. The question of which timber management expenditures may be deducted from ordinary income and which must be capitalized, to be recovered through depreciation, depletion, or sale of the asset is covered in Sections 161,162, and 263 of the 1954 Code, applicable to all taxpayers, without specific reference to forestry. Particular concerns have been answered in large part by many years contention between taxpayers and the Internal Revenue Service. The results are of great importance to intensive management interests. In particular, all direct costs (including depreciation of equipment used) of artificial regeneration must be capitalized and can be recovered only through the gradual allocation of the depletion process as the mature timber grown from that regeneration is harvested (or immature or mature timber is destroyed by a natural disaster). When you are pondering the relative merits of natural versus artificial regeneration, you must keep this requirement in mind.

Internal Revenue Service reasoning on these matters is often difficult to predict. Foresters familiar with I.R.S. requirements to capitalize planting costs have reasoned that Forestry Incentives Program cost-share payments should be treated as reductions from capital expenditures and entered in the depletion account. For example, amounts for planting costs would be reduced by the amount of the

government reimbursement. But, I.R.S. representatives have contended that FIP payments must be treated as ordinary income. Moreover, the I.R.S. advises that the entire expense, both the landowner's share and the government's, should be capitalized and recovered through depletion. This treatment "effectively reduces the maximum cost-share payment from the 75 percent intended by Congress to about 52 percent for an average landowner." (Bethune and Fortson, 1975)

The key to these decisions is whether an expenditure is an "ordinary and necessary" cost of maintaining an investment property, or carrying on a business, or is an expenditure that makes permanent improvements in or extends the life of a property. Thus, timber stand improvement expenditures are allowed to be deducted (or capitalized, at your option) only if they are part of a regular program of such treatment, followed consistently from year to year, hence an "ordinary and necessary" part of maintaining the quality of a timber stand. But, infrequent T.S.I. work may be challenged as fundamentally changing and improving the nature of a timber asset. In a famous case of the 1960's, the I.R.S. finally, at the direction of the courts, agreed to allow the expensing of pruning and shearing of Christmas trees, but only if those trees were planted and grown as Christmas trees from the start. If you prune and shear natural stock to convert it to Christmas trees, you will be required to capitalize the initial costs of those activities.

Carrying charges. Carrying charges, such as annual property taxes, interest payments, and protection costs, may be expensed or capitalized as you see fit. Research and experimental expenses may be deducted currently as business expenses, or amortized. Amortization is probably the proper treatment of purchased management plans, maps, aerial photographs, computer models, and so forth, though minor items in these categories may often be expensed.

Roads. Costs of permanent roads must be capitalized, except for depreciable components such as bridges, culverts, and surface gravel. Costs of temporary roads may be amortized over the term of their usefulness, either on a time scale or according to the units of timber harvested.

Cruises. Timber cruises for acquisition of a specific parcel of forest land must be capitalized into the book value of that property. Cruises for ordinary inventory and exploration of owned property may be expensed. You can try to expense the costs of cruises taken in connection with a 631(b) sale, but the I.R.S. will claim that such costs should be used to reduce the net gain on the sale, hence benefit you only at capital gains rates.

Investment credit. The investment credit can be a very significant incentive for intensive management. Perhaps the most important application, especially for larger landowners, is to logging road construction. I.R.S. Revenue Ruling 68-281 held that a certain taxpayer's logging truck roads qualified for the credit since they were an integral part of the operation of sawmills, the production of lumber products or other building materials, or the manufacture of paper (Anonymous, 1969). Whether the road is permanent or temporary, either the cost of the entire road or that of part or all of the depreciable portion may qualify for the credit, depending on the useful life of the portion in question.

In addition to logging roads, the investment credit would apply to many kinds of planting, T.S.I., and harvesting equipment.

Income averaging. The Tax Reform Act of 1969 added capital gains to the income that can be averaged by an individual under Section 1301 of the 1954 Code. This provision could be of significant help to a small woodland owner who makes sizeable, but infrequent timber sales.

Effects of State Income Taxes

The Maine income tax is patterned so closely after the Federal income tax that it can be viewed as a sort of surtax. It will have an effect on the profitability of a timber management investment, on decisions involving acquisition and disposal of timberland, and optimum rotation questions, but should make no differential impact on the outcome of different intensive management activities.

Effects of Property Taxes

James Yoho (1965) has written that there is simply not very much known about the influence of various property tax forms and levels on individual forest investment decisions, or on the magnitude and direction of aggregate forest investment decisions. It can be argued that high land values and consequently high taxes logically force landowners into intensive management in order to minimize the land base necessary to the production of a given volume of timber products. Indeed, it has been argued that intensive forestry is a necessity of coping with property taxes (Miralles, 1971). But, this effect can be overshadowed by taxes so high as to discourage timber management altogether.

General property taxes impose two kinds of cost burden on the forest land owner: 1) that of meeting annual cash flow demands and 2) that of holding costs. The first is especially burdensome to the small woodland owner, who usually does not have enough land to provide annual timber sales revenues to offset these taxes. The second influence can affect both rotation length decisions and judgments on whether to maintain ownership of a given parcel of land. A landowner must be able to manage his property, if it is to be a profitable venture, in such a way as to generate time-adjusted earnings which will cover his property taxes (and other custodial charges), cultural activities, sales expenses, and overhead costs and, in addition, return at least as much as could have been realized on an investment of the same capital in an alternative venture (Field, 1976).

In general, any property tax which includes the current value of the timber crop in its assessment base will penalize intensive management by comparison with lower levels of management and will shorten the optimum economic rotation in the same manner as an income tax. In the case of a productivity tax such as Maine's Tree Growth Tax Law, however, improvements on growth and yield on individual properties would not affect tax rates until enough properties were so treated as to influence the large geographic areas over which growth rates are averaged.

At the very least, property taxes can absorb funds that would otherwise be available for investment in intensive management practices. Partly in recognition of this, many specific property tax exemptions, rebates, and other subsidy measures have been enacted over the years to encourage particular forestry practices. Cumbersome enrollment mechanisms, weakness of the incentives, and fear of local assessor reprisal have combined to make such measures largely ineffective. Large-scale present use and productivity assessments, which are based more on arguments for equity than for subsidy, appear to offer more promise of success in encouraging sound timber management.

I have already stressed the significant impact of income taxes upon the profitability of a forestry venture. It would be well, at this point, to place the relative impact of the property tax burden in perspective. Consider, for example, a private, noncorporate, forest landowner in the 20% Federal income tax bracket who is faced with a 50¢/acre/year general property tax on his land and timber. Suppose he establishes a tree plantation, at a total cost of $50/acre, which he expects to yield 40 cords/acre at the end of a 40-year rotation. Suppose, finally, that the stumpage value of the wood at that time will be $10/cord and that the landowner's cost of capital is 8% per annum. The Federal income tax on the sale of this timber in year 40 will be:

[(40 cords/acre)($10/cord) - ($50/acre depletion)]
X [(.50 capital gains deduction)(.20 tax rate)]
= $35/acre.

The value of annual property tax outlays, compounded to year 40 @ 8%, less the cash flow from annual deductions of these outlays against ordinary income for Federal tax purposes, also compounded to year 40 at 8%, is:

$129.53/acre - $25.91/acre

for net property tax burden of $103.62/acre, nearly three times the Federal income tax burden.

This simple illustration ignores many complexities of forecasting and detail, but the values used are realistic and the message is clear: Property taxes rank high, perhaps highest, for most owners, among the costs of the timber growing enterprise.

Effects of Transfer Taxes

Transfer taxes can seriously disrupt long-range timber management plans. The most common reason for this effect is lack of cash with which to pay transfer taxes on the property. Often, the only way to raise this cash is to liquidate the assets themselves, which can mean premature timber harvest or forced sale of timber (or both land and timber) at bargain prices.

A variety of complex trust arrangements are possible which can lessen or postpone the impact of death taxes on a family's timberlands. But, perhaps the most straightforward approach to the problem of enabling descendents to continue management of a forest property is the lifetime gift. Conway (1974) has noted four advantages, under Federal tax law, of gifts made during the lifetime of the donor: 1) Federal gift tax rates are only 75% of estate tax rates. 2) Property can be shifted from under the burden of the highest tax rate to which an estate will be liable to the lowest gift tax rate possible in view of any previous gifts the donor may have made. 3) The amount of gift taxes paid is not subject to the estate tax. 4) Whereas the estate tax is imposed on the size of the estate, which includes the amount of estate taxes payable, the gift tax is levied only on the amount of the gift.

State death taxes are so similar to and, in some cases, so closely related to Federal estate taxes that management planning can be confined largely to the provisions of the latter.

TAX TRENDS

Future trends in income, property, and transfer taxation are no more certain than other futures, but it is well to monitor proposals for change and to judge the probable impacts on long-range decisions. The two most volatile topics at the moment appear to be the Federal income tax and Federal transfer taxes.

Federal Income Taxes

Capital gains treatment of timber has been criticized regularly over the years. Recent reforms of the percentage depletion allowance for oil wells, a monumental tax loophole with which timber cost

depletion has often been confused, may relieve pressure from that quarter. But, the Congressional Budget Act of 1974 requires an annual summary of "tax expenditures", defined as revenue losses due to provisions of Federal tax law which allow some sort of preferential exclusion or tax rate (Sunley, 1976). The capital gains treatment of timber is a tax expenditure, so is ensured of annual review, but I can see no logical argument for denying or modifying preferential treatment of timber as a capital asset unless all other capital assets are so treated. It might be reasonable, though, to expect a lengthening of the holding period for a long-term capital gain from six months to several years. Such a change would effectively deny capital gains treatment to most stumpage buyers, but should have little if any effect on intensive management.

Investment credit was first allowed under the Revenue Act of 1962. It was suspended, for property costing over $20,000, from October 10, 1966 through March 9, 1967, and was terminated altogether by the Tax Reform Act of 1969. The Revenue Act of 1971 restored a 7% credit for eligible property and the rate was increased to 10%, for most cases, by the Tax Reduction Act of 1975. Presumably, rates will return to the 1971 level if the reduction provisions are not continued.

Federal Transfer Taxes

The last thorough reform of Federal transfer tax law was in 1942. There has been much talk of change but little action since then (Conway, 1974). The Administration's Tax Reform Bill of 1973 emphasized three broad concerns, which are likely to continue: 1) maintenance of existing revenues from these taxes; 2) gradual, rather than abrupt changes, to protect those who have planned their estates under existing law; 3) maintenance of advantages which encourage support of charities. There have been serious proposals to revise the rate structures, eliminate the double benefit afforded by the separate $30,000 and $60,000 exemptions of the gift and estate tax laws, respectively, and to impose a capital gains tax at death on the fair market value of a property, less its cost basis. Perhaps the extreme example of attempts to block transfers of wealth from one generation to another was George McGovern's call a few years ago for a 100% estate tax.

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EFFECTS OF INCENTIVES PROGRAMS

by

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Abstract

Incentives have played an important role in forestry accomplishments on private forest lands. Direct cost-share assistance programs, such as the Forestry Incentives Program, stimulate additional accomplishments in greater proportion than their actual inputs. Two States currently operate their own "incentives" programs. In addition, the Pacific Northwest Regional Commission has provided funding to supplement Federal cost-sharing in Washington, Oregon, and Idaho.

In 1974 the Forestry Incentives Program treated 257,000 acres on 15,800 separate tracts of forest land. Tract size averaged better than 15 acres with more than three-fourths of the tracts treated exceeding a production capacity of 85 cubic feet/acre/year. Treatment costs are similar to those experienced on industrial and Federal lands.

It is a pleasure to be back in Maine again with old friends. I spent 4 days here in early May visiting some of the woodlands in which we have invested cost-share funds. You currently have here in southern and western Maine a market situation second to none. This is ideal, for it enables a forester to look at all possibilities of getting stand treatments accomplished. But I'm getting ahead of myself. Let's back up a little and get our perspective set on incentives programs in general--what they are--where they came from--how they operate.

Many of our direct "incentives" programs have been in operation for several decades. Programs such as cooperative fire protection and nursery production have been on the scene for more than 50 years. The Agricultural Conservation Program (ACP), under one or more names, has been around since 1936. Forest management assistance, which was formalized by the CFM Act of 1950, really had its beginning in the Norris-Doxey Act of 1937. And the latest, the Forestry Incentives Program (FIP), has been in operation for only a little more than 2 years.

During these years we have come to accept these programs as being basic to the accomplishment of forestry measures on certain private lands. Events over the past few years indicate this attitude may be changing fast. The rescission (and deferrals) requested on FIP and ACP in the past two congressional sessions and the proposed phasing out of the Clarke-McNary Section 2 (CM-2) fire protection funding, along with similar actions in other resource programs, give ample evidence that the Federal role on private lands is being seriously reviewed, and in some areas, questioned as to its propriety or effectiveness. The President's transmittal letter that accompanied the RPA documents to Congress states this in clear and unequivocal terms.

Despite the unprecedented demand for Forestry Incentives Program funds and its accomplishments of the past 2 years in getting tree planting and TSI done on nonindustrial private forest lands, certain groups and individuals insist that direct Federal incentives have no place on private lands. They believe that the unhampered operation of a free market will take care of the demand or need for forestry investments on these lands.

Are such "direct" incentives really necessary? This is not an easy question to answer. Some studies have shown (Yoho and James, 1958) that landowners indicate they would have carried out forestry measures without such assistance. Another recent study (Gregersen, 1975) shows that 41 percent of landowners responding to a questionnaire indicated they could have earned an alternative rate of return without the cost-share assistance. It is difficult to know what a person would have done in a situation he didn't have to face. We do know, however, that when cost-share assistance programs are terminated, such as was the case in 1972, TSI activities on nonindustrial private lands drop drastically. Tree planting activities do not react this quickly. Records show that when REAP was terminated by President Nixon in December 1972, planting and seeding activities did diminish--but only by about 35,000 acres, about 12 percent below the previous year's level. Tree planting activities require pre-planning, matched with the availability of nursery stock, and depending in degree on site preparation. Thus, when cranked-up, tree planting tends to be a more stable operation--not reacting as quickly to short-term fluctuations as is the case with TSI.

It is interesting to note that on the nonindustrial private forest lands tree planting accomplishments reached a peak in 1959 (1,465,000 acres) during the Soil Bank days. There was ample funding from Federal sources and tree nurseries reacted with greatly increased production. As this funding dropped off, an even deeper drop in tree planting activities occurred. By 1962, Federal funding for this purpose had declined to about $4 million, and tree planting dropped to less than 600,000 acres.

TSI accomplishments peaked in 1958 and declined until 1965, these levels being wholly dependent upon Federal cost-share assistance. So there seems to be little doubt that the presence of Federal incentives payments acts as a catalyst, and in the case of tree planting in a greater proportion than its total amount. The discouraging aspect is that levels of accomplishment for both planting and TSI on these ownerships are woefully below the levels needed--probably even below replacement of current losses. The size of the reforestation and stand improvement job is so immense--and the objectives of owners and constraints facing them are so varied--that a wide variety of approaches (including forest tax relief, loans, insurance, and many other "indirect" incentives) will be needed if these lands are to provide their commensurate share of forest products and services.

Let's take a quick look at some of the direct incentives programs in operation now.

Two States operate their own "incentives" programs

Virginia's RT (Reforestation of Timberlands, 1971) program is restricted to the planting of pine on private lands, both industrial and nonindustrial. It is financed by a levy on the forest products industries. Annual and/or up-to-3-year contracts may be approved. The 1975 planting level under this program exceeded 17,000 acres on 390 tracts of land.

Mississippi's FRDA (Forest Resources Development Act, 1974) program offers both planting and TSI practices on nonindustrial private, State, and municipal lands. It is financed by a special fund which includes the privelege tax on timber and timber products and any monies appropriated therefor. Other provisions closely follow the Federal FIP guidelines, including both site preparation/planting and TSI practices.

Using a somewhat different approach, the Pacific Northwest Regional Commission has granted funds to their three States in the Pacific Northwest (Idaho, Oregon, Washington) to supplement the regular FIP program in that region. The Regional Commission granted $200,000 to each State to provide incentives to landowners holding larger tracts than those eligible under FIP and also to assist small forest industries. To date Oregon and Washington have gotten their respective (OFIP and TIP) programs underway, but Idaho is not yet operative.

Perhaps the best known "incentives" program is the ACP (Agricultural Conservation Program). Originally authorized in 1936 as a part of the Soil Conservation and Domestic Allotment Act of 1936, its original intent was to prevent erosion and stabilize rural economies. ACP has been (under a variety of

acronyms) offering cost-share assistance to agricultural producers for a great number of conservation practices. Two forestry practices have been offered along with other county special practices to solve local problems unique to that area. Representative Jamie Whitten, Chairman of the Agriculture Subcommittee, House Appropriations Committee, has testified that more than 7 billion trees have been planted under the ACP since its inception.

In the recent past (1965-1971) funds for forestry practices under the ACP averaged slightly over $4 million each year on about 380-390 thousand acres. Thirty to 35 thousand landowners were assisted annually by this program. ACP has been unable to forcefully address the backlog in forestry treatments because it is primarily structured for agricultural purposes. In any given year the total amount of funds obligated for forestry purposes rarely exceeded 4 percent of the total national ACP allocation. Usually forestry practices utilized 2 to 3 percent of the budget. This was one of the reasons that a separate cost-sharing program designed specifically to accelerate timber production was necessary.

So now let's take a look at FIP, the newest of the direct incentives programs--what it is supposed to accomplish and how well it is doing to date.

The wording of testimony and the language of the Act make quite clear that the purpose of FIP is timber production. And President Nixon directed that FIP be carried out in a "cost-effective" manner in his message accompanying the legislation (P.L. 93-86). Funds to the States have been allocated on the basis of opportunities for timber production on nonindustrial private tracts less than 500 acres in size. In its first year of operation (1974) Congress did not appropriate any funds for FIP, so ASCS set aside $9 million from their regular RECP funds to operate the program. This meant that FIP operated under regular program rules that year. With this constraint, it was difficult to optimize timber production goals.

The 1975 FIP funds were truly "incentives" dollars, a hard cash appropriation, "no-year" funds available until expended and with a maximum per person payment of $10,000/year (as opposed to only $2,500 maximum under regular program). Fifteen million dollars were made available in May of 1975, and by December of that year these funds were obligated and a backlog of requests in excess of $8 million existed. The response to FIP has simply been overwhelming.

The Administration requested a rescission of the 1976 FIP funds; Congress refused this proposal; and these monies ($15 million) were just distributed to the field in late March. An additional $3.75 million to cover the transition quarter has been made available since July 1 of this year. The current situation on funding is that the Administration did not include funds for FIP in its 1977 budget. The House Subcommittee on Agriculture has just inserted $15 million in their budget at the time of writing. Now on July 22, I am able to give you an update on its status.

Now let's take a look at what FIP has accomplished along with some indicators of cost-effective performance.

THE 1974 FORESTRY INCENTIVES PROGRAM

Treated		257,000 acres
including	(36%)	100,000 acres of TSI and
	(64%)	157,000 acres of tree planting;
more than		15,800 separate forest tracts
owned by		13,500 landowners
were involved.		

Total Federal funds = $ 8.266 million

Landowner Expend. = $ 3.100 million
TOTAL $11.366 million

Considering the four major indexes of cost-effectiveness, 1974 FIP performed well in all.

Tract Size: Seventy-four percent of all the tracts treated were greater than 15 acres in size. In the South, one-third of all treatments were on tracts larger than 51 acres.

Site Productivity: More than 75 percent of all the acres treated under 1974 FIP were on sites capable of producing at least 85 cubic feet/acre/year (1 cord/acre/year). Sixteen percent of sites treated were capable of growing in excess of 121 cubic feet/acre/year. I'm happy to report that the State of Maine topped the Northeastern States in this category.

Kinds of Treatments Applied: Well-recognized practices were applied on the majority of acres treated with 1974 FIP.

The following practices, when applied with reasonable costs, are recognized as yielding favorable financial returns:

Site preparation and planting of southern pines.

Site preparation and planting of red, white, and jack pines.

Precommercial thinning and release in southern pines.

Precommercial thinning and release in maple/beech/birch.

Precommercial thinning and release in Douglas-fir, and ponderosa pine.

These five practices comprised 75 percent of the acres treated in 1974 FIP. There is little doubt that the majority of forest practices utilized in the 1974 FIP were capable of providing good financial returns when properly applied on productive sites.

Treatment Costs: The cost of applying these practices were highly variable between individual States and regions. The national average total cost for site preparation and tree planting was $52/acre, composed of a

$37 Federal cost-share, and a

$15 landowner contribution.

The national average total cost for all TSI measures was

$30/acre, composed of a

$22 Federal cost-share and an

$ 8 landowner contribution.

Costs for a combination of site preparation and planting were lowest here in the Northeast and in the Lake States. Lowest costs for TSI were found in the States of Georgia, Missouri, and Indiana and averaged from $19 to $21 per acre.

The average FIP treatment costs are similar to those experienced on industrial and Federal lands. We believe that our costs of installing forestry practices on nonindustrial private forest lands under this program to date are reasonable and prudent.

Of course, a comparison of true cost-effectiveness must include all or most of the indexes above. Our analysis to date shows the FIP to have contributed to the goal of cost-effective timber production.

In closing, I'd like to read you a letter which may typify some smaller private forest landowners' attitudes on incentives and the part they play in profitably growing timber. This letter certainly provides a perspective that foresters and economists often overlook.

Dear President Ford:

I hope you and your family have a very good and successful 1976, especially in November. I am writing directly to you since I am sure you are not aware of certain aspects of the Forestry Incentives Program for 1976.

In Virginia I am a tree farmer, raising loblolly pine, poplar, and native hardwoods on about 300 acres. I bought this land in 1965 for $30 per acre. It is now worth about $600-800 per acre. It costs me about $50 per acre to plant trees and another $50 per acre to kill the undergrowth two years later. It may cost me another $25 per acre to kill scrub trees to prepare site for planting.

This means I may have to put in, currently, $125 per acre for an established acre. I plant 10-20 acres each year. Thus, it will cost me eventually $1,250 to $2,400 a year to plant.

I must have this money tied up for 18-25 years in growth till the seedlings become pulpwood. In 18-25 years at 7-½ percent (which I get at a finance company) the $1,200-2,400 is worth from $4,800-9,600. I have been investing that kind of money since 1965, some years less, but averaging that.

Now--I have gotten at least half that money from State and/or Federal programs such as FIP, REAP, and I forget the initials of the earlier program.

I have known for five years it is a bad investment to continue reforestation programs--even with Federal help. But, as FIP is called--INCENTIVE is the word. Like any other human enterprise, a little encouragement has caused me to shut my eyes to the fact my farm could be sold for about $180,000-$240,000. If invested, my income would be about $15,000 per

year--starting NOW, not 18-25 years from now. I want to grow trees, and I want to keep my land in my future and my children's future and in my country's service. Please consider that there are thousands more like me.

Sincerely,

It has been said that there are only two kinds of fools in the world. One says, "It is old and therefore good." The other says, "It is new and therefore better." If forestry on private ownerships is ever to reach its considerable potential, we are simply going to have to take the best from the past and combine these with even better new techniques to create sufficient incentives for the private forest landowner.

The keynote of progress, we should remember, is not merely doing away with what is bad. It involves replacing the best with something even better. We need to keep this in mind as we strive to create a climate in which private forestry can prosper.

POSSIBLE LEGISLATIVE CONSTRAINTS TO INTENSIVE SILVICULTURAL PRACTICES IN NORTHERN FOREST TYPES

by Brendan J. Whittaker, Chief, Information & Education, Agency of Environmental Conservation, Montpelier, Vermont

Abstract

The question of legal constraints to forest practice is currently active again. Two sources of restriction are the historic concern for timber supply and related amenities, and the mandates of the Federal Water Pollution Law. Legislators by and large, both State and Federal, realize the need of the nation for timber and will give due weight to the data presented to them by professional foresters. Foresters, on their part, have the obligation to become even more involved in the legislative process and to present the basics of sustained yield forestry in a clear and understandable manner.

These comments on legal restraints to intensive silviculture come from the admittedly subjective viewpoint of one who, though he has a forestry background, now works in a state-level multi-discipline environmental agency in Northern New England. In this position I do follow quite closely our own state legislature but, on the other hand, can only, from general reading or other information sources, learn what is happening in the forest regulatory field over a wider area. I would ask, therefore, that you take the following comments and balance them against the situation in your own state or region.

First, although it is not in my assigned topic, let's recall that legislation or administrative regulation is not necessarily a detriment or restraint to forestry. They can be a benefit! A serious situation in Vermont, for example, is forest land taxation, the all-too-familiar story of land taxes far in excess of the

forestry or agricultural capacity of the land to produce a cash return. A good tax law revision in this instance would aid in removing a restraint to intensive silviculture.

An even more intriguing example in Vermont now comes at a time when we hear that interest in environmental legislation has ebbed. However, the latest information concerning "Act 250", our basic land development law, without going into a great amount of detail, is that due to the legislation as now written, there has been a proliferation of land subdivisions of just ten acres or slightly over - the minimum subdivision which escapes Act 250 jurisdiction - with obvious adverse effects on the practice of forestry. It is more difficult for logging operators or foresters to deal with a multiplicity of small ownerships of ten acres each laid out with no regard to natural features such as ridge tops or stream valleys.

The point to be made is that instead of cries for the dismantling of Act 250, what is heard are pleas for some innovative and creative strengthening of the law to remove the small or irregular lot detriment to forest management, while at the same time preserving, as far as possible, the free market concept in land sales. What the outcome will be is unclear at this time, but some very responsible people, including the Forests & Parks Commissioner, are seeking through law and regulation to enhance, rather than restrict, the practice of silviculture.

Now, it seems to me that possible legislative or regulatory restraints to intensive silviculture can be reasonably expected, if they come at all, from either or both of two governmental levels, state and federal, since, as most realize, New England has only a skeletal county government compared with much of the United States; and any prospective town laws or regulations on timber cutting would obviously have only an extremely local effect. As urbanization progresses, however, such local restrictions can become quite severe on woodland owners. For example, although not aware of them personally, I am told that local ordinances against tree cutting are extremely severe in such New Jersey townships as Hampton and Parsippany-Troy Hills.

Potential areas of regulation can reasonably expected to be:

1) Measures designed especially to fulfill the mandates of what has been recently described as "one of the most complex pieces of legislation ever passed by the United States Congress",[1] PL 92-500, the Federal Water Pollution Control Act.

2) Measures intended to maintain levels of forest productivity, a historic American concern, now widely expanded, however, to not only to the nation's timber supply, but related resources and amenities such as scenic values, clean water, and recreation areas. This latter would include the sometimes emotion-laden term "wilderness areas".

3) Combinations of these areas in such matters as pesticide and silvicide regulation, road building and other forest-related construction, even perhaps controlled burning if this should come into wider use in the northern forest. These latter concerns not only raise the wider interest of foresters and environmentalists as they always have, but now also will be examined in the light of PL 92-500 to see if their use will affect water quality in the forest.

* * *

To look at the first area, the Federal Water Quality Act, the Section numbers of 92-500 - "106", "201", "402", "404", "303(e)", and "208" - have become stock phrases among environmentally aware people at all levels, and if the numbers at least are unknown or a mystery to the general public, the effects of these Sections of the Law are beginning to reach to the remotest corners, hills, and valleys and river bottoms of all 50 states.

It's a massive program to say the least. 201 construction grants to build sewage treatment plants and related facilities now total billions of dollars annually. 303 River Basin Plans have had hearings in all parts of the region which, though generally sparsely attended, are sources of huge amount of detail for future water quality planning in the immediate area. The 404 section, the so-called Dredge and Fill, is of immediate interest to forestry since it, as the result of a federal court decision, requires the U.S. Army Corps of Engineers to extend jurisdiction on dredge activities to the most upland stream areas and their attendant wetlands. We are now, as of July 1 of this year, in phase 2 of Section 404 implementation which extends Corps jurisdiction to all major rivers. Next

year, July 1, will complete implementation of Corps jurisdiction right up into the headwaters. As of now, it is determined that permits will be needed for several activities commonly used in forestry such as stream crossings. In order to, as one water engineer in Vermont puts it, "soften the blow", the Corps is proposing general permits to be issued to a state to cover the more routine activities; but apparently negotiations on the details between the states and the Corps are not progressing too well at this point. To compound our own situation in Vermont, our State is split down the middle by two Corps jurisdictions and conceivably a timber operator somewhere on the height of land of the Champlain and Connecticut watersheds could find himself applying to both Albany and Waltham for permits for the same operation. Vermont, obviously, is currently trying to rectify this situation.

Several changes by amendment are now in process in Washington on the whole Water Quality Act. A proposal on this 404 section, however, to redefine Corps jurisdiction on dredge and fill to truly navigable waters, the so-called Breaux amendment, failed in June. Our own position in Vermont is that the states keep jurisdiction over most waters, with the Corps retaining jurisdiction over the traditional navigable waters, but we do realize the need for wetlands legislation of our own, an area which many feel is inadequately covered by law at this time. A possible compromise could be a requirement that all states enact suitable wetlands legislation and then be "signed off" by the Federal Government to run their own dredge and fill programs. We understand a major concern about this among environmentally oriented Congressmen is that approximately half of the states have no wetlands legislation at all.

The last section of PL 92-500 I will mention is 208. This is a broadly designed planning action designed to involve citizens at a very basic level in planning for future water quality needs where complex problems exist. 208 has been described as a form of land use planning, with all of the positive and negative connotations this term brings, since it is obvious that man's treatment of the land affects water quality. Vermont is just beginning its involvement with 208. We are being cautious. A state level committee headed by the Secretary of my Agency has been established with participants from all sectors with an emphasis on participation by the agricultural community. We plan to do the groundwork on 208 through the 13 Regional Planning areas in Vermont.

I would urge you to check carefully the 208 setup in your own state if you have not done so already, or if you are not participating at this time. Forestry needs to be represented on this planning level which will be recommending basic land use decisions affecting us for years to come. I do know that eastern Massachusetts, particularly, has 208 planning areas and staffs who are further along than we in northern New England, and though, obviously, that is a highly urbanized area, a visit to them if you are in the vicinity will show somewhat where we might be as 208 progresses.

208 is under consideration for change with some amendments in Washington at this time. One proposal receiving serious attention is to add air pollution and solid waste to the 208-type model. The result would be a complete waste planning effort and the ramifications for land use planning therefore even broader.

As a late update to the whole question of amendments to PL 92-500, our water resources people tell us that the most appropriate forum toward which we may address our comments is now Senate Bill S-2710 which has passed the House as HR 9560 and is now back in the Senate to resolve differences.

* * *

The second major area of regulation is that intended to maintain levels of forest productivity. This is a historic concern; it's been pointed out by others that debate on the timber supply issue has been strong in at least three previous periods in our history: 1910, 1923-1924, and 1938-1952.[2] At the present time, of course, the added concerns of many interest groups accompany the timber shortage worries. I will not go into great detail on forest practice laws but will make some general observations from our standpoint in Vermont. First, something is definitely "in the wind" again regarding the regulation of cutting on both government and private lands; it's an issue that is very active. To expand on this a little, we have the very concrete and highly visible congressional action in Washington rewriting the basic Forest Service Organic Act. As most of you undoubtedly know, this action grew out of a federal court ruling on clearcutting in West Virginia on Forest Service land, a ruling now known as the Monongahela decision. There is also in effect now a new federal law entitled the Forest and Range Land Renewable Resources Planning Act (RPA), requiring an ongoing long-range assessment, planning and program on the management primarily of federal lands. The status of

state and privately owned land resources will, however, also increasingly figure in Federal land program decisions.

Already these two major Federal activities, Forest Service Organic Act Revision and RPA, are becoming interrelated in that the major Organic Act rewrite, S-3091, the "Humphrey Bill", makes reference to, and ties in with, the RPA already passed. Now we, at the state level, could sit back, and say "that pertains only to federal lands". I don't think we should be misled, however. Any forest-related legislation as comprehensive as the two Federal actions just mentioned are bound to have "spin-off" effects on state and private forestry. Indeed, I an told that the states have been asked to assume responsibility for a Resources Planning Act type of effort on state and private lands. Even if that does not happen, a major debate with press and television coverage of, for example, Forest Service clearcutting practices, would bring that issue to the fore on state and private forest levels, also.

(Permit an anecdote here: Until now, tree length clearcutting and chip harvesting in Vermont has been confined to a relatively small and remote area in the northeastern section. Already, however, we have received at my Agency some heated comments and questions from travellers into the area such as snowmobilers and hunters. It is my contention that if and when the clear-cut-chip harvest operations move down state in view of Interstates 91 and 89, the public outcry for regulation for cutting, even on private land, will be very large.)

At least up to now, forest practice regulation has been at the state level with a measure of largely voluntary state-federal cooperation. That this is likely to continue is indicated in an important policy speech given by John R. McGuire, Chief of the U.S. Forest Service on February 10, 1975, to a joint Forest Service - EPA sponsored meeting on state forest practices legislation in Washington, D.C. McGuire said, in part, "Forest practice regulation, if necessary for whatever purpose, is not a federal function. Any such legislation should be developed, implemented, and administered within the established pattern of federal-state-private cooperation in forestry matters".[3]

Perry Hagenstein, Executive Director of the New England Natural Resources Center in Boston, has prepared a paper on forest practice legislation in New England.[4] This is an excellent source of information regarding

forest regulation on our own area. A conclusion Hagenstein drew was that regulations are most effective when designed to deal with specific problems fairly narrowly defined. On the other hand, he felt that broadly applicable laws on cutting when enacted in the past, have often simply not been enforced. Hagenstein wrote his paper to relate forest regulation to the water quality problem mentioned above, but it would seem his conclusions would apply to the timber supply and aesthetic concerns also.

I would like to step aside now for a moment in conclusion and,notwithstanding all my biases as a forester and professional environmentalist, try to put myself in the place of a Vermont legislator as he or she might look at the question of regulation of cutting on private lands in my state, if the matter comes up for legislation. Leaving the narrower question of water quality aside, I believe, as a legislator, I would be open toward leaving forest practices in private and professional hands with, however, some important qualifications. The most important of these is that, as a legislator or even private citizen, I would want to hear from professional foresters about the concept of sustained yield, defined something like this: "repeated crops of timber removed at regular defined intervals, into the future as far as man will control it; with no degradation of the soil or water base and the maintenance of a healthy, productive forest". I would like to hear that from foresters, and I would like them to delineate the areas on which they intend to do it.

Most legislators in Vermont are beginning to realize that wood is the only large-scale renewable resource we have. If, for example, as seems likely in out state, we move into generation of electrical power with wood fuel and/or if another large paper mill is located in the upper Connecticut Valley, the wood resources of Vermont would be even more crucial to our economy and well-being. Dialogue and debates with recreationists, environmental groups, and others, some of whom might wish to restrict cutting, will continue, but I believe that legislators will give due weight to reasoned, professional advice from foresters, if the lawmakers can believe that the timber business is here to stay on a sustained yield basis.

(A superb example of the sort of intelligent lucid professional testimony that would be most helpful to me were I a legislator was that of the President of the Society of American Foresters, R. Keith Arnold, before

the Forests Sub-Committee on Agriculture, U.S. House of Representatives, on March 24, 1976. Arnold was testifying on one of the proposed rewrites of the U.S. Forest Service Organic Act. This testimony may be found verbatim in the May 1976 Journal of Forestry.)

There will be debates and problems in the future in Vermont on forest practice regulation. I still think, however, if we do our own work, know what we are about, and are able to communicate it effectively, we will have our just hearing in the legislative process. In our system of government, we really cannot ask for more.

The major conclusion to be draws from all of this is one that has been repeated many times among professional foresters, but it now assumes a new urgency. Foresters must assume a more active role in guiding forest practice regulation. We will have to become involved in the political process, in information and education programs, in dealing face-to-face with recreation special interest groups, and in public relations efforts. And, we must make sure we do our own homework, so that we present our case for intensive silviculture on the soundest professional base.

In this light, I will end on a personal note. I have a son who is planning to enter forestry school next fall. There are two things I intend to share with him as he enters his professional studies. One is a paper by Benjamin A. Roach of the U.S. Forest Service, written for the Applied Forestry Research Institute at Syracuse. It is entitled, Selection Cutting and Group Selection. I have read it and marked it up at least three times. Having been out of forestry school for twenty years this summer, I had really forgotten a lot about the absolute basics of our profession: terms such as "regeneration method", "silvicultural system", "regulatory system", "sustained yield", "even age and uneven age management". Can you define each of the above in clear lucid terms to a layman? Roach can and does. He is well worth reading over and over again.[4]

I feel if I explained Roach's paper to my son and also gave him the rudiments of the use of basal area and, if he can walk out on our own 70-acre woodlot and explain these terms satisfactorily to a non-professional visitor, he will have the basics of what he, as a forester, will deal with all his professional career, no matter what sophisticated courses beyond that he may receive at a university.

Footnotes

[1]"Water Pollution Control and Forestry" - George W. Brown, Raymond M. Rice, and Robert B. Thomas. Journal of Forestry, Vol. 74, No. 6, June 1976. p. 344.

[2]Remarks by John R. McGuire, Chief, U.S. Forest Service, Washington, D.C., February 10, 1975

[3]ibid.

[4]"Selection Cutting and Group Selection" - A paper by Benjamin A. Roach, Research Forester, Northeastern Forest Experiment Station. The paper is available from the Applied Forestry Research Institute, State University of New York, College of Environmental Science and Forestry, Syracuse, New York 13210

TECHNICAL ASSISTANCE FOR INTENSIVE CULTURE OF NORTHERN FOREST TYPES

BY Timothy G. OKeefe, Extension Forester, University of Maine, Orono, Maine.

Origin & Types of Technical Assistance (TA):

During this Bicentennial celebration, it is interesting to note that in America TA programs in forestry have evolved from both a formal and an informal foundation. European foresters, attempting to motivate many small forest landowners to practice more intensive forest management, have learned that incentive and educational TA programs are far more effective than programs of regulation and control. Throughout American history there are many examples of "informal" arrangements that were in fact a form of technical assistance. In colonial America, the old custom of community barn raising is a good example of an informal kind of technical assistance. The Cooperstown forestry co-operative might be considered as a kind of formal program of TA. Another good example of a formal TA program is the educational forestry programs operated within the framework of the Cooperative Extension Service.

Today, there are many other types of TA programs in the forestry field. Most of these assistance programs can be classified as field or educational efforts. The field type of TA program is basically applied assistance. Most of the service forestry--both industrial and State C.F.M.--programs are operated as direct field types of TA. In many areas, private consulting foresters also offer a field type of TA on a fee basis. Attached to many State forestry organizations is a forest products utilization specialist who often functions in a field capacity by providing market information. Educational types of TA programs include forest Extension activities from the Land Grant college, as well as the organized I & E programs from state and federal forestry organizations. Industrial forestry organizations are also active in the educational type of TA program; AFI, APA, and in Maine the Forest Products Council and P-IIO are good examples of effective educational TA programs.

Technical assistance in forestry is also provided within a mixed framework of field/education programs by a number of unique organizations. At the federal level the State and Private Forestry Division of the U.S. Forest Service is actively engaged in a wide

variety of TA (e.g. sawmill improvement programs). Specialized research labs, such as the Madison Forest Products Lab, often carry out different types of TA. On the private level, many groups such as Christmas tree growers, maple products producers, and small forest landowners associations carry out active educational programs, as well as field assistance programs such as "cooperative" marketing. The Tree Farm program is an industrial TA program operated in a mixed framework.

Who are the recipients of all this TA action? Indirectly, any forest manager dealing with any size and any type of forest land is part of the TA client group. More specifically much of the TA work is directed to:

1. general citizen groups, including youth
2. small forest landowners
3. small forest products manufacturers
4. small producers of non-timber forest products.

Of course, many individuals may be a member of more than one client group. And the characteristics of these client groups are most variable.

Objectives and Success of TA:

Most field type TA programs are designed to supply some rather specific service to the client group. For example, service forestry programs usually aim to provide small forest landowners with a limited range of woodlot services, such as tree marking and TSI recommendations. The field type TA programs are usually structured so that, in general, most of the rather specific goals of the program can be clearly evaluated. In 1975, the USDA Forest Service published an evaluation of the CFM program. This evaluation reached a number of conclusions, such as:

1. a serious lack of manpower and funding prevents full return on the CFM program.
2. financial incentives for management are important.
3. information aspects of CFM must be improved.

The educational type of TA program is usually designed to meet a wide range of more general goals. For this reason, it is usually more difficult to determine the degree of success with an educational TA program. Such educational TA programs often attempt to provide some client group with correct forestry information that will result in a change of attitude or in some more specific action. When some specific action, such as a request for management assistance, is a primary goal of the

program it is usually easier to evaluate. However, the success of those programs aimed more directly at a change in client attitude are much more difficult to assess.

In recent years, the American Forest Institute contracted with a professional survey organization to evaluate the impact of forestry education programs on the general public. These evaluations show some interesting results. Generally, there seems to be increased awareness and concern about forestry in all segments of the general public. Forest industry seems to have maintained a generally creditable image with the public. Unfortunately, on the negative side, there is still a high degree of public misunderstanding about forestry and forest practice. Based on the results of these surveys, there is yet a great deal of educational TA to be completed.

Indirectly, there are certainly other ways to evaluate the success of the forestry TA program. For example, public attitude reflected in the ballot on a critical forestry issue, may be one indirect measure of the effectiveness of the educational TA program. With regard to field type TA programs, it might be possible to evaluate the program in terms of improved operation methods or improved quality of growing stock. Numbers of program participants, or even the percentage results of a survey can furnish part of the total success picture when forestry TA programs are evaluated.

Applications and Limitations:

Programs of TA in forestry must represent an important factor that will determine effective implementation of intensive cultural practices. Basic to implementation of any program of intensive cultural practices is public understanding and acceptance. Therefore, educational types of TA activities are essential if intensive forestry programs are to be successfully implemented. In fact, it will probably be necessary to increase the level of educational TA in proportion to the degree of complexity associated with proposed programs of intensive forestry practices.

For the small forest landowner (who represents about 59% of the nations forest landowners) in addition to education TA, the field TA program will be essential for successful implementation of intensive forest practices. Small landowners must first be motivated (educational TA) and then must be shown how (field TA) to accomplish the recommended intensive cultural practices on the ground.

Expanded TA programs designed to promote intensive forest practices can be successful only to the degree that the major obstacles can be overcome. In connection with large scale

(public and industrial private forestry) programs of intensive forestry, the major constraint is probably the large number of very diverse interest groups. A better understanding of forest landowner's goals will be necessary in order to determine the correct procedures for motivating the landowner to practice more intensive forest management. A solution to this problem possibly lies in greater use of the mass media for communication; more active use of established programs in public schools, adult education, and cooperative Extension. Another major TA problem connected with the small forest landowner lies in active contact with the very large number of landowners. In Maine alone, it is estimated that there are 100,000 small forest landowners. Thus, a field TA program that could reach each of these small landowners on a continual basis must require a very high input of manpower and money, above present levels.

In summary, the degree of success from most programs of intensive forest practice will depend upon the degree to which effective TA programs are developed and implemented. The basic technical information to implement intensive forest practices is generally available now. The most significant limitation for any program of intensive forestry is the component of effective TA - both educational and field programs.

CLOSING COMMENTS

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The papers presented during the two and one half days of this symposium have provided all of us with a deeper understanding of the present knowledge on intensive management but they have also left us with many questions about the future. There is first an overwhelming feeling that we are doing too little about our problems and perhaps we are too late to meet potential requirements. We should have all of our productive northern forest types under intensive multiple use management but how soon will this happen?

Why should we mention a note of pessimism when we have been shown that intensive management can be accomplished? Chief McGuire said and I quote from his paper - "There is no doubt that private lands--particularly small, non-industrial holdings - are the key to meeting future demands for forest resources. And please remember that while this conference deals mainly with wood supplies, the demands for other forest uses are increasing just as rapidly--in some cases, more rapidly". Can we get these private lands under intensive management soon enough to meet our future needs? Must we depend upon strict regulation to meet the requirements? Will rising prices and rising demands result in a wave of exploitation? Hopefully we can establish good management practices on all lands without excessive regulation before the pressure for more fiber destroys the opportunity.

Robert Phelps pointed out our needs and gave us our charge. He pointed out how we might get a little more production by improving efficiency of utilization and we could gain some addition to meet future needs through imports. But, in a competitive world our future needs for additional wood must come mainly through management.

We must set our goals and go after them without delay. Are we ready as a general public to set realistic goals that everyone understands? We have discussed many ideas related to these questions and we have shown clearly that we have knowledge that is not being utilized for various reasons. Some general impressions that I have developed from these discussions are as follows:

(1) We have much knowledge about intensive management but we are not utilizing that information on a large scale.

(2) The northern forest types may be managed inten-

sively in a variety of ways depending upon a host of varying conditions which may be biological, economic or social.

(3) Research must continue at a rapid pace to develop further methods for culture of the northern forests.

(4) There is a critical need for the development of an understanding in the public sector about the need for and methods of intensive management.

(5) The managers of forested tracts have a difficult adjustment to make in changing from present methods to more intensive procedures requiring closer supervision of on the ground activities.

(6) Education must concentrate on preparing more foresters with an interest in close attention to detail and a desire to stay in close contact with the forest. Intensive management requires more foresters with specializations but proportionally will require many more with a desire to work in the woods caring for relatively small acreages of forests.

(7) Management of northern forest types has been crude and rough. Intensive management requires the development of the attitudes of artists who look on work as a creative production and an exciting experience. The change requires a real commitment all along the line.

(8) Very little will be done unless the economic climate is adjusted considerably. The forest is the resource on which our large industry must subsist; it is the playground for millions of people; it is the home for many wild plants and animals; it has a profound influence on our physical lives. Yet, the forest receives the least portion of support possible. Timber buyers pay the least stumpage possible, Recreationists expect to use the forest for nothing, Game managers treat animals as a by-product and hunters pay very little of their fees toward management of the habitat. There are hopeful signs but we can only hope that the changes to a real recognition of forest values comes soon.

This symposium has provided all of us with a status report on management of northern forests. It has provided ideas for the future. Dr. Blum and his very fine committee should be complimented for developing a much needed review. It is up to all of us to carry out the program in the future.

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1977. **Proceedings of the symposium on intensive culture of northern forest types.** Northeast. For. Exp. Stn., Upper Darby, Pa. 356 p., illus. (USDA For. Serv. Gen. Tech. Rep. NE-29)

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